WHY THE PHYTOME PROJECT

Consumer studies demonstrate that the consumption of fresh beef and pig meat and of processed meat products in most European countries is stagnating. This can partially be explained by the fact that consumers are sensitive to WCRF (world cancer research fund) and WHO (world health organization) statements:
- Consumption of red meat is linked to the risk of developing colon cancer
- This is partly explained by the exposure to N-Nitroso compounds (NOCs)
- These NOCs can be formed in the gastrointestinal tract when meat products with heme-iron (naturally present in meat) and nitrite (added to processed meat as conservative) is consumed.

WCRF and WHO also report that consumption of vegetables and fruits can reduce the risk of colon cancer, which is explained by the presence of naturally occurring biologically active compounds (called phytochemicals).

COLLABORATION BETWEEN MEAT PROCESSING INDUSTRY AND ACADEMIA

In order to find good answers to the challenges brought forward by these reports and to look for alternative meat processing techniques that include phytochemicals and allow reduced levels of nitrite, meat processing industry has teamed-up with several universities and research institutes in Europe. This resulted in the EU funded PHTYOME project.

OBJECTIVE PHYTOME

The overall objective of this collaboration was to develop new meat processing techniques resulting in the addition of phytochemicals and a considerable reduction of nitrite, that are both microbiologically safe and attractive for consumers and which do not result in exposure of the large intestine to potentially cancer causing NOCs.

SELECTION OF BIOACTIVE PLANT EXTRACTS FOR PHYTOME CONCEPT

In the laboratory human colon cells were cultivated and exposed to NOCs. The exposure results in oxidative stress and DNA damage. Cells were incubated with plant extracts before the exposure in order to examine the effect of plant extracts on DNA damage. Differences in DNA damage were measured by the comet assay as displayed in figure 1.

Figure 1:
The comet assay shows differences in DNA damage. (increasing DNA damage from A to F).

ACHIEVEMENTS

The DNA damage caused by NOCs in cultured human colon cells can be reduced by plant extracts. Based on the findings of this screening, a selection of plant extracts was made for the PHYTOME concept.
MEAT TECHNOLOGY

TYPES OF MEAT PRODUCTS

Six products were chosen to cover a broad spectrum of most popular meat items in Europe. They included dried sausages (2 types), cooked sausages, dried hams (2 types) and cooked hams.

LEVELS OF NITRITE AND POLYPHENOL

Depending on meat items, added nitrites were reduced to a minimum of either 25 mg/kg (North style dry sausages, cooked sausages), 40 mg/kg (cooked hams) or 75 mg/kg (dry hams brine injected) or none (South style dry sausage and dry hams brine vacuum immersed). Fortification with natural red pigments was an aid for colour formation in minimally nitrite added or nitrite-free meats.

PHYTOCHEMICALS

Sourced from plant extracts, the phytochemicals were selected for their antioxidant potential and ability to fit in a meat matrix.

Table 1: Plant extracts used

<table>
<thead>
<tr>
<th>Plant extract</th>
<th>Source of</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polygonum Cuspidatum</td>
<td>Resveratrol</td>
</tr>
<tr>
<td>Sophora Japonica</td>
<td>Quercetin/Rutin</td>
</tr>
<tr>
<td>Green tea</td>
<td>Epigallocatechin Gallate</td>
</tr>
<tr>
<td>AquaROX®</td>
<td>Rosmarinic acid</td>
</tr>
<tr>
<td>Origanox WS LB</td>
<td>Flavonoids</td>
</tr>
<tr>
<td>NutriPhy®White Grape</td>
<td>Proanthocyanidins</td>
</tr>
<tr>
<td>Acerola</td>
<td>Ascorbic acid</td>
</tr>
</tbody>
</table>

Polyphenol amounts up to 2 grams/kg could be incorporated in minced meats, whether dried or cooked. Significantly lower additions (<0.5 grams/kg) were achieved with cooked hams and dried hams as obtained by brine injection. However, vacuum brine immersion enabled greater quantities (1 gram/kg) to be absorbed by dried hams.

ACHIEVEMENTS

- Sensory assessement of colour and flavour revealed lower red intensity and plant aftertaste in meat items with lowest nitrite and largest polyphenol addition respectively.
- Oxidation of processed meat with PHYTOME was limited or negligible, even in nitrite-free products.
- The added polyphenols showed to be stable during processing.


