Sanjeev Rastogi *Editor*

Ayurvedic Science of Food and Nutrition

Springer

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Foreword

For centuries Ayurveda has emphasized the role of food in health and disease. Modern medicine started out by basing all its treatments on drug-based principles and focused on specific problems rather than on individuals and the food they ate. This book satisfies a long-felt need of many physicians and nutritionists who were aware of the immense knowledge that existed but never knew how to access that information. The book covers almost every aspect of Ayurveda, from basic principles to therapeutic diets, and compares the principles of modern medicine and Ayurveda, which will demonstrate for the reader the rationale behind the information found in traditional treatises.

Part I deals with the fundamental Ayurvedic principles of food and nutrition. That food, or Ahara, drugs, or Aushadi, and Lifestyle, or Vihara, are important for well being was understood several centuries ago, and all three were considered essential for treatment; these are now being rediscovered by modern medicine. The book does not theorize but explains how this knowledge can be translated into day-to-day practice. One chapter deals with bioactive molecules, which is a very recent research issue. Food as an adjuvant in several disease states, including diabetes, hypertension, and cancer, as well as in convalescence, is described in detail with examples.

The role of stress and its role in food behavior is an aspect of pathophysiology that is extremely relevant to modern diseases like obesity and lifestyle disorders. One chapter in the book describes the science behind fasting and its benefits to health. Modern food practices and western dietary habits are reviewed and linked to the knowledge available in Ayurveda so that the younger generation can understand the scientific reasoning behind the disapproval of some of these habits and methods. The authors have also analyzed the nature of food, its texture, taste, and satiety, and its role in digestion and good health. The chapter on Ayurvedic nutrition and dietetics will be useful to students, teachers, and practitioners of dietetics. All of the

book's contributors are eminent scientists and teachers. One of the authors, who reviews the Western diet in the context of Ayurveda, is from the West.

This book contains invaluable information that will be useful to almost anyone in the field or with an interest in nutrition. I would welcome the appearance of more books like it covering various aspects of human health with a blend of modern and traditional practices. Springer is to be commended for committing to this book's publication.

Oklahoma City, OK, USA Dr. B. Sesikeran

Preface

Despite the consistent stress throughout the Ayurvedic classics that is placed on Ahara as a fundamental principle related to health and the elimination of disease, it is a painful revelation that we find it nowhere in contemporary Ayurvedic practice. Of the three basic components of the package offered for comprehensive health care in Ayurveda, Aushadhi came to overshadow the two other equally important components: Ahara and Vihara. The other two components gradually faded as elements of health care following the quick, tangible, and manageable effects on health offered by drugs. Only later, with the sudden and phenomenal upsurge of metabolic and degenerative diseases that have become the hallmarks of modern society, was it realized what was missing. Ayurveda stresses Aushadi, Ahara, and Vihara as the three pillars of a healthy and meaningful life. Throughout the period of the modern scientific renaissance, we have been trying to walk on one leg while ignoring the other two supports provided by the other leg, which we have had all along. The results are obvious; it has led to imbalances in our health and to disease.

Although it is now universally accepted that food plays a pivotal role in building and maintaining health and that Vihara, or lifestyle, significantly affects our overall health, it is still difficult to bring these two together in as accessible a format as drugs. Ultimately, the application of Ahara and Vihara to maintain and sustain health requires more than the mere application of a few set formulas aimed at curing or preventing a few disease conditions. This will possibly require a retuning of our minds to look inwardly at the preventive aspects of these interventions rather than looking into the immediate curative effects they might offer.

But promoting Ahara as a reliable approach to caring for one's health has not been easy. Ayurvedic fundamentals regarding diet and nutrition are too elaborate to be confined in to a small deliverable package of health care for all seasons. These principles must be applied with the highest precision on an individual basis to yield optimum results. Thus, Ayurvedic principles of food and nutrition can be subdivided on the basis of their generalizability and on the basis of their specificity for individuals based on a number of variables like *prakriti* (constitution), *agni* (metabolic status), *kala* (age/time/season), *desha* (geographical specificity), *satmya* (compatibility), and many more.

It would be desirable to test all Ayurvedic fundamentals on the basis of their variability and applicability in different population sets to attain the desired results. This would certainly require a thorough reconsideration of Ayurveda's claims regarding diet and nutrition and a reconsideration of conventional scientific approaches to verify the testability of traditional wisdom. If the traditional wisdom cannot be tested, it may be necessary to redesign many of the tools of conventional research to reveal what is not made evident by them. As a modest beginning, we can revisit all available scientific knowledge regarding Ayurvedic principles of food and nutrition. This would involve an exhaustive exploration of avenues perhaps not directly connected to Ayurveda, but a careful enquiry might uncover a fascinating applicability to what is taught in Ayurveda. The scientific exploration of the existing body of knowledge with reference to Ayurvedic principles of food and nutrition constitutes the theme of this book. This is certainly just the beginning. We still have a long way to go before we truly understand how to remain healthy with the help of the strongest medicine ever evolved – food.

Lucknow, India Sanjeev Rastogi

Acknowledgments

The present book is an offshoot of our previous work in an attempt to find evidence-based applications of Ayurvedic principles to health care. It was a great revelation over the course of research to discover that, despite its profound importance in Ayurvedic health principles , food is often neglected in the contemporary practice of Ayurveda. Together with the universal desire to find better health care solutions through the application of food in daily life, there was a need to determine the logic of Ayurvedic food principles in light of science and then find a way to relate this knowledge to a modern understanding of nutrition so as to formulate a food-based solution to health that was based on both a holistic understanding of health and a scientific commitment to knowledge. This book is the outcome of this prolonged thought process that spanned several years. Professor Diana Lurie from the University of Montana and Professor Francesco Chiappelli from the University of California at Los Angeles were instrumental in my decision to pursue this work. That decision was reinforced by Professor R.H. Singh from Banaras Hindu University, who was my mentor and inspiration in my journey to understanding Ayurveda more rationally.

The team at Springer provided the much needed support that made this work possible. Assistant editor of food science Rita Beck, senior editor Susan Safren, editorial director Carolyn Honour, and Springer officer William F. Curtis all deserve special mention for their efforts in turning an idea into a finished book.

A book like this would not be possible without the wholehearted support of family and friends. It was the support I received from my wife Ranjana and son Shashwat that enabled me to fully engage with the task of giving the book its final form.

Words are inadequate to express my indebtedness to Piyari, who offered me solace when I was feeling completely forlorn, exhausted, and destitute. It was a medicine for my soul that healed me all through and gave me a new life. This is for the love that was showered upon me selflessly when I needed it most. Piyari, it is a blessing to have you in my life. You have transformed me completely.

Finally, I acknowledge all my colleagues, friends, and family who helped me in many ways during the process of writing this book. An effort like this is impossible without the support of many people. This book represents the efforts of an entire team working in harmony on different fronts. I salute all who had a hand in this project in one way or another.

Contents

Part I
Ayurvedic Fundamentals of Food and Nutrition

Chapter 1
Ayurvedic Principles of Food and Nutrition: Translating Theory into Evidence-Based Practice

Sanjeev Rastogi

1.1 Introduction

Much has been done so far in science to understand food and nutrition with the objective of defining healthy food, which can ultimately reduce the occurrence as well as the impact of disease. At this juncture of advancements made in the field of food science, a lot remains obscure and our understanding is incomplete. We know by virtue of our experience that the same food does not act the same in all people. There are differences among likes and dislikes of food; and likewise there are differences among people in the quantitative and qualitative requirements of food. Many of these mysteries surrounding food appear abstract because they defy explanation in terms of contemporary science. Fortunately, Ayurveda, the ancient science of healthy living, provides some reasonable explanations about the role of food in ensuring health. In this chapter, we will explore Ayurvedic wisdom regarding food and nutrition and determine how this knowledge can be understood in terms of science to make it most useful in evidence-based clinical practice.

1.2 Quantitative Understanding of Food in Ayurveda

Matrashi syata (eat in appropriate quantity) has been the principal motto of Ayurveda for those who wish to be healthy [1]. This emphasizes the fact that individuals must be aware of their own specific needs in terms of quantity of food. Ayurveda takes into account the quantity of food required by each individual. *Charaka samhita*, the foremost compendium of Ayurvedic medicine, dedicates a whole chapter to various quantity-related aspects of food [1].

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1.2.1 *Appropriate Quantity of Food Required for an Individual at a Given Time*

Matra (quantity) signifies the most appropriate quantity of food needed by an individual at a given time. Contrary to the serving size idea of modern nutrition, which recommends a certain portion of food depending on the individual's age and sex and on the type of food [2], the idea of *ahara matra* (food quantity) is more individualized, dynamic, and flexible. Instead of being based upon generic and fixed variables like a person's age and sex, as in modern nutrition, the Ayurvedic principle of *ahara matra* is more subtle and is based on a dynamic interplay of various consumer- and food-related factors that may vary on a daily basis. The individualization of *ahara matra* in Ayurveda is in stark contrast to modern nutrition, which proposes a more generic approach to food quantity.

1.2.2 *Food Requirements May Differ Among People of the Same Gender and of Similar Age*

Contrary to the conventional belief that food requirements may be generic as per age and sex, Ayurveda proposes that the food requirements of two people of the same age and gender can also vary considerably. Real life provides plenty of such examples. Some people need less food to remain healthy compared to other people of the same age and gender, who may require much more food.

1.2.3 *Factors Determining the Quantitative Requirements of Food in a Person at a Given Time*

There are consumer-related and food-related factors that determine the quantitative requirements of food for a given individual. The two key questions to ask are simply what food and for whom?

1.2.3.1 Consumer-Related Factors: *Agni Bala*

Among the consumer-related factors, *agni bala* (individual digestive and assimilatory capacity) is the principal factor determining the food quantity needed at a given time [3] *agni* signifies the metabolic status of a person and is assessed by the digestive and assimilatory functions of an individual operating at various levels. Depending on the level of its operation, *agni* can be identified as those factors

working at the digestive level (*jatharagni*), tissue level (*dhatvagni*), and metabolite level (*bhutagni*). Consumed food is acted upon initially through *jatharagni* for digestion followed by *dhatvagni* for its assimilation into tissues and finally by *bhutagni*, where individual metabolites are used for various intracellular activities. Ayurveda identifies *agni* as the principal factor responsible for a separation between the retainable (*saara*) from the excretable (*kitta*). A major function of *agni* at every level is to separate the retainable from the excretable of a consumed substance. The malfunction of any of these *agni* will lead to an incorrect production of either of these products and, ultimately, to disharmony. Food quantity should therefore should be considered an *agni* that functions at every level to ensure the ultimate healthy fate of a consumed food.

Factors Determining *Agni Bala*

There are two major determinants of *Agni* in Ayurveda. Some are fixed or static for a particular person based upon his or her body type and are called *prakriti*; the others are dynamic and keep changing depending on the season, time of day, and age. Contrary to modern nutrition, Ayurveda does not consider gender a factor in the determination of required food quantity.

Body Type as a Determinant of Agni Bala

Prakriti is a genetic–epigenetic conceptualization of Ayurveda that personifies the genetic–epigenetic interplay of three major body types. These three body types are primarily the metabolic variants of individuals functioning variously at physical, physiological, and psychological levels [4]. Depending on their metabolic levels, three major body types may be categorized as follows: *Vata* are irregular metabolizers, *Pitta* are fast metabolizers, and *Kapha* are slow metabolizers [5].

Food Requirements According to Prakriti

Vata, for irregular metabolizers, require smaller, yet more frequent, quantities of food because they cannot cope with hunger. *Pitta*, the fast metabolizers, require large quantities of food per meal and need it more frequently because they also cannot cope with hunger and thirst. In contrast to these two, *Kaphai*, the slow metabolizers, require smaller quantities of food less frequently because they have a higher tolerance for thirst and hunger. There are several obvious implications of determining food requirements on the basis of *prakriti*. It can be used to determine the fasting tolerance of people who are fasting. Fasting has been a very popular form of religious ritual among Hindus and Muslims. Understanding an individual's *prakriti* can help in designing fasts depending on the person's tolerance without

compromising his or her physical or religious needs. A few more observations are in order regarding *prakriti* in relation to food. Aging is a differential phenomenon as some people age faster than others. Aging is determined primarily by metabolic activities taking place within cells. Clearly, a cell that is metabolically active will age earlier than other, less active cells provided no other protective mechanisms are at work to reverse the aging process [6]. For obvious reasons due to their higher metabolic turnover, *Pitta* people age faster than others. This phenomenon is beautifully noted in Ayurveda by observing that *Pitta* is characterized by increased hunger and thirst, an early graying and loss of hair, and increased mole formations. Contrary to this observation, *Kapha* is characterized by slow metabolic turnover, which is observed through lesser food and a greater tolerance for hunger. To arrest premature aging, it is important to balance food quantities appropriately in accordance with the individual *prakriti* without causing a food deficit or overload. The metabolic rate also determines individual differences among people. The concept of *prakriti* in Ayurveda suggests that every individual is distinct – physiologically, psychologically, and physically.

Dynamic Determinants of Agni

Like most other principles of Ayurveda, *Agni* is also a dynamic entity that varies depending on the age of the individual, the time of day, and the season of the year. Early age is characterized by a predominance of *Kapha* and therefore is marked by *mandagni*. It is a common observation that children are most fussy about food and their nutritional statuses are often compromised owing to poor food intake. Middle age is marked by a predominance of *Pitta* and hence is marked by *teekshnagni*. This is the time when we require a large amount of food at greater frequencies than in early or old age. Old age is characterized by a predominance of *Vata* and therefore is marked by *vishamagni*, causing an erratic appetite. This warrants careful decisions regarding food intake at every meal in old age, reflecting actual appetite and not the desire to consume food.

Age-related quantitative changes in food intake have scientific support as well. Known gastrointestinal (GI) changes occur in humans due to aging. Common changes are a decreased taste threshold, hypochlorhydria (low production of gastric acid in the stomach) due to atrophic gastritis, and decreased liver blood flow and size [7]. These changes reflect a reduced functional capability of the GI system and indicate a need for reduced quantities of food in the later stages of life.

Time of day also requires a careful consideration of food quantity. Morning is the time of *kapha*, and so food consumption should be lower, corresponding to *mandagni*. Therefore, a smaller breakfast is recommended. Daytime is marked by *pitta*, and so more substantial consumption is recommended to match *teekshnagni* of *pitta*.

Because evening is once again the period of *kapha*, food intake should be reduced at that time. A simple notion is that the daytime meal should be heavier than the morning and evening meals, and this is supported by the logic of Ayurveda.

The different seasons also affect the level of *agni* in the body and consequently affect requirements regarding food intake. Summer is marked by greater *vata* and, hence, requires smaller quantities of food compared to winter, when more food is recommended. It is for this reason that summer food should be lighter than winter food.

1.2.3.2 Food-Related Factors in the Determination of Quantity: Food Classification Based on Digestibility

Depending on the time needed for digestion, Ayurveda considers food as *guru* and *laghu. Laghu* refers to foods that take less time to digest. Examples of such foods are *shali* rice, *shastika* rice, and *mung*. On the other hand, *guru* foods are those that take more time to digest. Examples of such foods include those prepared from wheat (*pishta vikriti*), sugar (*ikshu vikriti*), or milk (*ksheer vikriti*). As a general rule, *guru* foods should be consumed in smaller quantities than *laghu* foods. According to Ayurveda, *laghu* foods are mainly composed of *vayu* and *agni*. Because of *agni*, they have the inherent property of stimulating digestion. A slightly excessive intake of *laghu* foods therefore will not cause problems. In contrast, *guru* foods are mainly composed of *jala* and *prithvi*. Because *Jala* has the property of countering *agni*, even a slight excess of this food may cause significant problems. To avoid such problems, *guru* foods should be consumed only partially.

1.2.4 Determining Whether Food Is Consumed in the Right Quantity

Anupahatya prakriti yatha kaalam jaram gacchati has been the observational method for knowing whether food is being consumed in the proper quantities. *Anupahatya prakriti* is that quantity of food that can be consumed without any adverse effects on the physical or physiological functions of an individual. *Yatha kaalam jaram gacchati* is that quantity of food that gets digested within a reasonable amount of time. As a consequence, if the proper quantity of food is consumed, one should not feel heavy or lethargic, and one should feel hungry at the appropriate time owing to the timely digestion of the consumed food.

1.2.5 Implications of Inappropriate Ahara Matra

An inappropriate quantity of food may lead to various undesired consequences. Besides commonly understood consequences such as under- or overnutrition, there can be a cascade of consequences related to excessive *ahara matra* identified as *Ama* and related pathogenesis. *Ama*, literally meaning *unripe*, is considered to be a byproduct of inefficient digestion at various levels of *Agni*. This has the property of clogging and clinging within pathways, resulting in a blockade and interruption in normal physiology.

1.2.5.1 *Ama* and Related Disorders

A huge number of clinical conditions having immunological or autoimmune bases are linked to *ama* pathogenesis. Overnutrition has been found to be an essential component of every pathogenesis related to *ama* [8]. Some common clinical conditions related to *ama* are as follows:

- Chronic skin conditions including eczema
- Lethargy, chronic fatigue syndrome
- Various joint and connective tissue disorders

Ama digestion therefore has become the foremost principle of treatment of such conditions in Ayurveda.

1.2.6 Contemporary Factors Driving Food Quantity

Many factors other than individual susceptibility and preferences also act synergistically in determining the quantity of food that is ultimately consumed. Regarding obesity, oversized meal portions may go undetected and seem normal in a certain context, eventually leading to overeating without being noticed. Some common factors involved in miscalculating food quantities are as follows:

- Variable size and weight of bread (eating the same number of slices of bread of variable weight)
- Variable size of spoons and bowls (measuring quantity through the number of spoons or bowls)
- Snacking between meals while thinking that one has had only two regular meals
- High-calorie food in smaller quantities thinking that one has consumed a lesser amount of food

1.3 Scientific Rationale of Quantitative Awareness of Food in Ayurveda

1.3.1 Sensory-Specific Satiety

Quantitative determination of diet in Ayurveda is primarily based upon a sensory-specific satiety (SSS) regulation system where one gradually loses the liking for a specific food after consuming it to the satiety level [9]. We recently have learned that SSS is a complex phenomenon with a number of attributes, including olfactory and gustatory reduction of pleasantness of a food following exposure to it for a certain amount of time [10]. It is also a volume-dependent factor, not component dependent one (Bell et al. 2003) [11].

1.3.1.1 Method of Intake and Sensory-Specific Satiety

A concentrated, undisturbed, and focused mealtime, without too many distractions and properly masticated food, helps us perceive SSS quickly and helps us in judging when to stop eating. As long as we can recognize SSS, overeating is not an issue. Ayurvedic principles on the methods of food intake, popularly called *Ashta ahara vidhi visheshayatana*, are definitive ways of recognizing SSS to identify the appropriate *ahara matra*.

1.3.2 Food Digestibility Index

Based on their digestibility status, foods may be grouped as follows:

- Rapidly digestible food
- Slowly digestible food
- Resistant food

When determining the quantity of a food to consume, its digestibility should be taken into account. Food that is simple and easy to digest may be consumed in larger quantities than food that is complex and, hence, more difficult to digest. The Ayurvedic concepts of *guru* (complex) and *laghu* (simple) foods contain a similar notion of digestibility.

1.3.2.1 Implications of Food Digestibility

Slowly digested starches (SDSs) have been found to blunt the postprandial increase and subsequent decline of plasma glucose and insulin concentrations, leading to

prolonged energy availability and satiety, compared to more rapidly digested starches. Sandsa et al. [12] examined the postprandial metabolic and appetitive responses of a slowly digested starch [wax maize (WM)] and compared it with rapidly digested carbohydrate, a maltodextrin-sucrose mixture (MS). The results supported the idea that WM promotes sustained glucose availability in young, insulin-sensitive adults [12]. For their long yet slow release properties, slowly digested substances are recommended in smaller quantities compared to rapidly digested substances required to meet immediate energy needs.

1.3.2.2 Implications of Ayurvedic Concepts of Food Digestibility

The Ayurvedic concepts of *guru* and *laghu* foods may have special implications for various target groups looking for ideal food combinations. In debility after a prolonged disease where rapid replenishment of nutrients is required, a large quantity of *laghu* foods that are easily and rapidly digested and subsequently metabolized may be more suitable. In contrast, for an obese, a filling and satisfying *guru* food could suppress the hunger urge for a longer amount of time compared to other foods. In normal conditions, there should be a useful combination of *guru* and *laghu* foods in the diet.

1.4 Ayurvedic Principles of Food Preparation and Intake

1.4.1 Eight Points of Consideration in Reference to Food Preparation and Intake

Ashta ahara vidhi visheshayatana, or eight principles of food preparation and intake, was among the most important contributions of Ayurveda to wholesome eating. These eight components incorporate various measures in relation to food preparation, combination, storage, and consumption. What follows is a description of the important aspects of these eight principles of healthy eating.

1.4.1.1 *Prakriti*

The prakriti of a food represents the integral characterstics that are reflected through a set of opposing properties called *gurvadi guna* (guru = heavy, adi = etcetera). These properties primarily represent the elemental (*panchamahabhuta*) predominance of a food. The ultimate biological effects of food are therefore largely dependent upon the *prakriti* of the food. The following list shows these properties and their opposite features:

Guru (heavy)	*Laghu* (light)
Sheet (cold)	*Ushna* (hot)
Snigdha (smooth)	*Ruksha* (rough)
Manda (slow acting)	*Teekshana* (fast acting)
Sthir (stable)	*Sara* (movable)
Mridu (soft)	*Kathin* (hard)
Vishada (nonmucilagenous)	*Picchila* (mucilaginous)
Slakshana (fine)	*Khara* (coarse)
Sthool (gross)	*Sukshma* (subtle)
Sandra (concentrated)	*Drava* (liquid)

1.4.1.2 *Karana* (Properties Induced by Food Processing)

Karana are the properties that are induced in food through its processing. Various methods used to enforce new properties in foods include processing with water or heat; cleaning or washing; rotating; saturating with other liquids; storing and keeping in a special vessel.

1.4.1.3 *Sanyoga* (Properties Induced by Food Combination)

Food combination is also supposed to evolve new properties in foods that are otherwise not available in the independent components of the combination. These combinations may act through the mechanism of synergism or antagonism.

1.4.2 Methods of Food Intake

Ayurveda also proposes some specific protocols for food intake. These are enumerated as follows:

Ushna (hot)
Snigdha (smooth, lubricated)
Mataravata (in appropriate quantity)
Jeerne (once the previously consumed food is digested)
Viryaviruddhama (compatible)
Ishte Deshe (at appropriate place and in appropriate position)
Ishta Sarvopakaranama (satisfying all personal preferences)
Nati Drutam (slowly)
Nati Vilambita (not too slow)
Ajalpan (without talking)
Ahasan (without laughing)
Tanmana (with adequate concentration)

1.4.3 Implications of Observing the Methods of Food Intake

To observe SSS without getting perverted, Ayurvedic methods of food intake are essential. Observing these methods may help to trigger the neurohumoral aspect of food digestion so that SSS may remain fully functional. These methods can also help one to avoid certain foods and problems related to their consumption.

1.5 Qualitative Attributes of Food

In addition to the classification of food on the basis of its digestibility and appropriateness for human consumption, Ayurveda classifies foods on the basis of abstract qualitative attributes affecting the mind and body of the consumer. The three kinds of food, namely *Sata*, *Raja*, and *Tama*, are usually preferred by people of similar dispositions and temperaments. These foods tend to support the properties in accordance with their inherent qualities [13].

Among these three kinds of food, those that are fresh, smooth, stable, and pleasant in taste and appearance are *satvika* foods. This type of food is promotive of life, health, mental abilities, physical strength, and pleasure [14]. Examples of such foods are freshly prepared foods, fresh fruits, and milk. *Raja* foods are bitter, sour, salty, hot, spicy, and dry. A burning sensation is often experienced after the consumption of *raja* foods. *Raja* food may cause sorrow, grief, and disease [15]. Most junk and preserved food consumed today belongs to the *raja* category. Their harmful effects on health are obvious.

Contaminated, dried, spoiled, old, stale, and fermented foods are considered *tamasika*. These types of food cloud the mind and affect its proper functioning [16].

1.6 Translating the Food and Nutrition Theory of Ayurveda into Practice

Despite the many excellent and wholesome components in the Ayurvedic view of food and nutrition, due to a lack of evidence and a lack of objectivity, sometimes it seems too cumbersome to translate these ideas into practice. In terms of the single most important area of devising an individualized food plan for everyone, first we need to know definitely about an individual's *prakriti*. Until recently, there were no substantiated methods that could have drawn valid, unambiguous conclusions about healthy individuals' *prakriti* [17, 18]. With the development of a Prototype Prakriti Analysis Tool (PPAT), we are now hopeful that we will have the ability to make evidence-based determinations regarding the *prakriti* of an individual [19].

The Ayurvedic *prakriti* doctrine has an empirical, genetic component that is currently attracting more scientific attention, and it is becoming more widely

understood that all people have their own unique qualities with respect to the availability or expression of certain genes associated with specific metabolic functions. Human anatomy and physiology, and their neuro-psychological functions, may differ slightly with regard to these functions [20, 21]. It would be very interesting to determine whether or not a *prakriti* analysis could be conducted for use as a clinical tool to decipher human genome specifications in reference to variable human behavior and functions. If confirmed, this may find extensive applications in defining the substrates that may up- or downregulate the functions of specific genes in the promotion or suppression of the specific functions of those genes [22, 23].

Much remains to be done to define various abstract concepts of Ayurvedic nutrition to develop their evidence-based practical applications. Determining food quantity depending on an individual's digestive system and age and on the type of food chosen, season and time of day are another complex area requiring a lot of research before a firm conclusions can be drawn. Defining *guru* and *laghu* foods on the basis of their digestibility can best be approached by exposing various foods to various enzyme solutions and noting the reactions in a time-dependent manner. The total amount of time required to digest certain foods completely may give a clear indication regarding the *guru* or *laghu* status of a food. Such in vitro studies, although perhaps not fully addressing various confounding aspects of food digestion that occur in vivo, would at least provide some sort of idea about the possible nature of food and its digestibility.

Functional food is another domain where Ayurveda specializes. Various processed and unprocessed foods mentioned in Ayurveda are known for their special properties, often called their *prabhava.* It is surprising to see how Ayurveda may explain many processed and unprocessed foods on the basis of their physiological effects and the benefits they offer. What is required is to validate all the insights of Ayurveda in terms of contemporary science to obtain further confirmation of their effective and reliable use in maintaining human health.

References

1. Charaka Samhita, Charaka (1998) In: Tripathi BN (ed) Sutra Stahan Matrashitiya adhyaya. Chaukhamba Orientalia, Varanasi
2. United States Department of Agriculture. www.mypyramid.gov. Accessed Dec 2012
3. Purvya MC, Meena MS (2011) A review of role of prakriti in aging. Ayu 32:20–24
4. Rastogi S (2010) Building bridges between Ayurveda and modern science. Int J Ayurveda Res 1(1):41–46
5. Patel MR (2010) Applying the knowledge of Ayurveda to appraise the US nutritional paradigm, a thesis submitted in partial fulfilment of the requirements for the degree of clinical Ayurvedic specialist. California College of Ayurveda, Nevada
6. Rastogi S (2012) Transforming Ayurveda. In: Rastogi S, Chiappelli F, Ramchandani MH, Singh RH (eds) Stepping into the realm of evidence – based practice in evidence based practice in complementary and alternative medicine: perspectives, protocols, problems and potentials in Ayurveda. Springer, Berlin, pp 33–50
7. Rastogi S (2009) Ayurveda for comprehensive health care. Indian J Med Ethics 6(2):101–102

8. Rastogi S (2012) Gut and joint interconnections: a reappraisal to Ayurvedic understanding of joint diseases. In: Rastogi S, Chiappelli F, Ramchandani MH, Singh RH (eds) Evidence based practice in complementary and alternative medicine: protocols, pitfall and potential in Ayurveda. Springer, Heidelberg, pp 139–158
9. Smith JM, Ditschun TL (2009) Controlling satiety: how environmental factors influence food intake. Trends Food Sci Technol 20:271–277
10. Olsen A, Ritz C, Hartvig DL, Moller P (2011) Comparison of sensory specific satiety and sensory specific desires to eat in children and adults. Appetite 57:6–13
11. Englyst HN, Kingman SM, Cummings JH (1992) Classification and measurement of nutritionally important starch fractions. Eur J Clin Nutr 46(Suppl 2):33–50
12. Sandsa AL, Leidyb HJ, Hamakercd BR, Maguiree P, Campbellad WW (2009) Consumption of the slow-digesting waxy maize starch leads to blunted plasma glucose and insulin response but does not influence energy expenditure or appetite in humans. Nutr Res 29:383–390
13. Srimadabhagvadgita, Chapter 17/7 (2010) Geeta Press, Gorakhpur
14. Srimadabhagvadgita, Chapter 17/8 (2010) Geeta Press, Gorakhpur
15. Srimadabhagvadgita, Chapter 17/9 (2010) Geeta Press, Gorakhpur
16. Srimadabhagvadgita, Chapter 17/10 (2010) Geeta Press, Gorakhpur
17. Rastogi S (2012) Prakriti analysis in Ayurveda: reappraising the need of better diagnostic tools. In: Rastogi S, Chiappelli F, Ramchandani MH, Singh RH (eds) Evidence based practice in complementary and alternative medicine: perspectives, protocols, problems and potentials in Ayurveda. Springer, Heidelberg, pp 99–112
18. Rastogi S, Chiappelli F (2010) Bringing evidence basis to decision making in complementary and alternative medicine (CAM): prakriti (constitution) analysis in Ayurveda. In: Chiappelli F et al (eds) Evidence-based practice towards optimizing clinical outcomes. Springer, Berlin, pp 91–106
19. Rastogi S (2012) Development and validation of a prototype prakriti analysis tool: inferences from a pilot study. Ayu 33:2
20. Lurie D (2012) Ayurveda and pharmacogenomics. Ann Ayurvedic Med 4:126–128
21. Bhalerao S, Deshpande T, Thatte U (2012) Prakriti (Ayurvedic concept of constitution) and variations in platelet aggregation. BMC Complement Altern Med 12:248. doi:10.1186/1472-6882-12-248
22. Rizzo-Sierra CV (2011) Ayurvedic genomics, constitutional psychology and endocrinology: the missing connection. J Altern Complement Med 17:1–5
23. Sethi TP, Prasher B, Mukerjie M (2011) Ayurgenomics: a new way of threading molecular variability for stratified medicine. ACS Chem Biol 6:875–880

Chapter 2
The Basic Tenets of Ayurvedic Dietetics and Nutrition

Ram Harsh Singh

2.1 Introduction

Food and diet are the most essential requirements of all living beings. Ayurveda, the ancient life and health science originating from India, considers food in a deeply comprehensive understanding, attaching to it notable emotional and spiritual significance, in addition to its material and biological attributes. According to Ayurveda (CS.Su.28:45) the living human body and the diseases that afflict it are both the products of food [1]. The Vedic texts count food a lifelike phenomenon (*Pranah*). Food is considered one of the three *Upastambhas* of life, meaning that life cannot be sustained without food. *Ahara* is categorized as *Hitahara* (wholesome) and *Ahitahara* (unwholesome). In a similar context, the terms *Pathya* and *Apathya* are also used to denote the acceptability and adoptability of a particular food in a given context. The Ayurvedic texts place great emphasis on the compatibility and incompatibility of certain foods. Caraka describes in detail the 18-fold denominators of *Viruddhahara*, i.e., dietary incompatibility. Ayurveda emphasizes the material quality of food but places even greater emphasis on the selection of food, its processing and cooking, and rules for healthy eating. Thus the Ayurvedic approach to food and dietetics is very different from the conventional Western approach.

Although *Ahara*/food is derived by an individual from the environment, its processing and use intimately depend on the integrity of internal biomechanisms. The sheet anchors in nutritional processes are (1) the integrity of *Agnibala* and (2) *Srotabala*. Unless the *Agni*/biofire system and *Srotamsi*/inner biotransport system are in order, processes of nutrition may not accomplish. Hence it is imperative to discuss *Ahara*, *Agni*, and *Srotas* in a close continuum. *Ahara* is essentially a *Panchabhautic* entity and can be related accordingly to the theories of *Triguna* and *Tridosh*. Likewise, the living human body is also *Panchabhautic*, and accordingly

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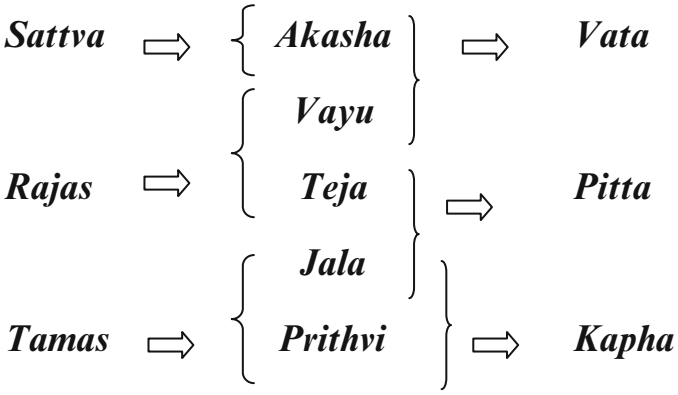
its functions are governed according to the laws of *Triguna* and *Tridosh*, both in relation to the states of *Prakriti* and *Vikriti*. The environment around us is also a *Panchabhautic* milieu that manifests in terms of the environmental rhythms of *Adana-visarga kala* and *Sad-ritus* and their chronobiological impacts. Thus Ayurveda urges dietary planning in close consideration of nature and environmental factors on the one hand and the *Prakriti* and *Vikriti* of the individual on the other hand. Over and above the integrity of A*gnibala* and *Srotabala* one should be mindful of maintaining the good nutritional status of an organism.

In addition to food and diet, Ayurveda propounds a separate concept of medicinal dietary supplements in the context of *Rasayana therapy*, which forms one of the eight branches of classical *Astanga Ayurveda* in which a wide range of medicinal and nonmedicinal restorative remedies is described. A *Rasayana* may be in the form of a dietary article, a restorative drug, or a healthy life style. The *Rasayanas* are claimed to be something like nutraceuticals. They improve the nutritional status of an individual and help in procuring the best qualities of *Dhatus*, i.e., bodily cells and tissues, through their positive action at the level of *Rasa*, *Agni*, and *Srotas.* The Ayurvedic texts describe a large number of *Rasayana* remedies that can be used as dietary supplements. The *Rasayanas* not only improve gross nutritional status; it is also claimed that they are immune enhancers and antiaging and biobalancing remedies in Ayurveda that possess a range of specific and nonspecific actions [2].

2.2 Food and Its Material Components

As stated earlier, all articles of food are comprised of five basic elements/ *Panchamahabhutas*: (1) *Akasha/ether,* (2) *Vayu/air*, (3) *Teja/fire*, (4) *Jala/water*, and (5) *Prithvi/earth*, which are the five fundamental qualities of matter possibly comprised of distinct categories of quantum clusters in terms of modern physics. The three *Doshas* – *vata-pitta-kapha* – are the biological derivatives of the five *Mahabhutas*, and the *Trigunas* – *sattva-rajas-tamasa* – are the initiating causal qualities responsible for the creation of the material world, including food. The following table approximately depicts the relationships [3].



In accordance with the preceding discussion of the basic nature of food, different articles of food manifest their qualities, potencies, tastes, and nutritional attributes to the body according to the relative preponderance of the *Panchabhautic* composition and related *Trigunatmaka* and *Tridoshic* properties. A balanced diet in Ayurveda is planned in relation to the known *Panchabhautic* composition and *Tridoshic* impacts in the living body. The following table depicts some of these features, which may help in planning a diet [4]:

		Biological impact		
Sadarasa (tastes)	*Panchabhautic* composition	*Kapha*	*Pitta*	*Vata*
1. Madhura/sweet	*Jala* + *Prithvi*	↑↑	↓↓	↓
2. Amla/sour	*Prithvi* + *Agni*	↑↑	↑↑	↓
3. Lavana/salt	*Agni* + *Jala*	↑↑	↑↑	↓
4. Katu/pungent	*Vayu* + *Agni*	↓	↓	↑↑
5. Tikta/bitter	*Akash* + *Vayu*	↓	↑↑	↑
6. Kashaya/astringent	*Vayu* + *Prithvi*	↓↓	↓	↑

2.2.1 Gunas/*Physical Properties and Their Attributes*

The Ayurvedic classics describe 20 basic properties of physical materials constituting the whole range of living and nonliving objects in this world, such as articles of food, drugs, all vegetation, minerals present in the environment, and bodily cells and tissues. The following 20 *Gunas* form the basic matrix of the transformation of the *panchabhautic* matter into living biologic factors in a living body:

1. *Guru*/heavy	2. *Laghu*/light	11. *Ghana*/dense	12. *Drava*/liquid
3. *Manda*/slow	4. *Tiksna*/sharp	13. *Mridu*/soft	14. *Kathin*/hard
5. *Sheeta*/cold	6. *Ushna*/hot	15. *Sthira*/stable	16. *Chala*/mobile
7. *Snigdha*/oily	8. *Shuska*/dry	17. *Sukshma*/subtle	18. *Sthula*/gross
9. *Picchila*/slimy	10. *Ruksha*/rough	19. *Shlakshna*/clear	20. *Avila*/cloudy

These physical properties, as found in various articles of food and drugs, produce similar effects on the body when administered and deplete the opposite properties in accordance with the theory of *Samanya* and *Vishesha*, i.e., homologous versus heterologous, as described in Ayurvedic texts [5].

2.2.2 Sources of Food Described in Ayurveda

The Ayurvedic texts describe 12 categories of food sources reflecting the then available varieties of food in historical perspective. A look at this classic information reveals that the whole range of food currently in use today remains the same as was

originally identified during the classical age of Ayurveda. These 12 categories of food are as follows.

1. *Shukadhanya* (corn)	7. *Madya Barga* (wines)
2. *Shamidhanya* (pulses)	8. *Ambu Barga* (water)
3. *Mamsa Barga* (meat)	9. *Gorasa Barga* (milk and milk products)
4. *Shaka Barga* (vegetables)	10. *Ikshu Vikara* (sugar cane and related products)
5. Phala *Barga* (fruits)	11. *Kritanna Barga* (cooked products)
6. *Harita Barga* (greens)	12. *Aharayoni* (food adjuvants)

2.3 Fundaments of Ayurvedic Biology

Thus, it would appear from the preceding descriptions that Ayurveda presents an entirely different version of biology in tune with its three unique features and approaches to studying and practicing biology and medicine, *viz.* (1) a pronature approach, (2) a holistic approach, and (3) a personalized approach to health care and treatment. In accordance with its theory of *Swabhavoparamvada*, Ayurveda teaches that a living body has powerful self-healing capacities, and whenever a disease afflicts us or a disease-causing factor invades our body, our body immediately starts counteracting the causal factor toward self-healing without waiting for an external aid or medication [6]. Hence a physician should always respect the natural response and should not apply any intervention that might obstruct the ongoing auto-healing process. All external artificial interventions, as far as possible, should be planned in such a way that the organism remains protected by nature. Natural food and diet represent one such attempt, in addition to many other strategies, that an Ayurvedic health provider may recommend. This is called the pronature approach of Ayurveda [7].

In view of the fact that a living mind–body system is a holistic entity, just as a disease entity is a complex holistic phenomenon, all efforts at providing health care and disease management must follow a holistic and inclusive approach, considering the whole organism as a single unit. In addition, disease should be managed in a holistic manner with a view toward overall life style management, dietetics, exercise, psychospiritual support, and medications where needed [8]. A reductionist approach is not welcome at any level in this system.

The third most important feature of Ayurveda is its personalized health care. Ayurveda believes that no two people are truly identical; each individual is unique in his or her biology and ill health. All individuals require individualized care depending on their unique *Prakriti* and *Vikriti* in line with their genomic profiles. Ayurveda classifies humanity into seven *Prakriti* types that are genetically determined in terms of the *Tridosha* theory of Ayurveda. Recent developments in the field of modern pharmacogenomics are now gradually converging toward the ancient Ayurvedic theory of *Dosha prakriti* and its relevance for patterns of disease susceptibility and treatment response [9]. The suitability or unsuitability of a particular food and diet is also governed by the same principle. A dietician should plan her clients' diet taking into consideration *Prakriti.*

2.4 Processing of Food and Its Consumption

The ultimate impact of a food depends not on its material qualities but largely on its processing, i.e., cooking and the discipline of eating. The foremost Ayurvedic classic *Caraka Samhita* (CS.Vi. 1:21) describes the eight principles of *Ahara vidhi*: (1) *Prakriti* (natural quality), (2) *Karana* (preparation), (3) *Samyoga* (combinations), (4) *Rashi* (quantity), (5) *Desha* (habitat and climate), (6) *Kala* (temporal factor), (7) *Upayoga Samstha* (rules of use), and (8) *Upayokta* (the user). Similarly, *Susruta* (SS.U.64:56) describes 12-fold considerations to be followed during the consumption of food. Caraka (CS.Su.26:86–87) describes the basic tenets of *Viruddhahara*, or dietetic incompatibility, which constitutes a fundamental consideration in planning a diet that is appropriate for an individual in a given situation. The 18-fold factors of dietetic incompatibility as described by Caraka are listed below:

2.5 Dietary Incompatibility (*Viruddhahara*)

1. *Desha viruddha*/climate	10. *Avastha viruddha*/patient's state
2. *Kala viruddha*/season	11. *Krama viruddha*/order of eating
3. *Agni viruddha*/digestive power	12. *Parihara viruddha*/restrictions
4. *Matra viruddha*/measure	13. *Upachara viruddha*/observances
5. *Satmya viruddha*/adaptability	14. *Paka viruddha*/cooking
6. *Dosh viruddha*/body humors	15. *Samyoga viruddha*/combination
7. *Samskara viruddha*/processing	16. *Hridaya viruddha*/palatibility
8. *Virya viruddha*/potency	17. *Sampata viruddha*/rich quality
9. *Koshtha viruddha*/bowel habits	18. *Vidhi viruddha*/mealtime rules

In addition to these factors of dietetic incompatibility, Caraka describes six important factors in determining the qualitative acceptability of an article of food irrespective of its material composition. These factors determine the *pathya-apathya* nature of food as mentioned below: (1) *Matra* (measure), (2) *Kala* (time), (3) *Kriya* (mode of preparation), (4) *Bhumi* (habitat), (5) *Deha* (body constitution), and (6) *Dosha* (morbidity factors).

2.6 Dietary Supplements and Nutraceuticals

As mentioned earlier, besides the core consideration of food and diet, Ayurveda also proposes a comprehensive science of medicinal dietary supplements in the context of *Rasayana Tantra*, which constitutes one of the eight branches of *Astanga Ayurved*a (CS.Ci.1, SS.Ci.27–30). The *Rasayanas* are not merely food supplements in the crude material sense. They are dynamic biofactors responsible for molecular nutrition, immunity enhancement, and longevity promotion. Most *Rasayanas*

produce their nourishing and rejuvenating effect by acting as direct nutrients, by promoting the *Agni Bala*, or by way of *Srotoprasadan*, resulting in an improved nutritional status, further leading to an improved quality of *Dhatus* or body tissues. Although the *Rasayans* are a generic class of restorative and rejuvenative supplements, many *Rasayans* could be tissue and organ specific such as *Medhya Rasayana* for the brain, *Hridya Rasayana* for the heart, *Twacya Rasayana* for the skin, and so on. Similarly, age-specific *Rasayans* can be used to compensate for age-related biolosses as described by Vagbhatt and Sharangdhara, *Balyam-briddhih-Chhabih-Medha-Twak-Dristi-Shukra-Vikaramau*; *Buddhih-Karmendriyam Ceto Jivitam Dashasto hraset*. On the other hand, as pointed out by Susruta and commentator Dalhana, certain *Rasayanas* are claimed to be disease specific such as *Shilajatu* for *Prameha* and *Tubarak* for *Kustha* [10]. Thus, in considering the Ayurvedic concept of food and nutrition it is necessary to refer to *Rasayanas* and their place as food supplements and as nutraceuticals. The deeper aspects of *Rasayana* therapy and rejuvenation, or *Kayakalpa*, of course, require separate consideration.

2.7 Host Biofactors in Ayurvedic Nutrition

As stated earlier, the processes of nutrition and its ultimate impact in living bodies is not the sole attribute of the physical composition of food items; rather they are largely governed by a range of host biofactors such as the integrity of *Agnibala* and *Srotabala*, i.e., digestive and metabolic fire and the inner transport system of an individual. Besides the three *Doshas* and seven *Dhatus*, the other most important biomechanisms involved in human physiology are the 13 types of *Agnis* located in the gut (*Jatharagni*), in tissues (seven *Dhatvagnis*), and in molecules (five *Bhutagnis*), which are responsible for the entire process of digestion of food and its metabolism. In addition, a living body contains innumerable microchannels called *Srotas* representing a unique quantized inner transport system that is responsible for transporting all biological fluids, nutrients, excretables, impulses, energy, emotions, and thoughts. Ayurveda considers that these channels may be crude as well as subtle, both tangible and intangible, performing their functions in a quantized fashion. There are as many *Srotamsi* in the body as there are biofactors conducting life process – *Yavantah bhavavisheshah tavantevasmin prakara-visheshah*. (CS.Vi.5). This is why the classics proclaim: S*rotomayam hi shariram* (Caraka). The relevance of the *Srotas* system, with the phenomenon of proper nutrition, is obvious from the statement of Caraka (CS. Su.25:45) in defining the *Pathya* or good diet, meaning that *Pathya* (right nutrition) is that which does not create difficulties in transactions of the *Srotas* function in an organism [11].

It cannot be overemphasized that the entire process of *Dhatu Poshan*, or nourishment, operates through the three basic *Nyayas*, or biotransport mechanisms: (1) *Kedarikulya Nyaya* (microcirculation and tissue perfusion), (2) *Khale Kapota Nyaya* (selective uptake of nutrients by corresponding cells and tissues), (3) *Ksiradadhi Nyaya* (assimilation and biotransformation). All three *Nyayas* will

function properly only if there is optimum integrity of *Agnibala* and *Srotabala.* Merely enriching the material components of food is not enough to ensure good nutrition.

Thus, Ayurveda proposes an entirely different approach to food, diet, and nutrition that is in strong contrast to the conventional Western approach. Ayurvedic dietetics places greater emphasis on processing food, its compatibility, and rules of food consumption. It considers the final impact of nutrition in the human body as a holistic attribute of the quality of food and its consumption as well as host factors such as *Agnibala* and *Srotabala.* Nutrition and dietetics should be practiced as a comprehensive science of nutrition encompassing food as well as host factors as discussed previously.

2.8 Conventional Versus Traditional Understanding

Conventional modern medicine suggests that food is essential for sustaining life. Fundamentally, food and nutrition serve three basic functions in the body: (1) as a source of energy for day-to-day bodily functions, (2) as the source of biomaterials for the growth and repair of daily wear and tear, and (3) to assist in certain vital functions of the body. The gross essential components of food are (1) carbohydrates, (2) fat, (3) protein, (4) vitamins, (5) minerals, and (6) water. Carbohydrates and fat provide energy to the body. Proteins are the building blocks for growth and repair, while vitamins and minerals assist in a range of vital functions in the body. Water is an important component of food and is essential for hydration and circulatory functions. Depending on a person's age and a range of functional conditions, different individuals require different proportions of these food components. A proper combination and proportion of food components is called a balanced diet and is formulated by a dietician based on rational principles.

Ayurveda has its own approach to planning a daily diet for an individual. It is not based on conventional chemistry; rather, it is based on classical *Panchmahabhautic* chemistry and *Tridoshic* functions. As such, Ayurveda considers the planning of a biobalancing diet rather than a balanced diet. Besides the physics of *Panch mahabhuta* and biology of *Tridosha*, Ayurveda puts great emphasis on the *Trigunatmaka* consideration of food, stressing especially a *Sattwika* diet, which is preferred for all. A *Sattwika* diet is one that is light and easy to digest and leaves minimal residue after digestion; at the same time, a *Sattwika* diet should contain an adequate amount of nutrients needed for the vital organs of the body, such as the brain, heart, and sense organs, rather than merely nourishing the support structures like bones and muscles. Such a diet, it is claimed, directs the body–mind system toward a positive balance of *Sattwa guna.*

Ayurveda thus adopts a very different approach to the science of food and nutrition as reflected by its fundamental features – a holistic and pronature approach and an emphasis on personalized considerations based on the concept of *Prakriti* and *Vikriti* [11].

2.9 Life-Style Factor in Health and Disease

Ayurveda places great emphasis on the impact of a positive life style on health preservation and the role of a negative life style in the promotion of disease. The whole range of *Swasthavritta*, *Sadvritta*, and *Acara Rasayana* described in the Ayurvedic classics is designed to foster a healthy life style for everyone as a promotive and preventive health care, which is the main focus of Ayurveda. An unhealthy life style leads to *Agnibala Vaisamya*, *Ojabala Dosha*, and *Sroto* distortion, leading in turn to a variety of ailments and immunocompromised states. Similarly, different kinds of tangible and intangible environmental factors, as depicted in Ayurvedic classics in the context of *Ayoga-Atiyoga-Mithyayoga* of *Kala-Buddhi-Indriyartha*, popularly described as *Kala-Parinam*, *Prajnaparadha*, and *Asatmyendriyartha Samyoga*, obviously lead to ill health and disease. The three classical categories of aetiological factors have been considered as primary causes of all diseases in Ayurveda; all other tangible causes of disease are secondary to these primary causes [12]. The classical *Hetutraya* represents three principal sources of informational stress constantly bombarding an organism and resulting in stress and disease. This phenomenon simultaneously brings about biological morbidity, e.g., *Agnibala Vaisamya*, *Ojabala Vaisamya*, and *Sroto* distortion, which forms the basic matrix of pathology of all diseases according to Ayurveda.

Environmental and life-style factors also bring about behavioral changes in different individuals, of course depending to some extent on an individual's *Prakriti.* Clearly, the mental state and behavior of individuals greatly reflects the type of food they consume and the kind of habitat they live in. The *Sattvika*, *Rajas*, and *Tama*s food and life style overtly manifest in an individual. Ayurveda rightly proclaims that people and their behavior are the products of their food and life styles [13].

2.10 Conclusions

Ayurveda, despite being one of the oldest systems of life science and health care, possesses a fairly well-developed knowledge base on food science with a range of hitherto unknown dimensions of food science on the one hand and a number of other unique principles and practices on the other, which, if combined with today's nutrition biology, could provide significant benefits to contemporary food science and nutrition [14]. A pronature approach, holistic considerations, and personalized dietary planning constitute the basic features of the Ayurvedic conception of dietetics and nutrition, features that are sorely lacking in modern approaches to nutrition [15].

