Aside from water, salt is the most ubiquitous food ingredient consumed by humankind. With the exception of a few societies, such as the primitive hunter-gathering Yanomamo Indians of Brazil, everyone consumes foods to which salt has been added. In fact, the Yanomamo Indians also consume salt that occurs naturally in the foods they find, such as giant grubs found in rotten logs and vegetation. (It was just discovered that gorillas eat rotten logs, specifically for the sodium available from them [21].)

Salt is a nutrient that is essential to life and good health. Having originally evolved from a marine environment, the human body’s salt/water ratio is critical to metabolism. Human blood contains 0.9% salt (sodium chloride) in order to maintain the electrolyte balance within and outside of cells. In the normal course of metabolism, we routinely eliminate sodium along with most other waste materials and the minimum balance must be replenished if we are to survive. Most of our salt intake comes from foods and some from water. Of course, any activity resulting in excessive loss of sodium, such as exercise, has to be counterbalanced by increased salt consumption to make up for this additional loss.

If we do not replenish the sodium, our bodies are biologically programmed to go into a sodium-saving mode so that we can maintain sufficient blood pressure. This has multiple significant consequences for us. Reductions in sodium intake are accompanied by significant increases in the rennin-angiotensin hormone-like system (RAS) (11). Although this reaction is designed to sustain pressure, an elevated RAS has negative effects on the condition of our circulatory system, smooth muscle cells, and stimulates inflammatory agents within the body. This results in the formation of plaque on the inner lining of arteries (5). For people with hypertension, increased RAS activity predicts increased potential for heart attacks and for the increased insulin resistance that often accompanies low-sodium diets (9). Thus, reductions of sodium in the diet have to be considered cautiously.

Our understanding of sodium is further complicated by the overall role of salt (sodium chloride) in the diet. While sodium is an essential nutrient, sodium chloride (the main source of sodium in the diet) is our most common and applied flavor enhancer. In particular, it makes many of our foods which carry other essential nutrients more palatable. For example, many cruciferous vegetables, which supply a wide ar-

The Great Salt Debate

M. Satin
The Salt Institute
Alexandria, VA

The food industry is currently in the midst of a long standing controversy centered upon the use of one of its most ubiquitous ingredients—salt—a nutrient that is essential to life.

The number of applications fulfilled by salt in foods are as varied as the number of different foods that exist.

Finland achieved significant salt reductions, yet its progress in improving health outcomes was retarded compared to its neighboring countries that did not reduce salt intakes.

According to the FDA Oral History Project papers, in 1958, when the FDA commissioner was asked to give an example of ingredients that would not be regarded as a food additive since they were generally recognized as safe, the first item he mentioned was salt.
ray of essential nutrients, are bitter and much more palatable with salt added. The same can be said for many whole grain and protein foods. The best sources of essential magnesium are groundnuts and tree nuts, beans, seeds, legumes, fish, and green vegetables (e.g., spinach, artichoke, and okra)—all foods to which salt is traditionally added. Without added salt, a lack of palatability may limit the consumption of these products and the consequent access to the nutrients they contain. Pomerleau et al. have (18) published reports indicating that the burden of disease in Europe is dependent upon access to fruit and vegetables. Palatability will equally impact upon consumption patterns and salt restriction may have the unintended consequence of reducing the intake of important vegetables.

The use of salt to make foods more palatable is a millennia-old phenomenon and not the result of commercial promotion, nor does it result from low cost and availability. The high esteem for salt as a flavoring ingredient was evident even during periods when it was a rare and costly commodity.

Thus, sodium should not only be evaluated on the basis of its specific metabolic function and requirements, but also upon its influence on delivering other essential nutrients to the diet.

The Debate

Salt has been prominently featured in the news for many years because of the purported link between its consumption and cardiovascular disease. This multi-decade long debate has been characterized by considerable misinformation, which, in turn, has led to a loss of perspective on the part of consumers and in certain cases on the part of regulators. An outstanding sense of the debate was captured by scientific journalist Gary Taubes in his award-winning article “The (Political) Science of Salt,” published in Science (20).

