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

Start date of project: 1 January 2012
Duration of project: 4 years
Call: FP7-KBBE-2011-5
Theme: KBBE.2011.2.3-05 [Processed foods with a lower salt, fat and sugar content]
Funding Scheme: Collaborative Project (small or medium-scale focussed research project targeted to SMEs)

Deliverable D2.5

Guideline for production process for nutritionally improved dry fermented sausages

Abstract: *A guideline outlining the newly developed production procedures. This include a summary of the main findings in the WP concerning important factors for production of dry fermented sausages, and also a description of the overall quality, safety, and consumer acceptability of the improved products.*

Due date of deliverable: M48
Actual submission date: M48
Lead contractor/partner for this deliverable: **ACTIA-ADIV**
WP2 Leader: **NOFIMA**
Contributors: **ADIV (Lead), BOADAS**

Dissemination level	**XX**
PU Public (must be available on the website)	[X]
PP Restricted to other programme participants (including the Commission Services)	[ ]
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)	[ ]

Table of Contents

Glossary

aw : water activity

cfu : colony-forming unit

DPH : Deffated Product Humidity

EC : European Commission

HGPB : Hygienic Good Practises Book

KCl : potassium chloride

K5 : Modified KCl

MDA : Malondialdehyde

MUFA : monounsaturated fatty acids

NaCl : sodium chloride

PUFA :polyunsaturated fatty acids

SFA : saturated fatty acids

w : weight

1. Summary

In the previously task 2.1, it was made a screening of the recipes and technologies available to reach a 60% saturated fatty acid reduction and a 30% sodium reduction in French dry sausages. In the tasks 2.4 and 2.5, ADIV and BOADAS have optimized two Spanish dry sausages: the chorizo extra and the snack fuet extra.

First, ADIV demonstrated at pilot scale that the use of fat emulsion and fibers was a good solution to reach the SFA reduction. For salt reduction, the cold predrying during 3 days associated with a 30% substitution of NaCl by KCl or addition of yeast extract associated with 40% salt substitution by KCl were efficient technologies.

Then, Boadas demonstrated at pilot plant and industrial scale that binary reduction in SFA and sodium can be achieved simultaneously.

For snacks of fuet the better tests in terms of texture and taste are with oil and fiber addition + modified KCl + flavor enhancer (yeast extract). 70% of SFA reduction and 35% of salt reduction can be obtained.

For chorizo the better tests in terms of texture and taste are with fat emulsion + modified KCl + natural flavouring. 60% of SFA reduction and 40% of sodium reduction can be obtained.

The sensorial evaluation of these reduced products (performed first by ADIV and Boadas and finally for expert judges and consumers) shows that new formulations are very close to the control and there aren't significant global differences with it.

Finally, we validate the microbial safety of new sausages by the challenge test approach. Cold drying contributes to manage the growth of *Salmonella* during all the process. To avoid *Listeria* growth, attention must be given by increase slightly salt content into the recipe, and/or increase the fat by addition of pork backfat, and/or control weigh losses of sausages (50% minimum).

TeRiFiQ objectives of binary salt and saturated fat reduction in dry sausages have been successfully achieved. BOADAS Company can now market Chorizo extra and Snack fuet extra with the claim "product reduced in salt and saturated fat" according to European regulation.

2. Introduction - Background

2.1 Conclusions from the task 2.1 of feasibility of technologies to reach a salt and saturated fatty acid reductions in dry sausages

In the task 2.1, several tests were conducted with dry sausages to reduce salt (sodium) content by 30% and to reduce saturated fatty acid content by 60 %. The feasibility of recipes and technologies imagined had been validated by assessing nutritional composition of products, physico-chemical characteristics as pH and water activity (aw) which change during the dry sausage process, and microbial quality, particularly the pathogen germs and the spoilage flora.

From these results, we selected the better recipes combined with technologies able to reach the salt and SFA reduction goals in dry fermented sausages in order to optimise the new products at pilot scale through the task 2.4.