References

1. Sharma PV (ed) Caraka (700BC) Caraka Samhita. Chaukhamba Orientalia Varanasi
2. Singhal GD et al (eds) Susruta (600BC) Susruta Samhita. Chaukhamba surabharati, Varanasi
3. Singh RH (2005) The holistic principles of ayurvedic medicine. Chaukhamba surabharati, New Delhi
4. Singh RH (2007) Kayachikitsa, chapter 12, vol 1. Chaukhamba surabharati, Varanasi, pp 406–423
5. Singh RH (2004) Swasthavritta vijnana, chapter 7. Chaukhamba surabharati, Varanasi, pp 120–138
6. Singh RH (2009) Body-mind-spirit integrative medicine. Chaukhamba surabharati, Varanasi
7. Singh RH (2009) Srotovijnan of Ayurveda. In: Proceedings of 1st international congress of Ayurveda, Ayurveda Point, Milan, 21–22 Mar 2009
8. Singh RH (2009) Development of research methodology in Ayurveda. In: Mehta PM (ed) Memorial oration. GAU, Jamnagar
9. Valiathan MS (2007) The legacy of susruta, chapters 18–20. Orient Longman, Chennai, pp 84–87
10. Singh RH (2009) The basic tenets of Ayurvedic dietetics. In: 11th international symposium on Ayurveda. The European Academy of Ayurveda, Birstein
11. Lurie DI (2012) Ayurveda and pharmacogenomics, guest editorial. Ann Ayurvedic Med 1(4):126–128
12. Basisht GK (2011) Symbio health – need of the hour. AYU 32(1):6–11
13. Singh RH (2009) Exploring quantum logic in Ayurveda. Ayu Int 30(4):360–368
14. Singh RH (2012) Trends of integrative practice of Ayurvedic medicine. Editorial. Ann Ayurvedic Med 1(4):123–125
15. Singh RH (2007) Panchkarma therapy. Chaukhamba Samskrit series, Varanasi

Chapter 3
The Concept of Diet in Ayurveda and Its Implications for the Modern World

Syal Kumar

3.1 Introduction

Biological food is a new subject of discussion among nutritionist globally. It is being widely covered by media and has been taken up as a new avenue of commerce. This puts a very logical question before us that is the biological food can make us healthy or we need healthy eating habits to remain healthy?

Ayurvedic science has been very concerned with food and its role in maintaining health and in treating diseases since before the emergence of modern medicine. The approach of Ayurveda to analyzing food substances is unique. It not only discusses healthy food items but also specifies habits and ways of eating because the last two also promote general well-being. Food, according to Ayurveda, is classified into categories like consistency, taste, properties, quality, compatibility, and incompatibility. Ayurvedic physicians practice with a thorough understanding of the sources, classification, nutritional merits, adverse effects, and therapeutic indications of food.

Substances that constitute food and drugs, living or nonliving, evolved from the same five elements. Ayurvedic theory strongly asserts that the universe is made up of five fundamental elements: prithvi (solid), ap (liquid), tejus (fire), vayu (gas), and akasha (space). Whatever we find in the universe is a combination of these five elements. The human body is also essentially a combination of these five elements. The food available in the universe is also a combination of the five elements, with a predominance of one or another of them.

Diet is an important controlling factor with regard to indigenous microbiotic activities. The gut microflora contains pathogenic, benign, and beneficial microbial species. A predominance of the former can lead to gut upset, which can be both

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acute (e.g., gastroenteritis) and chronic (e.g., inflammatory bowel disease). Foods, that pass through or get close to the gut affect the composition of activities aimed at achieving a more positive metabolism [1].

3.2 Food and Its Healing Process

3.2.1 Food Consistency

In Ayurvedic medicine, food is classified according to the mode of intake as Ashitam (wholesome foods), Peetam (beverages), Leedham (linctus), and Khaditam (masticables) [2]. Each intake method may have its own effects on food based on the mechanism of intake and subsequent production of enzymes. Food that is heavy needs to be chewed well in the mouth. This not only breaks the food down into small particles but also helps in combining the particles with digestive enzymes like linguale lipase, amylase, musin, and others produced by the salivary glands. Thus, here, digestion starts from the mouth itself. If not enough enzymes are combined with such food items, this may lead to indigestion. Indigestion is the major cause of Ama. To avoid such a complication, it is always recommended to consume heavy and sweet foods initially to ensure their digestion by a sufficient amount of enzymes. Light food can be ingested later because it may not require many digestive enzymes.

3.2.2 Classification of Food

The following table gives a detailed explanation of the varieties of food classified according to Ayurveda.

Sanskrit name	Common name	Examples
Sukadhanya	Husked grains	Varieties of rice and wheat
Samidhanya	Pulses	Green gram, black gram, sesame, etc.
Mamsa	Meats	Prasaha (animals that are aggressive around food): cow, goat, horse, etc.
		Bhumisaya (living in burrows): python, mongoose, etc.
		Anupamruga (living in marshes): boar, rhinoceros, etc.
		Varisaya (water dwelling): fish, crab, tortoise, crocodile, etc.
		Ambucari (moving on water): swan, crane, duck, etc.
		Jangalamruga (jungle dweling): deer, wild goat, hare, etc.
		Lavadya (scattering grain while eating): quail, partridge, pheasant, etc.
		Vartakadi (gallinaceous): peacock, bustard, etc.
		Pratuda (eating while pecking): pigeon, parrot

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Sanskrit name	Common name	Examples
Saka	Vegetables	Stems, tubers, leaves, flowers, all legumes, etc.
Phala	Fruits	Grapes, mangoose, coconut, etc.
Harita	Greens	Ginger, garlic, coriander, radish
Madhya	Fermented drinks	Grape, sugarcane, wine, vinegar, etc.
Jala	Water	Rain, river, sea, etc.
Gorasa	Milk and milk products	Milk of various animals, curd, ghee, etc.
Ikshu	Sugar	Sugarcane juice, jaggery, sugar, honey, etc.
Sneha	Fat	Oils, ghee, animal fat and marrow
Kritanna	Liquid, semiliquid, solid	Gruel, soup, boiled rice, preparations of grain, meat, flour, etc.
Aharayoga	Food additives	Oils, pepper, asafoetida, salts, etc.

From the preceding classification it is very clear that the Ayurvedic diet is not vegetarian. It clearly specifies the importance of meat and its types. It promotes a balanced diet of carbohydrates, proteins, and fats from all sources.

3.2.3 The Role of Taste in Ayurveda

According to Indian medicine, tastes influence the human body and mind. The six known tastes are madhura (sweet), amla (sour), lavana (salty), katu (pungent), tikta (bitter), and kashaya (astringent). Most food items will be a mixture of these or be dominated by one. The taste that is dominant will be easily detected by the tongue and will be the primary taste (rasa); other tastes that are latent will be secondary (anurasa).

The three humors of Ayurveda – Vata, Pitta, and Kapha – which are derived from specific combinations of five elements, are also affected by the six tastes. The influence of the five elements in food items is proportional to the influence of the five elements of the particular region. For example, fruits or vegetables growing in specific area rich in certain elements will also be rich in that corresponding element. An apple growing in a water-element-dominated area will also be dominated by the water element. This kind of specific combination of five elements accounts for tastes and their intensity. Being dominated by an element does not mean that the particular item looks like the element; rather, it is dominated by the qualities and functions of that element.

A basic concept in pathology is that a person addicted or prone to seeking out specific tastes will take on the qualities of these elements in his or her body, which will cause in imbalance in the corresponding Dosha, further leading to diseases supported by this particular Dosha. Diabetes, hyperlipidemia, duodenal and gastric ulcers, and others are some of the diseases caused by the improper consumption of tastes.

The six tastes are derived from the special combination of the five elements. The effects of taste on the body depend on the constituent elements that dominate them. The following table gives an overview of the tastes, five elements present in them, and their action on Doshas.

(a) Action of individual tastes

Tastes	Elements	Action on Dosha	General action	Diseases
MADHURA (sweet)	Solid + liquid	Vata ↓ Pitta ↓ Kapha ↑	Builds tissues, prolongs life span; good for skin, hair, and throat. Lubricant, cold and heavy; nourishes and stimulates healing	Obesity, excessive sleep, cough, fever, eye diseases, excessive mucus production
AMLA (sour)	Solid + heat	Vata ↓ Pitta ↑ Kapha ↑	Appetiser, light, hot, and lubricant; induces salivation, energizes the body, strengthens sense organs, stimulates mind, increases peristaltic movement	Promotes thirst, sensitivity in teeth, blood disorders, burning sensation; generates heat in muscles, suppuration in wounds
LAVANA (salt)	Liquid + Heat	Vata ↓ Pitta ↑ Kapha ↑	Improves appetite and digestion, removes stiffness, acts as laxative, opens channels	Vitiates blood, causes skin diseases, internal bleeding, inflammation, impotency, wrinkles in skin, gray hair, baldness
KATU (pungent)	Air + heat	Vata ↑ Pitta ↑ Kapha ↓	Clarifies sense organs; reduces obesity, blocks channels, promotes appetite and sweating; acts against itching and microorganisms	Causes burning sensation, impotency, giddiness, thirst, pain, tremors
TIKTA (bitter)	Air + space	Vata ↑ Pitta ↓ Kapha ↓	Improves digestion, reduces both fat and muscles if taken in excess	Causes dryness of mouth and skin, reduces tissues, obstructs channels, leads to emaciation and psychic disorders
KASHAYA (astringent)	Air + solid	Vata ↑ Pitta ↓ Kapha ↓	Qualities like moping, restraining, compressing, roughness	Causes problems with normal speaking, flatulence, blackish discoloration, obstruction of feces, urine, flatus, semen, spasms, convulsions

(b) Postdigestive taste

After ingestion, foods with different tastes combine with acids and digestive enzymes. Following this interaction, some tastes transform into another taste, which is known as Vipaka. The following table shows the transformation of tastes after digestion.

Taste	Changes	Taste after Digestion
MADHURA (sweet)	No change	MADHURA (sweet)
AMLA (sour)	No change	AMLA (sour)
LAVANA (salt)	Change	MADHURA (sweet)
KATU (pungent)	No change	KATU (pungent)
TIKTA (bitter)	Change	KATU (pungent)
KASHAYA (astringent)	Change	KATU (pungent)

Food that is converted into a specific taste after digestion will influence the Dosha. A person suffering from inflammatory hemorrhoids or intestinal ulcers who ingests a bitter taste will make the condition worse because of the postdigestive effect. Following digestion bitter changes to pungent, adding a burning sensation, bleeding, and inflammation to the aforementioned conditions.

3.3 Food and Its Properties

Each food has its own specific properties that facilitate the food's action. The properties and qualities of food items influence the individual Dosha that makes them balanced or unbalanced. The 20 properties give food its individual qualities. These properties are taken into account when giving advice to patients. The properties are mentioned in the following table [3].

Properties	Action	Properties	Action
Cold (Sita)	Pleasing to mind; relieves fainting, thirst, sweating, and heartburn; causes congestion and blocks channels	Hot (Ushna)	Improves digestion
Lubricant (Snigdha)	Promotes lubrication, softness; improves strength and complexion	Rough (Ruksha)	Causes dryness
Slimy (Picchila)	Strengthens, promotes healing and union, increases kapha	Nonslimy (Visada)	Absorbs moisture
Sharp (Tikshna)	Induces burning sensation, inflammation with discharge	Mild/soft (Mrudu)	Promotes softness on body
Heavy (Guru)	Promotes weight, strength	Light (Laghu)	Promotes lightness on body
Liquid (Drava)	Moistening	Solid (Sandra)	Hardening
Smooth (Slakshna)	Smoothening	Rough (Karkasha)	Causes roughness on body

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Properties	Action	Properties	Action
Fragrant (Sugandha)	Pleasing, appealing, fine	Foul smell (Durgandha)	Unpleasant feeling
Instantly absorbable (Vyavayi)	Quickly absorbing and digested in body	Relaxant (Vikasi)	Muscle relaxant
Fast acting (Asukari)	Fast radiating, acts quickly	Subtle (Sukshma)	Very small in size; can pass through minute channels

3.4 Food and Its Qualities

The seven major dhatus (tissues) are the end product of the food we eat. Our food metabolic system facilitates the proper conversion of food. The first digestion activity is activated in the gastrointestinal tract (GIT) with the help of Jatharagni, which is directly supported by the Dosha-Pachaka Pitta. Jatharagni refers to all the enzyme activity in the GIT that aids in the digestion of food. The digestion of carbohydrates, proteins, and fats is activated by the Jatharagni. Bhootagni is the second metabolic system that helps to digest food at the molecular level (bhoota). The fire element helps in the digestion of micromolecules of food substances. This helps in the proper absorption of particles for microcirculation. The final metabolic function occurs at the tissue/cellular level with the help of dhatwagni. The conversion of transported food particles in the tissues is accomplished by the dhatwagni. Dhatwagni is the metabolic function in tissues and is responsible for anabolic and catabolic activity. All three of the aforementioned functions of digestion facilitate the proper digestion, absorption, and assimilation of food. But certain factors disturb these processes of digestion. In this regard, quality of food plays a major role. Fresh, warm, and properly prepared food helps to regulate the digestive process.

Food stored in freezers and rewarmed is unhealthy. Freezing changes the quality of food and may promote Ama in the body when consumed. Ama, according to Ayurveda, refers to the toxic substances produced in the intestine or in tissues due to improper food or due to weak metabolic activity. Later Ama gets absorbed into the system, developing a very pathophysiological process in the body, leading to chronic and immunosuppressive diseases.

3.5 Compatibility and Incompatibility (Virudhahara)

All particles in the universe are made up of five elements, with one or another predominating. For this reason, substances (Dravya) are also dominated by one of the elements. The same holds true in the case of food or dietary substances.

A special combination of the five elements in food substances accounts for their normal functioning in the body. Combining foods that should not be consumed at the same time will become harmful to the body due to molecular interactions, leading to indigestion and eventual production of Ama. Virudha means anything that aggravates the Doshas but does not expel them from the body [4].

Foods and their combinations that interrupt the metabolism of tissues, inhibit the process of tissue formation, and have properties that are opposite those of tissues are called Virudhahara [5].

Charaka has classified foods that are incompatible with the body according to its cause and origin. They are explained in the table below [6].

Types of incompatibility	
Desha virudha	Food that grows in one place will not be suitable for an individual living in another region, e.g., consumption of dry and sharp substances in dry areas, Unctuous and cold food in marshy areas
Kala virudha	Food consumed contrary to the climate and season, e.g., The context is discussing about incompatible food. These foods are incompatible during summer and winter
Agni virudha	Food that affects the agni, e.g., consumption of heavy food when the power of digestion is mild, light food when digestion is strong
Matra virudha	Food that acts as a toxin when combined in varying quantities, e.g., honey and ghee in equal amounts
Satmya virudha	Foods that are contrary to one's daily diet regimen, e.g., sweet and cold food by someone accustomed to hot and spicy substances
Dosha virudha	Food that is contrary to the Dosha involved
Sanskar virudha	Improper mode of preparation, e.g., baked instead of cooked
Veerya virudha	Combination of different veerya food items, e.g., mixing of cold potency food with warm
Koshta virudha	Food that is contrary to an individual's intestinal nature, e.g., food with a laxative effect in a person with loose stools
Avastha virudha	Food that is contrary to a particular state of health, e.g., consumption of Vata-aggravating food after physical exercise and exertion
Krama virudha	Food that is consumed in the wrong order, e.g., before emptying waste materials, when one is not hungry, or after the onset of hunger
Parihara virudha	Food that is contrary to a disease pathology, e.g., cold foods following consumption of ghee
Upachara virudha	Food combination that is not suitable during particular treatments, e.g., heavy food during panchakarma treatments
Paaka virudha	Food that should not be combined during cooking/improper method of cooking, e.g., undercooked, overcooked, burned during cooking
Samyoga virudha	Improper combination of food items, e.g., sour substances with milk
Hridaya virudha	Foods that do not taste good or are not pleasant to the taste
Sampada virudha	Food that is of poor quality, e.g., not ripened, putrefied
Vidhi virudha	Food that goes against the rules of proper eating, e.g., eating in open, public places

The consumption of incompatible foods is a major cause of many illnesses. Modern food culture involves many combinations of such foods. Some basic incompatible foods are given below.

- The meat of animals of marshy regions is incompatible with Masha (black gram), Ksaudra (honey), Kshira (milk), Virudhaka (germinated grains), and Guda (jaggery). Uncooked meat with bile is not advisable. The meat of crane with wine is not healthy, and when fried with the fat of boar it is very toxic. The meat of black partridge, peacock, iguana lizard, and common quail processed with castor oil is not good for you.
- Fish eaten with milk and milk products causes the production of toxins. All sour substances are incompatible with milk and milk products. Consumption of milk and milk products after eating leafy vegetables should be avoided. One should avoid eating meat with milk or milk products.
- Ghee kept for more than 10 days in a bronze vessel.
- Milk pudding or sweet pudding should not be consumed with sweet liquor or with rice and green gram.
- Mixture of equal quantities of honey, ghee, muscle fat, oil, and water in the combination of two or three of all is incompatible.
- Drinks followed by a solution of corn flour should be avoided. Mustard oil is incompatible with curcuma.

Incompatible food to which one has become accustomed and that is consumed in very small quantities does not produce disease, although it is incompatible with someone who exercises, eats fatty foods, has a strong digestive power, is an adult, or is strong.

Unhealthy things (foods, drinks, activities) that one has become used to from long use should be discontinued gradually. Similarly, healthy things should be adopted gradually with intervals of 1, 2, or 3 days. Discontinuing unhealthy things and indulging in healthy things will suddenly create diseases of the satmya (habitual) and asatmya (nonhabitual).

3.6 General Dietary Guidelines

Type of food	For whom and when
Cold food articles and drinks	Those suffering from heat, thirst, liquor, intoxication, burning sensation, internal bleeding, poisoning, and fainting
Hot food	Sufferers from the vitiation of kapha and vata; following poor vakarma and panchakarma; dry body
Oily food	Those with Vata problems, rough body, overindulgence in physical or sexual activity
Rough food	Those who are obese, have excess kapha in their body, have prameha (diabetes)
Liquid diet	Those who are emaciated, weak, or thirsty

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Type of food	For whom and when
Dry food	Those with fluid accumulation in their body, wounds, prameha (diabetes)
Food consumed once in a day	To enhance digestive power
Mixed with drug	Patients who dislike taking drugs
Small in quantities	Those who have weak digestion, various disorders
Foods containing all tastes	Consuming all tastes helps to maintain the body and to keep healthy

3.7 Method of Food Preparation

Different methods exist for preparing food. They include boiling, frying, extracting, fermenting, flavoring, pickling, and concentrating. The idea of cooking in India developed thousands of years ago under the influence of Ayurveda. The basic idea of cooking was not only to make food tastier but also to convert raw food into an acceptable form for the srotus (microchannels) so that it could be transported to various parts of the body. It is fascinating to see how this process works. The hard materials of our body, like, for example, bones, are developed from soft and fluid food substances absorbed from the intestine. This absorption takes place following digestion and assimilation. The Jataragni, Bhootagni, and Dhatvagni in our bodies play a major role in this process.

The aforementioned methods of food preparation help make different varieties of food palatable to our system. For example, Here it is advised to cook the rice. Not good when baked or fried. Vegetables can be cooked or baked. Those that are cooked are easy to digest. Light vegetables can be baked or steamed. Thus, the cooking methods mentioned previously help in the proper processing of the different varieties of food.

3.8 General Concept of Dining in Ayurveda

3.8.1 Food Eaten at the Right Time and in the Proper Manner

One should try to relax and sit comfortably while eating. It is not good to keep the urine, stool etc. while eating. One should eat at a moderate pace, not too slow or fast. Do not eat if previously eaten food has not yet been digested. Eating small and large portions at irregular intervals disturbs digestion. After eating it is better to move around a bit instead of going straight to bed. This helps to activate enzymes, thereby aiding digestion.

Breakfast, lunch, and dinner are the major meals. Of these, lunch can be quantitatively large compared to dinner, which should be light. During noon hour, our system is active and produces more enzymes in the stomach and intestine, which activates metabolism. According to Ayurvedic principles, the pachaka pitta is active at noon due to the influence of the Sun. This makes the pitta stronger and helps speed up digestion. After a long and hectic day at work, the body is weak and digestive enzymes flow slower into the intestine, even though one might feel hungry. Due to modern work schedules, many people eat their big meal of the day in the evening, which is unhealthy due to the aforementioned factors. As a general rule, half portion the stomach can be consumed with solid food, a quarter with liquid food and the remaining quarter can be keep empty for good digestion.

3.8.2 Concentration and Time-Consuming Meals

One should focus on ones meal while eating, which helps to know the character of the food using the sense organs. Understanding the consistency, smell, and taste of the food one is eating helps in the production of particular enzymes in the stomach and intestines. Receptors in the sense organs help to transmit signals to the brain, which further stimulates the flow of particular enzymes into the stomach and intestines. According to Ayurveda, all three Doshas help in the metabolic process. Jataragni or pachaka pitta is what digests food in the stomach and intestines and refers to the total action of digestive acids and enzymes. The grahani (pylorus) is the organ that holds food for a certain time inside the stomach to facilitate digestion. The strength of the grahani and agni is depended each other. Digestion begins in the mouth and is completed only when the waste materials are expelled.

Food ingested at the proper time is taken into the alimentary tract with the help of Pranavata and mass of food and are Liquid/Fluid in the stomach. This is produced by the help of Kledaka Kapha. Then the Jataragni activated by the samanavata cooks the food. During digestion, food first becomes sweet and produces kapha and then becomes sour and gives rise to pitta. Thereafter it is transported into the large intestine and becomes solid and pungent and gives rise to vata. This process is called avastha paka.

The five characters of agni, bhouma, apya, agneya, vayavya, and nabhasa cook the five fundamental qualities within food. This is called nishtapaka. After digestion, each quality nourishes the equivalent qualities in the body.

The influence of emotions and activities on digestion is not only mentioned in Ayurveda. The results of recent studies in modern medicine support the concept of digestion discussed in Ayurveda. Brain–gut interactions are increasingly being recognized as underlying the pathomechanisms of functional gastrointestinal disorders. Bidirectional communication between the central nervous system (CNS) and the enteric nervous system (ENS) occurs in both health and disease. Various CNS and gut-directed stressors stimulate the brain–gut axis. Processes modulating responsiveness to stressors along the brain–gut axis involve neural pathways and

immunological and endocrinological mechanisms. Disturbances at any level of neural control of the gastrointestinal tract can affect modulation of gastrointestinal motility, secretion, immune functions, and perception and emotional responses to visceral events. ENS function, central processing, and autonomic regulation play an important role in the brain–gut dialog. Stress and emotions may trigger neuroimmune and neuroendocrine reactions via the brain–gut axis. Various non-site-specific neurotransmitters influence gastrointestinal, endocrine, and immune functions, as well as human behavior and emotional states, depending on their location. The physiology of the digestive tract and the subjective experience of symptoms, health behavior, and treatment outcomes are strongly affected by psychosocial factors [7].

3.8.3 Fresh Food

Consumption of fresh food is highly recommended in Ayurveda. Foods that are stale need many enzymes to be digested. For this reason, the chances of getting Ama is high. Reheating of food and oils create more oxidation and produces free radicles due to oxidative stress. When fatty acids are exposed to oxygen in the presence of heat or light, oxidative rancidity occurs, causing the formation of hydroperoxide compounds. These compounds further lead to the production of aldehydes [8]. Oxygenated aldehydes are toxic and cause oxidative stress in cells, which increases the risk of degenerative and atherosclerotic diseases. Lipid oxidation is caused by unsaturated fatty acids rather than saturated ones, which in turn are a good source of free radicals [9].

3.8.4 Too Much Raw Food

There is a general concept in the West that raw food is a good source of vitamins. When food is cooked, many valuable vitamins and minerals are destroyed. According to Ayurveda, metabolic activity in the body is individualized. The three agni – jataragni, bhootagni, and dhatwagni – constitute one's metabolic framework. Based on the three agni strength the food ingested is digested, absorbed, and assimilated. Any abnormalities in any of the three levels of agni functioning will impair the metabolic process. In this situation, even if you eat food rich in vitamins or minerals, it will not be converted into nutrients; instead, it remains a metabolic waste product, which Ayurveda calls Ama. To digest a raw substance, one should have good digestive power (agni). For this reason, cooking is very important because it facilitates the digestion, absorption, and assimilation of food. Even if the vitamin content is lower, it is completely absorbed into the system. For this reason Ayurveda insists on eating warm, cooked food. Such food is easy to digest and helps in secreting enzymes into the stomach and intestine, thereby creating good metabolism.

Raw food is sheeta veerya (cold potency) and generates cold in the system, thereby suppressing enzyme functions in the stomach. Cold substances always try to contract the pores through which enzymes leak into the gastrointestinal tract. For this reason raw food is not often digested completely and leads to the production of metabolic toxins.

3.8.5 Fast Foods

Due to modern life styles, people run out of time, even for eating. Thus, people eat fast food because it can be bought and eaten quickly. Deep frying of potatoes can produce toxins called acrylamide, which is carcinogenic [10]. One study found that the toxin 4-hydroxy-trans-2-nonenal (HNE) was higher in deep-fried foods. When fruits or vegetables are boiled in oil for frying, the oil molecules that penetrate into the fried food are converted into similar molecules like HNE. Once the food is cooled to room temperature, it is converted into toxic HNE [8]. HNE causes a variety of cytotoxic and genotoxic effects [11]. It causes metabolic inhibition and thiol oxidation and generates proarrhythmic changes in cellular excitability [12]. Fast foods also cause the production of free radicals. Free radicals can interact with almost all biomolecules in different ways, altering their natural properties and making them more susceptible to damage. Such oxidative damage affects almost all components of the cellular machinery such as carbohydrates, lipids, proteins, and nucleic acids. Both the reactive oxygen species (ROS) and the end products of their reaction with various biomolecules can cause DNA damage by altering its nitrogenous bases [13, 14].

All the factors discussed previously cause the production of Ama immediately or in the long run. Ama has a broader meaning than indigestion. It affects the three metabolic processes of digestion, absorption, and assimilation. Ama disturbs the three agni – jataragni, bhootagni, and dhatwagni. Abnormal indigestion and intolerances produce a wide range of gut and systemic symptoms, including gas, stomach pain, diarrhea or constipation, severe headaches, severe fatigue, loss of cognitive functions such as concentration, memory, and reasoning, muscle and joint pain, heart palpitations, and a variety of allergies [15–17].

These can be explained by the production of toxic metabolites from gut bacteria as a result of anaerobic digestion of carbohydrates and other foods not absorbed in the small intestine. These metabolites include alcohols, diols such as butan 2,3 diol, ketones, acids, and aldehydes such as methylglyoxal [18, 19]. These toxins induce calcium signals in bacteria and affect their growth, thereby acting to modify the balance of microflora in the gut [20–22].

The idea that toxins are the cause of many diseases was proposed over 100 years ago by one of the founders of immunology – Elie Metchnikoff (1845–1916), working at Institut Pasteur in Paris. Metchnikoff won the Nobel Prize in 1908 for his discovery of macrophages. But his real focus was on the role of gut bacteria in disease. He wrote in his book *The Nature of Man*, which represented a Darwinian

approach to the human body, "The large intestine must be regarded as one of the organs possessed by man and yet harmful to his health and his life. The large intestine is the reservoir of the waste of the digestive processes, and this waste stagnates long enough to putrefy. Bacterial putrefaction is the cause of all disease." Metchnikoff published several papers investigating the effects of putative bacterial toxins such as cresol on health and survival [23].

3.9 Conclusions

Ayurveda addresses not only how to treat disease but also how to prevent it. In both cases, diet plays a major role. Specific diets are recommended based on an individual's heath status. The diet concept in Ayurveda, which refers to diet concept in Ayurveda, is still important in the modern world. The Ayurvedic concept of incompatible foods and the concept of eating, when integrated with modern life, help to resolve many health issues. The aim of an individual diet plan in Ayurveda is to help the body to have a balanced metabolism. India, where Ayurveda originated, is a land of spices. From northern to southern India varieties of spices can be found depending on the climate and geographical features. Cooking with spices according to one's metabolic activity helps the individual to stabilize the Doshas.

Western society is slowly realizing the influence of food on the body. People have become aware of the importance of eating healthy food versus fast food. The proliferation of, for example, bio food markets, bio restaurants, and vegetarian restaurants organic concern towards food is positive. The use of spices and consumption of various herbal teas are becoming more widespread. Many research studies have been conducted to understand the effects of food and spices in, for example, diseases of the gastrointestinal tract, cancer, metabolic diseases, and autoimmune diseases. All these developments show that people are starting to care about their stomach and, hence, their body, mind, and soul.

References

1. Gibson GR (2008) Prebiotics as gut microflora management tools. J Clin Gastroenterol 42(Supp 2):S75–S79
2. (1985) Charaka Samhitha, vimanasthana 2/15, 2nd edn. Chowkhamba Sanskrit Series Office, Varanasi
3. (2010) Sushrutha Samhitha sutrasthana 46/514–524, reprint edn. Chaukhanbha orientalia, Varanasi
4. (1992) Charaka Samhitha sutrasthana, 26/85, 3rd edn. Chaukhamba sanskrit series, Varanasi
5. Sabnis M (2013) Virudhahara: acritical view. Ayu 33(3):332
6. (1992) Charaka Samhitha sutrasthana, 26/86–101, 3rd edn. Chaukhamba sanskrit series, Varanasi
7. Mulak A, Bonaz B (2004) Irritable bowel syndrome: a model of the brain-gut interactions. Med Sci Monit 10(4):RA55–RA62

8. Sabnis M (2013) Virudhahara: acritical view. Ayu 33(3):334
9. Wasowicz E, Gramza A, Hes M, Jelen HH, Korczak J et al (2004) Oxidation of lipids in food. Pol J Food Nutr Sci 13:87–100
10. Tareke E, Rydberg P, Karlsson P et al (2000) Acrylamide: a cooking carcinogen? Chem Res Toxicol 13:517–522
11. Esterbauer H et al (1991) Chemistry and biochemistry of 4-hydroxynonenal, malonaldehyde and related aldehydes. Free Radic Biol Med 11:81–128
12. Bhatnagar A (1995) Electrophysiological effects of 4-hydroxynonenal, an aldehydic product of lipid peroxidation, on isolation rat ventricular myocytes. Circ Res 76:293–304
13. Valko M, Izakovic M, Mazur M, Rhodes CJ, Telser J (2004) Role of oxygen radicals in DNA damage and cancer incidence. Mol Cell Biochem 266:37–56
14. Valko M, Leibfritz D, Moncol J, Cronin MT, Mazur M, Telser J (2007) Free radicals and antioxidants in normal physiological functions and human disease. Int J Biochem Cell Biol 39:44–84
15. Matthews SB, Campbell AK (2000) When sugar is not so sweet. Lancet 355:1330–11330
16. Matthews SB, Waud JP, Roberts AG, Campbell AK (2005) Systemic lactose intolerance: a new perspective on an old problem. Postgrad Med J 81:167–173
17. Waud JP, Matthews SB, Campbell AK (2008) Measurement of breath hydrogen and methane, together with lactase genotype, defines the current best practice for investigation of lactose sensitivity. Ann Clin Biochem 45:50–58
18. Campbell AK, Waud JP, Matthews SB (2005) The molecular basis of lactose intolerance. Sci Prog 88:157–202
19. Campbell AK, Waud JP, Matthews SB (2009) The molecular basis of lactose in tolerance. Sci Prog 92:241–287
20. Campbell AK, Wann KT, Matthews SB (2004) Lactose causes heart arrhythmia in the water flea *Daphnia pulex*. Comp Biochem Physiol B Biochem Mol Biol 139:225–234
21. Campbell AK, Naseem R, Holland IB, Matthews SB, Wann KT (2007) Methylglyoxal and other carbohydrate metabolites induce lanthanum-sensitive Ca2+ transients and inhibit growth in *E. coli*. Arch Biochem Biophys 468:107–113
22. Campbell AK, Naseem R, Wann K, Holland IB, Matthews SB (2007) Fermentation product butane 2,3-diol induces Ca2+ transients in *E. coli* through activation of lanthanum-sensitive Ca2+ channels. Cell Calcium 41:97–106
23. Campbell AK, Matthews SB, Vassel N et al (2010) Bacterial metabolic 'toxins': a new mechanism for lactose and food intolerance, and irritable bowel syndrome. Toxicology 278:268–276

Chapter 4
Applying Ayurvedic Eating Principles to the Science of Stress-Linked Food Behavior

Sanjeev Rastogi

4.1 Introduction

Conventional nutrition science focuses mainly upon the qualitative and quantitative aspects of food and their application in reference to the physiological needs of recipients on the basis of generic classifications like age and gender or physiological needs during some physiologically demanding or pathological events of life (e.g., pregnancy or lactation). In contrast to this, Ayurveda places a profound stress on the integrated relationship between food, its recipient, and the ambience for its contributory role in determining the net out come of the food consumed. Ayurveda perceives the dynamism of the food–consumer–environment matrix and proposes a perfect balance among them to derive maximum benefits from the food consumed.

It is for this reason, in addition to the type, quality, and quantity of food, that Ayurveda further recommend a perfect mental attitude and ambience when one sits down to eat. An ideal state of mind is considered essential to make one fully receptive to all the benefits of the food to be consumed. This code of eating, which is aptly called *asta aahara vidhi vesheshayatana* (eight principles of food consumption), is the foremost principle of Ayurveda and sets forth the ideal conditions to make most efficient use of food as a health promoter. Like many other principles of Ayurveda which had been deciphered for their soundness on scientific ground, the principles of eating in Ayurveda have also been found to be based on sound logic and scientific reasoning. Replicating the work done elsewhere by other researchers, it can easily be asserted that these principles of eating of Ayurveda are not only sound scientifically but also have tremendous applicability as a preventive health care measure to avert the many adverse outcomes of an unhealthy food–body–mind–environment interaction.

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4.2 Stress and Its Link to Diseases

Stress has long been linked with many unhealthy outcomes, including chronic degenerative and noncommunicable diseases like cancer, diabetes, and hypertension. A large body of scientific evidence exists establishing the role of stress in altering cellular mechanisms leading to erratic regulation of corresponding sets of genes causing disease. Psychological stress is found to play an immunosuppressive role that gradually weakens a body's defenses, thereby rendering the body vulnerable to many diseases. The first evidence of this weakened defense came from reduced leukocyte count in response to psychological stress to the body. Recently, activation of a stress gene, ATF3, was found to be associated with metastatic spread of breast cancer. ATF3 was proposed to be the crucial link between stress and cancer, playing a decisive role in its metastasis. Stress is already known as a risk factor for cancer. It is also known that ATF3 is activated and expressed in response to stressful conditions. Under typical circumstances, activation of ATF3 can actually cause normal and benign cells to undergo apoptosis. It has been suggested that cancer cells somehow escape immune-system cells that have been recruited to the site of a tumor to express ATF3. Eventually, ATF3 spurs the immune cells to act erratically and give cancer an escape route from a tumor to other areas of the body. In animals lacking ATF3 genes, a metastasis was found to be less significant compared to those having an ATF3 system.

ATF3 is a master switch type of gene: its gene product, the ATF3 protein, turns other genes on and off. There are many ways to activate ATF3 in cells, and stress signals sent out by cancer cells represent just one method of expressing this gene in immune-system cells and producing a chronic would-healing response. Other methods include radiation, chemotherapeutic agents, a high-fat diet, UV damage, and even chronic behavioral stress [1].

Psychological stress is associated with greater risk for depression, heart disease, and infectious diseases. Chronic psychological stress has been associated with erratic inflammatory responses. Prolonged stress alters the effectiveness of cortisol in regulating inflammatory responses because it decreases tissue sensitivity to this hormone. Specifically, immune cells become insensitive to cortisol's regulatory effect. Considering the common cold as a key example of stress reactions, the study suggested that cold symptoms could be more intense in people who are chronically stressed because of their increased level of cortisol and subsequently increased inflammatory response [2].

Inflammation is also a common link among various pathologies. Studies show how various dietary components can modulate key pathways to inflammation, including sympathetic activity, oxidative stress, transcription factor nuclear factor kappa B (NF-κB) activation, and proinflammatory cytokine production. Behavioral studies have demonstrated that stressful events can influence inflammation through the same processes. Therefore the combined contributions of diet and behavior to inflammation are certainly important. There are several far more intriguing interactive possible links between stress and disease and food choice. For example, stress

influences food choices; it also enhances maladaptive metabolic responses to unhealthy meals, and food can impact mood as well as proinflammatory responses to stressors. Furthermore, for vagal innervations of the digestive system its stimulation can influence metabolic responses to food and inflammation. Both depression and stress have documented negative effects on vagal activation. As one example, omega-3 fatty acid intake can boost mood and vagal tone, dampen NF-κB activation and responses to endotoxin, and modulate the magnitude of inflammatory responses to stressors. It has been proposed that a better understanding of how stressors, negative emotions, and unhealthy meals work together to enhance inflammation would benefit behavioral and nutritional research for its better applicability to human health [3].

4.3 Stress and Its Link to Food Behavior

It was long been debated whether stress caused immediate or long-term changes in food choices. As an initial proposal, it was suggested that the stressed and subsequently emotional eater usually craved energy-rich food compared to nonemotional eaters who do not have any such preference. It was also presumed that such preferences were more common in females than males, who are less labile emotionally. Oliver et al. [1] explored the issue of whether acute stress caused immediate changes in food choices or eating behavior. Their study confirmed the hypothesis that stress plays a key role in determining food preferences and this preference is marked by increased consumption of sweet and fatty foods during stressful periods. The study further proposed that stress may actually compromise the health of susceptible individuals through deleterious changes in food choices [4]. Stress influences human eating behavior in two ways, resulting in over- or undereating depending on the type and severity of the stressor. Chronic life stress seems to be associated with a greater preference for energy-rich foods that are high in sugar and fat. Longitudinal studies suggest that chronic life stress may be causally linked to weight gain, which is more visible in men. Stress-induced eating, however, may be one factor contributing to the development of obesity. Future studies with a measure of biological markers of stress can help us to understand the physiological mechanism underlying the stress–eating relationship and to know how stress might be linked to neurotransmitters and hormones responsible for satiety [5].

The mechanism through which emotions might affect food-related behavior is still poorly understood. It is hypothesized that eating patterns are directly related to a compensatory mechanism in response to emotional trauma. In one study aiming to identify the relationship between emotions and food-related behavior, negative emotions were induced and consumption of comfort food and noncomfort food was measured by means of taste tests. Emotion induction was preceded by measuring individual differences in emotion regulation strategies or by instructions to regulate emotions in either an adaptive (reappraisal) or maladaptive (suppression) manner. Relative to reappraisal and spontaneous expression, suppression led to increased

food intake, but only of comfort foods. Emotions themselves were not found to be directly responsible for the eating behavior; rather, the eating behavior was caused by the mechanism through which the emotions were handled [6].

Two more studies investigated the stress–eating relationship. The first examined self-reported changes in intake of snack foods, while the second investigated stress-induced overconsumption in a laboratory setting comparing high-fat (HF) and low-fat (LF) snacks. The study was conducted using the Dutch Eating Behaviour Questionnaire (DEBQ) [7] and with a self-reported measure designed to evaluate changes in eating in response to stress. Increased intake of HF snacks was associated with high emotional eating but not with restraint. A laboratory-based experiment compared intake of HF and LF snacks after ego-threatening tasks. Intake was suppressed by 31.8 % in restrained compared to unrestrained eaters across the tasks. Restrained eaters consumed significantly less following the ego threat. These results suggest that the type and variety of foods offered affect the link between stress and eating in laboratory settings. Further research could explore these findings and examine their application to clinical practice in reference to stress-related eating [8].

There are a few known predictors of stress-induced eating. It is, however, not known whether a few physiological and psychological variables are related to eating following a stressful event. A high cortisol reactivity in response to stress is often hypothesized as being linked with eating after stress, given the relations between cortisol and both psychological stress and mechanisms affecting hunger. In one study this hypothesis was tested by exposing 59 healthy premenopausal women to both a stress session and a control session on different days. The study suggested that high cortisol reactors consumed more calories on the stress days compared to low reactors. Both groups ate similar amounts on the control day. High reactors also differed significantly in their food choice and preferred sweet food throughout the day. These results suggest that psychophysiological response to stress may influence eating behavior and could eventually affect both weight and health [9].

Certain foods might be more frequently eaten during stressful periods. It is not known whether poor nutritional habits are associated with stress and depression symptoms or whether such relationships differ by country and gender. One recent study examined this in a sample from three European countries during a Cross-National Student Health Survey. A cross-sectional survey was conducted among first-year students in Germany ($N=696$), Poland ($N=489$), and Bulgaria ($N=654$). Self-administered questionnaires included a 12-item food frequency questionnaire, Cohen's Perceived Stress Scale, and a modified Beck Depression Index. Linear regression analyses were conducted for two outcomes, perceived stress and depression symptoms. The study suggested that food consumption frequencies differ by country and gender, as did depression symptoms and perceived stress. For male students, none of the food consumption groups was associated with perceived stress or depression symptoms. In females, perceived stress was associated with more frequent consumption of sweets/fast foods and less frequent consumption of fruits/vegetables. Additionally, depression symptoms were associated with less frequent consumption of fruits/vegetables and meat. The study suggests the existence of consistent associations between unhealthy food consumption and depression symptoms

and perceived stress among female students from three European countries, but not among male students. The study therefore suggests that efforts to reduce depression symptoms and stress may also lead to the consumption of healthier foods or vice versa [10].

4.4 Ayurvedic Approaches to Food Consumption

Besides the composition of a given food in reference to its quality, Ayurveda further proposes certain attributes related to food and to the method of eating it that ultimately yield the optimal benefits of the food consumed. Following are the specific eating principles recommended in Ayurveda.

Warm food (*Ushana*); food with a suficient quantity of fat (*Snigdha*); food in quantities suited to an individual's need (*Matravata*); food consumption only after previously eaten food is digested (*Jeerne*); compatible food (*Viryaviruddha*); consumption of food in an appropriate place (*Ishte deshe*); consumption of food containing all the material needed (*Ishta sarvopakaranam*); moderate eating pace (*Nati drutam*); not slow eating (*Nati vilambit*); eating without talking (*Ajalpana*); eating without laughing (*Ahasan*); focusing on food while eating (*Tanmana Bhunjeet*); eating in accordance with one's own choice and requirements (*Atmanambhisamikshya samyaka*). It would be worthwhile here to examine these Ayurvedic principles of eating in reference to current knowledge about stress, food-related behavior, and their connection to disease.

4.4.1 Consumption of Food in Appropriate Place (Ishte Deshe)

This aspect of Ayurvedic eating is particularly relevant in the current sense. Ishte deshe means taking food in a place that is appropriate for dining. From an Ayurvedic perspective, this should be a place near the kitchen where the food can be served warm. Unfortunately, in the modern world, food consumption has divergent presentations and ranges from street food at one extreme and upscale dining on the other. Workplace stress often does not allow us to sit comfortably to eat; this is also true during social gatherings where food is served in a buffet manner. In both such situations, the body is not allowed to become completely immersed in the eating experience, and hence the quantity of food consumed and even food preferences are often misappropriated. During social gatherings, food consumption often depends upon the ambience and upon the choice of the food available. As shown by recent studies, under stressful conditions, food choices are often shifted toward energy- and fat-rich foods, and this often happens in social gatherings. It is not surprising that people who often attend such gatherings also frequently suffer from problems related to inappropriateness of food consumption.

4.4.2 *Consumption of Food with All the Accessories* (Ishta Sarvopakaranam)

Ishta sarvopakaranam refers to the availability of every thing required while eating. It may be related to the desired food items or the utensils needed to consume the food. Typical examples of such accessories are chopsticks or forks for food like pasta or noodles or spoons with liquid foods like soup. In the absence of such accessories, the consumer may be stressed and thus unable to consume the food in an appropriate manner. Eventually, this might lead to stress-related reactions at the time of food consumption. Some accessory foods like pickles, spices, salads, water, and soup also add to net food consumption. In the absence of such accessories, food cannot be enjoyed properly.

4.4.3 *Moderate Eating Pace* (Nati Drutam) *and Eating Without Delay* (Nati Vilambit)

Nati drutam is the Ayurvedic principle of avoiding stressful eating. Food should be consumed neither too quickly nor too slowly. Fast or delayed food consumption may be reflective of a stress-related food consumption behavior where the time taken to eat the food may reflect the type and intensity of the stress stimulus. Usually in chronic and sustained stressful conditions, food consumption may be quickened, whereas in acute stressful conditions it may be delayed. A thorough scientific study would further elaborate the harmful effects of a delayed or quickened eating behavior on overall health.

4.4.4 *Eating Without Talking* (Ajalpana) *or Laughing* (Ahasana)

Talking and laughing during the act of food consumption may also be reflective of a person's anxious state. Besides the immediate physiological effects caused by improper placement of food particles, talking and laughing can also affect digestion by diverting attention away from the food and its consumption. A lack of attention to food consumption may lead to the consumption of an inappropriate quantity of food or of poor-quality food.

4.4.5 *Focusing on Food While Eating* (Tanmana Bhunjeet)

Focusing while eating on the food one is consuming is one of the most important components of Ayurvedic principles related to eating behavior. Good concentration ensures that the food will be enjoyed completely and the body will be fully aware of food choices and quantity in accordance with one's own needs. Clearly, good concentration on food can only be assured when the person is in a stable frame of mind and a good mood.

4.4.6 *Eating According to One's Own Preferences and Requirements* (Atmanambhisamikshya Samyaka)

This is the final principle of eating behavior, and it calls for individual vigilance toward what is being eaten and in what quantity. Of the many different kinds of food to choose from, clearly different people will have different preferences. This individual food choice may be reflective of personal choice, individual constitution (*prakriti*), or a *dosha* imbalance in the body. The body craves what is lacking inside.

4.5 Conclusions

Ayurveda has elaborate principles with regard to eating. Recent scientific research in the field has shown that stress is one of the most significant factors leading to disease and significant changes in eating behavior. It is proposed that a change in eating behavior due to stress may be the primary cause of pathologies related to stress. Identifying this factor early on, Ayurveda recommended guidelines related to ambience and mental attitude during food intake. This recommendation of Ayurveda stem from the simple recognition that stress may lead to various ailments, and because a pathology often begins with subtle changes in eating behavior, careful attention to the circumstances in which one consumes food may be the best way to prevent pathologies from occurring at all.

References

1. Wolford CC, McConoughey SJ, Jalgaonkar SP, Leon M, Merchant AS, Dominick JL, Yin X, Chang Y, Zmuda EJ, O'Toole SA, Millar EKA, Roller SL, Shapiro CL, Ostrowski MC, Sutherland RL, Hai T (2013) Transcription factor ATF3 links host adaptive response to breast cancer metastasis. J Clin Invest 123(7):2893

2. Cohen S, Janicki-Deverts D, Doyle WJ, Miller GE, Frank E, Rabin BS, Turner RB (2012) Chronic stress, glucocorticoid receptor resistance, inflammation, and disease risk. Proc Natl Acad Sci USA. doi:10.1073/pnas.1118355109
3. Janice K (2010) Kiecolt-Glaser, stress, food, and Inflammation: psychoneuroimmunology and nutrition at the cutting edge. Psychosom Med 72(4):365–369
4. Oliver G, Wardle J, Gibson EL (2000) Stress and food choice: a laboratory study. Psychosom Med 62:853–865
5. Torres S, Nowson C (2007) Relationship between stress, eating behavior and obesity. Nutrition 23(11–12):887–894
6. Evers C, Marijn Stok F, de Ridder DTD (2010) Feeding your feelings: emotion regulation strategies and emotional eating. Pers Soc Psychol Bull 36:792
7. Van Strien T, Fritjers JER, Bergers GPA, Defares PB (1986) Dutch eating behaviour questionnaire for assessment of restrained, emotional and external eating behaviour. Int J Eat Disord 5:295–315
8. Wallis DJ, Hetherington MM (2009) Emotions and eating. Self-reported and experimentally induced changes in food intake under stress. Appetite 52:355–362
9. Epel E, Lapidus R, McEwen B, Brownell K (2001) Stress may add bite to appetite in women: a laboratory study of stress-induced cortisol and eating behavior. Psychoneuroendocrinology 26:37–49
10. Mikolajczyk RT, El Ansari W, Maxwell AE (2009) Food consumption frequency and perceived stress and depressive symptoms among students in three European countries. Nutr J 8:31

Part II
Integrated Food Science and its Clinical Application

Chapter 5
Integrating the Science and Art of Using Food as Medicine

Sudha Raj

5.1 Introduction

Since the dawn of agriculture nearly 10,000 years ago, profound environmental changes have affected our diet and lifestyles. This has led to a mismatch between our ancient genetic endowments and contemporary lifestyle patterns, including diet and exercise, resulting in the emergence of noncommunicable chronic lifestyle-related degenerative diseases such as cancer and diabetes.

Approximately 2 million years ago, the foraging diet of our hunter-gatherer ancestors consisted of meat, fish, nuts, and roots – all of which were secured with enormous physical effort requiring the expenditure of over 3,000 cal/day [1]. The subsequent domestication of plants and animals led to the development of agricultural societies. Former hunter-gatherers became agriculturalists who toiled in the fields expending approximately 2,800 cal/day while consuming a spectrum of foods such as whole grains, fruits, vegetables, and dairy products. Despite the sporadic availability of food, our Paleolithic ancestors' survival for reproduction was ensured and supported by an efficient thrifty gene. Additionally, the extremely active agricultural lifestyle, coupled with a shorter life span, was successful at keeping nutrition-related chronic degenerative diseases of the present day at bay. However, in the last 250 years, industrialization, coupled with globalized food production, processing, and retailing, has transformed the modern food environment in terms of both the quantity and quality of food available. Contrary to the vagaries of the Paleolithic food supply, we currently enjoy a plethora of fresh, processed, convenience, and functional foods fortified or enriched with nutrients suited to a variety of palates and needs throughout the year. Despite this picture of plenty, unlike our Paleolithic ancestors, we continue to experience three insurmountable challenges. First, our

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dietary intakes are not in keeping with nutritional recommendations. A large proportion of present-day diets consists of high-glycemic-index foods that are low in fiber and high in salt, sugars, and oils [2]. For example, the fiber intake of hunter-gatherers was 40–100 g/day, whereas our current intakes are in the 15–20 g/day range [1]. Second, the ability to balance our caloric intakes with caloric expenditure is challenged by modern lifestyle patterns and a preponderance of sedentary activities of daily living [3]. Third, our genetic endowments are struggling to keep pace with the rapidity of our lifestyle changes that we continue to experience in the form of metabolic disorders, degenerative diseases, and their associated comorbidities [4, 5].

