Innovative solutions to reduce the use of nitrifiers in cooked meat preparations without affecting food safety andorganoleptic quality

Summary

This project arose out of the concern among companies for the safety and/or risk posed to consumer health by the use of nitrifying salts. The centuries-old use of nitrates and nitrites in meat derived-products has been subject to much controversy for the last 50 years. Currently, while consumer associations and some professionals are pushing government authorities to reduce the total allowable quantity or even ban it, many scientists are studying endogenous metabolism of nitrogen oxides, obtained from protein deamination, and stress that the amount ingested via meat-derived products is proportionally much lower than that produced endogenously, while also assessing its beneficial role as a cardio-regulator and antibacterial agent.

Companies manufacturing cooked meat products must ensure product quality over a very long shelf life (4 to 6 months), in many cases in sliced products. Thus it is essential to continue using nitrite as an additive to ensure safety, as only a part of the added nitrites are present after cooking, and it is necessary for them to remain active throughout the product shelf life, to help maintain quality and microbiological safety.

This project studied the kinetics of nitrifiers in cooked meat products and their antimicrobial effects. From the information obtained, companies will be able to propose new formulations for their products and will better understand how to apply nitrites during the product manufacturing process in order to ensure food safety and prolong its shelf life.

Objectives

The main objectives of this project are to answer the following questions:

- What can be done to prevent the loss of so much functional nitrite during the process? When and how is it added? Whatparameters help preserve its functionality.
- What adjuvants (chemical and technological) enhance the functionality of residual nitrite?

Description of the actions carried out in the project

Actions carried out:

- Meta-analysis of the kinetics of nitrites in cooked meats.
- Testing of chemical and physical alternatives in meat inoculated with *Clostridium sporogenes* (a surrogate of *C. botulinum* accepted in testing).
- Assessment of the organoleptic effects that influence quality and sales. Assessment of the effect of the raw material and of the production process on the residual nitrite and nitrate content and on the sensory characteristics of the product. Comparison of different product cooking methods.

Final results and practical recommendations

Studies on commercial products show that changes in nitrite levels are highly variable and associated with variability in the pH of the food stuffs and manufacturing process. The results show a highly significant reduction in nitrite concentrations in cooked products compared to the amount added to the formulations (range of addition: from 85 ppm to a maximum of 150 ppm $NaNO_2$). Thus, observations show that in the middle and at the end of the useful life of the products, in most cases the nitrite residue is very close to or below the detection limit (LOD = 4 ppm). Furthermore, in all the products studied (extra cooked ham, shoulder ham, turkey breast and bacon), the significant presence of nitrates (not intentionally added to the recipe) is observed in a range between approx. 20 and 40 ppm, partly due to those in fresh pork, those present in drinking water (limit <50 ppm $NaNO_3$ according to current regulations) and, finally, the transformation (oxidation) of nitrite into nitrate due to interaction with components in the brine and the meat matrix.

The results for nitrite kinetics:
- Raw masses with higher meat pH have higher nitrite content.
- In raw masses, the nitrite content decreases and nitrates increase as maceration is prolonged.
- The nitrite content decreases in the cooked product. However, the ratio of higher meat pH to the higher residual content remains.
- In the cooked product, the number of maceration days has no effect in terms of the final nitrifier level.

Significant interactions have been seen between mixture pH, brine pH and ascorbate level.

Lifetime studies show that bacterial growth increases without the presence of nitrites or at low doses. Regarding bacterial counts:
- Both the vegetative cell and spore have higher lethality due to nitrites in aqueous solution than in mixed solution, such as commercial brine (with sodium chloride, ascorbate and polyphosphates).
- Below 90 ppm of added nitrite, meat matrices inoculated with *C. sporogenes* present significant counts after cooking with 2 days of pre-maceration.
- When prior maceration lasts up to 6 days, the counts decrease so that no microorganism presence is detected after cooking.

Regarding physicochemical characteristics:
- The colour persists well up to two months after cooking in hams made with 60 ppm nitrite.
- In nitrite-free hams, the absence of preservatives together with a higher pH in the cuts after cooking would make marketing unfeasible, as the shelf life is very significantly shortened.

Conclusions

This project enabled a detailed study of the kinetics of nitrifiers in cooked meat products and their antimicrobial effects. From the information obtained, companies will be able to propose new formulations for their products and will better understand how to apply nitrites during the product manufacturing process in order to ensure food safety and prolong its shelf life. Given that the products have a very long shelf life (4 to 6 months) and many of them are sliced, it is essential to maintain the addition of nitrite to ensure safety.

Brine preparation

1- The increase in the **ascorbate concentration** in brine facilitates the transformation of nitrite into nitrate in processed brine. The results of the analyses 48 h after production show a decrease in nitrite and an increase in nitrate.

2- **Adding protein** to the brine also significantly affects the nitrifiers present in brine, decreasing nitrite and increasing nitrate.

3- **Brine aeration** by vortex does not show a significant effect on nitrite transformation.

4- The presence of a significant amount of ascorbate in brine without added nitrite does not appear to interfere with nitrite levels as the result of the analysis is below the detection limit.