2.1.1 Choice of technologies for salt reduction

Three technologies had been chosen to implement the task 2.4 :

- meat pre-drying technology to 14.5% weight loss associated with 1.9% salt 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 w/w (1.65% max. NaCl + 1.15% min. KCl into meat batter to achieve 30% salt-reduction).

In order to achieve the expected 30%-salt reduction, combination of meat or dry sausage pre-drying with KCl addition will be tested. 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.

2.1.2 Choice of technologies for SFA reduction

Only one strategy will be considered in the task 2.4 “process optimisation at pilot scale” because inclusion of cryo-crystallised vegetable fat into meat batter doesn’t provide good results. Thus, the solution choose to reach the 60% expected SFA reduction after drying is the reduction of pork fat addition into dry sausages (use of lean pork meat with fat content close to 7%). Other alternatives were proposed during the experimentations of the task 2.4.

2.2 Approach in tasks 2.4 and 2.5

Dry sausages optimisation was conducted through the two last tasks of the WP 2: the task 2.4 “process optimisation in pilot scale” and the task 2.5 “evaluation of product quality and consumer acceptance”. This involves close collaboration between ADIV (RTD partner) and BOADAS (SME partner) during all the experimentations.

The work on dry sausages had been conducted in 4 steps:

- **PART I and II : Technological tests at pilot scale**

The first step consisted in the choice of dry sausages products to apply the salt and SFA reduction strategies: “Snack fuet extra” and “Chorizo extra”, two representative BOADAS products, were thus considered in task 2.4. The aim for BOADAS is to communicate by nutritional claim on packaging, so nutritional values references for the both products were defined in order to determine the targeted salt and SFA contents that need to reach in optimized products.

At the beginning, it were selected the most suitable fat emulsions type to work in industrial conditions.

So, the experimental plan was designed for the objectives:

1) **Reduction of salt content by 30%** compared to Spanish current products by applying 3 strategies :

   – Partially substitution of NaCl by KCl and masking the bitter tastes by yeast extracts addition as flavour enhancers
   – Using of dried meat as dehydrated pork meat powder
   – Sausage pre-drying at low temperature

2) **Reduction of SFA content by 60%** compared to Spanish current products by applying 3 strategies :

   – Producing lean products
   – Addition of vegetable oil and fibre
   – Using of fat emulsions (pork fat and/or oil / water / animal protein)

From the conclusions of these experimentations, BOADAS began the work of the tasks 2.4 and 2.5 of industrial technological tests (see Part III).

- **PART III : Industrial technological tests and sensory product quality and consumer acceptance**

➢ Snacks of fuet:

Taking in account the results obtained previously for ADIV, the strategies to obtain the binary reduction in SFA and sodium are:

   – Addition of vegetable oil and fibre
   – Using of fat emulsions (pork backfat/oil/water/animal protein)
   – Partially substitution of NaCl by KCl, modified KCl and combinations with flavour enhancers (yeast extract or savory flavor)

➢ Chorizo extra:

Taking in account the results obtained previously in snacks of fuet and in chorizo for ADIV, the initial experimental plan was designed for every objective separately:

1) **Reduction of salt content by 30%** compared to Spanish current products by applying 3 strategies :

   – Partially substitution of NaCl by KCl
   – Partially substitution of NaCl by modified KCl for masking the bitter tastes
   – Combinations between KCl or modified KCl with flavor enhancers (yeast extract or savory flavor) for masking the bitter tastes

2) **Reduction of SFA content by 60%** compared to Spanish current products by applying 2 strategies :

   – Addition of vegetable oil and fibre
   – Using of fat emulsions (pork fat/oil/water/animal protein) with fibers

With the best combination results of both reductions, the strategies to obtain the binary reduction in SFA and sodium were:

- Using of fat emulsions (pork backfat/oil/water/animal protein) with or without fiber
- Partially substitution of NaCl by modified KCl and combinations with flavour enhancers (yeast extract or savory flavor)

At the end, Boadas evaluated the sensory product quality and consumer acceptance of the best reduced formulations for both products.