5.2 Diet and Lifestyle Interventions

Several etiological factors exert an influence either individually or in combination to fuel the current global pandemic of chronic diseases. For instance, the globalization of the industrialized food supply has resulted in altered, acculturated, and imbalanced dietary patterns in developed [6] and developing economies referred to as nutrition transition [7–9]. Other fueling factors include physical activity patterns that are not keeping pace with caloric intakes, food bioactive-gene interactions, epigenetic mechanisms that underlie fetal programming of chronic diseases, proinflammatory states arising from increased oxidative stress caused by environmental toxicity [10, 11], an imbalanced gut microbiome [12], chronic stress, and hectic lifestyles [13]. Health disparities stemming from rising healthcare costs, an increasing life span, ethnic diversity, inequitable access to adequate healthcare, and changes in sociocultural factors such as family dynamics further exacerbate the situation.

Conventional biomedicine, with its arsenal of pharmaceutical drugs, vaccines, antibiotics, and medical technology, is crucial in acute crisis situations. However, its specialized nature, dualistic approach of categorizing mind and body as separate entities, and consideration of nutrition as an ancillary component are viewed as limited in addressing chronic disease that is multifactorial in origin [14]. This has spurred a growing realization that perhaps the solution to this conundrum is to focus on the whole patient in the context of his or her biopsychosociocultural uniqueness [15]. Identifying the root causes that initiate and perpetuate chronic diseases in individuals is of greater relevance than comparing individuals to a set of preestablished laboratory criteria. Consequently, individualized assessment, diagnosis, and treatment using tailored interventions to address underlying causes, such as the food we eat in an environment that fosters a positive patient–provider relationship, are at the foundation of patient-centered medicine. Newer medical paradigms, such as integrative [16, 17] and functional medicine [18], encourage this practice of patient-centered medicine. Health and disease are viewed as existing on a continuum; consequently, a multipronged, holistic interventional approach that integrates multiple modalities is encouraged. Advocating a whole-foods approach using food as medicine, physical activity, stress, and lifestyle management, along with conventional biomedicine where necessary, is at the heart of these paradigms. Such salutogenic strategies are

believed to empower patients and play a pivotal role in moving the individual toward positive health and vitality, even in the face of significant disease pathology [19].

Ancient healing systems, such as Ayurveda and traditional Chinese medicine, have focused on salutogenesis with an eye toward making an impact on future generations [20]. Emphasis is on the regulation of a healthy lifestyle by conscious or mindful interactions with all aspects of the environment, including food and its quality and quantity to prevent the development of disease and maintain wellness. Wholesome food "Ahar" and practices to enhance its assimilation and utilization in the body are integral to these systems. Specific criteria are established for the types and amounts of food to be consumed based on seasonality and body constitutional assessment with the objective of maintaining balance or homeostasis. The modern-day practice of integrative nutrition builds on these principles using a three-pronged approach that (a) evaluates the impact of the individual's genetic makeup on (b) nutrient adequacy and availability so that (c) targeted food-based interventions can be designed as the first line of defense.

5.2.1 Genetic Uniqueness

First, the individual's biochemical uniqueness is taken into consideration to optimize health and wellness through food [21]. A wealth of information generated in the "omic" science, such as nutrigenomics, nutrigenetics, proteomics, metabolomics, and transcriptomics, continues to indicate that individuals and populations exhibit wide variations in the inherited genome ranging from single nucleotide polymorphisms (SNPs) to genomic mutations [22]. These variations contribute to a spectrum of disorders, from inborn errors of metabolism and monogenic conditions to polygenic diseases such as diabetes and metabolic syndrome. Food containing bioactives (e.g., nutrients, nonnutrient phytochemicals, antioxidants, and toxins) acts as an informational molecule. Bioactives contained in foods are influenced by plant varietals, availability, and dietary choices and sociocultural, economic, and geographical factors; they directly or indirectly impact transcription and translation of critical proteins such as enzymes, hormones, and transporters that function in metabolic pathways. Genomic variations, such as mutations and SNPs, influence nutrient bioavailability, utilization, and physiological processes, resulting in altered nutrient requirements [23]. This combination of variability in an individual's genetic predisposition and consumption as influenced by dietary choices can positively or negatively influence health outcomes, for example, malnutrition or optimal nutrition, which in turn affects genomic expression and stability. An emerging understanding of these factors begs the challenge of matching the nutriome (nutrient intake combinations) to optimize an individual's wellness potential based on genetic status, life stage, and environmental circumstances [24]. Further, diet, independently or in combination with other factors such as stress or environmental exposures, can cause heritable and programmable, yet modifiable, extragenomic, epigenetic changes via mechanisms such as DNA

methylation and histone modification [25]. Over a lifetime these changes, influenced by nutrient availability, modify DNA without altering the DNA sequence, also known as metabolic imprinting [26]. For instance, nutrients such as folate, vitamin B12, vitamin B6, choline, and methionine participate in the 1-carbon metabolic pathway; their role is critical in ensuring an adequate supply of methyl groups for methylation processes. Dietary factors can also modify the use of methyl groups, influencing methylation enzyme activity [27]. However, the extent of this influence is determined by factors such as bioavailability and differential rates of absorption and excretion. Bioactive food components that have the capability of modulating the epigenetic machinery include polyphenols, selenium, retinoids, essential fatty acids, allyl compounds, isothiocyanates, and short-chain fatty acids such as butyrates [28, 29]. Research initiatives have focused and continue to focus on the identification and use of dietary factors such as genistein in soy, hesperidin in citrus fruits, isothiocyanates in cruciferous vegetables, and resveratrol in grapes, to name a few. These products have been studied for their abilities to function as methylation modulators and regulators of epigenetic events [30]. Depending on the gene, timing of expression, and tissue, DNA hypo- or hypermethylation can silence or activate critical genes, contributing to inflammatory disease states, including cancer. The spectrum of chronic disease phenotypes that we see today is described as the result of the lifelong remodeling of our epigenome. Although much remains to be elucidated about the interrelationships between epigenetic, genetic, and environmental interactions and their translation into practical applications, current research initiatives focus on modulating the epigenetic mechanisms of key inflammatory genes using dietary strategies as one approach to handle the chronic disease epidemic [28].

5.2.2 Multifunctional Nutrients and Bioactives in Foods

Second, long-latency nutrient deficiencies or insufficiencies due to a lack of or less-than-optimal availability for meeting an individual's needs are believed to play a major role in chronic disease etiology. As multitasking molecules, nutrients have one or more necessary and purposeful coenzyme and cofactor roles in cellular metabolism, making them critical to the functioning of biochemical pathways. Dietary choices, genetic predispositions, stress, environmental exposures, gut health, and synergistic or antagonistic interactions with other nutrients are important determinants that influence nutrient bioavailability. Biochemical pathways are often the first to be affected; the binding affinities of required enzymes for coenzymes and cofactors adjust accordingly, resulting in varying degrees of metabolic impairments, with the accumulation of intermediary metabolites or products that can be evaluated by appropriate biomarkers [31]. For example, the functionality of the endogenous antioxidant enzyme glutathione reductase can be completely or partially compromised in frank or suboptimal riboflavin deficiency, resulting in decreased detoxification capacity. DNA damage, digestive and

detoxification imbalances, inflammatory responses, hormonal changes, or free radical production often ensues. Over time, such cellular and functional changes resulting from long-latency nutritional deficiencies or insufficiencies result in a myriad of core imbalances in various organ systems manifesting as signs and symptoms of chronic diseases [14]. The triage theory introduced by Bruce Ames posits that under conditions of micronutrient scarcity, multitasking nutrients prioritize their roles to ensure short-term survival processes at the expense of long-term health [32]. For example, vitamin K is a multitasking nutrient with roles in the blood coagulation cascade as well as in the skeletal system. Under conditions of a limited supply of vitamin K, its blood coagulation functions take precedence over its contribution to skeletal health [33].

While nutrient deficiency and its consequences are a well-recognized phenomenon that can be mitigated by nutrient supplementation, the question remains as to the generalized efficacy of such strategies. For example, large-scale randomized control trials on the impact of, for example, B-carotene on cancer [34], vitamin E on LDL oxidation [35], and homocysteine levels on the risk of CHD [36] have shown limited benefits. Supplemental folic acid has been shown to be of some value in preventing cancer at an early stage but promoting cancer at a later stage [37]. All of this research has underscored the importance of taking a holistic approach to the study of food and its impact on human nutrition. Food is more than a collection of isolated nutrients; therefore, the true impact of nutrients is best studied not in isolation but rather in their natural environment – the whole food.

5.2.3 Food as Medicine for Health and Wellness

Third, nutrition, as determined by food components, is an environmental input that is critically involved in the creation and mitigation of disease primarily by disrupting or restoring balance respectively in cellular mechanisms and physiological processes. Food, in the integrative and functional medicine paradigm, is seen not merely as a source of calories and nutrients but as a messenger molecule influencing homeostasis. Cell signaling, production and regulation of growth factors, cytokines, and eicosanoids are critical factors modulated by bioactives in foods we choose to consume [38]. These processes occur in a milieu influenced by genetic predispositions and environmental and lifestyle factors such as exercise, sleep, and toxic exposures. In essence, the choices we make every day about what we eat dictate what and who we are. On the one hand, unhealthy food choices and dietary behaviors, disregard for food sensitivities, and increasing toxic loads can contribute to the development of chronic diseases such as, for example, metabolic syndrome, asthma, and migraines. On the other hand, when we mindfully apply the current science of food and its components, we can use the restorative and therapeutic capacities of food to our health advantage. So how does food exert its therapeutic potential?

Food synergy is an approach that looks at all food components within a "whole" unprocessed food rather than using a reductionist approach of isolating a single

food component with a unique benefit [39]. This holistic, whole-food thinking of food first is in contrast with the research activities of the last century where the focus was on the discovery and application of single nutrient components as concentrated supplements and their role in combating nutrient deficiencies [40]. The premise of food synergy is that the action of the whole food matrix (the composite of naturally occurring food components in biological systems) is greater than or different from the corresponding actions of individual food components, regardless of whether they are isolated from whole foods, e.g., carotene, or produced by technological processes, e.g., trans-fatty acids. Individual food components consist of dietary nutrient and nonnutrient factors, e.g., nutrients such as carbohydrates, essential fats, phytochemicals, and antioxidants. These compounds are thought to be evolutionarily dependent and bioavailable to act in a well-orchestrated, synergistic manner affecting human biological processes [41, 42]. Flavonoids, phenolic compounds, tocopherols, coumarins, tannins, and carotenoids are examples of phytochemicals and antioxidants that, despite their quantitative and qualitative variability, originate in the plant kingdom. The combination of compounds within the food matrix exhibits their therapeutic potential in an anti-inflammatory diet through a variety of mechanisms often not demonstrated by isolated food components. These include enhanced biotransformation, intracellular signaling for blocking carcinogenic activity, regulation of transcription factor activity, enhanced DNA repair mechanisms, antibacterial or antiviral functions, and modulation of the amount and type of eicosanoids produced.

Justification of the food synergy approach is further provided by a growing body of in vivo and in vitro evidence that identifies synergistic, additive, and antagonistic interactions that occur between these food components. For example, green tea polyphenols, such as epicatechin (EC), epigallocatechingallate (EGCG), epigallocatechin (EGC), and epicatechingallate (ECG), are known to exert a variety of chemopreventive effects such as inhibition of malignant cell growth and cell apoptosis [43]. Studies on gastric carcinoma cells indicate that EC by itself has a limited effect on cell growth or induction of apoptosis. However, its chemopreventive effects are enhanced when EC is combined with the other catechins, showing the benefits of whole tea consumption rather than purified EGCG supplements. Spices such as ginger, turmeric, cinnamon, black pepper, garlic, and others that are common ingredients in everyday South Asian cuisine have been described and used for their therapeutic potential in the texts of the traditional Indian medical systems of Ayurveda and Siddha [44]. Spices and herbs have been used independently and in various combinations in a myriad of food preparations over millennia; their physiological impact is being unraveled now [45]. In addition to enhancing the flavor of dishes, herbs and spices are excellent sources of bioactives such as curcumin in turmeric, piperine in black pepper, and gingerol in ginger. These bioactives exhibit anti-inflammatory, antibacterial, and antithrombotic potential and have the ability to protect against oxidative damage by inhibiting and addressing free radical damage [46]. There is emerging evidence pointing to the complementary and synergistic effects of active ingredients in spices such as curcumin in turmeric and piperine in black pepper [47]. All of this evidence calls attention to the importance of the

judicious use of these food ingredients in daily food preparations that over a lifetime can contribute to optimal health and wellness through beneficial and additive therapeutic effects.

In the last decade the food synergy concept has been extended to analyze global dietary patterns and their influence on the risk of chronic diseases [48]. Dietary pattern analysis, wherein due consideration is given to the types and amounts of foods and nutrients and the combinations in which they are consumed based on geographical, cultural, and socioeconomic factors, is a better predictor of disease risk than the study of individual foods, food groups, or isolated nutrients. A significant amount of evidence links the benefits of diets with a whole-food focus. The traditional Okinawan diet of the southern Japanese Islands [49], the Mediterranean diet [50], and diets such as the DASH diet with clinical applications [51] are associated with a lowered risk for chronic disease. Despite regional variations, the Mediterranean diet emphasizes whole-grain cereals, legumes, and nuts and includes fish, extra virgin oil, and small quantities of red meat. Each of these food components within the dietary pattern offers nutritional advantages and disadvantages, such as a lowered glycemic load, anti-inflammatory components such as fiber, lignans, zinc, the B vitamins, and vitamin E, saturated fats, and an optimal ratio of omega 6:3 fatty acids. Yet, it is the sum total effect of all food components (quantity, quality, additive, antagonistic, and synergistic effects) and whether they are consumed in balanced amounts exemplified in the food synergy concept that is responsible for beneficial health outcomes. Despite these advantages, it is important to recognize the importance of balance, portion control, and the ill effects of overconsumption, reiterating the idea that it is the dose that makes the poison.

5.3 Conclusions

Food is a powerful clinical tool that aids in preventing and treating disease. Therefore, the choices we make about what we consume as food will have a bearing on our health. The therapeutic potential of food is further enhanced by an adequate functioning of the gastrointestinal system characterized by digestive wellness [52]. A corollary requirement is a well-functioning detoxification system represented by the optimal production and functioning of detoxification enzymes such as those in the CYP 450 family [53]. An integrative whole-food approach recommends a multipronged strategy aimed at normalizing multiple biological systems. This includes a gradual transition to an unprocessed whole-foods diet, paying due attention to the source of food, method of preparation, portion control, removing and controlling food allergens, recognizing and addressing food sensitivity, reducing the environmental toxic load, and following a holistic lifestyle intervention strategy that combines diet, exercise, stress management, and spirituality.

References

1. Aguilera JM (2013) Healthy habits. In: Edible structures. The basic science of what we eat. CRC Press/Taylor and Francis Group, Boca Raton, pp 349–365
2. Neustadt J (2006) Western diet and inflammation. Integr Med 5(4):14–18
3. Cordain L, Gotshall LW, Boyd Eaton S, Boyd Eaton III S (1998) Physical activity, energy expenditure and fitness. An evolutionary perspective. Int J Sports Med 19:328–335
4. Eaton SB, Cordain L (1997) Evolutionary aspects of diet: old genes, new fuels. In: Simopoulos P (ed) Nutrition and fitness: evolutionary aspects, children's health, programs and policies. Karger, Basel, pp 26–37
5. Nesse RM, Williams JC (1998) Evolution and the origins of disease. Sci Am 279(5):86–89
6. Shaw JE, Sicree RA, Zimmet PZ (2010) Global estimates of the prevalence of diabetes for 2010 and 2030. Diabetes Res Clin Pract 87:4–14
7. Popkin BM (2006) Global nutrition dynamics: the world is shifting rapidly toward a diet linked with non-communicable diseases. Am J Clin Nutr 84:289–298
8. Delavari M, Sonderlund AL, Swinburn B, Mellor D, Renzaho A (2013) Acculturation and obesity among migrant populations in high income countries- a systematic review. BMC Public Health 13:458. doi:10.1186/1471-2458-13-458
9. Hu FB (2011) Globalization of diabetes: the role of diet, lifestyle and genes. Diabetes Care 34(6):1249–1257. doi:10.2337/dc11-0442
10. Pruss-Ustun A, Vickers C, Haefliger P, Bertollini R (2011) Known and unknowns on burden of disease due to chemicals: a systematic review. Environ Health 10:9, http://www.ehjournal.net/content/10/1/9
11. Borchers A, Teuber SS, Keen CL, Gershwin ME (2010) Food safety. Clin Rev Allergy Immunol 39:95–141. doi:10.1007/S12016-009-81764
12. Gentschew L, Ferguson LR (2012) Role of nutrition and microbiota in susceptibility to inflammatory diseases. Mol Nutr Food Res 56:524–535
13. Malarkey WB, Jarjoura D, Klatt M (2013) Workplace based mindfulness practice and inflammation: a randomized trial. Brain Behav Immun 27:145–154, http://dx.doi.org/10.1016/j.bbi.2012.10.009
14. Jones DS, Hoffman L, Quinn S (2009) 21st century medicine: a new model for medical education and practice. Institute for Functional Medicine, Gig Harbor, http://www.functionalmedicine.org/ifm_ecommerce/ProductDetails.aspx?ProductID=174
15. di Sarsina PR, Iseppato I (2011) Why we need integrative medicine? EPMA J 2:5–7. doi:10.1007/s13167-011-0065-2
16. Maizes V, Rakel D, Niemiec C (2009) Integrative medicine and patient -centered care. Explore 5(5):277–289
17. Chang C (2013) Is integrative medicine the next frontier? Clin Rev Allergy Immunol 44(3):205–7. doi:10.1007/S12016-012-8313-3
18. Hyman M (2004) Paradigm shift: the end of "normal science" in medicine. Understanding function in nutrition, health and disease. Altern Ther 10(5):10–15, 90–94
19. Cloninger CR (2011) Person centered integrative care. J Eval Clin Pract 17:371–372
20. Rastogi S (2009) Ayurveda for comprehensive healthcare. Indian J Med Ethics 6(2):101–2
21. DeBusk R (2010) The role of nutritional genomics in developing an optimal diet for humans. Nutr Clin Pract 25(6):627–633
22. Trajillo E, Davis C, Milner J (2006) Nutrigenomics, proteomics, metabolomics, and the practice of dietetics. J Am Diet Assoc 106:403–413
23. Stover PJ, Caudill M (2008) Genetic and epigenetic contributions to human nutrition and health: managing genome-diet interactions. J Am Diet Assoc 108(9):1480–1487
24. Fenech M, El-Sohemy A, Cahill L, Ferguson LR, French TA, Tai ES, Milner J, Koh WP, Xie L, Zucker M, Buckley M, Cosgrove L, Lockett T, Fung KY, Head R (2011) Nutrigenetics and nutrigenomics: viewpoints on the current status and applications in nutrition research and practice. J Nutrigenet Nutrigenomics 4:69–80

25. Feinberg AP (2008) Epigenetics at the epicenter of modern medicine. JAMA 299(11):1345–1350. doi:10.1001/jama.299.11.1345
26. Waterland RA, Garza C (1999) Potential mechanisms of metabolic imprinting that lead to chronic disease. Am J Clin Nutr 69:179–197
27. SzarcvelSzic K, Ndlovu MN, Haegeman G, VandenBerghe W (2010) Nature or nurture: let food be your epigenetic medicine in chronic inflammatory disorders. Biochem Pharmacol 80:1816–1832
28. Belshaw NJ, Johnson IT (2011) Isothiocyanates and polyphenols. In: Niculescu MD, Haggerty P (eds) Nutrition in epigenetics. Wiley-Blackwell, Ames, pp 263–272
29. Ong TP, Moreno FS, Ross SA (2011) Targeting the epigenome with bioactive food components for cancer prevention. J Nutrigenet Nutrigenomics 4:275–292
30. Verma M (2012) Cancer control and prevention by nutrition and epigenetic approaches. Antioxid Redox Signal 17(2):355–364
31. Richard Lord JAB (ed) (2008) Laboratory evaluations for integrative and functional medicine, 2nd edn. Metametrix Institute, Duluth
32. Ames BN (2010) Optimal micronutrients delay mitochondrial decay and age associated diseases. Mech Ageing Dev 131(7–8):473–479
33. Ames BN (2006) Low micronutrient intake may accelerate the degenerative diseases of aging through allocation of scarce micronutrients by triage. Proc Natl Acad Sci USA 103(47): 17589–17594
34. Jacobs DR, Tapsell LC, Temple NJ (2011) Food synergy: the key to balancing the nutrition research effort. Public Health Rev 33(2):507–529
35. Asmis R, Llorente VC, Gey KF (1995) Prevention of cholesteryl ester accumulation in p388D1 macrophage like cells by increased cellular vitamin E depends on species of extracellular cholesterol. Conventional heterologous non-human cell cultures are poor models of human atherosclerotic foam cell formation. Eur J Biochem 233:171–178
36. Albert CM, Cook NR, Gaziano JM, Zaharris E, MacFadyen J, Danileson E (2008) Effect of folic acid and B vitamins on risk of cardiovascular events and total mortality among women at high risk for cardiovascular disease: a randomized trial. JAMA 299:2027–2036
37. Sauer J, Mason JB, Choi Sang-Woon (2009) Too much folate- a risk factor for cancer and cardiovascular disease? Curr Opin Clin Nutr Metab Care 12(1):30–36. doi:10.1097/MCO.0b013e 32831cec62
38. Wang S, Meckling KA, Marcone MF, Kakuda Y, Tsao R (2011) Synergistic, additive and antagonistic effects of food mixtures on total antioxidant capacities. J Agric Food Chem 59:960–968
39. Jacobs DR et al (2009) Food synergy: an operational concept for understanding nutrition. Am J Clin Nutr 89:1543S–1548S
40. Messina M, Lampe JW, Birt DF, Appel LJ, Pivonka E, Berry B, Jacobs DR Jr (2001) Reductionism and the narrowing nutrition perspective: time for reevaluation and emphasis on food synergy. J Am Diet Assoc 101(12):1416–1419
41. Jacobs DR, Tapsell LC (2007) Food, not nutrients is the fundamental unit in nutrition. Nutr Rev 65(10):439–450
42. Jacobs SR, Tapsell LC (2013) Food synergy: the key to a healthy diet. Plenary lecture II conference on “translating nutrition: integrating research, practice and policy”. Proc Nutr Soc 72:200–206. doi:10.1017/S0029665112003011
43. Morie N, Hirabayashi N, Takahashi Y, Miyauchi Y, Taguchi H, Takeishi K (2005) Synergistic effect of green tea catechins on cell growth and apoptosis induction in gastric carcinoma cells. Biol Pharm Bull 28:574–579
44. Govindarajan R, Vijayakumar M, Pushpangadan P (2005) Antioxidant approach to disease management and the role of Rasayana herbs of Ayurveda. J Ethnopharmacol 99:165–178
45. Vasanthi HR, Parameswari RP (2010) Indian spices for a healthy heart-an overview. Curr Cardiol Rev 6:274–279
46. Jungbauer A, Medjakovic S (2012) Anti-inflammatory properties of culinary herbs and spices that ameliorate the effects of metabolic syndrome. Maturitas 71:227–239

47. Hlavačková L, Janegová A, Uličná O, Janega P, Cerná A, Babál P (2011) Spice up the hypertension diet-curcumin and piperine prevent remodeling of aorta in experimental L-NAME induced hypertension. Nutr Metab (Lond) 8:72. doi:10.1186/1743-7075-8-72
48. Hu FB (2002) Dietary pattern analysis: a new direction in nutritional epidemiology. Curr Opin Lipidol 13:3–9
49. Mano R, Ishida A, Ohya Y, Todoriki H, Takishita S (2009) Dietary intervention with Okinawan vegetables increased circulating endothelial progenitor cells in healthy young women. Atherosclerosis 204:544–548
50. Estruch R, Ros E, Salas-Salvadó J, Covas MI, Corella D, Arós F, Gómez-Gracia E, Ruiz-Gutiérrez V, Fiol M, Lapetra J, Lamuela-Raventos RM, Serra-Majem L, Pintó X, Basora J, Muñoz MA, Sorlí JV, Martínez JA, Martínez-González MA (2013) Primary prevention of cardiovascular disease with a Mediterranean diet. N Engl J Med 368(14):1279–1290. doi:10.1056/NEJMoa1200303, Epub 2013 Feb 25
51. Foroughi M, Akhavanzanjani M, Maghsoudi Z, Ghiasvand R, Khorvash F, Askari G (2013) Stroke and nutrition: a review of studies. Int J Prev Med 4(Suppl 2):S165–S179
52. Bosscher D, Breynaert A, Pieters L, Hermans N (2009) Food based strategies to modulate the composition of the intestinal microbiota and their associated health effects. J Physiol Pharmacol 60(Suppl 6):5–11
53. Murray M (2006) Altered CYP, expression and function in response to dietary factors: potential roles in disease pathogenesis. Curr Drug Metab 7(1):67–81

Chapter 6
Integrated Food and Nutrition in the Management of Diabetes

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6.1 Introduction

The prevalence of chronic noncommunicable diseases (NCDs) is now reaching epidemic proportions in the developing countries [1]. Indeed, India already has the highest number of diabetic and prediabetic patients in the world, reaching 62.4 million and 72.7 million, respectively [2]. A recent study from the Indian Council of Medical Research–INdia DIABetes (ICMR– INDIAB) showed that the weighted prevalence of diabetes (both known and newly diagnosed) in the urban population of Chandigarh (14.2 %) was the highest, followed by Tamil Nadu (13.7 %), Jharkhand (13.5 %), and Maharashtra (10.9 %). At every age interval, the prevalence of diabetes in urban areas was higher compared with rural areas [2]. This national estimate shows a trend of an increasing number of people with diabetes in India over the last decade [3]. The cause behind the huge epidemic is the alteration of dietary patterns with a rise in refined-grain consumption due to growing industrialization and the country's economic conditions. A natural method of precaution that entails using functional foods present in foods may be one of the most beneficial measures in combating the growing epidemic of diabetes.

6.2 Changing Face of India

The evolution of current dietary and food habits of Indians reflects the agricultural and industrial revolutions of the country. The Bengal famine resulted in an acute decline in food production in India. The so-called Green Revolution, in the context

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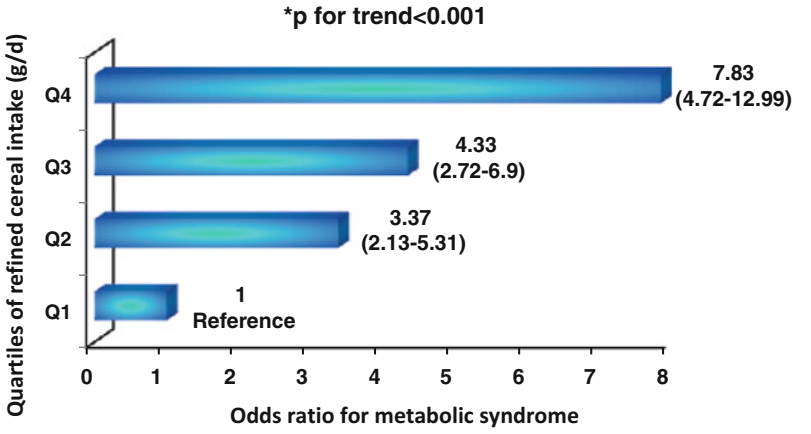
of agriculture in India, led to record grain output and ensured self-sufficiency in cereal grains and reduced hunger. The Green Revolution prominently featured cereal grains, especially wheat and rice, which resulted in a shift in dietary patterns. Today India suffers from conditions such as "affluenza," which leads to excessive food intake, a decrease in physical activity, and urbanization. The probable reasons for the escalation of diabetes in Indians are rapid urbanization, industrialization, and demographic transitions leading to increasing income levels, all of which has resulted in altered lifestyles [4, 5]. In addition, migration to urban environments from rural settings may also be a major contributor to the epidemic of type 2 diabetes in Indians. Obesity, especially central obesity and increased visceral fat due to physical inactivity, and the consumption of a high-calorie/high-fat and high-sugar diets are other major contributing factors [6]. The results from the Chennai Urban Rural Epidemiological Study (CURES) show a high prevalence of both general and central obesity, among both men and women, with women having slightly higher rates [7].

6.2.1 Refined Grains, Dietary Carbohydrates, and Diabetes Risk

A population-based, epidemiological cross-sectional study, undertaken to assess the dietary patterns of the Chennai population as the urban component of the Chennai Urban Rural Epidemiological Study (CURES), shows that carbohydrates were the major source of energy (64 % E), followed by fat (24 % E) and protein (12 % E). Refined cereals contributed to the bulk of the energy (45.8 % E), followed by visible fats and oils (12.4 % E) and pulses and legumes (7.8 % E). However, energy supply from sugar and sweetened beverages was within the recommended levels of <10 % E. Intake of micronutrient-rich foods, such as fruits and vegetables (265 g/day) and fish and seafood (20 g/day), was far below the FAO/WHO recommendation [8].

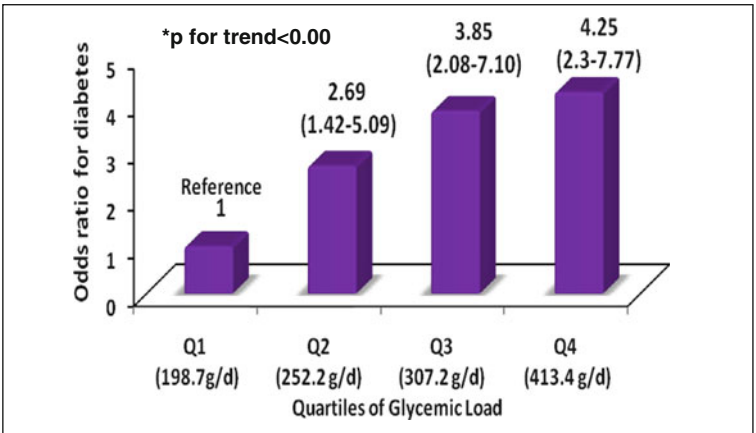
Refined grains in southern India mainly consist of polished rice, refined wheat flour (white flour), semolina, and ragi (finger millet) flour. Of these, white rice, a high glycemic index (GI) cereal staple, is the main component of the diet (76 %, mean 253 g/day) and represents the major source of energy and contributes up to 66 % of the total glycemic load (GL) [GL = GI % x amount of available carbohydrates provided by the portion of the food eaten] in urban Chennai diets. The commonly consumed highly polished white rice in India has a high GI value (approximately 75–80), and the refining process leads to a loss of fiber, vitamins, magnesium and other minerals, lignans, phytoestrogens, and phytic acid, many of which may be protective factors against diabetes and cardio vascular diseases (CVD). Research carried out in the urban Chennai population showed a higher intake of refined cereals, and a high-glycemic-load diet was associated with a metabolic syndrome in Asian Indians who habitually consume high-carbohydrate diets (Figs. 6.1 and 6.2) [9, 10].

Whole grains like brown rice were reported to have health benefits in reducing the risk of chronic diseases like diabetes. Brown rice has intact bran and a germ that



*P denotes the trend calculated using the median of each category of intake as a continuous variable in the regression model. Adjusted for age, sex, smoking, alcohol, BMI, METS, total energy, legumes, visible fats and oils, dairy products, sugars, fruits and vegetables, tubers, fish and seafood, and nuts and oil seeds

Fig. 6.1 Relation of refined cereal intake to metabolic syndrome disorders [10]



*Tests for a linear trend were conducted across increasing categories by treating the medians of intake in categories as a continuous variable. The 95% confidence interval is in parentheses. The model was adjusted for age, sex, BMI, family history of diabetes, cigarette smoking, alcohol consumption, physical activity, and Income in Indian Rupees

Fig. 6.2 Relation of glycemic load to type 2 diabetes [9]

contains micronutrients, phytonutrients, and dietary fiber as compared with fully polished white rice, as reported by studies conducted in the West [11]. Many people are unaware of the health benefits of brown rice and consider that Kerala red rice, parboiled rice, or even hand-pounded rice as brown rice. Hence, in this context,

research on people's awareness of brown rice is being carried out for the first time on Indian foods by determining the GI of foods containing brown rice and comparing them with their white rice counterparts.

6.2.2 Oil Intake and Metabolic Syndrome

Edible oil is an important source of fat in the Indian diet. Besides being a source of energy, it adds a special flavor and palatability to food. The quality of fat in terms of essential fatty acids and the ratio of omega 6:3 are very essential to maintaining good health. A community-based study carried out in Chennai showed that almost 63 % of the Chennai population preferred modern sunflower oil and only 7 % preferred traditional groundnut oil (7 %) and sesame oil (2 %) [8]. The use of omega-6 poly unsaturated fatty acids (PUFA) PUFA-rich vegetable oils like sunflower/safflower oil can aggravate the risk of obesity and its consequences, particularly among Asian Indians, who habitually consume a cereal-based diet consisting mainly of refined grains with low intakes of omega-3 fats [12]. The use of traditional oils such as groundnut/sesame/mustard and even soybean oils or blends of oils seems to be a better option because it could ensure an optimal ratio of saturated, monounsaturated, omega-3 and omega-6 fatty acids and reduce the risk of metabolic problems, a pre-event that leads to diabetes and cardiovascular disorders.

6.2.3 Functional Foods

The erosion of healthy diet as an outcome of modernization and industrialization has led to the development of dietary supplements and functional foods. Functional foods are foods, including whole foods and fortified, enriched, or enhanced foods or dietary components, that may reduce the risk of chronic disease and provide a health and physiological benefit beyond the traditional nutrients it contains. Functional food is a key concept for the future of nutrition. Some functional foods that play a major role in the prevention of chronic diseases and the promotion of health are mentioned in what follows.

6.2.4 Omega-3 Fatty Acids

Apart from being a source of energy, fatty acids build up cellular membranes, regulate gene expression, and function as signaling molecules. There are indeed indications that omega-3 PUFAs have a positive effect on glucose tolerance by reducing insulin resistance, as demonstrated by animal models of obesity [13]. For the benefits in cardiovascular disorders, the American Heart Association recommends that the degree of PUFAs in the diet should be increased and the ratio of omega 6:3

PUFAs needs to be reduced. This can be achieved by increased consumption of α linolenic acid, which is abundant in fatty fish like salmon, herring, and mackerel, as well as in lean fish liver, which contains large amounts of EPA and DHA, plant oils derived from flaxseed, soybean, and rapeseed and nuts like walnuts.

6.2.5 Medium-Chain Triglycerides

Medium-chain triglycerides (MCTs) have a number of unique characteristics related to energy density, absorption, and metabolism. MCTs can decrease body fat in the long term because it provides an approx. 50 % increase in diet-induced thermogenesis, which over time may help to induce weight loss and prevent weight gain [14]. The satiating properties of MCTs involve multiple preabsorptive and postabsorptive mechanisms, which further help in appetite control and, hence, obesity. Daily consumption of MCT oil by humans is safe up to 1 g/kg of body weight; there are few naturally occurring sources of MCTs, but they include milk fat, palm kernel oil, and coconut oil. A comparison trial with MCT (35 g) and LCT (32 g) supplementation showed that food intake was lower following consumption of MCT, suggesting an important role of MCTs in satiation, but energy expenditure did not significantly differ between groups [15]. Very few studies have been recorded on MCT supplementation and its effect on satiety and energy expenditure, and more research should be done on improvements in body composition, energy expenditure, and diminished weight gain resulting from MCT consumption [16].

6.2.6 Resistant Starch

Depending upon food consumption practices and individual gastrointestinal processes, it is possible that some starch will actually pass through the small intestine undigested and contribute to the amount of resistant starch (RS). RS is defined as "starch and starch degradation products not absorbed in the small intestine of healthy humans" [17]. RS is associated with nutritional, metabolic, and physiological changes that make it an essential ingredient for the management of diabetes and its complications [18]. The presence of RS in foods reduces their caloric density. Researchers have shown that RS acts as a prebiotic in the gut and produces short-chain fatty acid (SCFA); it has also been proposed that it affects carbohydrate and lipid metabolism. RS is present in a physically inaccessible form in legumes, cereals, roots, and tubers, but the formation of RS in these foods varies with processing and storage conditions. A study on the effect of processing on RS content of staple Indian cereal foods showed that roasting, baking, and pressure cooking increased the RS content, whereas frying and steaming decreased the naturally present RS content in Indian foods [19]. Hence, appropriate processing technologies for RS formation in foods and clinical trials with RS supplementation are needed to assess its health benefits.

6.2.7 Nondigestible Oligosaccharides

Nondigestible oligosaccharides (NDOs) resist hydrolysis and digestion in the human digestive system and are partially or completely fermented by the colonic microbiota in the large intestine. The ingestion of NDOs may thus lead to the advantageous proliferation of certain types of beneficial bacteria (*lactobacilli and bifidobacteria*) and suppression of harmful bacteria [20]. The major products of NDO metabolism are SCFAs and gases. SCFAs are absorbed in the blood stream of the host. Butyrate is absorbed and used by colonocytes as the preferred fuel, whereas the other SCFAs are transferred to various organs, primarily the liver, where they enter various metabolic pathways. Some of the essential NDOs are fructooligosaccharides, inulin, galactooligosaccharides, lactulose, galactomannan, and cyclodextrin.

6.2.7.1 β-Glucan

β-glucan, found in oats and barley, is a highly viscous, soluble, and fermentable polysaccharide shown to have a positive effect on weight control management. It acts as a prebiotic and has been suspected to influence the glucose metabolism by modulation of glycemia or insulin response to a meal. It works by slowing the rate of nutrient absorption and lowering the glycemic index of foods and postprandial glucose [21]. It also has properties similar to those of prebiotics and produces SCFAs, which helps in various metabolic pathways and in turn in the management of metabolic syndrome by reducing weight, glycemic and insulinemic response, and inhibiting cholesterol synthesis [20].

6.3 Conclusions

Modernization and lifestyle modifications have resulted in poor nutrition (quantity and quality). Conversely, improved nutrition is important in preventing diabetes. Many functional foods may help in diabetes prevention and control. However, there is a need for a more systematic research approach to incorporate these functional foods in the newer evidence-based health foods for the management of the physiological and metabolic consequences of diabetes and related chronic disorders.

References

1. International Diabetes Federation, Unwin N, Whiting D, Gan D, Jacqmain O, Ghyoot G (eds) (2009) IDF diabetes atlas, 4th edn. International Diabetes Federation, Belgium, p 12
2. Anjana RM, Pradeepa R, Deepa M, Datta M, Sudha V, Unnikrishnan R et al (2011) Prevalence of diabetes and prediabetes (impaired fasting glucose and/or impaired glucose tolerance) in

urban and rural India: Phase I results of the Indian Council of Medical Research–INdia DIABetes (ICMR–INDIAB) study. Diabetologia 54:3022–3027
3. Mohan V, Deepa M, Deepa R, Shanthirani CS, Farooq S, Ganesan A, Datta M (2006) Secular trends in the prevalence of diabetes and impaired glucose tolerance in urban South India – the Chennai Urban Rural Epidemiology Study (CURES-17). Diabetologia 49:1175–1178
4. Mohan V, Sandeep S, Deepa R, Shah B, Varghese C (2007) Epidemiology of type 2 diabetes: Indian scenario. Indian J Med Res 125:217–230
5. Pradeepa R, Mohan V (2002) The changing scenario of the diabetes epidemic: implications for India. Indian J Med Res 116:121–132
6. Deepa R, Sandeep S, Mohan V (2007) Abdominal obesity, visceral fat and type 2 diabetes – "Asian Indian Phenotype". In: Mohan V, Gundu HRR (eds) Type 2 diabetes in South Asians: epidemiology, risk factors and prevention, Under the Aegis of SASAT. Jaypee Brothers Medical Publishers, New Delhi, pp 138–152
7. Deepa M, Farooq S, Deepa R, Manjula D, Mohan V (2009) Prevalence and significance of generalized and central body obesity in an urban Asian Indian population in Chennai, India (CURES: 47). Eur J Clin Nutr 63:259–267
8. Radhika G, Sathya RM, Ganesan A, Saroja R, Vijayalakshmi P, Sudha V, Mohan V (2010) Dietary profile of urban adult population in South India in the context of chronic disease epidemiology (CURES – 68). Public Health Nutr 14:591–598
9. Radhika G, Van Damb RM, Sudha V, Ganesana A, Mohan V (2009) Refined grain consumption and the metabolic syndrome in urban Asian Indians (Chennai Urban Rural Epidemiology Study 57). Metab Clin Exp 58:675–681
10. Mohan V, Radhika G, Rangaswamy MS, Selvi Ramjothi T, Ganesan A, Sudha V (2009) Dietary carbohydrates, glycemic load, food groups and newly detected type 2 diabetes among urban Asian Indian population in Chennai, India (Chennai Urban Rural Epidemiology Study 59). Br J Nutr 102:1498–1506
11. Sun Q, Spiegelman D, van Dam R, Holmes M, Malik V, Willett W, Hu F (2010) White rice, brown rice and risk of type 2 diabetes in US men and women. Arch Intern Med 170:961–969
12. Lakshmipria N, Gayathri R, Praseena K, Vijayalakshmi P, Geetha G, Sudha V, Krishnaswamy K, Anjana RM, Henry J, Mohan V (2012) Type of vegetable oils used in cooking and risk of metabolic syndrome among Asian Indians. Int J Food Sci Nutr 64(2):131–139
13. Storlien LH, Higgins JA, Thomas TC, Brown MA, Wang HQ (2000) Huang XF and else PL diet composition and insulin action in animal models. Br J Nutr 83(Suppl 1):S85–S90
14. Clegg ME, Golsorkhi M, Henry CJ (2013) Combined medium-chain triglyceride and chilli feeding increases diet-induced thermogenesis in normal-weight humans. Eur J Nutr 52(6):1579–1585
15. Wymelbeke VV, Louis-Sylvestre J, Fantino M (2001) Substrate oxidation and control of food intake in men after a fat-substitute meal compared with meals supplemented with an isoenergetic load of carbohydrate, long-chain triacylglycerols, or mediumchain triacylglycerols. Am J Clin Nutr 74:620–630
16. Rego Costa AC, Rosado EL, Soares-Mota M (2012) Influence of the dietary intake of medium chain triglycerides on body composition, energy expenditure and satiety; a systematic review. Nutr Hosp 27(1):103–108
17. Asp NG (1992) Resistant starch – proceedings from the second plenary meeting of EURESTA: European Flair Concerted Action no.11 on the physiological implications of the consumption of resistant starch in man. Eur J Clin Nutr 46(Suppl 2):S1
18. Higgins JA (2004) Resistant starch: metabolic effects and potential health benefits. J AOAC Int 87:761–768
19. Vaidya RH, Sheth MK (2010) Processing and storage of Indian cereal and cereal products alters its resistant starch content. J Food Sci Technol 48(5):622–627
20. Roberfroid M, Gibson GR, Hoyles L, McCartney AL, Rastall R, Rowland I et al (2010) Prebiotic effects: metabolic and health benefits. Br J Nutr 104(S2):S1–S63
21. Battilana P, Ornstein K, Minehira K, Schwarz JM, Acheson K, Schneiter P, Burri J, Jequier E, Tappy L (2001) Mechanism of action of β glucan in postprandial glucose metabolism in healthy men. Eur J Clin Nutr 55(5):327–333

Chapter 7
Convalescent Food Practices in Ayurveda

Sanjeev Rastogi and Priyanka Chaudhari

7.1 Introduction: What Are Convalescent Foods?

Perhaps nowhere else in medical science other than Ayurveda is a convalescent diet (*pathya*) given so much importance in conjunction with treatment; according to Ayurveda, a treatment without *pathya* is considered to be of no significance. In a hyperbolic tone, a celebrated text of Ayurveda, *Vaidyajivana* [1], asserts that if a sick person is on a suitable diet, he may not require medicine (for he will get cured through the effects of food only), and similarly, if he is on an unsuitable diet, he may not require medicine (for in the absence of suitable food a cure is unexpected irrespective of the course of medicine). This may be a slight exaggeration in this assertion, but it reflects the notion that food-centered health care has been an essential component of treatments plans throughout the history of medicine. Hippocrates, the father of medicine, was enthusiastic about food and its potential use as medicine ("*Let food be thy medicine and medicine be thy food*").

Consideration of food as an essential component of a treatment plan continued till the advent of rapidly acting forms of curative therapeutic interventions that paid little heed to diet or other adjuncts to the main therapy. As a result of the predictable and reproducible curative effects of stronger synthetic medicines and surgery, unfortunately, the fundamental principles of health were gradually sidelined by both patients and physicians. Although a better understanding of the pathogenesis of several diseases where diet might play a role in pathogenesis or cure has partially renewed an interest in diet in biomedicine, this interest remains confined to the

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purview of a strict evidence-based approach and to a limited set of diseases where such evidence is available. Diabetes, renal diseases, hepatic diseases, gout, cardiovascular diseases, obesity, and cancer are a few clear examples of conditions where a conventionally trained dietitian may play complementary role within the whole spectrum of disease management within a biomedical framework. Because of a clear association of food at various levels of disease precipitation or management, a dietary recommendation in such conditions is scientifically justified [2]. Besides these few clinical conditions, diet has not established a solid foundation in biomedicine, and until recently a dietary recommendation in many clinical conditions remained generic from a biomedical point of view and not specific to a particular disease condition.

Contrary to biomedicine, food as a definitive disease management strategy has long been part of traditional health care. Many special foods have been linked to the traditional management protocol of certain diseases. In fact, every civilization and culture has incorporated food-related practices in connection with disease management, and Ayurveda in particular has been at the forefront of this convalescent food knowledge [3].

Convalescent foods are those foods that assist the body in healing, primarily by providing nutrients that are essential for healing in their rapidly absorbable forms. At the same time, by conserving energy that is expended in the digestion of food, convalescent food may render additional help in the healing process. Besides this, the convalescent foods recommended in a particular clinical condition may also have certain functional components to facilitate healing in a specific situation.

7.2 Types of Convalescent Foods Recommended in Ayurveda

7.2.1 Rice-Based Convalescent Foods

Rice is the principal convalescent food in Ayurveda. Ayurveda recognizes the properties of rice in terms of its age and the method of cooking employed, which make rice useful in particular conditions. The type and age of the rice, the amount of water used for cooking, the duration of cooking, and the intensity of the heat together define the final outcome of rice preparation. Besides this, additions of certain herbs or spices can also change the therapeutic spectrum of rice preparations, making them more suitable for given disease conditions.

The following foods are the main types of rice-based convalescent foods:

Manda

This is a rice preparation where the maximum amount of water is used. Sharangadhar, a principal proponent of Ayurvedic pharmaceutics, proposes that *manda* be prepared in a 1:14 ratio with water (Sh.Sa. Madhayama Khanda 2/170). For cooking in a large amount of water, the rice in *manda* completely disintegrates and results in complete disorganization of rice in the form of a starch solution. *Manda* is

Table 7.1 Eightfold components and properties of *Ashta Guna Manda*

Components	English name	Property
Dhanyaka	Coriander	Clears the bladder
Shunthi	Zingiber officinale	Eliminates Kapha
Marich	Piper nigrum	Enhances digestion
Pippali	Piper longum	Eliminates fever
Saindhava salt	Rock salt	Enhances blood
Hingu	Asafetida	Eliminates Vata
Rice	Oryza sativa	Vitalizer
Munga	Faciolus mungo	Eliminates Pitta

considered the lightest of all rice-based convalescent foods in Ayurveda. The special properties associated with *manda* are said to be a digestive fire promoter, prokinetic, softener, and diaphoretic. *Manda* is especially recommended in conditions where people are fasting or are detoxifying through panch karma procedures. *Manda* is also recommended in periods of thirst caused by the excessive intake of fatty foods (Ch. Su. 27/251–52). Starch is a natural emulsifier and thus facilitates fat digestion through its emulsification and eventual exposure to gastric lipases in the gastrointestinal (GI) tract. Vagabhatta, another proponent of Ayurvedic dietetics, recommends *manda* because of disease eliminative properties after a pancha karma or detoxification process. It is recommended that *Manda* be combined with *saindhava* (rock salt) and *shunthi* (zingiber). This combination enhances *agni* promotive property to *manda*.

Ashta guna manda is a variant of *manda* comprised of eight components and is reportedly has eight special properties (Sh. Sa. Madhayam Khanda) (Table 7.1).

There are many more variants of *manda* that are made up of cereals other than rice. They will be dealt with in subsequent sections of this chapter.

Peya

Peya refers to rice preparation where the rice is cooked in water 14 times greater than the amount of rice to be cooked. In this regard, it is similar to *manda*; however, in *peya*, the cooking is less intense so as not to disintegrate the rice completely. Therefore, *peya* represents a preparation where a starch solution is mixed with a small amount of partially disintegrated rice (*siktha*). *Peya* is said to eliminate, thirst, hunger, infirmity, diseases pertaining to the GI tract, and fever. In addition, it is diaphoretic, restores digestion, and helps regulate peristalsis (Charaka Su 27/250). In addition to these properties, Sushruta recommends *peya* for its diuretic properties (Sushruta Su 46/343-44). Sharangdhara adds that *peya* has antidiarrheal properties as well (Sharangdhara Ma.2/167).

Vilepi

Compared to *manda* and *peya*, *vilepi* is thicker with a less starchy solution and more partially disintegrated rice (Table 7.2). *Vilepi* is prepared in a 1:4 ratio of *vilepi* to water. *Vilepi* is said to have additional properties supportive of body tissue. It is also said to be satisfying and conducive to heart health. For those suffering from trauma or eye disease or debilitated through prolonged illness or through repeated biocleansing, *vilepi* is an ideal food preparation (As. Sa. 7/42).

