TeRiFiQ

Project no. 289397

Combining Technologies to achieve significant binary Reductions in Sodium, Fat and Sugar content in everyday foods whilst optimizing their nutritional Quality

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Deliverable D2.1 – Feasibility of multiple emulsions, cryo-crystallised fats and pre-drying technology in sausage production

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Dissemination level	XX
PU Public (must be available on the website)	[X]
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RE Restricted to a group specified by the consortium (including the Commission Services)	[ ]
CO Confidential, only for members of the consortium (including the Commission Services)	[ ]

This short version of the deliverable is public. The full deliverable has been submitted confidentially to the EC.

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Glossary

NaCl	Sodium chloride or Salt
a_W	water activity
KNO_3	Potassium nitrate
$NaNO_2$	Sodium nitrite
SFA	Saturated Fatty Acids
KCl	Potassium chloride
MUFA	MonoUnsaturated Fatty Acids
PUFA	PolyUnsaturated Fatty Acids
DPH	Defatted Product Humidity
RH	Relative Humidity
HGPB	Hygienic Good Practise Book
TPA	Texture Profile Analysis
CFU	Colony Forming Unit
TBARS	ThioBarbituric Acid Reactives Substances
MDA	MalonDiAldehyde
PGPR	Polyglycerol polyricinoleate
WOW	Multiple emulsion (Water-in-Oil-in-Water)

1. Dry Sausages

1.1 Context and objectives

In dry sausages, salt (NaCl) improves protein binding capacity, enhances flavour, and reduces water activity (a_w). a_w reduction is essential, especially during the first steps of the process. With preservatives (KNO_3 or $NaNO_2$), it controls the microbial growth of spoilage or pathogenic bacteria, before the action of lactic bacteria during the fermentation stage. It controls too final a_w of products after drying to achieve a_w values between 0.88 and 0.86, which provides a 60-days shelf-life at ambient temperature. Fat plays a critical role for the flavour, texture and appearance of meat products such as dry fermented sausages. Fat has a large impact on the development of characteristic odour and flavour compounds during fermentation.

In France, in 2009 (Oqali, 2009), the average composition of current dry fermented sausages was 1.82% sodium and 36.4% lipids with 14.6% saturated fatty acids (SFA). That corresponds to 4.6% salt (NaCl) content in dry products. The targets of TeRiFiQ project are to reduce salt and SFA content by 30% and 60% respectively in dry fermented sausages. So, the expected salt and SFA content of dry sausages are 3.2% (1.28% sodium) and 5.84% respectively, with the same drying level as current dry sausages, at the end of the process.

For **fat reduction**, two alternative technologies were applied: fat suppression or fat substitution thanks to cryo-crystallised fat to reach the expected reduction of total and/or saturated fats. Cryo-crystallisation improves functionality of solidified fats giving them physico-chemical properties more similar to higher saturated fats. For **sodium reduction**, three approaches were used to reduce a_w: i) meat pre-drying before meat batter production, ii) dry sausage pre-drying at cold temperature (+8°C) before fermentation stage or iii) addition of chemical molecules with a_w depressor properties (KCl).

1.2 Salt (sodium) reduction: main results

<u>Meat pre-drying technology</u> is a relevant technology even if a maximum 26%-salt reduction is achieved. On current and lean dry sausages, reducing salt content of meat batter from 2.8% to 1.9% requires to reach 10.4% or 14.5% weight loss on raw meat before dry sausage production, respectively. Nevertheless, 2 hazards have to be taken into account when using pre-dried meat: meat pre-drying duration and final water activity of dry sausages after drying. For the first hazard, pre-drying has to be steered quickly (roughly 4 days) in order to avoid *Pseudomonas* growth, but without crust forming on meat surface, in order to lower a_w at meat core and not on surface only. For the second hazard, sufficient weight losses of dry sausages have to be reach especially on lean sausages in order to achieve water activities below 0.92. Generally, water activity of dry sausages with reduced salt content oscillates between 0.910 and 0.920. During, the later phase of the project, it will be essential to assess the shelf life of dry sausages with reduced salt content, especially regarding *Salmonella* and *Staphylococcus aureus* behaviour. Moreover, acidification kinetic of dry sausages made with pre-dried meat seems to be slower. Therefore, formulation (sugars content, type of starter,…) has to be adapted to correct this gap.