- **PART IV : Challenge tests**

Finally, ADIV assess microbial status of the best technological strategies of combined salt and fat reduction defined for snacks fuet. The safety of products and process was thus validated.

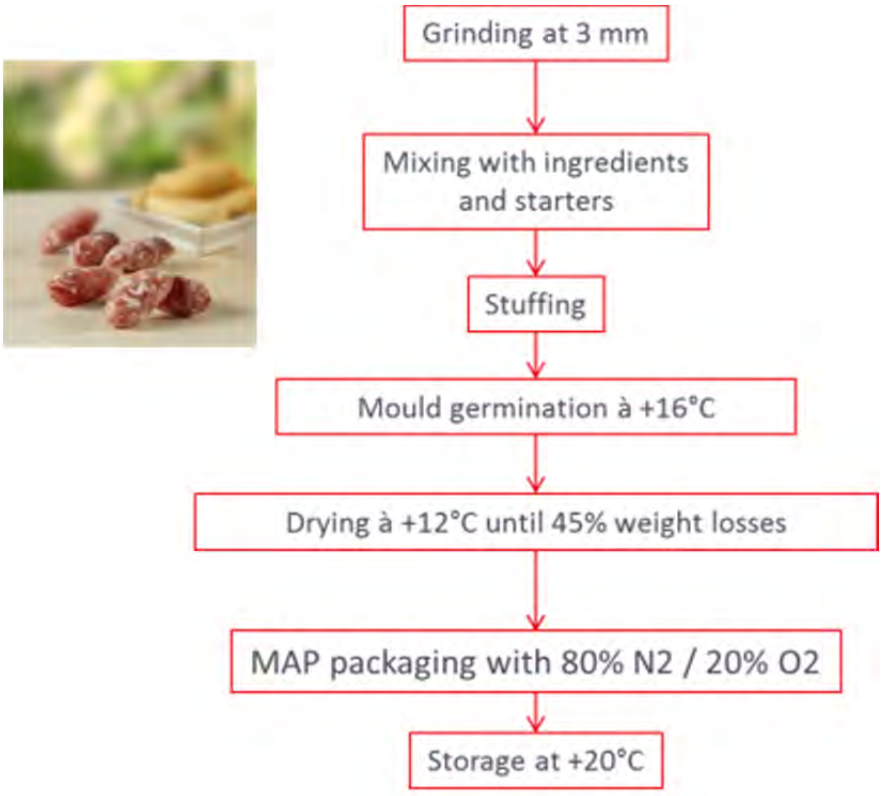
2.3 Description of products currently processed by BOADAS

For the work of tasks 2.4 and 2.5, two kinds of dry sausages manufactured by the SME BOADAS, snack fuet extra and chorizo extra, had been chosen as product models in order to begin the industrial transfer of the results.

2.3.1 Description of Snack fuet extra

The formulation of snack fuet extra comprises lean muscle, fat, salt (23.3 g/kg meat), sugars, potato starch, additives and starters. The simplified manufacture diagram is presented in figure 1. The weight loss reaches 45% at the end of the process, with a water activity of 0.870 and a pH from 5 to 5.2.

