Use of Spices in Foods

Oiye, S. O., Muroki, N. M.

Applied Nutrition Programme, Department of Food Technology and Nutrition,
University of Nairobi.
P. O. Box 442, Uthiru, Kenya.

Abstract

In this era of increased concern on safety of chemical food additives, natural methods of preservation and natural preservatives are receiving increased attention. Despite their demonstrated potential use in food as preservatives, spices still remain primarily as food condiments. A lot of research has been done in the effort to demonstrate the antimicrobial potency of spices in cultured media. Though spices are less effective in foods than in cultured media, it is the use in foods that is of practical importance. This has not been exploited vis-a-vis the chemical additives. The antioxidant components of spices have been investigated but with minimal commercial utilization. Spices mostly used as antimicrobials and antioxidants do not exhibit toxicity at levels consumed. These are therefore evidently a group of plants, which have not fully been utilized in food technology. This review discusses and evaluates the antimicrobial and antioxidant potency of spices and advocates for more research and commercial utilization in foods.

Key words: Spices, chemical additives, anti-microbials, antioxidants

Introduction

Spices are plants with intensive and distinctive flavours and aromas used in fresh or dry form (Belitz and Grosch, 1987). They are a prized group of minor components in human diets. The spice trade is one of the oldest trades known. Overland trade routes across Old World predate recorded history (Shibamoto and Bjedanes, 1993). Passages of the Holy Bible also throw light on the history and uses of the spices in the ancient world with the first mention in the book of Genesis, chapter 37, in connection with the story of Joseph. Different spices grow best in specific environmental condition. **Table 1** shows the cultivation regions of some spices. It can be deduced from the table that most spices originate from the Temperate and Mediterranean regions.

Historically, spices have been used for different purpose right from trade, medicinal and food uses. Spices were used as exchange currencies in oldest trade among other commodities including ivory, salt e.t.c. Nutmeg and its close relative; mace have been used extensively in folk medicine for treatment of wide range of ailments including digestive disorder, rheumatism, cholera and flatulence (Shibamoto and Bjedanes, 1993). Rosengarten (1969) reports that spices were also used as perfumes, antidotes against poisons and cosmetics and ointments. He also notes that it was until 1st century A.D in Rome that there was, for the first time, a notable increase in utilization of spices as condiments in food. While spices are currently added to food simply as flouvoring agents, many spices and their oils have been found to posses some antimicrobial properties (Davidson *et al*, 1983). Also, it is not until the work of Chipault *et al.* (1952) that spices were compared as antioxidant in various fat sources. The earliest report on use of spices as preservatives was around 1550 BC., when the ancient Egyptians used these substances not only for food preservation, but also for embalming their dead (Davidson *et al*, 1983).

Processing and distribution of spices

Processing of spices is mainly by drying. Processors are usually careful to avoid loss of essential oils. High concentration of essential oils is believed to be reached at the time the plant becomes into bloom which is the time harvesting is usually carried on (Parry, 1969). When artificial heat is employed in drying, it is carefully controlled and effectively circulated; beginning with moderate degree of heat and gradually increasing the temperature to a permissible maximum. When spices reach the spice merchants, some are set aside for sale as such, and some reduced to powder to meet the needs and demands of consumers. Ground spices are sold in bulk quantities to industrial users. Those meant for direct consumers are usually packed in small quantities. In Africa, distributors import or procure locally in bulk and then repackage either for consumers or industrial use. Essential oils are volatile. Thus, ground spices must be kept tightly capped in their containers when not in use to maintain quality and flavour.

Steam or water distillation will codistil all volatiles out of ground spices leaving all fixed oils, tannins, resins, proteins, cellulose e.t.c, in flavour exhausted still charge. The essential oils being generally water-insoluble will separate on condensation and cooling and can readily be collected. In addition to steam distillation, some essential oils have been produced by manual or machine expression (Guenther *et.al.*, 1974)

Use of spices as flavouring agents

Spices are used as flavourants or as seasoning both in their fresh and dried form. This is obviously the original use of spices in foods. Not all parts of a spice plant are used for flovouring. **Table 1** lists the most important spice plants used in food preparation/

