Chapter 13
Biological and Cultural Bases of the Use of Medicinal and Food Plants

Washington Soares Ferreira Júnior, Letícia Zenóbia de Oliveira Campos, Andrea Pieroni, and Ulysses Paulino Albuquerque

The ethnobiological literature has usually dealt separately with the use of food and medicinal resources by human populations. There is no doubt that these two types of resources are essential for human survival; they nourish our species and/or prevent or treat illnesses. Some studies show that the use of food plants may impact the maintenance of health in a group or even be used to treat illnesses (Johns 1990; Pieroni and Price 2006; Etkin 2006).

This overlap may suggest much more than the simple fact that individuals use the same resource for both needs. Instead, it may indicate the existence of an evolutionary continuum in the use of food plants and of medicinal plants. This continuum may shed light on the understanding of how humans appropriated nature throughout their evolutionary history and, from this starting point, began to develop the medicinal and nourishment systems.

In this chapter, we attempt to expand on the ideas behind a food–medicine continuum that has enabled humans to deal with plants. From this starting point, we discuss the role of this continuum during human evolution, particularly at the origin of medicinal systems, by presenting some biological and cultural bases that drove human beings to perceive and access the food–medicine continuum.

W.S. Ferreira Júnior (✉) • L.Z. de Oliveira Campos • U.P. Albuquerque
Laboratory of Applied and Theoretical Ethnobiology (LEA), Department of Biology,
Federal Rural University of Pernambuco, Av. Dom Manoel de Medeiros, s/n,
Dois Irmãos, Recife, Pernambuco 52171-900, Brazil
e-mail: kba.bio@hotmail.com

A. Pieroni
University of Gastronomic Sciences, Piazza Vittorio Emanuele 9,
Pollenzo (Cuneo) 12042, Italy

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13.1 The Food–Medicine Continuum

In some situations, it is hard to differentiate between the medicinal and food uses of plants, suggesting the existence of a continuum between these two categories. For example, south-Asian immigrants living in northern England include plants in their cuisine that are also used as medicine (Pieroni et al. 2007). Strong overlap between these two uses has also been observed in communities in Nigeria (Etkin and Ross 1982).

From a pharmacological point of view, there is evidence indicating that certain plants used as food contain substances with important pharmacological activity. The Maasai community in eastern Africa regularly eats certain plants that have been shown to have a large amount of saponins and phenols, which have the potential to minimize the incidence of cardiovascular problems in the community; notably, the diet in this community is rich in cholesterol and fats (Johns et al. 1999). In addition, these food plants have been shown to have in vitro activity against the measles virus, an illness with a high incidence rate in the children of this community (Parker et al. 2007). Thus, given their vast pharmacological potential, the plants added to the diet of the Maasai may have an important role in maintaining local health.

The use of a set of resources as medicine and as food may be classified in the following manner (Pieroni and Quave 2006): (1) There are plants that are indicated for medicinal and food use, but these two uses are unrelated. For example, the fresh shoots may be used as food but are considered medicinal when they are ground and applied topically. In this case, the two uses are unrelated. (2) A plant may be ingested as food, and its use may also be recognized by people as having a positive impact on health without being indicated for one or more specific illnesses. Such plants may act as “folk functional foods” in a human group. (3) Finally, there are plants that are used as food, and this use is also associated with preventing and/or treating one or more specific illnesses. This is the case, for example, when the seeds of a plant are used as food when ingested after cooking, and the same use is indicated to treat illnesses that affect the gastrointestinal tract. These three cases show that a given resource may be used as medicine or as food depending on how it is prepared and/or on the intent and goal with which this resource is used (Jennings et al. 2015). These three examples reflect different levels of a food–medicine continuum, with the third case exemplifying how at times it is difficult to separate between the food and medicinal uses (Jiang and Quave 2013; Jennings et al. 2015).

As diseases have been an important selective force throughout human evolution (Brown 1987), the attribution of food and medicinal use to a set of resources may be due to biocultural adaptations of the human species in response to the occurrence of illnesses (Etkin and Ross 1982). Thus, the selection of nourishing resources that simultaneously aid in the prevention and treatment of diseases may have been advantageous for populations throughout human evolution. For example, hunter-gatherer populations have been considered the most well-nourished populations in human history because they had at their disposal a large variety of species used for food; these food sources contained a wide variety of substances that simultaneously sated hunger and prevented and/or treated illnesses (Etkin 2006).

However, changes in food habits, especially after the development of agriculture, may be connected to the appearance of many illnesses in modern populations, as there was an approximately 50 % decrease in the diversity of plants used in the diet (Etkin 2006; Leonti 2012).

