Use of innovative methods for the production and valorization of typical dry-cured ham with reduced salt content

Roberta Virgili
“Fa’ che il cibo sia la tua medicina e che la medicina sia il tuo cibo”

MISSION

Research

Cooperation with enterprise associations

Consultancy to public institutions

Dissemination

Training

Private contracts
INDEX OF THE PRESENTATION

- Scenario of salt reduction
  consumers and salt
- Meat products as source of salt
  salt change and maintenance of typical properties
- MIS: an affordable technology to classify hams
  Fat Analyzer™ application before salting
  QMEAT prototype to classify meat quality
- Revision of salting and resting steps to reduce salt
  monitoring of salt uptake
  PROCURED project
- Properties of salt reduced typical dry-cured ham
- Conclusions
19 highly contributed factors to mortality

- High blood pressure
- Tobacco use
- High blood glucose
- Physical inactivity
- Overweight and obesity
- High cholesterol
- Unsafe sex
- Alcohol use
- Childhood underweight
- Indoor smoke from solid fuels
- Unsafe water, sanitation, hygiene
- Low fruit and vegetable intake
- Suboptimal breastfeeding
- Urban outdoor air pollution
- Occupational risks
- Vitamin A deficiency
- Zinc deficiency
- Unsafe health-care injections
- Iron deficiency

Decrease sodium intake is a priority

[WHO: Global Health Risks, 2009]
Salt, main source of sodium

<table>
<thead>
<tr>
<th>Item</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bread</td>
<td>20 – 30 %</td>
</tr>
<tr>
<td>Processed meat products</td>
<td>15 -20 %</td>
</tr>
<tr>
<td>Sauces</td>
<td>5 – 10 %</td>
</tr>
<tr>
<td>Ready-to-eat</td>
<td>5 - 10 %</td>
</tr>
<tr>
<td>Breakfast cereals</td>
<td>3 – 5 %</td>
</tr>
<tr>
<td>Snacks</td>
<td>2 – 4 %</td>
</tr>
</tbody>
</table>
**AVERAGE SALT INTAKE = 9.5 g /day***

Recommended WHO salt intake < 5 g / day

Tertiles of daily salt intake in the general population in a multi-national study*

- **Low intake**
  - 3-5 g

- **Medium intake**
  - 6-12 g

- **High intake**
  - 12-24g

*from Newson et al., Appetite, 2013

Based on an online questionnaire, size 7000 participants from Europe, USA, India, China, South Africa and Brazil
Salt reduction: from contemplation to action*

Pre-contemplation: no intention to change

Contemplation: interested in changing without a commitment

Preparation: intention to change within the next months

Action: modification in salt intake for a defined period

Maintenance: modification of salt intake for a long period

Potential purchasers of salt-reduced products

one third of population

*From Zandstra et al., Food Quality and Preference, 2015
Acceptability of salt reduction in typical dry-cured ham

- Subjects with high hedonic sensitivity to salt dislike salt-reduced taste
- Subjects more interested in health are less interested in typical products
- An antagonism between typicality and innovation is possible
- Salt reduction can match nutritional innovation with typical quality

Model connecting food choices with traditional foods

From Pieniak et al., Appetite 2009
OVERVIEW OF SALT CONTENT IN ITALIAN MEAT PRODUCTS

Adapted from *Salumi Italiani: Nuovi Valori, Nuovo Valore* (2011)
Effect of salt reduction on product characteristics

- Texture changes (e.g. hardness decrease)
- Aroma changes (less volatility of VOCs)
- Increase in proteolysis
- Changes in amino acid pattern
- Increase in aftertastes (e.g. bitter taste)
- Possible microbial changes
- Possible increase in biogenic amines
- Less iodine (sea salt)
- Less oligo-minerals (mine salt)
Less salt in PDO dry-cured ham