Table 7.2 Rice-based convalescent food in Ayurveda

Name	Amount of water	Method of cooking	Physical look
Manda	14 times	Prolonged	Starchy solution
Peya	14 times	Less prolonged	Starch solution added with small amount of partially disintegrated rice (*siktha*)
Vilepi	4 times	Less prolonged	Less starch solution and more *siktha*
Yavagu	6–16 times	Less prolonged	Cooked in herbs soaked or boiled water, almost homogenous mix of starch solution and partially disintegrated rice

Yavagu

Yavagu refer to rice-based therapeutic preparations where the rice is cooked in water pretreated with herbs specific to certain disease conditions. It can also be combined with preparations like *takra* (butter milk), goat milk, or various herbal decoctions. *Yavagu* find significant application in Ayurveda in the area of food-based therapeutics. There are 28 types of *yavagu* described in Charaka in reference to various disease conditions (Table 7.3). *Yavagu* are unique in the sense that they provide essential nutrition and medicine for a particular disease condition at the same time. Similarly to *yavagu, peya* is also sometimes indicated for some specific therapeutic purposes.

Bhakta

Rice washed with water when cooked, with the excess starch removed, is called *bhakta*. It is considered *laghu* (easily digestible) and should be served fresh and warm. In contrast to this, if the rice is cooked unwashed, without removal of excess starch and if served cold, it is considered *guru*. As a variant to *bhakta*, rice may be roasted before being cooked. This *bhakta* that is made of roasted rice is suitable in treating poisoning and respiratory tract diseases.

7.2.2 Convalescent Foods Made from a Mix of Rice and Lentils

Krishara

Rice combined with an equal or half amount of *mung* lentil, when cooked with salt, zinger, asafetida, and turmeric, is called *krishara. Krishara* is said to increase *pitta* and *kapha*, is *balya* (strength provider) and eliminates *vata* (Su. Su. 46/348). In addition *krishara* is also said to have aphrodisiac and cognition enhancing properties.

Table 7.3 Main type of *yavagu/peya*, their actions, and ingredients

Type of *Yavagu/Peya* by therapeutic action	Components
Antispasmodic	Pippali (Piper longum)
	Pippali mula (Root of Piper longum)
	Chavya (Piper chava)
	Chitraka (Plumbago zeylanica)
	Shunthi (Zingiber officinale)
Antisecretory and digestive	Kaith fruit (Limonia acidissima)
	Bilva fruit (Aegle marmalos)
	Changeri (Oxalis corniculata)
	Dadim (Punica granatum)
	Buttermilk
Peya for loose stool with mucus and burning	Shalparni
	Bala (Cida cardifolia)
	Bilva (Aegle Marmelos)
	Prishna parni
	Dadim (Punica granatum)
Peya for loose stool with blood	Water mixed with goat milk
	Gandhabala (Pavonia odorata)
	Utpala (variant of lotus)
	Nagarmotha (Cyprus rotundus)
	Prishnaparni
Peya for loose stool with mucus and tenesmus	Ativisha (Aconitum heterophyllum)
	Shunthi (Zingiber officinale)
	Dadima (Punica granatum)
Peya for dysuria	Gokshura (Tribulus terestris)
	Kantakari (Solanum xanthocarpum)
	Fanita (concentrated extract of sugarcane)
Yavagu for intestinal worms	Vidanga (Embelica ribes)
	Pippali mula (Piper longum)
	Shigru (Moringa olifera)
	Maricha (Piper nigrum)
	Buttermilk
	Sajjikshara
Yavagu for excessive thirst	Munakka (resins)
	Ananta mula
	Dhan lava (roasted rice grains)
	Honey
	Nagarmotha (Cyprus rotundus)
Antidote *yavagu*	Bakuchi (Psoralia corylipholia)
Anabolic *yavagu*	Pig meat
Catabolic y*avagu*	Roasted gavedhuka
	Honey
Unctuous *yavagu*	Clarified butter
	Sesame seeds
	Saindhava salt
Roughening *yavagu*	Kush root
	Amala (Embelica officinalis)
	Saanva rice
Yavagu for cough and dyspnea	Dashamoola (ten roots)

(continued)

Table 7.3 (continued)

Type of *Yavagu/Peya* by therapeutic action	Components
Yavagu for lower abdominal pain	Yamaka (honey and salt mixed together)
	Madira
Purgative *yavagu*	Shaka
	Maamsa
	Tila (Sesame seeds)
	Maasha
Antidiarrheal *yavagu*	Jaamun seed
	Mango seed
	Bilva fruit (Aegle marmelos)
Yavagu for drastic purgation	Yavakshara
	Chitraka (Plumbago zeylanica)
	Hingu (Asafoetida)
	Amala veta
Prokinetic *yavagu*	Haritaki (Terminalia chebula)
	Pippali Mula (root of Piper longum)
	Shunthi (Zingiber officinale)
Yavagu to eliminate discomfort caused by excess *Ghrita* consumption	Buttermilk
Yavagu to eliminate discomfort caused by excess *taila* intake	Buttermilk
Yavagu for irregular fever	Sesame cakes
Yavagu for throat diseases	Cow meat
	Dadima (Punica granatum)
	Yamaka (oil and Ghrita mixed in equal proportion)
	Barley
	Pippali (Piper longum)
Yavagu to eliminate pain in male reproductive system	Amala (Embelica officinalis)
Yavagu for improved reproductive function	Chicken meat
Yavagu for alcoholism	Masha fried in *Ghrita* and cooked in milk
	Upodika shaka
Yavagu to decrease appetite	Curd
	Milk
	Apamarga seeds (Acyranthus aspera)
	Godha meat

7.2.3 Convalescent Food Made of Lentils

Besides rice there are many other cereals used in making convalescent food indicated in different clinical conditions. After rice, lentils are most commonly used staples for such purpose. *Shimbi dhanya* is the name given to dicots having two cotyledons contrary to the *shuka dhanya* which are monocots. The common examples to *shimbi* are lentils and of *shuka* are rice, maize and wheat.

Yusha

Yusha are food preparations made with lentils. They are prepared using different varieties of lentils, viz. munga, masha, masura, or moth, with either water or some other liquid medium such as an herbal decoction or buttermilk. Depending on the processing method, *yusha* can be further subdivided into *krita yusha*, where the whole preparation is finally processed with *ghrita* and spices, and *akrita yusha*, where the preparation is devoid of such processing. *Yusha* in general are said to possess the properties of an appetizer, vitalizer, and an enhancer of voice, complexion, vitality, and digestive capacity. It is diaphoretic, satisfying, and nourishing. Because it is fatty and warm, *yush* controls *vata*, because of its fatty and *kashaya* nature controls *pitta* and for warm and processed nature controls *kapha*. It is evident that *yusha* for its variety of properties can be used to treat all clinical conditions and hence is useful in all diseases.

7.3 Fundamental Uses of *Pathya Kalpana* in Ayurveda

Pathya kalpana, or the notion of convalescent food, was initiated in Ayurveda in reference to the post-pancha karma state of digestion where *agni* is said to be hypofunctioning and hence to require help to become activated again. For this reason, after any major purification process in Ayurveda, food is gradually reintroduced in order to provide sufficient time for gastrointestinal recovery and to promote digestion in a stepwise manner. A gradual introduction to *peya, vilepi, yusha, mamsa rasa*, and *anna* is therefore recommended after pancha karma procedures like *vamana* and *virechana*.

7.4 Scientific Rationale of *Pathya Kalpana*

Intricate details about various convalescent food preparations of Ayurveda propose that a small difference in the method of cooking or processing can result in huge differences in the net properties and eventual therapeutic effects of those food preparations. This comes as a natural curiosity to enquire if these claims of infusing therapeutic benefits through the method of cooking have a scientific basis? We examined Ayurvedic convalescent food preparations in the spirit of scientific enquiry in light of experimental and clinical evidence from the fields of biomedicine, Ayurveda, and allied sciences and have been able to link the threads of wisdom scattered throughout Ayurveda with that of stringent evidence from the field of science. The journey was revealing and breathtaking and showed how many Ayurvedic convalescent food practices could be applied to health care.

7.4.1 Aged Versus Fresh Rice

Ayurveda attaches considerable importance to aged over fresh rice for its prohealth attributes. Aged rice is considered *laghu*, which means it easily digested and hence suitable for all clinical conditions. Fresh rice, in contrast, is considered *guru* and, hence, delays digestion, eventually causing conditions like *prameha* or diabetes mellitus. A *laghu* or *guru* classification of food in Ayurveda is principally a working classification of food based on its composition, explaining its digestion in different proportions of time. A food composed of complex components is presumed to consume more time for digestion compared to simple foods, which are digested in less time. The former is considered *guru* and the later *laghu*, according to Ayurveda.

Different cultures have different preferences between fresh and aged rice. India prefers aged rice over fresh rice, whereas in many places in Southeast Asia fresh rice is preferred [4]. Fresh rice when cooked gives a highly sticky and soft texture comparing to the hard and nonsticky texture of aged rice. Many factors have been proposed to explain the textural differences between fresh and aged rice upon cooking. An increase in free fatty acid content during rice storage and subsequent prevention of gelatinization [5], changes in the physicochemical properties of rice starch [6], and changes in grain-structure-maintaining substances [7] have been cited as causes of the textural differences between fresh and aged rice. Starch granules of stored rice have been shown to be more resistant to swelling than those of fresh rice. An larger amount of resistant starch has been identified in aged rice compared to fresh rice, which has more rapidly digestible starch. This produces a very remarkable therapeutic benefit associated with the aging of rice – its low glycemic index compared to fresh rice, which has a high glycemic index [8]. Besides its quick digestibility, this might also be why Ayurveda considers aged rice better than fresh rice. Incidentally, *navanna* (fresh staple) is said to be a prominent causative factor in *Prameha*, an Ayurvedic corollary to diabetes mellitus. Despite the Indian preference for aged rice, a high incidence of diabetes in India compared to many other countries where fresh rice is preferred over aged rice is, however, a contradictory observation that will require scientific clarity [9]. Textural changes in aged rice have also been attributed to the oxidation of proteins in the external grain layer. Fresh rice has some albumen and globulin in its external layers that are dissolved when fresh rice is soaked in water. During aging, albumin and globulin are polymerized and their intermolecular disulfide linkage become difficult to dissolve [4].

Rice grain storage has also been found to lead to the hydrolysis or degradation of some of its starch components, causing a proportional increase in reducing sugars and a decrease in nonreducing sugars. The health impacts of such changes in rice, however, remain unknown [10].

7.4.2 Effect of Water Soaking and Boiling on Rice Grains

The preceding discussion about rice-based convalescent food proposes that the principal difference between varieties of cooked rice arises from the amount of water, how long it is cooked, and the amount of heat used for cooking.

The Ayurvedic proposition of rice-based convalescent food suggests a sequential food order beginning with food that may require a minimum of digestion before it can be absorbed. Foods higher in the order imply an increasing amount of digestion required before the food can be absorbed and until one can switch to normal food with the return of normal digestion.

A rice grain is composed of 90 % starch, 2 % lipids, 6 % protein, and approximately 1 % minerals [11]. There are two types of starch in rice, amylose and amylopectin. The proportion and structure of these two starches largely define the quality of the rice when it is cooked. Amylose is a linear form of starch and its quantity is inversely related to the stickiness of rice upon cooking.

Soaking of rice grains in water allows the water to enter into the amorphous space of rice starch. Gelatinization is the thermal disordering of the crystalline structure of starch granules and includes related events such as the swelling of the granules and leaching of the soluble polysaccharides [12] in the external medium. Rice starch granules consist of two α-D glucose polymers: nearly linear amylose and highly branched amylopectin. Within starch granules, three different regions are distinguished, i.e., alternating amorphous (low electron density) and semicrystalline growth rings (thickness 120–400 nm). The latter consist of crystalline (high electron density) and amorphous (low electron density) lamellae with a repeat distance of 9–11 nm [13]. Crystalline lamellae result from the double helix formation of amylopectin side chains, which aggregate to form crystals, whereas amorphous lamellae mainly contain amorphous amylopectin branch points [14]. When starch granules are heated in excess water above the gelatinization temperature (the temperature at which gelatinization occurs), the supramolecular order (crystalllinity) and 9–11 nm repeat are lost. Apart from this phenomenon, water absorption, and thus swelling of the granule, and amylose leaching occur during gelatinization.

The sequential events that take place during the boiling of rice are the swelling of starch granules followed by disordering of the crystalline structure, followed by further temperature-dependent swelling to reach a maximum swelling factor. Swelling is evidently a property of amylopectin, and amylose acts as diluent. Upon further swelling beyond the maximum swelling factor, polysaccharides are leached from the granules to produce a starch solution. Upon cooling, the starch solution retrogrades to form a thick gel, and this retrogradation time depends upon the relative proportion of amylose and amylopectin in the starch. An amylose-rich starch solution crystallizes early compared to the delayed crystallization of amylopectin. Upon cooling, a starch gel is formed that undergoes structural changes during staling. This so-called retrogradation process involves the crystallization of amylose (after several hours) and amylopectin (after several days or weeks) [15].

Stale rice and stale rice starch solutions are discarded in Ayurveda. It is possibly because of retrogradation property of starch, which allows soluble starch to recrystallize and renders them difficult to digest besides many other chemical changes affecting the ultimate desired sensory and biological characteristic of the rice or its solution [16]. Incidentally, stale and cooled rice is considered *guru* in Ayurveda, which again symbolizes the resynthesised complexity of starch, rendering it difficult to digest. Retrogradation limits the possibility of amylase hydrolysis to occur.

Manda preparation with water in a water-to-rice ratio of 14:1 allows the rice grains to swell up completely until they burst and allow the dissolved amylose to leach out into the outer solution. If more water is used in cooking, all the starch actually leaches out to create a starch solution. The advantage of creating such a solution is that it provides a greater surface area of starch for starch-digesting enzymes to act upon. *Peya*, the next in order to rice preparations, is a combination of a starch solution with a certain amount of partially degraded rice grains. Because of the availability of partially degraded rice grains, *peya* requires more time to digest and hence is considered *guru* compared to *manda. Vilepi*, the next preparation, is considered a *guru* of all three because it contains the largest amount of partially degraded rice, which forms a kind of sediment in the starch solution.

Another advantage of cooking rice in a high water rice ratio is that it reduces its arsenic content [17]. Although it may not directly affect the digestibility of the rice preparation, its beneficial effects upon a convalescing digestive system cannot be overlooked.

7.4.3 Food Made of a Rice and Lentil Mix

Rice and lentils constitute an ideal composition of food in terms of the advantages offered by these two foods independently. Rice is deficient in essential amino acids such as lysine, which is found in abundance in legumes. Legumes, on the other hand, are deficient in methionine, which is abundant in rice. Rice and legumes therefore complement each other, offering the best food through a combination that is not available from the two foods individually. In recognition of this fact, rice is almost universally used in conjunction with legumes throughout the world, especially in India, where several varieties of the combination are common [18]. The beneficial effects of a cereal-pulse mix supplementation are not limited to its ideal nutrient combination; it also offers glycemic and lipemic control. One study on 30 non-insulin-dependent diabetes mellitus patients indicated that supplementation of a cereal-pulse mix for 1 to 2 months had a favorable effect in controlling hyperglycemia and hyperlipidemia [19]. Ayurvedic health benefit recommendations associated with *krishara* may be viewed in light of these studies; however, more studies may be required to elucidate these benefits further.

7.4.4 Lentil Broth and Soup

Lentils contain an average of 28.6 % proteins, 4.4 % fiber, 63.1 % total carbohydrate (nitrogen-free extract), 44.3 % starch, and 4,186 kcal/kg of gross energy. Lentil starch contains 36.1 % amylose. Approximately one-half (47.1 %) of lentil proteins are soluble in salt solution and 3.8 % in water. Lentils contain 6.8 % of total nitrogen as nonprotein nitrogen. The major amino acids found in lentils are glutamic acid,

aspartic acid, arginine, leucine, and lysine; the minor amino acids are methionine, cystine, and tryptophan. Because of the lower concentrations of the latter amino acids, lentil proteins give a chemical score of 35, a protein score of 46, and an essential amino acid index (EAAI) of 63 relative to egg protein [20].

Lentil broth is a watery solution made of lentils without admixing it with other foods or thickening agents. One nutritional advantage linked with lentil broth is that it contains higher amounts of water-soluble amino acids. A high amount of leucine, phenylalanin, glycine, and proline is detectable in the watery contents of lentil broth. EAAI, which is a crude score for nutritive values of raw and cooked lentils, increases in lentils after cooking. Furthermore, the addition of salt to the cooking water increases the soluble fraction of amino acids in lentil broth [21].

It is appropriate to note here that in Ayurveda, a *yush* preparation, which resembles lentil broth, has two varieties, *akrita* and *krita. Akrita* consists of a plain water solution of lentils, whereas *krita* is the one when the same solution is treated with salt, *ghrita*, and other appetizing spices. These two preparations of lentils are introduced one by one for a specific number of meal times in accordance actual requirement. The transition from *akrita* to *krita* is a method for gradually introducing food of increasing nutritive value and complexity. A *sansarjana krama*, which is followed after major evacuative procedures like *vamana* and *virechana*, is a natural way to gradually accustom an assaulted digestive system to the normal digestive process within the span of a few days ranging between 3 and 7 days.

7.4.5 Method of Food Processing and Glycemic Index

The classification of foods based on their glycemic index has disproved the notion that carbohydrate-rich foods are deleterious to one's health, and hence their consumption should be limited [22, 23]. Numerous evidence-based studies endorse the Ayurvedic view of process-based differentiation of food effects and dismiss the negativity surrounding carbohydrate-rich foods by demonstrating that not all carbohydrates have the same physiological effects [24–26]. A variation in the physicochemical properties of complex carbohydrates has been shown to elicit dissimilar physiological effects when consumed [27]. The method of cooking is the most important factor because it can alter the structure and nature of starches, resulting in significant effects on postprandial blood glucose responses [28]. One study showed that boiling sweet potatoes elicited lower GI values compared to frying, baking, and roasting [29]. This differential glycemic response may be linked to the chemical structure of starches, that is, the amylose-amylopectin ratio [30]. Rice with higher amylose content is reportedly associated with a lowered metabolic response and lower GI values [24, 31]. Boiling induces gelatinization and makes starches more readily digestible by permanent disruption of amylose–amylopectin bonds. At the same time, retrograded amylose is indigestible due to the presence of stronger hydrogen bonding in comparison with retrograded amylopectin [32]. At the same time, larger amounts of resistant starches may be retained in boiled foods. Furthermore, as these foods cool, the possibility of

forming resistant starches (retrograded starches) increases. This occurs as the starches undergo recrystallization due to the formation of intermolecular hydrogen bonds. Other resistant starches present in foods after the leaching of free sugars during the boiling process also play a role in retarding the enzymatic degradation of starches, thereby reducing the glycemic response. It is reported that approximately 7 % of starch in reheated boiled potatoes (*Solanum tuberosum* sp.) escapes digestion in the ileum compared with approximately 3 % in freshly cooked potatoes [28]. Ayurveda similarly proposes various methods of cooking and endorses differentially processed food with different biological properties. In a similar vein, roasted barley is recommended for diabetics compared to other methods of food preparation. The idea behind this is that a lower GI is associated with roasting compared to other methods of cooking. Because roasting requires a small amount of water, it causes an incomplete gelatinization of starches, eventually leading to an incomplete conversion of resistant starches to less-resistant starches. This incomplete conversion eventually leads to a lower glycemic response to roasted foods.

7.5 Conclusions

Convalescent foods are foods that assist the body's healing process, primarily by providing essential nutrients needed for healing and at the same time by conserving energy normally expended on the digestion of food that may now be consumed in the healing process. In addition, the convalescent foods recommended in a particular clinical condition may also have certain functional components to facilitate healing in a specific situation. A roasted barley preparation for use in diabetes treatment and a buttermilk-based rice and lentil mix (*krishara*) for use in the treatment of diarrhea are examples of the latter situation. Moreover, *samsarjana krama*, which is practiced as a specified dietary protocol following the exhaustive eliminative therapies of Ayurveda, particularly *vamana* and *virechana*, constitutes recognition of the mucosal insult of the GI tract following such procedures. As a result, secretory cells in the intestinal mucosa shed more rapidly than usual, resulting in poor digestion until the cells are regenerated. Depending on the intensity of the eliminative process, the insult may be mild, moderate, or severe, and the subsequent recovery period may be short or long depending on the actual insult. This is why a 3- to 7-day *samsarjana* is usually recommended following the eliminative processes of pancha karma. The order of food introduction in *samsarjana* is again interesting. It begins with rapidly digestible starches and moves on to more complex starches, followed by a gradual introduction of water-oluble amino acids alone and processed in spiced *ghrita*. A more complex protein is introduced subsequently before the body is exposed to ormal food. Clearly, the whole exercise is a systematic attempt to cope with the posible harm caused by the eliminative process and to provide the body with an excellent pportunity to heal in an orderly manner. Convalescent food as a healing modality seems to be a unique contribution of Ayurveda and requires more rigorous investigation for incorporation into conventional health care across the globe [33].

References

1. Lolimbaraja, Vaidyajivan English translation and notes by Nirmal Saxena, Chaukhambha Publication, Varanasi 2010
2. Dahm CC, Keogh RH, Spencer EA, Greenwood DC, Key TJ, Fentiman IS, Shipley MJ, Brunner EJ, Cade JE, Burley VJ, Mishra G, Stephen AM, Kuh D, White IR, Luben R, Lentjes MA, Khaw KT, Rodwell Bingham SA (2010) Dietary fiber and colorectal cancer risk: a nested case–control study using food diaries. J Natl Cancer Inst 102(9):614–626. doi:10.1093/jnci/djq092, epub 20 Apr 2010
3. Gupta LP (1999) Biogenic secrets of food in Ayurveda. Chaukhambha Sanskrit Pratishthan, Delhi
4. Ohno T, Ohisa N (2005) Studies on textuaral and chemical changes in aged rice grains. Food Sci Technol Res 11(4):385–389
5. Yasumastu K, Moritaka S, Kakinuma T (1964) Effects of the change during storage in lipid composition of rice on its amylogram. Agric Biol Chem 28:265–272
6. Villareal RM, Resurreccion AP, Suzuki LB, Juliano BO (1976) Changes in the physicochemical properties of the rice during storage. Starke 28:88–94
7. Shibuya N, Iwasaki T (1982) Effects of enzymatic removal of endosperm cell wall on the gelatinization property of aged and unaged rice flours. Starch 34:300–303
8. Panlasigui LN, Thompson LU, Juliano BO, Perez CM, Yiu SH, Greenberg GR (1991) Rice varieties with similar amylose content differ in starch digestibility and glycemic response in humans. Am J Clin Nutr 54(5):871–877
9. Wild S, Roglic G, Green A, Sicree R, King H (2004) Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes Care 27(5):1047–1053
10. Zhou Z, Robards K, Helliwel S, Blanchard C (2002) Aging of stored rice: changes in chemical and physical attributes. J Cereal Sci 35(1):65–78
11. Cuevas RP, Fitzgerald M (2007–08) Linking starch structure to its cooking quality. IREC Farmers' Newsletter, no. 177, p 16–17
12. Atwell WA, Hood LF, Lineback DR (1988) The terminiology and methodilokgy associated with basic starch phenomena. Cereal Foods World 33:306
13. Cameron RE, Donald AM (1993) Carbohydr Res 244:225–236
14. Donald AM, Perry PA, Waigh TA (1999) Fibre Diffr Rev 8:31–37
15. Suzuki T, Chiba A, Yano T (1997) Carbohydate Polymers 34:357–363
16. Yao Y, Zhang J, Ding X Retrogradation of starch mixtures containing rice starch. Journal of Food Sciences, 68(1):260–265
17. Raab A, Baskaran C, Feldmann J, Meharg AA (2008) Cooking rice in a high water to rice ratio reduces inorganic arsenic content, First published as an Advance Article on the web 20 Nov 2008. J Environ Monit 11:41–44, doi:10.1039/b816906cw.rsc.org/jem
18. http://culinarydesignsolutions.wordpress.com/2010/02/07/amino-acids-its-all-about-rice-and-legumes/
19. Mani UV, Iyer U, Mani I, Desikachar HSR (1997) Long-term effect of cereal-pulse mix (diabetic mix) supplementation on serum lipid profile in non-insulin-dependent diabetes mellitus patients. J Nutr Environ Med 7(3):163–168
20. Bhatty RS, Slinkard AE, Sosulski FW (1976) Chemical composition and protein characterstics of lentils. Can J Plant Sci 56(4):787–794. doi:10.4141/cjps76-128
21. Pirman T, Stiblij V, Stekar JMA, Combe E (2001) Amino acid composition of beans and lentil. Zb Bioteh Fak Univ Ljubl, Kmet Zooteh 78(1):57–68
22. Liu S, Willett WC (2002) Dietary glycemic load and atherothrombotic risk. Curr Atheroscler Rep 4(6):454–461
23. Willett W, Manson J, Liu S (2002) Glycemic index, glycemic load, and risk of type 2 diabetes. Am J Clin Nutr 76(1):274S–280S
24. Miller JB, Pang E, Bramall L (1992) Rice: a high or low glycemic index food? Am J Clin Nutr 56(6):1034–1036

25. Bahado-Singh PS, Wheatley AO, Ahmad MH, Morrison EY, Asemota HN (2006) Food processing methods influence the glycaemic indices of some commonly eaten West Indian carbohydrate-rich foods. Br J Nutr 96(3):476–481
26. Jenkins DJA, Kendall CWC, McKeown-Eyssen G et al (2008) Effect of a low-glycemic index or a high-cereal fiber diet on type 2 diabetes: a randomized trial. JAMA 300(23):2742–2753
27. Riley CK, Bahado-Singh PS, Wheatley AO, Ahmad MH, Asemota HN (2008) Relationship between the physicochemical properties of starches and the glycemic indices of some Jamaican yams (Dioscorea spp.). Mol Nutr Food Res 52(11):1372–1376
28. Englyst HN, Cummings JH (1987) Digestion of polysaccharides of potato in the small intestine of man. Am J Clin Nutr 45(2):423–431
29. Bahado-Singh PS, Riley CK, Wheatley AO, Lowe HIC (2011) Relationship between processing method and the glycemic indices of ten sweet potato (Ipomoea batatas) cultivars commonly consumed in Jamaica. J Nutr Metab. Article ID 584832
30. Bjorck I, Granfeldt Y, Liljeberg H, Tovar J, Asp NG (1994) Food properties affecting the digestion and absorption of carbohydrates. Am J Clin Nutr 59(3):699S–705S
31. Goddard MS, Young G, Marcus R (1984) The effect of amylose content on insulin and glucose responses to ingested rice. Am J Clin Nutr 39(3):388–392
32. Englyst H, Wiggins HS, Cummings JH (1982) Determination of the non-starch polysaccharides in plant foods by gas–liquid chromatography of constituent sugars as alditol acetates. Analyst 107(1272):307–318
33. Rastogi S (2012) Transforming Ayurveda: stepping into the realm of evidence – based practice. In: Rastogi S, Chiappelli F, Ramchandani MH, Singh RH (eds) Evidence based practice in complementary and alternative medicine: perspectives, protocols, problems and potentials in Ayurveda. Springer, Berlin/London, pp 33–50

Chapter 8
Food-Based Interventions for Cancer Management: An Ayurvedic Perspective

Sanjoy Kumar Pal

8.1 Introduction

Cancer remains a major cause of mortality and morbidity worldwide [1]. There are over 200 different known cancers that afflict humans. The global burden of cancer continues to increase largely because of the aging and growth of the world population alongside an increasing adoption of cancer-causing behaviors. Although overall cancer incidence rates in the developing world are half those seen in the developed world in both sexes, overall cancer mortality rates are generally similar. Cancer survival tends to be poorer in developing countries, most likely because of a combination of a late stage at diagnosis and limited access to timely and standard treatment [2]. Commonly used cancer treatments, including chemotherapy and radiation therapy, often have side effects, and a complete cure is sometimes impossible. Therefore, prevention, suppression, or delaying the onset of the disease is important [3]. The majority of cancers are due to modifiable lifestyle and environmental risk factors and are potentially preventable [4, 5]. Experimental evidence indicates a strong connection between oxidative damage, cancer, and aging. Epidemiological observations suggest that a diet rich in fruits and vegetables is associated with lower incidence of some cancers and longer life expectancy; since fruits and vegetables contain natural antioxidants, considerable effort has been dedicated to understanding their effects in experimental studies and in human trials [6]. There is increased appreciation by the scientific community that dietary phytochemicals can be potential weapons in the fight against cancer. Emerging research has provided new insights into the molecular and cellular framework needed to establish novel mechanism-based strategies for cancer prevention by selective bioactive food

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components [7]. In the future, diet will play an important role in the management of cancer as it will be the major intake source of important functional components [8].

In recent decades, research on various complementary and alternative medicine (CAM) practices that deal with cancer management have received tremendous attention. Ayurveda, a traditional Indian system of medicine, has been successful since ancient times at using many natural drugs in preventing or suppressing a variety of tumors using various lines of treatment [9, 10]. Ayurveda is almost 5,000 years old and deals not only with the body but with the mind and spirit as well. It is designed to promote good health and longevity rather than to fight disease [29]. According to Ayurveda, most diseases connected with psychophysiologic and pathologic changes in the body are caused by imbalances in three different *doshas* (i.e., *Vata*, *Pitta*, and *Kapha*). The fundamental aim of Ayurvedic therapy is to restore the balance between these three major body systems [11–13]. Ayurvedic texts emphasize proper diet (*ahara*) as being vital for promoting health and well-being. The Ayurvedic system of medicine also prescribes more than 700 plant-based medicines that contain spices and food additives to encourage good health [14]. Although this traditional medicine has been around for thousands of years, the scientific community has started to pay serious attention to it only recently. Following Ayurvedic principles a new paradigm for food-based cancer prevention and management can be developed to reduce the burden of this malignant disease.

8.2 Conventional View of Cancer

Cancers are primarily an environmental disease, with 90–95 % of cases attributable to environmental factors and 5–10 % to genetics, i.e., they are inherited genetically [15]. Many things are known to increase the risk of cancer, including tobacco use, certain infections, radiation, lack of physical activity, obesity, and environmental pollutants [5]. Cancer is a highly complex disease whose development may take as many as 20–30 years before it can be detected (Garodia et al. [29]). In general, a given cancer cannot also be blamed entirely on a single event or a single cause. As a rule, the genesis of a cancer requires several independent, rare genetic accidents to occur together in one cell with cumulative effects. The development of cancer generally involves many steps, each governed by multiple factors. There are many intrinsic factors, like oncogenes, tumor suppressor genes, DNA repair genes, angiogenesis, stem cells, and hormones, and extrinsic factors, like infection, contact with (touching, eating, drinking, or breathing) harmful substances, radiation (both ionizing and nonionizing), and environmental pollutants; and, most importantly, diet and lifestyle play a key role in the development of cancer.

Many types of genes are involved in the development of cancer. The first group of genes implicated in the development of cancer are damaged genes, so-called oncogenes. Oncogenes are genes whose presence in certain forms or overactivity can stimulate the development of cancer. When oncogenes arise in normal cells, they can cause the cells to become malignant or cancerous [16]. Oncogenes

contribute to the development of cancer by instructing cells to make proteins that stimulate excessive cell growth and division. A second group of genes implicated in cancer are the tumor suppressor genes. Tumor suppressor genes are normal genes whose absence can lead to cancer. In other words, if a pair of tumor suppressor genes is either lost from a cell or inactivated by mutation, its functional absence can cause cancer [17]. One particular tumor suppressor gene codes for a protein called p53, which can trigger cell suicide (apoptosis). In cells that have undergone DNA damage, the p53 protein acts like a brake pedal and halts cell growth and division. If the damage cannot be repaired, the p53 protein eventually initiates cell suicide, thereby preventing the genetically damaged cell from growing out of control. A third class of genes implicated in cancer are called DNA repair genes. DNA repair genes code for proteins whose normal function is to correct errors that arise when cells duplicate their DNA prior to cell division [18]. Mutations in DNA repair genes can lead to a failure in DNA repair, which in turn allows subsequent mutations in tumor suppressor genes and proto-oncogenes to accumulate.

Angiogenesis is a physiological process through which new blood vessels form from preexisting vessels. This is distinct from vasculogenesis, in which new blood vessel formation of endothelial cells takes place from mesoderm cell precursors [19]. The first vessels in the embryo form through vasculogenesis, after which angiogenesis is responsible for most, if not all, blood vessel growth during development and in disease. Angiogenesis is a normal and vital process in growth and development, as well as in wound healing and in granulation tissue [20]. However, it is also a fundamental step in the transition of tumors from a dormant state to a malignant one. It may be possible at a particular given time our body may contain many malignant micro tumors. However, these tumors cannot grow and become life threatening in the absence of blood supply. However, some tumors can mimic signals for making new blood vessels around them, and as they start securing a reliable food supply, they gradually increase in size and shed cells that can metastasize into other organs.

Stem cells are primal cells common to all multicellular organisms that retain the ability to renew themselves through cell division and can differentiate into a wide range of specialized cell types [21]. Cancer stem cells (CSCs) are cancer cells (found within tumors or hematological cancers) that possess characteristics associated with normal stem cells, specifically the ability to give rise to all cell types found in a particular cancer sample. CSCs are therefore tumorigenic (tumor-forming), perhaps in contrast to other nontumorigenic cancer cells. CSCs may generate tumors through the stem cell processes of self-renewal and differentiation into multiple cell types. Such cells are proposed to persist in tumors as a distinct population and cause relapse and metastasis by giving rise to new tumors [22].

Some hormones play an important role in the development of cancer by promoting cell proliferation. Hormones are important agents in sex-related cancers such as cancer of the breast, endometrium, prostate, ovary, and testis and of thyroid cancer and bone cancer [23].

Substances that cause DNA mutations are known as mutagens, and mutagens that cause cancers are known as carcinogens. Decades of research has led to the identification of many carcinogens [24]. A strong association has been found

between tobacco use and cancer of the lung, larynx, head, neck, stomach, bladder, kidney, esophagus, and pancreas. Tobacco smoking is associated with many forms of cancer, and causes 90 % of lung cancer [25]. Tobacco smoke contains over 50 known carcinogens, including nitrosamines and polycyclic aromatic hydrocarbons. Tobacco is responsible for approximately one in three of all cancer deaths in the developed world, and approximately one in five worldwide. Up to 10 % of invasive cancers are related to radiation exposure, including both ionizing radiation and non-ionizing radiation [5]. Additionally, the vast majority of noninvasive cancers are nonmelanoma skin cancers caused by nonionizing ultraviolet radiation.

8.3 Cancer from an Ayurvedic Perspective

In contrast to the critical analytical approach of modern Western medicine, Ayurveda adopts a holistic approach and propounds a broad-based understanding of the entities of life, health, and disease [26]. Ayurvedic literature defines three body-control systems, viz., the nervous system (*Vata* or air), the venous system (*Pitta* or fire), and the arterial system (*Kapha* or water), which mutually coordinate to perform the normal functions of the body [9]. Any imbalance in these body-control systems can result in a disease state. The fundamental aim of Ayurvedic therapy is to restore the balance between these three major body systems. The therapeutic approach of Ayurveda has been divided into four categories: *Prakritisthapani chikitsa* (health maintenance), *Roganashani chikitsa* (disease cure), *Rasayana chikitsa* (restoration of normal function), and *Naishthiki chikitsa* (spiritual approach) [27]. Finding the cause of an illness is the basic goal of Ayurvedic therapy. It classifies disease development into six stages, including aggravation, accumulation, overflow, relocation, buildup in a new location, and manifestation into a recognizable disease. Ayurvedic physicians can diagnose an illness even at the initial stages of body imbalance, and their therapeutic approach maintains a balance by supplying deficient substances and reducing excessive ones [9].

Ayurveda describes the different stages of tumorigenesis as chronic inflammatory and intractable diseases with the possibility of developing malignancy. Two well-known Ayurvedic classics, *Charaka* samhita [13] and *Sushruta* samhita [12], describe cancer as inflammatory or noninflammatory swelling and mention them as either *granthi* (minor neoplasm) or *arbuda* (major neoplasm).

According to Ayurveda, cancer results from lifestyle errors, such as unhealthy foods, poor hygiene, or poor behavior, or from physical trauma, all leading to imbalances of *Vata*, *Pitta*, and *Kapha*, resulting in injury to the inner layer of the dermis *Rohini* (the sixth layer of the skin) and the formation of abnormal branches of blood vessels [28]. In this stage, early *granthi* or a*rbuda* can develop in the form of bubble-shaped glandular growths; however, both are external and visible growths only. *Granthi* has been described as a round, hard, and bulging swelling produced owing to the aggravation of *Vata* and *Kapha*, vitiating the muscle, blood, and fatty tissues. *Arbuda* has been described as a round, large, muscular, immovable, deeply rooted,

slowly growing swelling produced owing to the aggravation of doshas, vitiating the muscle, blood, and fatty tissues. Both types of swelling can be inflammatory or non-inflammatory, depending on the doshas involved. In benign neoplasm (*Vataja*, *Pittaja*, or *Kaphaja*) one or two of the three bodily systems are out of control which is not too harmful because the body is still trying to coordinate among these systems. Malignant tumors (*Tridosaja*) are very harmful because all three major bodily systems lose mutual coordination and thus cannot prevent tissue damage, resulting in a deadly morbid condition [9]. Internal tumors are represented in the context of different diseases having various symptoms caused by such tumors. In every disease description, the *trodoshaja* presentation gives an opportunity for tumorigenesis to set in. Intra-abdominal tumors may be identified under the head of *Gulma* (abdominal swellings). It is important to state that the Ayurvedic nomenclature of a disease is based only on the similarity of the manifestations and not as per the specific pathophysiology involved therein. The different pathophysiologies leading to the same presentation is dealt with under the subdivisions of the disease where imbalances of various bodily systems like *Vata, Pitta*, or *Kapha* are attributed to the cause of the disease.

Cancer pathogenesis in Ayurveda is explained on the basis of *Tridoshas. Agni* or *Pitta*, which is present in all cells, is responsible for digestion and metabolism in the human body. A decrease in *agni* is inversely proportional to the related tissue, and therefore, in *arbuda*, a decreased state of *dhatwagni* (deranged metabolism) will result in excessive tissue growth. *Vata* can be correlated with the catabolic phase of growth and *kapha* to the anabolic phase. Cancer originates due to a metabolic crisis, i.e., aggravation of *Vata* forces and suppression of *kapha* forces, both interacting with one another, resulting in proliferation of the cancer. However, abnormal cancerous growth in a specific organ (*Eka-desa-vriddhi*) is managed through compensation from other parts of the body (*Anya-sthaniya-kshaya*), e.g., body weight loss (cachexia). Various signs and symptoms, viz., anemia, cachexia, or anorexia, arising due to the progression of the cancer have also been described in detail in the classic Ayurvedic literature [29].

The factors responsible for the vitiation of *doshas* are as follows [9]:

(a) *Vata-aggravating factors*: excessive intake of bitter, pungent, astringent, dry foods and stressful conditions.
(b) *Pitta-aggravating factors*: excessive intake of sour, salty, fried foods and excessive anger.
(c) *Kapha-aggravating factors*: excessive intake of sweet, oily food and a sedentary lifestyle.
(d) *Rakta-aggravating factors*: excessive intake of acid- or alkaline-containing foods, for example, fried or roasted foods, alcoholic beverages, and sour fruits. Excessive anger or severe emotional upset, sunbathing, or working under a scorching sun or near fire and hot conditions are some other causes.
(e) *Mamsa-aggravating factors*: excessive use of exudative foods like meat, fish, yoghurt, milk, and cream. Behaviors leading to exudation, like sleeping during the day and overeating, are some of the causes of pathogen invasions of fatty tissues.
(f) *Medo-aggravating factors*: excessive intake of oily foods, sweets, and alcohol and a lazy attitude.

8.4 Diet and Cancer Prevention

The relationship between diet and health has been recognized throughout recorded history. Dietary habits are one of the major contributory factors for the genesis of cancer. Diet, physical inactivity, and obesity are related to approximately 30–35 % of cancer deaths [30]. Physical inactivity is believed to contribute to cancer risk not only through its effect on body weight but also through negative effects on the immune and endocrine systems. Diets that are low in vegetables, fruits, and whole grains and high in processed or red meats are linked with a number of cancers. A high salt diet is linked to gastric cancer, aflatoxin B_1, a frequent food contaminant, with liver cancer, and betel nut chewing with oral cancer [31].

Surveys conducted in the USA have shown that cancer incidence is above 300 cases per 100,000, whereas in Asian countries it is less than 100 cases per 100,000 (Garodia et al. [29]). Also, although the incidence of cancer of the prostate, lung, breast, and colon is highest in Western countries, it is lowest in Eastern countries [32–34]. The reason for this high incidence of cancer in the USA is unclear; however, lifestyle has been thought to be one of the major contributors to the incidence of cancer. The higher incidence of cancer among immigrants from the East to the West further emphasizes the role of lifestyle [35, 36]. Additionally, diet is considered an important aspect of lifestyle related to cancer development [37]. While many dietary recommendations have been proposed to reduce the risk of cancer, few have significant supporting scientific evidence [38]. The primary dietary factors that increase the risk of cancer are obesity and alcohol consumption, with a diet low in fruits and vegetables and high in red meat being implicated but not confirmed [39]. Consumption of coffee is associated with a reduced risk of liver cancer [40]. Studies have linked the consumption of red or processed meat to an increased risk of breast cancer, colon cancer, and pancreatic cancer, a phenomenon that could be due to the presence of carcinogens in foods cooked at high temperatures [41, 42]. Thus, dietary recommendations for cancer prevention typically include mainly vegetables, fruit, whole grains, and fish and a reduced intake of red meat, animal fat, and refined sugar [38].

Disease prevention through the healthy preparation of foods and eating habits has been discussed in religious and civil writings for thousands of years [14]. Since the nineteenth century, Western scientific methodologies have been applied to the study of diet and disease with the intent of reducing the disease burden from noncommunicable diseases such as cancer, coronary heart disease, and other conditions endemic to societies after the advent of industrialization. Diet in India developed over thousands of years and is based on a mix of religious and secular beliefs. A large percentage of Indians, particularly Hindus, practice vegetarianism and avoid meat and fish products in their diet. Vegetarian diets have been associated with decreased risk of prostate cancer [43]. An impressive body of data exists in support of the concept that Indian food ingredients can be used in preventive strategies aimed at reducing the incidence and mortality of different types of cancers because of their antioxidative, antimutagenic, and anticarcinogenic properties [44]. Case–control studies comparing nonvegetarian and vegetarian diets and alcohol and tobacco use in India have reported that vegetarians have a reduced risk of oral,

esophageal, and breast cancers [14]. Vegetarian diets rely on pulses (e.g., beans, chickpeas, and lentils) as a source of protein, and pulses have been significantly associated with reductions in cancer [45].

Our knowledge of the transformation of a normal cell into a cancer cell has greatly expanded over the past decade. The simplistic, stepwise concept of initiation, promotion, and progression has matured to a better understanding of the serial genotypic changes that ultimately lead to cancer [46]. Chemoprevention inhibits the development of invasive cancer either by blocking the DNA damage that initiates carcinogenesis or by arresting or reversing the progression of premalignant cells in which such damage has already occurred [47]. Many of the chemopreventive agents are antioxidants and might suppress carcinogenesis through (1) inhibiting Phase I enzymes, (2) inducing Phase II enzymes, (3) scavenging DNA reactive agents, (4) suppressing type-2 cell proliferation induced by carcinogens, or (5) inhibiting certain properties of neoplastic cells [48]. The Phase I detoxification system, composed mainly of the cytochrome P450 supergene family of enzymes, is generally the first enzymatic defense against foreign compounds. Most pharmaceuticals are metabolized through Phase I biotransformation. Phase II conjugation reactions generally follow Phase I activation, resulting in a xenobiotic that has been transformed into a water-soluble compound that can be excreted through urine or bile. Several types of conjugation reactions are present in the body, including glucuronidation, sulfation, and glutathione and amino acid conjugation. These reactions require cofactors that must be replenished through dietary sources. The human diet contains a variety of compounds that exhibit chemoprevention effects toward an array of xenobiotics [49]. Epidemiology studies have suggested that some dietary constituents may act as naturally occurring cancer prevention agents and may explain some of the differences in cancer incidence seen in populations with varying dietary intakes [50, 51].

Oxidative stress is one of the main ways in which DNA is damaged from either an exogenous or an endogenous source (e.g., inflammation). Antioxidant micronutrients have been reported to oppose this effect [52]. Thus, food interacts in different ways with the initiation phase, and the protective effect of food is likely to be more important than food's contribution as a mutagen. The promotion step is the clonal proliferation of mutated cells that occurs as a result of genetic alteration and epigenetic modulations and thus achieves tumor growth. Reactive oxygen species (ROSs) are necessary to intracell signaling for the synthesis of growth factor and antioxidants that may interfere in this pathway. Little is known about the effect of food at the invasion step. Food can interfere with genetic and epigenetic alterations in this phase; for example, some experimental work suggests that dietary phenolic compounds can modify angiogenesis [53].

Chemoprevention by natural products has been obtained in several hundred animal studies [52]. Chemopreventive agents can be grouped into three broad categories [54]. The first category is blocking agents. These compounds prevent carcinogenic agents from reaching or reacting with a critical target site; thus, they act by exerting a barrier function. The second category is composed of compounds that decrease the vulnerability of target tissue to carcinogenic stimuli. The third category is suppressing agents. These compounds prevent the evolution of neoplastic processes in tissue that otherwise would become malignant.

8.5 Preventing Cancer by Dietary Modulation: Ayurvedic Viewpoint

Ayurveda promotes health by enlivening the body's inner intelligence to create harmony [55]. Unlike modern nutritional theories, which tend to recommend "one size fits all" guidelines that change with each new wave of research, Ayurvedic physicians maintain there is no one single diet or food that is healthy for all individuals. Ayurveda identifies six major tastes we need in our diet every day – sweet, sour, salty, pungent, bitter, and astringent. Each of these tastes has specific health-giving effects. By including all six, one can be most completely nourished. When we consistently eat only a few of the tastes, it not only causes health problems but also triggers cravings for unhealthy foods. For instance, fast food contains mostly sweet, sour, and salty tastes. If we eat a steady diet of fast food, we can develop a craving for sweets. Adding more pungent, bitter, and astringent tastes can help tame an out-of-control desire for fast foods.

Ayurvedic texts compare the process of digestion to cooking over a flame. Digestive "fires," collectively called *agni*, "cook" food so that nutrients can be optimally utilized. When *agni* is strong, our body fully assimilates nutrients and eliminates what it doesn't need. Ultimately a fully functioning digestive system uses the food we eat to produce a biochemical called *ojas*, a fluid substance that nourishes the body and maintains the balance of all bodily systems. If the digestive fire is weak, the incompletely digested portion of the meal forms a sticky, toxic substance called *ama*. The opposite of *ojas*, *ama* blocks the flow of the body's inner intelligence. It settles in areas of the body that are out of balance, taking on many forms, such as calcium deposits in the joints, plaque in the arteries, and cysts and tumors. A coated tongue, bad breath, dullness of the senses, depression, and unclear thinking can indicate the presence of *ama*. To prevent *ama* from forming, plenty of warm water should be taken and eating late at night should be avoided. Eating freshly prepared meals and cooking with seasonal, organic fruits and vegetables are essential. Strengthen *agni* by "kindling" it with heating foods and spices, such as ginger and black pepper. Every food has its own taste (*rasa*), a heating or cooling energy (*virya*), and a postdigestive effect (*vipaka*). Some also possess *prabhava*, an unexplained effect. So while it is true that an individual's *agni* largely determines how well or poorly food is digested, food combinations are also of great importance. Poor combinations can produce indigestion, fermentation, putrefaction, and gas formation and, if prolonged, can lead to toxemia and disease [56].

Ayurveda recommends strict dietary principles for maintaining healthy life. For example, *Satvika ahara* (fresh food composed of milk, fruits, and vegetables consumed in a congenial environment), as recommended in *Gita*, is considered wholesome compared to *rajas* food (spicy, hot, fast food, acidic food) and *tamas* food and habits (stale food, alcohol, smoking, nonvegetarian food). We can deduce that *rajas* and *tamas* foods may have a greater affinity for developing malignancy compared to *satvika* foods.

8.6 Preventing Cancer with Vegetables, Fruits, Spices, and Herbs: The Contemporary Viewpoint

An interesting finding that has been observed repeatedly is that individuals who consume relatively large amounts of vegetables, fruits, grains, and herbs are at a decreased risk of cancer of many organs [52, 57]. An investigation by Block et al. [58] of 24 epidemiological studies showed that the consumption of a relatively large amount of vegetables and fruits was associated with a decreased incidence of lung cancer. Recent data from 11 cohort and case–control studies showed an inverse relationship between fruit and vegetable consumption and lung cancer [59]. Multiple mechanisms are undoubtedly involved in the protective effect of diets rich in fruits and vegetables [60–62]. However, it is difficult to identify the relative contribution of various components of a plant-based food to overall cancer risk reduction. The issue is further complicated by the recent demonstration of synergism among protectors [63, 64]. Attention has been focused on intercellular signaling as a common molecular target for various chemopreventive phytochemicals [65].

Natural products encompass three main categories of compounds, phenylpropanoids, isoprenoids, and alkaloids, which are widely distributed in plant foods and medicinal herbs. This large array of molecules is crucial to human nutrition and health. Plant-derived foodstuffs and beverages also constitute the so-called functional foods and beverages, which include mainly fruits, vegetables, herbs, and spices [66]. Several plant constituents, including polyphenols, appear to be potent antimutagens and antioxidants [67]. Flavonoids and procyanidins are two major classes of polyphenolic phytochemicals demonstrating a wide range of biochemical and pharmacological effects. The flavonoids, such as apigenin and quercetin, have been shown to inhibit melanoma growth and metastatic potential. When tested for the ability to inhibit lung colonization, these polyphenols decrease the number of B16-BL6 colonies in lung in a dose-dependent manner [68]. Dragsted et al. [69] found that polyphenols in fruits, vegetables, herbs, and spices inhibit tumor formation in experimental animals exposed to carcinogens. The role of dietary plant polyphenol has been emphasized in relation to health maintenance. The various polyphenols have been shown to possess antiatherogenic and anticarcinogenic properties, inhibiting the oxidative destruction of various oxylabel biological structures, inhibiting the processes of bioactivation of carcinogens, blocking LDL oxidation, and stimulating the activity of antioxidant and detoxification enzymes [70].

