Chapter 8: Spices and Herbs

Introduction

A plant-based dietary pattern is receiving increased attention since it enables food synergies among many different classes of compounds found in foods (1,2). Studies suggest that ancient hunter-gatherers ate hundreds of different plant-derived foods, including stems, leaves, flowers and roots (3). Spices used since Stone Age times have unique biological properties. They were traditionally valued for their health benefits as well as their taste (4–6). They are even richer in antioxidants than many fruits and vegetables, since they no longer contain the water, which makes up a good part of the weight of most fruits and vegetables.

Spices and food herbs are only slightly different, and for the purposes of this chapter no distinction will be made. While many spices have health benefits, the nutritional rather than medicinal uses of herbs in foods and dietary supplements will be discussed rather than prescribed herbal medicines. A food herb is generally defined as the leaf of a plant when used in cooking, but any other part of the plant, often dried, can be a spice. Spices can be the buds (cloves), bark (cinnamon), roots (ginger), berries (peppercorns), aromatic seeds (cumin) and even the stigma of a flower (saffron). Many of the aromatic seeds known as spices are actually gathered from plants when they have finished flowering. A familiar example would be coriander, with the leaves being referred to as an herb, and the dried seeds as a spice. When referring to the stem and roots of coriander, which are used in cooking, and to onions, garlic and the bulb of fennel, these parts of these plants tend to be classified along with herbs, as they are often used fresh and applied in a similar way to cooking.

In the last century, the health-enhancing properties of specific foods have been documented scientifically (7) beginning with the discovery of vitamins and minerals essential to life and most recently with the documentation of some 25,000 different substances, many with antioxidant and anti-inflammatory properties. These foods are often called functional foods, and the many spices would qualify for this classification.

The modern American diet consists of many low-cost foods that provide adequate or even excessive calories, salt, fat and sugar, but often lack the unique plant nutrients found in spices. These foods are calorie-dense but nutrient-poor. Vitamin deficiency at levels that could impair health still exist in America as documented by Ames and co-workers (8), but the obvious vitamin deficiency diseases such as scurvy and rickets are uncommon due to food fortification and the widespread use of multivitamins. On the other hand, even adequate levels of vitamins and minerals cannot make up for a lack of plant nutrients in the diet that have special properties as antioxidants and inhibitors of excessive inflammation.

The History of Spices

Spices have long been used to enhance the taste of food, to provide health benefits and to act as food preservatives prior to the advent of refrigeration. In the Mesopotamian cradle of civilization where agriculture began, there is evidence that humans were using thyme for its health properties as early as 5,000 B.C. and were growing garlic as early as 3,000 B.C. (4–6). The international trade in spices was extremely valuable and whole towns grew up around the spice trade throughout the Middle East, the Asian Silk Road to China and in North Africa.

Mint leaves, garlic, and garlic cloves were found in the tomb of King Tutankhamen where they were intended to preserve his meals for a long afterlife. In order to keep slaves healthy, the Egyptians fed them large amounts of radishes, onions and garlic and they used many other spices in their foods, including coriander, fennel, juniper, cumin, garlic and thyme. The Assyrians, in what is today Iraq and Iran developed knowledge around the health benefits of spices, including juniper, saffron and thyme, at about the same time. Hippocrates, who lived between 460 and 377 B.C., developed about 300 remedies that included garlic, cinnamon and rosemary. Mint was highly valued for its positive effects on the digestive system. Rosemary was used to improve and strengthen memory.

Traditionally, the Chinese have integrated food, nutrition and health, and include spices in specially prepared soups, dishes or beverages for their health benefits. Two legendary Chinese emperors are credited with discovering and recording the medicinal properties of spices – Sheng Nong, the Divine Husbandman (2,838 to 2,698 B.C.), and Huang Di, the Yellow Emperor (2,698 to 2,598 B.C.). Nutmeg was used to treat diarrhea, and cinnamon was used for colds and flu.