When considering the evidence reinforcing the existence of a food–medicine continuum from an evolutionary perspective, we ask the following question: what does this continuum reveal about the evolution of the relationships between humans and nature? In an attempt to answer this question, we first present the chemical-ecological perspective of Timothy Johns regarding the relationships between human beings and chemical substances in the environment (Johns 1990, 1999). Under this perspective, the use of plants and animals as human food has a long evolutionary history, during which human beings developed a number of strategies to address the chemical substances ingested from the diet to maximize the beneficial substances and minimize the effects of potential toxins. According to Johns (1990), the basis of human medicine is the use of plants for food during our evolutionary past. When experimenting with food plants in the past, it is likely that humans identified some resources that relieved symptoms of illnesses while also providing nutritional benefits (Johns 1990). In this case, the development of the use of medicinal plants may have started when humans observed that certain food plants also treated diseases, thus reflecting the food–medicine continuum. Our first answer to the question above is that the food–medicine continuum was the basis for humans to perceive the medicinal use of plants and is thus the basis of the evolution of medicinal systems.

Daniel Moerman is another scientist who contributed to this discussion. Moerman analyzed a data set on the use of plants by 291 North American tribes, encompassing the use of 3895 different species (Moerman 1996). When assessing the relationships between food and medicinal uses, he found that 19 % of the plants were used exclusively as food, 45 % were used as medicine, and 29 % were used as both as food and medicine, demonstrating an overlap between the two uses. Moerman suggests that these data do not corroborate Timothy Johns' idea that medicinal use derived from food use, as he expected to find a greater number of plants used as both food and medicine. When analyzing the species used as both food and medicine, the uses did not necessarily overlap regarding the parts of the plant used. Therefore, even for species with an overlap between the two uses, the parts used for the different goals were often different. For example, the data show that fruits were indicated mostly for food but were seldom cited for medicinal use. Similarly, lianas and vines were mostly indicated for medicinal use but were seldom used as food (Moerman 1996). Based on these data, Moerman states that medicinal use did not necessarily derive from food use but rather evolved independently from it. Moerman's data are robust, and his argument is valid if we consider that a medicinal or food tradition must remain static. However, the work of Gottlieb et al. (1995) presents interesting evidence that in a certain way supports the findings of Moerman (1996), for which we have a different interpretation.

Gottlieb and collaborators conducted a study with three groups of indigenous peoples of the Amazon to assess the distribution of food and medicinal uses among plant families (Gottlieb et al. 1995). They observed that food plants tend to belong to more basal groups, whereas medicinal plants tend to belong to more derived groups. The subclasses with a large number of food plants had few medicinal plants and vice versa (Gottlieb et al. 1995). These data once again indicate that this low overlap would be expected, corroborating Moerman's findings, but they do not invalidate the idea of a continuum. We thus suggest that the food–medicine continuum had an important role in the origin of the medicinal use of food but that medicinal knowledge and practices evolved independently after originating from the food–medicine continuum. Therefore, the continuum may have played a role in the origin of human medicine but not necessarily in its evolutionary trajectory.

Further confirmation of our ideas comes from recent data collected from a mountainous and remote area of the Southern Balkans (Quave and Pieroni 2015), where pastoralist Albanians have lived together with the Gorani ethnic minority for several centuries. Despite this contiguity and the fact that these groups inhabit the same inhospitable ecological landscape, Gorani and Albanian medicinal plant uses remarkably diverge, while wild food plants and related preparations are similar. The fact that these wild food plants-based dishes are considered important for "maintaining" health, especially during long snowy winters, i.e., they represent "folk nutraceuticals" (Pieroni and Quave 2006), could confirm that this gray area represents the core of an original "medicinal cuisine" from which very divergent plant medicines originated. Moreover, while folk knowledge concerning food and medicinal foods is ubiquitously distributed, specific medicinal plant knowledge is often retained by specific knowledgeable persons/healers.

This could explain also why in the Mediterranean region for example—where medicinal plant healers have surely played a minor role in the last Centuries in the delivery of health care among peasants—the medicinal plant knowledge is still very linked to medicinal foods and it is often considered a common heritage of the whole community.

To understand the role of the continuum in the origin of medicine, it is necessary to answer a second question: how did humans perceive the therapeutic properties of plants based on the food–medicine continuum? To help answer this question, we present two topics on the biological and cultural bases that would have been important during our evolutionary history, as they provided our species with a greater degree of proximity to and experimentation with species that reflected the food–medicine continuum.

13.2 Biological Bases Involved in the Food–Medicine Continuum

Under this topic, we highlight the biological bases that enabled humans to access and perceive the food–medicine continuum. We use as an example the production of detoxifying enzymes by the body and the human chemosensory perception.