8.6.1 Vegetables and Cancer Prevention

The consumption of cruciferous vegetables such as cabbage, broccoli, Brussels sprouts, and cauliflower has been shown to have cancer-chemoprevention effects in human and experimental animals [52, 71]. A striking and characteristic chemical property of cruciferous plants is their high content of glucosinolates, which often approaches 1 % or more of their dry weight. Glucosinolates and their isothiocyanate

hydrolysis products are well-known protectors against carcinogenesis [72]. Indole-3-carbinol, found in these cruciferous vegetables, has been shown to have a cancer-chemopreventive effect on liver, skin, colon, and mammary tissue when given before or concurrently with exposure to a carcinogen [71]. The topical application of indole-3-carbinol resulted in a significant protection in 7,12-Dimethylbenz(α) anthracene-initiated and 12-O-tetradecanoylphorbol-13-acetate-promoted mouse skin carcinogenesis [73]. Lycopene, a natural antioxidant found predominantly in tomato, is also reported as a cancer-prevention agent. Serum and dietary lycopene levels have been found to be inversely related to the incidence of cancer. Although the antioxidant properties of lycopene are thought to be primarily responsible for its apparent beneficial affects, other mechanisms may also be involved [74]. Alternative approaches focusing on the development of tomato-based food products for human clinical trials targeting cancer prevention and as an adjunct to therapy have been planned [75]. The consumption of *Phaseolus vulgaris* bean species, such as pinto, black, navy, or kidney, may be beneficial in the prevention and treatment of many chronic diseases including cancer [76].

Soy foods are the major source of isoflavones, which are believed to play important roles in the genesis of breast cancer and its progression. A prospective study conducted in China indicated that soy food intake is associated with longer survival and low recurrence among breast cancer patients [77]. Meta-analyses of epidemiological studies of soy consumption and breast cancer risk have demonstrated modest protective effects. Moreover, concern has been expressed that the estrogenic activity of isoflavones may have adverse effects on breast cancer recurrence. Recent studies on the mechanisms of action of soy in breast cancer provide insights into the epigenetic effects and the interaction of isoflavones with IGF-1 and with a number of polymorphisms of genes associated with breast cancer risk such as MDM2 and CYP1B1. In particular, women who are at increased risk of breast cancer due to gene polymorphisms may benefit from high soy isoflavone intake. Consumption of soy food has also been found to be associated with lower lung cancer risk [78, 79].

From time immemorial, mushrooms have been valued by human beings as a culinary wonder and folk medicine in the East [80]. Mushrooms are considered a natural medicine that is widely used and recommended by Asian physicians and naturopaths for its supporting effects on the immune system. Laboratory research and a handful of preclinical trials have suggested that the nonedible Reishi mushroom (*Ganoderma lucidum*) carries promising anticancer and immunomodulatory properties [81]. Many other commonly consumed edible mushrooms, such as button mushrooms (*Agaricus bisporus*), oyster mushrooms (*Pleurotus ostreatus*), shiitake mushrooms (*Lentinus edodes*), and maitake mushrooms (*Grifola frondosa*) might also play a role in cancer prevention [161].

8.6.2 Fruits and Cancer Prevention

Emblica officinalis Gaertn. or *Phyllanthus emblica* Linn, commonly known as Indian gooseberry or amla, is arguably the most important medicinal plant in

Ayurveda. Various parts of the plant are used to treat a range of diseases, but the most important is the fruit. Experimental studies have shown that amla and some of its phytochemicals, such as gallic acid, ellagic acid, pyrogallol, some norsesquiterpenoids, corilagin, geraniin, elaeocarpusin, and prodelphinidins B1 and B2, also possess antineoplastic effects [82]. Amla is an important component of an Ayurvedic preparation called Triphala, which is made by combining three fruits – *Emblica officinalis* Gaertn, *Terminalia chebula* Retz., and *Terminalia belerica* Retz. It is widely used as a colon cleanser, digestive, diuretic, and laxative. Experimental studies have shown that Triphala possesses antineoplastic, radioprotective, and chemoprotective properties [83, 84]. Triphala has tumor-specific cytotoxicity and does not harm normal cells [85]. A recent study showed that Triphala could induce angiogenesis by suppressing vascular endothelial growth factor receptor-2 phosphorylation and, hence, have tumor-specific activity [86].

Citrus fruits are essential foods in cancer prevention: for their capacity to act directly on cancerous cells as well as their potential for enhancing the anticancer effects of other phytochemical compounds present in diet [87, 88]. A growing body of evidence from human clinical trials has demonstrated that the consumption of grapes, wine, and grape juice exerts many health-promoting and possibly anticancer effects [89]. The resveratrol present in red wine possesses powerful anticancer properties, which may be responsible for the beneficial effects of wine on the prevention of certain cancers. Grape juice and cranberry juice contain resveratrol, but at levels ten times less than red wine. Grape seed polyphenols or procyanides are shown to have anticarcinogenic or antitumor promoting agents [90]. Several lines of evidence suggest that apples and apple products possess a wide range of biological activities that may contribute to beneficial effects on one's health against cardiovascular disease, asthma, and pulmonary dysfunction, diabetes, obesity, and cancer [91]. Apple products have been shown to prevent skin, mammary, and colon carcinogenesis in animal models. Epidemiological observations indicate that regular consumption of one or more apples a day may reduce the risk of lung and colon cancer [92].

The anticancer activity of many other fruits, such as black plum (*Eugenia jambolana* L.) [93], jackfruit (*Artocarpus heterophyllus*) [94], mango (*Mangifera indica* L.) [95], plum (*Prunus domestica*) [96], pineapple (*Ananas comosus*) [97], prickly custard apple (*Annona muricata*) [98], papaya (*Carica papaya*) [99], pomegranate (*Punica granatum*) [100], strawberry [101], watermelon (*Citrullus lanatus* T.) [102], guava (*Psidium guajava* L.) [103], and banana [104], was also verified in in vitro experimental studies.

8.6.3 Spices and Cancer Prevention

Hippocrates is frequently quoted as having said, "Let food be thy medicine and medicine be thy food." Epidemiological, preclinical, and clinical studies continue to provide fundamental insights into the dynamic relationships between nutrients – defined here as any substance in the diet that brings about a physiological effect – and health.

Today, claims about the ability of foods, including spices, to lower disease risk or to enhance the quality of life continue to captivate our attention [105]. Out of the thousands of chemical structures that have been identified in plant foods, many are found in spices. Typically, spices are the dried aromatic parts of plants – generally the seeds, berries, roots, pods, and sometimes leaves – that mainly, but not invariably, grow in hot countries [106]. Spices comprise an important component of our daily diets [107]. Indian spices have been known around the world since ancient times. Spices add aroma and taste to food and possess certain medicinal properties as well. Many spices, like turmeric, red chili, coriander, cumin, and mint, have been shown to cure diseases ranging from the common cold and cough to cancerous tumors [108]. Some spices are rich sources of flavonoids, which can block carcinogenesis. For instance, the potential of turmeric (curcumin), red chilli (capsaicin), cloves (eugenol), ginger (zerumbone), garlic (diallyl sulfide), fennel (anethole), kokum (gambogic acid), fenugreek (diosgenin), and black cumin (thymoquinone) in cancer prevention has been established [109].

When it comes to dealing with cancer, turmeric (Haridra) can be considered the king of spices. Turmeric contains the powerful polyphenol curcumin, or diferuloylmethan, which has been clinically proven to retard the growth of cancer cells causing prostrate cancer, melanoma, breast cancer, brain tumor, pancreatic cancer, and leukemia, among a host of others [110]. Various preclinical cell culture and animal studies suggest that curcumin has potential as an antiproliferative, anti-invasive, and antiangiogenic agent, as a mediator of chemoresistance and radioresistance, and as a chemopreventive agent [111, 112]. Curcumin promotes apoptosis, which safely eliminates cancer breeding cells without posing a threat to the development of other healthy cells. The various cell-signaling pathways inhibited by curcumin include NFκB, AP-1, STAT3, Akt, Bcl-2, Bcl-X(L), caspases, PARP, IKK, EGFR, HER2, JNK, MAPK, COX2, and 5-LOX [113]. Moreover, curcumin was reported to act in synergism with several natural compounds or synthetic agents commonly used in chemotherapy [114]. The results of a small number of clinical pilot studies conducted with curcumin at doses of up to 12 g suggest tentatively that it is safe in humans [115].

The rhizomes of *Zingiber officinale* Roscoe (Zingiberaceae), commonly known as ginger, is one of the most widely used spices and condiments. It is also an integral part of many traditional medicines and has been extensively used since ancient times in Ayurvedic, Chinese, Unani-Tibb, Srilankan, Arabic, and African traditional medicines for many unrelated human ailments [116]. Ginger is an excellent source of several bioactive phenolics, including nonvolatile pungent compounds such as gingerols, paradols, shogaols, and gingerones [117]. A number of preclinical investigations with a wide variety of assay systems and carcinogens have shown that ginger and its compounds possess chemopreventive and antineoplastic effects [118–120]. A number of mechanisms have been observed to be involved in the chemopreventive effects of ginger. The cancer-preventive activities of ginger are supposedly due mainly to free radical scavenging, antioxidant pathways, alterations of gene expression, and induction of apoptosis, all of which contribute to decreases in tumor initiation, promotion, and progression [116].

The medicinal properties of garlic (*Allium sativum* L.) have been widely known and used since ancient times. Garlic enhances immune functions and has antibacterial, antifungal, and antiviral activities [121]. In Ayurveda garlic is used for the treatment of various conditions like asthma, bronchitis, and chest congestion, skin diseases like leprosy, and skin conditions like leucoderma. A few Ayurvedic physicians use garlic in repeated worm infections. Fresh and grounded garlic has been shown to inhibit cancer caused by polycyclic aromatic hydrocarbons and nitrosamines [122]. The protective effect of garlic has been attributed to the presence of organosulfur compounds like diallyl sulfide (DAS), diallyl disulfide (DADS), ajoene, allixine, allyl mercaptans, and allyl methyl sulfides [123]. These compounds in garlic may give rise to its antibacterial properties, which in turn may block the formation of cancer-causing substances, halt the activation of cancer-causing substances, enhance cell repair, reduce cell proliferation, or induce cell death [124]. Several population studies show an association between an increased intake of garlic and a reduced risk of certain cancers, including cancers of the stomach, colon, esophagus, pancreas, and breast. Population studies are multidisciplinary studies of population groups that investigate the cause, incidence, or spread of a disease or examine the effect of health-related interventions, dietary and nutritional intakes, or environmental exposures. An analysis of data from seven population studies showed that the higher the amount of raw and cooked garlic consumed, the lower the risk of stomach and colorectal cancer [125]. A randomized clinical trial was conducted in China to evaluate the effect of synthetic allitridum (an extract of garlic used as a medicine in China for over 3,000 years) and selenium intake on gastric cancer risk involving over 5,000 Chinese men and women at high risk of stomach cancer. The study indicated that the risk for all tumors combined was reduced by 33 % and the risk of stomach cancer was reduced by 52 % in comparison with a group that received only a placebo [126].

Clove (*Syzygium aromaticum*) is one of the most commonly used spices in Indian kitchens [108]. It has been shown to be a potent chemopreventive agent and has been used by the traditional Ayurvedic healers of India since ancient times to treat respiratory and digestive ailments [127]. The major chemical constituents of clove include sesquiterpenes, volatile oil (eugenol), caryophyllene, tannins, and gum. The therapeutic benefits of eugenol are well known. It has been reported to participate in photochemical reactions and to possess insecticidal, antioxidant, and anti-inflammatory activities (162). Recent studies have also identified the promising anticancer properties of clove [108]. Fennel seed (*Foeniculum vulgare*) methanolic extract (FSME), studied in Swiss albino mice, was shown to possess antioxidant, cytotoxic, and antitumor potential. The FSME antitumor effect was due to the lipid peroxidation modulation that augmented the antioxidant defense system in Ehrlich ascites carcinoma-bearing mice with or without exposure to radiation [128]. The chemopreventive potential of fennel seed was also observed against DMBA-induced skin carcinogenesis and benzo[a]pyrene-induced forestomach papillomagenesis in Swiss albino mice [129]. *Nigella sativa* (NS), also known as black cumin, has been used as a traditional medicine for centuries. The crude oil and thymoquinone (TQ) extracted from its seeds and oil are effective against many diseases such

as cardiovascular complications, diabetes, asthma, kidney problems, and cancer [130]. Studies conducted on SiHa human cervical cancer cells indicated that NS induced apoptosis in SiHa cells through both p53 and caspase activation [131]. A lot of research interest has been generated in the last decade on the chemopreventive effects of saffron on neoplastic cells, and experimental evidence indicate anticarcinogenic and antitumor activities of saffron and its compounds in vitro and in vivo platforms [132]. Cinnamon bark (*Cinnamomum cassia*) is another popular herbal ingredient in traditional oriental medicine; it possesses diverse pharmacological activities including antibacterial, antiviral, and anticancer properties [133]. Research studies have suggested that the antitumor effect of cinnamon extracts is directly linked to enhanced proapoptotic activity and to the inhibition of NFκB and AP1 activities and their target genes in vitro and in vivo mouse melanoma models [134]. Cardamom, which belongs to the family Zingiberaceae, is one of the most common ingredients used in Indian cooking and in various parts of Europe [105]. As with many spices, cardamom, especially black cardamom (*Amomum subulatum*), has also been found to have antioxidant properties. The ability of cardamom to inhibit chemical carcinogenesis was shown by Banerjee et al. [135]. It was observed that Swiss albino mice fed cardamom oil (10 μL daily for 2 weeks) experienced a significant decrease in liver CYP content.

8.6.4 Herbs and Cancer Prevention

Medical history since its beginnings is filled with descriptions of persons who used herbs to heal the sick of society. However, parallel to the onset of the industrial revolution was the rise of allopathic medicine. Herbal medicine was also an effective healing method but was viewed less enthusiastically [136]. Botanical and herbal compounds have a substantial place in cancer treatment and palliation globally [137]. Dietary phytochemicals offer nontoxic therapeutic management as well as chemopreventive intervention for slow-growing cancers [118]. Various herbs are mentioned in the classic Ayurvedic texts for possessing potential anticancer properties. Sadabahar or *Catharanthus roseus*, commonly known as Madagascar periwinkle, has been used routinely for centuries in Ayurvedic medicine for the treatment of several diseases, including cancer. The two well-known chemotherapeutic agents vinblastine and vincristine are extracted from this plant, which is now used in the conventional treatment of leukemia and Hodgkin's lymphoma [138, 139]. The benefit of an herbal decoction is that it can nourish the body as a whole by supporting various organ systems [9] as they work on multiple biochemical pathways and are capable of influencing several organ systems simultaneously. Ayurvedic herbs can help in total healing and reduces side effects and cancer-associated complications [140]. Many herbs have been scientifically proven to have anticancer properties. A list of various herbs used for cancer treatment is given in Table 8.1.

Next to water, tea (*Camellia sinensis*) is the cheapest beverage humans consume. Drinking tea has been considered a health-promoting habit since ancient times.

Table 8.1 Herbs and plants used in Ayurvedic anticancer treatment

Scientific name	Sanskrit/Hindi name	English name
Abrus precatorius	Gunja	Coral bead vine
Agati grandiflora	Gaach-munga	Hummingbird tree
Albizzia lebbeck	Sirisha	Rain tree
Allium sativum	Lasuna	Garlic
Aloe vera	Kumari	Aloe
Alstonia scholaries	Sapta parni	Milky pine
Amorphopallus campanulatus	Jimikand	Elephant foot yam
Amura rohitaka	Harinkhana	Rohituka tree
Anacardium occidentale	Kajutaka	Cashew
Anona squamosa	Sitaphala	Custard apple
Annona atemoya		Sugar apple
Aristolochia indica	Ishwari	Birthwort
Asparagus racemosa	Shatawari	Asparagus
Azadiracta indica	Nimba	Margosa tree
Bacopa monnieri	Brahmi	Indian penny wort
Baliospermum montanum	Hastidanti	Wild castor
Barleria prionitis	Kuranta	Porcupine flower
Basella rubra	Pui Ki sag	Ceylon spinach
Bauhinia racemosa	Kanchanara	Mountain ebony
Berberis aristata	Daru haridra	Indian ophthalmic barberry
Berginia ligulata	Prashanbheda	Winter begonia
Boswellia serrata	Shallaki	Indian olibanum
Calotropis gigantean	Arka	Gigantic swallow wort
Caesalpinia sappa	Baka	Sappanwood
Capparis spinosa	Himsra	Caper
Capparis sepiaria	Kanthari	Wild caper bush
Cassia fistula	Bandarlauri	Golden shower tree
Cedrus deodara	Devadaru	Devdar
Centella asiatica	Mandukaparni	Gotu kola
Curcuma longa	Haridra	Turmeric
Cymbopogon citrates	Bhustrina	Lemongrass
Datura metal	Dhattura	Angel's trumpet
Elephantopus scaber	Mayura-shikhaa	Elephant's foot
Euphoria hirta	Dugdhika	Hairy spurge
Euphorbia neriifolia	Sehund	Indian spurge tree
Ficus bengalensis	Bargad	Banyan
Ficus glomerata	Udumbara	Goolar fig
Flacourtia romontchi	Vikankata	Indian plum
Gynandropis pentaphylla	Hurhur	Spider flower
Heliotropium indicum	Hathsura	Indian heliotrope
Holarrhena antidysenterica	Kutaja	Kurchi tree
Hygrophila spinosa	Gokulakanta	Hydrophilia
Inula cappa	Gaaitihaare	Sheep's ear
Ixora undulata	Kukurajihva	West Indian jasmine
Jasminum auriculatum	Juuhi	Jasmine
Juniperus indica	Hapusha	Black juniper

(continued)

Table 8.1 (continued)

Scientific name	Sanskrit/Hindi name	English name
Lagenaria vulgaris	Lauki	Bottle gourd
Leea macrophylla	Hathikana	Dinda
Luffa cylindrical	Ghia torai	Sponge gourds
Madhuca indica	Mahua	Butter tree
Mallotus philippensis	Kamala	Kamala tree
Manilkara hexandra	Khirni	Ceylon iron wood
Melia azadirachta	Maha nimba	Neem tree
Moringa oleifera	Shigru	Horseradish tree
Musa sapientum	Kela	Banana
Nerium indicum	Kara veera	Oleander
Nigella sativa	Krishna jeeraka	Black cumin
Occimum sanctum	Tulasi	Holy basil
Oxoxylum indicum	Bhut-vriksha	Midnight horror
Pandanus odoratissimum	Kevada	Screw pine
Paederia foetida	Gandha prasarani	Chinese fever vine
Phyllantus fraternus	Niruri	Leafflower
Picrorrhiza kurroa	Katuki	Kutki
Piper betle	Nagavalli	Betel leaf pepper
Piper longum	Pippali	Indian long pepper
Pisum sativum	Kalaya	Garden pea
Plumbago zeylanica	Chitraka	Leadwort
Plumbago rosea	Rakta chiktraka	Radix plumbago
Podophyllum hexandrum	Ban kakari	Himalayan mayapple
Pongamia glabra	Karanja	Indian beech
Prosopis cineraria	Khejri/shami	Prosopis
Pterospermum acerifolium	Muchukunda	Maple-leaved bayur tree
Rubia cordifolia	Manjistha	Indian madder
Saussurea lappa	Kustha	Costus root
Saraca indica	Ashoka	Ashoka tree
Semecarpus anacardium	Bhallataka	Varnish tree
Sinapis dichotoma	Serson	Indian rape
Solanum xanthocarpum	Choti Katheri	Yellow-berried nightshade
Soymida febrifuga	Raktarohan	Indian redwood
Syzygium cumini	Jamun	Black plum
Symplocos racemosa	Lodhra	Lodh tree
Taxus buccata	Talispatr	Himalayan yew
Tectona grandis	Sagon	Teak
Tinospora cordifolia	Guduchi	Indian tinospora
Terminalia arjun	Arjun	White marudah
Terminalia chebula	Harra	Chebulic myrobalan
Tylophora asthmatica	Aja dweshi	Indian ipecac
Vernonia species	Sahadevi	Ironweed
Vitis vinifera	Draksha	Grape
Vinca rosea	Sadabahar	Periwinkle
Withania somnifera	Ashwagandha	Indian ginseng
Xantium strumarium	Chota dhatura	Burdock datura

Source: Garodia et al. [29], Balachandran and Govindarajan [9], Smit et al. [140]
Names in *boldface* represent plants whose anticancer activity is supported by experimental research

Encouraging data showing the cancer-preventing effects of green tea from cell cultures and animal and human studies have emerged. Evidence is accumulating that black tea may have similar beneficial effects [141]. The prophylactic and therapeutic properties of tea have been attributed to green tea catechins and black tea theaflavins, besides several other polyphenolic compounds such as thearubigins, epigallocatechin gallate (EGCG), epicatechin (EC), gallic acid (GA), gallocatechin (GC), catechin gallate (CG), gallocatechin gallate (GCG), epicatechin gallate (ECG), and epigallocatechin (EGC), in addition to a certain amount of caffeic acid and proteins [142, 143, 144]. Recent studies show the inhibitory effects of EGCG on the growth of existing tumors, including breast cancer, skin cancer, ovarian, esophageal, and gastrointestinal tract cancers [145–148]. Another mode of action of biologically active compounds in green tea involves inhibiting the neoplastic process (initiation, promotion, and progress). Several independent factors, such as beverage temperature, duration of consumption, amount of tea consumed, and diet intake, have a decisive effect on the final outcome of plant polyphenols in the process of carcinogenesis [145].

For thousands of years, Ayurvedic physicians and laypeople have observed the beneficial effects of using so-called Holy Basil or Tulsi (*Ocimum sanctum*). Modern research and clinical studies have confirmed dozens of Holy Basil's traditional known actions and therapeutic uses including its remarkable adaptogenic and anti-stress activities, as well as its power support for the immune system. Recent studies have also established that Tulsi also has remarkable anticancer activity [149]. Extracts of *O. sanctum* leaves inhibit the proliferation, migration, and invasion and induce the apoptosis of pancreatic cancer cells in vitro [150]. The action of the novel flavonoid vicenin-2 (VCN-2), an active constituent of Tulsi, was studied in prostate carcinoma (CaP) cell lines. It was found that VCN-2 effectively induced antiproliferative, antiangiogenic, and proapoptotic effects in CaP cells (PC-3, DU-145, and LNCaP) irrespective of their androgen responsiveness or p53 status. VCN-2 inhibited the EGFR/Akt/mTOR/p70S6K pathway while decreasing c-Myc, cyclin D1, cyclin B1, CDK4, PCNA, and hTERT in vitro [151].

Azadirachta indica, commonly known as neem, has a wide range of medicinal properties [152]. Because of its tremendous therapeutic, domestic, agricultural, and ethnomedicinal significance and its proximity to human culture and civilization, neem has been called "the wonder tree" and "nature's drugstore." All parts of this tree, particularly the leaves, bark, seed oil, and their purified products, are widely used in the treatment of cancer. Over 60 different types of biochemicals, including terpenoids and steroids, have been purified from this plant. Preclinical research done over the last decade has fine-tuned our understanding of the anticancer properties of the crude and purified products from this plant. The anticancer properties of the plant have been studied largely in terms of its preventive, protective, tumor-suppressive, immunomodulatory, and apoptotic effects against various types of cancer and their molecular mechanisms [153]. Neem extracts and its purified products have been examined for the induction of apoptosis in multiple cancer cell types; however, its underlying mechanisms remain undefined [152]. Thirty-five limonoids, including 15 of the azadiradione type (1–15), 5 of the gedunin type (16–20), 4 of the azadirachtin type (21–24), 9 of the nimbin type (25–33), and 2 degraded limonoids

(34, 35), isolated from Azadirachta indica seed extracts, were evaluated for their cytotoxic activities against 5 human cancer cell lines. Seven compounds (3, 6, 7, 16, 18, 28, and 29) exhibited cytotoxic activity against one or more cell lines. Among these compounds, 7-deacetyl-7-benzoylepoxyazadiradione (7), 7-deacetyl-7-benzoylgeduin (18), and 28-deoxonimbolide (28) exhibited potent cytotoxic activity against HL60 leukemia cells, with IC(50) values in the range 2.7–3.1 μM [154]. Neem leaf preparation (NLP) was found to activate natural killer (NK) cells [CD56(+)CD3(−)] to enhance their cytotoxic ability to kill tumor cells and stimulate the release of interleukin-12 (IL-12) from macrophages from healthy individuals and head-and-neck squamous cell carcinoma patients [155]. The anticancer properties of neem have been reported in many cell lines studies [156–158].

8.7 Conclusions

The ancient Ayurvedic text *Sushrita Samhita* states, "He whose *doshas* are in balance, whose appetite is good…whose body, mind, and senses remain full of bliss, is called a healthy person." By following these simple, time-tested Ayurvedic dietary principles in our daily lives, one can enhance good health and keep cancer away. The disease-preventive and health-promotion approach of Ayurveda takes into consideration the whole body, mind, and spirit while maintaining health, and its approach to promoting health and treating ailments is holistic and is now finding increasing acceptance in many regions of the world. Ancient Ayurvedic physicians developed certain dietary and therapeutic measures to arrest/delay aging and rejuvenate whole functional dynamics of the body [159]. The Ayurvedic system of medicine prescribes more than 700 plant-based medicines, strict dietary principles, and yoga to encourage good health. Hundreds of bioactive chemical compounds have been identified in plant foods. Consuming a diet rich in plant foods will provide a milieu of phytochemicals, nonnutritive substances that possess health-protective benefits [160]. Hence, embracing a cuisine rich in vegetables, fruits, spices, and herbs will enhance the chemopreventive capacity of one's diet. The prevention of cancer through food is a better option than toxic cancer treatment. A proper healthy and balanced diet can definitely prevent or delay the onset of cancer. Urgent attention is thus required to scientifically reevaluate the Ayurvedic concept of food-based cancer prevention and management.

References

1. Siegel R, Naishadham D, Jemal A (2013) Cancer statistics, 2013. CA Cancer J Clin 63:11–30
2. Jemal A, Bray F, Center MM, Ferlay J, Ward E, Forman D (2011) Global cancer statistics. CA Cancer J Clin 61(2):69–90
3. Chung MY, Lim TG, Lee KW (2013) Molecular mechanisms of chemopreventive phytochemicals against gastroenterological cancer development. World J Gastroenterol 19(7):984–993

4. Wang JB, Jiang Y, Liang H, Li P, Xiao HJ, Ji J, Xiang W, Shi JF, Fan YG, Li L, Wang D, Deng SS, Chen WQ, Wei WQ, Qiao YL, Boffetta P (2012) Attributable causes of cancer in China. Ann Oncol 23(11):2983–2989
5. Anand P, Kunnumakkara AB, Kunnumakara AB, Sundaram C, Harikumar KB, Tharakan ST, Lai OS, Sung B, Aggarwal BB (2008) Cancer is a preventable disease that requires major lifestyle changes. Pharm Res 25(9):2097–2116
6. Dolara P, Bigagli E, Collins A (2012) Antioxidant vitamins and mineral supplementation, life span expansion and cancer incidence: a critical commentary. Eur J Nutr 51(7):769–781
7. Syed DN, Chamcheu JC, Mukhtar VM (2013) Pomegranate extracts and cancer prevention: molecular and cellular activities. Anticancer Agents Med Chem 13(8):1149–1161
8. Pal D, Banerjee S, Ghosh AK (2012) Dietary-induced cancer prevention: an expanding research arena of emerging diet related to healthcare system. J Adv Pharm Technol Res 3(1):16–24
9. Balachandran P, Govindarajan R (2005) Cancer – an ayurvedic perspective. Pharmacol Res 51:19–30
10. Patel D, Mansoori A (2012) Cancer – an ayurvedic perspective. IJARPB 2(2):179–195
11. Chopra A, Doiphode VV (2002) Ayurvedic medicine, core concept, therapeutic principles, and current relevance. Complement Alternat Med 86:75–89
12. Murthy KRS (2005) Sushruta Samhita (700 BC). Choukhamba Orientalia, Varanasi
13. Sharma PV (1981) Charaka Samhita. Choukhamba Orientalia, Varanasi
14. Sinha R, Anderson DE, McDonald SS, Greenwald P (2003) Cancer risk and diet in India. J Postgrad Med 49:222–228
15. Kinzler KW, Vogelstein B (eds) (2002) The genetic basis of human cancer, 2nd edn. McGraw-Hill/Medical Pub., New York, Division, p 5
16. Croce CM (2008) Oncogenes and cancer. N Engl J Med 358(5):502–511
17. Sherr CJ (2004) Principles of tumor suppression. Cell 116(2):235–246
18. Lodish H, Berk A, Matsudaira P, Kaiser CA, Krieger M, Scott MP, Zipursky SL, Darnell J (eds) (2004) Molecular biology of the cell, 5th edn. WH Freeman, New York, p 963
19. Risau W, Flamme I (1995) Vasculogenesis. Annu Rev Cell Dev Biol 11:73–91
20. Flamme I, Frölich T, Risau W (1997) Molecular mechanisms of vasculogenesis and embryonic angiogenesis. J Cell Physiol 173(2):206–210
21. Gupta PB, Chaffer CL, Weinberg RA (2009) Cancer stem cells: mirage or reality? Nat Med 15(9):1010–1012
22. Matsui W, Wang Q, Barber JP et al (2008) Clonogenic multiple myeloma progenitors, stem cell properties, and drug resistance. Cancer Res 68(1):190–197
23. Henderson BE, Bernstein L, Ross RK et al (2000) Hormones and the etiology of cancer. In: Bast RC, Kufe DW, Pollock RE (eds) Holland-Frei cancer medicine, 5th edn. B. C. Decker, Hamilton
24. Sasco AJ, Secretan MB, Straif K (2004) Tobacco smoking and cancer: a brief review of recent epidemiological evidence. Lung Cancer 45(Suppl 2):S3–S9
25. Biesalski HK, Bueno de Mesquita B, Chesson A, Chytil F, Grimble R, Hermus RJ, Köhrle J, Lotan R, Norpoth K, Pastorino U, Thurnham D (1998) European consensus statement on lung cancer: risk factors and prevention. Lung cancer panel. CA Cancer J Clin 48(3):167–176
26. Singh RH (2002) An assessment of the ayurvedic concept of cancer and a new paradigm of anticancer treatment in ayurveda. J Alternat Complement Med 8(5):609–614
27. Thatte U, Dhahanukar S (1991) Ayurveda, the natural alternative. Sci Today 2001:12–18
28. Dash B, Kashyap L (1987) Diagnosis and treatment of Galaganda, Gandamala, apaci, granthi and arbuda. Concept Publishing Company, New Delhi
29. Garodia P, Ichikawa H, Malani N, Sethi G, Aggarwal BB (2007) From ancient medicine to modern medicine: ayurvedic concept of health and their role in inflammation and cancer. J Soc Integr Oncol 5(1):25–37
30. Abdulla M, Gruber P (2000) Role of diet modification in cancer prevention. Biofactors 12(1–4):45–51

31. Park S, Bae J, Nam BH, Yoo KY (2008) Aetiology of cancer in Asia. Asian Pac J Cancer Prev 9(3):371–380
32. Haenszel W, Kurihara M (1968) Studies of Japanese migrants. I. Mortality from cancer and other diseases among Japanese in the United States. J Natl Cancer Inst 40:43–68
33. Parkin DM, Bray F, Ferlay J et al (2005) Global cancer statistics 2002. CA Cancer J Clin 55:74–108
34. Ziegler RG, Hoover RN, Pike MC et al (1993) Migration patterns and breast cancer risk in Asian-American women. J Natl Cancer Inst 85:1819–1827
35. Kolonel LN, Altshuler D, Henderson BE (2004) The multiethnic cohort study: exploring genes, lifestyle and cancer risk. Nat Rev Cancer 4:519–527
36. Wong AH, Gottesman II, Petronis A (2005) Phenotypic differences in genetically identical organisms: the epigenetic perspective. [Special issue] Hum Mol Genet 14(1):R11–18
37. Tjønneland A, Olsen A, Boll K, Stripp C, Christensen J, Engholm G, Overvad K (2007) Study design, exposure variables, and socioeconomic determinants of participation in diet, cancer and health: a population-based prospective cohort study of 57,053 men and women in Denmark. Scand J Public Health 35:432–441
38. Cappellani A, Di Vita M, Zanghi A, Cavallaro A, Piccolo G, Veroux M, Berretta M, Malaguarnera M, Canzonieri V, Lo Menzo E (2012) Diet, obesity and breast cancer: an update. Front Biosci (Scholar edition) 4:90–108
39. Key TJ (2011) Fruit and vegetables and cancer risk. Brit J Cancer 104(1):6–11
40. Larsson SC, Wolk A (2007) Coffee consumption and risk of liver cancer: a meta-analysis. Gastroenterology 132(5):1740–1745
41. Ferguson LR (2010) Meat and cancer. Meat Sci 84(2):308–313
42. Zheng W, Lee SA (2009) Well-done meat intake, heterocyclic amine exposure, and cancer risk. Nutr Cancer 61(4):437–446
43. Rajaram S, Sabate J (2000) Health benefits of a vegetarian diet. Nutrition 16:531–533
44. Sengupta A, Ghosh S, Bhattacharjee S, Das S (2004) Indian food ingredients and cancer prevention – an experimental evaluation of anticarcinogenic effects of garlic in rat colon. Asian Pac J Cancer Prev 5(2):126–132
45. Jain MG, Hislop GT, Howe GR, Ghadirian P (1999) Plant foods, antioxidants, and prostate cancer risk: findings from case–control studies in Canada. Nutr Cancer 34:173–184
46. Bishop MJ (1991) Molecular themes in oncogenesis. Cell 64:235–248
47. Hong WK, Sporn MB (1997) Recent advances in chemoprevention of cancer. Science 278:1073–1077
48. Tanaka T, Kohno H, Mori H (2001) Chemoprevention of colon carcinogenesis by dietary non-nutritive compounds. Asian Pac J Cancer Prev 3:165–177
49. Shukla Y, Arora A, Taneja P (2003) Antigenotoxic potential of certain dietary constituents. Teratog Carcinog Mutagen 23(Suppl 1):323–335
50. Willett WC, MacMohan B (1984) Diet and cancer – an overview (first of the two parts). N Engl J Med 310:633–638
51. Willett WC, MacMohan B (1984) Diet and cancer – an overview (second of the two parts). N Engl J Med 310:697–703
52. Shukla Y, Pal SK (2004) Dietary cancer chemoprevention: an overview. Int J Hum Genet 4(4):265–276
53. Gerber M (2001) The comprehensive approach to diet: a critical review. J Nutr 131:3051S–3055S
54. Wattenberg LW (1997) An overview of chemoprevention: current status and future prospect. Proc Soc Exp Biol Med 216:133–144
55. Hospodar M (2013) The dosha balancing diet. http://www.yogajournal.com/health/646. Accessed 28 November 2013
56. Lad V (1997) Food combination. In: Lad U, Lad V (eds) Ayurveda cooking for self-healing. The Ayurvedic Press, Albuquerque
57. Park EJ, Pezzuto JM (2002) Botanicals in cancer chemoprevention. Can Metas Rev 21:231–255

58. Block G, Patterson B, Subar A (1992) Fruits, vegetables and cancer prevention: a review of the epidemiological evidence. Nutr Cancer 18:1–29
59. Koutsokera A, Kiagia M, Saif MW, Souliotis K, Syrigos KN (2013) Nutrition habits, physical activity, and lung cancer: an authoritative review. Clin Lung Cancer 14(4):342–350
60. Steinmetz KA, Potter JD (1991) Vegetables, fruits, and cancer. I. Epidemiology. Cancer Causes Control 2:325–357
61. Steinmetz KA, Potter JD (1991) Vegetables, fruits, and cancer. II. Mechanisms. Cancer Causes Control 2:427–442
62. Steinmetz KA, Potter JD (1996) Vegetables, fruits, and cancer prevention: a review. J Am Diet Assoc 96:1027–1039
63. Brenner DE (2000) Multiagent chemoprevention agent combinations. J Cell Biochem 34(Suppl):121–124
64. Torrance CJ, Jackson PE, Montgomery E, Kinzler KW, Vogelstein B, Wissner A, Nunes M, Frost P, Discafani CM (2000) Combinatorial chemoprevention of intestinal neoplasia. Nat Med 6:1024–1028
65. Surh YJ (2003) Cancer chemoprevention with dietary phytochemicals. Nat Rev Cancer 10:768–680
66. Bajbouj K, Schulze-Luehrmann J, Diermeier S, Amin A, Schneider-Stock R (2012) The anti-cancer effect of saffron in two p53 isogenic colorectal cancer cell lines. BMC Complement Alternat Med 12:69–77
67. Ren W, Qiao Z, Wang H, Zhu L, Zhang L (2003) Flavonoids: promising anticancer agents. Med Res Rev 4:519–534
68. Caltagirone S, Rossi C, Poggi A, Ranelletti FO, Natali PG, Brunetti M, Aiollo FB, Piantelli M (2000) Flavonoids apigenin and quercetin inhibit melanoma growth and metastatic potential. Int J Cancer 87:595–600
69. Dragsted LO, Strube M, Leth T (1997) Dietary levels of plant phenols and other non-nutritive components: could they prevent cancer? Eur J Cancer Prev 6:522–528
70. Zloch Z (1996) The role of dietary plant polyphenols in health maintenance. Cas Lek Cesk 135:84–88
71. Kim DJ, Shin DH, Ahn B, Kang JS, Nam KT, Park CB, Kim CK, Hong JT et al (2003) Chemoprevention of colon cancer by Korean food plant components. Mutat Res 523–524:99–107
72. Talalay P, Fahey JW (2001) Phytochemicals from cruciferous plant protects against cancer by modulating carcinogen metabolism. J Nutr 131:3027S–3033S
73. Srivastava B, Shukla Y (1998) Antitumour promoting activity of indole-3-carbinol in mouse skin carcinogenesis. Cancer Lett 134:91–96
74. Hwang ES, Bowen PE (2002) Can the consumption of tomatoes for lycopene reduce cancer risk? Integr Cancer Ther 2:121–132
75. Tan H, Thomas-Ahner J, Grainger E, Wan L, Francis D, Schwartz S, Erdman J, Clinton S, Hsueh-Li T (2010) Tomato-based food products for prostate cancer prevention: what have we learned? Cancer Metastasis Rev 29(3):553–568
76. Hutchins AM, Winham DM, Thompson SV (2012) Phaseolus beans: impact on glycaemic response and chronic disease risk in human subjects. Br J Nutr 108(Suppl 1):S52–S65
77. Magee PJ, Rowland I (2012) Soy products in the management of breast cancer. Curr Opin Clin Nutr Metab Care 15(6):586–591
78. Yang G, Shu XO, Chow WH, Zhang X, Li HL, Ji BT, Cai H, Wu S, Gao YT, Zheng W (2012) Soy food intake and risk of lung cancer: evidence from the Shanghai women's health study and a meta-analysis. Am J Epidemiol 176(10):846–855
79. Yang WS, Va P, Wong MY, Zhang HL, Xiang YB (2011) Soy intake is associated with lower lung cancer risk: results from a meta-analysis of epidemiologic studies. Am J Clin Nutr 94(6):1575–1583
80. Patel S, Goyal A (2012) Recent developments in mushrooms as anti-cancer therapeutics: a review. Biotech 2(1):1–15

81. Batra P, Sharma AK, Khajuria R (2013) Probing Lingzhi or Reishi medicinal mushroom *Ganoderma lucidum* (higher Basidiomycetes): a bitter mushroom with amazing health benefits. Int J Med Mushrooms 15(2):127–143
82. Baliga MS, Dsouza JJ (2011) Amla (*Emblica officinalis* Gaertn), a wonder berry in the treatment and prevention of cancer. Eur J Cancer Prev 20(3):225–239
83. Baliga MS (2010) Triphala ayurvedic formulation for treating and preventing cancer: a review. J Altern Complement Med 16(12):1301–1308
84. Kaur S, Michael H, Arora S, Härkönen PL, Kumar S (2005) The *in vitro* cytotoxic and apoptotic activity of Triphala-an Indian herbal drug. J Ethnopharmacol 97(1):15–20
85. Sandhya T, Lathika KM, Pandey BN, Mishra KP (2006) Potential of traditional ayurvedic formulation, Triphala, as a novel anticancer drug. Cancer Lett 231(2):206–214
86. Lu K, Chakroborty D, Sarkar C, Lu T, Xie Z, Liu Z, Basu S (2012) Triphala and its active constituent chebulinic acid are natural inhibitors of vascular endothelial growth factor-a mediated angiogenesis. PLoS One 7(8):e43934
87. Kim J, Jayaprakasha GK, Patil BS (2013) Limonoids and their anti-proliferative and anti-aromatase properties in human breast cancer cells. Food Funct 4(2):258–265
88. Meiyanto E, Hermawan A, Anindyajati (2012) Natural products for cancer-targeted therapy: citrus flavonoids as potent chemopreventive agents. Asian Pac J Cancer Prev 13(2):427–436
89. Zhou K, Raffoul JJ (2012) Potential anticancer properties of grape antioxidants. J Oncol 2012:803294
90. Zhao J, Wang J, Chen Y, Agarwal R (1999) Anti-tumor promoting activity of a polyphenolic fraction isolated from grape seeds in the mouse skin two stage initiation promotion protocol and identification of procyanidin B 5-3′-gallate as the most effective antioxidant constituent. Carcinogenesis 20:1737–1745
91. He X, Wang Y, Hu H, Zhang Z (2012) *In vitro* and *in vivo* antimammary tumor activities and mechanisms of the apple total triterpenoids. J Agric Food Chem 60(37):9430–9436
92. Gerhauser C (2008) Cancer chemopreventive potential of apples, apple juice, and apple components. Planta Med 74(13):1608–1624
93. Baliga MS (2011) Anticancer, chemopreventive and radioprotective potential of black plum (*Eugenia jambolana* lam). Asian Pac J Cancer Prev 12(1):3–15
94. Arung ET, Shimizu K, Kondo R (2007) Structure-activity relationship of prenyl-substituted polyphenols from *Artocarpus heterophyllus* as inhibitors of melanin biosynthesis in cultured melanoma cells. Chem Biodivers 4(9):2166–2171
95. García-Rivera D, Delgado R, Bougarne N, Haegeman G, Berghe WV (2011) Gallic acid indanone and mangiferin xanthone are strong determinants of immunosuppressive anti-tumour effects of *Mangifera indica* L. bark in MDA-MB231 breast cancer cells. Cancer Lett 305(1):21–31
96. Yu MH, Im HG, Kim HI, Lee IS (2009) Induction of apoptosis by immature plum in human hepatocellular carcinoma. J Med Food 12(3):518–527
97. Bhui K, Tyagi S, Prakash B, Shukla Y (2010) Pineapple bromelain induces autophagy, facilitating apoptotic response in mammary carcinoma cells. Biofactors 36(6):474–482
98. Torres MP, Rachagani S, Purohit V, Pandey P, Joshi S, Moore ED, Johansson SL, Singh PK, Ganti AK, Batra SK (2012) Graviola: a novel promising natural-derived drug that inhibits tumorigenicity and metastasis of pancreatic cancer cells *in vitro* and *in vivo* through altering cell metabolism. Cancer Lett 323(1):29–40
99. Nguyen TT, Shaw PN, Parat MO, Hewavitharana AK (2013) Anticancer activity of *Carica papaya*: a review. Mol Nutr Food Res 57(1):153–164
100. Shirode AB, Kovvuru P, Chittur SV, Henning SM, Heber D, Reliene R (2013) Antiproliferative effects of pomegranate extract in MCF-7 breast cancer cells are associated with reduced DNA repair gene expression and induction of double strand breaks. Mol Carcinog. doi: 10.1002/mc.21995
101. Somasagara RR, Hegde M, Chiruvella KK, Musini A, Choudhary B, Raghavan SC (2012) Extracts of strawberry fruits induce intrinsic pathway of apoptosis in breast cancer cells and inhibits tumor progression in mice. PLoS One 7(10):e47021

102. Abdelwahab SI, Hassan LE, Abdul Majid AM, Yagi SM, Mohan S, Elhassan Taha MM, Ahmad S, Chuen CS, Narrima P, Rais MM, Syam S, Moharam BA, Hadi AH (2012) Cucurbitacin L 2-O-β-glucoside demonstrates apoptogenesis in colon adenocarcinoma cells (HT-29): involvement of reactive oxygen and nitrogen species regulation. Evid Based Complement Alternat Med 2012:490136
103. Bontempo P, Doto A, Miceli M, Mita L, Benedetti R, Nebbioso A, Veglione M, Rigano D, Cioffi M, Sica V, Molinari AM, Altucci L (2012) *Psidium guajava* L. anti-neoplastic effects: induction of apoptosis and cell differentiation. Cell Prolif 45(1):22–31
104. Deneo-Pellegrini H, De Stefani E, Ronco A (1996) Vegetables, fruits, and risk of colorectal cancer: a case–control study from Uruguay. Nutr Cancer 25(3):297–304
105. Kaefer CM, Milner JA (2011) Herbs and spices in cancer prevention and treatment. In: Benzie IFF, Wachtel-Galor S (eds) Herbal medicine: biomolecular and clinical aspects, 2nd edn. CRC Press, Boca Raton
106. Lampe JW (2003) Spicing up a vegetarian diet: chemopreventive effects of phytochemicals. Am J Clin Nutr 78(3 Suppl):579S–583S
107. Tapsell LC, Hemphill I, Cobiac L, Patch CS, Sullivan DR, Fenech M, Roodenrys S, Keogh JB, Clifton PM, Williams PG, Fazio VA, Inge KE (2006) Health benefits of herbs and spices: the past, the present, the future. Med J Aust 185(4 Suppl):S4–S24
108. Dwivedi V, Shrivastava R, Hussain S, Ganguly C, Bharadwaj M (2011) Comparative anticancer potential of clove (*Syzygium aromaticum*) – an Indian spice – against cancer cell lines of various anatomical origin. Asian Pac J Cancer Prev 12:1989–1993
109. Aggarwal BB, Kunnumakkara AB, Harikumar KB, Tharakan ST, Sung B, Anand P (2008) Potential of spice-derived phytochemicals for cancer prevention. Planta Med 74(13):1560–1569
110. Aggarwal BB, Sundaram C, Malani N, Ichikawa H (2007) Curcumin: the Indian solid gold. Adv Exp Med Biol 595:1–75
111. Baumeister P, Reiter M, Harréus U (2012) Curcumin and other polyphenolic compounds in head and neck cancer chemoprevention. Oxid Med Cell Longev 2012:902716
112. Goel A, Kunnumakkara AB, Aggarwal BB (2008) Curcumin as "Curecumin": from kitchen to clinic. Biochem Pharmacol 75(4):787–809
113. Aggarwal BB, Shishodia S (2006) Molecular targets of dietary agents for prevention and therapy of cancer. Biochem Pharmacol 71(10):1397–1421
114. Teiten M, Eifes S, Dicato M, Diederich M (2010) Curcumin – the paradigm of a multi-target natural compound with applications in cancer prevention and treatment. Toxins 2:128–162
115. Steward WP, Gescher AJ (2008) Curcumin in cancer management: recent results of analogue design and clinical studies and desirable future research. Mol Nutr Food Res 52:1005–1009
116. Baliga MS, Haniadka R, Pereira MM, D'Souza JJ, Pallaty PL, Bhat HP, Popuri S (2011) Update on the chemopreventive effects of ginger and its phytochemicals. Crit Rev Food Sci Nutr 51(6):499–523
117. Karna P, Chagani S, Gundala SR, Rida PC, Asif G, Sharma V, Gupta MV, Aneja R (2012) Benefits of whole ginger extract in prostate cancer. Br J Nutr 107(4):473–484
118. Brahmbhatt M, Gundala SR, Asif G, Shamsi SA, Aneja R (2013) Ginger phytochemicals exhibit synergy to inhibit prostate cancer cell proliferation. Nutr Cancer 65(2):263–272
119. Krell J, Stebbing J (2012) Ginger: the root of cancer therapy? Lancet Oncol 13(3):235–236
120. Liu Y, Whelan RJ, Pattnaik BR, Ludwig K, Subudhi E, Rowland H, Claussen N, Zucker N, Uppal S, Kushner DM, Felder M, Patankar MS, Kapur A (2012) Terpenoids from *Zingiber officinale* (Ginger) induce apoptosis in endometrial cancer cells through the activation of p53. PLoS One 7(12):e53178
121. Iciek M, Kwiecień I, Włodek L (2009) Biological properties of garlic and garlic-derived organosulfur compounds. Environ Mol Mutagen 50(3):247–265
122. Siegers CP, Steffen B, Robke A, Pentz R (1999) The effects of garlic preparations against human tumour cell proliferation. Phytomedicine 6:7–11
123. Fanelli SL, Castro GD, De-toranzo EG, Castro JA (1998) Mechanisms of the preventive properties of some garlic components in carbon tetrachloride-promoted oxidative stress, diallyl sulphide, diallyl disulphide, allyl mercaptan and allyl methyl sulphide. Res Commun Mol Path 102:163–174

