Comprendre et utiliser la structure des aliments
pour améliorer leurs qualités nutritionnelles et sensorielles

Modulation de perception du salé par reformulation de matrices alimentaires

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Excessive intake of sodium has undesirable effects on health such as hypertension and other diseases such as cancer and osteoporosis...

Consequently, WHO and other health organisms recommended to modern countries to decrease 25% salt content in targeted foods.

Role of salt in processed foods such as cheese; meat products... is complex and multifunctional (technological, preservation, organoleptic)

Many solutions were proposed to decrease salt in foods such as: progressive reduction of salt in foods, substitution (total or partial) by other salts (KCl in particular), use of saltiness enhancers...but most of them imply significant addition of compounds which are not present in the original product

Other proposed solutions:
- Enhance saltiness intensity using aroma perception (cross-modal perceptive interaction)
- Increase heterogeneity in salt distribution (higher contrast in salt concentration)
- Change in the matrix structure and/or composition in order to increase the quantity of salt released in mouth or at least modify the release kinetic
The objective of this presentation is to review a series of results on these 3 strategies: cross modal interactions, heterogeneity of distribution, change in food composition as a mean to enhance salty taste in food.

1- Saltiness enhancement by aroma in water medium
   - saltiness-aroma
   - saltiness-aroma-sourness

2- Salt reduction strategies applied on solid foods
   - Saltiness enhancement by aroma in model cheeses
   - Heterogeneity in stimuli distribution
   - Influence of matrix composition on flavour release and perception

3- Conclusion
Selection of odours evoking salty taste

Experimental

Aroma stimuli names

Bacon
Chicken
Mushroom
Strawberry
Lemon
...

Procedure

Bacon
This food seems you:
Bitter
Sour
Salty
Sweet
0 10

81 consumers

78 food names associated with saltiness and
8 controls not associated with saltiness

Selection of odours evoking salty taste

Differences in expected saltiness were observed and are correlated with actual salt content of food products.
Impact of odours on saltiness enhancement in water solutions

Experimental

30 consumers

Aroma stimuli

15 aroma solutions without or with salt (0.02M)

Procedure

Bacon

Odour*

Bitter

Sour

Salty

Sweet

0

10

* Odour intensity

Impact of odours on saltiness enhancement in water solutions

$OISE (\text{Odour Induced Saltiness Enhancement}) = \text{saltiness [aroma + salt]} - \text{saltiness [salt]}$

Salt associated aroma could enhance saltiness in solutions containing a low level of salt

Impact of odours on saltiness enhancement in water solutions

- Only salt associated aroma could enhance saltiness in solutions containing a low level of salt.

Impact of odours on saltiness enhancement in water solutions

Effect of salt concentration

64 consumers

Aromas
- No
- Sardine
- Carrot

Salt contents
- No
- Salt1: 0.01 M
- Salt2: 0.02 M
- Salt 3: 0.04 M

OISE depends on odour-taste congruency but also clearly on salt concentration (i.e. saltiness intensity). OISE increased significantly for low- or medium-salt content solution when subjects perceived the congruent sardine aroma but OISE was no more significant in case of high saltiness solutions.

Saltiness enhancement by aroma: Combination with other strategies

Ternary mixture


- Solutions containing a mixture of NaCl and KCl were the saltiest (no influence of sardine aroma).
- Mixing NaCl (20 mM) and citric acid did not modify saltiness (/ sample containing salt only).
- Adding sardine aroma led to a significant increase of saltiness in the acid+salt mixture only.
- In all the other solutions (apart from 20 mM NaCl), adding sardine aroma led to a significant increase of saltiness (confirmed by OISE values).
Impact of odours on saltiness enhancement in model cheeses

Experimental

Aroma stimuli

1
370-20

2
370-40

3
440-20

4
440-40

27 consumers

12 flavoured and 4 unflavoured model cheeses with 0.5% salt

Procedure

- Odour intensity
- Taste intensity
  - Sourness
  - Bitterness
  - Saltiness
  - Sweetness
- Congruency of aroma to product
- Texture
  - Firmness
  - Graniness
  - Moistness
- Liking

Salt associated aromas could enhance saltiness in solid foods containing a low level of sodium chloride.

Influence of composition on the size of OISE.

OISE NS in the firmest product.

Impact of odours on saltiness enhancement in model cheeses

**OISE**

Impact of odours on saltiness enhancement in model cheeses

- **OISE seems driven by odour intensity**

- **OISE is NS at higher salt content**
  Higher salty perception inhibits OISE potency

Flavoured products with 0.5% of salt

- Blue Ch. C1
- Blue Ch. C2
- Comté C1
- Comté C2
- Sardine C1
- Sardine C2

Flavoured products with 1% of salt

- Blue Ch. C1
- Blue Ch. C2
- Comté C1
- Comté C2
- Sardine C2

Heterogeneity of stimuli distribution

Stimuli contrast: Experimental

- **Product** composed of four cream-based layers (served at 55°C)
- Same overall salt concentration in each product (0.8%)
- Salt distribution varied among the layers
  - According to 3 levels of heterogeneity
  - According to 3 different spatial distributions

- **Saltiness Evaluation**
  - 102 consumers
    - Not salty
    - Very salty

- **Liking Evaluation**
  - 80 consumers
    - I do not like
    - I like very much

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CARREFOURS DE L'INNOVATION AGRONOMIQUE
Generally, the products are well accepted.