There are several key players involved in this contentious issue: the national and international medical authorities, local physicians, consumer advocates, industry advocates, journalists, and consumers. Of course, there are also dieticians, nutritionists, and health scientists carrying out work in the field of salt and health. Among the most influential on the antisalt side of the salt and health debate is an international group dubbed World Action on Salt and Health (WASH) established in 2005 as a spin-off to Consensus Action on Salt and Health (CASH). Sounding very much like a money laundering operation, the UK-based CASH/WASH group is an international collection of physician advocates whose stated mission is to reduce the amount of salt consumed in foods. Most of the renowned antisalt advocates in the United Kingdom, the United States, and Canada are members of WASH and, as a result, repeat the same words and text regardless of where they are in the world. What is rather interesting is that although they are ardently antisalt in their outlook, they continue to serve on health evaluation panels and committees whose credibility is dependent upon objectivity.

By far the majority of research carried out on salt and health has been observational in nature and based upon epidemiological analysis—the relationship between two or more measured phenomena. As an example, because people in Italy consume a lot of olive oil and because their cardiovascular disease figures are good, the results of past epidemiological research indicated that consumption of olive oil leads to good cardiovascular health. The problem is that one could equally conclude that olive oil consumption also resulted in wild driving, the habit of using your hands when talking, an inability to stand in an orderly line, and a distinct dislike for long lasting governments. The relationships don’t really establish a cause and effect. Results depend upon the phenomena chosen to establish the relationship. As we shall see, this has been part of the problem surrounding the salt and health controversy.

No one has ever denied that salt consumption can affect blood pressure. That is one of salt’s essential roles—to regulate blood pressure. At one time or another, most people have eaten really salty foods and have experienced swelling in the fingers and difficulty in removing their rings. This phenomenon is normal and fully reversible. However, there are certain conditions such as aging, where the circulatory system loses its resiliency and blood pressure creeps up and remains at an elevated level (hypertension).

Some individuals whose combination of genetics and poor diet leads to salt sensitivity will also experience hypertension on a high salt diet. This situation can be considered to be a risk factor for cardiovascular disease. However, people do not die of hypertension; they die of heart attack or stroke. The question is really whether a reduction in the consumption of salt will reduce the risk of heart attack and stroke—two definitive health outcomes.

Salt Reduction Initiatives

In the last few years, the salt content of foods has taken on a much greater profile because of three highly publicized initiatives. The Food Standards Agency (FSA) of the United Kingdom has instituted an aggressive antisalt campaign directed at the food industry. Although this campaign has had limited success, it has been persistently hyped to appear as a government triumph. The second initiative has been the efforts of the Center for Science in the Public Interest (CSPI) to remove the GRAS (generally recognized as safe) status of salt and have it regulated as an additive in foods with a negative labeling association. Finally, the Canadian government has just established a multi-stakeholder working group to discuss dietary sodium reduction. It is worthwhile to examine each initiative in some detail.

In 1994, the UK Committee on Medical Aspects of Food and Nutrition Policy, appropriately acronymed COMA, recommended reducing the average salt intake of the population from 9 to 6 g/d. This recommendation was based on the link between high salt intake and high blood pressure—not between salt and any definitive health outcome. Ten years later, in September 2004, the FSA launched a high-profile consumer-awareness campaign on salt stressing the message that “too much salt is bad for your heart.” A second phase of the campaign was launched in October 2005 to encourage consumers to check food labels and aim to eat no more than 6 g of salt (2,300 mg sodium) a day. Work is being done on food labeling to highlight and warn (such as red light symbols) against foods with supposed high salt contents. Their latest televised campaign, “Full of It,” which employs a female comedian checking food labels and tossing away those foods deemed too high in salt, gives an idea of the sort of thought that went into the effort to influence food production and consumption patterns.