Figure 1 : Simplified diagram to manufacture snack fuets extra

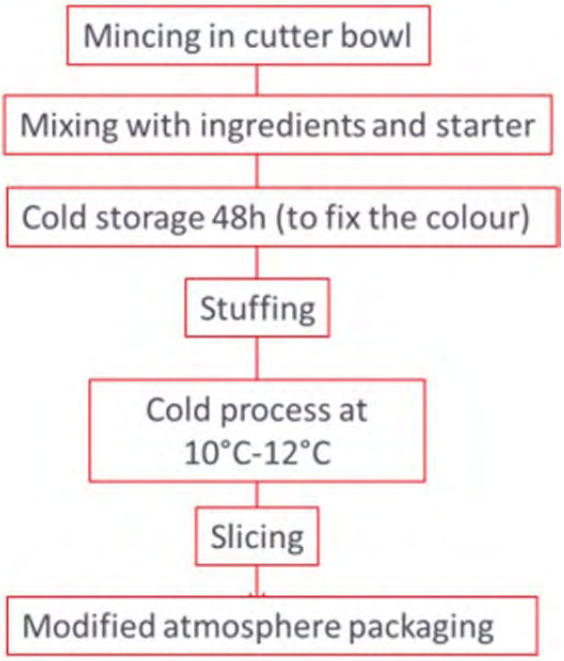


The nutritional composition of Snack fuet extra expressed by 100 g is: 485kcal, 42g of lipids with 16g of SFA, 3.2 g of carbohydrates as 2.5g as sugars, 24g of proteins and 3.5g of salt corresponding to 1.4g of sodium.

2.3.2 Description of Chorizo extra

The formulation of chorizo extra comprises lean muscle, fat to obtain the quality "extra", salt (23 g/kg meat), sugars, dairy and soya proteins, additives and starters. The simplified manufacture diagram is presented in figure 2. The weight loss reaches 28% at the end of the process, with a water activity from 0.91 to 0.918 and a pH of 4.8.

Figure 2: Simplified diagram to manufacture chorizo extra



The nutritional composition of Chorizo extra expressed by 100 g is: 298kcal, 23.1g of lipids with 11g of SFA, 2.1g of carbohydrates, 25.9g of proteins and 3.5g of salt corresponding to 1.4g of sodium.

3. PART I: Industrial Technological tests at pilot scale before ADIV tests

3.1 Materials & methods

3.1.1 Strategies of SFA reductions (fat emulsions) and salt

Before the first ADIV tests, 7 different strategies of fuet extra (not in snacks) were performed in Boadas to select the most suitable fat emulsions type and to know the general behaviour of this kind of reduced products. Additionally to the fat emulsions tests, also was tested salt reductions using KCl and fat reductions using lean product without fat in formulation. Boadas send samples of these tests to NIZO partner to work on the aromas effects on taste and texture perception of sausages with low salt, lower saturated fat content and low salt & lower saturated fat content (WP5-task 5.1).

3.1.1.1 Industrial experimental plan for fat emulsions

Table 1 shows the 3 kinds of emulsions with different compositions that were tested:

Table 1 : Types of emulsions

	Protein	Water	sunflower oil	porck bacfat
Emulsion 1	yes	yes	high dose	No
Emulsion 2	yes	yes	middle dose	high dose
Emulsion 3	yes	yes	low dose	low dose

Figure 3: Pictures of emulsions

Fat emulsions conclusions

- All emulsions were OK. The texture of emulsion 1 was worse than texture of emulsion 2 and 3. In addition, emulsion 1 was considered very difficult to work in industrial conditions because is too liquid. Moreover, after 3 days at 3º-5ºC a slight syneresis appeared. It was decided to choose emulsion 2 and 3 to do the pilot scale tests.

- Emulsion 2 was chosen because it has the best texture and it will be more stable for a long time. The emulsion will be used refrigerated and frozen to compare which is better. Compared with emulsion 3 it has lower SFA content.

3.1.1.2 Industrial experimental plan for fuet extra

Taking in account the previous fat emulsion conclusions, the experimental plan designed includes 7 trials for fuets.

