September 20, 2012

Technological Strategies for Sodium Reduction in Processed Meat Products

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Lisle, Illinois, USA

9th International Meat Industrialization Seminar

MERCOAGRO

Chapecó, SC, Brazil | 20 September 2012

Presentation Outline

I. Contributions of Processed Meats to a Healthy Lifestyle

II. Dietary Sodium: Public Health Implications

III. Dietary Sodium: Consumer Perceptions

IV. Food Contributors to Sodium Intake

V. Sources of Sodium in Processed Meats

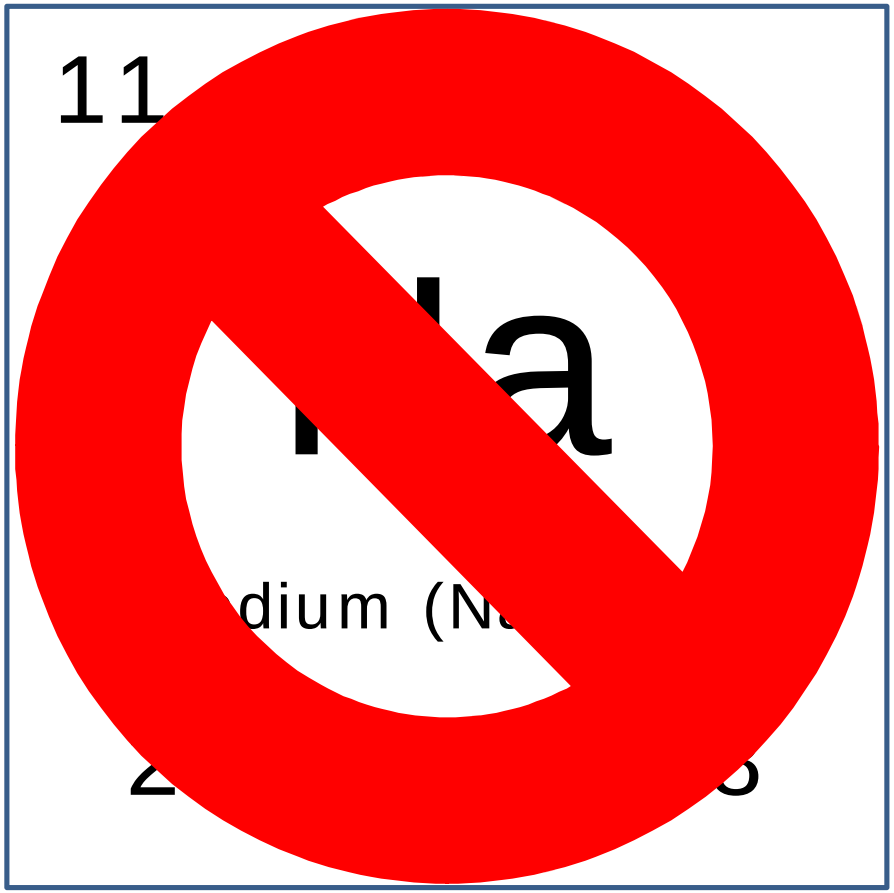
VI. Technological Alternatives for Sodium Reduction in Processed Meats

VII. Summary

Disclaimer

Throughout this presentation, any written or verbal reference to any specific commercial products by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply endorsement or recommendation on the part of the speaker or of the John Morrell Food Group, its subsidiaries or employees.

The Culprit



A Brief History of Salt

- Most ancient known food preservative.
- Historically used to preserve meat, fish, vegetables, fruit.
- Of crucial economic importance in ancient times.
  - Served as currency in various places at various times.
  - Wars have been fought over it.
- Roman soldiers received salt as part of their pay.
  - "salarium argentum" → en. *salary*, pt. *salário*, es. *salario*
- Historical association with meat and other foods.
  - Lat. *sal* (salt), *salsus* (salty), *salsicus* (seasoned with salt)
    - en. *sausage,* fr. *saucisse,* pt. *salsicha,* es. *salchicha*
    - en. *salad*, fr. *salade*, pt. *salada*, es. *ensalada*
    - en. *sauce*, fr. *sauce*, pt. *salsa*, es. *salsa*

I. Contributions of Processed Meats to a Healthy Lifestyle

Dietary Contributions

- Excellent source of various essential nutrients:
  - High-quality protein
  - B vitamins (thiamin, riboflavin, niacin, B_6, B_{12})
  - Minerals: iron, zinc, selenium
    - Minerals from meat have higher bioavailability than those from vegetable sources
- Satiety
  - Protein helps promote satiety.
- Variety
- Enjoyment

Socio-cultural Contributions

- Convenience/Comfort
  - Ease of use
  - Time
- Safety
- Accessibility to meat

II. Dietary Sodium:
Public Health Implications

Physiology of Salt

- Essential mineral; must be consumed in adequate amounts.
- Key roles
  - Proper balance and acid-base balance of body fluids.
  - Regulation of movement of fluids into and out of cells (together with potassium).
  - Regulation of blood volume and pressure.
  - Nerve function and muscle contraction.
- Excessive consumption
  - Positively associated with prevalence of hypertension, which can lead to cerebrovascular disease (CVD) (i.e., heart disease and stroke)
  - WHO (2002) has estimated that globally 62% of cerebrovascular disease and 49% of ischaemic heart disease were attributable to elevated blood pressure (systolic >115 mmHg).
  - According to WHO, high blood pressure is the wold's leading preventable risk factor for mortality.

