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Nutrition and Quality in Processed Meats: Can They Co-exist?

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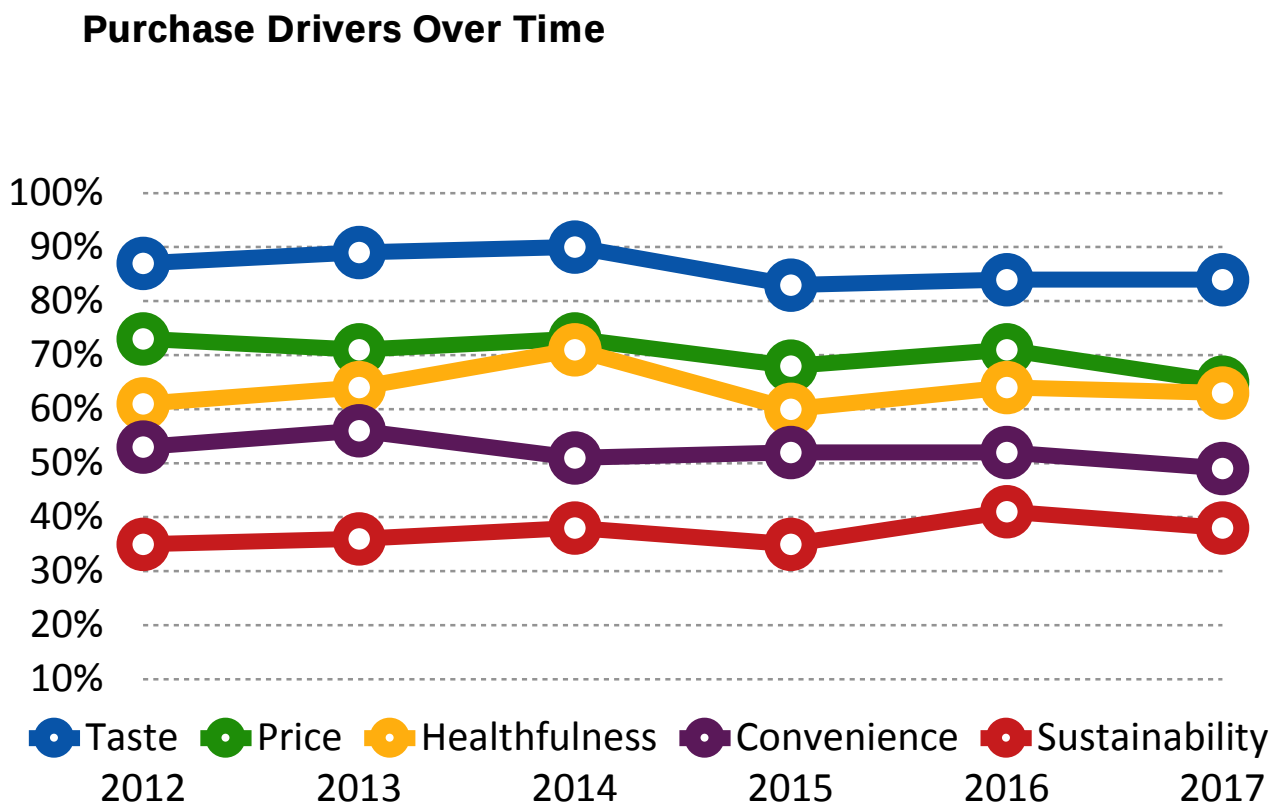
In the U.S., when buying food…it's *still* mostly about Taste, Price, and Healthfulness



