Improving the quality of meat products with inline optical sensors

Summary

This project was divided into three working groups, all of which worked on the development and validation of inline optical sensors.

Objectives

WP1. Reduction of cooking losses in the manufacture of Frankfurter sausages using an inline optical sensor (EmulsioScan). The aim is to calibrate and validate the proposed optical technology for emulsification control.

WP2. Development of a low cost NIR system to establish: food quality and safety parameters during the curing process of cured raw sausages; physical/chemical parameters for cured raw sausages at different stages in the process.

WP3. Optimisation and improvement of the preparation process for preparing extra cooked ham with an FO-NIRS optical sensor, to obtain a high-quality product with no organoleptic shortcomings and increase cooking and slicing yields.

Description of the actions carried out in the project

WP1.

- Debugging and adjustment of the technology in situ.
- Selection of parameters to create a range of cooking losses, calibration and industrial validation of prediction algorithms.

WP2.

- Identification of the company's meat products most appropriate for NIR control.
- Implementation of the product control procedure during the preparation, sampling and composition parameter analysis process.
- Study of the mathematical models that relate the physical/chemical parameters with the spectra of the product in the various stages and validation of the methodology.

WP3.

- Integration of the FO-NIRS system in the sorting line.
- Characterisation of the raw material with the current methods and with the FO-NIRS system
- Comparative study of raw material selection methods
- Analysis of results, reports and dissemination.

Final results and practical recommendations

The expected results will be the validation of the various technologies developed in each company.

WP1. Reduction of cooking losses in the manufacture of Frankfurter sausages using an inline optical sensor (EmulsioScan). The aim is to calibrate and validate the proposed optical technology for emulsification control.

Calibration and industrial validation tests of the first meat emulsification sensor prototype, optical technology for emulsification control in Frankfurter sausages was carried out successfully directly on the production line at the Argal plant (see Figures).

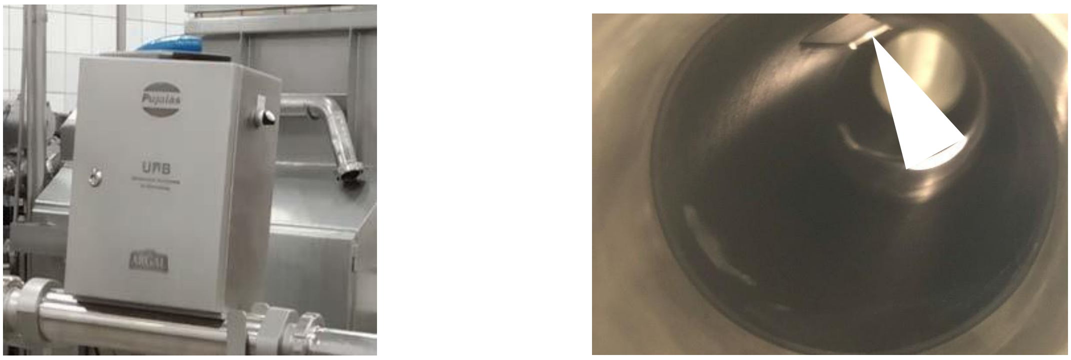

Figure 1. Meat emulsion sensor installed on the Frankfurter sausage production line at the homogenizer outlet

This technology is anticipated to be a paradigm shift in making decisions during processing, as for the first time, it will be possible to estimate the reduction in mass caused by heat treatment objectively and before the cooking stage. Furthermore, the new optical processing technology will improve the monitoring of the product's texture properties, and the homogeneity between batches.