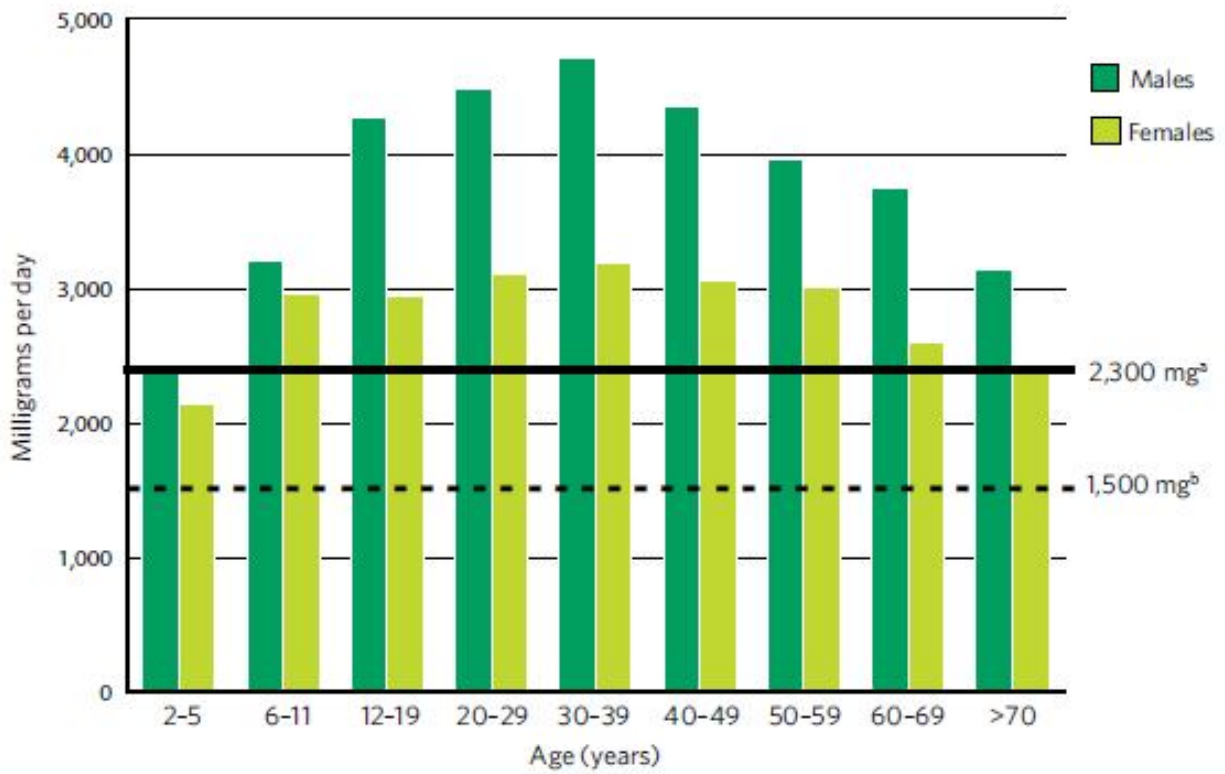
Salt Intake in the Americas*

- Exceeds 6 g/day by age 5.
- Averages between 9 and 12 g per day in many countries.
- Daily intake estimates:
  - Brazil 11 g (= 4,323 mg Na)
  - Argentina 12 g (= 4,716 mg Na)
  - Chile 9 g (= 2,537 mg Na)
  - United States 8.7 g (= 3,419 mg Na)
- Is highly correlated to caloric intake.
- Sources of dietary salt vary.
  - 75% coming from processed food in developed countries.
  - 70% coming from discretionary salt added in cooking or at the table in parts of Brazil.

* Legetic B., & Campbell, N. (2011). Reducing salt intake in the Americas: Pan American Health Organization actions. *Journal of Health Communication, 16 Suppl 2*, 37-48.

Sodium Intake in the United States

FIGURE 3-1. Estimated Mean Daily Sodium Intake, by Age–Gender Group, NHANES 2005–2006



a. 2,300 mg/day is the Tolerable Upper Intake Level (UL) for sodium intake in adults set by the Institute of Medicine (IOM). For children younger than age 14 years, the UL is less than 2,300 mg/day.
b. 1,500 mg/day is the Adequate Intake (AI) for individuals ages 9 years and older.

Source: U.S. Department of Agriculture, Agricultural Research Service and U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. What We Eat In America, NHANES 2005-2006. http://www.ars.usda.gov/Services/docs.htm?docid=13793. Accessed August 11, 2010.

Sodium Intake in Brazil*

- Mean daily sodium availability in Brazilian households in 2002-2003 was 4.5 g per person (or 4.7 g considering a daily calorie intake of 2,000 kcal).
- Although "most of the sodium available for intake across all income strata was derived from kitchen salt or salt-based condiments (76.2%), the fraction derived from processed foods with added salt showed a strong linear increase as household purchasing power increased, representing 9.7% of total sodium intake in the lower quintile of the per capita income distribution and 25.0% in the upper quintile."

* Sarno et al. (2009). Estimated sodium intake by the Brazilian population, 2002-2003. *Revista de Saúde Pública, 43(2),*1-6.

Current National Recommendations

- United States
  - Reference Daily Value (DRV) for sodium is currently 2,400 mg/day.
  - Institute of Medicine, National Academy of Sciences
    - "Analysts estimate that population-wide reductions in sodium could prevent more than 100,000 deaths annually."
    - For healthy populations 19 to 50 years old (2004):
      - Adequate Intake (AI) = 1,500 mg/day
      - Tolerable Upper Intake Level (UL) = 2,300 mg/day
  - *Dietary Guidelines for Americans*, USDA (2005)
    - "Reduce daily sodium intake to less than 2,300 milligrams (mg) and further reduce intake to 1,500 mg among persons who are 51 and older and those of any age who are African American or have hypertension, diabetes, or chronic kidney disease. The 1,500 mg recommendation applies to about half of the U.S. population, including children, and the majority of adults."

Current National Recommendations

- United States, cont.
  - Institute of Medicine, National Academy of Sciences
    - *Strategies to Reduce Sodium Intake in the U.S.* (2010):
      1. The Food and Drug Administration (FDA) should expeditiously initiate a process to set a mandatory national standards for the sodium content of foods.
         - FDA should modify the level at which salt is considered GRAS (Generally Recognized As Safe).
      2. The food industry should voluntarily act to reduce the sodium content of foods in advance of the implementation of mandatory standards.
      3. Government agencies, public health and consumer organizations, and the food industry should carry out activities to support the reduction of sodium levels in the food supply.
      4. In tandem with recommendations to reduce the sodium content of the food supply, government agencies, public health and consumer organizations, health professionals, the health insurance industry, the food industry, and public-private partnerships should conduct augmenting activities to support consumers in reducing sodium intake.
      5. Federal agencies should ensure and enhance monitoring and surveillance relative to sodium intake measurement, salt taste preference, and sodium content of foods, and should ensure sustained and timely release of data in user-friendly formats.

Current National Recommendations

- United States, cont.
  - Institute of Medicine, National Academy of Sciences
    - Research Need Areas
      - Understanding of how salty taste preferences develop throughout the lifespan.
      - **Development of innovative methods to reduce sodium in foods while maintaining palatability, physical properties, and safety.**
      - Enhancement of current understanding of factors that impact consumer awareness and behavior relative to sodium reduction.

Current National Recommendations

- United States, cont.
  - National Salt Reduction Initiative (NSRI)
    - Partnership of more than 85 state and local health authorities and national health organizations, coordinated by New York City Health Department.
    - Sets voluntary targets for salt levels in 62 categories of packaged food and 25 categories of restaurant food to guide food company salt reductions in 2012 and 2014.
    - Goal is to reduce Americans' sodium intake by 20% by 2014 through voluntary corporate commitments to lower sodium in packaged and restaurant food.
    - Specific targets can be found at http://www.nyc.gov/health/salt.
    - As of August 2011, 4 meat companies had committed to NSRI targets.

Current National Recommendations

- Europe
  - E.U. Framework for National Salt Initiatives (2008)
    - Overall goal "to contribute towards reduced salt intake at population level in order to achieve the national or WHO recommendations."
    - Minimum benchmark of 16% salt reduction over 4 years for all food products was established, including restaurants and catering.
    - 12 categories of foods were identified as priorities; member states must select at least 5 for their national plan.
- Canada
  - Sodium Reduction Guidelines, Health Canada (2012)
    - Goal of reducing sodium intake to 2,300 mg/person/day by end of 2016.
    - Food companies were asked to voluntarily reduce sodium in their products and Guiding Benchmark Sodium Reduction Levels were provided to assist industry in this effort.

