Reducing salt in meat products

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Salt reduction

PhD
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Conflict of interests

- Human needs/instincts
  - sweet: energy
  - sour: homeostasis; acid-base balance/spoilage
  - salty: mineral balance
  - bitter: toxic
  - umami: protein
- People want to eat sweet, salty, and umami-tasting foods, repeatedly and as much as possible
- "Fat has no taste receptor", but internal signalling
  - textural and indirect effects
  - pool of flavour precursors
  - CD36 fat transporter (Dransfield, ICoMST 2008)
- If eating is not limited in a long term: fatness, unbalanced nutrition: health problems
Conflict of interests

- Human needs are utilized by the industry
  - fat, salt, sugar is added alone or in combination
  - consumers do instinctly want that
- Health problems/responsibility??
  - science: nutrition
  - health: authorities/industry??/consumers??
  - information and consciousness
    - what do you want that your children eat?
- When to start, when there is a proper time?
  - those who do not, get their products well sold?
- A legal issue, and nutritional guidance as well required
Coronary heart disease mortality, men 35-64 y. Cases/100 000 (WHO)

1970‡
about 70 000+ early deaths less
Of that reduction of blood pressure 15 000-20 000
(Informal calculations/Epu)
The real and predicted CHD mortality by 35-64 men in Finland.
Figure 1 A pie chart to show sources of salt intake from various foods (a total of 76% of daily salt intake) (Henderson et al. 2003 and FSA 2003).
### Sources of sodium (%) in the diet

<table>
<thead>
<tr>
<th>Food sector</th>
<th>Ireland(^1)</th>
<th>UK(^2)</th>
<th>USA(^3)</th>
<th>Finland(^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals and cereal products</td>
<td>35</td>
<td>38</td>
<td>27</td>
<td>35</td>
</tr>
<tr>
<td>Meat &amp; meat products</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>30(^5)</td>
</tr>
<tr>
<td>Soups &amp; sauces</td>
<td>7</td>
<td>13</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Processed vegetables</td>
<td>4</td>
<td>9</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Milk and cream</td>
<td>9</td>
<td>5</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Fish dishes</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

\(^1\)FSAI (2005); \(^2\)SACN (2003); \(^3\)Engström et al. (1997); \(^4\)Findiet 2002; \(^5\)included meat dishes
Salt consumption Europe

2008 Collated information on salt reduction in the EU

From Theo Verkleij, TNO, NL

NPA HLG/2008 28 april
Deaths attributed to leading risk factors

Deaths in Europe 2000

- urban air pollution
- alcohol use
- physical inactivity
- low fruit and vegetable intake
- high body mass index
- use tabacco
- high cholesterol
- high blood pressure

From Theo Verkleij, TNO, NL

World Health Report 2002
Salt in Finnish diet in 2002 and 2007 (Food Balance Studies 2007)
# Meat products as source of sodium

Pearson and Wolzak, 1982

<table>
<thead>
<tr>
<th></th>
<th>Added amount g/kg</th>
<th>Na content %</th>
<th>Na mg/100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Na</td>
<td></td>
<td></td>
<td>5-15</td>
</tr>
<tr>
<td>NaCl</td>
<td>18-30</td>
<td>39.3</td>
<td>707-1178</td>
</tr>
<tr>
<td>Na tripolyphosphate</td>
<td>2.5-5.0</td>
<td>31.2</td>
<td>78-156</td>
</tr>
<tr>
<td>Na ascorbate or erythorbate</td>
<td>0.6</td>
<td>11.6</td>
<td>7</td>
</tr>
<tr>
<td>NaNO₂</td>
<td>0.12</td>
<td>33.2</td>
<td>4</td>
</tr>
<tr>
<td>NaNO₃</td>
<td>0.3</td>
<td>27.1</td>
<td>8</td>
</tr>
<tr>
<td>Monosodium glutamate</td>
<td>1-2</td>
<td>13.6</td>
<td>14-27</td>
</tr>
<tr>
<td>Na lactate</td>
<td>12</td>
<td>24</td>
<td>288</td>
</tr>
</tbody>
</table>
The role of water content in cooked sausage

Water-binding

Firmness and consistency

“Quality”
Basis for osmotic pressure

Myofilaments

Cross-bridges

pH, salts, phosphates

WBC
Positive ions form a "cloud" around the negatively charged myofilament.
Chloride is important for WBC and structure.
Sodium is important for taste.
A) Salt content and water-binding
- $o = \text{no added water}$, $\bullet = 60\% \text{ added water}$. (Hamm 1975).

B) Swelling of a myofibril (Offer 1988).
Mechanism of swelling
(a) before salting
(b) salted myofilament (myosin)
(c) high salt and added water. (Offer & Knight 1988).
1.5 % is critical
Fat moves the curve "to the northwest"
† low fat, low salt challenging!
FIG. 8. Swelling of a myofibril in high concentrations of NaCl. Phase contrast light micrographs of the same rabbit psoas myofibril are shown after irrigation (a) with the preparation buffer at pH 7, (b) to (i) after further successive 3 min irrigations with NaCl at the molar concentrations shown, together with 1 mM MgCl₂ and 10 mM sodium acetate buffer at pH 5.5. The sarcomere length of the myofibril is 2.7 μm. Reproduced by permission of Applied Science Publishers.