Unfortunately, as of the time of this publication, the FSA has not applied the same thought to the health of consumers because it never established a single metric to determine the health impact of such a policy. They do not measure heart disease death rates, stroke deaths, or any other health outcome to see if their program of reducing salt in foods is benefitting people. Certainly one would expect that such measurements would be planned before the start of such a campaign in order to establish a baseline upon which to compare the impact of this policy, but this is not the case here.

The FSA campaign appears to be mired down. Earlier this year, FSA announced that per capita consumption has been reduced from 3,800 mg of sodium to 3,600 mg (7). At this rate, it will take another 32 years to achieve their goals. In the mean-
time, the FSA continues to “name and shame” those companies and products that they believe do not fit their image of healthy food, while travelling around the world describing the “success” of their program.

As the law of unintended consequences inevitably comes into play, the salt-reduction hysteria in the United Kingdom has impacted one of the most important contributors to good health—vegetable consumption. Pomerleau et al. from the London School of Hygiene and Tropical Medicine have attributed the burden of disease across Europe to the degree of access to fresh fruit and vegetables (18). Fueled by the FSA advertising campaign, the UK Secretary of Education requested that salt shakers be banned from school lunch rooms. The Daily Telegraph correspondent Paul Eastham complained that his 14-year-old daughter had stopped eating vegetables at school because they are so bland (6).

“All the goodness they promise to deliver remains untouched on the plate—a complete waste of nutrients, health potential and money—all because they remain unpalatable.” Fortunately, she is able to eat her vegetables at home, where she is allowed salt to make them palatable.

On November 8, 2005, CSPI petitioned the FDA to revoke the GRAS status of salt, to set ceilings on the amount of sodium in processed foods, to require a health warning on packaged salt, and to reduce the daily recommended value for sodium. The FDA scheduled its first public hearings on this petition for November 29, 2007. This meeting was preceded by a joint Grocery Manufacturers’ Association (GMA) and CSPI conference on October 22–23, 2007, titled, “Salt Conference—Getting to 2,300: Balancing Health with Consumer Preferences & Industry Challenges.” What was billed as a salt conference was arranged entirely without the input of the salt industry, whose members stood to be amongst the most greatly impacted by the meeting’s outcome. From his opening remarks, CSPI head and WASH member, Michael Jacobson, stated, “The debate on sodium is over. There is no longer a debate if salt is good or bad.” He was followed by WASH member Steve Havas of the American Medical Association who stated that if the sodium contents of restaurant foods were to be cut by 50%, more than 150,000 American lives would be saved every year.

Thus, the meeting started with a statement handed down as if by fiat—the debate on sodium was over. This was immediately followed by a uniquely one-sided set of presentations whose purpose was to show that sodium was indeed bad—a questionable use of participants time if, indeed, the debate was over. Because most of the professionals at the GMA/CSPI meeting disregarded the notion that the debate was over and agreed that a singular focus on salt reduction was not a proven solution, the conclusion of the meeting was that a more holistic approach was needed to improve overall dietary quality. The CSPI tactic of ramming through the notion that there was no longer any debate on salt and health ultimately backfired. The most telling statement of the meeting was by a prominent nutritionist in one of the breakout working groups, “The eight hundred pound gorilla in this room is that not all of us are convinced of the relationship of salt to cardiovascular disease.”

At the GRAS petition meeting held at the FDA, the morning session featured many of the same antisalt speakers that spoke at the GMA/CSPI meeting. Additional speakers, including well-known hypertension physicians, nutritionists, and industry representatives had the opportunity to make 10 minute presentations in the afternoon session. The FDA has asked for written comments and have placed an initial deadline at March 28, 2008. It is likely that it will take some time before any decisions are made.