Current National Recommendations

- Brazil
  - Guia Alimentar para a População Brasileira (1ª edição), Ministério da Saúde (2008)
    - Maximum salt intake level of 5 g/day (2,000 mg Na/day), which amounts to 50% reduction in dietary intake.
    - Consume salt in moderation and avoid processed foods with elevated sodium content.
  - National Strategy for Reducing Sodium Consumption
    - Call for voluntary reduction of sodium in processed foods and those sold at restaurants and foodservice establishments.
    - Sodium reduction targets have been negotiated for certain foods.

International Recommendations

- World Health Organization (WHO)
  - "Current recommendations indicate that in order to prevent chronic diseases, the population average consumption of salt should be < 5g/day (< 2 g [2,000 mg]/day of sodium) (WHO 1983, WHO 2003)."
  - In the Americas, a Pan American Health Organization expert group recommends that this be achieved by 2020.

III. Dietary Sodium:
Consumer Perceptions and Behavior

What are U.S. consumers doing to limit sodium intake?

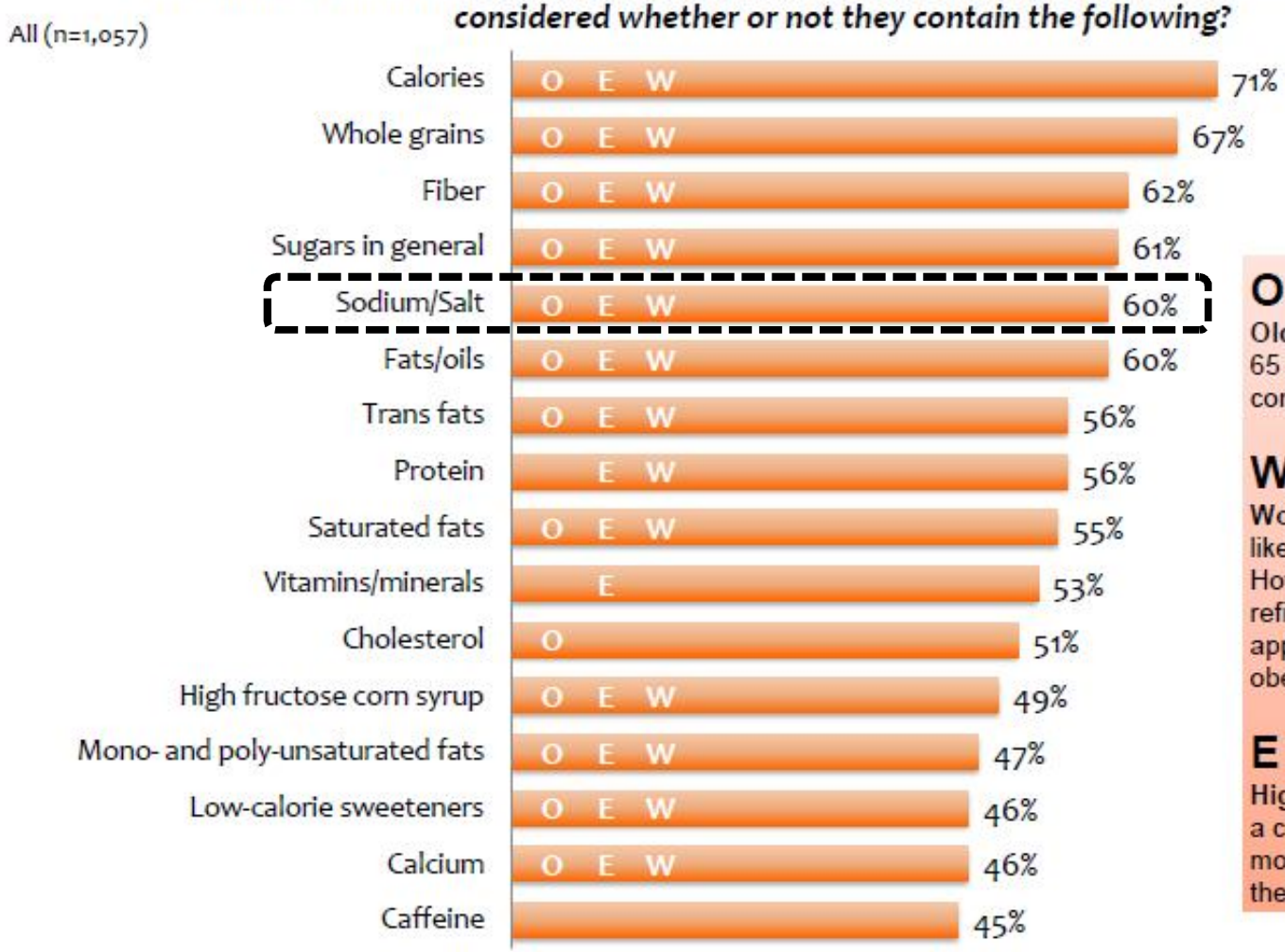
8 out of 10 have taken at least one of six specified actions

Which of the following, if any, do you regularly do regarding your sodium consumption?

Source: International Food Information Council Foundation. 2012 Food & Health Survey.

Sodium content ranks high among U.S. consumers when making food purchase decisions

Over the past year, when making decisions about buying packaged food or beverages, have you ever considered whether or not they contain the following?



O
Older consumers, especially those 65 to 80, are more likely to consider these food components.

W
Women are also generally more likely than men to consider them. However, for fats, sugars, and refined carbohydrates, there is no apparent gender difference among obese consumers.

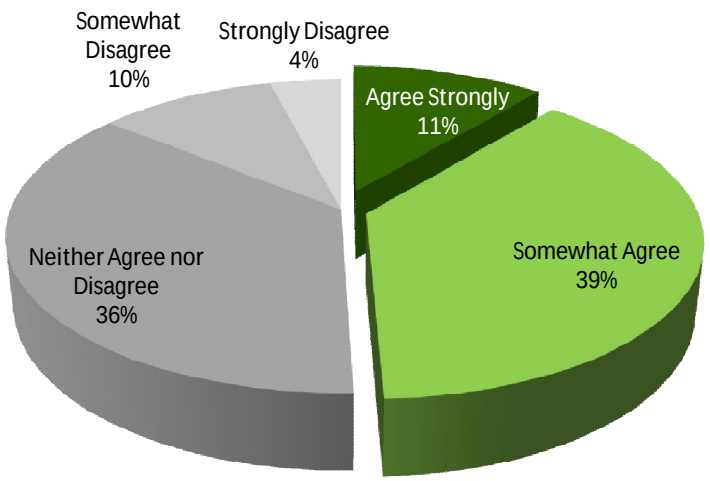
E
Highly-educated consumers (with a college degree or more) are also more apt to consider almost all of these ingredients.

Source: International Food Information Council Foundation. 2012 Food & Health Survey.