124. National Cancer Institute (2008) Garlic and cancer prevention. http://www.cancer.gov/cancertopics/factsheet/prevention/garlic-and-cancer-prevention. Accessed 14 July 2013
125. Fleischauer AT, Arab L (2001) Garlic and cancer: a critical review of the epidemiologic literature. J Nutr 131(3s):1032S–1040S
126. Li H, Li HQ, Wang Y et al (2004) An intervention study to prevent gastric cancer by micro-selenium and large dose of allitridum. Chinese Med J 117(8):1155–1160
127. Banerjee S, Panda CK, Das S (2006) Clove (*Ayzygium aromaticum* L.), a potential chemopreventive agent for lung cancer. Carcinogenesis 27:1645–1654
128. Mohamad RH, El-Bastawesy AM, Abdel-Monem MG, Noor AM, Al-Mehdar HA, Sharawy SM, El-Merzabani MM (2011) Antioxidant and anticarcinogenic effects of methanolic extract and volatile oil of fennel seeds (*Foeniculum vulgare*). J Med Food 14(9):986–1001
129. Singh B, Kale RK (2008) Chemomodulatory action of *Foeniculum vulgare* (fennel) on skin and forestomach papillomagenesis, enzymes associated with xenobiotic metabolism and antioxidant status in murine model system. Food Chem Toxicol 46(12):3842–3850
130. Khan MA, Chen HC, Tania M, Zhang DZ (2011) Anticancer activities of *Nigella sativa* (black cumin). Afr J Tradit Complement Altern Med 8(5 Suppl):226–232
131. Hasan TN, Shafi G, Syed NA, Alfawaz MA, Alsaif MA, Munshi A, Lei KY, Alshatwi AA (2013) Methanolic extract of *Nigella sativa* seed inhibits SiHa human cervical cancer cell proliferation through apoptosis. Nat Prod Commun 8(2):213–216
132. Bhattacharjee B, Vijayasarathy S, Karunakar P, Chatterjee J (2012) Comparative reverse screening approach to identify potential anti-neoplastic targets of saffron functional components and binding mode. Asian Pac J Cancer Prev 13(11):5605–5611
133. Hong JW, Yang GE, Kim YB, Eom SH, Lew JH, Kang H (2012) Anti-inflammatory activity of cinnamon water extract *in vivo* and *in vitro* LPS-induced models. BMC Complement Altern Med 12:237. doi:10.1186/1472-6882-12-237
134. Kwon HK, Hwang JS, So JS, Lee CG, Sahoo A, Ryu JH, Jeon WK, Ko BS, Im CR, Lee SH, Park ZY, Im SH (2010) Cinnamon extract induces tumor cell death through inhibition of NFκB and AP1. BMC Cancer 10:392. doi:10.1186/1471-2407-10-392
135. Banerjee S, Sharma R, Kale RK, Rao AR (1994) Influence of certain essential oils on carcinogen- metabolizing enzymes and acid-soluble sulfhydryls in mouse liver. Nutr Cancer 21:263–269
136. Pal SK, Shukla Y (2003) Herbal medicine: current status and the future. Asian Pac J Cancer Prev 4:281–288
137. Gullett NP, Ruhul Amin AR, Bayraktar S, Pezzuto JM, Shin DM, Khuri FR, Aggarwal BB, Surh YJ, Kucuk O (2010) Cancer prevention with natural compounds. Semin Oncol 37(3):258–281
138. Cravotto G, Boffa L, Genzini L, Garella D (2010) Phytotherapeutics: an evaluation of the potential of 1000 plants. J Clin Pharm Ther 35:11–48
139. Patel B, Das S, Prakash R, Yasir M (2010) Natural bioactive compound with anticancer potential. Int J Advan Pharm Sci 1:32–41
140. Smit HF, Woerdenbag HJ, Singh RH, Meulenbeld GJ, Labadie RP, Zwaving JH (1995) Ayurvedic herbal drugs with possible cytostatic activity. J Ethnopharmacol 47:75–84
141. Bailey HH, Mukhtar H (2013) Green tea polyphenols and cancer chemoprevention of genitourinary cancer. Am Soc Clin Oncol Educ Book 2013:92–96. doi:10.1200/EdBook_AM.2013.33.92
142. Darvesh AS, Bishayee A (2013) Chemopreventive and therapeutic potential of tea polyphenols in hepatocellular cancer. Nutr Cancer 65(3):329–344
143. Graham HN (1992) Green tea composition consumption and polyphenols chemistry. Prev Med 21:334–350
144. Du GJ, Zhang Z, Wen XD, Yu C, Calway T, Yuan CS, Wang CZ (2012) Epigallocatechin Gallate (EGCG) is the most effective cancer chemopreventive polyphenol in green tea. Nutrients 4(11):1679–1691
145. Donejko M, Niczyporuk M, Galicka E, Przylipiak A (2013) Anti-cancer properties epigallocatechin-gallate contained in green tea. Postepy Hig Med Dosw (Online) 67:26–34

146. Lee AH, Su D, Pasalich M, Binns CW (2013) Tea consumption reduces ovarian cancer risk. Cancer Epidemiol 37(1):54–59
147. Wang ZH, Gao QY, Fang JY (2012) Green tea and incidence of colorectal cancer: evidence from prospective cohort studies. Nutr Cancer 64(8):1143–1152
148. Zheng P, Zheng HM, Deng XM, Zhang YD (2012) Green tea consumption and risk of esophageal cancer: a meta-analysis of epidemiologic studies. BMC Gastroenterol 12:165. doi:10.1186/1471-230X-12-165
149. Nangia-Makker P, Raz T, Tait L, Shekhar MP, Li H, Balan V, Makker H, Fridman R, Maddipati K, Raz A (2013) *Ocimum gratissimum* retards breast cancer growth and progression and is a natural inhibitor of matrix metalloproteases. Cancer Biol Ther 14(5). http://www.ncbi.nlm.nih.gov/pubmed/23380593
150. Shimizu T, Torres MP, Chakraborty S, Souchek JJ, Rachagani S, Kaur S, Macha M, Ganti AK, Hauke RJ, Batra SK (2013) Holy Basil leaf extract decreases tumorigenicity and metastasis of aggressive human pancreatic cancer cells *in vitro* and *in vivo*: potential role in therapy. Cancer Lett 336(2):270–280
151. Nagaprashantha LD, Vatsyayan R, Singhal J, Fast S, Roby R, Awasthi S, Singhal SS (2011) Anti-cancer effects of novel flavonoid vicenin-2 as a single agent and in synergistic combination with docetaxel in prostate cancer. Biochem Pharmacol 82(9):1100–1109
152. Srivastava P, Yadav N, Lella R, Schneider A, Jones A, Marlowe T, Lovett G, O'Loughlin K, Minderman H, Gogada R, Chandra D (2012) Neem oil limonoids induces p53-independent apoptosis and autophagy. Carcinogenesis 33(11):2199–2207
153. Paul R, Prasad M, Sah NK (2011) Anticancer biology of *Azadirachta indica* L (neem): a mini review. Cancer Biol Ther 12(6):467–476
154. Kikuchi T, Ishii K, Noto T, Takahashi A, Tabata K, Suzuki T, Akihisa T (2011) Cytotoxic and apoptosis-inducing activities of limonoids from the seeds of *Azadirachta indica* (neem). J Nat Prod 74(4):866–870
155. Bose A, Baral R (2007) Natural killer cell mediated cytotoxicity of tumor cells initiated by neem leaf preparation is associated with CD40-CD40L-mediated endogenous production of interleukin-12. Hum Immunol 68(10):823–831
156. Elumalai P, Gunadharini DN, Senthilkumar K, Banudevi S, Arunkumar R, Benson CS, Sharmila G, Arunakaran J (2012) Induction of apoptosis in human breast cancer cells by nimbolide through extrinsic and intrinsic pathway. Toxicol Lett 215(2):131–142
157. Schumacher M, Cerella C, Reuter S, Dicato M, Diederich M (2011) Anti-inflammatory, pro-apoptotic, and anti-proliferative effects of a methanolic neem (*Azadirachta indica*) leaf extract are mediated via modulation of the nuclear factor-κB pathway. Genes Nutr 6(2):149–160
158. Vasenwala SM, Seth R, Haider N, Islam N, Khan T, Maheshwari V, Ur Rehman SA (2012) Study on antioxidant and apoptotic effect of *Azadirachta Indica* (neem) in cases of cervical cancer. Arch Gynecol Obstet 286(5):1255–1259
159. Govindarajan R, Vijayakumar M, Pushpangadan P (2005) Antioxidant approach to disease management and the role of 'Rasayana' herbs of ayurveda. J Ethnopharmacol 99(2):165–178
160. Craig WJ (1997) Phytochemicals: guardians of our health. J Am Diet Assoc 97(10 Suppl 2): S199–S204
161. Xu T, Beelman RB, Lambert JD (2012) The cancer preventive effects of edible mushrooms. Anticancer Agents Med Chem 12(10):1255–1263
162. Scott EN, Gescher AJ, Steward WP, Brown K (2009) Development of dietary phytochemical chemopreventive agents: biomarkers and choice of dose for early clinical trials. Cancer Prev Res 2:525–50

Chapter 9
Food-Based Therapeutics: A Converging Paradigm of Traditional and Modern Food Science

Rishi Pal and K.K. Pant

9.1 Introduction

Hippocrates stated around 2,000 years ago, "Let food be your medicine and medicine be your food." Herbs and spices have a long history of both culinary and medicinal uses. They are an integral part of the daily diet. Herbs and spices can add variety, flavor, color, and aroma to everyday food while contributing a wide range of both nutrients and bioactives that may contribute to improved health. They can act synergistically to enhance the health-promoting properties of other food. Many of the pharmacological properties of traditional herbs have been well documented [1, 2].

Since prehistoric times, herbs have been the basis of nearly all medicinal therapy until synthetic drugs were developed in the nineteenth century. Today, herbs are grown and used for their ability to enhance and complement the flavors of a wide variety of foods. The majority of herbs and spices constitute important bioactive secondary metabolites that possess versatile pharmacological and medicinal properties. The health-promoting effects of vegetables and fruits is thought to relate not only to their general nutritional profile – high in dietary fibers, low in fat and salts, low energy density, and high in vitamins A, C, and foliate – but also to a wide range of nonnutrient bioactives and phytochemicals such as flavonoids and phenols. It has been proposed that the additive and synergistic effects of the complex mixture of phytochemicals in fruits and vegetables, herbs, and spices are largely responsible for their health benefits. Wild vegetables have been reported to contain comparatively high amounts of vitamins A and C and other antioxidant micronutrients and promote good health by assisting in the prevention of cancer and high blood pressure, stimulating the immune system, and improving drug metabolism and tissue regeneration. Food-based therapeutics utilize traditional knowledge based on

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Table 9.1 Common food plants and their medicinal properties

Plants	Scientific name	Medicinal properties/indication
Ajowain	*Trachyspermum roxburghianum*	Expectorant, antiflatulent
Asafoetida	*Aerula asfoetida*	Antihelminthic, antitussive
Capsicum pepper	*Capsicum frutescens*	Analgesic, counterirritant
Cinnamon cassia	*Cinnamomum zeylanicum*	Antiseptic, antidiarrheal
Clove	*Syzygium aromaticum*	Topical anesthetic, antidyspeptic
Coriander	*Grewia tilaefolia*	Antispasmodic, diuretic, anti-inflammatory
Cumin	*Cuminum cyminum*	Antimicrobial, vermifuge, diuretic
Black pepper	*Piper nigrum*	Carminative, anti-inflammatory
Curry leaves	*Murraya koenigii*	Antiemetic
Ginger	*Zingiber officinale*	Cold, antiemetic, antirheumatic
Nutmeg	*Myristica fragans*	Astringent, hallucinogenic
Peppercorns	*Piper nigrum*	Expectorant, antimicrobial
Saffron	*Crocus sativa*	Antirheumatic, for neuralgia
Turmeric	*Curcuma longa*	Antiarthritic, antioxidant, anticancer
Garlic	*Allium ativum*	Antimicrobial, antihypercholesterolemic, anticancer, antihypertensive
Mustard	*Brassica compestris*	Eczema, intestinal catarrh, colic pain, flatulence
Onion	*Allium cepa*	For cold, expectorant, anticancer, antiasthma
Aniseed	*Brassica oleracea*	Counterirritant, emetic, purgative antispasmodic, expectorant
Cardamom	*Elettaria cardamomum*	Antiseptic
Fennel	*Foeniculum valgae*	Antispasmodic, diuretic
Lemon grass	*Cymbopogon citrates*	Fever, insect bites
Sesame seed	*Sesamum indicum*	Diuretic, galactogogue, demulcent
Dalchini	*Cinnamomun zelanicum*	Menstrual pain, indigestion
Mint	*Menthe arvensis*	Expectorant, for cold, local anesthesia, antispasmodic
Oregano	*Origanum vulgare*	Antitussive, antirheumatic, vermifuge
Poppy seed	*Papaver somniferum*	Sedative, antispasmodic
Coffee	*Coffea robusta*	Stimulant, diuretic, bronchodilator
Tea	*Thea sinensis*	Antioxidant, source of theophylline
Tamarind	*Tamarindus indica*	Antiseptic, cholagogue, laxative, antipyretic
Tejpatra	*Cinnamomum tamala*	Migrane, peptic ulcer
Bail	*Aegel marmelos*	Constipation, diarrhea, peptic ulcer, diabetes
Mulethi	*Glycyrrhiza glabra*	Muscular pain, mouth ulcers, sore throat
Soyabean	*Glycine max*	Malnutrition, allergies, diabetes, dandruff
Tulsi	*Ocimum sanctum*	Anti-inflammatory, expectorant, analgesic, antitumor, antibacterial
Banana	*Musa paradisiaca*	Mild laxative, diarrhea/dysentery

Chinese and indigenous herbal food recipes from ancient times [3–5]. Some of the common plants used since ancient times in food preparation and also traditionally used in "grandma's recipes" are given in Table 9.1.

It has been observed that food herbs works better when administered as a whole compared to the isolated compounds. In Ayurveda it is mentioned that polyherbal

formulations have better therapeutic potential compared to single herbs or their isolated active compounds due to the synergistic pharmacological effects of each herb. These food-based herbs have significant potential in preventing rather than curing diseases [6].

9.2 Food as Antioxidants

One of the benefits of culinary herbs and spices is due primarily to their antioxidant properties. Free radicals and related species are generated in the body as a result of metabolic reactions. The accumulation of free radicals causes damage in living systems, resulting in oxidative stress. Free radical scavengers (antioxidants) have the potential to prevent, delay, or ameliorate many human chronic and aging diseases such as cancer, diabetes, heart disease, stroke, and rheumatoid arthritis. Free radical scavenging is an important mechanism for the inhibition of lipid peroxidation and can be a good marker for antioxidant activity. Results of studies indicate that the addition of some spices and herbs to food products can prevent the oxidative deterioration of foods. The multiple roles of traditional vegetables as food and medicinal sources have been widely documented [7].

The newly developed branches of food science are briefly discussed in what follows.

9.2.1 Nutraceuticals

Any substance that is a food or part of a food and provides medical or health benefits, including the prevention and treatment of diseases, is called a nutraceutical. Such products may range from isolated nutrients, dietary supplements, and specific diets to genetically engineered designer foods and herbal products [7].

There is a slight difference between functional foods and nutraceuticals. When food is being cooked or prepared using "scientific intelligence" with or without knowledge of how or why it is being used, the food is called a functional food. Thus, functional food provides the body with its daily requirements of vitamins, fats, proteins, carbohydrates, and other nutrients needed for healthy survival. When functional food aids in the prevention or treatment of diseases or disorders other than anemia, it is called a nutraceutical. Examples of nutraceuticals include fortified dairy products (e.g., milk) and citrus fruits (e.g., orange juice).

9.2.2 Probiotics

Probiotics are live microorganisms (in most cases bacteria) that are similar to beneficial microorganisms found in the human gut. They are also called friendly

bacteria or good bacteria. Probiotics are available for consumers mainly in the form of dietary supplements and foods. They are also used as complementary and alternative medicine (CAM). Most often, the bacteria come from two groups, *lactobacillus* or *bifidobacterium*. Probiotics can be used to alleviate lactose intolerance, treat diarrhea, and enhance immune functions. In reference to using probiotics to treat diarrhea, but the evidence supporting the prevention of travelers's diarrhea by probiotics is weak. There exists an overall protective effect in the prevention and treatment of antibiotic-associated diarrhea, with strong evidence for the efficiency of *lactobacillus* in treating diarrhea-induced by rotavirus infection. As probiotics play a role in immunomodulation, naw a days, has received most attention. Several in vitro and in vivo studies on probiotics have reported an immune-boosting role. The specific mechanisms of the probiotics-induced observed changes remain unclear. Generally, enhanced sIgA production and splenocyte proliferation were observed during probiotics treatment. Moreover, regarding cytokine production, several studies have shown that cytokine production by the cells of the immune system can be altered by probiotic use, which may lead to immunomodulation. Hence, probiotics may play a significant role in defense against various infectious microorganisms [8, 9].

9.3 Food-Based Therapeutics

The basic qualities of food products, such as, for example, aroma, flavor, pungency, and color, must be conserved for value-added products and this must start at the farm level. The first spice, oil, and oleoresin industry was launched in 1930 in India at Calicut. An extract of ginger was manufactured for therapeutics during World War II. The major oils extracted for therapeutic purposes were from black pepper, chili seed, capsicum, clove, nutmeg, mace, cassia, juniper, and peppermint. Pepper, ginger, and peppermint oils are the major oils exported from India. The food spices exported from India are black pepper, chilies, capsicum, ginger, turmeric, white pepper, coriander, cumin, fennel, mustard seed, garlic, clove, nutmeg, and curry powder, which are food ingredients and have therapeutic potentials. The role of these food plant products has been known since ancient times for the prevention of many diseases and for the treatment of diseases [10–14]. Green tea extract (*Camellia sinensis*) was given qualified approval by the U.S. Food and Drug Administration for cancer prevention due to the presence of (−)-epigallocatechin gallate.

Some of the common herbs used as food ingredients since antiquity, with their scientific validity as pharmaceuticals, are described in what follows.

9.3.1 Garlic (Allium sativum)

Garlic has been the most important food ingredient since ancient times, and its uses are widely described in Ayurveda. The scientific therapeutic effects of

garlic as a hypolipidemic, antithrombotic, antihypertensive, antihyperglycemic, antihypercholesterolemia, and immunomodulatory substance have been reported [15, 16]. The bioactive components responsible for the health benefits of garlic are assumed to be allylic sulfur compounds. The use of herbs to displace fats and salts in the diet may reduce cardiovascular risk. The most convincing studies on the specific herbs or spices shows beneficial effects in cardiovascular diseases similar to garlic which is commonly used to reduce cholesterol and cardiovascular risk [15].

The consumption of garlic or garlic oil has been associated with a reduction in total cholesterol, low density lipoprotein (LDL) cholesterol, and triglyceride levels. An intake of the one half and one garlic per day may reduce total cholesterol by 9 %. Garlic extracts have been shown to have anticlotting properties and to cause a modest reduction in blood pressure, an approximately 5.5 % decrease in systolic blood pressure. Its effectiveness is associated with the active substances in garlic such as allicin and other breakdown products. Allicin has also been isolated and identified as the component responsible for remarkable antibacterial activities. It has been observed that these therapeutic effects are more pronounced compared to the isolated components alone [17].

The therapeutic application of allicin as an antifungal, antiparasitic, and anti viral agent having other antibiotic effects as well has been shown. Inhibition of certain thiol-containing enzymes in microorganisms by the allicin assumed to be the main mechanism involved in its antibiotic effect. Allicin and ajoene, the major sulfur containing compounds of garlic, were shown to inhibit inducible nitric oxide synthetase (iNOS), by reducing the protein and mRNA, and thus to promote vasodilatation. Rodent cancer model have shown that diallyl sulfite, a compound of garlic, is effective in the detoxification of carcinogens through its effect on Phase I and Phase II enzymes [18–20]. Modern medicine has also adopted garlic as a medicine, especially for cardiovascular diseases, and pharmaceutical preparations of it are now available.

9.3.2 Ginger (Zingiber officinale)

Ginger is used in food recipes and in herbal tea preparation worldwide and is widely used to treat the common cold. It has many therapeutic attributes such as antimicrobial, antithrombotic, antiinflammatory, and anticancer activities [21, 22]. It has also been demonstrated to possess antimutagenic properties, induce detoxification, prevent DNA damage in vitro, and reduce nausea and vomiting in pregnancy [23]. Ginger has a mixture of several of 100 known constituents, including gingerols, shagaols, β-carotene, caffeic acid, curcumine, salisylates, and capsaicin.

The aroma of ginger is due to the constituents of its steam-volatile oils, which are mainly sesquiterpene hydrocarbon, monoterpine hydrocarbon, and oxygenated hydrocarbons, while its pungency is due to the nonsteam volatile components also known as gingerols. The major sesquiterpene hydrocarbon constituent of ginger oils is a-zingiberene. Certain ginger oils have a reputation for possessing a particular

lemony aroma due to their high contents of the isomers neral and geranial, often collectively referred to as citral.

Ginger is a major tranquillizer and carminative agent due to its gingerols. It is used as a spice and as an important medicinal product. It has been recommended for use in treating peptic ulceration due to its action as a thromboxane synthatase inhibitor. Several controlled clinical trials suggest that ginger root can relieve symptoms of motion sickness by a mechanism of action that differs from that of antihistamines. The responsible constituents are believed to be gingerols and shagaols. Ginger root is a putative agent for preventing aging-dependent vascular changes and impotence. A recent reverse pharmacological study on ginger aqueous extracts of whole rhizome showed an antihypertensive activity of the extracts in experimental animals [22–24]. Clinical studies must be designed to scientifically validate the potential of this plant.

9.3.3 Nutmeg (Myristica fragans)

Nutmeg is a spice that has been used in culinary arts and food preparation since ancient times. It is claimed that nutmeg can be used to treat ailments of the digestive tract such as stomach cramps and diarrhea as well as catarrh of the respiratory tract. Extracts of nutmeg were found to stimulate mounting behavior in mice and to significantly increase their mating performance, with no conspicuous general short-term toxicity. Nutmeg oil possesses strong antibacterial, antifungal, anti-inflammatory, and insecticidal properties due to the presence of sarbinen, β- and α-pinenes, eugenols, isoeugenols, methyl engenol, safrol, neolignan, myristicin, ellemicin, and linalool. Myristicin isolated from the nut has hallucinogenic properties, and lignin types of the constituents are anticarcinogenic [25]. There is a need to scientifically validate the therapeutic potential of nutmeg using a reverse pharmacology approach.

9.3.4 Onion (Allium cepa)

Onions are commonly used worldwide as food component and whole green plant & their dried bulbs are used in food preparations. Onion juice has been claimed to treat appetite loss, the prevention of age-related changes in blood vessels (arteriosclerosis), minor digestive disturbances, and other ailments such as cold, cough, asthma, and diabetes. Onions undergo enzymatic breakdown of sulfur-containing substances due to damage to tissues, and this gives off pungent volatile compounds that cause weeping. The pharmacological activity and the pungent smell are due to sulfur-containing compounds, mainly sulfoxides and cepanenes. The therapeutic properties of onion require more clinical emphasis to scientifically validate the potential of this plant.

9.3.5 *Black Pepper* (Piper nigrum)

Black pepper is the core spice in the preparation of curry, which has been used since ancient times. It contains β- and α-pinenes, δ-limonene, and β-caryophyllene as major components. Major compounds in fresh pepper include trans-linanalool oxide and α-terpineol. Pepper has long been recognized as a carminative due to its beneficial effects of stimulating gastric acid secretion by piperine. It has impressive antioxidant and anti-inflammatory effects. Chili causes dyspepsia in patients with or without ulcers, and patients with ulcers are often advised to avoid its use. The protective effect of capsicum could involve vanilloid receptors because resiniferatoxin, an ultrapotent analog of capsaicin, also displays antiulcer activity. Piperine has synergistic effects and increases bioavailability of some modern drugs [26]. Recent reverse pharmacological studies also suggest that piperine has good antioxidant potential and shows protective effects against heavy metal toxicity. A reverse pharmacological approach is needed to scientifically validate the therapeutic use of black pepper. Some pharmaceutical preparations of piperine are available in combination with some antibiotics to increase its bioavailability and reduce toxicity.

9.3.6 *Chili* (Capcicum frutescens)

Chili pepper is a hot spice and an essential component of culinary preparation. Scientifically, it may interact with epithelial cells of the gastrointestinal tract to modulate their transport properties. It contains piperine and capsaicin as the main components. Several pharmacological effects of capsaicin transiently reduced resistance and piperine increased resistance, making them similarly effective as seen with crude spice extract. Both red and black pepper may induce epigastric pain by removing the stomach's hydrophobic lining and activating intramucosal pain receptors. Chili, being rich in phenolic compounds, would be expected to bind iron in the intestine and inhibit its absorption. Capsaicin in commercially available therapeutic skin creams is effective in the treatment of various kinds of pain [27, 28].

9.3.7 *Red Pepper* (Capsicum annuum)

Red pepper contains capsain and capsaicin and is used as a spice and as medicine. Capsaicin, the pungent active principal component of red chili, has been shown to cause gastric mucosal edema and hyperemia and decrease gastric acid output. Capsaicin helps in the metabolism of epoxide aromatic hydrocarbons, which interferes with their ability to bind to DNA (causing mutations). Capsaicin interacts with

the cough receptor and sensitizes it and produces coughing [28, 29]. The reverse pharmacological approach is further needed to validate Ayurvedic claims and to understand this spice's molecular mechanisms of action.

9.3.8 Tamarind (Tamarindus indica)

The fruit of tamarind has a sour taste and is commonly used in food preparations to increase taste. It has numerous traditional therapeutic uses, including in the treatment of liver and bile disorders. The fruit pulp is used as a drink and is rich in pectin, monosaccharides, and organic acids. Further research is needed to scientifically validate the use of tamarind as a therapeutic preparation.

9.3.9 Turmeric (Curcuma longa)

Turmeric is a yellow powder obtained from the dried rhizome of the *Curcuma longa* plant. Apart from its culinary appeal and common use as a spice, it has been well known in India for its medicinal properties for more than 6,000 years. The powder form is used in various dishes. It is a widely and extensively studied spice of Indian origin. It is used in the treatment of peptic ulcer and for its carminative effects. Curcumin [1,7-bis (4-hudroxy-3-methoxy phenyl)-1-6-heptadine-3-5-dione], demethoxycurcumin, and bis-dimethoxycurcumin are the main yellow compounds isolated from turmeric. Its immunomodulatory, antioxidant, anti-inflammatory, and antitumor properties are well documented. The molecular structure of turmeric is widely understood. The pharmacological actions of turmeric are wast, and some of them are discussed in what follows.

Curcumin reduces nitric oxide (NO) and exerts beneficial effects in experimental colitis, which is why inflammatory bowel disease (IBD) due to oxidative and nitrosative stresses is treated using this yellow pigment. The three types of curcuminoids, I, II, and III, differ with regard to their hydroxyl and methyl groups. Whole turmeric or extracted curcuminoids appear to be active in many disease processes, with specific reference to chronic ailments such as cardiovascular, degenerative, infective, and inflammatory disorders as well as cancers [30].

The chemopreventive and bioprotectant properties of curcumin in turmeric increases cancer cells' sensitivity to certain drugs commonly used to combat cancer, rendering chemotherapy more effective. Curcumin also possesses strong antimicrobial activity and inhibits the HIV-1 integrase enzyme. Curcumin and capsaicin alter bile salt secretion to make it less lithogenic and lower cholesterol levels, with no significant effect on fat absorption. Capsaicin with curcumin acts as a lipotrope, preventing triglyceride accumulation and increasing preferential utilization of fats [31]. It also stimulates lipid mobilization and lowers adipose tissue weight and serum triglycerides in fat-fed rats. The therapeutic uses of curcumin are limited

because of its unstable nature in isolated form. According to researchers studying turmeric, the bioavailablity of curcumin is very low. When curcumin is combined with piperine, its unstable nature and bioavailability increased. It is a wonder spice and has strong therapeutic potential in preventing many diseases including cancer [32]. But no single drug comes out from this golden spice for medical practice till date. There is a need for further research using pharmaceutical techniques to increase curcumin's stability and to enhance its bioavailability. Drug targeted delivery systems like nanotechnology are needed to take advantage of the therapeutic potential of curcumin to treat and prevent noncurable diseases like cancer [30, 33]. Reverse pharmacological approaches and use of molecular biology techniques are needed to understand its molecular mechanisms of action at signal transduction level.

9.3.10 Star Anise (Illicium verum)

In star anise, the presence of prenyl moiety in the phenylpropanoid plays an important role in antitumor-promoting activity. Hence, prenylated phenylpropanoids might be valuable as a potential cancer chemoprotective agent. Star anise is the industrial source of shikimic acid, a primary ingredient used to create the antiflu drug Tamiflu, which is regarded as the most promising drug to mitigate the severity of the bird flu H_5N_1 strain of virus. Tamiflu is the only therapeutic drug available for clinical use in modern medicine that may reduce the severity of bird flu [34].

9.3.11 Tulsi (Ocimum sanctum)

Preliminary studies on Tulsi have shown that its leaves and seeds may help people with type 2 diabetes to control their blood sugar level. Its protective effects in stress and anxiety disorders have also been proven. Its leaves are used in medicated diets and in herbal teas, which have some potential protective effects against sore throat and respiratory infections. It is commercially available in powder form for therapeutic purposes [35].

9.3.12 Curry Leaf (Murraya koenigii)

The curry leaf plant is highly valued for its characteristic aroma and medicinal value. A number of leaf essential oil constituents and carbazole, murrayacine, and koenigine alkaloids have been extracted from the plant. There are a large number of oxygenated mono- and sesquiterpenes present, for example, cis-ocimene (34.1 %), β-caryophyllene (9.5 %), α-pinene (19.1 %), δ-terpine (6.7 %), and β-phellandrene,

which appear to be responsible for intense odor associated with stalk and flowery parts of curry leaves. Both *Murraya koenigii* and *Brassica juncea* showed significant hypoglycemic action in experimental rats [36].

9.3.13 Bitter Gourd (Momordica charantia)

Commonly known as bitter melon, bitter lemon, and karela in Hindi, the gourd is an economically important medicinal food plant. The immature fruit is eaten as a vegetable and is a good source of vitamins C and A, phosphorus, and iron. The vitamin content of Chinese bitter gourd varies from 440 to 780 mg/kg per edible portion. The secondary metabolites are cucurbitane-type triterpenoids. These compounds and their glycones showed some biological effects that are beneficial in the treatment of diabetes and obesity. A scientific review on the antidiabetic and hypoglycemic effects of *M. charantia* in animal and clinical studies showed some promising protective abilities. The fruits and seeds of the bitter gourd possess medicinal properties such as anti-HIV, anticancer, anti-inflammatory, antileukemic, antimicrobial, antitumor, and antidiabetic properties [37]. Freeze-dried bitter melon capsules are widely available and marketed in health food stores worldwide. The low-calorie bitter gourd buccal tablet commonly has an auxiliary therapeutic use in the treatment of diabetes.

9.3.14 Lotus (Nelumbo nicifera)

The juice of the lotus is extracted from edible fruits and mixed with some edible medicinal herbs for health benefits. Fresh lotus (*Nelumbo nicifera*) leaves are a good example of hypolipidimic & hypoglycemic agent documented in the *Compendium of Metrica Medica* and *Pharmacopoeia* of the People's Republic of China (2005). Studies on the lotus leaf methanolic extract shows its hypoglycemic effects and may be useful in the control of hyperglycemia in non-insulin-dependent diabetes mellitus through their pharmacological action as insulin secretagogues in vitro and in vivo [38]. The total alkaloid extracts of the lotus leaf have the therapeutic function of regulating lipids of hyperlipidemic rats. Clinical observations showed that lotus leaves have a significant role in reducing the blood lipid profile after 3 months of treatment [39]. To further scientifically validate the data, reverse pharmacological approaches are needed.

9.3.15 Grapes (Vitis venifera)

Grapes are edible food, and the first grape extract was used for human health more than 2,000 years ago. The extract of grapes, a commercially available *drakchsava*, a

well-known Indian Ayurvedic herbal preparation whose main ingredient is *Vitis vinifera* L., is prescribed as a cardiotonic and is administered in the treatment of several disorders. The use of dried grapes (also called *manakka*) as a carditonic is well documented. A high-performance liquid chromatography analysis of *drakchsava* revealed the presence of polyphenols such as resveratrol and pterostilbene. Interest in this ancient formulation grew in light of the recent knowledge of resveratrol [40].

Besides its cardioprotective effects, resveratrol exhibits anticancer properties, as suggested by its ability to suppress the proliferation of a wide variety of tumor cells, including lymphoid and myeloid cancers, multiple myeloma, and cancer of the breast, prostrate, and colon. Reverse pharmacological studies suggest that the growth-inhibiting effects of resveratrol are mediated through cell-cycle arrest, upregulation of p21, p53, and Bax genes and downregulation of survivin, cyclin D1, cyclin E, bcl-2, and bcl-Xl, and activation of caspases. Resveratrol has been shown to suppress the activation of several transcription factors, including NF-kB and AP-1; inhibit protein kinases, including IkBα kinases, JNK, MAPK, PKC, and casein kinase-II; and downregulate products of genes such as COX-2, 5-LOX, VEGF, IL-1, IL-6, IL-8 androgen receptors, and prostrate-specific antigens. In vivo, resveratrol blocks the multistep process of carcinogenesis at various stages. Besides its chemopreventive effects, resveratrol appears to exhibit therapeutic effects against cancer [41]. Limited clinical data in humans have revealed that resveratrol is quite safe. Currently, structural analogs of resveratrol with improved bioavailability are being pursued as potential therapeutic agents.

Some of the food-based therapeutic molecular targets are given in Table 9.2.

9.4 Medicated Food

India and China have represented the hub of traditional medicines for treating and preventing diseases since ancient times. In the theories of traditional Chinese and Ayurvedic medicine, food and medicine are of equal importance in regulating the body's physiology, preventing disease, or promoting recovery. In China, such food is known as medicated diet/food [42]. With the development of the economy and the continuous increases in people's living standards, medicated diets are becoming increasingly valued by people, and a number of scientific works on medicated diets have been published recently [43]. Medicated food has therapeutic effects. Medicated/herbal tea is the mixed powder of tea with herbs, such as fruits, flowers, and vegetables, which are often used as ingredients of medicated tea [44]. Fresh ginger and sugar tea are used to treat the wind cold-type of common cold, cough, and gastrointestinal problems [45]. Repeated administration of aqueous constituents of ginger augments serum corticosterone levels, and this could gradually induce anti-inflammatory activity [22]. The volatile oil of ginger has protective antioxidant effects on carbon tetrachloride-induced damage in mice and antiplatelet activities in rats [24].

Table 9.2 Molecular therapeutic target of some Ayurvedic food plants

Plant name	Uses	Molecular target
Asal rai (*Brassica oleracea*)	Rheumatism, sciatica, body massage	↓NF-kB, ↓cdc25, ↓Bcl-2
Bail (*Aegel marmelos*)	Constipation, diarrhea, peptic ulcer respiratory disorders, diabetes	↓NO
Dalchini (*Cinamomun zelanicum*)	Cold, diarrhea, edema, flu, liver problem menorrhagia, menstrual pain, indigestion	↓PGE_2
Pomegranate (*Punica gratum*)	Cough, digestive disorders, piles, pimples, dysentery	↓NF-kB
Dhanyaka (*Coriandrum sativum*)	Menstrual disorders, skin diseases, conjunctivitis	↓NF-kB, ↓AP-1, ↓JNK, ↓MAPK
Draksha (*Vitis venefera*)	Constipation, blood circulation, cancer	↓COX-2, ↓iNOS, ↓JNK, ↓MEK, ↓AP-1, ↓NF-kB, ↑p53, ↑Caspases, ↑5-LOX
Jambulan (*Syzygium cumini*)	Diarrhea, inflammation	↓NF-kB
Mulethi (*Glycyrrhiza glabra*)	Constipation, mouth ulcers, sore throat	↓p21
Mustard (*Brassica compestris*)	Eczema, intestinal catarrah, colic pain, indigestion	↓NF-kB, ↓cdc25, ↓cdk1 ↓Bcl-2, ↓Bcl-xL
Sauf (*Foeniculum vulgare*)	Hookworm	↓NF-kB, ↓AP-1, ↓JNK, ↓MAPK
Soyabean (*Glycine max*)	Malnutrition, allergies, dandruff	↓NF-kB
Tulsi (*Ocimum sanctum*)	Anti-inflammatory, expectorant, analgesic antitumor, antibacterial	↓NF-kB
Turmeric (*Curcuma longa*)	Antiseptic, anti-inflammatory, antioxidant	↓NF-kB, ↓TNF, ↓AP-1, ↓IL-6, ↓ICAM-1, ↓VCAM-1 ↓iNOS, ↓COX-2

Aggarwal et al. [33]
COX Cyclooxygenase, *iNOS* Inducible nitric oxide synthase, *LOX* Lipoxygenase, *NF-kB* Nuclear factor B, *NO* Nitric oxide, *PGE* Prostaglandin E, *PKC* Protein kinase C, *cdc25* Cyclin-dependent calcium 25, *MAPK* Mitogen-activated protein kinase, *cdk* Cyclin-dependent kinase, *ICAM* Intracellular cell adhesion molecule, *IL* Interleukin, *TNF* Tumor necrosis factor, *VCAM* Vascular cell adhesion molecule

9.5 Future Trends

Ayurveda is an indigenous system of medicine based on science. Traditional food-based medicine is quite common in India and China. Traditional medicine in the developed world is known as complementary and alternative medicine (CAM). Chinese traditional medicine is based on herbs that can prevent diseases and strengthen an individual's body. In recent years, there has been an emphasis on

secondary metabolites in relation to dietary components that may have a considerable impact on human health. Reports from studies on animal models and in vitro systems will direct future research perspectives in this area. The action of spices on reproductive functions as well as their potential role as regulators of fertility or conception is an area that holds great promise. Synergy is an important concept in spice physiology and has a pharmacokinetic basis. The components of whole spices that are not active themselves can act to improve the stability, solubility, bioavailability, or half-life of the active components. Hence a certain chemical might in pure form have only a fraction of the pharmacological activity that it has in its plant matrix. This suggests that measuring an individual's food intake and assessing individual variations in the disposition, bioavailability, and metabolism of micronutrients might allow for more accurate and individualized nutritional approaches to dietary prescription. Dietary modifications will only work if they are in consonance with individual preferences, cultural values, and philosophical orientation toward health and disease. Traditional Indian and Chinese medicine will require extensive scientific research to further validate the therapeutic and preventive claims of food-based herbal medicines.

References

1. Charaka (700BC) Charaka samhita. Chaukhamba Orientalia, Varansi
2. Kapoor LD (1990) Hand book of Ayurvedic medicinal plants. CRC Press, Florida
3. Rastogi S, Chiappelli F, Ramchandani MH, Singh RH (eds) (2012) Evidence-based practice in complementary and alternative medicine: perspectives, protocols, problems and potentials in Ayurveda . Springer, Berlin/Heidelberg
4. Achinewhu SC, Ogbonna CC, Hart AD (1995) Chemical composition of indigenous wild herbs, spices, fruits, nuts and leafy vegetables used as food. Plant Food Hum Nutr 48:341–348
5. Chu YF, Sun J, Wu X, Liu RH (2002) Antioxidant and anti-proliferative activities of common vegetables. J Agric Food Chem 50(23):6910–6916
6. Balentine DA, Albno MC, Nair MG (1999) Role of medicinal plants, herbs and spices in protecting human health. Nutr Rev 57 volume (9 pt2):S41–S45
7. Jaouad B (ed) (2012) Nutrition, well being and health., pp 189–200. ISBN 978-953-51-0125-3
8. Santosa S, Farnworth E, Jones JHP (2006) Probiotics and their health claims. Nutr Rev 64(6):265–274
9. Eriction KL, Hubbard NE (2000) Probiotic immunomodulation in health and disease. J Nutr 130(2S):403S–409S
10. Farnsworth NR (1985) Medicinal plant in therapy. Bull World Health Organ (WHO) 63: 695–981
11. Heber D, Bowerman S (2001) What color is your diet? Heper Collins/Regan, New York
12. Craig WJ (1999) Health-promoting properties of common herbs. Am J Clin Nutr 70:4918–4998
13. Kochhar KP (2008) Dietary spices in health and diseases (II). Indian J Physiol Pharmacol 52(4):327–354
14. Krishnaswami K (2008) Traditional Indian spices and their health significance. Asia Pac J Clin Nutr 17(S1):256–268
15. Lawrence VA (2001) Garlic shows promise some cardiovascular risk factor. Arch Intern Med 161:813–824
16. Stevinson C, Pittler MH, Ernst E (2000) Garlic for treating hypercholesterolemia. A meta-analysis of randomized clinical trials. Ann Intern Med 133:420–429

17. Agarwal KC (1996) Therapeutic action of garlic constituents. Med Res Rev 16:111–124
18. Block E (1985) The chemistry of garlic and onion. Sci Am 252:95–99
19. Cavallito C, Baily JH (1994) Allicin, the antibacterial principle of *Allium sativum*, isolation, physical properties and antibacterial action. J Am Chem Soc 66:1944–1952
20. Ohaeri OC, Adoga GI (2006) Anticoagulant modulation of blood cells and platelet reactivity by garlic oil in experimental diabetes mellitus. Biosci Rep 26:1–6
21. Schulick P (1996) Ginger: common spice and wonder drug. Herbal Free Press, Brattleboro
22. Hiroshi U, Katsunari I, Atsuko T (2010) Repeated oral administration of a squeezed ginger (*Zingiber officinale*) extract augmented the serum corticosterone level and had anti-inflammatory properties. Biosci Biotech Biochem 74(11):2248–2252
23. Phillips S, Ruggier R, Hutchinson SE (1993) *Zingiber officinale* (ginger), an anti-emetic for day care surgery. Anesthesia 48:715–717
24. Sun XS (2010) Effect of ginger extract on lipid peroxidation in liver of carbon tetrachloride damaged mice. Guide of China Med 8(23):26–27
25. Narasimhan B, Dhake AS (2006) Antibacterial principles from *Myristica franrans* seeds. J Med Food 9(3):395–399
26. Vijay kumar RS, Surya D, Nalini N (2004) Antioxidant efficacy of black pepper (*Piper nigrum*) and piperine in rats with high fat diet induced oxidative stress. Redox Rep 9(2): 105–110
27. Bhatia SJ (2000) Red hot chilli pepper: irritating the irritable colon. Indian J Gatroenterol 19:156–157
28. Desai HG, Venugopalan K, Philipose M, Zaveri MP, Kalro RH, Anita FP (1977) Effect of red chilli powder on gastric mucosal barrier and secretion. Indian J Med Res 66(3):440–448
29. Columbus LF (1987) Capsicum and capsaicin: past, present and future. Acta Physiol Hung 69:265–273
30. Bush TA, Cheung KJJ, Li G (2001) Curcumin induces apoptosis in human melanoma cells through a Fas receptors/caspase pathway independent of p53. Exp Cells Res 27(2):305–314
31. Jensen-Jarolim E, Gaidzik L, Haberl I, Karaft D, Scheiner O, Graf J (1998) Hot spices influence permeability of human intestinal epithelial monolayers. J Nutr 128:577–581
32. Kitts DD (1994) Bioactive substances in food: identification and potential uses. Can J Physiol Pharmacol 72:423–434
33. Aggarwal BB, Ichikawa H, Garodia P, Weersinghe P, Sethi G, Bhat ID, Pandey MK, Shishodia S, Nair MG (2006) From traditional Ayurvedic medicine to modern medicine: identification of therapeutic targets for suppression of inflammation and cancer. Expert Opin Ther Targets 10(1):87–118
34. Goodman PS (2005) Star anise in fight against bird flu: demand for a Chinese skyrockets. Washington Post Foreign Service, 18 Nov, p DO1
35. Rai V, Mani UV, Iyer UM (1997) Effect of *Ocimum sanctum* leaf powder on blood lipoproteins, glycated protein and total amino acids in patients with non insulin-dependent diabetes mellitus. J Nutr Environ Med 7:113–118
36. Khan BA, Abraham A, Leelamma S (1996) Biochemical response in rats to the addition of curry leaf (*Murraya koeigli*) and mustard seeds to the diet. Plant Foods Hum Nutr 49: 295–299
37. Sun FQ, Zhang GZ (2000) Clinical observation of bitter gourd buccal tablet in treating diabetic. Liaoning J Prac Diabetol 8(4):34–35
38. Xie JX (2010) Clinical observation of the effect of lotus leaves on hyperlipidemia. Chronic Pathematol J 12(7):634
39. Zang YB, Li CX, Li J, Wu YQ (2005) Study on extracted flavonoid from lotus leaf. Food Res Dev 26(5):94–96
40. Paul B, Masih I, Deopujari J, Charpenter C (1999) Occurrence of resveratrol and pterostilbene in age-old drakchsava, an Ayurvedic medicine from India. J Ethnopharmacol 68:71–76
41. Steinmetz KA, Potter JD (1996) Vegetables, fruits and cancer prevention: a review. J Am Diet Assoc 96:1027–1039

42. The Pharmacopoeia Commission of PRC (eds) (2005) Pharmacopoeia of People's Republic of China. Chinese Medicine and Technology Press, Beijing, ISBN 978-750-6744-37-9
43. He RR, Kurihara H, Bao L, Yao XS (2008) The effect of Wang Laoji Liangcha on plasma lipid metabolism in restraint mice. China J Expl Trad Med Formulae 14(10):31–33
44. He QT, Yu YG, Li JT, Wu H (2011) A comparative study of antioxidant activities of 20 kinds of herbal tea saled in the market. Food Sci 32(7):47–51
45. Trevisanato SI, Kim YI (2000) Tea and health. Nutr Rev 58(1):1–10

Chapter 10
Fasting as a Curative Practice: Historical, Traditional, and Contemporary Perspective

Rajiv Rastogi and Devesh Rastogi

10.1 Introduction: Historical Perspectives of Fasting

Fasting has been practiced since time immemorial for religious, spiritual, physical, and psychological purposes [1]. Historically, fasting was an ancient and universal practice. The Romans, Babylonians, Cynics, Stoics, Pythagoreans and Neoplatonist philosophers extolled fasting. Adherents of Zoroastrianism practice it. Jews observe an annual fast on the Day of Atonement in commemoration of the descent of Moses from Mount Sinai after having spent 40 days fasting in order to be able to receive the divine revelation. Jesus observed fasting for 40 days in the desert and commanded his followers to fast. In brief, the practice of fasting has been common in one form or another in many human societies. Before the advent of Islam, fasting was resorted to by way of repentance or penance, to celebrate some particular occasion, or to control an epidemic. The form of fasting also differed. For example, Jews ate only once in 24 h. In fact, in ancient faiths and creeds, the objects of fasting were very limited, the intention generally being self-mortification, self-denial, or the satisfaction of some superstitious urge. In Islam, fasting entails not simply refraining from eating or drinking but carries the added significance of worship, psychological comfort, morality, and legislation. It is neither the irrational motionlessness of pre-Islamic Arabs nor the mere abstaining from eating and drinking; it represents the building of one's character, exerting control over one's desires, and inspiring one toward social and scientific creativity [2].

Fasting as a religious observance has long been practiced for the accomplishment of certain goods. Religious fasting is of early origin, antedating recorded history. Partial or total abstinence from food, or from certain kinds of food, in certain

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seasons, was prevalent in Assyria, Persia, Babylon, Scythia, Greece, Rome, India, Nineveh, Palestine, China, Northern Europe among the Druids, and in the Americas among the Native Americans. It was a widely diffused practice, often indulged in as a means of penitence or mourning and as a preparation for participation in religious rites, such as baptism and communion [3].

10.2 Fasting in Indian Scriptures

Hindu scriptures contain abundant references to fasting as a method of attaining greater purity and strength in body and mind with the aim of achieving a desired goal with the blessings of the presiding deity. Hindu scriptures mention an ancient saint, *Dadhichi*, whose bones became very strong due to perennial fasting, and Indra (King of Gods) used those bones to make his weapon Vajra to fight demons [4]. In *Rigveda*, fasting is considered supreme medicine for eliminating accumulated toxins from the body. The *Bhagavat Gita* has elucidated in detail the three varieties of food, *Sattvik, Tamasik*, and *Rajasik*, and their effects on the human body and mind [5]. The *Anushasan* chapter of *Mahabharata* says:

> Whosoever fasts is blessed in every way,
> He draws the benefits of all the great medicines,
> All his diseases are cured and he becomes strong and virile. [6]

The *Manu Smriti*, while setting down the rules and regulations regarding personal hygiene, explains the methods of fasting [4].

Ayurveda mentions fasting as a process of "making one lighter"(*langhana*). When properly done, it is a process of revitalization [7].

In modern times, fasting has been used as a contemporary tool to raise one's voice in protest against societal ills. Several notable people were able to evoke mass public sentiment due to this. Mahatma Gandhi (India) was an exemplar of the use of fasting for nonpersonal reasons [8]. In 1933, when Gandhi was on his tenth day of fasting, he was examined by his physicians. One of the physicians stated that "despite his 64 years, from a physiological point of view the Indian leader is as healthy as a man of 40" [4]. Dr. Herbert Shelton, in his book *The Science and Fine Art of Fasting*, also refers to the fasting of Jayaprakash Narayan, leader of the Indian Socialist party, who fasted for 21 days, which enabled him to better fulfill his public duties. He underwent this purification fast at a nature cure clinic under the supervision of the clinician who had supervised several of Gandhi's fasts [3].

10.3 Understanding Fasting

A fast constitutes an abstinence from specific food items. Fasting is a period of abstinence during which the fast is observed. Fluids are consumed in sufficient quantity to satisfy thirst and physiologic requirements. In the absence of food, the

body systematically cleanses itself and consumes stored food. Starvation occurs only when the body uses up what is stored and is forced to survive on protein. Although protein is used by the body during a fast, a person fasting for even 40 days on water will not suffer from a deficiency of protein, vitamins, minerals, or fatty acids. During the breakdown of unhealthy cells, all essential substances are used and conserved in a most extraordinary manner. There is an unwarranted fear that during fasting, strength diminishes from the catabolism of proteins from muscle fibers. Even during long fasts, the number of muscle fibers remains the same. Although healthy cells may be reduced in size and strength for a time, they remain perfectly sound.

A. J. Carlson, professor of physiology at the University of Chicago, states that a healthy, well-nourished man can live from 50 to 75 days without food, provided he is not exposed to harsh elements or emotional stress. Human fat is valued at 3,500 cal per pound. Each extra pound of fat will supply enough calories for 1 day of hard physical labor. Ten pounds of fat are equal to 35,000 cal! Most of us have sufficient reserves that are capable of sustaining us for many weeks.

Rest is understood to be a big factor in enhancing recovery, because it is when the body is at rest that it is able to direct the most energy toward the various chemical and mechanical processes of detoxification. When fasting, a person experiences recovery at a rate that is swifter than normal. He is ridding his body of toxins and excesses, allowing the body to use its own wisdom to healthfully reorganize itself from the atomic level. As the toxic load is reduced, the functioning of every cell is enhanced. The human body has many ordinary modes of achieving elimination, for example, the liver, lungs, kidneys, and colon. When these are overloaded, the body will resort to "extra ordinary" methods of elimination: boils, mucus and other discharges, sweat, vomiting, diarrhea, and many others. Should elimination be impossible or uneconomical of body energy, the toxic overload will go into storage forms in the joints, vessels, muscles, and organs – almost any tissue in the body. While fasting, the body is highly conservative of its energy and resources. During this deep and profound rest, toxin intake and production are reduced to a minimum, while autolysins and elimination proceed unchecked. Anabolic processes such as tissue and bone healing also proceed at a maximal rate during fasting.

In the body, the first stage of cleansing removes large quantities of waste matter and digestive residues. The first few days of a fast can be rough due to the quantity of waste passing into the blood stream. The tongue becomes coated and the breath foul as the body excretes waste through every opening. After the third day of the fast, there is little desire for food. The second stage is the cleansing of mucus, fat, and diseased and dying cells, and that more easily removes toxins. As the fast continues, the cleansing process becomes more thorough. The last stage is the cleansing of toxins that have been accumulating in cellular tissues and in the microscopic channels transporting vital elements everywhere in the body. Cleansing of the last layer is only possible through a combination of juice fasting, water fasting, and a healthy diet high in raw foods. To overcome a severe disease like cancer, it is important to continue through a series of fasts, to the point where the full scouring action of catabolism removes the disease from the tissue.