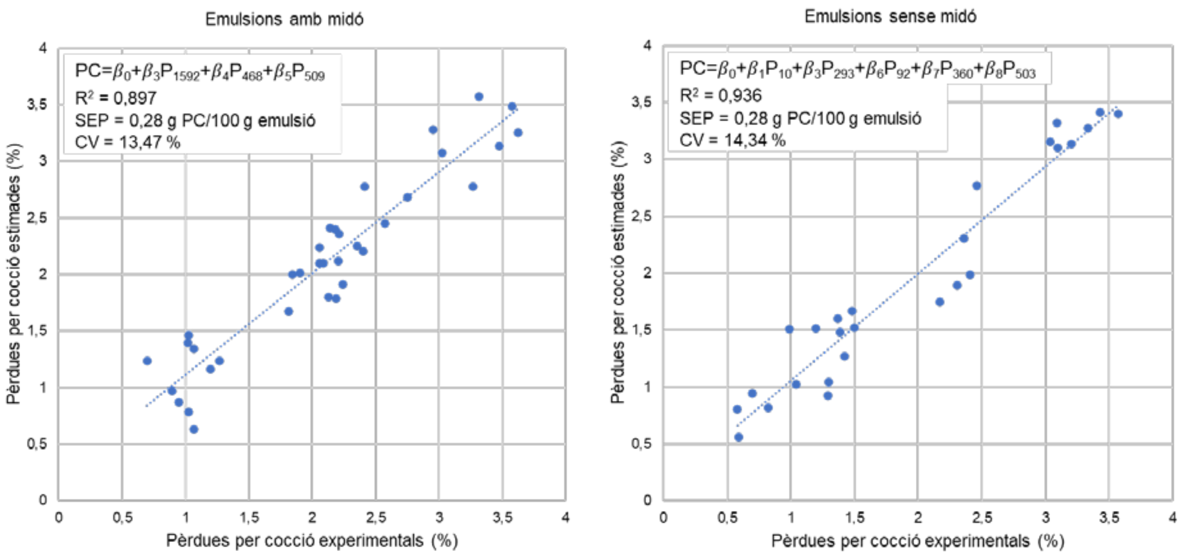

Figure 2. Adjustment of the data to the selected models according to the starch.

Original	**Traducció**
Emulsions amb midó	Emulsions with starch
Emulsió sense midó	Emulsions without starch
Pèrdues per cocció estimables (%)	Estimated cooking losses (%)
Pèrdues per cocció experimentals (%)	Experimental cooking losses (%)
EP = 0.28 g PC/100 g emulsió	EP = 0.28 g PC/100 g emulsion

Thanks to the vast amount of data on formulation and processing conditions used by modern industry, among other information, and the contribution made by artificial intelligence, the spectra collected continuously by the probe have enormous potential as a tool for process control analytics. Precisely for this reason, it is to be anticipated that this technology will also be of interest in the production of other meat and food emulsions and even in other industrial sectors such as pharmaceuticals and cosmetics, exponentially increasing the potential of this innovative technology.

WP2. Development of a low cost NIR system to establish: food quality and safety parameters during the curing process of cured raw sausages; physical/chemical parameters for cured raw sausages at different stages in the process.

Boadas 1880 decided to assess the NIR technology to determine the fat and water content in masses of Llonganissa de Pagès pork sausage and Extra chorizo before the forming stage. At Salgot, the most interesting parameters and product for study were the water activity and water content in Fuet sausages during the drying process.

In the masses of Llonganissa de Pagès pork sausage and Extra chorizo, the variance in the error when determining the parameters of interest was studied depending on whether the spectrum was taken at the outlet of the kneader or after reducing the particle size and homogenising the sample of the mass using a mincer (Figure 1). The results showed that when the mass was collected from the kneader and homogenised by mincing, the prediction error for the parameters of fat and moisture in the dough was reduced (Table 1).

Mass at the kneader outlet

Mass homogenised by mincing

Figure 1. NIR spectrum taken in the mass of the product at the outlet of the kneader after homogenising by mincing.

Table 1. Errors in cross-validation (RMSE) and coefficient of determination (R^2) in the NIR prediction models developed for Llonganissa de Pagès pork sausage and Extra chorizo.