<u>Concerning dry sausage pre-drying,</u> a maximum 24%-salt reduction can be achieved. On lean dry sausages, reducing salt content of meat batter from 2.8% to 1.75% requires to reach 16% weight loss on dry sausages before fermentation stage. Nevertheless, as meat pre-drying, dry sausages treated with pre-drying technology, keeps at the end of the

process, higher water activity (roughly 0.912) than current dry sausages (0.88). Therefore, as meat pre-drying technology, it will be essential, during the later phase of the project, to assess the shelf life of dry sausages with reduced salt content, especially regarding *Salmonella* and *Staphylococcus aureus* behaviour.

Finally, NaCl substitution by KCl seems to be a good way to reduce sodium content of dry sausages. 30% substitution (w/w) of NaCl by KCl (1.95% NaCl + 0.8% KCl in raw dry sausage before fermentation stage) has no significant impact on weight losses, pH kinetic or sensory characteristics. Unlike pre-drying technologies, water activities of dry sausages after drying are closer than control (roughly 0.900). But, with this substitution ratio, only 14% sodium reduction is achieved. To achieve the expected 30% reduction, the substitution ratio NaCl/KCl (w/w) must be 60%-40% (w/w). In this case, impacts on sensory characteristics and on water activity evolution of dry sausages during the process will have to be assessed.

To conclude, 3 technologies will be considered for the next steps of the project, especially task 2.4 “process optimisation at pilot scale”:

- meat pre-drying technology to 14.5% weight loss associated with 1.9% addition into meat batter (26%-salt reduction),
- dry sausages pre-drying at +8°C to 16% weight loss before fermentation stage, associated with 1.75% salt addition into the meat batter (24%-salt reduction),
- NaCl substitution by KCl with a substitution ratio of 60/40 (1.65% max. NaCl + 1.15% min. KCl into meat batter to achieve 30%-salt reduction).

For the two first strategies, combination of meat or dry sausage pre-drying with KCl addition will be tested in order to achieve the expected 30%-salt reduction. For dry sausages made with pre-dried meat, formulation corrections (sugars content, type of starter…) will be undertaken in order to get the same acidification profile than controls. For dry sausages pre-dried at cold temperature before fermentation stage, spices formulation will be adapted. Every test will be done on lean sausages in order to achieve sufficient SFA reduction.

1.3 SFA reduction: main results

In order to reduce SFA content without increasing oxidative stability of dry sausages, inclusion tests concerned vegetable fats rich in mono-unsaturated fatty acids (MUFA), as oleic sunflower oil, chosen for tests.

Oleic sunflower oil cryo-crystallization in liquid nitrogen can be well steered. A homogeneous oil powder at -80°C is obtained. Nevertheless, inclusion of this cryo-crystallised vegetable fat into meat batter doesn’t provide good results. After one day of storage at +25°C, 56% of oleic sunflower added into meat batter is released from dry sausages. Therefore, cryo-crystallised oil addition seems to be inappropriate for dry sausage process.
An alternative strategy has been thought up to include vegetable fat sources into meat batters. It consists in including oleic sunflower oil emulsions. Two types of emulsion were done: emulsion with lean meat (8% lipids) and oleic sunflower and emulsion with oleic sunflower oil, water and caseinates. In both cases, results are not satisfying. Dry sausages with oil/meat emulsion have big fissures and holes form into the core of the product after drying. Taste is not pleasant with acid and rancid flavours. Dry sausages made with water/oil/caseinates keep acceptable aspect after drying, but their hardness remains significantly lower than control, from the beginning to the end of the process. From a