5- The detection of **residual nitrate in brines** made without the addition of nitrite may be explained mainly by the presence of nitrates in mains water.

Raw material and formulation

6- The **pH of fresh meat** has a significant effect on the nitrite and nitrate content of cooked ham. The lower the pH of fresh meat, the lower the nitrite and nitrate content in the final product. The pH of the raw material also directly affects the pH of the final product and the external visual appearance or colour and the cut, where hams made with higher pH meat are redder.

7- The **pH of brine** significantly affects the nitrite content in cooked ham, with higher nitrite in higher pH brine. The pH of the brine also significantly affects the pH of the final product, but the effect is less than that of the pH of the raw material.

8- A low meat pH decreases the nitrite content in the cooked ham, regardless of the brine pH. Furthermore, the combination of high meat pH and high brine pH results in higher residual nitrite content and also a higher pH for cooked ham.

9- The **level of ascorbate** significantly affects the nitrite and nitrate content of cooked ham. The effect on nitrite content is of a similar magnitude to the effect of brine pH. Higher amounts of ascorbate reduce the nitrite content and increase the nitrate content. The ascorbate level does not affect the pH of the end product.

10- The low meat pH results in lower nitrite and nitrate content, regardless of the level of ascorbate. The combination of high meat pH and low ascorbate level results in the highest residual nitrite content in cooked ham, whereas the combination of high meat pH and a high ascorbate level gives the highest residual nitrate content in the cooked ham.

11- Similarly, the combination of **high pH brine and low ascorbate level** results in the highest residual nitrite content while the combination **high pH brine and high ascorbate level** produces the highest residual nitrate content.

12- Batches of cooked ham made with low pH meat, regardless of the brine pH and ascorbate level, have the lowest residual nitrate content, while cooked ham made with high pH meat, high pH brine and high ascorbate levels have the highest residual nitrate content.

Production process

13- The **maceration time** evaluated (1 day vs 4 days) has a significant effect on nitrite and nitrate content in the raw mixture (decreasing nitrite and increasing nitrate) but not in cooked ham.

14- The addition of part of the nitrite in the brine injection and the rest directly to the drum during the last massage before moulding, increases the nitrite content in the final product, especially in high pH meats, in comparison to the addition of all the nitrite in the injection.

15- In a cooked ham made with whole muscles, the muscles or areas with a higher final pH have higher residual nitrite concentrations than the mean concentration for the sample slice. There would be greater variability within the ham than between the two nitrite addition processes.

Radio-frequency cooking

16- **Radio-frequency (RF) cooking** combined with a conventional final cooking phase in the oven (RF CONV) results in a significantly higher residual nitrite content than **conventional cooking** in the steam oven (CONV) in hams made with 150 ppm of added nitrite, while the differences are not significant in hams with 60 ppm. The higher final nitrite content in RF+CONV hams compared to CONVs may be explained by the shorter heat treatment time of the RF+CONV process (222 min) compared to the duration of conventional cooking (360 min).

17- **Inversion of the location of the cold spots in the ham in the two cooking processes**: the centre of the ham in the conventional cooking and the outer part of the ham in the case of RF+CONV cooking may explain the observed trend in which the nitrite content is slightly higher in the centre with regard to the periphery in conventional cooking, but lower in the centre with respect to the periphery in RF+CONV cooking.

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Subject area(s) of application

☐ Agricultural production system
☐ Agricultural practice
☐ Agricultural equipment and machinery
☐ Livestock farming and animal welfare
☐ Vegetable production and horticulture
☐ Landscape / Territorial management
☐ Pest and disease control
☐ Fertilisation and nutrient management
☐ Soil management
☐ Genetic resources
☐ Forestry
☐ Water management
☐ Climate and Climate Change
☐ Energy management
☐ Waste and by-product management
☐ Biodiversity and environmental management
☒ Food quality/processing and nutrition
☐ Supply chain, marketing and consumption
☐ Competitiveness and agricultural and forestry diversification
☐ General

Geographical area(s) of application

PROVINCE(S)	REGION(S)
GIRONA	GIRONÈS GARROTXA

	LA SELVA

Dissemination of the project (publications, seminars, multimedia, etc.)

News on the INNOVACC website published on 28 November 2017 which gives information on obtaining subsidies for the project, a brief description, the participants, funding and the expected date of completion.
https://www.innovacc.cat/2017/11/28/projectes-presentats-en-la-linia-de-grups-operatius-2017-del-darp/

Project website

https://www.innovacc.cat/2019/02/06/soluciones-innovadoras-para-reducir-el-uso-de-nitrificantes-en-elaborados-carnicos-cocidos-manteniendo-la-seguridad-alimentaria-y-la-calidad-organoleptica/?lang=es

More information on the project

PROJECT DATES	TOTAL BUDGET
Start date (month-year): June 2018	Total budget: €125,002.79
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	Own funding: €35,378.14

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Order ARP/133/2017 of 21 June, approving the regulatory bases for grants for cooperation for innovation by promoting the creation of European Association for Innovation operational groups in the areas of agricultural productivity and sustainability and the execution of innovative pilot projects by those groups, and Resolution ARP/1868/2017, of 20 June, announcing the call for the grant.

Generalitat de Catalunya
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