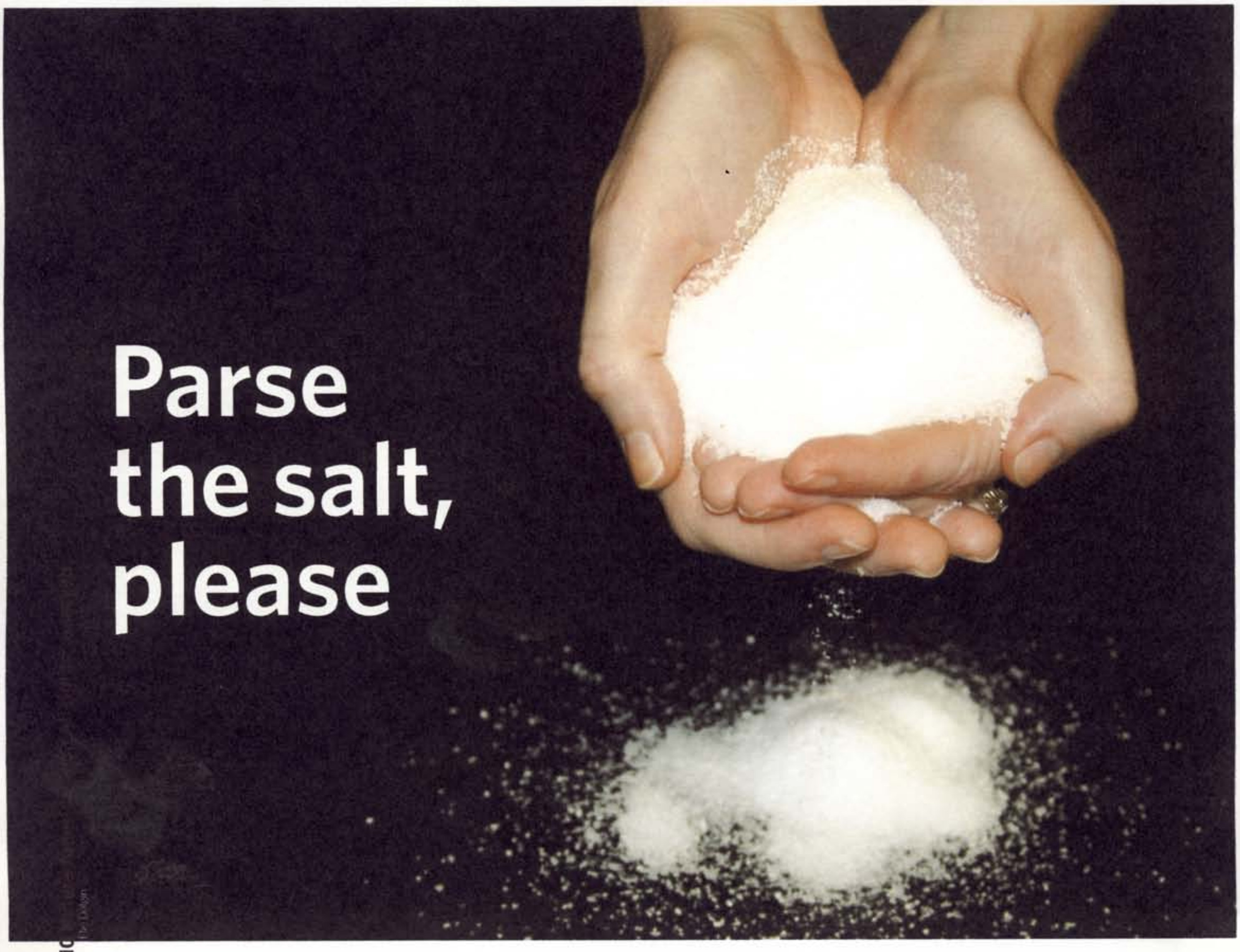


Parse the salt, please

Salt has been humanity's great taste enhancer, preservative and all-around go-to food ingredient for 8,000 years. But the ubiquitous white crystal is now thought to have caused an epidemic of heart attacks and strokes. In response, many food manufacturers are devising new ways to curb sodium intake while trying to maintain food's saline-stoked good flavor. **Stephen Strauss** gets a taste of the leading technological solutions for cutting back on the tabletop seasoning.