Salt only

Offer and Knight 1988

Salt + phosphates

FIG. 9. Swelling of a myofibril in NaCl plus pyrophosphate. The experimental details were as in Fig. 8, but in (b) to (i) 10 mM sodium pyrophosphate was also present in the irrigating solutions. The sarcomere length of the myofibril is 2.5 μm. Reproduced by permission of Applied Science Publishers.
Salt is necessary for sausage structure

With phosphates
The salt content in cooked sausages in Finland 1973-95

Puolanne
The First Finnish Concensus Meeting
Helsinki 1997
The effect of pH on the water-binding capacity of meat. (Hamm1972)
Fig. 3. The effect of pH and salt content on water-holding capacity (WHC) in cooked sausage. WOP, without; WP, with added phosphate.

Puolanne et al. 2001
Figure 3. The effect of ionic strength and pH on water-binding in sausage. Black line indicates the estimated course of pH-ionic strength in fermented sausage during ripening (Puolanne ja Peltonen, in preparation). In practice ca 3% NaCl.
Examples of salt substitutes: each row has the same sodium content

<table>
<thead>
<tr>
<th>NaCl, %</th>
<th>PANSalt®, %</th>
<th>Biosal, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.75</td>
<td>1.52</td>
</tr>
<tr>
<td>1.2</td>
<td>2.11</td>
<td>1.82</td>
</tr>
<tr>
<td>1.5</td>
<td>2.63</td>
<td>2.27</td>
</tr>
<tr>
<td>1.8</td>
<td>3.16</td>
<td>2.73</td>
</tr>
<tr>
<td>2.1</td>
<td>3.68</td>
<td>3.18</td>
</tr>
</tbody>
</table>

PANSalt®: 57% NaCl, 28% KCl, 12% MgCl$_2$, 2% Lysine-HCL
Biosal: 66% NaCl, 31% KCl, 3% protein hydrolysate etc

Sodium reduction is not the same as salt reduction!
Technological aspects

- Sausages, hams
- Fermented products
- Prepared foods
Cooked sausage

- without phosphate to 1.1 % NaCl (technologically)
- with phosphate 1.0 % (basic K-phosphate)
- problems of purge and/or grainy structure may arise
- in low salt products the phosphate is more important
- added water and/or fat maybe should be reduced (price!)
- with salt mixtures, easy to achieve
- soy protein, carrageenan, potato flour
- microbial safety is not relevantly changed (i.e. is perishable anyway!)
- at <1.3 -1.4 % NaCl typical flavour is lost!!!
- conclusion: total sodium max. 500 mg Na/100g can be reached!
- the same NaCl level does not necessarily apply to every population
(Sausage) formulation

- Prepare concentrated industrial foods
  - use extenders in moderation
  - usually increase the amount of salt, sugar and fat
  - again, conflict of interest
    - extending usually lowers the price/ kg
    - efficiency will be reduced
      - nutritionally, pricewise and environmentally
      - the consumer actually looses (and the producer wins?)
  - sensory effects?
  - easy to eat? 2 g salt
  - Extender effect 4 g salt + others
  - problem of changed food systems and eating patterns
  - preferably dense foods even with more sodium than large quantities of foods with low sodium content
  - "Enhanced" products!!!
    - brine injection to traditional meat foods!
Cooked ham

- without phosphate to 1.4 % NaCl
- with phosphate 1.3 % (basic K-phosphate)
- problems of purge and/or grainy structure may arise
- added water maybe should be reduced (price!)
- with salt mixtures, easy to achieve
- soy protein, carrageenan
- microbial safety is not relevantly changed (i.e. is perishable anyway!)
- at 1.4 – 1.6 % NaCl, typical flavour is lost!!!
- conclusion: total sodium max. 600 mg Na/100g can be reached!
Cooked hamburger

- consumers prefer 1.1-1.3 % NaCl
- when lowering, problems of purge and/or grainy structure may arise
- added water maybe should be reduced (price!)
- with salt mixtures, easy to achieve
- soy protein, carrageenan, potato flakes
- microbial safety is not relevantly changed (i.e. is perishable anyway!)
- lowering to 0.7 % possible (300 mg Na/100 g)
NaCl content of commercial meat balls in Finland (Ruusunen, unpublished)
Fermented sausages

- So many types and technologies!
- When real fermentation is used, 2.2% NaCl seems to be the lowest level
  - Quality?
  - Microbial safety?
- In ready product the level is about 4%
- Salt mixtures have been studied, and used as well
  - IRTA: 50% NaCL can be replaced with KCl
- The relevance of should be evaluated on the basis of consumption data
Microbiology and safety
Our results on keepability

In cooked sausage
- 1.1% NaCl/ 1.7% NaCl / 1.9% PanSalt (57% NaCl + 28% KCl + 12% MgCl₂ + 2% LysineHCL)
  - no relevant differences were seen
  - lower level showed, however, somewhat lower keepability at longer keeping times
  - pathogenic bacteria were not tested