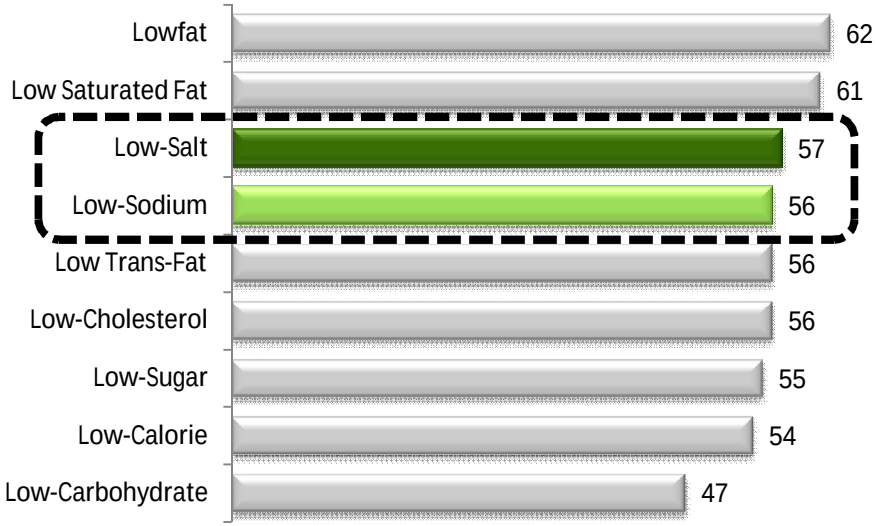
What label claims do consumers look for?

- 50% of consumers think more highly of products claiming to be low in sodium
  - Amid nutritional claims, sodium and salt-related benefits are the second most sought-after descriptors

"If a food or beverage is advertised as being low in sodium, I think more positively of that product."

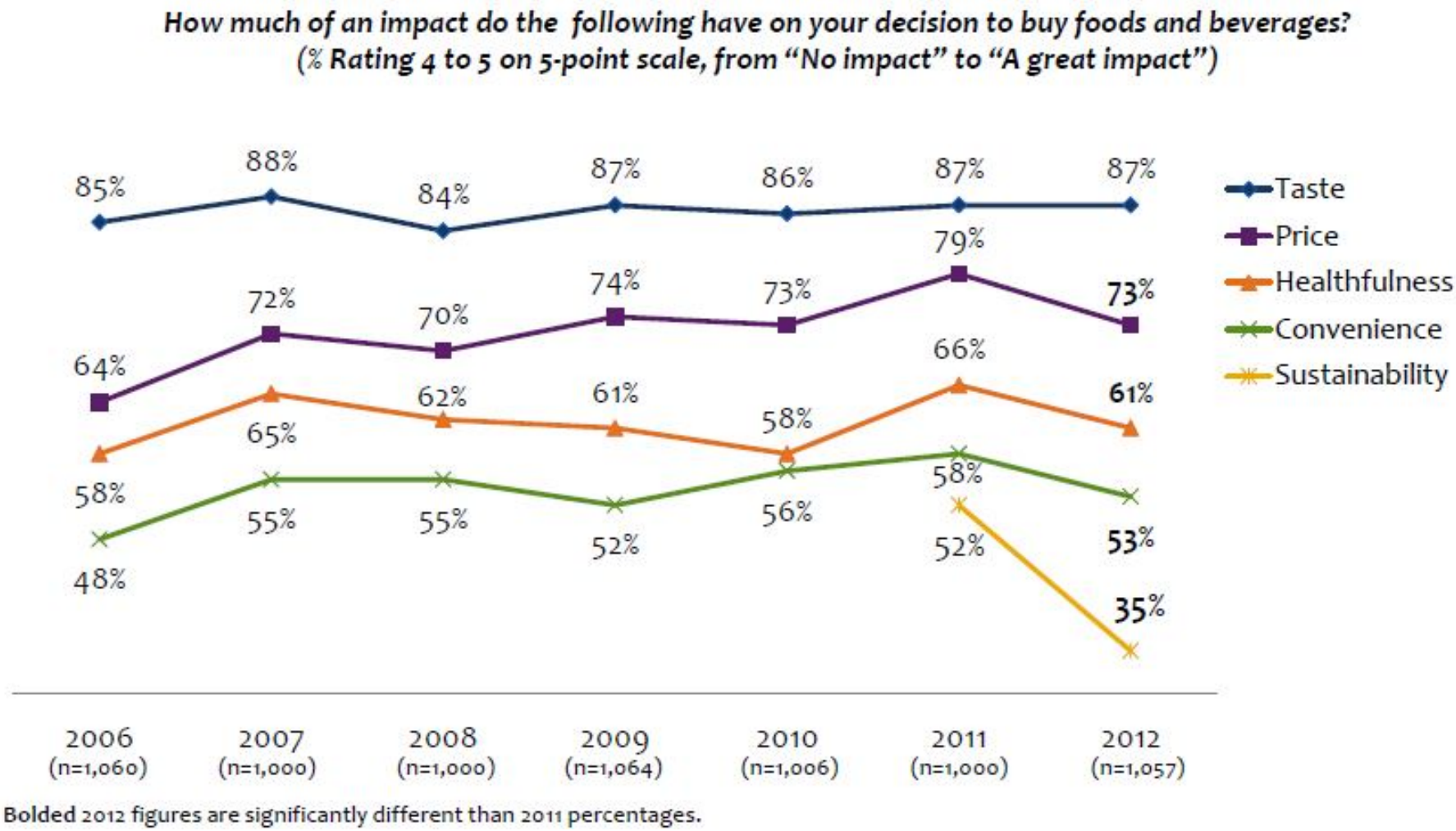


Descriptors looked for when purchasing food or beverage[a]



Sources: a) Technomic Inc., 2010, The Healthy Eating Consumer Trend Report
b) International Food Information Council, Sodium Report, August 2011

But…They *Still* Prefer Taste and Price!



Source: International Food Information Council Foundation. 2012 Food & Health Survey.