It seems a month can't go by without another group urging less salt consumption. In April, it was the US Institute of Medicine calling for average salt intake to fall from 3.4 to 2.3 grams per day. Last month, a Health Canada panel unveiled a nationwide effort to decrease salt intake 5% annually for five years. What is not said in these salt-slashing initiatives, however, is how exactly people are going to be weaned from a dependence on what may well be humanity's most versatile food chemical.

The cause for concern is obvious. Study after study has linked high levels of salt to rises in blood pressure and the concomitant increase in strokes and heart attacks. Modest reductions in dietary salt, health experts say, would be more cost effective than medications in improving public health (*N. Engl. J. Med.* **362**, 590–599, 2010).

And yet most people continue to munch on salty snacks. (By some estimates, people in the developed world get upwards of 75% of their sodium from processed food.) In response, various international food companies, including ConAgra, General Mills and Unilever, among others, have committed themselves to voluntarily reducing salt levels in their products. But this commitment has raised a host of practical issues. How does one make a 'healthy' low-salt food that isn't bland and tasteless? Can one still maintain salt's preservative benefits at lower concentrations? Is it even possible to make a salt substitute that is as cheap as good old NaCl, which costs about the same as water in developed countries?

Although clearly difficult to achieve, a less salty future seems to be in the offing, as industry and academic researchers have begun to tackle humanity's salt overindulgence in a host of innovative ways.

"There is no one magical salt substitute, but literally dozen of approaches are being used and should be used to reduce salt in foods," says Michael Jacobson, co-founder of the Centre for Science in the Public Interest, an advocacy group in Washington, DC focused on nutrition and food safety. "There is no other alternative."

Small package delivery

At Ryerson University in Toronto, Dérick Rousseau is trying to develop a radically new salt container—but not a curvier salt shaker, a more colorful box or a tear-proof bag. Rather, the food science professor is attempting to encapsulate salt crystals in other compounds in an effort to create a salt that slowly releases itself in the mouth.

"What we are proposing is to put less salt in, but make it work harder," he says.

The salt chemistry that Rousseau is looking at is based on what is already used in slow-release pain relievers. The idea is to coat salt crystals with proteins, lipids or carbohydrates—a strategy similar to how time-released drug formulations are encapsulated—allowing the salt to dissolve more gradually than traditional salt.

As such, the slow-acting salt lingers on the palate, meaning less salt is needed to achieve the same flavor.

Already, Rousseau and his colleagues have shown in principle that their salt repackaging works. In lab assays, the biopackages of salt broke down in a steady, controlled fashion, the researchers found. Now they are putting the repackaged salt into various types of processed foods to establish whether the same is true in the kitchen. Taste tests are planned for later this year.

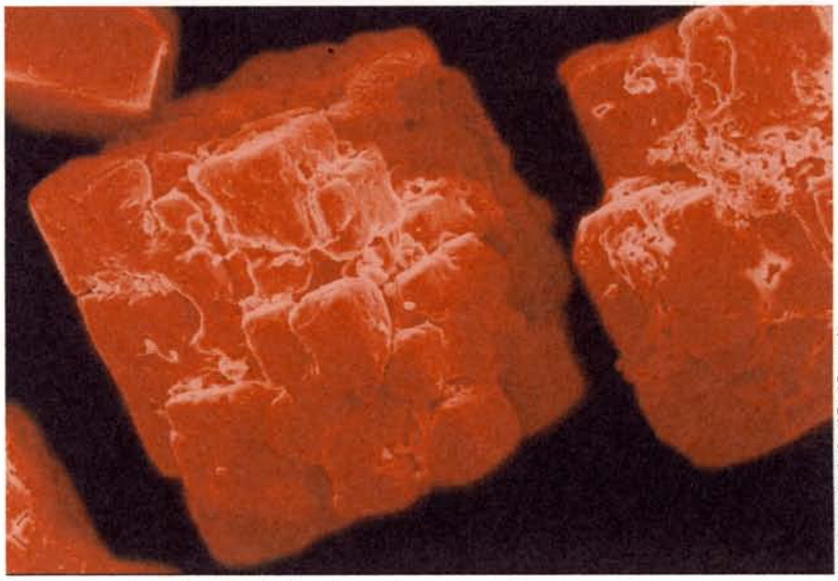
A fundamental issue with this research, however, is that salt replacements of the sort Rousseau is developing don't work with all foodstuffs. "The reality is that release is strongly food specific," Rousseau says, "so a single replacement approach will not work equally well for bread, potato chips or soup, unfortunately." That's why his team has developed one kind of chemical packaging for salts intended for solid forms of food and a different coat for salts going into liquids.