Table 1: Spices used in food preparation/processing

Number	Common name	Latin name	Class/order family (bot)	Cultivation region
Fruits				
1	Pepper, black	*Piper nigrum*	Piperaceae	Tropical and subtropical regions
2	Vanilla	*Vanilla planifolia*	Orchidaceae	Madagascar, Comore Island,
3	Allspice	*Pimenta dioica*	Myrtaceae	Caribbean Islands, Central America
4	Paprika (red pepper)	*Capsicum annuum*	Solanaceae	Mediterranean and Balkan region
5	Bay tree[a]	*Laurus nobilis*	Lauraceae	Mediterranean region
6	Juniper berries	*Juniperus communis*	Cupressaceae	Temperate climate region
7	Chili	*Capsicum frutescens*	Solanaceae	Tropical region
8	Aniseed	*Pimpinella anisum*	Apiaceae	Temperate climate region
9	Caraway	*Carum carvi*	Apiaceae	
10	Coriander	*Coriandrum sativum*	Apiaceae	
11	Dill[a]	*Anethum graveolens*	Apiaceae	
Seeds				
12	Mustard	*Sinapsis alba*[b] *Brassica nigra*[c]	Brassicaceae Brassicaceae	Temperate climate region
13	Nutmeg	*Myristica fragrans*	Myristicaceae	Indonesia, Sri Lanka, India
14	Cardamom	*Eletaria cardmomum*	Zingiberaceae	India, Sri Lanka
Flowers				
15	Clove	*Syzygium aromaticum*	Myrtacea	Indonesia, Sri Lanka Madagascar
Rhizomes				
16	Ginger	*Zingiber officinale*		South China, India, Japan, Caribbean Islands, Africa
17	Turmeric	*Curcuma longa*	Zingiberaceae	India, China, Indonesia
Barks				
18	Cinnamon	*Cinnamomum zeylanicum* *C. aromaticum* *C. burmanii*	Lauraceae	China, Sri Lanka Caribbean Islands
Roots				
19	Horseradish	*Armoracia rusticana*	Brassicacea	Temperate climate region
Leaves				
20	Parsley	*Petrosedlinum crispum*	Apiaceae	Temperate climate region
21	Marjoram	*Origanum majorana*	Lamiaceae	Temperate climate region
22	Origano	*Origanum heracleoticum* *O. onites*	Lamiaceae	Temperate climate region
23	Rosemary	*Rosmarinum officinalis*	Lamiaceae	Mediterranean region
24	Sage	*Salvia officinalis*	Lamiaceae	Mediterranean region
25	Thyme	*Thymus vulgaris*	Lamiaceae	Temperate climate region

[a] Fruits and leaves. [b] White mustard. [c] black mustard

Source: (Belitz, 1987).

Table 2: Examples of spice flavours and their respective attributive chemicals.

Flavour	Characterizing key chemicals
Anisile, finnel	Anethole
Bitter almond	Benzaldehyde
Dill	D-carvone
Spearmint	L-carvone
Cassia,cinnamon	Cinnamaldehyde
Lemon peal, lemon grass	Citral
Cumin	Cuminaldehyde
Terragon (estragon)	Estragole
Clove, allspice, bay leaf	Eugenol
Eucalyptus	Eucalyptol
Peppermint	L-menthol
Oil wintergreen, sweet birds, teaberry	Methyl salicylate

Source: (Sinki and Schlegel, 1990)