The GRAS list arose out of deliberation on the 1958 food additive law, according to the FDA Oral History Project papers. During the Congressional hearings, the FDA commissioner was asked to give a list of examples of ingredients that would not be regarded as a food additive since they were generally recognized as safe. The first item he mentioned was salt. Shortly thereafter, it was decided to draw up a formal GRAS list. Indeed, according to the testimony of William W. Goodrich, whenever an example of a product on the GRAS list was called for, salt was the material always chosen (10). This was not surprising because salt was the most ubiquitous ingredient in the entire range of foods prepared around the world and has proven to be safe for thousands of years. If any one product exemplified what a GRAS substance is, it is salt.

In concert with the initiatives going on elsewhere, the Canadian government has established a working group on dietary sodium reduction. It is interesting to note that, unlike all the professional nutritionists and dieticians that attended the GMA/CSPI meeting, the Ministry of Health has indeed accepted the CSPI fiat that the debate is over, naming to their working group only persons they feel accept their view that the science is conclusive. This flies in the face of the latest evidence that Canada’s cardiovascular performance without salt reduction has been far, far better than the one country, Finland, that has managed to reduce salt consumption.

The Evidence

Obviously, it is beyond the scope of this paper to review all the science behind the salt and health controversy. At the risk of being accused of cherry-picking, I have tried to highlight the most significant work. It can never do justice to all the research that has been done, but will hopefully contribute to a rational perspective of the issue.

**Salt Intake and Blood Pressure Rise with Age (INTERSALT)**

![Fig. 1. INTERSALT study taken from CASH website (3).](image-url)
The costly crusade to demonstrate a link between sodium and cardiovascular disease began in 1988 with the famous Intersalt epidemiological study of 10,000 subjects in 52 centers around the world (12). As anticipated, researchers reported that societies with higher sodium intakes also had higher average blood pressures (Fig. 1).

The presumption made is that those countries that showed higher blood pressures suffered from cardiovascular disease and died earlier than those that showed lower blood pressure. A natural conclusion to this study was that the more salt you ate, the younger you died. But there is no need to project such a conclusion, because you can easily look the data up. If you were to take the same Intersalt data and plot sodium intakes against life expectancy as taken from the U.S. Census Bureau international database, you end up with Figure 2.

The inescapable conclusion using the published Intersalt and the U.S. Census Bureau data is that the higher the level of salt intake, the greater the life expectancy. It’s classic epidemiology and so much depends upon what you choose to look at.

As can be seen there are a few points in the far left hand side of the charts that represent primitive societies. These people have little in common, either sociologically or economically, with the rest of the word. If these points are removed from both charts, the remaining points indicate that there is no clear relationship between salt intake and blood pressure. Much has been made of the fact that the Yanomamo Indians of Brazil show no age-related rise in blood pressure compared to modern societies (supposedly because of no salt consumptions). The fact is that among the Yanomamo, there is not much of a comparable rise in age. They have a life expectancy of 48.5 years! Comparing modern societies with those that have less stress, eat far fewer calories and much more fiber from fruits and vegetables, reach puberty at the age of six, and experience a midlife crisis at the age of 17 is not valid. It’s one thing to compare apples and oranges, but this is comparing apples to wombats.

A significant breakthrough was made in the Dietary Approaches to Stop Hypertension (DASH) study. Here it was determined that a balanced diet, replete with the recommended levels of fruits and vegetables and low fat dairy products had a significant impact on reducing blood pressure. Not happy that the DASH diet by itself had such a significant impact, the salt reduction advocates created an additional study to show the combined impact of both the DASH diet and salt reduction. Figure 3 shows the results.

When the DASH Sodium trial is examined, it is immediately apparent that moving to a DASH-type balanced diet (red line) has a far greater impact on blood pressure than lowering salt consumption. Dropping from the current level of sodium consumption to the recommended dietary level reduced the systolic pressure by an average of 2.1 mm Hg. However, simply changing from a regular diet (blue line) to the DASH diet, without any changes to sodium consumption, reduced the systolic blood pressure by 5.9 mm Hg, almost three times the drop resulting from the sodium reduction. This clearly explains why Mediterranean people enjoy an excellent cardiovascular status despite their high salt consumption. With a DASH diet, the impact of sodium on the blood pressure of hypertensives is minimal (and of no significance to normotensive people—the majority in the population [8]). However, when the WASH members describe the DASH Sodium trial, they inevitably give salt reduction more significance than the DASH diet itself.