- Control: current fuet made with pork shoulder and pork backfat, with current salt
- P1(fuet-low fat): fuet extra with 30% of fat reduction: replacing the pork backfat by fat emulsion 2 refrigerated
- P2 (fuet-low salt): fuet with pork shoulder and pork backfat, with low salt + KCl addition➔ 25% of NaCl reduction

- P3(fuet-low fat): fuet extra with 30% of fat reduction: replacing the pork backfat by fat emulsion 2 frozen
- P4(fuet-low salt and fat): mix between P2 and P3
- P5(fuet-low fat): lean fuet produced with defatted pork shoulder and without backfat addition
- P6(fuet-low salt and fat): mix between P2 and P5

Each meat batter (one for control and one for the 6 trials) contained the same rate of colouring, ingredient mix, KNO_3 and starter.

In summary, 7 tests with repetition were elaborated. 2 identical tests were done due to the high variability of the dry cured products (variability of meat, variability in drying process…). If both tests do not present significant differences, could be concluded that results are quite reliable.

3.1.2 Products analysis

For each trials of the experimental plan for fuet, physical and chemical analyses were done:

- Lipid (norm B.O.E. 29-08-1979) and humidity content (norm UNE 34552) on dry products: 1 measurement / trial (corresponding to the SFA reduction plan)
- Sodium and NaCl content (norm AOAC 969.23, 990.23, 985.35) on dry products: 1 measurement / trial (corresponding to the salt reduction plan)
- Weight loss measurement on 3 pieces per test at days 7, 14, 21, 28, 30, 34 or 37 or 42 (end of drying process). Weight loss at day "n" is calculated thanks to the formula: weight loss $_{(day\ n)}$ (%) = 100 x (weight $_{day\ n}$ (kg) –weight$_{day\ 0}$ (kg))/ weight$_{day\ 0}$ (kg)
- pH measurement on 2 pieces per test, at days 0 , 20, end of drying, at the core of the product with pH-meter Hanna© HI 99163.
- Visual aspect of dry sausages at the end of drying (day 28, 34, 37 or 42)
- Informal sensorial evaluation of dry products by BOADAS team.

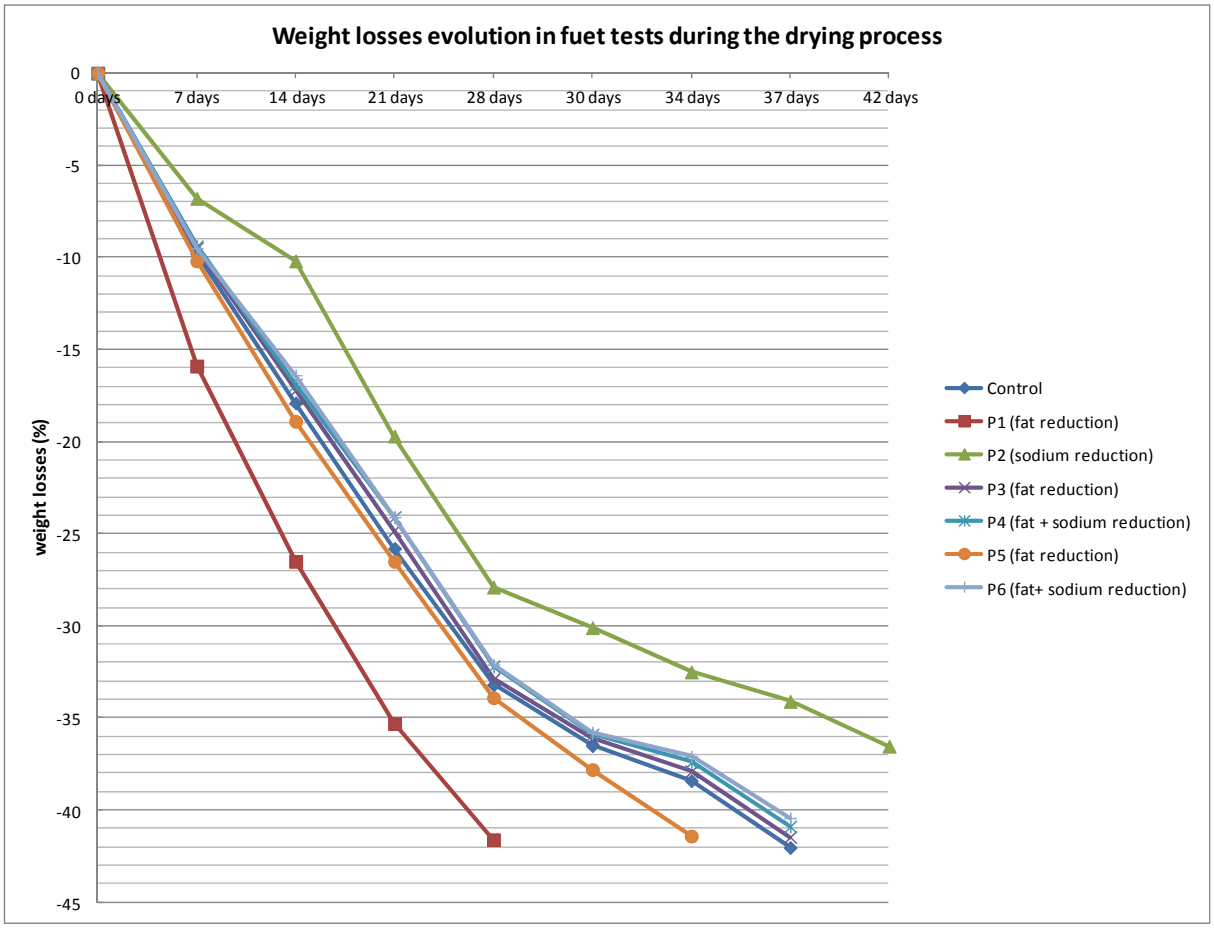
3.2 Results of the industrial technological tests