THE CHALLENGE

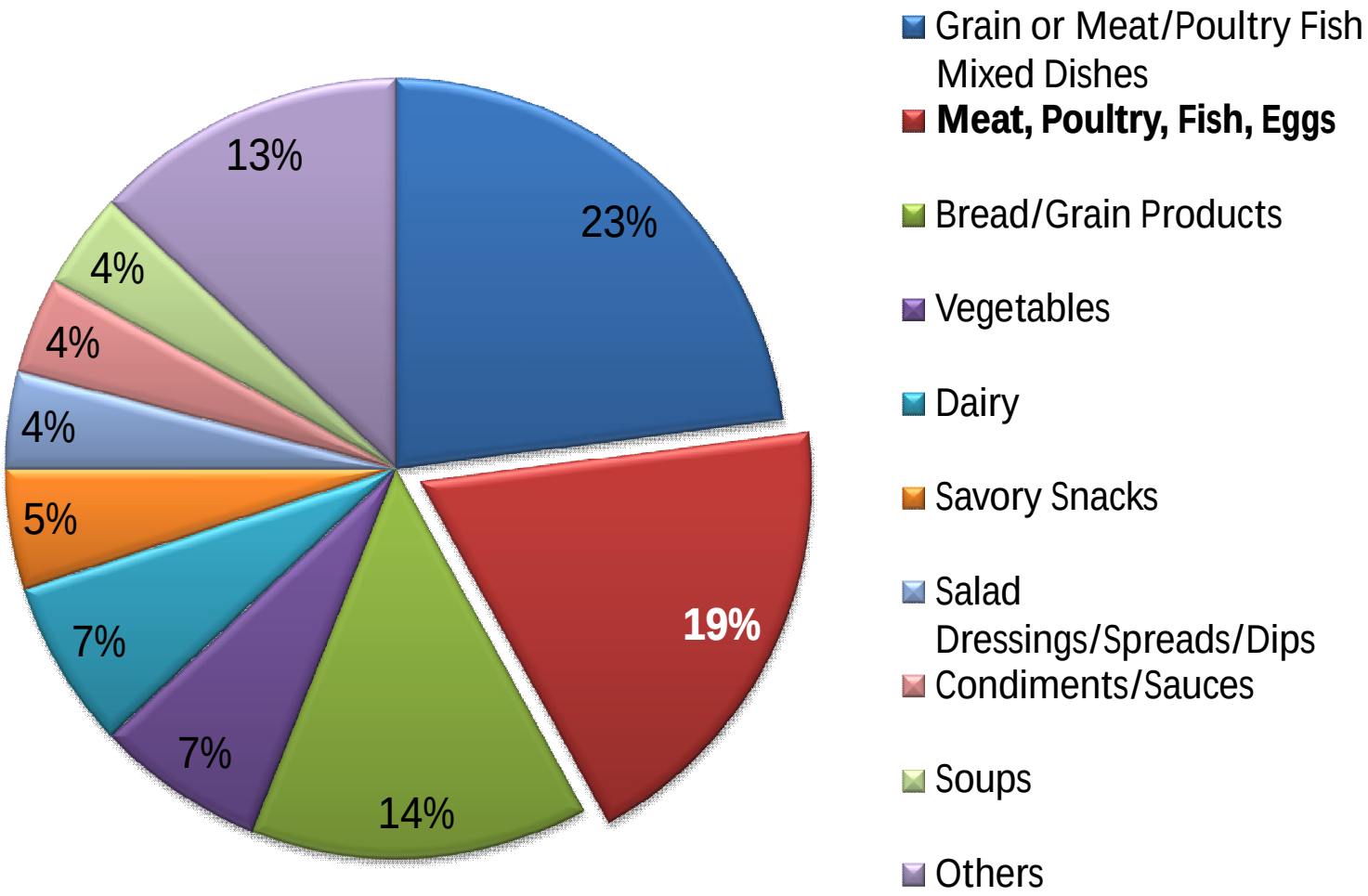
To significantly lower Sodium without compromising:

1. Product Eating Quality
2. Competitive Price
3. Healthy Profit Margins

IV. Food Contributors to Sodium Intake

III. Food Contributors to Sodium Intake

United States, 2007-2008*



* 75% of total intake; does not include sodium from salt added in the home during food preparation or at the table, estimated at 20% of total intake

Source: *What We Eat in America*, NHANES 2007-2008, Day 1 dietary intake weighted.

United States, 2007-2008*

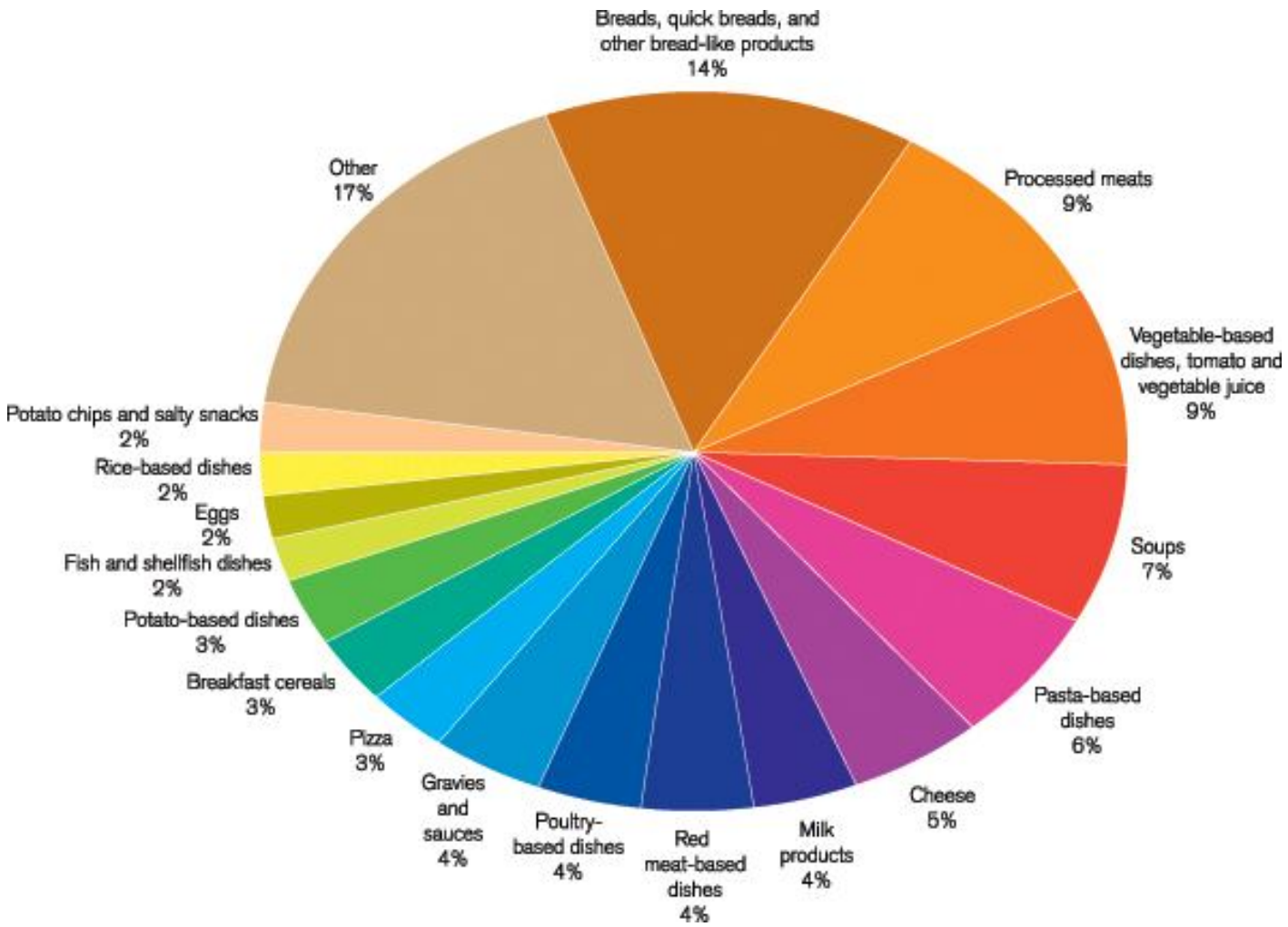
Meat, Poultry, Fish, Eggs

	% of Category	% of Total Diet
TOTAL	**100**	**19**
Deli/Cured Meats Ham, luncheon meats, frankfurters, bacon, sausage	47	9
Poultry Fried/baked chicken, patties, nuggets, turkey, duck	21	4
Meats Beef, pork, lamb, game	11	2
Fish/Seafood Finfish and shellfish, cakes, salads	11	2
Eggs/Egg Dishes Scrambled/fried, omelets, quiches, soufflés	11	2

Source: *What We Eat in America*, NHANES 2007-2008, Day 1 dietary intake weighted.