84%

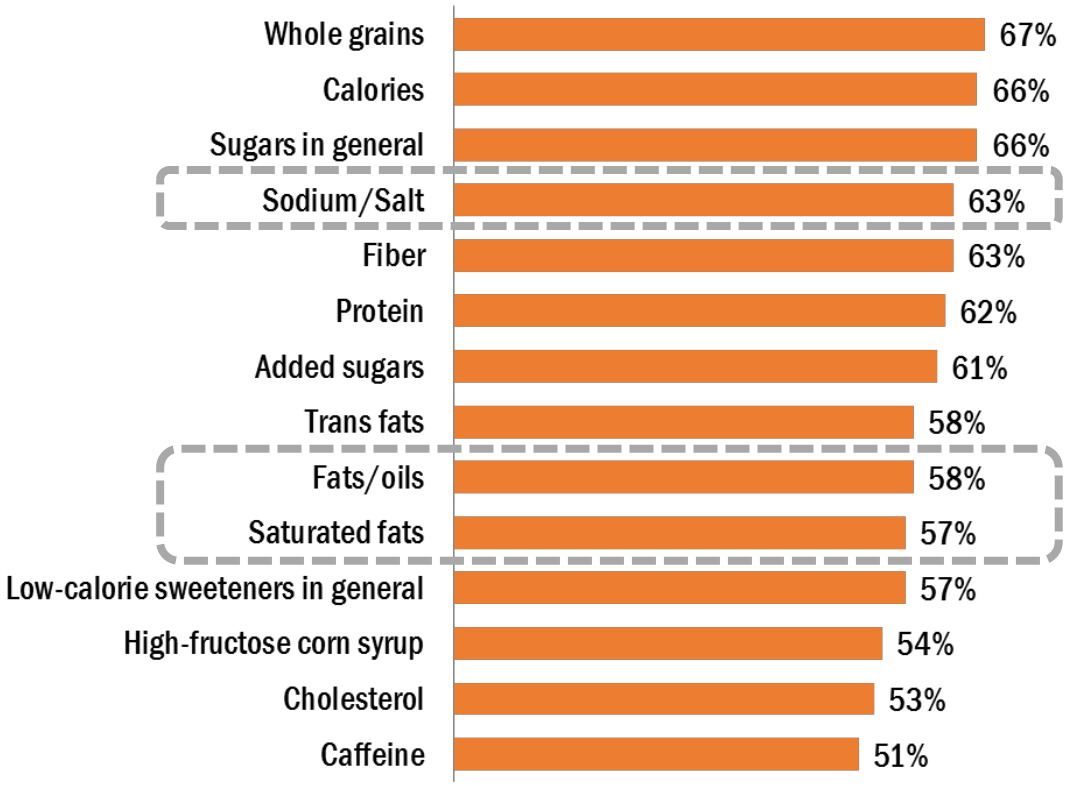
Of consumers say taste is a top (4-5 of 5) driver of purchases. Only 35% say the same for brand

Q: How much of an impact do the following have on your decision to buy foods and beverages? (n=1,002)

Source: International Food Information Council Foundation 2017 Food and Health Survey.

Food components considered by Americans when making purchase decisions

Thinking back about the past twelve months, when making decisions about buying packaged food or beverages, have you ever considered whether or not they contain the following? *(Percent saying Yes.)*



n=1,007

Source: International Food Information Council Foundation 2015 Food and Health Survey.