All the results are an average of the 2 performed tests (initial and repetition)

3.2.1 Weight losses and pH evolution

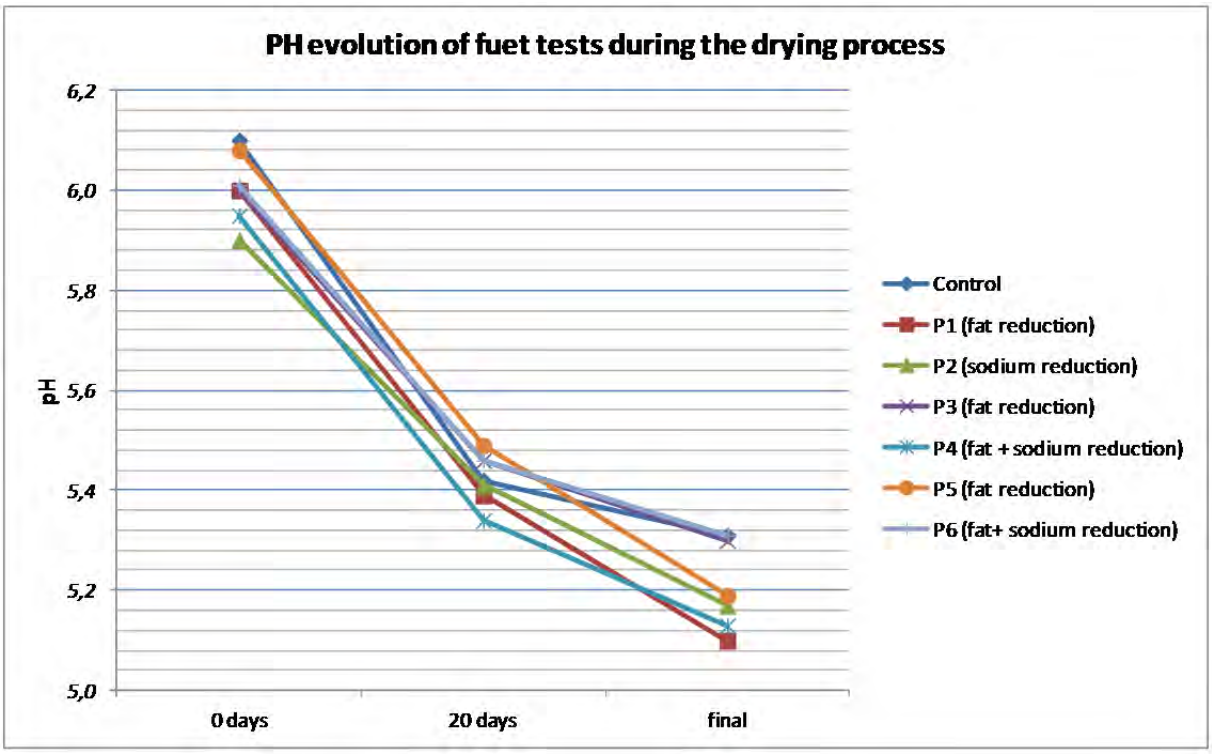
Process of fuet extra was managed to reach a weight loss of 42% in the control at the end of drying step. Results (figure 4) demonstrate quicker weigh losses for fuet P1 (fat reduction) and P5 (fat reduction) compared to control. However, there was an exception: P3 which weigh loss was similar to control. Conversely, slower weight losses were observed for fuet P2 (sodium reduction).