IV. Food Contributors to Sodium Intake

Canada, 2004



Source: *Sodium Reduction Strategy for Canada* (2010) [Data from: CCHS 2.2 (Fischer PWF, Vigneault M, Huang R, Arvaniti K, Roach P (2009). Sodium food sources in the Canadian diet. *Appl Physiol Nutr Metab* 34:884-92)]

V. Sodium in Processed Meats

V. Sodium in Processed Meats

Primary Sources

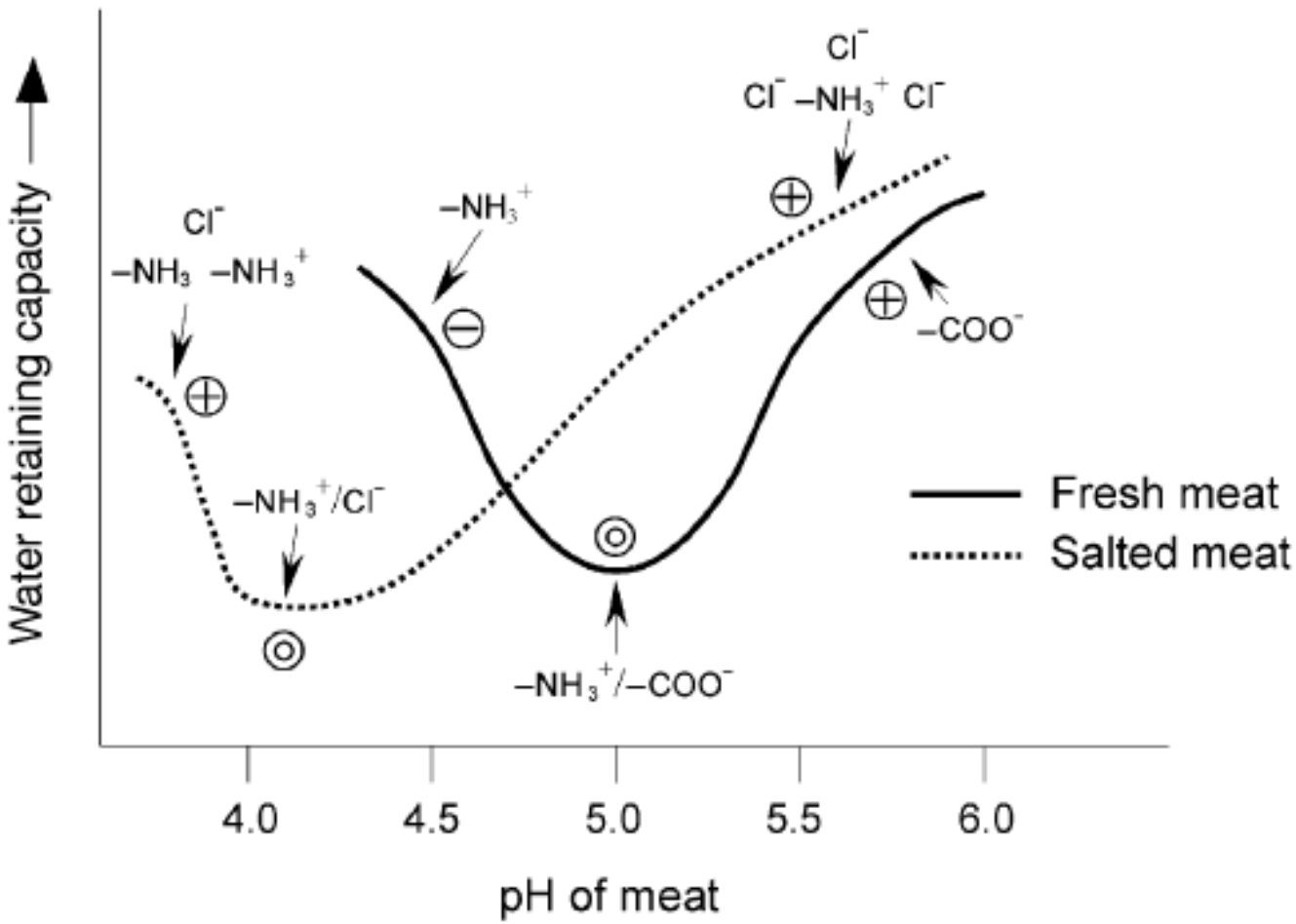
Ingredient	Function	Na content, %	Usage level, %	Na contribution, mg/100 g
Sodium chloride	Water and fat binding Preservation Safety Flavor	39.3	1.0–2.5	393–983
Sodium lactate	Safety Preservation	20.5	1.0–2.5	205–513
Sodium tripolyphosphate	Water binding and holding	31.2	0.20–0.50	62–156
Meat	Endogenous content	0.07–0.08	50-280	35–224
Sodium ascorbate/erythorbate	Cure accelerator	11.6	0.30–0.55	35–64
Sodium diacetate	Safety	16.2	0.05–0.20	8–32
Sodium nitrite	Safety Preservation Flavor	33.3	0.006–0.019	2–6
Water, softened (15 grain hardness)	Formula water	0.012	0–30	3.6

Salt, sodium lactate and sodium phosphates account for approximately 90% of the sodium content of most processed meat products.

Salt - Functions

- Solubilization of myofibrillar proteins
  - Allow proteins to bind water and fat.
  - ~4% is required for efficient extraction and solubilization.
- Increase of water holding capacity
  - Lowers isoelectric point (pI) from ~pH 5.1 to ~pH 4.0, increasing repulsion between protein chains in the pH range of 5.6-6.3 and causing a corresponding increase in water holding capacity.
- Flavor enhancement
  - In general, consumers tolerate up to ~2% salt.
- Antimicrobial activity
  - Retards microbial growth, increasing shelf life and improving food safety.

Salt - Effect on Water Holding Capacity



Source: Xiong YL (2004). Muscle proteins. In Yada RY (Ed.), *Proteins in food processing*. Cambridge, England: Woodhead Publishing.