THE SITUATION

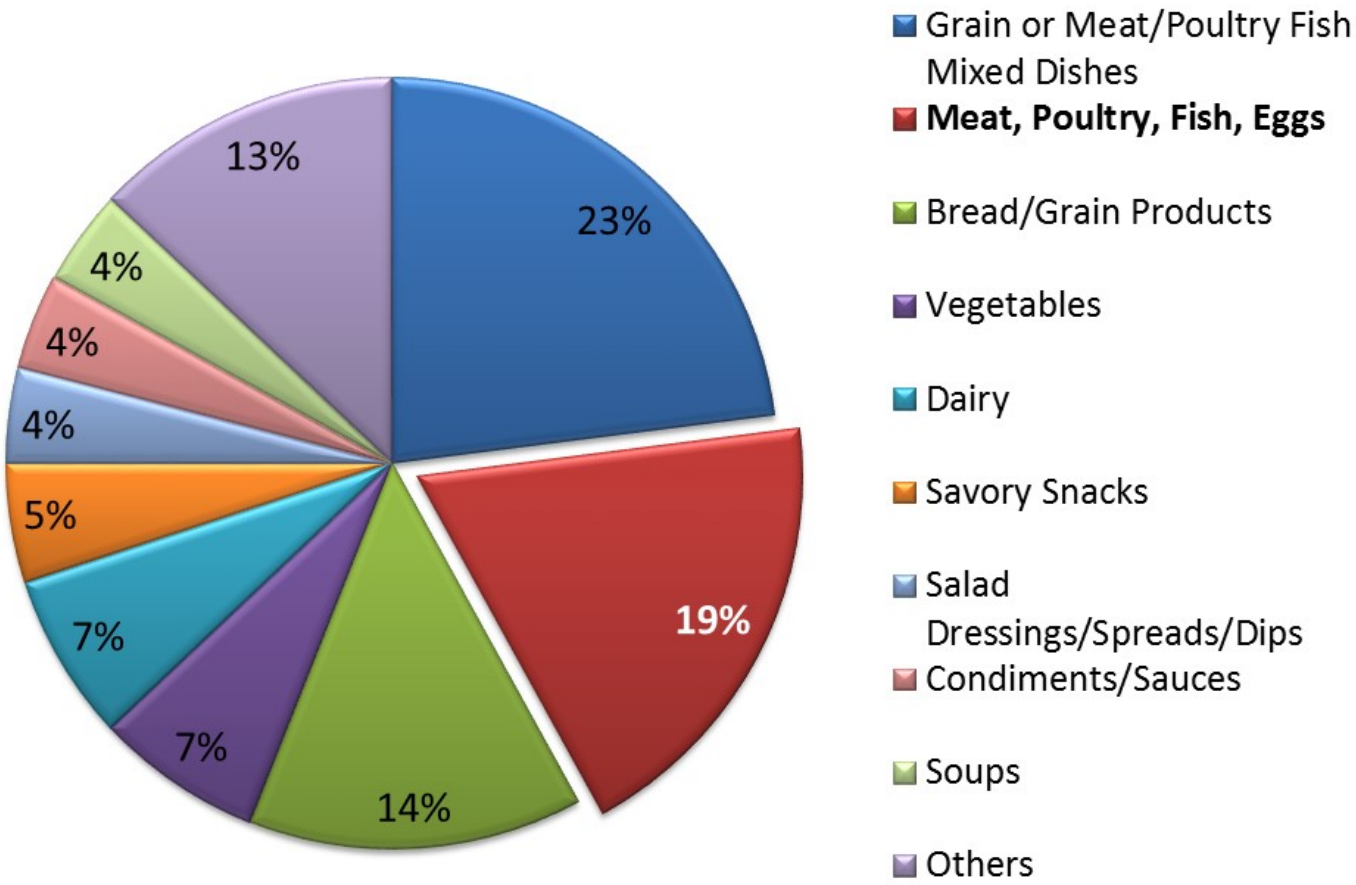
1. **Sodium**
   a. Key component of ingredients that contribute to product flavor; texture; microbial shelf-life and safety; and production yields
   b. Associated with prevalence of hypertension, which can lead to cerebrovascular disease (CVD) (i.e., heart disease and stroke)
2. **Saturated Fat**
   a. Present in all animal fats, which contribute to flavor, texture, appearance and mouthfeel
   b. Associated with increased serum cholesterol levels (C18:0 is an exception), which can lead to cardiovascular disease

THE CHALLENGE

To significantly lower **Sodium** and **Saturated Fat** without compromising:

1. Product Quality and Consumer Liking
   a. Palatability
      - Flavor, texture, appearance, mouthfeel
   b. Safety and shelf-life
2. Competitive Price
3. Healthy Profit Margins

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.

Salt Intake in Various Countries

- Daily intake estimates:

Country	Salt (g/d)	Sodium (mg/d)
Brazil [1]	11	4,323
Argentina [1]	12	4,716
China [2]	9.1	3,580
Chile [1]	9	3,537
United States [1]	8.7	3,419

  - Highly correlated to caloric intake.
- Sodium intake recommendations:
  - WHO[3]: 2,000 mg/d; United States[4]: 2,300 mg/d

[1] Legetic & Campbell, 2011; [2] Hipgrave et al. 2016; [3] WHO, 2013; [4] USDHHS/USDA, 2015

Primary Sources of Sodium in Processed Meats

Ingredient	Function	Na content (%)	Usage (%)	Na contrib. (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