In Italy, data shows that there is an average consumption of 11 g of salt per day, yet they have had amongst the best cardiovascular health data in the world. Olives, bacalada (salt cod), anchovies, capers, and botarga (salt-cured tuna roe) are all part of the diet, yet voluntary salt addition still makes up approximately 40% of the salt intake! This is because it is not possible to eat all those healthy vegetables without salt. Indeed, it is legitimate to question whether 2,300 mg sodium per day will be sufficient to get people to eat all the vegetables we want them to in order to achieve a balanced diet.

Up until recently, the question remained whether reducing population salt intakes would save the thousands of lives promised by WASH and the FSA in the United Kingdom. CSPI categorically stated that it would. In their publication, “Salt—The Forgotten Killer” (13), CSPI states that reducing salt consumption by half would save 150,000 lives per year in the United States. Unfortunately, without a large-scale controlled trial to test the effects of reduced salt consumption on health outcomes, these estimates remain a matter of debate. The Salt Institute has repeatedly asked the U.S. Secretary of Health for such a definitive study that all sides could accept. Unfortunately, no answer to this request has been received thus far.

The situation changed recently with the publication of a research article by WASH member Heikki Karppanen and Eero Meriava (14). In this publication they state: In this paper, we provide evidence that strongly suggests that the progressive decrease in salt intake, which has continued in Finland for 25 to 30 years, has played an important role both in the impressive fall in the average blood pressure of the population and in the pronounced 75% to 80% decrease in both stroke and coronary heart disease mortality.
in the population younger than 65 years (14, p. 59).

The authors refer to an aggressive national antisalt campaign involving influential newspapers, labeling programs, and a consensus agreement of government and scientific organizations with the food industry. The result of this effort was a drop in per capita salt consumption from 14 g per day down to 8 g per day—close to a 50% reduction. Finland has been the only country which has managed to do this.

To strengthen the case for salt reduction, the authors went on to state, “Evidence is presented to indicate that the comprehensive salt reduction has also played an important part in the remarkable 5- to 6-year increase in the life expectancy of the Finnish population during the past 25 to 30 years” (14, p. 59).

This paper has considerable significance for two reasons. For the first time, it describes an actual example of a nationwide reduction in salt consumption—something no other country has been able to accomplish until now. Secondly, the study highlights real endpoint health impacts, i.e., cardiovascular disease incidence and life expectancy, to measure the benefits of the national salt reduction program. These health outcomes overcome the deficiency of relying solely on blood pressure as a proxy for cardiovascular outcomes. Hypertension is not an endpoint per se, but rather one of several risk factors for cardiovascular diseases.

The Finnish embrace of health outcomes stands in favorable contrast to that in the United Kingdom where FSA waged an aggressive antisalt campaign solely on the basis of a surrogate outcome. It is likely that the Finnish study will serve as the benchmark for salt reduction programs for some time to come, and all WASH members and other salt reduction advocates have readily endorsed it.

The figures in that paper clearly show a dramatic drop in per capita salt intake in Finland. As the authors state, “Finland, so far, appears to be one of the few countries where it has been possible to produce a marked population-wide reduction in salt intake” (14, p. 60). They go on to describe how salt consumption in the United States has not been reduced during that same time period and, in fact, has increased slightly. As advocates of salt reduction, the authors predictably attribute the dramatic improvements in health outcomes to salt reduction in Finland and drew a comparison with the United States, which has continued at its historic salt intake levels. Unfortunately, they did not go that extra step and actually record the U.S. cardio-

**Fig. 3.** DASH-Sodium trial results.

**Fig. 4.** Age standardized death rates for ischemic heart disease.

**Fig. 5.** Per capita U.S. salt consumption (g/d).
vascular data for comparison. Therefore I decided to do so.

The Global Cardiovascular Infobase (www.cvdinfobase.ca/) makes possible a clear comparison of patterns of heart disease in all countries over the last 35 years. The comparison of Finland to the United States is illustrated in Figure 4.