Sodium Phosphates - Types

- Alkaline
  - Sodium (STPP) or potassium tripolyphosphate (KTPP)
  - Sodium (SHMP) or potassium (KHMP) hexametaphosphate
  - Disodium (DSP) or dipotassium (DKP) phosphate
  - Sodium (SPP) or potassium (KPP) pyrophosphate
- Acidic
  - Sodium (SAPP) or potassium (KAPP) acid pyrophosphate
  - Monosodium (MSP) or monopotassium (MKP) phosphate

Sodium Phosphates - Functions

- pH control
  - Alkaline phosphates raise meat pH (~0.2-0.3 units) and move it further away from the isoelectric point, thus increasing WHC.
- Protein extraction
  - Dissociate actomyosin complex, thus freeing myosin for emulsification and making more room for water.
- Chelation and sequestration
  - Bind divalent cations (e.g., Fe^{+2}; Ca^{+2}; Mg^{+2}), thereby reducing oxidative rancidity.
- Acceleration of the curing reaction
  - Acidic phosphates accelerate the reaction of nitrite and myoglobin to form nitrosomyoglobin (cured pink pigment).

Sodium Lactate - Functions

- Control of *Listeria monocytogenes*
  - Inhibits bacterial growth, primarily *Listeria monocytogenes.*
    - Effect is listeriostatic, not listericidal.
  - More effective in combination with sodium diacetate.
  - *Listeria monocytogenes* is the most important pathogen in ready-to-eat processed meat products because:
    - It can grow at refrigeration temperatures.
    - It tolerates high salt concentrations.
    - Listeriosis can be a serious, life-threatening infection, especially for those most susceptible (infants, unborn, elderly, immunocompromised).

Functional Contributions of Major Sodium Sources

	Quality Attribute				
	Texture	Yield	Taste/Flavor	Preservation	Food Safety
Sodium chloride	X	X	X	X	X
Sodium lactate			X	X	X
Sodium phosphates	X	X			

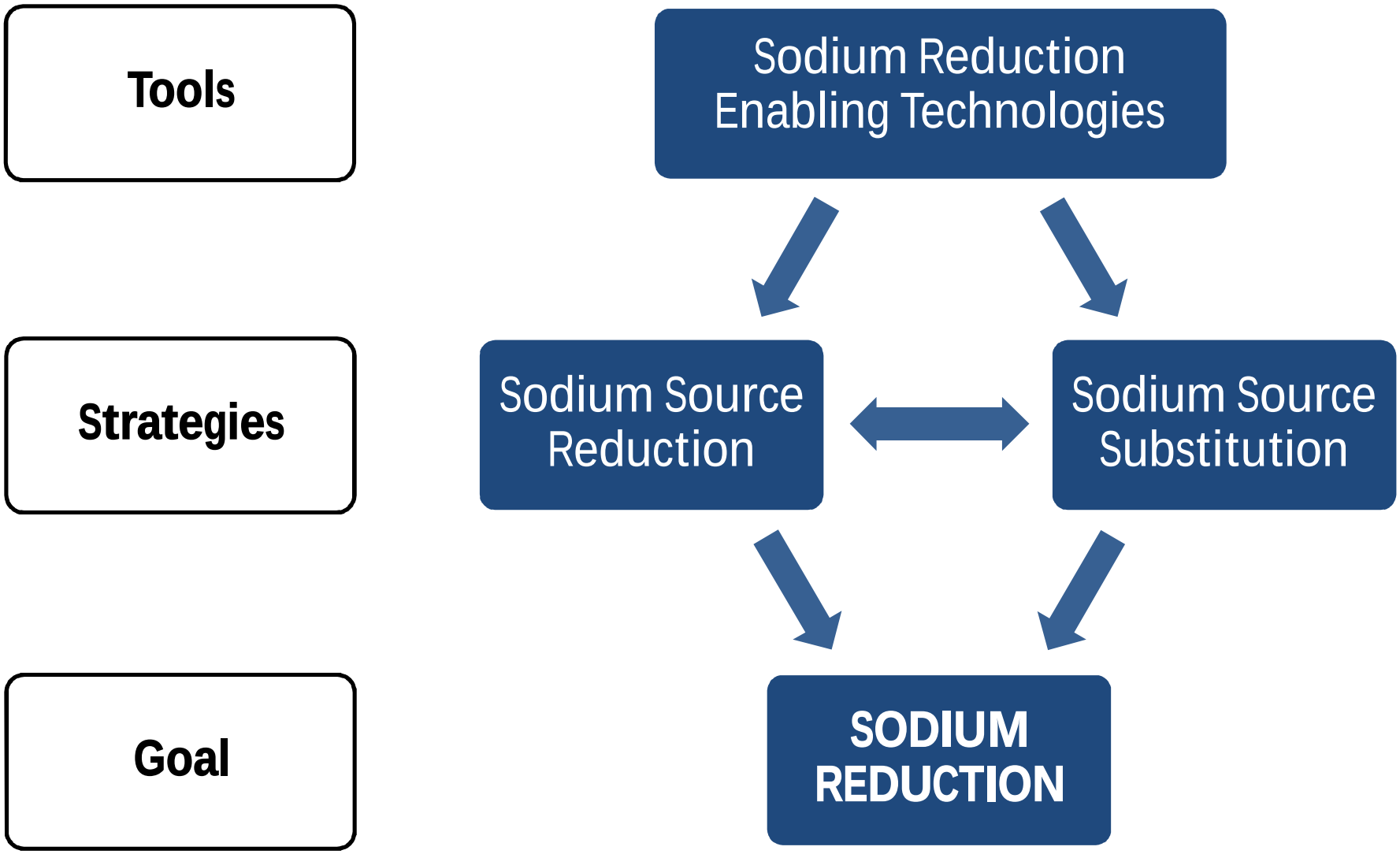
Due to it's multi-functional nature, a true replacement for NaCl has not been found. Therefore, replacement efforts generally require a multi-technology approach.

VI. Technological Alternatives for Sodium Reduction in Processed Meats

Primary Technical Considerations of Sodium Reduction

- Cost
  - Salt is inexpensive, so most sodium reduction strategies will likely result in increased product costs.
  - Lower sodium products, and their supporting technologies, are costly to develop.
- Commercial Risk
  - Consumers tend to associate “low or reduced sodium” with “low or reduced flavor.”
  - Some sodium reduction alternatives may not be label-friendly.
- Regulations
  - Regulations may not permit the use of certain ingredients.
- Research Funding
  - Lack of public funding for food-based sodium reduction solutions; much of the science has been undertaken by private industry.

Technological Strategic Framework



Sodium Reduction Enabling Technologies

- Fat and Water Binding
- Sodium Source Substitution
- Taste/Flavor Enhancement
- Taste Modification
- Salt Crystal Modification
- Alternative Antimicrobials
- Non-ingredient Approaches

Sodium Reduction Enabling Technologies

- Fat and Water Binding
  - Principle
    - Removal of salt reduces the fat/water binding and emulsification capacity of the meat system, thus negatively impacting texture and yield.
    - Addition of binder ingredients can help recover some of this lost functionality.
  - Examples
    - Starches, proteins, gums, emulsifiers, enzymes .