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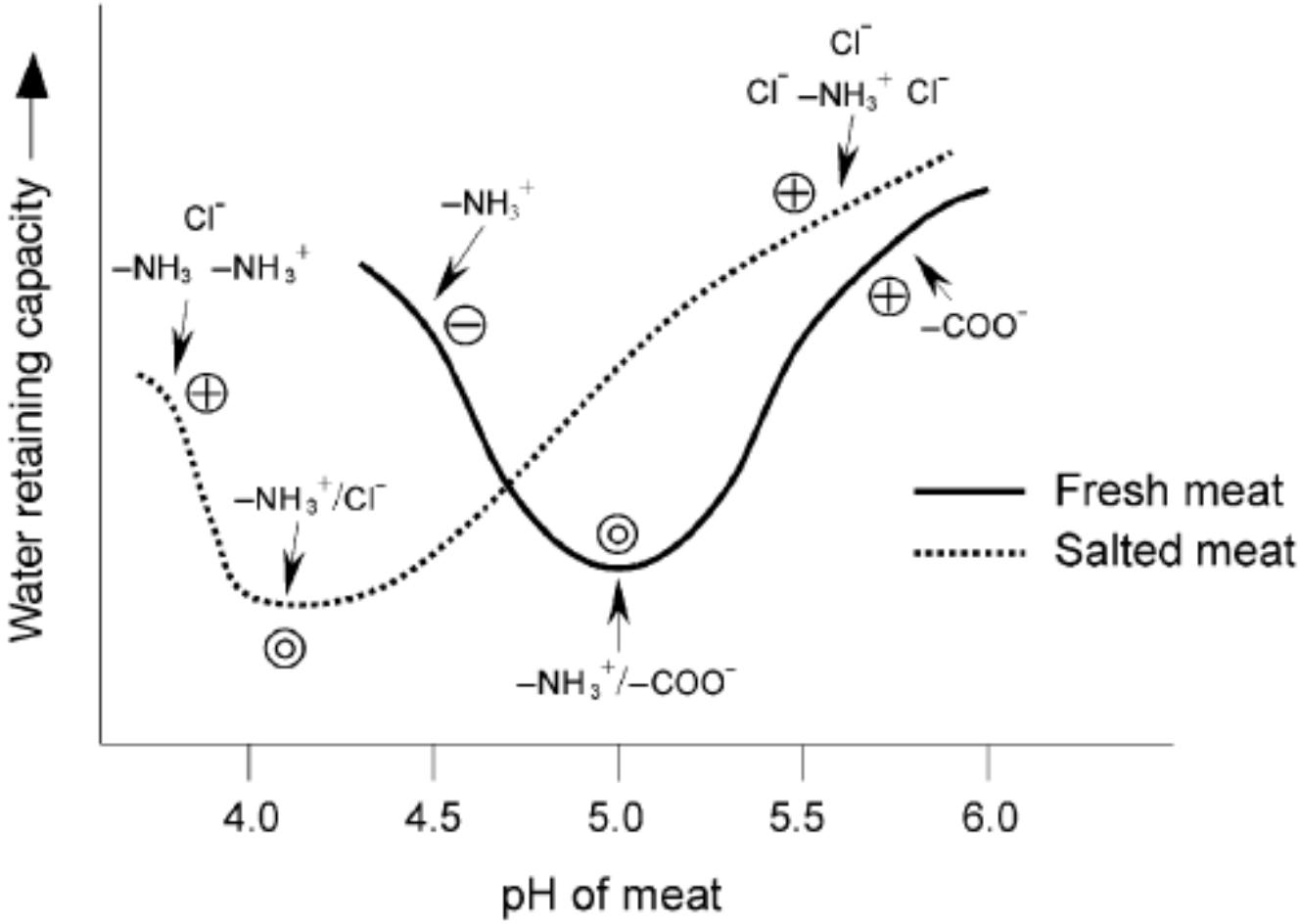
Salt, **Na lactate** and **Na phosphates** account for approx. 90% of Na content of most processed meat products

Functions of Salt in Processed Meats

- **Solubilization of myofibrillar proteins** to facilitate binding of water and fat
- **Increase of water holding capacity** due to pI shift
- **Flavor enhancement**
  - In general, consumers tolerate up to ~2% salt
- **Antimicrobial activity**
  - Retards microbial growth, increasing shelf life and improving food safety

Effect on Salt on Water Holding Capacity of Meat



Source: Xiong, 2014.

Functions of Phosphates in Processed Meats

- **pH modification**
  - Alkaline phosphates raise meat pH (~0.2-0.3 units) and move it further away from pI, thus increasing WHC
- **Meat protein extraction**
  - Dissociate actomyosin complex, freeing myosin for emulsification and making more room for water
- **Metal chelation and sequestration**
  - Bind divalent cations (e.g., Fe^{2+}, Ca^{2+}, Mg^{2+}), which reduces oxidative rancidity
- **Acceleration of the curing reaction**
  - Acidic phosphates accelerate reaction of nitrite and myoglobin to form cured pink pigment
- **Antimicrobial**