The rate of ischemic heart disease (IHD) has decreased in both countries. In fact, the degree of heart disease reduction is far superior in the United States, having started at a significantly higher rate in the late 1960s and dropping down to a lower rate by the year 2000. Yet, unlike Finland, where the per capita salt intake has steadily declined from 14 g/d down to 8 g/d, U.S. per capita food salt consumption has fluctuated in the range between 7 g/d and 11 g/d. Figure 5 confirms that U.S. salt consumption has not declined. If anything the trend is slightly upward.

Karppanen and Mervaala were clearly wrong in attributing reduced cardiovascular disease to a reduction in salt consumption. If anything, the evidence would suggest just the opposite. Perhaps their chosen example of the United States, however, was atypical. Looking at five more European countries and Canada, however, confirms the relationship. All of these countries significantly reduced their ischemic heart disease mortality over the past 30 years, yet none but Finland claim any reduction in dietary salt. In fact, in the early 1970s, the closest risk rate to Finland’s was that of Canada. By the year 2000, with no salt reduction in Canada, Canadians had reduced their IHD mortality rate by twice as much as Finland. (Will the Canadian Working Group be refused permission to consider this information?) Finland had the least impressive improvement of the entire group and, as the authors boldly remind us, Finland was the only country to achieve a significant and sustained reduction in per capita salt consumption (Figure 6).

The authors’ second health outcome metric is longevity. They claim that the 5-6 year increase in life expectancy experienced in Finland is also the result of the reductions in salt intake. Again, let’s look at the evidence using the same country set. The United States led the group in increased life expectancy, improving fully 45% more than Finland. In fact, Finland’s improved life expectancy appears modest when compared to most of its neighbors. As the authors point out, Finland was the only country to achieve salt reduction, but, as far as increases in life expectancy are concerned, earned a sub-par health benefit for all this effort. Countries with consistent salt consumption levels set the pace for extending their citizens’ lives as shown in the following table derived from the International Data Base of the U.S. Census Bureau (Table I).

It is difficult to see how the authors attribute both the reduction in heart disease and the increase in life expectancy uniquely to a pattern of salt reduction without any attempt to compare this to real data readily available to anyone. Indeed, the lengths to which the authors went to attribute the reduction of cardiovascular disease and increase in longevity to salt reduction appears to be a reflection of how committed they are to reducing salt, not objectively reporting the evidence.

The evidence of health impacts of reduced salt consumption invites reconsideration of public health policy on universal sodium reduction. The study from Finland has crystallized the impacts for all to see. Finland achieved significant salt reductions, yet its progress in improving health outcomes was retarded compared to its neighboring countries and countries that share similar social, economic, food, and medical systems, but did not reduce salt intakes. Despite an almost 50% reduction in the consumption of salt in Finland, there were no health benefits attributable to this intervention—the most definitive lesson thus far that salt reduction will accomplish nothing.

The Role of Salt

The number of applications fulfilled by salt in foods are as varied as the number of different foods there are. These range from a taste enhancer to a taste suppressant; as a mediator of water activity and a regulator of texture, mouthfeel, juiciness, and friability. Blanching in salt water retains color and crispness in vegetables destined for freezing and salt initiates granule formation producing the unparalleled taste and texture of Parmesano Reggiano cheese.

Salt is not only our oldest known food preservative, but it fulfills a critical antimicrobial function in the most modern hurdle technologies employed in the production of high quality, minimally processed chilled foods that have become so popular in recent years.

Despite the myriad established uses of salt in food preparation at home and in the food industry, the overarching attraction of salt for people is sensorial. Simply put—salt makes food taste good. Salt doesn’t just deliver salty flavor, it delivers flavor in many ways.