Products perceived as saltier seem less liked.

(Emorine et al, Heterogeneous salt distribution in hot snacks enhances saltiness without loss of acceptability, Food Research International, 2013, 51, 641-647.)
**Heterogeneity of stimuli distribution**

- Odour-induced saltiness enhancement whatever the tastant distribution
- High heterogeneity of salt distribution leads to higher saltiness enhancement as compared to homogeneous distribution

(Emorine et al, in preparation)
Influence of fat content on Na release and perception in model lipoprotein matrices

**Products**: lipoproteic matrices (= model cheeses) 2 fat levels

**5 subjects** selected with different stimulated salivary flow (SF, parafilm test) and masticatory performance (MP, Optosil test).

**Higher salt concentration**: ↗ Fat content ⇣ Cmax

**Low salt conc**: ↗ Fat content ⇣ Imax

Higher salt conc : ↗ Fat content ⇣ Imax

Effect of fat and salt content on aroma release in model cheeses

✓ 3 lipids/protein ratios, 2 salt levels
✓ No syneresis

✓ Cheese with ratio Lipids/Proteins = L28/P20
  ▪ without or with 1% NaCl added (S)

✓ Cheese with ratio Lipids/Proteins = L24/P24
  ▪ without or with 1% NaCl added (S)

✓ Cheese with ratio Lipids/Proteins = L20/P28
  ▪ without or with 1% NaCl added (S)
Effect of fat and salt content on cheeses structure

- **Work at maximal deformation**
  - Firmness increases from high fat to low fat cheeses
  - Firmness decreases with addition of salt

- **Confocal microscopy**
  - Differences in structure:
    - Bigger fat globules (red) in cheeses with salt added

**Boisard et al., The structure and composition of model cheeses influence sodium release and mobility, Food Chemistry, 136, 1070-1078.**
Effect of fat and salt content on aroma release in cheeses

Total area under the curve:
Higher aroma release for high fat and low protein content softer cheese

Effect of salt depend both on aroma and on cheese composition

A2/A1: Released after swallowing/ Release before swallowing
Nonan-2-one, more hydrophobic, More released after swallowing when salt added: effect of droplet size larger which reduces mass transfer
Few effect on the less hydrophobic compound

Oral parameters: number of swallowing events higher when salt added
Higher aroma release for subject with a high number of swallowing events

Effect on perception

- when the salt content ↑, the overall aroma perception intensity and the specific aroma notes ↑;

- when L/P ratio ↓, the overall aroma perception intensity and the specific aroma notes ↓

For salted products, the L20P28 is perceived less salty due to differences in composition.
- OISE could be a very interesting strategy to enhance saltiness perception in liquid and in solid foods with reduced salt content. However, it is dependent on the texture and salt concentration.

- OISE can be used in combination with other strategies developed to compensate salt reduction such as taste-taste interactions, stimuli contrast, change in composition. However, changes in composition influence both aroma and salt release.

- A good solution to efficiency decrease salt content without decrease saltiness could be to combine different solutions such as change in composition until acceptable limits (for technology and acceptability) and to add or favour the formation of aroma notes enhancing significantly saltiness.

- These aspects are developed now in Terifiq FP7 project. (www.terifiq.eu)
Combining Technologies to achieve significant binary Reductions in Sodium, Fat and Sugar content in everyday foods whilst optimizing their nutritional Quality

Improving the Quality of Everyday Food

Using research and technological innovation, TeriFiQ will improve the quality of everyday foods and achieve significant reductions in the levels of salt, fat and sugar, in line with the European Commission’s objective to implement preventative policies to combat emerging nutrition-related pathologies.

- Reduce sodium content (up to 30%) in different cheese types while improving fat quality.
- Reduce levels of fats and sodium (from 30% to 60%) in cooked sausages and dry-fermented sausages.
- Reduce fat and sugar levels in “muffin”-type products (up to 25%).
- Reduce fat levels (up to 50%) in sauces used in ready-to-eat foods.
- Study mechanisms that control in-mouth perception and cross-modal perceptions.

The TeriFiQ consortium comprises 17 European partners with a range of skills and expertise

Non-SME Partners: Research and Management
INRA (FR), ACTIA – ACTILAIT – ADIV – ITERG (FR)
WUR (NL) – NOFIMA (NO) – IFR (UK) – IT (FR)

SME Partners: Research, Consumer studies and Upscaling reformulated food
NIZO (NL), CENTIV (DE), HERVE SOCIETE (BE), MILBA (NO), ADRIA Dev. (FR), LEIV VIDAR (NO), ORHAL (BE)
CHAZAL (FR), FEDSERV (IT), DOGARO (IT), SATVA (RO)

The first three years will be devoted to research, with technology transfer, including consumer studies and the upscaling of reformulated foods to industrial level, carried out in the final year.

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Please visit our website at www.terifiq.eu for more information about the project
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