13.2.1 Detoxifying Enzymes in Humans

There are a variety of detoxifying enzymes produced by humans that are important for breaking down toxic compounds ingested during feeding (Ingelman-Sundberg 2005), such as UDP-glucuronosyltransferases, glutathione transferases, sulfotransferases, and the cytochrome P450 superfamily (Nebert and Dieter 2000). These enzymes played an important role in human adaptation to the chemical environment to which the first hominids were exposed (Johns 1990), resulting in a high degree of genetic polymorphisms and a large number of copies of some of the genes that code for these enzymes (Wang et al. 2007).

There is evidence that individuals with multiple copies of the genes coding the detoxifying enzyme CYP2D6 are able to metabolize a larger number of toxic compounds than individuals with few copies of this gene (Ingelman-Sundberg 2001; Aklillu et al. 2002). We may therefore infer that a larger number of copies of these genes in a given individual allows for increases in the amount and diversity of food ingested without causing a toxic reaction in the body.

From an evolutionary viewpoint, the presence of these enzymes may have facilitated access to the food–medicine continuum by the first human groups that dealt with nutritional and therapeutic needs (Johns 1990). A diet that included plants with toxic secondary compounds may thus have been favored, as these enzymes can break down a large amount of toxic compounds, decreasing their concentration in the body (Ingelman-Sundberg 2005). The ingestion of these plants may have also aided in maintaining a healthy body, as bioactive secondary compounds have important pharmacological properties (Leonti 2012).

13.2.2 Chemosensory Perception and the Bitter Taste Perception Threshold

Another way in which humans may have perceived the food–medicine continuum is taste perception. For example, communities descending from Albanians, who migrated to Southern Italy in the fourteenth and fifteenth centuries, use plants with a slightly bitter taste only for food and plants with a more intense bitter taste both as food and especially as medicine only; plants with a bitter taste that is perceived as strong are only used as medicine (Pieroni et al. 2002). From this example, we may infer that the use of a plant as food and as medicine may be seen as a continuum that is assessed based on the perception of the bitter taste. A set of studies conducted in several cultural groups suggested a relationship between bitter taste and the indication of a plant as medicinal—in other words, bitter taste is an indicator that the resource has medicinal value (Brett 1998; Brett and Heinrich 1998). In addition, it has been observed that bitter taste is associated with a set of pharmacologically active compounds (Mennella et al. 2013).

Although not all studies found an association between taste and a particular set of illnesses (see Casagrande 2000), some studies have suggested the existence of such an association (Ankli et al. 1999; Leonti et al. 2002). A study by Medeiros et al. (2015), for example, showed an association between perceived taste and the indication of plants for a set of illnesses in a local community in the Brazilian northeast. However, this association was only observed for the most popular therapeutic indications and for the tastes most commonly mentioned by the study group, such as bitter taste. In this case, plants with a perceived bitter taste were indicated mostly for certain illnesses, whereas tasteless plants or plants with a perceived good taste were indicated for other illnesses (Medeiros et al. 2015). This result suggests that taste perception plays an important role in the use of medicinal plants, particularly for the most commonly mentioned illnesses and tastes and that bitter taste is especially important in the recognition of medicinal plants by individuals. When considering that bitter taste is important in the medicinal use of plants, we may infer that the study of human perception of bitter taste may aid in gaining understanding of how humans first perceived the food–medicine continuum.

Bitter taste perception varies among individuals, and this variation is influenced by genes. The *TAS2R38* gene has been associated with taste perception, namely, to a high sensitivity to bitter taste, as individuals with this allele perceive bitter taste even when the concentration of a known bitter compound is low (Mennella et al. 2005). In contrast, another allele of this gene has been associated with low sensitivity to bitter taste, with individuals perceiving bitter taste only when a known bitter tasting compound is present in high concentrations (Mennella et al. 2005). The combination of the alleles of this gene has been associated with the formation of three groups of individuals based on bitter taste perception, namely, (1) supertasters, with high sensitivity to bitter taste, (2) tasters, with intermediate taste perception threshold, and (3) nontasters, with low sensitivity to bitter taste (Bartoshuk 2000). The frequencies of the taster and nontaster alleles in the human population have been estimated to be approximately 50 % (Guo and Reed 2001; Wooding et al. 2004). Analyses of data collected in the USA show the frequencies of the nontaster, taster, and supertaster phenotypes to be 25, 50, and 25 %, respectively, in the American population (Bartoshuk 2000). The identification of these groups of individuals may help elucidate possible variations in the perception of the taste that these individuals attribute to food and medicine plants in different human groups.