In India, the traditional medicine, Ayurveda, evolved more than 5,000 years ago in the Himalayas, with knowledge transmitted orally until it was written down in Sanskrit poetry – the Vedas – around 1,500 B.C. It flourished in the VII century. Ayurveda focuses on disease prevention and health promotion, with an emphasis on diet (9,10). Examples of Ayurvedic use of spices for health effects include turmeric for jaundice, basil to protect the heart, mace for stomach infections, cinnamon to stimulate circulation and ginger as the universal medicine, in particular for relieving nausea and indigestion.

Westerners came to learn of the benefits of spices at a later date. During the XI century, the knowledge of Arabic medicine filtered back to Europe, and by the XIII century, trade with Africa and Asia was bringing in new herbs and spices. Around this time, galangal was called the “spice of life.” A close relative of ginger, galangal is an important and popular ingredient in the foods of Indonesia and Southeast Asia, especially in Thailand. Ground galangal (formerly called Laos powder) is easier to work with than whole galangal and is commonly called for in recipes. The flavor is similar to ginger, but more flowery and intense. Its flavor combines with ginger and lemon grass in Thai cooking, and with white pepper and/or cayenne for seasoning fish, meat or poultry.

Garlic has been highly regarded for centuries for its protective properties (5). Garlic was used by herbalists during the plague presumably to little effect since over 90 percent of major cities were wiped out in the plague. Nonetheless, Louis Pasteur found that garlic killed bacteria, and it was used on battlefields in the 1,800s to prevent gangrene.

Many traditional diets around the world include considerable amounts of added spices. Indian cooking uses spices to add distinctive and rich flavors, and significant quantities can be consumed in one meal. It has been estimated that an adult in India can eat as much as 4 g of turmeric daily, which could provide 80 to 200 mg/day of the bioactive component curcumin (11). Some Indians have been reported to eat as much as 50 g of garlic in a week. Mediterranean diets have been associated with lower incidence of age-related chronic diseases, such as heart disease and cancer. There are many potentially healthful aspects to the traditional Mediterranean diet, so it is difficult to attribute their healthfulness to any single property. Nonetheless, the diet contains considerable amounts of garlic, rosemary, basil and thyme, which may help to explain some of the protective effects observed in populations following traditional Mediterranean diets. Asian diets are rich in spices as are Mexican and Latin American cuisines.

The American diet is among the few in the world without a characteristic spice other than ketchup and mustard. The bland tastes of foods that are sweet, salty and creamy in America combined with large portion sizes have been proposed to contribute to the growing epidemic of obesity. Spices such as chili (capsaicin) result in activation of a pain receptor on the tongue, which limits the amounts of spicy foods eaten, and chili may also result in modest increases in energy expenditure at high doses. On the other hand, bland foods can be eaten rapidly and in large portions.

In addition to their potential role in the battle against obesity (12), spices are a rich source of antioxidants (13) and research is uncovering many potential preventive benefits of spices based on their biological activities. As the ancient knowledge of spices encounters modern science and technology, there will be new opportunities developed that encourage the use of spices in cooking not only for their taste benefits but also for their health benefits. This review will highlight some of the major advances in our understanding of the health benefits of spices and will point out some of the opportunities that lie ahead for the "ounce of prevention" provided by spices.

Spices as Functional Foods

Functional foods have been defined as "foods that provide benefit beyond basic nutrition." The definition applies to foods rather than drugs and implies a benefit beyond that supplied from calories or basic nutrition alone, including the provision of minimum required levels of vitamins and minerals. The Dietary Guidelines have recognized the concept of foods being eaten not only for the prevention of deficiencies, but to provide optimal health and to reduce the risks of common age-related chronic diseases. These benefits are likely to result from healthy dietary patterns, and the interaction of multiple compounds found in foods such as fruits, vegetables, nuts, grains, and spices. This is a relatively new area of nutrition science investigation but one that holds great promise.