During extended fasts the body removes dead, dying, and diseased cells; unwanted fatty tissue, trans-fatty acids, and the hardened coating of mucus on the intestinal wall; toxic waste matter in the lymphatic system and bloodstream; toxins in the spleen, liver, and kidney; mucus from the lungs and sinuses and toxins imbedded in cellular fibers and deeper organ tissues; deposits in the microscopic tubes responsible for nourishing brain cells; and excess cholesterol.

Nearly everyone who fasts discovers the same thing: when they fast, they actually have no hunger yet have more energy than usual [9].

10.4 Why Fast?

Probably the most important reason to fast is that the body uses quite a bit of energy to digest food, and during fasting this energy becomes available for other uses. During the fasting state, the body scours for dead cells, damaged tissues, fatty deposits, tumors, and abscesses, all of which are used as fuel that eventually gets exhausted. The elimination of these obstructions restores the immune system functionality and metabolic process to an optimum state. Fasting restores good digestion and elimination, and peristaltic action is quickened. Fasting allows the digestive organs to have a deep, physiological rest, and the energy saved goes to self-healing and self-repairing. By eliminating obstructions, cleansing, detoxifying, and purifying the intestines, blood, and cells, we can overcome many of our physical ailments or handicaps and obtain an energy boost. Fasting not only removes obstructions and helps the body heal itself; it is also rejuvenating and life-extending. These resulting benefits can have lasting effects on the mental and emotional health of a person.

The other very important aspect of fasting is that one's self-awareness will be elevated. If one is sick and depressed, then this might be the most important thing one can try in a healing program because it gives an immediate energy boost and increased awareness that might allow a clearer perspective, making possible the first step out of sickness and onto the path of recovery. While fasting one becomes more aware of bodily processes and life in general. It becomes a period where one can engage in objective introspection since more free time is available for contemplation because of avoidance of time used for food preparation and eating. One becomes more aware of what the body likes and dislikes when one starts to eat again. Self-confidence in the ability to control one's own life process is also increased [9].

10.5 Fasting as a Curative Practice

The practice of fasting for the treatment of physical ailments dates back to prehistoric periods, with wild animals experiencing the avoidance of food as a method of treatment [10]. For more than 2,000 years now fasting has been advocated and practiced as a rule in connection to religious ceremonies [11]. Hippocrates

recommended fasting regularly to many of his patients. He asserted that when you feed the sick, you feed the disease. On the other hand, if you withhold food, disease ebbs away [4].

Plutarch said: "Instead of using medicine, better fast a day [8]."

During the sixteenth century, the renowned Swiss physician Paracelsus claimed that "Fasting is the greatest remedy." In the seventeenth century, Dr. Hoffman wrote a book titled *Description of the Magnificent Results Obtained Through Fasting in All Diseases.* Dr. Anton Nikolai followed in the next century with recommendations of fasting instead of food for those who were ill. Later, Dr. Von Seeland of Russia wrote: "As a result of experiments I have come to the conclusion that fasting is not only a therapeutic of the highest degree possible but also deserves consideration educationally." In Germany, Dr. Adolph Mayer asserted that "fasting is the most efficient means of correcting any disease," and Dr. Moeller wrote that "fasting is the only natural evolutionary method whereby through a systemic cleansing, you can restore yourself by degrees to physiologic normality" [8].

10.5.1 Conditions Where Fasting Is Beneficial

Although fasting is not recommended in every situation (cancer of the liver is one instance where fasting is contraindicated), in many other situations fasting is the only known solution. Fasting has been beneficial for arthritis, asthma, high blood pressure, lupus, chronic fatigue, colitis, Crohn's disease, diverticulitis, spastic colon, irritable bowel, paralysis, neuritis, neuralgia, neuroses, and mental illness, as well as many others. Fasting may also lead to the breaking down of tumor cells, and for this reason many people have overcome cancer by fasting.

Fasting is the gateway to health [6]. It is considered a universal remedy for treating most disease conditions and is especially recommended in treating disorders such as, for example, indigestion, constipation, flatulence, hyperacidity, bronchial asthma, obesity, high blood pressure, and gout [21].

10.5.2 Benefits of Fasting

Fasting is linked with many benefits for the healthy as well as to the sick. A few such benefits are observed commonly during a supervised fast.

Clearing of the mind and improved perception
Rapid yet safe weight loss
Increased energy level
Revitalization of the organs
Harmonization of cellular biochemistry
Rejuvenation of the skin
Ease of movement

Fuller, freer, and deeper breathing
Rejuvenation of digestive system to become more effective; strengthening of peristaltic action of intestines
Increased confidence in our ability to have control over our lives and our appetite and that our body is self-regulating and self-healing
Realization that our organism is capable of establishing balance when given the opportunity to do so
Normalization of metabolic cycle and cell oxygenation
Detoxification: as soon as the body realizes it is fasting, it will begin to eliminate those things that cause disease, such as, for example, dead cells, cellular plaques, mucus, and tumors [9].

10.5.3 Fasting Enhances Mental Acuity

Perhaps the most instructive testimony as to the acuteness of mental powers during fasting comes from Dr. Herbert Shelton, who supervised the fasting of more than 40,000 people over a period of 50 years. His message is that the freer the body is of toxic materials flowing through the blood and lymphatic system, the clearer is the ability to think.

These facts are due to physiological causes. Large amounts of blood and nervous system energies must be sent to the digestive organs to digest a meal. If these energies are not required there, they may be used by the brain for better thinking. This increase in mental acuity does not usually happen until after the first few days of a fast because the body is busy cleaning out excess toxins and substances, and so the first few days can be a period of depression, with headaches and various pains as the process gets under way. This makes the first stage of fasting difficult, but after the body has thrown off its load of toxins, the brain is fed by a cleaner bloodstream and the mental powers and clarity of thought are extraordinarily increased, and the other senses also become more acute.

One's mind becomes clearer and one's ability to think and solve intricate problems is enhanced. One is simply more alert, and one's mind seems to open up into new fields. The mental and physical senses are heightened, and often there can be a feeling of euphoria, especially during longer fasts. Some, for the first time, will experience emotional stability. The reasons for this are manifold – the elimination of the emotional dependence on food, exclusion of stimulating foods like caffeine, processed sugars, recreational drugs, tobacco, and trans-fatty acids, all of which can have a devastating effect on delicate emotions.

Dr. Ehret stated an amazing fact at the turn of the twentieth century. He said that, for a water fast to awaken the higher mental functions, it had to be longer than 21 days. Fasting has a history of awakening intuitive senses, creativity, and deeper spiritual questions in those with enough determination to get past the 21-day mark.

10.5.4 Healing Through Fasting

During a fast, a metamorphosis occurs. The body undergoes a tearing down and rebuilding of damaged materials. For this reason, fasting is known for its ability to rejuvenate the body and give it a more youthful tone. Why does fasting have such a powerful effect in healing the body? Fasting dissolves diseased cells in a systematic manner, leaving healthy tissues behind. The result is a thorough cleansing of the vessels, membranes, and cellular components. There is a remarkable redistribution of nutrients in the fasting body. It hangs on to precious minerals and vitamins while catabolizing old tissue, toxins, and inferior materials.

Each cell of the body is a complete living entity with its own metabolism. It needs a constant supply of oxygen and sufficient nourishment. Due to nutritional deficiencies, sluggish metabolism, sedentary lifestyle, overeating, and consequent poor digestion and assimilation of food, a lack of fresh air, and sufficient exercise and rest, cells get deprived and start to degenerate. The normal process of cell replacement and rebuilding slows down and the body starts to grow old, its resistance to disease diminishes, and it becomes sick.

Animals naturally fast when they are sick or injured. Incidentally, when humans are ill, the appetite diminishes. If we step out of the way and allow nature to take its course, we will find that we can heal ourselves of any ill. Since the dawn of recorded time, in fact, since before the word "doctor" came into existence, priests provided sanctuaries where people could go to fast. Modern medical practitioners admit they have no cures, only drugs that mask the symptoms while causing yet other symptoms to emerge.

10.6 Fasting as a Therapeutic Modality: Empirical Evidences

The empirical evidences of fasting are numerous. It affects the skin, gastrointestinal system, and excretory system and rejuvenates the body. In the words of Dr. Shelton, "The skin becomes more youthful, acquires a better color and better texture. The eyes clear up and become brighter. One looks younger. The visible rejuvenation in the skin is matched by evidences of similar but invisible rejuvenation throughout the body."

During a fast, the assimilative powers of the body increase. This is shown through an improved state of the blood during the rapid assimilation of food after the fast. The assimilation of food after a fast reaches the highest possible levels. Kagan observed that when rabbits were fasted for 17 days, they gained 56 % of their weight on a diet that, under usual conditions, would barely be sufficient to maintain a state of equilibrium. People who are chronically underweight, in spite of eating heavily, often gain weight to the normal level after a fast, even if large quantities of food are not consumed. The improved assimilation enables the body to utilize more of the food it has consumed. Fasting offers the body's organs the closest possible state to

total physiological rest. Many organs are overworked and overstimulated, and hence weakened, through the constant influx of substrates and metabolites. During a fast, the work done by the organs is reduced to the lowest possible minimum. In the absence of further intake, the body redistributes the elements already stored within. Thus, the organs are given a chance to recuperate and restore their vital powers. Because there are no additional foods to deal with, damaged structures may be repaired in the meantime. Broken bones, wounds, and open sores heal much more rapidly during a fast. Any inflammation that may be present tends to subside. The body undergoes a general healing process.

Associated with the physiological rest of an organ is increased elimination. This is one valuable advantage of fasting. Part of the energy that would normally be devoted to the work of assimilation may, during a fast, be used to expel any accumulated waste and toxins. Decomposed food in the digestive tract, which often acts as a source of toxins, is quickly eliminated through the process of fasting. A marked improvement in nervous and mental functions occurs during a fast. Fasting thus serves many purposes in terms of physiology and biochemistry. It rejuvenates tissues, induces autolysis of abnormal growths, improves digestive and assimilatory powers, reestablishes normal bodily chemistry and secretion, gives bodily organs a physiological rest, increases elimination, promotes nerve conduction, strengthens the mind, and perhaps improves bodily functions in various ways that we do not yet understand [8].

10.7 Fasting as a Therapeutic Modality: Contemporary Evidences

10.7.1 Physiology of Fasting and Hypothesis

Fasting is merely a digestive and physiological rest during which the body is enabled to devote all its energy to the elimination of accumulated waste, toxins, and undesirable material that might be responsible for diseases [1]. Fasting (abstention from all food and drink except water), combined with total rest (whenever possible), is the most logical and most valuable approach to regaining full health [12].

The primary function of fasting is to allow the gastrointestinal tract to rest and permit the system to turn its energies away from the processing of a continuously incoming stream of food and concentrate instead on the process of cleansing [7]. Dr. H. Lindlahr says that "in most cases proper adjustment of diet, both as to quality and quantity, together with the various forms of natural treatment, must precede fasting. The great majority of patients have become chronic because their skin, kidneys, intestines and other organs of elimination work sluggishly. As a result the system overloads with morbid matter which again reabsorbs unless promptly eliminated to prevent reabsorption" [13].

Foremost among the methods of purification is fasting [13]. It is characterized as a healing measure of nature [14]. It is undoubtedly one of the most potent and cheapest of all natural remedies. The reason that it is not more universally applied

is that society at large, as well as the medical profession, is under the impression that the interruption of eating for a brief period will greatly reduce the vitality of the individual [15].

Dr. Gian-Cursio, in the *Journal of Natural Hygiene* (1955–1956), explains this process clearly when he says that the chief function of the body during a fast is "to obtain within itself the elements essential to life," and that "removal of toxins stored in the cells is secondary to the more basic function of supplying the body (the vital or functioning tissues) with the (nutritive) essentials of life during the fast" [10, 16].

10.8 Perspectives of Fasting in *Ayurveda*

Fasting (*langhana*) is given its due importance in Ayurveda and is counted as one of the six primary therapeutic measures (*shada-upakramas*) [11]. It is considered a primary remedy in the treatment of diseases arising from excess intake of food (*santarpana*). *Langhana* produces *laghutva* (lightness) [17].

10.9 Perspectives of Fasting in Naturopathy

Fasting represents *Akasha tatva*, i.e., space, one of the *pancha-mahabhootas.* Fasting is the most convenient method of cleansing the body and getting rid of disease [18]. According to Dr. Carington, a specialist in fast therapy, a fast starts with leaving the first meal and ends when the feeling of a genuine appetite appears. Fast is an excellent method for physical, mental, and spiritual uplift, but its advantages can be realized only if it is done systematically [18].

Naturopathy accepts fasting as a therapy for the treatment of most disorders. During fasting, the body recoups considerably the *Aakash tatva* (space element) [6]. Dr. Herbert M. Shelton worked extensively on fasting and successfully treated thousands of patients suffering from various chronic ailments [19, 20]. He shared his experiences with fasting in his book *Fasting Can Save Your Life*. The success of fasting also depends on the process through which it is broken. The rules for breaking a fast as recommended in naturopathy are as follows:

Take several days to gradually transition back to the normal diet.
Eat slowly and chew food thoroughly.
Do not overeat.

Naturopathy believes that fasting is a process of giving rest to the digestive system. During this process, the vital energy that digests food is wholly engaged in the elimination of diseases from the body [21].

Mahatma Gandhi stated his views on fasting in his book *Key to Health*: "*We must not fill up the digestive tract with unnecessary food stuffs. We should eat only as much as we need and not more. Often one over eats or eats indigestible things*

without being aware of them. An occasional fast, say once a week or once a fortnight, will enable one to keep the balance. If one is unable to fast for the whole day one should miss one or more meals during the day" [22].

10.10 Methods of Fasting

Fasting can be done with water, fruit juices, or raw vegetable juices. Short fasts may be done with water alone. The safest and most effective method of fasting is a lime juice and honey fast. The body burns up and eliminates the accumulated wastes during fasting. This cleansing process is accelerated by drinking alkaline juices prepared from fresh fruits or vegetables. Preserved juices are not recommended during fasting.

Complete emptying of the bowel is important before the start of fasting. This can be done by taking an enema. Enemas may be used every day during the period of fasting. During a fast the digestive system consumes and expels large quantities of accumulated waste matter [23]. Since considerable energy is spent during fasting, in the process of elimination of accumulated poisons and toxic waste materials, during the fast, patients are advised to take as much physical and mental rest as possible.

The duration of a fast is an important factor. It depends on various factors, i.e., the age of the individual, the nature of the disease, the amount and type of drugs consumed earlier, and various other circumstances. However, there are no hard and fast rules dictating the length of a fast. Each case is handled according to the specific needs of the individual [24]. In naturopathy, patients are usually advised to undertake short fasts of 2–3 days with proper rest during fasting. Fasting is not advised in tuberculosis and diabetic conditions.

One should feel healthy and tension free while fasting. The benefits of a fast enhances by avoiding stimulating thoughts and by making the mind peaceful and cheerful. One can realize a fast's advantages by having a strong will and positive thoughts [25].

Fasting has been appropriately called "a rest for metabolism." There is no doubt that the digestive and endocrine glands that are the agents of control of the metabolic processes are given a rest and thus permitted to normalize both their structures and their activities as a result of the fast. The excretory organs do not rest during a fast. On the contrary, they increase their activities. There can be no doubt that this increased excretion is largely responsible for much of the benefits that flow from a period of abstinence [19].

10.11 Role of Fasting in Various Disease Conditions

Fasting is an excellent treatment for removing the disorders of mind and body [21]. Dr. K.M. Modi in his book *Health Farming* refers to his experiments on 1,189 fasting individuals between April 1970 and November 1974 at Arogya Mandir,

Gorakhpur, India. Fasts were undertaken for 3 days to 3 weeks and in a few cases up to 5 weeks. The results were encouraging. A total of 69.67 % cases completely recovered from their illness, 26.99 % cases showed improvement, and in only 3.33 % cases did fasting not help [4].

Old age brings a decrease in the metabolic rate. However, fasting produces rejuvenation by inducing a permanent increase in the metabolic rate. In experiments conducted at the Hull Biological Laboratory at the University of Chicago, both dogs and humans were fasted for extended periods. During fasts of 30–40 days, a 5–6 % increase in the metabolic rate was observed [8].

Various studies have been conducted on the role of fasting in the management of various disorders, for example, bronchial asthma, hypertension, musculoskeletal disorders, and anxiety, and fasting therapy (FT) has proven effective in the management of these lifestyle and psychosomatic disorders.

Michalsen et al. [26] conducted a controlled, nonrandomized pilot study that compared two inpatient treatment strategies, an integrative medicine (IM) approach that included FT and a conventional rheumatology (CM) approach in fibromyalgia. IM used a fasting cure and mind-body medicine as specific methods. Findings indicate that a multimodal IM treatment with FT might be superior to CM in the short term and noninferior in the midterm [26].

In a controlled, nonrandomized study on the influence of a Mediterranean diet or a fasting cure on the intestinal microflora, a subgroup of patients with fibromyalgia experienced greater improvement than nonfasters [27]. Prolonged modified fasting (fasting cure, FT) with defined periods of voluntary abstention from solid food and a daily total energy intake of <500 kcal has been found effective in several randomized trials on rheumatoid arthritis [28, 29]. The anti-inflammatory, pain-relieving, antinociceptive, and mood-enhancing effects of fasting and caloric restriction have been well described in experimental and clinical studies [30, 31]. Both patients with rheumatoid arthritis and fibromyalgia frequently report that elimination diets and meal skipping alleviate their symptoms [27, 32, 33]. In another trial with a heterogeneous sample of chronic pain patients, fasting led to an amelioration of mood and well-being [34].

Arankalle [34] stressed that a monitored treatment protocol of naturopathy and yoga can benefit a large number of musculoskeletal disorders. An ideal treatment protocol in naturopathy involves correcting an individual's lifestyle and implementing therapeutic fasting, followed by diet modifications and using modalities like hydrotherapy, mud therapy, massotherapy, physiotherapy, yoga, and exercise therapy [35].

Kanazawa and Fukudo [34] suggested that FT may have beneficial effects on intractable patients with irritable bowel syndrome (IBS) [34]. Body mass index and plasma leptin concentrations concomitantly and significantly decreased during fasting, whereas serum orexin concentrations significantly increased and were negatively correlated with plasma leptin concentrations in nonobese adults (Komaki et al. 2001). Fasting affects immune variables such as T-cell subsets and natural killer cell activity at least in part through changes in adrenal-gland-related hormones (Komaki et al. 1997). FT caused high magnitude rapid changes in immune and endocrine variables, similar to those that occur during various psychological and

environmental stresses (Manuck et al. 1991). Huber et al. [35] showed that, in contrast to total fasting and fasting with limited physical activity, 8 days of juice fasting without limitation of physical activity results in a decrease in free cholesterol and an only an initial increase of low-density lipoprotein (LDL) cholesterol. The study showed that after 8 days insulin, tryglycerides (TG), and very low density lipoprotein (VLDL) were still lower than at baseline; however, they increased compared to the initial phase, probably counter regulatory to a further increase in nonessential fatty acids (NEFA) [35].

10.12 Conclusions

Both Ayurveda and naturopathy consider fasting a reliable remedy for several diseases [18]. Based on the foregoing discussion, it can be concluded that fasting is a purificatory process that has been used since antiquity with great health benefits in terms of purifying the body and mind. Therapeutic fasting is used in naturopathic hospitals as an important practice and treatment modality with great potential. Though various studies have been conducted on FT, more scientific, clinical, and long-term studies are still needed to assess the clinical impact of FT and to establish the effectiveness of FT as evidence-based medicine for the management of various lifestyle and psychosomatic disease conditions.

References

1. Jussawalla JM (1993) Natural dietetics. Vikas Publishing House, New Delhi, 49, 48, 50
2. http://www.herald.co.zw. Downloaded 26 May 2013
3. Shelton HM (1978) The science and fine art of fasting. Natural Hygiene Press, Chicago, 52, 49, 50
4. Modi KM (1989) Health farming. Health Farm Publications, Bombay, 89, 90, 92, 91, 102, 103
5. Bhaktivedanta Swami Prabhupada AC (2011) Bhagavad-Gita as it is. Bhaktivedanta Book Trust, Mumbai
6. Dewan AP (1999) Healthy living. AC Specialist Publishers, New Delhi, p 84
7. Ballentine R (1989) Diet & Nutrition-A holistic approach. The Himalayan International Institute, Honesdale, 381, 383
8. De Vries A (1963) Therapeutic fasting. Chandler Book Company, Los Angeles, 10, 5, 6, 11, 12, 13, 14, 15
9. http://www.falconblanco.com/health/fasting.htm. Downloaded 26 May 2013
10. Brown HR (1961) The fast way to health and vigour. Thorsons Publishers, London, W.C.2 ; 20, 21, 23
11. Carrington H (1978) Fasting the master remedy. Nature Cure Research Hospital, Lucknow, 16, 8, 9
12. Upton D (1963) The effects of fasting. Gram Bhavna Prakashan, Pattikalyana/Haryana, 27, 3
13. Lindlahr H (1990) Philosophy and practice of nature cure. Sat Sahitya Sahayogi Sangh, Hyderabad, 327, 322
14. Buchinger HE (1980) About fasting. Thorson Publishers, Northamptonshire, 7

15. Lindlahr H (1990) Practice of natural therapeutics. Sat Sahitya Sahayogi Sangh, Hyderabad, 115
16. Moyle A (1950) Nature cure explained. Health for All, Henrietta Street, Strand, W.C.2. Westminster, 102, 104, 105
17. Singh RH (1998) The holistic principles of Ayurvedic medicine. Chaukarba Sanskrit Pratishthan, Delhi, 87, 88
18. Rastogi R (2001) An introduction to naturopathy. Asha Prakashan, Agra, 45, 46
19. Shelton HM (1978) Fasting for renewal of life. Natural Hygiene Press, Chicago, 115
20. Shelton HM (1978) Fasting can save your life. Natural Hygiene Press, Chicago
21. (1999) Yogic and Nature cure treatments for Common ailments. CCRYN Publication, New Delhi, 12
22. Gandhi MK (1999) Key to health. Navjivan Publishing House, Ahmedabad, 43
23. Hiralal (1990) Health through raw eating. Jan Swasthya Prakashan, Magawara/Unnao, 206
24. Jaggi OP (1991) Health care for plus fifty. Hind Pocket Books, New Delhi, 44
25. Rastogi R (2003) Food principles for healthy living. Chaukhamba Sanskrit Pratishthan, Delhi, 40
26. Michalsen A, Li C, Kaiser K, Lüdtke R, Larissa M, Rainer S, Kessler C (2013) Patient treatment of fibromyalgia: a controlled nonrandomized comparison of conventional medicine versus integrative medicine including fasting therapy. Evid Based Complement Alternat Med 2013:908610
27. Michalsen A, Riegert M, Lüdtke R, et al. (2005) Mediterranean diet of extented fasting's influence on changing the intestinal microflora, immunoglobulin A secretion and clinical outcome in patients with rheumatiod arthritis and fibromyalgia: an observational study. BMC Complement Alternat Med 5, article 22
28. Kjeldsen-Kragh J, Haugen M, Borchgrevink CF, et al. (1991) Controlled trial of fasting and one-year vegetarian diet in rheumatoid arthritis. The Lancet 338(8772):899–902; Müller H, Wilhelmi de Toledo F, Resch KL (2000) A systematic review of clinical studies on fasting and vegetarian diets in the treatment of rheumatoid arthritis. Scandinavian J Rheumatol 30:1–10
29. Johnstone AM (2007) Fasting-the ultimate diet? Obes Rev 8(3):211–222
30. Michalsen A (2010) Prolonged fasting as a method of mood enhancement in chronic pain syndromes: a review of clinical evidence and mechanisms. Curr Pain Headache Rep 14(2):80–87
31. Haugen M, Kjeldsen-Kragh J, Nordvag BY, Forre O (1991) Diet and disease symptoms in rheumatic diseases. Results of a questionnaire based survey. Clin Rheumatol 10(4):401–407; Kjeldsen-Kragh J, Haugen M, Fforre O (1992) Diet therapy in rheumatoid arthritis. The Lancet 339(8787, article 250)
32. Michalsen A, Schneider S, Rodenbeck A, Lüdtke R, Huether G, Dobos GJ (2003) The short-term effects of fasting on the neuroendocrine system in patients with chronic pain syndromes. Nutr Neurosci 6(1):11–18
33. Arankalle DV (2013) Integrating naturopathy and yoga in management of musculoskeletal disorders. Int J Prev Med 4(1):120–121
34. Kanazawa M, Fukudo S (2006) Effects of fasting therapy on irritable bowel syndrome. Int J Behav Med 13(3):214–220
35. Huber R, Nauck M, Ludtke R, Scharnagl H (2003) Effects of one week juice fasting on lipid metabolism: a cohort study in healthy subjects. Forsch Komplementarmed Klass Naturheilkd 10(1):7–10

Part III
Ayurvedic Food Science: Challenges of Proving its Uniqueness in the Purview of Science

Chapter 11
A Scientific Examination of Western Dietary Practices as They Relate to Food Practices in Ayurveda

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11.1 Introduction

11.1.1 Theory of Nutrition in Ayurveda

In Ayurveda, food plays a critical role in maintaining health and preventing disease. Indeed, Ayurveda stresses *Anna* (food) and *Ahara* (diet) as being key to health, wellness, and a good life [1]. Healthy, natural, and wholesome food is considered to nourish the body as well as the mind and the soul. Health centers on food in Ayurveda, good digestion depends upon our lifestyle, and our lifestyle depends upon a whole host of socioeconomic and environmental factors that can affect how food is grown and processed. Thus our environment affects the quality of our food, which in turn affects the quality of our health [2]. Ayurveda links nutrition and good digestion with our environment [2], and in our modern era how we live is radically different from the previous thousands of years. Yet we are not well educated about how the modern environment affects our food, particularly in terms of pollution, genetic engineering, farming practices, freezing, microwaving, and processing with chemical additives and how these practices affect our health.

Ayurveda has recommended for thousands of years that warm, cooked foods should be eaten because they are easily digested. However, overcooking should be avoided as that depletes the life force of the food. Additionally, cooking with too much heavy oil should be avoided as it can lead to weakening of the digestive fire. It is proposed that food is best eaten when cooked or steamed rather than raw. Eating large amounts of raw food should be avoided because raw foods are considered to be less nutritive and building. However, fruit is better fresh and uncooked [3]. Organic, fresh, and homegrown foods are suggested, and the diet can be either

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vegetarian or nonvegetarian. Portion size and content are tailored to the individual, the season, and environmental and personal factors that impact the individual. Ayurveda very strongly states that wholesome food promotes health while unwholesome food results in disease [1]. So how does Ayurveda define unwholesome food as it relates to our modern world?

A good example is the modern microwave. Microwaved food is considered to be damaging to the life force of food and should be avoided in Ayurveda. Yet microwaves are a fact of life in the twenty-first century, and many turn to the microwave as an easy and cost-effective way to prepare a nutritious meal given the time constraints of our busy modern lifestyles. Another important concept in Ayurveda is the avoidance of ice-cold food and drinks. Cold food and drinks are thought to have a negative impact on digestion by extinguishing *jathar agni*, our gastric fire. Yet one of the first things that occurs in America when you sit down to a meal in a restaurant is that the server places a large glass of ice-cold water in front of you. Is there any biomedical evidence that drinking ice-cold water inhibits digestion?

Ayurveda, along with Western dietitians, also recommends avoiding junk food but goes farther by stating that canned and frozen foods and food prepared with additives, preservatives, and artificial colors should also be avoided [3]. In addition, several food combinations or practices are proposed by Ayurveda to inhibit digestion and ultimately predispose one toward disease. Some of these combinations and practices include eating fruit with other foods, eating equal amounts of ghee and honey, heating honey, and eating fish products with milk [3, 4]. Yet can we find a biomedical basis for these Ayurvedic dietary recommendations?

One clear example of how modern science supports the ancient concepts of Ayurveda is in the use of spices. Spices are essential to the Ayurvedic diet as a way to improve digestion, increase strength, enhance the senses, and maintain a healthy weight. There is a plethora of biomedical studies examining the physiological properties of spices, and this topic will therefore not be addressed in the current chapter. However, this raises the point that biomedical research has confirmed the beneficial effects of spices on human health and physiology, so perhaps we can find research that will either confirm or negate the dietary recommendations of Ayurveda in terms of food preparation and food combinations.

This is an extremely relevant issue because fewer and fewer of us have the time or the resources to prepare home-cooked meals from fresh, organic ingredients for every meal. We rely on frozen foods, the microwave, barbecue grilling, and processed foods as supplements to our fresh foods in order to create a meal on the go. According to Ayurveda, we are increasing our risk for disease by engaging in these practices, but can we find evidence-based research that supports these dietary recommendations? Most of our food preparation practices such as freezing, microwaving, canning, and processing with chemicals were completely unknown to the ancient *vaidyas*. Their recommendations for fresh, wholesome food made sense in an ancient world where food spoiled very quickly. But Ayurveda extends these recommendations into our modern way of preparing and consuming food, and this naturally raises the issue of whether our modern food practices are indeed

detrimental to our health. This chapter will evaluate the evidence-based research regarding Ayurvedic dietary recommendations as they relate to practices in modern food processing and food consumption.

11.1.2 Ice-Cold Food and Beverages

Let us begin with a scientific evaluation of the simple dictate of Ayurveda that ice-cold food and drinks should be avoided because they inhibit digestion. By drinking the large glass of ice-water that your server in the U.S. restaurant has placed before you, Ayurveda says you are inhibiting your digestion before you have even started your meal. Your *jathar agni* will be extinguished, your poorly digested food will create *ama*, and the accumulation of *ama* will eventually lead to disease. So is there any evidence-based research that suggests that cold temperatures inhibit digestion? In fact, there are a number of studies that have examined the effect of temperature on digestion.

One study assessed the effect of temperature on gastric emptying. In this protocol, a temperature sensor was introduced through the nose into the stomach in six men, and the intragastric temperature was monitored after ingestion of orange juice at 4 °C, 37 °C, and 50 °C [5]. The mean intragastric temperature following ingestion of the cold orange juice fell and reached a peak decrease by 45 s after ingestion of the juice. Interestingly, the mean intragastric temperature returned to normal within 30 min of ingestion of the cold orange juice and within 20 min of ingestion of the warm orange juice. Thus gastric temperatures recovered more slowly from a cold drink than a warm drink. Gastric emptying was then measured following ingestion of cold, room-temperature, and warm orange juice. Both the warm and the cold juice appeared to empty from the stomach more slowly initially, but the cold juice appeared to empty more slowly from the stomach over a 10 min time course compared to the warm or room-temperature juice [5]. Thus the ingestion of cold juice slowed down the initial phase of gastric emptying when the intragastric temperature was much lower than body temperature. A later follow-up study demonstrated that both cold and warm liquids could suppress gut motility for over 30 min after ingestion but that the cold liquid showed greater inhibition [6]. Thus there is a small body of scientific literature supporting the idea that ingesting cold substances does inhibit gastric motility and gastric emptying. It is worth noting that the experiments described here used a single ingestion of a cold liquid to produce these short-term effects. Drinking ice-cold water throughout a meal would repeatedly inhibit gastric emptying and motility and could potentially have a significant effect on digestion. The authors also hypothesized that temperature may have a much larger effect during gastric emptying of semisolid or fatty meals because these meals would have a higher thermal inertia than the juice [5]. Therefore, eating a very cold, high-fat substance such as ice cream could also have a profound effect on gastric emptying and digestion. Ayurveda does not recommend eating cold foods such as ice cream regularly and strongly prohibits the drinking of ice-cold beverages with meals.

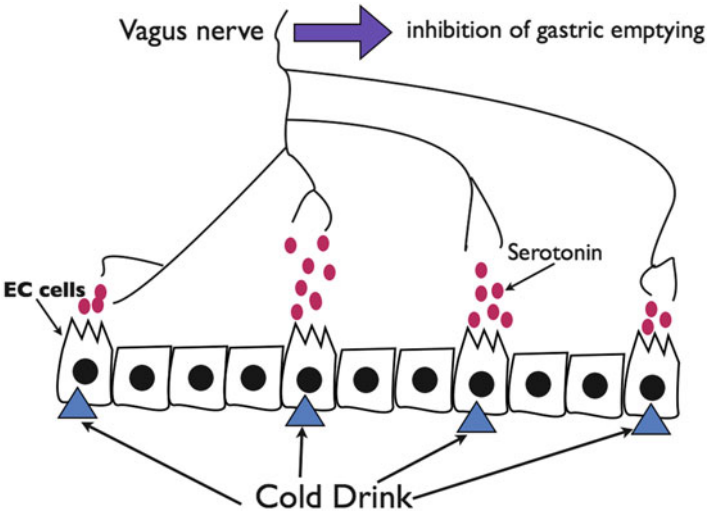

Fig. 11.1 Schematic illustration of hypothesized effect of a cold drink on GI system. Cold activates the TRPA1 receptors (*blue triangles*) located on enterochromaffin (*EC*) cells. This causes the release of serotonin (*red circles*) from the EC cells, which then activates the vagus nerve and inhibits gastric emptying

What could be a potential mechanism whereby cold foods and drink inhibit gastric motility? Recent studies implicate the transient receptor potential (TRP) cation channel TRPA1 that is highly expressed in serotonergic enterochromaffin (EC) cells in the gastrointestinal (GI) system. TRPA1 is activated by pungent compounds and cold temperatures, and controls GI motility [7, 8]. EC cells are located on the mucosal surface of the GI tract, and the neurotransmitter serotonin is released from these cells when TRPA1 is activated. When serotonin is released from EC cells, nerves within the GI system are activated, resulting in a number of different physiological responses including GI contraction. It is thought that TRPA1 acts as a sensor molecule for EC cells and may modulate GI function [8]. Cold is one of the activators of the TRPA1 receptor, so cold food and drinks are a signal by which serotonin is released by EC cells.

Approximately 95 % of all serotonin in the body is located in the GI system, and serotonin has multiple effects in the gut due to the many types of serotonin receptors that are present in the GI tract [9]. Because serotonin has so many actions in the gut, it is difficult to decipher exactly what is going on physiologically when EC cells release serotonin. Serotonin has been found to make the bowel contract or relax depending on the experiment, and serotonin also controls the peristaltic reflex [10]. The release of serotonin by EC cells when TRPA1 receptors are activated has been shown to delay gastric emptying [11], probably through the modulation of the vagus nerve that controls gastric reflexes and ultimately retards gastric emptying [9]. Thus activation of the TRPA1 receptors by cold food or drink could be the mechanism by which cold retards gastric emptying and motility (Fig. 11.1). This body of work now

provides a scientific basis to support the basic recommendation of Ayurveda to avoid drinking ice-cold beverages with meals and to limit the consumption of cold food and drinks.

11.1.3 Carbonated Beverages

Naturally bubbling mineral waters have been consumed by humans for thousands of years. The ancient Greeks and Romans considered these mineral waters to be beneficial to health, for both bathing and drinking [12]. The invention of artificial sparkling waters occurred in the mid to late 1700s in England, when Joseph Priestly produced the first sparkling water [13]. T. Henry in England and J. Schweppe in Switzerland then commercially produced bottled carbonated water. Carbonated water was included in the US pharmacopoeia until 1830 and was considered to be a therapeutic agent [14]. Carbonated beverages are now found everywhere across the globe and are a staple of the modern diet. Carbonated beverages include sparkling waters, colas, sodas, beer, and sparkling wine. These beverages have high levels of carbonation, can be very acidic, and usually contain large quantities of sugar or artificial sweeteners [13]. Carbonation occurs when gaseous CO_2 is dissolved in liquid under pressure, and acidity is a common characteristic of many carbonated drinks. In an Ayurvedic diet, limiting the consumption of carbonated beverages is recommended. And indeed, the effects of carbonated beverages on the GI system and the body as a whole has been under investigation in recent years by the biomedical community. There are differing opinions regarding the effect of carbonation on health and the GI system. Some consider carbonated beverages to be beneficial to the GI system, whereas others believe these beverages to be detrimental [12]. Before we examine the literature pertaining to carbonated beverages, it is important to understand a few facts about the biology of carbonation.

To begin with, approximately 1 mL (2 mg) of carbon dioxide dissolves in 1 mL of a solution at pH 7 (neutral solution). Much of the CO_2 in a carbonated drink is lost when the can or bottle is opened (fizzing), so much of the CO_2 does not actually reach the stomach. In addition, some CO_2 merges with swallowed air to produce belching and thus never makes it to the stomach. So only a very small amount of CO_2 in a carbonated beverage actually reaches the digestive tract. There is no evidence that the ingested carbonation has a pathological effect on the intestinal tract, particularly because the ingested CO_2 is almost completely absorbed by the time it reaches the lower GI tract [12]. Thus carbonation is thought to affect the oral cavity and taste, the esophagus, and the stomach, and scientific studies have focused on these three components of the GI system. We will concentrate on the effect of carbonation on the esophagus and GI system.

The main issue regarding carbonation and the esophagus revolves around gastroesophageal reflux disease (GERD). This is a chronic disease that occurs when gastric acid flows back into the esophagus, with the main symptom of the disease being heartburn. The medical community recommends treating GERD in part by

eliminating carbonated beverages from the diet, but it remains controversial as to whether carbonated beverages actually exacerbate GERD [13].

The impact of carbonated beverages in the lower esophageal sphincter (LES) has been examined in several studies [15, 16]. The LES is the major sphincter that protects the esophagus from reflux of gastric secretions. Hamoui et al. found that carbonated beverages produced a decrease of LES pressure within the first 20 min of ingestion. They hypothesized that this decrease in LES pressure could be due to gastric distention produced by the carbonation. However, the sample size of this study was small. A more recent study evaluated the effect of carbonated beverages on LES and on transient lower esophageal sphincter relaxations (tLESrs) [16]. The tLESr is a motor pattern that occurs in the absence of a swallow and involves a protracted relaxation of the LES, along with the inhibition of the crural diaphragm, and is associated with reflux events [16]. The researchers found that not only was there a decrease in LES pressure, but tLESr occurred with greater frequency following ingestion of a carbonated beverage compared to baseline or water. However, further studies are needed to determine whether this increase in tLESr does indeed lead to GERD.

In terms of the effect of carbonation on the stomach, ingestion of carbonated beverages does result in gastric distention, and early studies indicated that this led to a decrease in gastric emptying [12]. However, a more recent study found that sparkling water did not affect total gastric emptying. Instead, the carbonation modified the distribution of both liquids and solids within the stomach such that the proximal stomach contained a greater proportion of solids and liquids when taken with carbonated water [14]. In support of this, a second study that assessed fluid emptying and gastric gas by magnetic resonance imaging found that only cola delayed gastric emptying compared to water, a sweetened noncarbonated beverage, and a lightly carbonated beverage [17]. Overall, studies on the effect of carbonated beverages on the stomach indicate that these beverages seem to influence the function of the stomach but that symptoms related to gastric distress only occur when carbonated fluids are ingested in quantities greater than 300 mL [12].

While a relationship between carbonated beverages and GERD remains to be fully elucidated, it is worth noting that the high sugar content of most carbonated beverages can have a very negative impact on health. A recent study found that a premeal administration of a noncaloric carbonated beverage had no effect on food intake, even though it clearly resulted in gastric distention [18]. Interestingly, increasing the caloric content of a carbonated beverage does not appear to reduce the intake of solid food by a corresponding amount (reviewed in Wolf et al. 2007). In a fascinating study, participants had to consume either 450 kCal day^{-1} of a soft drink or the same amount of energy in jelly beans. They could eat any other food they wanted but had to keep a log of their intake. Those who ate the jelly beans reduced their total caloric intake by slightly more than the 450 kCal day^{-1} contained in the jelly beans. In contrast, the soft drink consumers actually increased their consumption of other foods and increased their total caloric intake [19]. It appears that the calories contained in fluids are not sensed appropriately by the GI tract and thus do not activate mechanisms that control appetite and ultimately regulate body fat [20]. Therefore, it is easy to understand how the increased consumption of

large quantities of sugary carbonated beverages can lead to obesity. In summary, carbonated beverages do affect the GI system and may contribute to acid reflux, although this remains under study. The high sugar content of most carbonated drinks may contribute to obesity by apparently bypassing our body's caloric sensors and caloric compensatory mechanisms in the GI system. People that consume a high caloric beverage before or during a meal eat the same number of calories as a person drinking a calorie-free beverage with a similar meal [20]. Ayurveda's recommendation to limit the intake of carbonated beverages is supported on many levels by the scientific literature.

11.2 Food Preparation

Now that we have discussed the scientific basis for avoiding cold and carbonated beverages, let us turn our attention to food preparation. As you will recall, Ayurveda recommends that we eat warm, cooked foods, that we cook without heavy oils (such as deep frying), and that we avoid microwaved, frozen, and processed foods. But microwaves, freezers, and chemical processing of foods are recent inventions and were certainly not present in the ancient world. So are there truly scientific reasons for avoiding these types of food preparation, or is Ayurveda simply stuck in the past and not keeping pace with the modern world? To begin this discussion, we will first analyze microwave cooking.

11.2.1 Microwave Cooking

Microwave cooking is not recommended by Ayurveda because it is considered to damage the life force of food [3]. But heating and cooking food using a microwave is very common in the industrialized world and is fast becoming more widespread in the developing world. The convenience and ease of microwave use has made the microwave oven a permanent fixture in many households and is also becoming more prevalent in industrial settings [21]. Heating by microwave is much faster than conventional methods, such as a standard oven, and microwave ovens are also cheaper, smaller, and portable. Although faster, microwave ovens heat food using a different process than conventional heating. In conventional heating, the surface of the food heats first, and conduction and convection are used to transfer heat from the heating source to the surface of the food, and then throughout the product [21]. Thus heat diffuses from the surface of the food, which heats up first, into the rest of the food. Conventional heating is therefore characterized by high surface temperatures with colder internal temperatures [22]. In contrast, microwaves are high-energy electromagnetic waves, and microwave heating occurs when electromagnetic field energy is transformed into thermal energy by affecting the polar molecules, such as water, in a substance [21]. Specifically, the electromagnetic waves oscillate and

cause the polar molecules to rotate following the magnetic fields, and this movement (vibration) of the water or other polar molecules generates heat. Thus, microwaves heat food from the inside out, and this heating is nonuniform. In addition, microwave heating is unable to achieve high enough temperatures on the surface of the food to create a crisp crust [22].

The nonuniform temperature distribution is one of the chief problems of using a microwave to heat or cook food. For example, temperature differences in mashed potatoes in a ready-to-eat meal show a temperature difference of more than 70 °C between the hottest and coldest spot after 30 s of heating in the microwave [23]. The large temperature differential following microwave cooking raises the concern that microbes in food may not be completely killed because of the uneven temperature distribution. This becomes particularly concerning in meat products where bacteria that survive the cooking process could result in serious health problems [21]. So large variations in temperature within food is one reason to be careful when using the microwave to cook.

But do microwaves alter the basic chemical structure of the food itself? The consensus in the scientific community is that in general, it does not. Estimates have shown that the number of microwave photons generated by microwave ovens are "orders of magnitude too small to establish multiphoton dissociation or ionization" that would be required to create chemical radicals that would result in changes in the basic chemistry of the food [24]. However, microwaves can alter the texture of food, particularly baked goods that toughen following microwaving. Starch in food seems to be the source of this textural change when the starch content of the food product is above 37 %. What actually seems to be causing the toughening of baked goods by the microwave is the boiling that occurs during the microwave process. The nonuniform heat generated by microwaves eventually results in localized spots that are superheated, and this creates a localized area of boiling. When this boiling occurs within starch, two things occur. The first is that there is an increase in the solubility of the starch, and amylose begins to leach out. The second is that this amylose solution is redistributed within the food product. When the product cools, the amylose solidifies into a crystalline form, resulting in toughening. If baked products are heated below the boiling point, then toughening does not occur [22]. So in this case, microwaves do not necessarily alter the basic chemistry of bread, for example, but they do change the solubility and distribution of starch within the product, resulting in an unpleasant textural change.

In addition to the household use of microwave cooking, microwave technology is being increasingly utilized for drying in the food industry. Microwave treatment is also being considered as a good method for eliminating pests and mildew in food. But few studies have examined the effect of microwaves when they are used to dry food products such as rice. An interesting study recently examined the effect of microwaves on the quality of rice during storage [25]. Raw rice was microwave-treated as it traveled on a transport belt and then was either vacuum packed or atmosphere packed. The rice was then stored for up to 180 days and analyzed for water content and other biochemical parameters, protein content, and the sensory quality of the rice when it was cooked after storage. The analysis of the rice was performed

at 0, 30, 60, 120, 150, and 180 days of storage. These researchers found that microwave treatment reduced the free fatty acid and protein content of the rice, but the BV ratio increased. The BV is defined as the ratio of the amylose to amylopectin content, and higher BV numbers signify a higher amylose content. The authors hypothesize that the higher BV content is the result of the dispersion of the amylose and amylopectin caused by the microwaves. Interestingly, the sensory quality of the cooked rice improved with microwave treatment, perhaps due to the better adhesiveness of the rice resulting from an apparent increase in amylose [25]. In addition, free fatty acids tend to increase during the storage of rice, but these changes were smaller following microwave treatment. Microwave-treated rice was also lower in protein and sugar content compared to untreated rice at the beginning of the study, but there was no difference observed by the end of the study. Fat content was higher in the treated rice at the beginning of the study, but there was no difference by the end of the study. (On a side note, the amylose content and fat content of rice increase over time, while the protein and sugar contents decrease with time. Thus, the biochemistry of rice does change with age. This provides a scientific underpinning for the Ayurvedic recommendation to eat rice that has been aged by 1 year [26]).

This group also used near-infrared reflectance spectroscopy (NIRS) to examine the chemical identity of the rice. They found a change in molecular conformation in the treated rice compared to the control rice that could not be detected by chemical methods but did recover somewhat over time. Thus microwaves did induce some molecular changes in the rice that appeared to recover over time. But the result of this was a better taste experience when the microwaved rice was cooked compared to the nonmicrowaved rice.

The scientific findings indicate that the major issues with microwave cooking are uneven heating with areas of very high boiling temperatures within food. Foods containing starches are prone to toughening in a microwave oven, and microwaving raw foods, such as rice, can lead to changes in molecular structure that partially recover over time. The scientific community would therefore say the effect of microwaves on food is fairly minimal. However, there are some structural changes that appear to occur following microwave treatment. How this relates to the life force or *prana* is impossible to evaluate from a scientific perspective because we do not have a way to measure or define *prana* using Western science.

11.2.2 Influence of Cooking Methods on Vegetables

So now let us examine how different cooking methods, including microwave cooking, can affect the nutritional content of vegetables. This is an important issue because fruits and vegetables are considered to be the major source of reactive oxygen species (ROS)-scavenging antioxidants in our diet [27]. Most of these antioxidants are thought to react with or scavenge free radicals and chelate catalytic metals, resulting in decreases in lipid peroxidation [28]. Lipid peroxidation is the oxidative degradation of lipids, such as the lipids in cellular membranes. This results in

cellular damage and is associated with aging and a number of degenerative disease processes. Because of their antioxidant properties, fruits and vegetables are considered to be functional foods that help to ameliorate diseases such as cancer and cardiovascular diseases [27–30]. There is a large body of literature demonstrating that a diet rich in fruits and vegetables contributes to good health, but we tend to eat fruit raw rather than cooked. In contrast, we usually cook vegetables before they are eaten, so how does cooking alter the phytochemical components of vegetables? Ayurveda suggests that we should mostly consume vegetables that have been lightly cooked. Can we find a scientific basis for this, and is there a preferable method for cooking vegetables that retains or enhances their health-promoting qualities?

Vegetables contain antioxidants such as flavonoids, vitamins such as vitamin C (ascorbic acid), carotenoids, and polyphenols [27, 29, 30]. Glucosinolates are found in *Brassica* vegetables such as broccoli and are thought to contribute to the anticancer properties of these vegetables [31]. Glucosinolates are a large class of sulfur- and nitrogen-containing secondary metabolites of most plants and are particularly abundant in *Brassica* vegetables. They are rapidly metabolized to isothiocyanates when they come into contact with the enzyme myrosinase, which is stored in a different compartment of the plant than glucosinolates. When plant tissues are damaged by chopping or cooking, for example, glucosinolates come into contact with myrosinase, and isothiocyanates are produced. These compounds are thought to have a protective effect against cancers, especially colon, lung, and bladder cancers [31, 32]. A number of studies have examined in detail the effect of cooking methods on these phytochemicals, but the literature is rather confusing and incomplete, and it is quite difficult to make comparisons among studies. However, a few themes do emerge from this work.

Turkmen et al. examined the effects of boiling, microwave cooking, and steaming on spinach, squash, leeks, peppers, peas, and green beans. They evaluated the total phenolic content and total antioxidant content of the vegetables after each type of cooking. They reported that cooking did not negatively affect total antioxidant activity or total phenolic content, except for some small losses of phenolics in leeks, squash, and peas [30]. Indeed, they found that moderate heat treatment actually improved the antioxidant activity of peppers, broccoli, and spinach, and it did not matter which cooking method was used. A similar study looked at the effect of boiling, microwave cooking, and frying (2 tablespoons oil in a frying pan) on phenolics and total antioxidant activity of spinach, cabbage, carrots, yellow turnip, white turnip, and cauliflower [28]. This group found that the total phenolic content was reduced the most with microwaving, but boiling and frying also reduced phenolic content. The researchers concluded that boiling and frying vegetables were preferable to microwaving them [28]. However, it should be noted that Turkmen et al. microwaved the vegetables for longer times (5 min) than the Sultana group (1–1.5 min). Another group examined the antioxidant activity (as related to the inhibition of lipid peroxidation) of a variety of vegetables following different cooking methods [27]. Boiling produced the greatest decrease in antioxidant activity in most of the vegetables, but baking and microwaving were the two methods that retained the most antioxidant activity in many of the vegetables. For some

vegetables, antioxidant activity was actually increased following these cooking methods [27]. In this study, microwaving times varied between 2 and 4.5 s depending on the vegetable. Baking times varied between 14 and 49 min, and frying times varied between 6 and 17 min. The researchers found that beetroot, garlic, and green beans retained their antioxidant activity after most cooking treatments. Swiss chard and peppers lost most of their activity in all of the cooking processes. They concluded that, depending on the vegetable, microwaving and grilling on a griddle produced the lowest loss of antioxidant activity, frying was intermediate, and pressure cooking and boiling resulted in the greatest losses [27].