		Sample format	RMSE	R^2
Llonganissa de Pagès pork sausage	Fat, %	Mass	0.888	0.941
		Minced mass	0.443	0.985
	Moisture content, %	Mass	0.782	0.926
	Minced mass	0.425	0.978	
Extra chorizo	Fat, %	Minced mass	0.916	0.945
	Moisture content, %	Minced mass	0.628	0.941

For Fuet sausage, consideration was given to taking the spectrum with static and moving equipment to minimise the effects of particle heterogeneity (fat and lean) on the surface and in the centre of the product. As the reading/scanning area of the NIR equipment is about 2 cm^2 and the particle size of the Fuet sausage is about 4 mm, the area was considered large enough to contain a representative spectrum of the product (including fat and lean particles), and measurement with a static device therefore enabled the spectrum to be taken (Figure 2) and made it more independent of the user. As such, it was deemed a more appropriate method. The predictions of water content and water activity using the models developed show that the margins of error are less than 1% when measuring inside the product (Table 2), and slightly higher when measuring on the surface of the product. A correlation between the water activity measured at the surface and the water activity measured inside the product was also observed (Figure 3). An estimation of the water activity inside the product based on the NIR measurement on the surface is considered feasible as long as the initial product characteristics (composition, diameter, mincing, etc.) and the process conditions (temperature, relative humidity, ventilation) are the same in all of the various production batches measured.

Table 2. Errors in cross-validation (RMSE) and coefficient of determination (R^2) in the NIR prediction models developed for Fuet sausage.

	Sampling area	RMSE	R^2
w_a	Surface	0.0063	0.982
	Inside centre	0.0035	0.982
Moisture content, %	Surface	1,426	0.984
	Inside centre	0.920	0.986

NIR sampling on surface

NIR sampling in interior

Figure 2. NIR sampling on the surface and in the centre of Fuet sausages

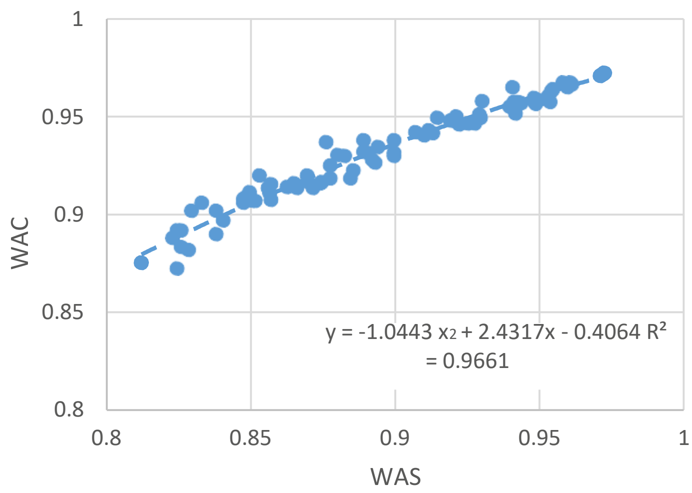

Figure 3. Relationship between water activity determined on the surface of Fuet sausages (WAS) and the water activity determined at the centre of Fuet sausages (WAC).

WP3. Optimisation and improvement of the preparation process for preparing extra cooked ham with an FO-NIRS optical sensor, to obtain a high quality product with no organoleptic shortcomings and increase cooking and slicing yields.

Different batches from 30 hams from each of the above categories were identified and separated during the tests that were carried out. The selection was made using products provided by different suppliers, and in different non-consecutive weeks. A second random selection was made from the product selected in each category. A total of 30 hams from each category were therefore analysed. This analysis was performed on the end product, after it had been cooked. The method used as a benchmark was visual inspection by two expert quality specialists from J. Albertí, who assessed the quality of the ham in terms of its appearance, colour, texture, the presence of defects, water retention and organoleptic properties.

Figure 4. PSE ham

The studies carried out identified a strong incidence of low-quality hams within the group of hams classified as "PSE meat". However, the percentage of defective hams was significantly higher within the "Sour Meat" and "Pale Meat" groups. Meanwhile, the incidence of defective hams in the group classified as RFN was significantly lower than the average incidence.