Considering that bitter taste perception is important for recognizing plants with medicinal use and that there are people who genetically perceive bitter taste more strongly, it is possible that during the cultural evolution, supertasters encompassed shamans or people with a vast knowledge of medicinal and food plants in human communities. From an evolutionary point of view, individuals with alleles that confer a stronger perception of the bitter taste were able to perceive and approach plants that reflected the food–medicine continuum and to actively participate in the building of medical traditions. Thus, a stronger perception of bitter taste may favor an association of a food's perceived taste with its medicinal properties. We believe that this association may be more difficult for individuals who are genetically less sensitive to bitter taste, as they tend to perceive food as slightly bitter or not bitter. Therefore, the medicinal knowledge acquired by these supertasters through experimentation was transmitted to other individuals by cultural transmission and social learning processes.

13.3 Cultural Bases Involved in the Food–Medicine Continuum

The techniques adopted to process food throughout human cultural evolution also played an important role in the approach to plants reflecting the food–medicine continuum. Thus, food-processing techniques enabled the use of a greater variety of resources for food by reducing plant toxicity and facilitating their ingestion without causing damage to the body.

Culture is an important factor in the interaction between people and the environment because of its role in both altering environmental selective pressures and favoring changes in dietary patterns, which in turn may also affect health and lead to certain types of illnesses (Etkin 2006). From a chemical-ecological perspective, it has been found that the most important cultural stages in the evolution of human diet were the technological leap and the origin of agriculture (Johns 1990). Different practices were developed by hunter-gatherer populations to assess which species were appropriate for consumption, and these techniques are the result of cultural practices developed by these populations.

For example, it was with the use of fire for cooking and with the use of geophagy, fermentation and drying that food considered unpalatable began to be used in the diet. The substances present in some plants that were not consumed by humans include toxic substances, represented by different secondary compounds (Johns 1990). It is also important to note that in some human groups, bitter-tasting foods tend to be considered “bad foods” or “hard foods” and therefore unpalatable (Johns 1990). The use of techniques to reduce the toxicity and the effects of certain flavors may thus have led food previously considered as “hard foods” to become “soft foods”, i.e., food appropriate for human consumption (Johns 1990). Although the use of the abovementioned detoxifying techniques has been indicated as important in promoting evolutionary advantages in the human species, we must also consider that this process may affect the amount of nutrients, vitamins and minerals present in a given plant (Etkin 2006).

Geophagy, or detoxification by clay, is an important detoxification method, especially when plants with a high concentration of tannins and alkaloids are consumed. This technique was commonly used in many regions of the globe. For example, geophagy was often used in the Andes to detoxify the body after the consumption of native potatoes. In turn, fermentation is a food detoxification and transformation technique used from ancient to modern times. It is still in use because, depending on the microorganism (bacteria or fungus) used in this process, not only the toxicity but also the flavor and consistency of the food may be altered. This process is commonly used in the production of bread, sauces, and dairy and alcoholic beverages (Etkin 2006). Another important detoxification process is drying, which is used mainly to remove volatile toxins from food. This method is usually used alongside other detoxification methods to remove non-volatile toxic substances (Johns 1990).

Another cultural adaptation factor that significantly influenced the concentration of toxins in plants consumed by human populations throughout the world was domestication (Etkin 2006). Domestication is an essential aspect of agriculture, as it plays an important role in modifying or alleviating the effects caused by the concentration of certain allelochemicals. However, the disadvantages related to domestication must also be considered, as this process may affect the nutritional availability of certain substances in the plant. For example, the origin of agriculture is associated with an increase in the amount of dense carbohydrates present in plants, which considerably reduced the amount of secondary compounds in domesticated plants (Johns 1990). Depending on their concentration, such secondary compounds may be essential for the survival of a species under adverse environmental conditions.

13.4 Final Considerations

The study of the overlap between the use of plants for food and for medicine is an important field of ethnobiological research. Below, we give examples of some topics that may be of interest for future studies:

- In humans, plants used as food can affect certain diseases, such as reducing metabolic diseases and preventing infection. Thus, the addition of these plants to the diet can reduce the use frequency of resources in a local medical system to treat infections. Local systems that utilize plants to treat infectious diseases cannot be appreciated if we neglect to investigate the plants used in the diet.
- Studies related to the food–medicine continuum offer important contributions for bioprospecting, as they may broaden the choice of possible plants with pharmacological potential. For example, plants regularly used as food can be perceived by the members of a group as being effective for the control of specific illnesses and may even contain classes of compounds of pharmacological interest (Johns et al. 1999; Parker et al. 2007). Studies focusing on medicinal plants may often ignore some food resources that may also have medicinal potential.
- Ethnobiological field studies are needed that more seriously consider the “central” part of the continuum between food and medicine, which is often related to domestic practices managed by women within the households. These studies should use appropriate, sophisticated research methods for eliciting data that borders between food and medical anthropology.

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