Regarding the meat products with added natural compounds and reduced nitrite (PHYTOME meat products), three consumer studies have been conducted:

1. QUALITATIVE FOCUS GROUP DISCUSSIONS

**Exploration of consumer and stakeholder opinions**
(n = 54 in BE, NL, GE and IT)
- Reactions on the idea of nitrite replacement with phytochemicals were positive
- Despite low levels of awareness, nitrite received a negative health image among consumers, while phytochemicals were perceived as natural and healthy
- Nitrite-replacing agents should fit with the meat matrix and be free of controversy or risk
- Sensory characteristics and proven healthiness were key attributes for acceptance
- Matching perceptions with facts about ingredients emerged as communication challenge

2. QUANTITATIVE CONSUMER ONLINE SURVEY

**Consumer attitude and purchase intention**
(n = 2057 in BE, NL, GE and IT)
- Half of the consumers had heard of nitrite being used in meat products
- Attitudes and purchase intentions towards PHYTOME meat products were generally favourable
- Among the four consumer segments: “enthusiasts”, “accepters”, “half-hearted” and “uninterested”, as attitude is the main driver for purchase intention, “accepters” and “half-hearted” can be the primary targets of interests for communications (figure 3.)

3. CONSUMER ACCEPTANCE AND PREFERENCE

**Consumer acceptance and willingness to pay more. Tested with cooked ham and cooked sausage with and without PHYTOME.**
(n=221 in BE and n =107 in NL)

**Figure 3: Consumer attitude and purchase intention**

<table>
<thead>
<tr>
<th>Attitude</th>
<th>Accepters</th>
<th>Enthusiasts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase intention</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

| Uninterested |
| 1 |

**Figure 4: Consumer preference**

### Overall preference before tasting

- Pref BE: 43% Conventional, 41% PHYTOME, 4% I don’t know
- Pref NL: 38% Conventional, 32% PHYTOME, 4% I don’t know

**Overall preference after tasting**

- Pref BE: 45% Conventional, 15% PHYTOME, 39% I don’t know
- Pref NL: 45% Conventional, 15% PHYTOME, 39% I don’t know

**ACHIEVEMENTS**

- Sensory evaluation indicated apparent differences between the conventional and PHYTOME meat products and the PHYTOME meat products were proven to be acceptable among consumers
- Appearance of the conventional meat products was preferred, but consumers’ preference shifted to the PHYTOME meat products after tasting
- Overall liking of the PHYTOME cooked sausage and of the cooked ham after sensory evaluation were important determinants of consumers’ willingness-to-pay
- Consumers were not willing to pay more than the reference market price of similar conventional products for the PHYTOME meat products
- The consumers studies provide guidelines for successful positioning of the PHYTOME concept.
- The sensory quality of PHYTOME products is positively evaluated.

HEALTH EFFECTS OF PHYTOME MEAT PRODUCTS

The potential health impact of the new meat products was evaluated in a human dietary intervention study with 80 volunteers (male and female, between 18 and 70 years old, with a Body Mass Index of 18-25).

The participants were divided into two different groups and fed different treatments (Figure 1).

Figure 6: Impact of meat types on exposure to NOCs.

![Figure 6: Impact of meat types on exposure to NOCs.](image)

A conventional meat products, normal nitrite
O period with only white meat;
B1 meat products with plant extracts + normal nitrite;
B2 meat products with plant extracts with reduced nitrite;
C drinking water nitrate (7mg/kg BW) combined with one of the 4 meat types;
X sampling moment.
* sampling without colonic tissue collection.

During each of the periods, lasting 14 days, participants received a food package containing meat (300 grams per day per 80 kg body weight). Bottled water, fruits and vegetables were consumed according to a predetermined schedule (based on body weight). After each period, samples were collected from urine, faeces, saliva and colon tissue. Faecal samples were used to measure differences in exposure to NOCs. Colon tissue was used to study molecular changes in biological processes and DNA damage.

KEY FINDINGS OF THE INTERVENTION STUDY

The PHYTOME meat concept make it feasible to reduce exposure to NOCs.


ACHIEVEMENTS

• Bioactive compounds present in the meat products can (fully) reduce the exposure to background levels both with and without reduction of added nitrite.
• Drinking water nitrate stimulates NOC formation in combination with both white and processed meats, but to a lesser extent when the natural extract was added.
• Evaluation of gene expression levels in colonic tissue demonstrate that relevant processes involved in cancer development are modulated differently between the different dietary groups, potentially explaining differences in cancer risk.

OVERALL CONCLUSIONS

• Polyphenols from plant extracts selected for the PHYTOME concept showed to reduce DNA damage caused by NOCs in vitro.
• Innovative meat technologies enable the addition of these plant extracts and the reduction/elimination of nitrite for healthier processed meats. (not meats)
• Implementation of PHYTOME in processed meat can account for 15 - 20 % of the daily intake of polyphenols from vegetables and fruits.
• Meat products with the PHYTOME concept were well accepted as shown in different sensory tests.
• The PHYTOME meat concept make it feasible to reduce exposure to NOCs.
• The PHYTOME concept relevantly influences biologic processes as demonstrated by gene expression techniques.