Sodium Reduction Enabling Technologies

- Sodium Source Substitution
  - Principle
    - In meat systems, negative ions (Cl^-, phosphate, lactate) are more functionally important than positive ions (Na^+, K^+).
    - Therefore, salts that contain lower sodium, or that contain potassium or other cations instead of sodium, should provide equivalent functionality, although this should be validated.
  - Examples
    - Potassium chloride (KCl) to replace NaCl
    - Lower-sodium sea salts to replace NaCl
    - Potassium lactate to replace sodium lactate

Sodium Reduction Enabling Technologies

- A Note on Potassium
  - In U.S., Adequate Intake (AI) of potassium for people >14 years old is 4,700 mg/day.
  - In a significant subset of the population, excessive potassium intake (>4,700 mg/day) can result in hyperkalemia (elevated serum potassium), which can lead to arrhythmia.
  - At greatest risk for hyperkalemia are individuals with impaired urinary potassium excretion, such as those with type 1 diabetes, chronic kidney disease, severe heart failure, adrenal insufficiency, and those who are on drugs that increase serum potassium levels.
  - As a result, U.S. Institute of Medicine has called for vigilance of the increasing use of KCl as a salt substitute and for systematic tracking, monitoring, and possible mitigation, of its use in foods.
  - U.K. Food Standards Agency (FSA) and Department of Heath advise against the use of potassium-based ingredients to replace salt.

Sodium Reduction Enabling Technologies

- Taste/Flavor Enhancement
  - Principle
    - Taste enhancers are substances that, while not possessing a pronounced taste in and of themselves, increase the intensity of how the salty taste is perceived.
    - Taste enhancers work by activating receptors in the tongue and mouth.
    - Many taste enhancers possess umami (savory) taste characteristics.

Sodium Reduction Enabling Technologies

- Taste/Flavor Enhancement
  - Examples
    - Glutamates
      - Enhance salty taste due to their umami properties.
      - e.g., monosodium (or monopotassium) glutamate.
    - Nucleotide-containing ingredients
      - Can act synergistically with other salt substitution ingredients to provide a fuller umami character.
      - e.g., disodium inosinate, disodium guanylate, calcium inosinate, calcium guanylate.
    - Hydrolyzed proteins (meat, soy, corn, etc.)
      - Contain high levels of peptides.
      - Act as flavor enhancers by providing “meaty” and “brothy” notes.

Sodium Reduction Enabling Technologies

- Taste/Flavor Enhancement
  - Examples, cont.
    - Meat stocks and broths.
      - Enhance flavor by contributing “meaty" and “brothy” notes.
    - Yeast products
      - Rich in peptides, nucleotides and glutamic acid.
      - e.g., autolyzed yeast, yeast extract, inactive dry yeast.
    - Soy sauce
      - High in glutamic acid.

Sodium Reduction Enabling Technologies

- Taste Modification
  - Principle
    - Taste modifiers generally act by blocking or activating specific taste receptors, such as those for bitterness, which permits the addition of higher levels of bitter ingredients than would otherwise be possible.
    - Typically added to proprietary salt substitution mixtures.
  - Examples
    - Adenosine monophosphate (AMP)
      - Blocks bitterness by blocking activation of certain sensory receptors.
    - Peptides

Sodium Reduction Enabling Technologies

- Salt Crystal Modification
  - Principle
    - Salt (NaCl, KCl) crystals can be modified by physical and/or chemical means in order to change the way in which they deliver taste (i.e., saltiness, bitterness) while preserving other functional benefits.
  - Examples
    - Soda-Lo (Eminate Ltd.) – restructured NaCl crystals consisting of microscopic hollow balls that deliver intense saltiness. May be better suited for topical applications.
    - Nu-Tek salt (Nu-Tek Salt, LLC) – restructured crystals of KCl with reduced bitter and metallic notes.

Sodium Reduction Enabling Technologies

- Alternative Antimicrobials
  - Principle
    - Alternatives to sodium lactate have been shown to be effective at controlling *L. monocytogenes* and other pathogens.
  - Examples
    - Potassium lactate
      - Use may be limited by bitter and metallic flavor notes.
      - Use may be negated by replacement of NaCl with KCl.
      - May need to be used in conjunction with bitterness masker.
    - Sodium benzoate, calcium propionate, potassium sorbate
      - Used at much lower levels than lactate (0.1–0.3% vs. 2–3%).
      - Effective against *L. monocytogenes* in combination with sodium diacetate.
      - May be more effective in combination than alone.

Sodium Reduction Enabling Technologies

- Alternative Antimicrobials, cont.
  - Examples, cont.
    - Fermentation products (e.g., cultured sugar, cultured dextrose)
      - Mostly proprietary compositions and blends.
      - Antimicrobial effectiveness of each blend should be validated.
    - Lauric arginate
      - Commonly applied topically post-lethality.
  - Note: the effectiveness of alternative antimicrobials must be demonstrated and modeled and/or validated.

Sodium Reduction Enabling Technologies

- Non-ingredient Approaches
  - Post-lethality Interventions
    - Principle
      - Antimicrobial intervention after final packaging can decrease or eliminate need for antimicrobial ingredients, such as sodium lactate.
        - » . . . *as long as package remains unopened or atmospherically intact*
    - Examples
      - Post-package pasteurization
      - High pressure processing (87,000 psi for 3–4 min)
      - Irradiation

Sodium Reduction Enabling Technologies

- Non-ingredient Approaches, cont.
  - Meat Functionality Improvements
    - Principle
      - Processing interventions that result in increased meat protein functionality may allow the use of less salt.
    - Examples
      - Pre-rigor processing
        - » Salting of meat prior to onset of rigor mortis.
        - » Increased water holding capacity due to higher meat pH.
      - Ultra High Pressure
        - » Limited studies have been performed on the effects of high pressure on protein structure and functionality.
        - » More research is needed.

Potential Solutions to Common Technical Challenges

Challenge	Potential Solutions
Reduced water retention and/or emulsification capacity	• KCl • Binders - e.g., starches, proteins, gums, emulsifiers, enzymes • Non-ingredient approaches - e.g., pre-rigor processing
Reduced taste and/or flavor	• Taste/flavor enhancers • Restructured salts • Small step reductions
Potassium-induced bitter, metallic, or chemical taste and flavor notes	• Taste modifiers (bitterness blockers, etc.) • Restructured KCl crystals
Reduced antimicrobial activity	• Increased level of antimicrobials or addition of new antimicrobials - e.g., K lactate, benzoate/propionate/ sorbate, fermentates, lauric arginate • Post-lethality interventions - e.g., high pressure, post-package pasteurization, irradiation

VII. Summary

Putting It Together: Elements of a Na Reduction Strategy

Nutrition	• Define target sodium levels
Quality/Regulatory	• Define desired/acceptable organoleptic quality • Understand labeling implications (ingredients, claims)
Finance	• Define adequate price point • Define desired profit margin • Define cost targets (price vs. margin)
Marketing	• Announced vs. silent reductions • Single or stepwise reductions
Technology	• Select strategic approach • Select appropriate sodium reduction technology(ies)

Agradecimentos

Katherine Oliveira de Matos

Karina Ferreira Takemura

Martina Kostolowicz

The entire staff of SENAI Santa Catarina

MUITO OBRIGADO!