sensorial point of view, texture of the product is unpleasant and not cohesive. Fragility of emulsion (lack of structural tissue as collagen in pork backfat) and lack of binding between meat grains due to emulsion inclusions can explain these textural defects. Improving textural properties of dry sausages elaborated with water/oil/caseinates emulsions thanks to alternative technologies seems to be difficult. Finally, use of vegetable fat emulsion into dry sausages in order to decrease SFA content, will not be pursued as inclusion of cryo-crystallised vegetables fat into meat.
Thus, in order to reduce SFA content by 60% into dry sausages, only one strategy will be considered for the next steps of the project: task 2.4 “process optimisation at pilot scale”. Efforts will be focused on reducing pork fat addition into dry sausages. Tests have been done on the occasion of salt reduction study. Using lean pork meat with fat content close to 7%, provides the 60% expected SFA reduction after drying.

2. Cooked sausages

The main aim of this task was to explore the use of multiple emulsions for reduction of fat in cooked sausages.

2.1 Background

Cooked sausages are widely sold in European countries, usually with fat levels of 15 – 25 %. Fat contributes substantially to texture, taste and aroma of the sausages. Different strategies for reducing fat levels in meat products are known, like changing processes and using additives to facilitate products that will not differ too much from the traditional products. Challenges with producing low fat cooked sausages often include firm and dry texture and loss of flavour. In this task, we have worked with multiple emulsions trying to produce cooked low fat sausages with a quality in line with conventional controls without emulsions.

2.2 Approach

The multiple emulsion strategy for cooked sausages is comprised of two main activities; 1) development of different multiple emulsions, and 2) validation of proof-of-concept for sausage production in pilot scale. In conjunction with WP4, formulations and processing strategies for multiple emulsions were developed in collaboration with Institute of Food Research (IFR). For further information about the emulsions, see deliverable D4.1. As the texture of the sausages is harder than for products in WP4, the water droplets should be composed of heat stable gel particles which should add stability and texture to the final product. The emulsions were characterised for stability and structure using microscopy and yield measurements. The structural stability to typical processing conditions was studied to enable development of suitable formulations for pilot scale testing. These strategies were then incorporated in pilot-scale production of cooked sausages to demonstrate their feasibility.

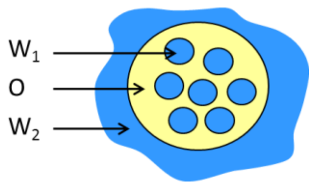

Fig. 1. Multiple water-oil-water (WOW) emulsion containing oil droplets and water droplets within them (drawing from Peter Wilde, IFR).

The work of task T2.1 for cooked sausages involved a stepwise approach: first the production and testing of WOW emulsions with vegetable oil or pork fat, the incorporation and testing of WOW emulsions in hot dog sausages in pilot scale with bowl chopper technology, and finally the testing of the emulsions under small scale industry conditions with microcutter technology.

2.3 Conclusions

Based on the experiments with emulsions, pilot scale sausages and upscale sausages we can conclude that:

- A reduction from 18 to 15 or 12 % fat seems possible without major changes to product quality
- Emulsions with sunflower oil and emulsifier were well emulsified, but may give a slight off-taste in the cooked sausage
- Emulsion with pork leaf fat and emulsifier had a different microstructure than sunflower oil based emulsions, indicating insufficient emulsification, in addition to signs of off-taste
- The microstructure of sausages produced with bowl chopper and microcutter technologies differed slightly, with a more even distribution of particles from the microcutter
- Upscaling the pilot plant tests to a commercial process worked well
- A further reduction of fat below 12 % will require replacing relatively cheap meat raw materials (high in fat) with expensive materials (low in fat), which inevitably will increase recipe costs
- By replacing low fat meat raw materials with emulsions, recipe cost is also bound to increase
- The results of this study indicate that a less firm and more juicy low fat sausage would be beneficial. This can be achieved by lowering the protein content and including water binding ingredients in the recipe
- A sausage with 9 % fat (50 % reduction from typical Norwegian cooked sausages) should be possible, taken into account the considerations above.