Salt Taste

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Sodium chloride (NaCl) has played a central role in human society throughout history. As a highly valued commodity, wars have been fought to control salt access and availability and it has served as a major basis for taxation for millennia (see Gandhi, 1930 for example). People have been paid in salt ("salaries") and salt has been transported, sometimes requiring considerable effort and expense, across long distances.
Until recently, a major problem for many peoples has been to obtain sufficient salt, both for themselves and also for their domestic animals, especially herbivores that cannot obtain sufficient sodium (Na) from most plants. Times have changed, however, and the salt problem in much of today's world is not one of insuffiency, but of excess. The consensus is that intake of too much salt is unhealthy for at least some proportion of the population. Consequently, achieving a more thorough understanding of salt taste, including how it is detected, the role it plays in food palatability, and how salt intake may be modified, carries public health implications. A better understanding of all aspects of salt taste is thus a necessity.

Why does salt taste salty?

NaCl and LiCl (lithium chloride) are the only two substances that taste almost purely salty, lacking virtually any bitter, sour, sweet or umami quality. This paucity of salty stimuli contrasts starkly with bitter and even sweet taste, for each of which there are numerous and diverse molecular stimulants. These observations suggest a highly specific mechanism for salty taste detection. And since the primary ion in salty taste is thought to be Na this mechanism must be specific to sodium. These and other observations have led investigators to hypothesize that a specific sodium channel, an ENaC, of the same kind that is used by kidneys to regulate sodium is also a salt taste receptor. Although this is a very attractive hypothesis, it has not been unequivocally proven and there are several other potential receptors for salty taste. It is highly likely that within the next few years we will fully understand the molecular basis for salt taste and this understanding should help in the design of novel salt taste enhancers.

Why do people like the taste of salt?

Many animals develop a salt appetite when they are deprived of salt; indeed this is the basis for the efficacy of salt licks. But this is not relevant to human salt liking since it is very rare for people to be depleted of salt since there is so much in our diet. If this is so, why do people like their food with substantial added salt?
Two explanations have been proffered. The first suggests that herbivores and some omnivores have an innate liking for the taste of salt. According to this rationale, it is to an organism's benefit to consume salt when it is available. There is no cost for this behavior, with the exception of some adult-onset diseases, as excess sodium is easily removed by the kidneys. Furthermore, it has been hypothesized that high Na intake may

reflect evolutionary pressure to protect against sudden dehydration. The second explanation is that individual exposure to salt, particularly early exposure, results in a heightened desire or avidity. This is a commonly-held belief among nutritionists, dieticians, physicians and others (e.g. MacGregor & de Wardener, 1998) but the evidence for this is fragmentary. Liking for salt and salty foods is surely the result of an interaction between innate and acquired information. Human infants at birth are either indifferent to salt or reject it, particularly at hypertonic concentrations. By approximately 4 - 6 months of age, infants show a preference for low to moderate saline solutions around the level of isotonicity. This age-related hedonic shift may represent in part the maturation of an innate transductive or neurological mechanism. Prior exposure to foods containing salt may modulate this developmental change. We have recently found that infants fed starchy foods between months 2 and 6 of life show heightened salt preferences relative to infants not exposed to these foods. Since one characteristic accompanying ingestion of starchy foods is likely a substantial exposure to salt, it is possible that this difference represents effects of prior exposure to salt. Perhaps salt exposure during a critical period of receptive element maturation permanently alters peripheral and/or central structures and is thereby particularly potent in establishing childhood and perhaps even adult habits of intake. This is surely an area that should be investigated since it has major public health implications.

In addition to probable effects of early exposure, environmental factors play a major role in determining salt avidity and consumption. The existence of societies where salt intake is very low has been interpreted to indicate that higher intake, such as that of Western societies, is the result of habit and commercial interests. However, in most of these societies low salt intake reflects low availability; wherever salt is inexpensive and widely available, it is noteworthy that most cultures consume roughly the same amount although the reasons for this are not clear.

<u>Why is salt used in food?</u>

Virtually all the salt people consume is in or on food; very few individuals eat pure salt outside that context. In foods, salt has several technical functions which I will not discuss here. Salt plays sensory roles in addition to making food taste salty. Consider bread and bread products. The salt in these makes up the single largest source of sodium consumed in the U.S. diet; yet, we typically do not perceive bread as salty. Bread without salt tastes insipid or bad; when salt is added, the flavor is enhanced without making the bread taste salty. Thus salt, when added to food, must have functions other than adding saltiness. What are they?

One supposition is that the sense of taste imparts not only a quality, but also a sensation of quantity, amount or bulk although a mechanism for this is not known. Additionally, sodium is an outstanding inhibitor of certain bitter tasting compounds. At Monell, we have shown that a sodium salt added to a mixture of bitter and sweet suppresses the bitterness, thereby releasing the sweet from inhibition. This may help explain why salt is added to so many foods when the intent is not to add saltiness.

<u>How can we reduce salt consumption?</u>

There appear to be two approaches to reducing sodium consumption. In both salt is removed from foods. In the first approach, it is believed that people would adjust to or at least tolerate the changes in taste (if the non-taste functions could be accounted for by other means) whereas in the second, an alternative taste-active substance is added to offset the loss of salt.
Consider the first strategy. When people undertake a low-sodium diet, the immediate response is misery. However, the lower sodium diet eventually becomes accepted and in fact, foods containing the previous amount of salt are perceived as too salty as we demonstrated at Monell many years ago. After assuming a diet with about a 50% reduction in sodium content for 2 - 3 months, volunteers came to prefer their food with lower salt levels. They acclimated to this diet. We also showed that preference could be moved in the other direction: when people were put on a higher salt diet, they began to like more concentrated salt in their foods.
This evidence supports the view that if somehow an entire population were to undertake a low sodium diet, it would soon come to be the norm and no one would notice or feel deprived. There are of course many practical problems with instituting such a change so it is questionable how successful this would be. Currently the United Kingdom (with the United States and other countries in Europe likely to follow) is actually trying to introduce this strategy. The goal is to reduce salt intake 40% - 50% in the next few years. It will be interesting to see how successful this strategy is.
A second alternative is to develop non-sodium salt enhancers. (A salt substitute - a sort of aspartame for salt - is very unlikely due to the specificity of the presumed receptor as discussed above.) Some amino acids and amino acid salts have this property, thus demonstrating proof of principle. What is needed is a concerted effort, most efficiently using the (yet unidentified) human salt receptor as a screening device, to search for such molecules as we at Monell are currently doing. Of course, if one is found, many practical problems will arise. Is it safe? Does it have the other functions of salt, for example the bitter blocking activity? Is it sufficiently inexpensive? Will people accept a new "chemical" in their food? In spite of these problems, the search for a salt enhancer is worthwhile and has promise.

Final comment.

There is still much to learn about how salt taste is perceived and what factors are responsible for preferences for salt in foods. Given the apparent role of excess salt intake in human disease, primarily essential hypertension, it is imperative that this gap in our knowledge be closed.

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