> "There is no one magical salt substitute, but literally dozen of approaches are being used and should be used to reduce salt in foods."

Meanwhile, instead of chemically manipulating the shape of salt, the Surrey, UK–based company Leatherhead Food International (LFI) has turned to supercool temperatures to physically create a much smaller salt crystal. With the help of liquid nitrogen, the company says it can reduce table salt's particle size from around 500 microns to a mere five to ten microns—about the size of a single red blood cell.

Notably, the reduced size seems to translate to a reduced need for sodium. When applied on potato chips, an expert taste panel found that the smaller crystals were about 25% more intense in their saltiness than chips dipped in regular table salt. In terms of taste appeal, consumers liked potato chips with a 50/50 mix of normal and smaller crystals significantly more than either the normal or the smaller crystals, according to Cindy Beeren, head of sensory and consumer science at LFI.

Despite the early success, however, scaling up the freezing procedure to an industrial scale faces challenges, most notably cost. Liquid nitrogen is pricey, and the extra processing steps needed to dissolve, freeze and dry the salt all add further expenses that would considerably increase a company's electric bill. "This is not necessarily the cheapest way to do things," Beeren says.



Kathy Groves, Leatherhead Food Research

Salty snapshot: A single grain of table salt contains many smaller salt cubes.

Salt of the earth

To overcome the cost barrier, many researchers have been searching for natural and plentiful products that taste salty to the tongue yet contain much less hypertension-inducing sodium. For Andrew Fairclough and his colleagues at Sheffield Hallam University, UK, this means looking no further than the northern seas. In collaboration with Seagreens, a seaweed supplier in West Sussex, UK, Fairclough's team is investigating the potential of ground-up Arctic wrack—the common name for several species of seaweed in the family *Fucaceae*.

Besides tasting much like the real thing, the seaweed salt stand-in—which does not contain salt molecules but does have sodium and chloride in small separate amounts—can also activate baker's yeast, and, in so doing, create bread with a browner crust and a fluffier body than most salt substitutes. In 2009, Fairclough gave slices of whole-wheat bread made with either real salt or seaweed to a panel of untrained taste testers. Among the 12 participants, none could taste a difference.

"It looks the same; it bakes the same," says Fairclough, and "you can't tell if it's Seagreens or real salt."

However, when he tested the seaweed in white bread, members of the taste panel often detected a faint fishy taste in the bread. Mixing ordinary salt with the coarse seaweed grains eliminated this problem. Indeed, nine of the 12 tasters preferred the flavor and look of half seaweed–half salt bread over loaves made entirely with one product or the other. Fairclough's findings will appear in an upcoming issue of the *International Journal of Food Science and Technology*.

In a similar vein, the Swiss flavor and fragrance company Givaudan has begun to look for natural salt substitutes in a manner reminiscent of pharmaceutical firms' search for medicinal agents in the world's jungles. "We have a cuisine trek where our natural-products people go into rain forests looking for ingredients used in cooking and baking," says Robert Eilerman, Givaudan's senior vice president for global science and technology.

So far, the safari has turned up few salty compounds. But Givaudan's search for salt enhancers has yielded some compounds that boost the sensation of saltiness when sodium levels are cut, even though they don't taste salty themselves.