Figure 4: Weight losses evolution in fuet tests during the drying process



In reference to pH evolution (figure 5), there is no significant difference between tests and control.

Figure 5: pH evolution of fuet tests during the drying process



3.2.2 Chemical analysis

In reference to the chemical analysis of fuet tests and control after drying process (table 2), it was achieved more than 39% reduction in fat reduction tests (P1) and more than 37% reduction in sodium reduction tests (P6).

Table 2 : Chemical Analysis results of fuet tests and control after drying process

Test	Description	Fat (%)	% reduction of fat	Salt (%)	% reduction of NaCl	Sodium (%)	% reduction of sodium
Normal	control	36,09	-18,53	3,69	-3,91	1,48	-6,33
P1	fat reduction	26,62	-39,91	5,53	44,01	2,21	39,87
P2	sodium reduction	37,87	-14,51	2,61	-32,03	1,04	-34,18
P3	fat reduction	31,19	-29,59	3,44	-10,42	1,37	-13,29
P4	fat and sodium reduction	35,63	-19,57	2,88	-25,00	1,15	-27,22
P5	fat reduction	28,41	-35,87	3,11	-19,01	1,24	-21,52
P6	fat and sodium reduction	35,27	-20,38	2,44	-36,46	0,98	-37,97
Average similar products from		44,30		3,84		1,58	
Terget for project		31,01		2,88		1,18	

3.2.3 Sensorial assessment

About the sensorial assessment of the fuet tests, the table 3 shows that all the tests have good sensory quality. In the fat reduction tests, one test has good overall aroma (P3). In sodium reduction test at the end of the tasting the fuet has a spicy and unpleasant taste.

Table 3 : Sensory evaluation results for fuet by Boadas

TEST	TEST DESCRIPTION	BOADAS sensorial evaluation	OVERALL EVALUATION
Control	Boadas standard	Boadas standard	
P1	Fat reduction	Lean aspect Good aroma but lower spicy taste than control	+
P2	Sodium reduction	Spicy test with unpleasant taste at the end of the tasting	+/-
P3	Fat reduction	Lean aspect Better than P1, very close to control	++
P4	Fat and sodium reduction	Lean aspect Taste also spicy and perceptible bitter taste	+/-
P5	Fat reduction	Lean aspect and good overall aroma Taste also spicy taste	+
P6	Fat and sodium reduction	Lean aspect Good overall aroma, very close to control	++

3.2.4 Conclusion of the industrial technological tests before ADIV tests

- ✓ The different initial assays and their repetitions didn't show significant differences, so it could be concluded that the results are quiet reliable.