Antioxidant Activity

When oxygen (denoted as O_2) is a gas, all eight of the electrons in each of the two atoms of oxygen are paired. However, under the influence of radiation, ultraviolet light or heat, an oxygen atom with an unpaired electron can be formed. This atom is called oxygen radical, and it reacts aggressively with proteins, fats, carbohydrates and DNA in the body to cause damage. Therefore, it has been essential for the body to build defenses against this common phenomenon.

These oxygen radicals are also formed in the body as part of normal metabolism or as part of the reaction of white blood cells against invading bacteria and other pathogens. However, these uses of the oxygen radical are carefully controlled and usually do no harm. On the other hand, chemicals ingested by the body, such as cigarette smoke and pollutants, can result in the formation of excessive amounts of oxygen radicals. Age-related changes in the function of mitochondria, the subcellular structures that produce energy inside the cells of the body, result in an increased production of oxygen radicals with aging, and this is one of the primary theories for the cause of age-related changes in the cells of the body.

To defend against these insults, the body has developed antioxidant defense: Specialized proteins called enzymes, such as superoxide dismutase and catalase, can convert the oxygen radicals to harmless forms such as water through chemical reactions. Other enzymes form stores of cellular antioxidants such as glutathione and uric acid. Finally, the body can store ingested antioxidants from fruits and vegetables such as vitamin C, vitamin E and many antioxidant phytochemicals defined by their ability to inhibit the types of chemical reactions carried out by oxygen radicals.

Spices have high antioxidant concentrations that have the potential to inhibit the oxidation of LDL, the protein that binds cholesterol in the blood (14–16). Like fruits and vegetables, herbs and spices contain many different classes of antioxidants in varying amounts. It has been shown that the intake of herbs can contribute significantly to the total intake of plant antioxidants (17). Phenolic compounds are the largest group of antioxidant phytochemicals found in plants. One study found that the total phenolic content of culinary herbs ranged from 0.26 mg to 17.51 mg of gallic acid per gram fresh weight (See Chart 1) and these lead to significant antioxidant activity (see Chart IB) (17).

At this stage of our scientific knowledge, evidence of benefit from any form of antioxidant intake is restricted to biomarkers of cardiovascular disease risk, such as oxidative damage, rather than clinical outcomes. Many of the biomarkers of oxidant stress are not accepted by the FDA at this time as valid markers of clinical outcome. Only blood cholesterol levels have that distinction. Nonetheless, spices may contribute to a significant extent to total dietary antioxidant intake.

Chart 1A: Antioxidant Content of Common Spices
as Measured by the Content of Phenolic Compounds (17)

Herb or Spice	Botanical Name	Total Phenolic Content**
Basil (sweet)	*Ocimum basilicum L.*	2.23 ± 0.15
Coriander (Vietnamese)	*Polygonum odoratum*	3.09 ± 0.12
Chives	*Allium schoenoprasum*	1.05 ± 0.05
Dill	*Anethum graveolens*	3.12 ± 0.06
Marjoram (hard sweet)	*Origanum x majoricum*	11.65 ± 0.29
Oregano (Cuban)	*Plectranthus amboinicus*	0.34 ± 0.00
Oregano (Mexican)	*Poliomintha longiflora*	17.51 ± 0.22

Parsley	*Petroselinum crispum*	1.12 ± 0.01
Rosemary	*Rosmarinus officinalis L.*	2.19 ± 0.15
Spearmint	*Mentha spicata*	0.94 ± 0.15
Thyme (lemon)	*Thymus x citriodorus*	1.78 ± 0.03
Garlic	*Allium sativum L.*	1.03 ± 0.10

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**(mg of gallic acid / g fresh weight)(Mean ±SEM*)
*SEM = standard error of the mean

Chart 1B: Antioxidant Activity of Common Dried Herbs and Spices (16)