Table 3: uses of herbs and spices

Herb or spice	Beverages	Cheese	Fish	Meat	Salad dressings	Sauces	Vegetables	Egg dishes	Game & poultry	Sweet products	Soups
Aniseed	*	*					*			*	*
Basil	*	*	*	*	*	*	*	*	*	*	*
Bay (Laurel)	*		*	*		*	*		*	*	*
Caraway		*		*	*	*	*	*	*	*	*
Cardamom	*	*			*					*	*
Cassia						*				*	
Capsicum & Cayenne		*	*	*	*	*					
Celery		*	*	*	*	*	*	*	*	*	*
Chervil		*	*	*		*					
Cinnamon	*					*				*	
Clove	*			*		*					*
Coriander		*		*	*		*			*	*
Cumin				*			*	*	*	*	
Dill		*	*	*	*	*	*				*
Fenngreek			*	*					*		
Fennel		*	*		*	*	*			*	*
Garlic		*	*		*	*			*		*
Ginger	*			*		*				*	*
Mace	*	*		*		*	*	*		*	
Marjoram		*	*	*	*	*	*	*	*	*	*
Mustard		*	*		*	*	*	*	*		*
Nutmeg	*	*		*	*	*	*	*		*	
Onion		*	*	*	*	*	*	*	*		*
Oregano		*	*	*	*	*	*	*	*		*
Origanum		*	*	*	*	*	*	*	*		*
Paprika		*	*	*	*	*		*	*		*
Parsley		*	*	*	*	*	*	*			*
Pepper		*	*	*	*	*	*	*	*		*
Pimento (Allspice)				*		*			*	*	*
Rosemary	*	*	*	*	*	*	*	*	*	*	*
Sage		*	*	*	*	*	*	*	*	*	*
Tarragon	*	*	*	*	*	*	*	*	*		*
Thyme	*	*	*	*	*	*	*	*	*		*
Turmeric			*	*	*	*		*	*		*

Source: Heath (1966)

processing with the respective part of the plant used for seasoning. Weather a fruit, berry, seed, bark, twig, leaf or root, the dried spice contain the flavour components and extraneous plant matter. For the most part, volatile oils are the vital flavour components. Rogers (1966) reports that essential oil of cinnamon bark, clove and pimento berries represents almost the total flavour in dried spices. In red pepper or capsicum, the non-volatile amides are responsible for the heat or flavour. In black pepper, a combination exists between non-volatile piperine (an amide), which gives bite, and essential oil of pepper which gives flavour top note and odour character. In those spices which the flavour compounds are found in the volatile portion, the essential oils are most satisfactory product to produce for a concentration of representative flavour. **Table 2** shows examples of spice flavour and their respective attributive chemicals. The flavour compounds in different spices are distinct and thus used in different foods as depicted in **Table 3**.

Antimicrobial potency of spices

While used primarily as flavouring and seasoning agents in foods, many spices possess significant microbial activity. In all instances, antimicrobial activity is due to specific chemical or essential oils (Jay, 1987)

Clove and Cinnamon

The major antimicrobial components in cloves, cinnamon and cassia have been reported to be eugenol and cinnamic aldehyde (Davidson *et al*, 1983). According to Bullerman *et al.* (1977), Cinnamon contains 0.5-1.0% volatile oil of which 75 % is cinnamic aldehyde and 8% eugenol. Cloves contain 14-21% volatile oil, which is 95% eugonol. Fabian *et al.* (1939) found that cloves and cinnamon were only two spices out of nine tested, which had antibacterial activity. Cinnamon was only slightly inhibitory at a 1:50 dilution (extract of 10g of 100 ml of water); however, cloves inhibited *Bacillus substilis* at 1:100 and *Staphylococcus aureus* at 1: 800. The inhibition was dependent upon gram type and species. Zaika and Kissinger (1979) tested the effect of spices in a Lebanon bologna formulation on the growth of fermented meat starter cultures. All spices were stimulating at 4g/litre except clove, which inhibited growth and acid production. Cinnamon at 8 and 12g/litre delayed growth slightly. At low concentration, both spices stimulated acid production. The effect of these spices on yeast is questionable. Yeast may adapt to antifungal effect of these spices (Webb and Tunner, 1944). However, significant effect has been demonstrated in fungi. Bullerman (1974) found out that 1% of cinnamon has significant inhibition on growth of *Aspergillers paraciticus* spores and aflatoxin production. He also found out that cinnamon and clove oil were inhibitory to *Aspergillers paraciticus* at 200-250 ppm in YES broth while only 125ppm were needed for a similar effect with eugenol and cinnamic aldehyde.

Oregano and Thyme

The antimicrobial activity of oregano and thyme has been attributed to their essential oils, which contain the terpenes carvacrol and thymol (Beuchart, 1976: Zaika and Kissinger, 1979). Katayama and Nagai (1960) tested the isolated terpenes carvacrol and thymol against the micro-organisms *Bacilus Subtilis*, *Salmonella enteridis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Proteus morganii* and *Escherichia coli.* They found inhibition of all spices tested at dillution of 1:2000 and higher.