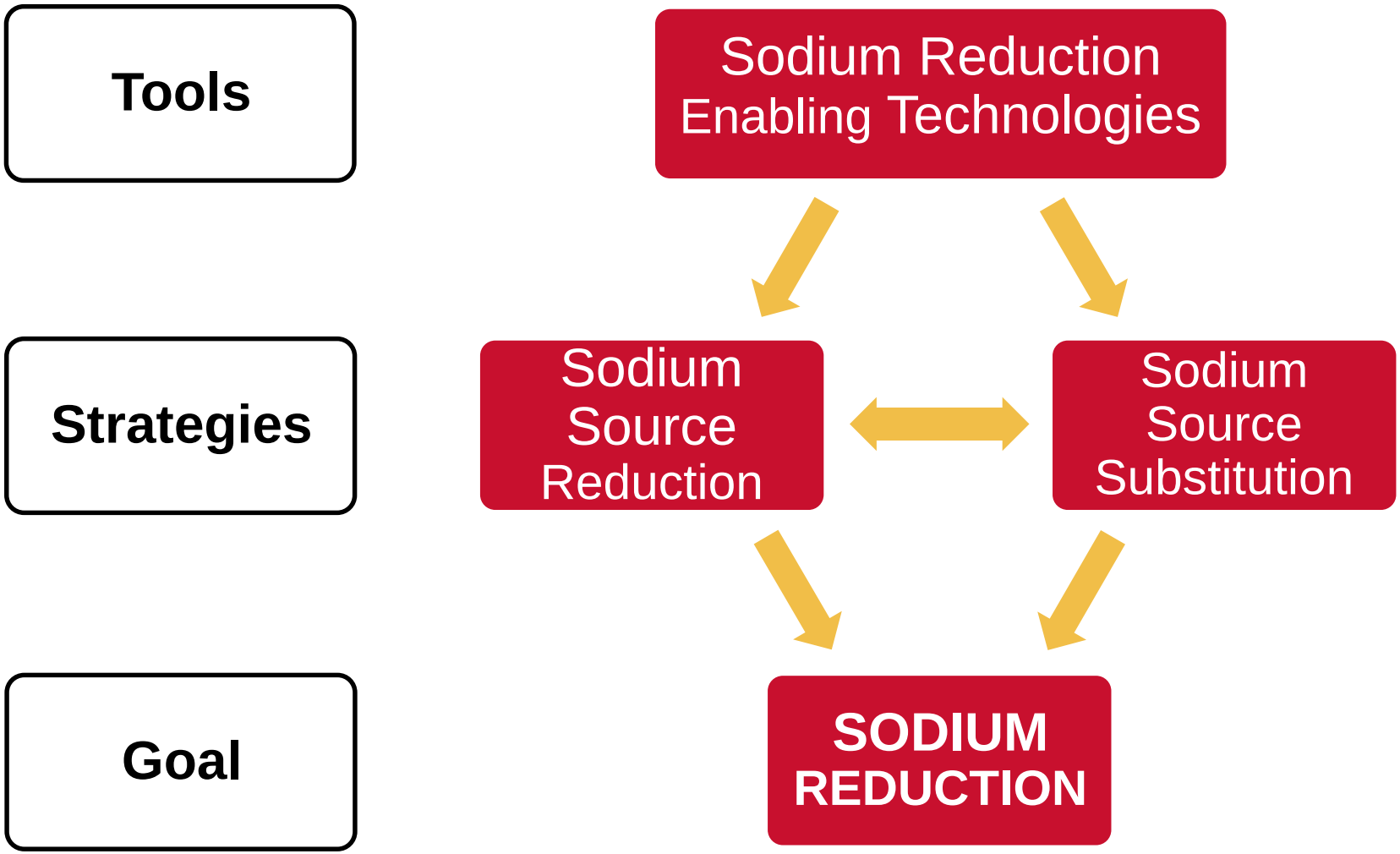
Functions of Lactate in Processed Meats

- Inhibits bacterial growth
  - More effective in combination with sodium diacetate
- Control of *Listeria monocytogenes*
  - *Listeria monocytogenes* is the most important pathogen in ready-to-eat (RTE) processed meat products because:
    - Can grow at refrigeration temperatures
    - Can tolerate high salt concentrations

Primary Challenges of Sodium Reduction

- Cost
  - Salt is inexpensive, so most likely to increase 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 Na reduction alternatives may not be "label-friendly."
- Regulations
  - Regulations may not permit the use of certain ingredients.
- Public Research Funding
  - Limited public funding for food-based Na reduction solutions; much of the science undertaken by private industry.