Salt is the oldest, most common, and most important single flavoring substance (17). From a food appeal point of view, salt cannot be considered to be merely desirable, but by far the most satisfying of

<table>
<thead>
<tr>
<th>Country</th>
<th>30-year increase in life expectancy (yr)</th>
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<tbody>
<tr>
<td>United States</td>
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</tr>
<tr>
<td>Canada</td>
<td>6.8</td>
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<tr>
<td>Italy</td>
<td>6.7</td>
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<tr>
<td>Sweden</td>
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<tr>
<td>Denmark</td>
<td>5.5</td>
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<td>United Kingdom</td>
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<td>Finland</td>
<td>5.5</td>
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<tr>
<td>Netherlands</td>
<td>4.5</td>
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</tbody>
</table>

Source: International Data Base of the U.S. Census Bureau.
flavor components for all starchy and proteinaceous foods. This propensity for humans and animals to prefer a salty taste may originate from our marine evolution or may simply be a mechanism to ensure we receive an adequate amount of this essential nutrient in our diet. When faced with foods that don’t meet their taste expectations, most people will simply take up a salt shaker and add enough to satisfy their needs.

Thus, in a country such as Italy, where bread baking traditions result in regional products that vary from high to almost no salt, consumers at home and diners in restaurants will readily make up any taste deficit by voluntarily adding salt at the table prior to consumption. The same can be said for the consumer response to all other food products—those that demonstrate a deficiency in taste will be corrected by the consumer on a voluntary basis. Throughout history, even during periods when it was a costly commodity, salt was considered to be an economic necessity of life.

There is a body of thought that states that consumers can be weaned off of a preference for salty taste. A few trials with a small number of individuals over a limited time period support this notion. However, this does not coincide with the far more common experience we have seen after periods of war, dislocation, or incarceration where people have been involuntarily separated from salt for extended periods. In all cases, consumers return to their previously established higher level after an extended time.

One of the most important uses of salt in taste is to moderate bitterness in certain foods. For example, some of or most nutritious cruciferous vegetables, such as broccoli, spinach, brussels sprouts, cabbage, kale, mustard greens, and radicchio will not be acceptable to consumers unless a certain amount of salt is added. This is particularly true for children as the most recent results of tests from Ohio State University reveal (4). Restricting the amount of salt that consumers can add to these foods risks their access to the nutritional benefits they hold. Of course, bitter natural foods such as olives would not be an edible food commodity unless they were fully debittered with salt.

When added in small amounts, salt intensifies the sweetness of many foods such as caramel, taffy, fudge, fruits, mild vegetables, and various sauces. For example, lightly salting a slice of watermelon makes it taste sweeter. Salt also makes food taste more palatable by suppressing other unpleasant flavors. In these instances the goal of the consumer or manufacturer is not to make a food taste salty, but rather to enhance the overall taste profile and acceptability of the food.

Salt has a profound effect on the texture of an incredible array of food products. Because of its functional impact on the gelation properties of proteins, salt is used to respond to consumer preferences for texture, mouthfeel, and ease of swallowing for all national and imported cheeses and cheese products, processed meat, and fish products. Items such as bologna, frankfurters, restructured beefsteaks, chicken pieces, dry-cured ham, surimi from all fish sources, battered calamari rings, minced fish balls, etc., serve as some examples. Salt has a critical impact on the texture, color, and cooking loss of a range of fresh, processed, and dehydrated vegetables, such as runner beans, carrots, cucumbers, broccoli, and cauliflower.

Of course, not only food processors love salt. The use of salt by consumers to improve the texture of foods is common. Preparing for the holidays, a cursory search on Google using the term “brining turkey” yields more than 800,000 citations! As an example, a quote from the San Francisco Chronicle reads, “The Chronicle Food section cooked 28 turkeys to find the best method of producing a plump, juicy bird. Our favorite—by far—was the turkey that we brined before roasting” (1, p. WB-4).

