Bacteriostatic and Synergistic Properties of Spices

Aside from their use to add flavor or enhance palatability of foods, spices have been utilized as food preservatives for hundreds and perhaps thousands of years. Egyptians, as early as 1500 BC, utilized spices not only for food preservation but also in the process of embalming their deceased (Branen and Davidson, 1983). Spices have played a major role in the development of civilization. World exploration by Marco Polo, Vasco da Gama, Ferdinand Magellan and others was supported as a means of opening new supply routes for the spice trade. Many of these spices were used to preserve food.

The antimicrobial activity of spices has been studied for more than 100 years and many compounds have been identified which are responsible for this antimicrobial activity (Shelef, 1983, Zaika, 1988, Beuchat and Golden, 1989, Beuchat, 1994, Nakatani, 1994, Snyder, 1997). Although spices possess antimicrobial activity, they still can harbor large numbers of microorganisms including pathogens. These microorganisms contaminate the spices during cultivation, harvest and storage. The extent of microbial contamination is related to the extent of processing as well as the naturally occurring antimicrobial activity of the spice. Typical aerobic plate counts range from less than 10^3 to over 10^7 CFU per gram (Shalef et al 1980, Schwab et al 1982). It is not unusual to find *Clostridium perfringens* and/or *Bacillus cereus* present in spices although fewer microorganisms are found in spices with higher antimicrobial activity. Cleaning and applying microbial reduction process (MRP) such as irradiation or ethylene oxide or steam are usually effective treatments.

The following table summarizes antimicrobial activity for selected spices.

Table 1. Antimicrobial Activity of Selected Spices and Herbs

Inhibitory Effect	Selected Spice or Herb
Strong:	Cinnamon (Cassia), Clove, Mustard, Garlic, Onion, Allspice, Oregano
Medium:	Bay Leaf , Cumin, Tarragon, Thyme, Rosemary, Caraway, Coriander, Sage, Dillweed
Weak or No Effect:	Black Pepper, Anise, Ginger, Parsley, White Pepper, Marjoram, Basil

It is well known that cinnamon, clove and mustard have strong antimicrobial activity (Zaika, 1988). In addition, onion, garlic and allspice posses strong antimicrobial properties. Spices having a lesser but significant antimicrobial effect include bay leaf, cumin, tarragon, thyme, rosemary, caraway, coriander and sage. Black pepper, ginger, and anise have little or no antimicrobial activity (Billing and Sherman, 1998). Antimicrobial activity has an impact on testing methodology.

The antimicrobial effect of spices has been related to compounds found in the essential oil fraction. These compounds include eugenol, carvacrol and thymol in cloves, cinnamon, sage and oregano; allicin in garlic; myristicin in mace; and ally isothiocyanate in mustard. Low concentrations of oregano,

however, were found stimulatory to lactic acid bacteria (Zaika and Kissinger, 1981). Furthermore, earlier work by Kissinger and Zaika (1978) found that black pepper, allspice, and nutmeg stimulated growth and lactic acid production by a starter culture. The following table summarizes the essential oils known to have antimicrobial activity in spices.

Essential Oils and Other Antimicrobial Constituents of Spices
From Zaika, 1988

Compound	**Found in**	**Reference**
Allicin	Garlic	Cavallito and Bailey, 1950
Allyl isothiocyanate	Mustard	Blum and Fabian, 1943
Anethole	Anise, star anise, fennel	Hitokoto, et. al., 1980
Carvacrol	Oregano, thyme	Blum and Fabian, 1943, Kellner and Kober, 1955
Carvone	Caraway, dill	Kellner and Kober, 1955
1,8-Cineole	Sage, rosemary, laurel, cardamom	Kellner and Kober, 1955
Cinnamaldehyde	Cinnamon, cassia	Blum and Fabian, 1943, Bullerman, et. al., 1977, Ueda, et. al, 1982
p-Cymene	Cumin, thyme, oregano	Kellner and Kober, 1955
Eugenol	Clove, allspice, cinnamon	Blum and Fabian, 1943, Bullerman, et. al. 1977, Kitokoto et. al. 1980, Kellner and Kober, 1955, Ueda, et.al. 1982
Limonene	Celery seed, caraway, dill	Kellner and Kober, 1955
Linalool	Coriander, sage, rosemary, basil	Kellner and Kober, 1955
Thymol	Thyme, oregano	Buchanan and Shepherd, 1981, Hitokoto, et. al.,

		1980, Kellner and Kober, 1955
n-proply-allyl disulphides, di-n-propyl-disulphides	Onion	Hargreaves, et.al. 1975

Spices, may require a neutralization step or a reduction in the sample to initial dilution ratio to enhance detection of *Salmonella*. The FDA has also recognized this and special procedures have been published in the Bacteriological Analytical Manual (BAM) for detection of *Salmonella* in selected spices. A pre-enrichment in Trypticase Soy Broth (TSB) containing 0.5% potassium sulfite is recommended for onion and garlic in the 8th Edition of BAM, Chapter 5, section C -10 b. Section C -10 c, of Chapter 5, recommends that allspice, cinnamon, cloves and oregano be diluted beyond their toxic levels. Allspice, cinnamon and oregano are diluted at 1:100 sample to broth (TSB) and cloves are diluted 1: 1000 sample to broth (TSB) ratio. These provisions further indicate the toxic effects that spices have on recovery of microorganisms, and in particular, *Salmonella*. No provisions for recovery of *Salmonella* have been published for those spices having weak or no known antimicrobial activity.

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