Common Name	Botanical Name	Antioxidant Activity*
Clove	*Syzygium aromaticum*	465.3 mmol/100 g
Oregano	*Origanum vulgare*	137.5 mmol/100 g
Cinnamon	*Cinnamomum zeylanicum*	98.4 mmol/100 g
Peppermint	*Mentha piperita*	78.5 mmol/100 g
Thyme	*Thymus vulgaris L.*	74.6 mmol/100 g
Rosemary	*Rosmarinus officinalis L.*	66.9 mmol/100 g
Marjoram (sweet)	*Origanum majorana*	55.8 mmol/100 g
Basil	*Ocimum basilicum L.*	30.9 mmol/100 g
Ginger	*Zingiber officinale*	22.5 mmol/100 g
Dill	*Anethum graveolens*	15.9 mmol/100 g
Curry	*Murraya koenigii L.*	13.0 mmol/100 g
Chives	*Allium schoenoprasum*	7.1 mmol/100 g
Parsley	*Petroselinum crispum*	3.6 mmol/100 g
Coriander	*Coriandrum sativum L.*	3.3 mmol/100 g
Vanilla seeds	*Vanilla planifolia*	2.6 mmol/100 g
Garlic	*Allium sativum L.*	2.1 mmol/100 g

*Mean total antioxidant activity per 100 g

Inhibition of Lipid Peroxidation

Recent studies by Heber and co-workers demonstrated that an antioxidant spice mixture could inhibit lipid peroxide formation during the cooking of hamburger meat (22). Spices are a rich source of polyphenols, which directly correlate with their antioxidant potency as listed above. However, there are few studies of in vivo antioxidant effects of polyphenols from spices.

In hamburger meat, which normally forms lipid peroxides during cooking, the antioxidants in the spice mixture reduced significantly the formation of lipid peroxides in hamburger meat during cooking. Malondialdehyde is an established measure of the presence of oxidized lipids in the meat, in plasma and in urine. There was a 71 percent reduction in the malondialdehyde concentration in the meat of the burgers cooked with spices compared with the malondialdehyde concentration in the meat of the control burgers. Rosmarinic acid from oregano, one of several spices in the mixture, was monitored to assess the effect of cooking on spice antioxidant content. Forty percent (19 mg) of the added rosmarinic acid remained in the spiced burger after cooking. Urinary malondialdehyde concentrations (μmol/g creatinine) decreased by 49 percent ($P = 0.021$) in subjects consuming the burgers cooked with spice compared with subjects consuming the control burgers. The overall effect of adding the spice mixture to hamburger meat before cooking was a reduction in malondialdehyde concentrations in the meat, plasma and urine after ingestion. Therefore, cooking hamburgers with a polyphenol-rich spice mixture can significantly decrease the concentration of malondialdehyde, which suggests potential health benefits for both atherogenesis and carcinogenesis.

Foods such as cooked hamburger meat containing oxidized products affect endogenous lipid metabolism and can lead to excess lipid-peroxidation product exposure that leads to the promotion of the multistep processes of atherogenesis and carcinogenesis. This observation extends to other meats and fish that are cooked but the extent to which the fats can contribute a load of oxidized lipid to the body has not been determined.

Although there is a great deal of evidence suggesting that healthy diets that are low in fat and refined sugars and rich in colorful fruit and vegetables can reduce the risk of heart disease and common forms of cancer, there is less evidence on the effects of adding spice to commonly eaten foods known to contain lipid-peroxidation products such as red meats cooked at high temperatures.

This study showed that spices that are rich in antioxidants may be useful when cooking meat products to reduce the formation of lipid-peroxidation products. The results also suggest that the lower concentrations of malondialdehyde observed in plasma and urine after ingestion of meat products seasoned heavily with antioxidant-rich spices may lead to reduced in vivo formation and action of lipid-peroxidation products relevant to the oxidant stress-related risk of heart disease and common forms of cancer.

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