Darwinian gastronomy: Why we use spices

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Abstract:
Humans have borrowed plants' chemical "recipes" for evolutionary survival for use in cuisine to combat foodborne microorganisms and to reduce food poisoning. This explains the use of spices.

Spices are plant products used in flavoring foods and beverages. For thousands of years, aromatic plant materials have been used in food preparation and preservation, as well as for embalming, in areas where the plants are native, such as Hindustan and the Spice Islands (Govindarajan 1985, Dillon and Board 1994). During and after the Middle Ages, seafarers such as Marco Polo, Ferdinand Magellan, and Christopher Columbus undertook hazardous voyages to establish routes to trading ports in primary spice-growing regions (Parry 1953). The spice trade was so crucial to national economies that rulers repeatedly mounted costly expeditions to raid spice-growing countries, and struggles for the control of these countries precipitated several wars. When Alarich, a leader of the Goths, laid siege to Rome in AD 408, he demanded as ransom various precious metals and 3000 pounds of pepper (Scheiper 1993).

Today, spice use is ubiquitous, but spices are far more important in some cuisines than others. Most people have experienced this variability firsthand, when traveling in foreign lands, dining at international restaurants, or preparing exotic recipes at home. Japanese dishes are often "delicate," Indonesian and Szechwan dishes "hot," and middle European and Scandinavian dishes "bland." Usually these differences are merely chalked up to cultural idiosyncrasies. Several years ago, we became curious about this interpretation. We wondered if there are any predictable patterns of spice use and, if so, what factors might underlie them. In this article, we summarize the results of our inquiries. We found that spice use is decidedly nonrandom and that spices have several beneficial effects, the most important of which may be reducing foodborne illnesses and food poisoning.

What is a spice?

"Spice" is a culinary term, not a botanical category-it does not refer to a specific kind of plant or plant part (Farrell 1990). Indeed, spices come from various woody shrubs and vines, trees, aromatic lichens, and the roots, flowers, seeds, and fruits of herbaceous plants (Figure 1). Cookbooks generally distinguish between seasonings (spices used in food preparation) and condiments (spices added after food is served), but not between herbs and spices. However, herbs, which are defined botanically (as plants that do not develop woody, persistent tissue), usually are called for in their fresh state, whereas spices generally are dried (Figure 2). Salt is sometimes thought of as a spice, but it is a mineral.

Each spice has a unique aroma and flavor, which derive from compounds known as phytochemicals or "secondary compounds" (because they are secondary to the plant's basic metabolism). These chemicals evolved in plants to protect them against

herbivorous insects and vertebrates, fungi, pathogens, and parasites (Fraenkel 1959, Walker 1994). Most spices contain dozens of secondary compounds. These are plants' recipes for survival-legacies of their coevolutionary races against biotic enemies.

Patterns of spice use

Conventional wisdom tells us that cuisines of tropical countries are spicier than those of northern countries, but patterns of spice use around the world have not been quantified. To do so, we located "traditional" cookbooks, which were written primarily to archive the author's native cuisine. We analyzed recipes in 93 traditional cookbooks from 36 counties (at least two books from each country) and quantified the use of 43 spices in these countries.

Antimicrobial properties of spices

Why are spices used? The obvious answer is that they enhance food flavor, color, and palatability. Of course this is true as far as it goes. However, such an immediate explanation does not address the ultimate evolutionary questions of why cuisines that contain pungent plant products appeal to people and why some phytochemicals are tastier than others. A clue to the ultimate reason for spice use may lie in the protective effects of phytochemicals against plants' biotic enemies.

Prediction 1. Spices should exhibit antibacterial and antifungal activity. Microbiologists and food-product developers have conducted laboratory experiments that involve challenging numerous foodborne bacteria, fungi, and yeasts with phytochemicals extracted from spice plants. It is now clear that many spices have potent antimicrobial properties (e.g., Hargreaves et al. 1975, Shelef 1984, Deans and Ritchie 1987, Zaika 1988, Beuchat 1994, Nakatani 1994, Hirasa and Takemasa 1998). All 30 spices for which we located laboratory test results were found at some concentration to kill or inhibit at least 25% of the bacterial species on which they had been tested, and 15 of these spices inhibited at least 75% of bacterial species. Garlic, onion, allspice, and oregano were found to be the most potent spices: They inhibited or killed every bacterium they were tested on.

Prediction 2. Use of spices should be greatest in hot climates, where unrefrigerated foods spoil especially quickly. Uncooked meats and meat dishes that are prepared in advance and stored at room temperatures for more than a few hours typically build up massive bacterial populations, especially in tropical climates (Hobbs and Roberts 1993). We found that as average temperatures increased among countries, there were significant increases in the number of recipes that called for at least one spice, as well as the mean numbers of spices per recipe. For example, India's cuisine included 25 different spices, of which an average of 9.3 were called for per recipe, whereas Norwegian cuisine included only 10 different spices and called for an average of 1.6 per recipe.

Costs of spices

In light of the beneficial effects of spices, why aren't spices used equally often everywhere? The answer probably lies in the costs of spice use, including financial costs to procure parts of plants that do not grow locally (e.g., consider the price of Spanish saffron).

There may be other physical costs to using spices. As one example, in small quantities chilis have antimicrobial and therapeutic effects, but ingestion of large amounts of capsaicin has been associated with necrosis, ulceration, and carcinogenesis (Surh and Lee 1996). The implication is that too much of a good thing can be bad. In hot climates, benefits of avoiding foodborne illnesses and food poisoning apparently outweigh the various costs of spices. But in cool climates, where unrefrigerated foods decay more slowly, benefits of further retarding spoilage may not be worth the costs and risks.

Even in countries where spices are heavily used, pre-adolescent children (Rozin 1980) and women in their first trimester of pregnancy (Profet 1992) typically avoid highly spiced foods, especially meats. These differences in spice use may have a similar adaptive basis. For example, Profet (1992) suggested that morning sickness may function to reduce maternal intake of foods containing teratogens during the early phase of embryogenesis, when delicate fetal tissues are most susceptible to chemical disruption. Indeed, women who experience morning sickness are less likely to miscarry than women who do not (Weigel and Weigel 1989). Young children, who are growing rapidly, may also be particularly sensitive to environmental mutagens. Once pregnancy has progressed into the second trimester and once children reach puberty, the dangers of food poisoning and foodborne illnesses may again outweigh the mutagenic risks associated with phytochemicals (Flaxman and Sherman in press). Interestingly, maternal ingestion of spices late in pregnancy or during lactation can slightly bias offspring toward accepting spices (e.g., Altbacker et al. 1995).

Conclusion

Use of spices takes advantage of plant defensive compounds. Not surprisingly, in view of their evolved functions, these phytochemicals have antioxidant, antimicrobial, and antiviral properties. The use of spices essentially borrows plants' recipes for survival and puts them to similar use in cooking. Over time, recipes should "evolve" as new bacteria and fungi appear or indigenous species develop resistance to phytochemicals, requiring the addition of more spices or new spices to combat them effectively. However, there is a limit to how much of any one spice can be added before beneficial phytochemicals become phytotoxins. Thus, cookbooks from different eras are more than just curiosities. Essentially, they represent written records of our coevolutionary races against foodborne diseases. By cleansing foods of pathogens before consumption, spice users contribute to the health, longevity, and fitness of themselves, their families, and their guests. A Darwinian view of gastronomy thus helps us understand why "some like it hot" (spicy, that is!).