Interestingly, deep frying carrots, broccoli, and courgettes (summer squash) resulted in a loss of carotenoid, flavonoids, and ascorbic acid and a large decrease in phenolics [29]. Avoiding deep-fried foods is part of following an Ayurvedic diet regime. This group also demonstrated that glucosinolates were completely preserved by steaming only, and that steaming actually increased their concentration by 30 %. Taken together, these studies demonstrate that there is a preferential cooking method for individual vegetables, but in general, deep frying and boiling should be avoided.

Much attention has focused on *Brassica* vegetables, particularly broccoli, because of its clearly demonstrated antioxidant properties. As mentioned earlier, glucosinolates are an important phytochemical found in *Brassica* vegetables. Other important components include vitamins, minerals, and other antioxidants. Considerable attention has been paid to how cooking methods and freezing affect this class of vegetables. But again, the data are contradictory. Microwaving induces the loss of vitamin C in broccoli, and it was hypthosized that the smaller losses in phenolics, glucosinolates, and minerals was mostly due to leaching into the cooking water [33]. Glucosinolates are also modulated by the type of oil that broccoli is stir-fried in. Refined olive oil and sunflower oil significantly reduce glucosinolates, whereas extra virgin olive, soybean, safflower, and peanut oils do not significantly affect glucosinolate content [34]. Freezing also affects the phytochemical content of broccoli and other vegetables. In general, freezing vegetables and then cooking them results in very large losses of antioxidants. For example, fresh *Brassica* vegetables retain phytochemicals and total antioxidants better than frozen vegetables [35, 36]. Frozen vegetables are often blanched before freezing, and this leads to a disruption of the cell membrane and a leaching out of phytochemicals before the cooking process [35]. Thus it is not the freezing itself but the blanching process that decreases the nutritional value of vegetables. However, let us examine the process of freezing in more detail because the Ayurvedic diet stresses fresh foods, and the eating of frozen foods is discouraged.

11.2.3 Freezing

Frozen foods have been a part of world culture since ancient times. Ice cellars were used to preserve food in ancient China, and the Greeks and Romans stored their

food in cold cellars filled with ice. Flavored ices and ice creams have been consumed since the 1500s, and frozen fish and meats was a thriving industry by the late 1800s [37]. The majority of frozen foods are quick frozen. This entails a freezing process that rapidly freezes the food product such that it passes through the zone of maximum crystallization as rapidly as possible [37]. As discussed previously, many foods go through some type of processing, such as blanching, before they are frozen. Blanching is used to inactivate enzymes that might lead to the deterioration of the food product over time [37]. Blanching is usually performed for a few seconds to minutes, in water below the boiling point [38]. As we have seen, blanching before freezing affects the antioxidant content of vegetables, and it appears to have an effect on other phytochemicals.

Freezing and storage also appear to decrease the folate content of vegetables. Folate (B vitamins) prevents neural tube defects and has also been shown to reduce the risk of other diseases, including cardiovascular diseases and colon cancer [38]. Folates are very unstable compounds that are highly sensitive to pH, high temperatures, storage time, and food processing. Indeed, folates are degraded by simply washing vegetables in water. Czarnowska and Gujska [38] examined the effect of freezing and storage on six vegetables – green and yellow beans, peas, cauliflower, broccoli, and spinach. They found that not only did blanching reduce folate levels but frozen vegetables stored over time lost additional folate. Cauliflower lost a significant amount of folate by 3 months of storage, while the remaining vegetables lost over 90 % of their folate between 6 and 12 months.

While freezing is generally considered to be a safe method for preserving foods, some microorganisms may not be completely destroyed by freezing. Bacterial spores such as botulinum toxin appears to survive freezing and freeze-thaw cycles. Protozoa such as *Cyclospora* also appear to survive freezing, and gram-positive bacteria are less affected by freezing than gram-negative bacteria. Salmonella are well known to survive the freezing process, and *campylobacter* has been found in frozen chicken (reviewed in Archer [37]). It is very clear that freezing does not eliminate all foodborne pathogens and that one of the risks inherent in frozen foods is the potential for contamination by microorganisms that survive the freezing process.

Many of these microorganisms are found in meat, so that is an obvious risk factor in freezing meat products. But does freezing alter other components of meat? Freezing, and the resulting thawing before cooking, mainly affects the water component of meat. Water is found within and between muscle fibers. As the water within meat freezes, there is a concomitant increase in the remaining proteins, minerals, vitamins, lipids, and carbohydrates. This results in changes in the muscle fibers themselves, and this modifies the characteristics of the muscle cell membrane and affects the meat quality [39]. Denaturation of the meat proteins occurs, and myosin has been reported to be the protein altered the most by freezing [40]. However, other studies suggest that there is not a major effect on protein denaturation with freezing, and clearly more research is needed [39]. Significantly, biochemical reactions have been shown to still take place in meat that is stored at temperatures higher than 20 °C. This is because at these temperatures, there remains sufficient unfrozen water in the meat for various chemical reactions to occur,

including oxidation of lipids and proteins, particularly when the meat is thawed. This in turn leads to the production of thiobarbituric acid reactive substances (TBARS), which can produce rancid meat. TBARS can be measured and are significantly higher in meat that has been stored for 90 days at 20 °C than in fresh meat (reviewed in Leygonie et al. [39]). Protein oxidation can produce free radicals, and, as we have discussed, these can be detrimental to human health.

11.2.4 Preparation of Meat

Ayurveda recommends a diet rich in plant products with very limited consumption of meat, especially red meat. A diet high in red meat is associated with increased risk for cardiovascular disease and cancer. Indeed, the American Cancer Society (ACS) in its most recent 2012 guidelines suggests a "healthy diet, with an emphasis on plant foods." If red meat is consumed, then it should be lean meat and served in small portions. In addition, the preparation of meats such as red meat, poultry, and fish should be by broiling, baking, or poaching rather than charbroiling or frying [41]. According to the ACS, there is a 15–20 % risk of developing colon and rectal cancer for every 1,000 g of red meat or 50 g of processed meat eaten each day. Studies have shown an association between preferential consumption of heavily browned meat surfaces and colorectal cancer [42] as well as a potential association between increased consumption of grilled meats and prostate cancer [43].

Components of meat include heterocyclic amines and polycylic aromatic hydrodocarbons (PAHs), and these are considered carcinogens and mutagens. These substances are produced when meat is cooked at high temperatures (grilled or barbecued over an open flame) with charring of the meat surface [41, 44, 45]. Heterocyclic amines have been found in the urine of healthy volunteers eating a normal diet. But it should be noted that the average actual human daily intake of these amines is probably too low for cancer production by heterocyclic amines alone. However, animal studies suggest that giving other known carcinogens concurrently with heterocyclic amines can lead to additive or synergistic carcinogenic effects (reviewed in Sugimura et al. [45]). An example of this is that a high fat diet can enhance colon carcinogenesis when a relatively small dose of the heterocyclic amine PhIP is given to rats [46]. Therefore, it is recommended that meat not be cooked for long periods of time or cooked over an open flame. Interestingly, heterocyclic amine levels can be lowered in fried ground meat patties by reducing the temperature and flipping the hamburger every minute. The patties also reach an internal temperature of 70 °C faster using this cooking method [47].

Carcinogenic PAHs are found in tobacco smoke and are also generated in food through grilling and smoking. Food cooked over an open flame has some of the highest levels of PAHs, and marinating meats might influence their levels of PAHs [44]. Taken together, these studies indicate that a diet that overemphasizes charbroiled and grilled red meat in particular is a risk factor for cancer, thus supporting the Ayurvedic diet that emphasizes plant-based foods.

11.3 Processed Foods

The modern Ayurvedic diet also avoids processed foods. There is a large body of literature summarizing the negative effects of processed foods on human health, but here we will discuss just a couple of aspects of this issue. The deleterious effects of processed foods fall into several categories. The first is the harmful effects of the processing chemicals on cellular physiology and function. The second is the way in which the nutrient content of food is changed in order to preserve it. A good example of this, as discussed previously, is the blanching of vegetables before freezing and how it changes the phytochemistry of plants. A third aspect of processed food that is deleterious to health is the rapid proliferation, low cost, and availability of fast foods that are high in fat and sugars and contribute to poor health outcomes.

11.3.1 Phosphates

Let us take an example of a chemical commonly used in food processing, phosphate additives. Phosphate is a natural component of many foods, including starch-rich foods such as breads and other food classes such as meats. This type of phosphate is organically bound, and approximately half of it is absorbed in the GI system. The phosphates that are used as food additives or preservatives are not organically bound and are therefore absorbed much more efficiently by the GI system. Foods that have artificial phosphates include colas and soft drinks, canned fish, baked items, and processed meats such as ham and sausages (reviewed in Ritz et al. [48]). Currently, phosphates in food do not have to be listed on food or beverage labels, and these foods and drinks can add as much as 1 g of phosphate per day to our diet [49].

Phosphates can damage the cardiovascular system and negatively effect renal function, even in healthy people. Individuals with chronic renal failure are usually on a phosphate-restricted diet because high hyperphosphatemia is associated with increased morbidity in these patients. Phosphates are used as preservatives in a wide array of food products, including meats and powdered products such as milks, puddings, and coffee, and they are a component of soft cheeses. Flavored carbonated drinks and colas contain large quantities of phosphates as well. They are ubiquitous in fast foods and ready-to-eat meals. It is clear that phosphate additives are a cause for concern [48]. Phosphate homeostasis is regulated by the peptide hormone FGF23, and this hormone modulates mineral metabolism by acting on the kidney and parathyroid gland [49]. Dysregulation of this system can result in vascular calcification, metabolic bone disease, cardiomyopathy, and kidney disease [49]. This is just one example of the potentially harmful compounds that are added to fast foods and processed foods.

11.3.2 Refining of Foods

As we discussed earlier, food processing can also affect the nutritional components of foods. In addition to vegetables, grains are also impacted by processing. The antioxidant phytochemicals in wheat, barley, and beans are mostly located in the outermost layers, and these layers are removed during the milling and refining process to make flours and bran. Similarly, the hulls of nuts such as hazelnuts and almonds are also rich in antioxidant compounds. These hulls are also often removed during their processing [50]. These are examples of how processing can negatively affect the nutritional content of foods, although this is not through the addition of manufactured chemicals. It is important to point out that some treatments actually increase the phytochemical content of foods. For example, the processing of tomatoes to produce ketchups and pastes results in the release and increased absorption of the antioxidant lycopene [51]. Handling, chopping, and milling of food can impact its phytochemistry properties, but much of this is unavoidable and not all of it has a negative impact on human health.

11.3.3 Ultra-processed foods

Finally, ultra-processed foods, such as cakes and pastries, breakfast cereals, pizza, hamburgers, and ready-to-eat meals, are high-calorie foods that contain a lot of fat and sugars. This is very detrimental to human health. In the United States alone, regular soft drinks, cakes and pastries, hamburgers, pizza, and potato chips/popcorn are the top five foods that contribute to energy intake in the population. The top ten food groups (including beer, cheese, and french fries) contribute almost 75 % of energy intake, and this was in 2000 [52]. It is hard to imagine that this number has not increased over the last decade. What is very concerning is that at least one quarter of all energy intake comes from foods that have large quantities of sugar and fat and few micronutrients. This trend is increasing worldwide and is particularly obvious in studies that classify foods based on the amount of industrial processing. A Brazilian study classified foods into three groups: (1) unprocessed or minimally processed, (2) processed ingredients, and (3) ultra-processed [53]. Minimally processed foods include fresh and frozen fruits and vegetables, frozen meats, and fresh and pasteurized meats. Processed ingredients included vegetable oils, butter, milk, cream, and sugar. Ultra-processed foods include breads, cakes and pastries, candies, breakfast cereals, frozen dinners, and pickled and smoked meats. An analysis of food purchases based on these three classifications revealed that consumption of Group 1 and 2 foods has been steadily declining and replaced by the consumption of Group 3 foods [53]. Group 3 foods now represent more than one quarter of the total energy that was purchased in Brazilian households. This is a worldwide trend and contributes to the rising incidence of obesity and other diseases. Consumption of refined sugar is also on the rise, with worldwide consumption tripling over the

last 50 years. Most people are consuming on average more than 500 cal per day from added sugar [54]. Sugar induces a wide range of diseases associated with metabolic syndrome, and some consider that "sugar also has the clear potential for abuse" [54].

It is important to point out that fast foods and low-nutrition foods are also a social issue. People eat these types of foods when there is easy access and low cost. For example, in the United States, McDonald's ensures that there is a restaurant within a 3–4 min car ride for the average American [55]. In addition, in the United States there are 1.6 times more fast-food restaurants that are located within predominately low-income and black neighborhoods as compared to predominately white neighborhoods [55]. The situation is reversed in India, where fast food is more readily available to the affluent compared to the rural poor [56].

Thus, it is very clear that processed foods contribute to the global burden of obesity and disease, and there is a great deal of scientific evidence to support this. We are becoming increasingly aware of the negative health issues associated with processed foods, and Ayurveda supports a diet that does not contain these types of foods.

11.3.4 Honey and Ghee

We will end our examination of the scientific studies that support many of the Ayurvedic diet recommendations by discussing honey and ghee. Honey and ghee are two food items that are used extensively in the Indian diet; ghee was produced in ancient India as early as 1500 BC [57, 58]. Ghee is the Indian name for clarified butter that is usually prepared from cow's milk. But many other countries produce ghee or gheelike products, including Iran, Egypt, Ethiopa, Sudan, and Uganda [58]. Ghee is used for cooking but also has medicinal qualities, and many herbal preparations in Ayurveda are formulated in ghee. In Ayurveda, heated honey and honey mixed in equal parts with ghee are considered to be detrimental to health [3, 57]. But are there any scientific studies that support these ancient ideas?

Throughout the world, honey is considered both a medicine and a food. Honey contains a number of different constituents, including glucose, fructose, water, proteins, organic acids, vitamins, minerals, and antioxidant flavonoids [59, 60]. Many of the substances that give honey its distinct aroma, flavor, and biological activity are sensitive to heat [61]. Heat and thermal processing are used to eliminate microorganisms and reduce the moisture content of honey so that it does not ferment and spoil and to modify its tendency to crystallize [60, 61]. Thus there is quite a large body of literature examining the effects of heat on honey. Heating honey results in a decrease in thermosensitive aromatic substances, and in general these losses are proportional to the temperature and heating time. In contrast, heating honey at fairly low temperatures (50–70 °C) for up to 12 days actually increases the antioxidant activity of honey [60]. This is thought to occur because there is an increase in the formation of brown pigment through the Maillard reaction. When honey and other substances containing sugar are heated, sugars condense to form amino acids, and this leads

to the formation of brown pigment. This reaction is called the Maillard reaction, and Maillard reaction products are thought to have antioxidant properties [60]. Thus, heating honey at low temperatures induces the Maillard reaction and the formation of brown pigment showing antioxidant activity.

However, when honey is heated at high temperatures, e.g., when cooking, then many of the substances in honey break down. Heating can produce a decrease in diastase activity. Diastase is an enzyme that naturally occurs in honey, and diastase hyrodrolyzes starch. The Honey Quality and International Regulatory Standards have set the standard that diastase in honey must not be $\leq$8. Heating at high temperatures reduces this activity below this standard [61, 62]. Heating has also been shown to increase the hydroxymethylfurfural (HMF) content. HMF is a cyclic aldehyde that is formed by fructose and glucose dehydration under acidic conditions [61]. HMF is a major freshness and quality factor for honey; fresh honey contains very little HMF. HMF levels rise with heating, are a measure of overheated honey, and are associated with the browning of honey [57, 60, 61]. Both diastase and HMF affect the quality of honey, but neither is associated with a disease process. Honey has also been shown to contain metabolites of nitric oxide (NO). NO is an important cellular signaling molecule and plays a positive role in many biological processes and systems, including the immune and nervous systems. Honey contains several metabolites of NO, and this may play a role in its medicinal properties. Heating and lengthy storage times decrease levels of NO metabolites in honey [63]. Therefore, heating honey could negatively impact its medicinal properties.

To date, only one scientific study has examined the properties of honey mixed with ghee. It was found that heated honey mixed with ghee in unequal amounts resulted in enhanced browning and increased antioxidant activity compared with heated honey alone [57]. The researchers then administered (1) unheated honey, (2) heated honey, (3) honey and ghee, or (4) heated honey and ghee to rats for 7 weeks and found no changes in food consumption or organ weight [57]. A major limitation of this study for our purposes was that the honey and ghee were not mixed in equal proportions. It would be very interesting to determine how the properties of the honey/ghee mixture might change when mixed together equally.

The scientific evidence does demonstrate that antioxidants in honey do increase with low levels of heating, and NO decreases with heating. But it is not known how this might impact health, and no studies to date have examined phytochemical changes in a mixture of equal parts honey and ghee. Thus there is currently no scientific explanation for Ayurveda's prohibition on mixing equal parts honey and ghee.

11.4 Conclusions

This chapter examined some of the common dietary guidelines given by Ayurveda to determine whether we could find evidence-based biomedical research to support these basic principles. And in fact we could. Science supports many of these concepts, ranging from the avoidance of ice-cold beverages and food, to avoiding

Ayurvedic guideline	Supported by science?	Mechanism of action	Reference
Avoid ice-cold drinks with meals	**Yes**	1) Inhibits gastric emptying 2) Suppresses gut motility through activation of TRPA1 receptors	Sun et al. [5, 6], Nozawa et al. [8], Doihara et al. [11]
Avoid carbonated beverages	**Yes**	1) Decrease in LES pressure and tLESr 2) Modifies distribution of liquids and solids in the stomach 3) GI system does not register calorie content of caloric beverages	Hamoui et al. [15], Shukla et al. [16], Pouderoux et al. [14], Ploutz-Snyder et al. [17], DiMeglio and Mattes [19], Wolf et al. (2007)
Avoid microwaved food	**Somewhat**	1) Large temperature differentials may incompletely kill bacteria 2) Can induce molecular changes in raw rice that appear to recover over time	Ryynanen [23], Vadivambal [21], Zhao et al. [25]
Vegetable should be lightly cooked. Avoid deep-fried foods	**Yes**	1) Frying, pressure cooking, boiling can reduce antioxidants depending on the vegetable 2) Deep frying reduces carotenoids, flavonoids, ascorbic acid, phenolics	Jimenez-Monreal et al. [27], Miglio et al. [29]
Avoid frozen foods	**Somewhat**	1) Blanching vegetables before freezing can reduce healthful phytochemicals 2) Freezing can reduce folates 3) Freezing may incompletely kill microorganisms in food	Archer [37], Czarnowska and Gujska [38]
Limit red meat consumption	**Yes**	1) Increased risk for cancer and cardiovascular disease 2) Association between heavily browned meat and grilled meat and colorectal and prostate cancer 3) Heterocyclic amines combined with a high fat diet can enhance colon carcinogenesis 4) TMAO produced by gut bacteria from L-carnitine in meat is associated with atherosclerosis and cardiovascular disease	Kushi et al. [41], Gerhardsson de Verdier et al. [42], Tang et al. [43], Ubagai et al. [46], Koeth et al. [64]
Avoid processed foods	**Yes**	1) Phosphate additives can damage the cardiovascular and renal systems and bone 2) Food processing can affect the nutritional components of food 3) Ultra-processed foods contain excess fat and sugars and have low nutrient content	Ritz et al. [48], Hu et al. [49], Shahidi [50], Lustig et al. [54]
Do not heat honey; Do not consume equal amounts of honey and ghee	**Somewhat**	1) Many of the substances that give honey its flavor, aroma, and biological activity are heat-sensitive including diastase and NO 2) Heating honey increases HMF content 3) No studies on effect of equal proportions of honey and ghee	Tosi et al. [61, 62], Al-Waili [63]

Fig. 11.2 Summary of scientific evidence for Ayurvedic dietary guidelines and recommendations

cooking by boiling and extensive grilling, to eliminating processed food from our diets (summarized in Fig. 11.2). Where science fails us is when we try to overlay our scientific principles with the concepts that are unique to Ayurveda. A good example of this is microwaving food. We have seen that microwaves can alter certain aspects of the structure of food and change the quality of our experience with it, e.g., the toughening of baked products following heating by microwaves. Microwaving can also lower the antioxidant activity of some vegetables, but there is no strong scientific link between the effects of microwaving and a detrimental effect on human health. In Ayurveda, microwaving decreases the *prana* or life force of food. But we have no way of measuring or even scientifically identifying *prana*.

This does not mean that *prana* does not exist, just that modern science has no way to identify or measure it. We are therefore unable to design an evidence-based study to test the effect of microwaves on *prana.* Thus, science must remain silent for the time being regarding the idea that microwaves reduce *prana* in food.

For Ayurveda to be fully accepted by the Western biomedical community, it is crucial that we document and support Ayurvedic concepts and principles with evidence-based science. That being said, we are making slow progress (as discussed in this chapter), and new information from the biomedical community is emerging daily that is applicable to Ayurvedic principles. An excellent example is a fascinating new study demonstrating that gut bacteria metabolize L-carnitine in meat to trimethylamine-N-oxide (TMAO). The production of TMAO modulates cholesterol metabolism, leading to increased atherosclerosis and cardiovascular disease [64]. In addition, people who ate a lot of meat produced more TMAO from L-carnitine than did vegans or vegetarians who ingested L-carnitine. This was due to different populations of gut bacteria in meat eaters versus vegetarians [64]. This study provides a novel cellular pathway by which the consumption of red meat leads to cardiovascular disease through the transformation of L-carnitine by gut bacteria. Not only does this support the Ayurvedic principle that red meat should be mostly avoided in the diet, but it also provides irrefutable scientific evidence that gut bacteria and diet are inextricably linked and modulate human health. Indeed, a new body of literature has emerged over the last several years that highlights the role of gut bacteria in determining health outcomes. In Ayurveda, a healthy GI system with good digestion and elimination is essential to good health. It is remarkable that thousands of years later, modern medical science is reaching the same conclusion! It will be very exciting to watch this new area of biomedicine develop, and Ayurveda will certainly benefit from these studies. The acceptance by the medical and scientific communities that gut bacteria can significantly contribute to human health will most certainly help Ayurveda gain a foothold in modern medical practices. These and other studies serve to validate the principles and practices of Ayurveda within a twenty-first-century framework of health and disease.

References

1. Guha A (2006) Ayurvedic concept of food and nutrition. SoM articles paper 25
2. Zisman S, Goldberg DL, Veniegaas M (2003) Nutritional theory in Ayurveda. Altern Complement Ther 9:191–197. doi:10.1089/107628003322256904
3. Tirtha S (2007) In: Uniyal DRC (ed) The Ayurveda encyclopedia: natural secrets to healing, prevention and longevity. Ayurveda Holistic Center Press, Bayville, pp 127–129
4. Pole S (2008) The Ayurvedic approach to digestive health and nutrition. Nutrition 2:1–9
5. Sun WM, Houghton LA, Read NW, Grundy DG, Johnson AG (1988) Effect of meal temperature on gastric emptying of liquids in man. Gut 29:302–305
6. Sun WM, Penagini R, Hebbard G, Malbert C, Jones KL, Emery S, Dent J, Horowitz M (1995) Effect of drink temperature on antropyloroduodenal motility and gastric electrical activity in humans. Gut 37:329–334

7. Hale MW, Raison CL, Lowry CA (2013) Integrative physiology of depression and antidepressant drug action: implications for serotonergic mechanisms of action and novel therapeutic strategies for treatment of depression. Pharmacol Ther 137:108–118. doi:10.1016/j.pharmthera.2012.09.005
8. Nozawa K, Kawabata-Shoda E, Doihara H, Kojima R, Okada H, Mochizuki S, Sano Y, Inamura K, Matsushime H, Koizumi T, Yokoyama T, Ito H (2009) TRPA1 regulates gastrointestinal motility through serotonin release from enterochromaffin cells. Proc Natl Acad Sci USA 106:3408–3413. doi:10.1073/pnas.0805323106
9. Gershon MD (2012) Serotonin is a sword and a shield of the bowel: serotonin plays offense and defense. Trans Am Clin Climatol Assoc 123:268–280, discussion 280
10. Sikander A, Rana SV, Prasad KK (2009) Role of serotonin in gastrointestinal motility and irritable bowel syndrome. Clin Chim Acta 403:47–55. doi:10.1016/j.cca.2009.01.028
11. Doihara H, Nozawa K, Kawabata-Shoda E, Kojima R, Yokoyama T, Ito H (2009) TRPA1 agonists delay gastric emptying in rats through serotonergic pathways. Naunyn Schmiedebergs Arch Pharmacol 380:353–357. doi:10.1007/s00210-009-0435-7
12. Cuomo R, Sarnelli G, Savarese MF, Buyckx M (2009) Carbonated beverages and gastrointestinal system: between myth and reality. Nutr Metab Cardiovasc Dis 19:683–689. doi:10.1016/j.numecd.2009.03.020
13. Johnson T, Gerson L, Hershcovici T, Stave C, Fass R (2010) Systematic review: the effects of carbonated beverages on gastro-oesophageal reflux disease. Aliment Pharmacol Ther 31:607–614. doi:10.1111/j.1365-2036.2010.04232.x
14. Pouderoux P, Friedman N, Shirazi P, Ringelstein JG, Keshavarzian A (1997) Effect of carbonated water on gastric emptying and intragastric meal distribution. Dig Dis Sci 42:34–39
15. Hamoui N, Lord RV, Hagen JA, Theisen J, Demeester TR, Crookes PF (2006) Response of the lower esophageal sphincter to gastric distention by carbonated beverages. J Gastrointest Surg 10:870–877. doi:10.1016/j.gassur.2005.11.010
16. Shukla A, Meshram M, Gopan A, Ganjewar V, Kumar P, Bhatia SJ (2012) Ingestion of a carbonated beverage decreases lower esophageal sphincter pressure and increases frequency of transient lower esophageal sphincter relaxation in normal subjects. Indian J Gastroenterol 31:121–124. doi:10.1007/s12664-012-0206-0
17. Ploutz-Snyder L, Foley J, Ploutz-Snyder R, Kanaley J, Sagendorf K, Meyer R (1999) Gastric gas and fluid emptying assessed by magnetic resonance imaging. Eur J Appl Physiol Occup Physiol 79:212–220
18. Cuomo R, Savarese MF, Sarnelli G, Nicolai E, Aragri A, Cirillo C, Vozzella L, Zito FP, Verlezza V, Efficie E, Buyckx M (2011) The role of a pre-load beverage on gastric volume and food intake: comparison between non-caloric carbonated and non-carbonated beverage. Nutr J 10:114. doi:10.1186/1475-2891-10-114
19. DiMeglio DP, Mattes RD (2000) Liquid versus solid carbohydrate: effects on food intake and body weight. Int J Obes Relat Metab Disord 24:794–800
20. Wolf A, Bray GA, Popkin BM (2008) A short history of beverages and how our body treats them. Obes Rev 9:151–164. doi:10.1111/j.1467-789X.2007.00389.x
21. Vadivambal R, Jayas DS (2010) Non-uniform temperature distribution during microwave heating of food materials-A review. Food Bioprocess Technol 3:161–171
22. Mizrahi S (2012) Mechanisms of objectionable textural changes by microwave reheating of foods: a review. J Food Sci 77:R57–R62. doi:10.1111/j.1750-3841.2011.02515.x
23. Ryynanen S, Ohlsson T (1996) Microwave heating uniformity of ready meals as affected by placement, composition, and geometry. J Food Sci 61:141–148
24. Vollmer M (2004) Physics of the microwave oven. Phys Educ 39:74–81
25. Zhao S, Xiong S, Qui C, Xu Y (2007) Effect of microwaves on rice quality. J Food Prod Res 43:496–502
26. Kumar MBS (2009) The science and art of Ayurveda. In: Osborne D (ed) Science of the sacred: ancient perspectives for modern science. LuLu.com, pp 101–121. doi:978-0-557-27724-7
27. Jimenez-Monreal AM, Garcia-Diz L, Martinez-Tome M, Mariscal M, Murcia MA (2009) Influence of cooking methods on antioxidant activity of vegetables. J Food Sci 74:H97–H103. doi:10.1111/j.1750-3841.2009.01091.x

28. Sultana B, Anwar F, Iqbal S (2008) The effect of different cooking methods on the antioxidant activity of some vegetables from Pakistan. Int J Food Sci Technol 43:56–567
29. Miglio C, Chiavaro E, Visconti A, Fogliano V, Pellegrini N (2008) Effects of different cooking methods on nutritional and physicochemical characteristics of selected vegetables. J Agric Food Chem 56:139–147. doi:10.1021/jf072304b
30. Turkmen N, Sari F, Velioglu S (2005) The effect of cooking methods on total phenolics and antioxidant activity of selected green vegetables. Food Chem 93:713–718
31. Song L, Thornalley PJ (2007) Effect of storage, processing and cooking on glucosinolate content of Brassica vegetables. Food Chem Toxicol 45:216–224. doi:10.1016/j.fct.2006.07.021
32. Yuan GF, Sun B, Yuan J, Wang QM (2009) Effects of different cooking methods on health-promoting compounds of broccoli. J Zhejiang Univ Sci B 10:580–588. doi:10.1631/jzus.B0920051
33. Lopez-Berenguer C, Carvajal M, Moreno DA, Garcia-Viguera C (2007) Effects of microwave cooking conditions on bioactive compounds present in broccoli inflorescences. J Agric Food Chem 55:10001–10007. doi:10.1021/jf071680t
34. Moreno DA, López-Berenguer C, Garcia-Viguera C (2007) Effects of stir-fry cooking with different edible oils on the phytochemical composition of broccoli. J Food Sci 72:S64–S68
35. Bernhardt S, Schlich E (2006) Impact of different cooking methods on food quality: retention of lipophilic vitamins in fresh and frozen vegetables. J Food Eng 77:327–333
36. Pellegrini N, Chiavaro E, Gardana C, Mazzeo T, Contino D, Gallo M, Riso P, Fogliano V, Porrini M (2010) Effect of different cooking methods on color, phytochemical concentration, and antioxidant capacity of raw and frozen brassica vegetables. J Agric Food Chem 58:4310–4321. doi:10.1021/jf904306r
37. Archer DL (2004) Freezing: an underutilized food safety technology? Int J Food Microbiol 90:127–138
38. Czarnowska M, Gujska E (2012) Effect of freezing technology and storage conditions on folate content in selected vegetables. Plant Foods Hum Nutr 67:401–406. doi:10.1007/s11130-012-0312-2
39. Leygonie C, Britz TJ, Hoffman LC (2012) Impact of freezing and thawing on the quality of meat: review. Meat Sci 91:93–98. doi:10.1016/j.meatsci.2012.01.013
40. Wagner JA, Ason MC (1985) Effect of freezing rate on the denaturation of myofibrillar proteins. Int J Food Sci Technol 20:735–744
41. Kushi LH, Doyle C, McCullough M, Rock CL, Demark-Wahnefried W, Bandera EV, Gapstur S, Patel AV, Andrews K, Gansler T, American Cancer Society N & Physical Activity Guidelines Advisory C (2012) American Cancer Society Guidelines on nutrition and physical activity for cancer prevention: reducing the risk of cancer with healthy food choices and physical activity. CA Cancer J Clin 62:30–67. doi:10.3322/caac.20140
42. Gerhardsson de Verdier M, Hagman U, Peters RK, Steineck G, Overvik E (1991) Meat, cooking methods and colorectal cancer: a case-referent study in Stockholm. Int J Cancer 49:520–525
43. Tang D, Liu JJ, Rundle A, Neslund-Dudas C, Savera AT, Bock CH, Nock NL, Yang JJ, Rybicki BA (2007) Grilled meat consumption and PhIP-DNA adducts in prostate carcinogenesis. Cancer Epidemiol Biomarkers Prev 16:803–808. doi:10.1158/1055-9965.EPI-06-0973
44. Farhadian A, Jinap S, Abas F, Sakar ZI (2010) Determination of polycyclic aromatic hydrocarbons in grilled meat. Food Control 21:606–610
45. Sugimura T, Wakabayashi K, Nakagama H, Nagao M (2004) Heterocyclic amines: mutagens/carcinogens produced during cooking of meat and fish. Cancer Sci 95:290–299
46. Ubagai T, Ochiai M, Kawamori T, Imai H, Sugimura T, Nagao M, Nakagama H (2002) Efficient induction of rat large intestinal tumors with a new spectrum of mutations by intermittent administration of 2-amino-1-methyl-6-phenylimidazo[4,5-b]pyridine in combination with a high fat diet. Carcinogenesis 23:197–200
47. Salmon CP, Knize MG, Panteleakos FN, Wu RW, Nelson DO, Felton JS (2000) Minimization of heterocyclic amines and thermal inactivation of *Escherichia coli* in fried ground beef. J Natl Cancer Inst 92:1773–1778
48. Ritz E, Hahn K, Ketteler M, Kuhlmann MK, Mann J (2012) Phosphate additives in food–a health risk. Dtsch Arztebl Int 109:49–55. doi:10.3238/arztebl.2012.0049

49. Hu MC, Shiizaki K, Kuro-o M, Moe OW (2013) Fibroblast growth factor 23 and Klotho: physiology and pathophysiology of an endocrine network of mineral metabolism. Annu Rev Physiol 75:503–533. doi:10.1146/annurev-physiol-030212-183727
50. Shahidi F (2009) Nutraceuticals and functional foods: whole versus processed foods. Trends Food Sci Technol 20:376–387
51. Rao AV, Ali A (2007) Biologically active phytochemicals in human health: lycopene. Int J Food Prop 10:279–288
52. Block G (2004) Foods contributing to energy intake in the US: data from NHANES III and NHANES 1999–2000. J Food Compos Anal 17:439–447
53. Monteiro CA, Levy RB, Claro RM, de Castro IR, Cannon G (2011) Increasing consumption of ultra-processed foods and likely impact on human health: evidence from Brazil. Public Health Nutr 14:5–13. doi:10.1017/S1368980010003241
54. Lustig RH, Schmidt LA, Brindis CD (2012) Public health: the toxic truth about sugar. Nature 482:27–29. doi:10.1038/482027a
55. Block JP, Scribner RA, DeSalvo KB (2004) Fast food, race/ethnicity, and income: a geographic analysis. Am J Prev Med 27:211–217. doi:10.1016/j.amepre.2004.06.007
56. Diamond J (2011) Medicine: diabetes in India. Nature 469:478–479. doi:10.1038/469478a
57. Annapoorani A, Anilakumar KR, Khanum F, Murthy NA, Bawa AS (2010) Studies on the physicochemical characteristics of heated honey, honey mixed with ghee and their food consumption pattern by rats. Ayu 31:141–146. doi:10.4103/0974-8520.72363
58. Sserunjogi ML, Abrahamsen RK, Narvhus J (1998) A review paper: current knowledge of ghee and related products. Int Dairy J 8:677–688
59. Subramanian R, Umesh Hebbar H, Rastogi NK (2007) Processing of honey: a review. Int J Food Prop 10:127–143
60. Turkmen N, Sari F, Poyrazoglu ES, Velioglu YS (2006) Effects of prolonged heating on antioxidant activity and colour of honey. Food Chem 95:653–657
61. Tosi EA, Ré E, Lucero H, Bulacio L (2004) Effect of honey high-temperature short time heating on parameters related to quality, crystallisation phenomena and fungal inhibition. Lebensmitt-Wiss Technol 37:669–678
62. Tosi E, Martinet R, Ortega M, Lucero H, Re E (2008) Honey diastase activity modified by heating. Food Chem 106:883–887
63. Al-Waili NS (2003) Identification of nitric oxide metabolites in various honeys: effects of intravenous honey on plasma and urinary nitric oxide metabolites concentrations. J Med Food 6:359–364. doi:10.1089/109662003772519921
64. Koeth RA, Wang Z, Levison BS, Buffa JA, Org E, Sheehy BT, Britt EB, Fu X, Wu Y, Li L, Smith JD, Didonato JA, Chen J, Li H, Wu GD, Lewis JD, Warrier M, Brown JM, Krauss RM, Tang WH, Bushman FD, Lusis AJ, Hazen SL (2013) Intestinal microbiota metabolism of l-carnitine, a nutrient in red meat, promotes atherosclerosis. Nat Med. doi:10.1038/nm.3145
65. Wolf A, Bray GA, Popkin BM (2007) A short history of beverages and how our body treats them. Obes Reviews 9(2): 151–164

Chapter 12
From Book to Bedside: Challenges of Translating Ayurvedic Science of Food and Nutrition for the Common Benefits

Sanjeev Rastogi

12.1 Introduction

Ayurvedic principles of food and nutrition have a universal appeal for their constructive compactness and for the reasonability through which they are propounded. In India, Ayurvedic principles of nutrition are laid deep into the culture in a way that they reach to the level of a routine practice without getting noticed for possession of their special values.

The novelty of Ayurvedic food science lies in its integral connectivity with the consumer at the same time when connects to the quality of the food. This makes Ayurvedic food propositions completely tailor made where the food is recommended in conjunction with the knowledge about the ultimate consumer. This is also important to understand here that the food and consumer matrix in Ayurveda is totally dynamic and thereby the food propositions are highly individualistic yet variable in reference to the conditions warranting a change in food related need or behavior in a particular person. It clearly proposes that it is not the property of food which makes sense but also the consumer sided conditions interplay to determine a final food related outcome in a given condition.

Ayurvedic food science proposes the dual nature of food: the one as health promotive, including the convalescent foods to speedup recovery and the conventional food to sustain the health. The others are the foods which are disease promotive either in their entirety or for being helpful in building up a pro disease environment if consumed consistently beyond a normal thresh hold level as per the individual susceptibility. An erratic combination of otherwise two health promotive foods (*viruddahara*) can also be disease promotive as is identified in Ayurveda.

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12.2 Evaluating the Other Side of the Coin: The Food Which Can Make One Sick

At same time while talking about the pro-health attributes and compositions of the food, Ayurveda puts a strong emphasis upon the food which can make one sick either because of its absolute anti health properties or because of intake related quantitative violation. More over some good foods can also act contrary on the basis of their processing, consumption or quantity related faults. Giving emphasis to food as the cause of health as well as of disease, *mithya ahara* (inappropriate diet) has been considered a generic disease promoter where specificity of the food causing disease may be linked with the pathogenesis of a specific disease.

12.3 Food Based Clinical Researches: Challenges in Ayurveda

Many food related practices prevalent in Indian subcontinent are actually the embodiment of Ayurvedic concepts about healthy and unhealthy food practice. Surprisingly as many of these fundamentals are there in the practice either as folklore or as a traditional belief, they remain unquestioned and are practiced ritually. This is also true that despite of considering food as a vital component of any treatment plan in Ayurveda, serious efforts have not been taken to establish it as a dependable management modality in clinical conditions where it may give rise some predictable results. Because of ambiguity of the subject and also because of unavailability of the research based data to prove its effectiveness as a therapeutic agent, use of diet in Ayurvedic clinical practice remained minimal. As the food practices recommended in Ayurveda are told to be linked with health benefits or with diseases, this would have been imperative to establish these link through various epidemiological studies specially the case–control and the cohort studies.

12.3.1 Questioning About Food: The Difficulty in Epidemiological Studies

Because the food practices are not as tangible as other medical therapies or as other disease precipitatory or health promotive practices, this becomes difficult to frame a particular food habit for its link with any health related risk or benefit. Food Frequency Questionnaire (FFQ) had been the sole tools so far to evaluate such links between food practices and disease in epidemiological studies [1]. Prior to the development of FFQ conventionally a diet history was used to identify the food related behavior of an individual in a case control or cohort study. This conventional method of recording the diet history required substantial sum of time and used to be

in the form of unstructured interview taken by a nutritionist. Because of various confounding factors operating in between, the results obtained through such histories have not always been reliable. The results obtained through diet histories are found to be as variable as 10–70 % [2]. Subsequently a simplified, self-administered, and inexpensive form of the diet history was arrived in the form of the food frequency questionnaire [3].

The development of FFQ has eliminated many inconsistencies associated with diet history utilized in earlier food association studies but gradually it was also found to be of limited value. FFQ in larger cohort studies and in long term follow ups could not lead to the consistent results [4]. Many strong findings of links on diet and cancer risk from case control studies could not be replicated in cohort studies or clinical trials using the FFQ as the study tool [5–7]. Some pragmatic solution have recently been proposed to overcome the limitations associated with FFQs to make them more dependable and reliable in linking the food behavior and risk of developing a disease. Of many suggestion the most important ones are to redesign the food frequency type of approach, improving the accuracy in quantitative recording of food consumption, using computer assisted technologies to keep a track record of food related behavior of the participants and using the long term food behavior in the case–control format.

12.3.2 Questioning About Food: Finding Its Relevance to Ayurveda

Ayurveda links a huge number of food related behavior to a variety of diseases. It identifies a few food items as completely unwholesome irrespective of the time and person of its actual consumption. These are considered *ahitahara* and are largely discarded for their health demotive values. On the other hand there are many foods and their combination which are health demotive on the basis of the quantity actually consumed. Food also has got a relation to disease in reference to its combination with other edibles at the same time. The food processed variously may develop a biological incompatibility if combined in a specified proportion or method to another edible which may otherwise is totally devoid of any unhealthy effects. *Apathya* or unwholesome diet is being considered as the primary cause to almost every disease enlisted in Ayurveda and the disease *dosha* variability is often found linked with the type of actual food which is consumed. Unfortunately this huge account of Ayurvedic idea of unwholesomeness of food and their association with some specific disease or an unhealthy state has never been endorsed scientifically. While having an over view with the food related etiopathogenesis of the diseases, this is easy to find certain homologies in many disease conditions. For example *prameha* and obesity are found to have similar kind of food enlisted as the cause of their initiation. Similarly many hepatobilliary diseases, ulcerative diseases and hematological diseases have a similar food based etiology. Ayurveda endorses this homology of food based etiopathogenesis and identifies two broader food based

disease groups. The one caused by excess of nutrition are called *santarpana janya* disease and the other caused by depletion called *apatarpana janya* disease. This account of disease seems much similar to what we conventionally know as diseases caused by over and under nutrition. Interestingly the treatment offered in these two conditions is just to reverse what caused a disease. It is to offer *santarpana* to them who are depleted and *apatarpana* or abolition from them who are over nourished. Looking striking simple and appealing however this simple analogy of Ayurvedic cause and effect also requires to be tested on the parameters of science before any such generalization can be made.

What could have been most interesting in case of establishing a cause and effect relationship to food and disease in the purview of Ayurveda is to go for a case control study with those having a clear diagnosis on Ayurvedic basis [8]. These people might have been identified for their food habits in the past and then this observation might have been compared with a similar control group to check if the differences really exist.

This food history in Ayurveda is however much more difficult to observe and to interpret comparing to the food history taken by a conventional nutritionist. As the foods are not the sole source of pathogenesis and as they behave differentially among different people, a lot of variables are to be taken into account before any such correlation may be established. For example the *prakriti* of the consumer, time of the consumption, quantity of the consumption and mental state of the consumer all is said to affect the net outcome of a food related behavior. Therefore the inferences about the food and its association with diseases are never complete unless they are viewed in reference to all the confounding factor and variable which may lead to a different outcome.

12.4 From Abstract to Reality: Challenges of Proving the Fundamentals as the Tools of Clinical Practice

Ayurvedic science of food and nutrition is full of such thoughts which look appealing on a metaphysical ground but at the same time fail to appeal to a scientifically tuned mind. As these principals are given abundant importance in Ayurveda in terms of causes leading to health or disease, this is unquestionable to find methods to perceive them more objectively for their better application in health care. Some of the key thoughts of Ayurvedic food science and pragmatic methods to perceive them objectively are presented here.

12.4.1 Consideration of Guru *and* Laghu

Guru and *laghu* had been the digestibility index of Ayurveda aiming to differentiate between easy to digest and difficult to digest food items. Although a clear

demarcation between such foods can never be made, we can easily make a digestibility scale on the basis of in vitro analysis of the digestion of certain food items. As the digestibility of food often depends upon the state of food and also upon the methods of processing, it can be elaborated extensively in terms of various factors influencing the ultimate digestion. Methods similar to identify Protein digestibility corrected amino acids score (PDCAAS) may prove to be a template for such studies [9]. In vitro digestibility studies may have an edge over the in vivo study that they can deal with huge number of substrates at the same time and in processed and unprocessed forms exactly in the way as they are proposed for eating. Although good and easy to perform, in vitro studies of this kind are also going to be questioned for individuality of the digestion which makes the net difference in causing a healthy or a sick outcome related with food. For the beginning however we presume that in vitro digestibility studies may give us sufficient lead for how to move further. These digestibility studies may also be clubbed with identification of the glycemic index for the same food to see if there are any realistic relations between food digestibility and its glycemic load [10].

12.4.2 Identifying the Physiological Response to Rasa

Rasa as an attribute to food is said to be the representative of elemental composition of the food. The physiological effects of a food thereby are the responses of the elemental predominance and can directly be judged with the help of primary taste of the substance. Similar *Rasa* are found to have similar pharmacological actions, this hypothesis was proved recently when oleocanthal was found to have similar pharmacological actions as that of ibuprofen predicted on the basis of their taste [11]. A huge work actually can be done to prove the physiological effects of various *rasa* both in human and in animal studies. With the development of appropriate measures to check the physiological responses upon a fixed taste diet, this would be easy to conclude if the tastes are having a definitive physiological relationship. A step ahead, this observation is also going to give a huge impetus to the Ayurvedic concepts of five elemental constitution and its subsequent application in the health care.

12.4.3 Examining the Methods of Eating

Ayurveda proposes a very orderly method of consuming the food in order to achieve the maximum benefits from the food. Some easy experimental studies can be planned to see if the methods of eating make any difference to the physiology and subsequent health related outcomes. The experiment can expose the subjects under study to certain conditions considered unhealthy in Ayurveda and then can compare the outcome with that of the controls kept under healthy eating conditions as were recommended in Ayurveda . There can be the human or the animal studies of this kind.

12.4.4 Examining the Agni *in Reference to Age/Time of the Day/Season*

Agni being one most prominent fundamental of Ayurvedic dietetics requires a thorough examination before it can be dependably applied to an evidence based health care. Ayurveda proposes that in natural course *agni* is variable as per the age, time of the day and season. There are evidences that digestive capabilities get diminished as a consequence of aging. There occurs atrophy of gastric mucosa and also the liver shrinkage resulting in reduced amount of enzymatic secretion [12]. This reduced metabolic state resembles strikingly to physiological *vata* predominance of old age. This is also proposed that there are diurnal variations in the human physiology which affect the level of enzymatic secretions and subsequent food based behavior [13]. *Agni* however is difficult to be interpreted through such simple methods. A very good example of linking *agni* with that of enzymatic status of the human digestive system comes from the clinical observation of the people who had undergone eliminative procedures of *panchakarma*. A process like *vamana* and *virechana* is said to create diminution of *agni* consequential to the procedure and hence requires a periodic repair to rebuild the *agni*. Now we know that the mucosal cells in the gastrointestinal tract have a regular shedding phenomenon and this phenomenon increases many fold in case of a forced insult to luminal cells, an event which occurs during the process of forced purgation or emesis. It takes 3–5 days to regenerate such cell to recuperate the digestive capability [14]. Very meaning fully Ayurveda proposes a 3–7 day dietary protocol for such patients who had undergone any such procedure just to bring the distorted lumen back into the order. Most surprisingly the dietary regime recommended in these conditions begin with readily digestible starches, in endorsement of the fact that amylase secreting cells in the lumen are the one who are least affected by any toxin or any insult. This is how we find proposal of adding rice starch with oral rehydration solution for its use even in cases of acute diarrhea.

12.5 Conclusions

Bringing the Ayurvedic fundamentals of food and nutrition into evidence based, user friendly and applicable format in order to enhance their impact upon health care is a big deal of work. As many of such principles look abstract, they require a serious thinking of how they can be brought into a scientific reality. There can be many pragmatic ways as are suggested here and many more can be thought of as per the actual need. As this is true with all the traditional systems of health care, they require to be experimented for what they actually offer. An Ayurvedic end point would therefore be the guiding principle for letting every scientific experiment to come into the being.

References

1. Kristal AR, Peters U, Potter JD (2005) Is it time to abandon the food frequency questionnaire? Cancer Epidemiol Biomarkers Prev 14:2826
2. Doll R, Peto R (1981) The causes of cancer: quantitative estimates of avoidable risks of cancer in the United States today. J Natl Cancer Inst 66:1193–1308
3. Stefanik P, Trulson M (1962) Determining the frequency of foods in large group studies. Am J Clin Nutr 11:335–343
4. Potter JD (2005) Vegetables, fruit, and cancer. Lancet 366:527–530
5. Voorrips LE, Goldbohm RA, van Poppel G, Sturmans F, Hermus RJJ, van den Brandt PA (2000) Vegetable and fruit consumption and risks of colon and rectal cancer in a prospective cohort study. Am J Epidemiol 152:1081–1092
6. Schatzkin A, Lanza E, Corle D et al (2000) Lack of effect of a low-fat, high-fiber diet on the recurrence of colorectal adenomas. N Engl J Med 342:1149–1155
7. Alberts DS, Martinez ME, Roe DJ et al (2000) Lack of effect of a high-fiber cereal supplement on the recurrence of colorectal adenomas. N Engl J Med 342:156–162
8. Rastogi S (2012) Transforming Ayurveda: stepping into the realm of evidence – based practice. In: Rastogi S, Chiappelli F, Ramchandani MH, Singh RH (eds) Evidence based practice in complementary and alternative medicine: perspectives, protocols, problems and potentials in Ayurveda. Springer, Berlin, pp 33–50
9. Bhatty RS, Slinkard AE, Sosulski FW (1976) Chemical composition and protein characteristics of lentils. Can J Plant Sci 56(4):787–794. doi:10.4141/cjps76-128
10. Miller JB, Pang E, Bramall L (1992) Rice: a high or low glycemic index food? Am J Clin Nutr 56(6):1034–1036
11. Beauchamp GK, Keast RSJ, Morel D, Lin J, Pika J, Han Q, Lee C-H, Smith AB, Breslin PAS (2005) Phytochemistry: ibuprofen-like activity in extra-virgin olive oil. Nature 437:45–46
12. Lovat LB (1996) Age related changes in gut physiology and nutritional status. Gut 38: 306–309
13. Cummings DE, Purnell JQ, Frayo RS, Schmidova K, Wisse BE, Weigle DS (2001) A preprandial rise in plasma ghrelin levels suggests a role in meal initiation in humans. Diabetes 50(8):1714–1719
14. Okamoto R, Watanabe M (2004) Molecular and clinical basis for the regeneration of human gastrointestinal epithelia. J Gastroenterol 39(1):1–6

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