In cooked ham
- 1.4 and 1.7% NaCl, 2.1% Biosal (66% NaCl, 31% KCl, 3% protein hydrolysate etc.)
  - no systematic differences
  - in 1.4% NaCl after longer keeping time: off-flavours more than in others

The main concern is the after-process-contamination.
Perceived saltiness

Taste bud

confocal microscopy

pig

rat

Epithelium

Support Cells

Pore

Taste cells

Without courtesy of Eric Dransfield or U of Copenhagen
Perceived saltiness

- Perceived saltiness: salt ions must be simultaneously in salt taste cells
  - only the salt in saliva tastes salty
  - saliva salt level is a reference when less salt is used in diet, less salt will be perceived salty
  - detection threshold, recognition threshold, just noticeable difference, terminal threshold, all vary from product to product
  - salt influences other aspects than taste only, and they in turn affect the taste and flavour (e.g. consistency, water-binding, the binding of aroma compounds to the matrix)

- Meat proteins bind salt less perceived saltiness
Loosely bound sodium and chloride?

Positive ions form a "cloud" around the negatively charged myofilament.
Chloride is important for WBC and structure.
Sodium is important for taste.
Perceived saltiness of meat patties containing different amount of fat and lean meat

This is a significant message!
THE EFFECT OF FAT CONTENT ON THE PERCEIVED SALTINESS OF ‘BOLOGNA-TYPE’ COOKED SAUSAGES

Fat content varied by replacing lean pork with pork fat

This is a significant message!
THE EFFECT OF FAT CONTENT ON THE PERCEIVED SALTINESS OF BOLOGNA-TYPE COOKED SAUSAGES
Fat content varied by replacing water with pork fat

![Graph showing the effect of fat content on perceived saltiness](image)

- This is a significant message!
Timing of salting

With the on-plate salting a salt reduction of 30-40 % for beef and 50-60 % for pork can be achieved. Similar reduction will be in prepared foods.
Concluding, perceived saltiness

- Meat proteins bind salt ‡ less perceived saltiness
- When salt added on plate, the salt does not penetrate into the meat ‡ food will be perceived more salty
  - beef steak ‡ ca. 40% reduction
  - pork chops ‡ ca 60% reduction

- Do not use salt at all into the food during the preparation!
  - check where it is possible (in most ready-to-eat foods)
  - do not listen to your mother or a cook!
  - one gram, on plate, is enough for a whole meal!!!
  - insert a one-gram bag of salt with the food!, i.e. let the consumer decide, how much salt will be enough!!!
  - in most cases the keepability is not a problem
Reduction

- Most simple: cut first the highest contents
- General reduction slowlier
- Recognize the development!
- When lower levels turn more usual, higher values may offer a commercial advantage!
Policy?
Policy?
**Finnish "reduced salt" claim**

<table>
<thead>
<tr>
<th>Food category</th>
<th>Highly salty (g salt per 100g)</th>
<th>Reduced salt (&gt;25% less salt than normal product, all max levels salt per 100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh bread</td>
<td>&gt; 1.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Crisp bread</td>
<td>&gt; 1.6</td>
<td>1.2</td>
</tr>
<tr>
<td>Cheese</td>
<td>&gt; 1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Sausage (cooked and raw)</td>
<td>&gt; 1.7</td>
<td>1.3 [★]</td>
</tr>
<tr>
<td>Cold whole meat cuts</td>
<td>&gt; 1.9 [★]</td>
<td>1.4 [★]</td>
</tr>
<tr>
<td>Breakfast cereals</td>
<td>&gt; 1.6</td>
<td>1.2</td>
</tr>
<tr>
<td>Soups, broths, sauces</td>
<td>&gt; 0.9</td>
<td>0.7</td>
</tr>
<tr>
<td>Prepared and semi-prepared foods</td>
<td>&gt; 1.1</td>
<td>0.8</td>
</tr>
</tbody>
</table>
Finnish "reduced salt" claim

- Salt?
- Normal? where?
- Formulation/cooked?
  - a marginal of about 0.2 % required
  - e.g. frankfurter 1.4 % NaCl when prepared (cooking loss, cooling in brine in -6 °C increase the content)
- Low fat/low salt/low sodium?
Concluding remarks

- Technologically a significant reduction in salt contents can be achieved, by using e.g.
  - phosphates
  - (high pH meat)
  - salt substitutes
  - other ingredients: extenders and thickening agents like soya, modified starches, caseinates, etc.
    (amount/content relation must be checked!!!)
  - transglutaminases
  - hydrostatic high pressure
- Technology or shelf life are not particular problems

- But: The taste is the limiting factor
Concluding remarks (cont.)

- Sodium reduction depends on the composition of the meat product
  - Meat products with higher percentage of lean meat need more salt to achieve the same level of perceived saltiness than those with lower percentage
  - Meat products with lower fat content need more salt to achieve the same level of perceived saltiness than those with higher

- The acceptance level must be tested
  - product by product,
  - by consumer segments
  - as well as by nationalities