Of particular interest are coolants. These substances make the mucous membranes feel colder and are today used in chewing gums, beverages and other foodstuffs. Coolants at quite low levels can increase the sensation of saltiness such that salt amounts could be cut by as much as 20–30% without compromising flavor. However, natural cooling compounds have proved too expensive to put in foods, and Eilerman fears that artificial coolants will be labeled as 'unnatural', which would undermine the product's attraction as a salt enhancer.

Elie Dolgin

Saline stand-in: BetraSalt's alternative flavor enhacer.

In good taste

One of the greatest hurdles to eliminating table salt from most tried-and-tested recipes is that scientists still don't really understand how we sense what salt does in our food. "We may detect salt through mechanisms other than taste—they could be touch or pain or smell," notes Paul Breslin, an experimental psychologist at Monell Chemical Senses Center in Philadelphia. On a basic biology level, "we know salt tasting is complex and requires more than one receptor, possibly even more than one coding cellular system."

Some of these receptors are beginning to be discovered. In 2008, for instance, the San Diego–based biotech company Senomyx reported that it had found the primary human salt taste receptor, which it dubbed SNMX-29. Using the protein in *in vitro* assays, Senomyx claims it has discovered more than 250 proteins that enhance the tongue's receptivity to saltiness, and the company is screening a further 500,000 synthetic and natural compounds to see if any will bind the receptor to enhance its salt perception.

But much of what Senomyx is doing remains cloaked in a premarketing mystery. "We have not discussed how we are going about doing our research and the steps we are taking," says Gwen Rosenberg, vice president of industrial relations and corporate communications for the company.

Assault on salt: commercially available salt replacements

Type	Brand	Characteristics
KCl- or NaCl-based blends	Synevo salt	Special grinding technology delivers composition with improved taste property.
	Sub4salt	Blend incorporates gluconate to boost saltiness.
	Pansalt	Contains amino acids to overcome bitter taste at higher dosage.
Recrystallized mineral salts	Betrasalt, Ocean's Flavor, Solo salt, Eco salt	Low-sodium, potassium- and magnesium-enriched sea salts.
	Lacto salt	Whey protein–based composition with a high potassium content.
Salt enhancers based on dairy and/or cereal proteins	Savoury Powder	Uses fermented milk protein, which has both salty and umami taste-boosting properties.
	Amplify	Salt enhancer based on a proprietary protein-peptide technology with high monosodium glutamate and potassium content.
	Zalt ND	Uses sea salt and fermented milk proteins.
	Mycoscent	Based on mold fermentation.
	Saltwise	No details available.
Other salt enhancers	Trehalose	Found in artichokes and mushrooms. This sugar in combination with KCl can enhance salty taste and mask unpleasant ones.

Adapted from Dötsch, M. *et al. Crit. Rev. Food Sci. Nutr.* **49**, 841–851 (2009).

To date, the most common salt substitutes on the market are those based on using potassium chloride (see 'Assault on salt'). This alternative food enhancer has many of sodium chloride's cooking and tasting properties, but in high doses the compound often tastes metallic or bitter. Other salt surrogates cost far more to synthesize than table salt, and this has translated into a reality where nothing has proven truly commercially viable.

"The salt substitute market is only about \$30 million—tiny in relationship to artificial sweeteners," which is estimated to hit \$2 billion next year in the US alone, remarks Ray Salemme, chief executive of Redpoint Bio, a small biotech in Ewing, New Jersey that markets a product, called Betrasalt, combining a number of proprietary flavor ingredients with potassium chloride.

But the market is palpably growing. "Back 20 years ago, when soup companies were already asking for sodium reduced products, there were no real credible solutions," says Eilerman. "If you look today, there are credible solutions."

Crucially, Eilerman adds, the push for a reliable product is coming not just from governments and the medical community but from a salt-conscious public at large. "All of our customer base is self motivated," he says. "They are driven by the consumers who are demanding products with less salt in them." Clearly, this research is being taken with much more than a grain of salt.

Corrected after print 3 August 2010.

Stephen Strauss is a freelance science writer based in Toronto.