The level of salt used in bread manufacture significantly affects the physical nature of the final product. Most standard bread is made from doughs containing somewhere around 1.5–2% salt by weight of flour. Salt has a significant physical effect on the properties of wheat gluten, resulting in a less sticky, more manageable dough. Salt also affects the rate of fermentation, and its addition is timed after the dough has been partly fermented. The role of salt in controlling fermentation is not only due to the increase in osmotic pressure, but also to the actions of sodium and chloride ions on the semipermeable membranes of yeast cells. Inadequate levels of salt will result in excessive yeast fermentation, resulting in gassy, sourdough breads (16) that are difficult to process and result in loaves with an open grain and poor texture (2).

Many types of flat bread have become widely available in recent years. These include single-layered, leavened dough products such as naan, pizza crust, ciabatta, and focaccia; batters such as crepes and pancakes; as well as double layered products such as pita bread; and unleavened products like chapattis, paratha, and tortillas. Salt is an essential ingredient in most formulations, many of which are sour-dough or yeast-leavened products (19). Salt, temperature, aeration, and flour quality are all used to control bread quality.

Salt affects the physical nature and properties of biscuit doughs, especially hard doughs, in a similar way to bread (23). In doughs with significant gluten development (15), such as crackers and semi-sweet types, salt toughens the gluten and gives a less sticky dough. It may also slow down the rate of yeast fermentation. Typical levels of addition are generally less than 2%, based on flour, resulting in about 1.5% in the final product.

Salt has a variety of technological functions in meat products. While many of the major effects relate to preservation, especially in cured and salted products, it also has other, direct effects on the nature and quality of the product. Some of these involve texture and flavor as noted above.

Salt is used in the manufacture of both hard and soft cheeses. The salting of some of the most famous Italian, Swiss, and Dutch cheeses is carried out after they are formed into rounds. The rounds are then immersed in saturated salt brine for up to 20 days. For many traditional manufacturers, the saturated brine baths are a source of pride, some having been in continuous operation for more than 100 years (showing perfectly cubic sodium chloride crystals from 5–6 inches on a side, sitting in crystal clear brine).

Salt is the oldest food preservative known to humankind—it has been used for thousands of years. The main mechanism of salt preservation is through the reduction of water activity. Microorganisms require water to survive and grow and salt preferentially ties up a portion of the water, leaving the microorganisms without sufficient free water. In inhibiting microbial growth, salt interacts with both the acidity (pH) of the medium and its temperature as well as other factors.

Conclusions

The food industry is currently in the midst of a long standing controversy centered upon the use of one of its most ubiquitous ingredients—salt—a nutrient that is essential to life. The latest evidence indicates that salt reduction will not deliver the health benefits stated by the salt reduction advocates. On the contrary, it may have the opposite effect and reduce or reverse the pattern of cardiovascular advances we have seen over the last three decades.

This often acrimonious debate will have significant consequences for our food supply, our health, and the degree of leeway we permit legislators to control our food production and consumption. These sobering matters that should not be decided upon by broad pronouncements governed
by subjective opinions, but by high quality scientific research, conducted by the most credible and objective researchers.

References

Morton Satin is a seasoned executive with international experience in food research, management, and marketing. He is currently the director of technical and regulatory affairs for the Salt Institute in Alexandria, VA. For more than 16 years, he directed the Global Agro-Industry program at FAO in Rome. Prior to FAO, Morton served as the vice president of research for the Steinberg/Multimarques corporation in Canada, where he supervised their introduction of the world’s first commercially successful natural high fiber white breads as well as the first large-scale supplementation of food products with folic acid and biotin in 1978—two decades before it was made mandatory. He has several technology patents to his name and has published more than 250 articles on a wide range of food science, technology, and agribusiness topics and has authored five text books in English and Spanish on the subject of food safety. His latest book, Death in the Pot: The Impact of Food Poisoning on History, came out in August 2007. He can be reached at morton@saltinstitute.org.

An advertisement appeared here in the printed version of the journal.