Oil from oregano has high antimicrobial activity against fungi and bacteria (Maruzella and Henry, 1958).Oregano purposely contaminated with salmonela cannot allow outgrowth in pre-entrichment broth when the spice is presented in amounts of 5% or greater (Julseth and Diebel, 1974). Thymol has significant effect against fungi. Buchanan and Sheperd (1981) found out that at 100ppm, thymol was 99% effective after 7 day. However growth and aflatoxin production resumed in 10 days at lower concentration.

Rosemary and Sage

The inhibitory effect of sage and rosemary is bacteriostatic at 0.3%, whereas 0.5% is bacteriocidal. This is attributed to terpene fraction , which is composed of borneole, aneole, pinene and camphor (Jay, 1987). Shelef *et al.* (1980) tested sage, rosemary and allspice against 22 gram negative and 24 gram positive bacteria. Sage and rosemary were most inhibitory, exhibiting the greatest activity against gram positive bacteria.

Other spices

Martha (1966) reviewed studies which reported antimicrobial activity by spice oil and extract of sweet marjoram, laurel, pimiento, coriander, anise, carvon, peppermint, caraway, cardamon, cumin, fennel, sabadilla, celery, dill and mustard. Many of these preparations seem to be active against only one spices and some are even active in one study but not in another. The normal inhibitory concentrations used in the studies are very high, indicating little activity. Julseth and Diebel (1974), in their studies with *Salmonella* found slight inhibition by allspice. In contrast, Kissinger and Zaika (1978) found that black pepper, allspice and nutmeg stimulated growth and lactic acid production by a starter culture even at 12g/litre. Beuchart (1976) found slight inhibition of *Vibrio parahaemolyticus* by nutmeg, curry powder, mustard, black pepper and sassafras. Spice extract and oils which have been found to exhibit little or no activity include allspice, anise, bayleaf, black pepper, cardmon, celery seeds and flakes, chilli powder, coriander, cumin, curry powder, dill, fenugreek, ginger, juniper oil, mace, marjoram, mastard, nutmeg, orris root, paprika, parsley, red pepper, rosemary, sage, sesame, spearmint, tarragon and white pepper (Davidson *et al*, 1983). However combination of some of these spices with other antimicrobials have yielded positive effect. Oiye (1999) reports that 0.3% rosemary spice, 12g nitrite pickling salt (NPS) (per Kg meat mass) combination had comparable antimicrobial inhibition to18g NPS without spice combination. 0.4% rosemary spice, 6g NPS combination exhibited greater antimicrobial effect than the two. The first and the last combinations had generally accepted organoleptic qualities.

It should however be noted that although spices have inhibitory or antimicrobial effects, as food ingredient they also are often a source of high microbial numbers. Flanning and Hui

Table 4: Protection factors of various spices in various foods.

Substrate	Lard	Pie crust	O/W Emulsion	Ground pork		Sauce mayonnaise	
Test Temp. °C:	99	63	40	-5	-15	20	20
Spice per 100g fat	0.2	0.2	0.1	0.25	0.25	0.20	0.56
Allspice	1.8	1.1	16.7	>5.3	>10.0	1.4	3.1
Cloves	1.8	1.3	85.8	>5.3	>10.0	2.0	4.6
Oregano	3.8	2.7	7.9	>7.2	3.7	8.5	9.1
Rosemary	17.6	4.1	10.2	>5.3	>10.0	2.2	-
Sage	14.2	2.7	7.8	>5.3	>10.0	2.4	3.4
Thyme	3.0	1.9	6.8	6.0	3.2	1.8	

The higher the value, the higher the protective factors of the respective spices.
Source: (Schuler, 1990)

(1976) reported that 1 out of 20 spices contained Aspergillus flavus and 4 out of these spices supported the growth of this mould and production of aflatoxin. Spices may contain over 10^8 aerobic bacteria per gram (Banswart, 1981). Mean standard plate count of over 10^6 per gram were obtained from black pepper, ginger and paprika (Julseth and Diebel, 1974).