Technological Strategic Framework



Sodium Reduction Enabling Technologies

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

Sodium Reduction Enabling Technologies

- **Improvement of 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) 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

- **Taste/Flavor Enhancement**
  - Principle
    - Taste enhancers are substances that, while themselves not possessing a pronounced taste, 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, cont.**
  - 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

Sodium Reduction Enabling Technologies

- **Taste/Flavor Enhancement, cont.**
  - Examples, cont.
    - Hydrolyzed proteins (meat, soy, corn, etc.)
      - Contain high levels of peptides
      - Act as flavor enhancers by providing “meaty” and “brothy” notes
    - 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 Reduction Enabling Technologies

- **Alternative Antimicrobials, cont.**
  - Examples, cont.
    - Sodium benzoate, calcium propionate, potassium sorbate
      - Used at 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
    - Fermentates (e.g., cultured sugar, cultured dextrose)
      - Mostly proprietary compositions and blends
    - 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 performed on the effects of high pressure on protein structure and functionality

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

Functions of Fat in Processed Meats

- Flavor
- Texture
- Appearance
- Succulence and Juiciness

Typical Fat Content of Traditional Processed Meats

Product	Fat Content, %
Hot Dogs, Frankfurters	20–30
Chorizo	30–40
Bacon	35–45
Salami	30–40
Ham (pork)	1–10
Turkey Breast	0.5–5

Degrees of Saturation of Animal Fats*

Species	Saturated, %	Mono-unsat., %	Poly-unsat., %	Degree of Saturation
Beef**	45–55	40–50	3–7	↑
Pork**	35–45	40–50	12–15	
Turkey	35–45	25–40	20–35	
Chicken	25–35	37–47	20–30	
Fish	20–30	15–25	50–60	

* Mean values; ranges vary according to anatomical location of the fat

** Stearic acid (C18:0) does not raise serum cholesterol levels. Subtracting this fatty acid, "bad" saturated fats in pork and beef is 25–30%

Alternatives for Fat Reduction

- Removal
- Substitution

Fat Removal

- High reduction levels may result in significant changes in organoleptic quality (flavor, color, texture, appearance, etc.).
- In high-fat (25-40%) products (e.g., hot dogs, chorizo, bologna), reductions of up to ~25% can be accomplished in this manner. Greater reductions may result in lower consumer liking.

Fat Substitution

- e.g., starches, proteins, proprietary technologies
- Better option to achieve greater reductions
- Difficult to replicate the organoleptic properties of fat
- New technology: oleogelation
  - Gel in which continuous phase is liquid oil
  - Mechanical properties similar to solid fat
  - Demonstrated potential for "total" (≈97%) fat replacement in frankfurters (Wolfer et al., 2017)

Summary

- Sodium and fat make **fundamental organoleptic contributions** to many processed meat products.
- Sodium and fat reduction technologies exist.
  - However, research studies and commercial experience show that **a majority of consumers are reluctant** to believe that low-sodium and low-fat products are **organoleptically equivalent to their full-fat counterparts.**
- Therefore, fat reduction strategies must either be done in a **stealth** manner or be accompanied by effective **marketing and communication** strategies.

References

- Hipgrave DB, Chang S, Li X, Wu Y. 2016. Salt and sodium intake in China. J Am Med Assoc. 315:703–705.
- Legetic B, Campbell N. 2011. Reducing salt intake in the Americas: Pan American Health Organization actions. J Health Commun. 16(2 Suppl):37–48.
- Tarté R, editor. 2009. Ingredients in meat products: properties, functionality and applications. New York (NY): Springer Science + Business Media. 419 p.
- [USDHHS/USDA] US Department of Health and Human Services and US Department of Agriculture. 2015. 2015–2020 Dietary Guidelines for Americans. 8th ed. [accessed 2017 April 27]. https://health.gov/dietaryguidelines/2015/guidelines/.
- Wolfer TL, Acevedo NC, Prusa KJ, Sebranek JG, Tarté R. 2017. Potential of rice bran wax and soybean oil oleogels as a pork fat replacement in frankfurters. Manuscript in preparation.
- World Health Organization. 2003. Diet, nutrition and the prevention of chronic diseases. Report of a Joint WHO/FAO Expert Consultation (WHO Technical Report Series, No. 916). Geneva: World Health Organization.
- Xiong YL. 2004. Muscle proteins. In: Yada RY, editor. Proteins in food processing. Cambridge, England: Woodhead Publishing. p. 100–122.

謝謝

Thank You

Gracias

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Merci