Conclusions

WP1. Reduction of cooking losses in the manufacture of Frankfurter sausages using an inline optical sensor (EmulsioScan). The aim is to calibrate and validate the proposed optical technology for emulsification control.

Protocols for the use of the software and for the cleaning and maintenance of the equipment were created and validated during the project. No problem was identified when the sensor was used continuously for 1h 30', but the amount of data generated was critical. The models obtained in the calibration which were validated have biases of less than 0.3% of the cooking losses, and in some cases are improvements on previous projects, due to their requiring fewer predictors. However, this project provided a general model that would be suitable for all formulas, regardless of whether or not they contain starch, and even for formulas with raw material from poultry only, which has a different optical response. Finally, a tool was developed to analyse the enormous number of spectra that are generated in-line, which is a necessary step not only for analysing the data generated continuously, but also in situ.

WP2. Development of a low cost NIR system to establish: food quality and safety parameters during the curing process of cured raw sausages; physical/chemical parameters for cured raw sausages at different stages in the process.

The development of a method for predicting physical/chemical parameters such as fat content, moisture and water activity in different matrices of meat products using a low-cost pocket NIR system provided some calibration models with margins of error of less than 1%. In specific terms, the models of moisture and fat obtained are for the masses of meat mixture at the outlet of the kneader and slices of Llonganissa de Pagès pork sausage and Extra chorizo. The models obtained for Fuet sausages are for the determination of water activity and moisture inside the product. Models were also obtained for the prediction of the parameters studied in unminced masses and for the surface of Fuet sausages, although the errors increased slightly. The NIR system used is therefore potentially a useful tool in the industrial environment for determining the quality control and food safety parameters studied.

WP3. Optimisation and improvement of the preparation process for preparing Extra cooked ham with an FO-NIRS optical sensor, to obtain a high quality product with no organoleptic shortcomings and increase cooking and slicing yields.

- The QMEAT inspection system was implemented successfully in the LaSelva cooked ham production line.
- The measurement modules (pH and FONIRS) were shown to operate well throughout the test period, both in functional terms and in terms of accuracy and repeatability
- Industrial validation tests showed the sensitivity of the QMEAT system for discriminating between different categories of meat. In particular, what were in many cases serious defects were found in the pale hams group.
- The implementation of the QMEAT system in production has enabled different product qualities to be established based on objective parameters (pH and PSEINDEX)

The FO-NIRS system ensures a very large percentage of exudative hams are identified. Meanwhile, while it may become a valid system in the in situ classification of boned ham, the sorting system based on the Japanese colour scale has major limitations when this system is applied to the whole piece. In contrast, the FO-NIRS system has been shown to be a valid, reliable and robust method for the classification of ham on reception. In addition, a key advantage of this system lies in the fact that it provides a quantitative, objective, repetitive index which acts independently of the operator. Based on this quantitative parameter, criteria can be established to allocate each piece to the preparation of a specific product quality (whole piece, sliced, etc.), while at the same time ensuring the consistency of the quality of the end product.

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Subject area(s) of application

☒ Food quality/processing and nutrition

Geographical area(s) of application

PROVINCE(S): LLEIDA, BARCELONA, GIRONA

REGION(S): EL PLA D'URGELL, EL GIRONÈS, LA GARROTXA, EL VALLÈS ORIENTAL, EL BARCELONÈS

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

INNOVACC annual magazine 2021, where there is an article on the project.
https://www.innovacc.cat/wp-content/uploads/2021/06/disseny-revista-innovacc-2021_ok.pdf

Project website

https://www.innovacc.cat/2021/08/11/millora-de-la-qualitat-de-productes-carnis-amb-sensors-optics-on-line-3/

More information on the project

PROJECT DATES	TOTAL BUDGET
Starting date: July 2019	Total budget: €212,000.00
End date: September 2021	DARP funding: €86,640.00
Current status: Executed	EU funding: €65,360.00
	Own funding: €60,000.00

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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/1282/2018, of 8 June, announcing the call for the grant.

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