Antioxidant activity of spices

Spices have achieved some commercial importance as antioxidants. Beneficial influence of certain ground herbs and spices in fat stability has been known (Schuler, 1990). A systematic investigation during 4 years and covering 32 species of herbs and spices has been carried out by Chipault *et al*, (1952). Several food models have been tested under various conditions including (lard: active oxygen method (AOM); emulsion: Warburg apparatus; ground pork: frozen storage; mayonnaise: storage at room temperature; pie crust: storage at 63°) and the peroxide values determined. The antioxidant efficacy was expressed as a protection factor indicating the ratio of carbon dioxide absorption in food model without spice to oxygen absorption in food models with spice. This is a measure of stability (**Table 4**). It can be deduced that the most potent spices are rosemary and sage. The effectiveness of spices and herbs depend not only on variety and quality but also on substrate and storage conditions (Schuler, 1990). However many of the extracts have strong odour and bitter taste and therefore unsuitable for use in many food products.

The antioxidant compounds of spices have been investigated. In rosemary, carnosic acid has been described as the most active antioxidant constituents by Brieskorn and Domling (1969). Other phenolic compounds have been investigated eg. rosemaric acid, which has in model system an activity comparable to that of caffeic acid. But Gerhardt and Schroter (1983) could not find a correlation between the antioxidative efficacy of the tested spices and their rosmaric acid content.

Antioxidant extract from spices (usually rosemary) commercially available are usually fine powders. Depending on their content of active substances, it is recommended they be used at levels between 200 and 1000mg/Kg of finished product to be stabilized (Schuler 1990). Generally, the powders are dispersible in oils or fats, insoluble in water, but soluble in organic solvents. Due to their powder characteristics they can also be used in dry mixes.

Toxicological aspects

Some spices have inherent toxic substances, which in large amounts are contraindicated as reported by Shibamoto and Bjedanes (1993): Large amounts of celery oil can cause sedative effect in people. However, it appears that this would only happen when unusually large amounts are consumed. 3-n-butylphthalide and sedanenolide are primarily responsible. Consumption of licorice spice candy (100g/day) on an extended period has led to severe hypertension, sodium retention and heart enlargement in people. These symptoms apparently have as their basis a corticosteron-like-activity in which sodium and potassium are depleted. Also, the reaction of nutmeg varies from no effect to full-blown hallucinogenic experiences like those caused by hashish. Continued use of moderate doses of nutmeg can result in liver damage and death. Side effects of even moderate doses of nutmeg include headache, cramps and nausea. Administration of (0.04-1%) safrole (found in sassafras) in the diet of male and female rats for 150 days to 2 years produced hepatitis and cancer. Due to these results, safrole is no longer allowed as a food additive in United States.

Conclusion and Recommendations

The common application of spices in foods is as flavouring agents. Much research has demonstrated the potency of some spices as preservatives (i.e. as antioxidants and antimicrobials) but application of those research findings in food processing has been minimal. Spices hitherto are used primarily as condiments and seasoning agents while antioxidant and antimicrobial benefits are usually incidental.

Spices reported to exhibit antioxidant and antimicrobial properties which include rosemary, oregano, thyme, cinnamon, sage, clove e.t.c have not been found to have toxic substances *vis-a-vis* the advertent chemical food additives such as nitrites, sulphur dioxide, butylated hydroxyanisole (BHA), butylated hydroxytoleune (BHT) and benzoic acid which have demonstrated toxicity. Replacement or combination of these additives with spices could attenuate the levels of consumption of these chemicals. It has been noted that in some food formulations, both the spices and chemical antioxidants and antimicrobial chemicals are added. The inclusion of spices should ideally prompt reduction of these chemicals. Insufficient research on potent levels of spices in foods and advocacy to back-up their as antimicrobials and antioxidants are the main constraints to this.

The potential of spices in reducing chemical additives has not been visited with the intensity it deserves despite the emergence of encouraging results. The search for nitrites-sparing agents generated new interests in spice and spice extracts in the late 1970s (Jay, 1987). Most the findings on spices since 19th century still remain unutilized. A lot of researches have been done on antimicrobial and antioxidant activity of spices on specific microorganisms and fats (fat rich foods) respectively. It is surprising then that with these substantial findings, spices are still branded almost purely as flavoring agents. Presently, spices are cheap and easily available even in countries where they do not grow. It is evidently a group of plants, which has not been utilised in food technology despite its undisputed potential.

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