- salt reduction (no replacement)
- at least -25% from a reference (nutritional claim)
- reduced salt must comply with tutelary guidelines

\[ \text{min. } \% \text{NaCl} \quad \text{established} \quad \text{reduced } \% \text{NaCl} \quad \text{calculated} \quad \text{reference } \% \text{NaCl} \quad \text{max. } \% \text{NaCl} \quad \text{established} \]

\[ \leq -25\% \]
Salt uptake = f (salting time, ham weight, fat content, …)

After 4 days of salting a few hams have received enough salt to meet -25% salt in final outcome

From: Fulladosa et al., Meat Science 2015
NON-DESTRUCTIVE TECHNIQUES TO PREDICT FAT AND LEAN CONTENT OF FRESH HAMS

**CT**
- *Computed Tomography*
- CT is a X-ray imaging technique mapping tissues of different X-ray attenuation

**US**
- *Ultrasound*
- Ultrasound propagation depends on meat structure, composition, fat and lean content

**MRI**
- *Magnetic Resonance Imaging*
- Differences in proton relaxation times $T1$ and $T2$ are turned into gradient images

Highly reliable expensive devices for research purposes
Magnetic Induction (MIS) principles

Perturbation at selected frequencies of the magnetic field generates current in meat.

Current generated in meat depends from meat impedance and induces a magnetic field and a signal.

Signal is affected by membrane integrity, lipids, extracellular and intracellular fluids and ions.
MIS contactless technology

- Single step scan
- In-line data acquisition
- Tailored for fresh hams
- Automatic weighing
- Reader of bar code
- Temperature probe

Fat-Inspector™
Magnetic Induction Spectroscopy Scanner

1) Signals are related to lean amount and to ion flow in ham
2) Fat/lean content of fresh hams can be predicted (calibration)
3) Fresh hams can be classified before salting
SALT UPTAKE IN «AD LIBITUM» SALTING

trimming line = 20 cm
sea salt grain = 1.5 mm
established cellar conditions

weight = 13.4 ± 0.3 kg
post-mortem time = 48 h
pH_u = 5.6 - 5.9

Model for fatty hams

Model for lean hams

Adapted from: Virgili et al., 59th ICoMST, 2013
To achieve -25% salt a ≈ 40% reduction in added salt was needed. The salting time was reduced from three to two weeks.

1. Salt addition was calculated on lean weight \((predicted)\).
2. Salt addition was calculated on ham weight.

the same variability in final salt
Classification of fresh hams with Multifrequency MIS and VIA

Magnetic Induction Spectroscopy (MIS)
Multifrequencies option (0.08 - 1.12 MHz)

Vision system (CVS)
colour indices L, a, b

Predicted information

Lean amount and meat quality
Multifrequency MIS system

Signals at different frequencies allowed a discrimination among fresh hams based on meat quality
“SMALL” HOMOGENEOUS GROUPS OF FRESH HAMS

Similar attitude to salt uptake within each group of fresh hams
Homogeneous fresh hams
- weight (13-13.5 kg)
- lean content (60-63%)
- fat content (25-30%)

were classified (Discriminant Analysis):
1. high L, high amplitudes (low pHu/WHC)
2. Intermediate values
3. low L, low amplitudes, (normal pHu/WHC)

were salted (3 weeks), dissected and analysed
NON-DESTRUCTIVE TECHNOLOGIES FOR SALT PREDICTION DURING SALTING

Magnetic Resonance Imaging

CT X-ray absorptiometry

Use of Magnetic Resonance Imaging for monitoring Parma dry-cured ham processing
P. Fantazzini, M. Gombia, P. Schembri, N. Simoncini, R. Virgili

X-ray absorptiometry for non-destructive monitoring of the salt uptake in bone-in raw hams during salting
E. Fulladosa, I. Muñoz, X. Serra, J. Arnau, P. Gou
SALT INCREASES IONS IN MUSCLE LIQUIDS

Fresh hams

Salting

End of salting

The increase in ionic current of salted hams increases MIS signals
CALIBRATION MODEL FOR SALTED HAMS
Salt measured with traditional vs MIS method
Control of salting in a fast non-invasive and non-destructive way

\[ R_{adj}^2 = 0.87 \]
\[ SEP = \pm 0.218 \]

Predicted % NaCl = f (MIS signal, lean)

NaCl = 1.6-1.8% -25% salt reference value at the end of salting
Optimization of the salting process for the production of healthier and higher quality dry-cured meat products with reduced and more standardized salt content

The aim
To equip meat processors with an in-line Ham Inspection and Salting Control System to improve the homogeneity of traditional and salt reduced hams

Who is involved?

Project facts
Coordinator: Lenz
Starting: 01-01-2014,
Duration: 24 months
Grant agreement: no 605608
Research for SMEs

 ..........www.procured.eu.........
System’s modules

Computer Vision System

- Lean colour
- Intramuscular fat
- Lean exposed area

Magnetic Induction Spectroscopy scanner

- Lean content (raw ham)
- Absorbed salt (salted ham)
System’s modules

Trained Artificial Neural Network software

Estimated
Ham lean/fat content
Lean colour
Lean exposed area
Intramuscular fat
Absorbed salt (1st salting stage)

Adding salt to ham to achieve a target salt content
Ham Inspection and Salting Control System

- Vision System
- MIS Scanner
- Salting control (ANN)
- Salt Inspection

1. Raw hams testing
2. Salting
3. Salted hams testing
-25% SALT REDUCED DRY-CURED HAM
Resting at low temperature up to $a_w < 0.97$

- Salt distribution and $a_w$ decrease in inner muscles
- Define time needed to decrease $a_w$ to warrant safety
- Define target salt in *Biceps femoris* muscle at resting end

NaCl $\approx 3\%$

Lean hams
Fatty hams

![Graph showing aw values for different resting days at 2 - 4°C]
-25% SALT REDUCED PARMA HAM: first trials

Salting in percentage of weight / 19 months processing time

* dry-cured hams obtained in the same trials and salted with a standard process
Salting in percentage of weight
19 months processing time

<table>
<thead>
<tr>
<th>Biceps femoris</th>
<th>control</th>
<th>Salt reduced</th>
<th>Sig. P</th>
</tr>
</thead>
<tbody>
<tr>
<td>aw</td>
<td>0.891</td>
<td>0.914</td>
<td>**</td>
</tr>
<tr>
<td>pH</td>
<td>5.78</td>
<td>5.91</td>
<td>**</td>
</tr>
<tr>
<td>%moisture</td>
<td>57</td>
<td>58</td>
<td>**</td>
</tr>
</tbody>
</table>

** P<0.01
25% salt Parma Ham: texture and colour

- Instrumental texture
  - Salt reduction resulted in:
    - 10% decrease in red index a*
    - 10% increase in hue angle
    - No differences in L*, b* and chroma
  - Treatment with High Pressure (600 MPa) resulted in:
    - Hardness and force decay recovery
    - Springiness higher than controls
    - Adhesiveness lower than controls

- CIE colour coordinates
  - Salt reduction resulted in:
    - 10% decrease in red index a*
    - 10% increase in hue angle
    - No differences in L*, b* and chroma
-25% salt Parma Ham: sensory properties (descriptive analysis)
Potential success in the market

Consumers interested in health and in typical products will buy salt-reduced dry-cured ham if...

The typical quality is preserved

There is a label informing of salt reduction

New nutritional markers (e.g. antioxidant activity from proteolysis) are claimed
Conclusions

- Salt reduced dry-cured hams should meet nutritional improvement and expected typical quality
- Thanks to new technologies and pilot trials, the salt reduced processing can be implemented without safety hazards
- Further work is needed to lower salt variability
- Further work is needed to counteract excessive proteolysis without depressing antioxidant capacity of selected proteolysis products
- The revised management of the maturation steps could be the next challenge to improve salt reduced dry-cured hams
Aknowledgements

Team

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