For the SFA reduction tests:

- ✓ The frozen fat emulsion 2 has the best texture and it's the most stable over time to make the fat reduced fuets at industrial scale. Recipe was optimized by fibers addition as polydextrose or fiber.
- ✓ Work only with lean meat without fat or sunflower oil addition is dismissed because the SFA reduction is insufficient.

For the sodium reduction tests

- ✓ The aim is to increase the percentage of substitution of sodium chloride by potassium chloride. As the taste of the products made with normal potassium chloride is slightly bitter it will be introduced a modified potassium chloride that reduces the bitter taste in the final product. In addition, two flavour enhancers will be tested.
- ✓ Besides, it will be tested the possibility to use dehydrated pork meat powder

4. PART II: Technological tests at pilot scale

4.1 Materials & methods

4.1.1 Strategies of salt and SFA reductions at pilot scale

4.1.1.1 Salt and SFA reduction objectives

To determine the targeted levels of salt and SFA in optimized snack fuet and chorizo, we compared nutritional composition of BOADAS products with reference values for similar products. The nutritional compositions of several similar products distributed in Spain were collected, analysed and means were calculated for the both kinds of products (table 4). New nutritional compositions after salt and SFA reductions by 25 and 30 %, respectively, were proposed. Theses reduction levels are determined by the regulation relative to nutritional claims (Regulation (EC) No 1924/2006):" A claim stating that the content in one or more nutrients has been reduced, and any claim likely to have the same meaning for the consumer, may only be made where the reduction in content is at least 30 % compared to a similar product, except for for sodium, or the equivalent value for salt, where a 25 % difference shall be acceptable".

For snack fuet extra, the claims "reduced in salt" and "reduced in SFA" implies a maximum of 2.88 g salt/100g and 13.37 g SFA/100 g. To achieve TeRiFiQ objectives (-30%

and -60% for salt and SFA, respectively), expected composition is 2.7g salt/100g and 5.3 g SFA/100g (or 18g fat/100g).

For chorizo extra, the claims "reduced in salt" and "reduced in SFA" implies a maximum of 2.58 g salt/100g and 6.7 g SFA/100 g. To achieve TeRiFiQ objectives, expected composition is 2.4g salt/100g and 3.8g SFA/100g (or 10g fat/100g).

Table 4 : Reference nutritional composition in salt and fat of snack fuet extra and chorizo extra representative to Spain market. Values targeted are calculated according to Regulation (EC) No 1924/2006 to obtain the claims "reduce in salt" and "reduce in fat"

NUTRITIONAL VALUES REFERENCES

		Salt (g)	Sodium (g)	Fat (g)	SFA (g)	MUFA (g)	PUFA (g)
SNACKS FUET EXTRA	Campofrio (label declaration)	4,00	1,68	44,30	19,10	22,46	5,85
	AESAN data base	3,68	1,47				
	Average similar products from market	3,84	1,58	44,30	19,10	22,46	5,85
	Values targeted for the future (25% and 30% reduction)	2,88	1,18	31,01	13,37	15,72	4,10

NUTRITIONAL VALUES REFERENCES

		Salt (g)	Sodium (g)	Fat (g)	SFA (g)	MUFA (g)	PUFA (g)
CHORIZO EXTRA	Auchan (BOADAS)	4,39	1,53	23,61	8,89	10,71	4,01
	Campofrio	3,01	1,27	23,58	9,88	10,61	3,09
	Embutidos Monter	3,29	1,41	28,32	10,94	13,02	4,36
	Argal	3,28	1,37	24,12	8,60	10,8	4,72
	AESAN data base	3,26	1,30				
	Average similar products from market	3,45	1,38	24,91	9,58	11,29	4,05
	Values targeted for the future (25% and 30% reduction)	2,58	1,03	17,44	6,70	7,90	2,83

4.1.1.2 Industrial experimental plan for fat emulsions and fuet

4.1.1.2.1 Experimental plan for SFA reduction

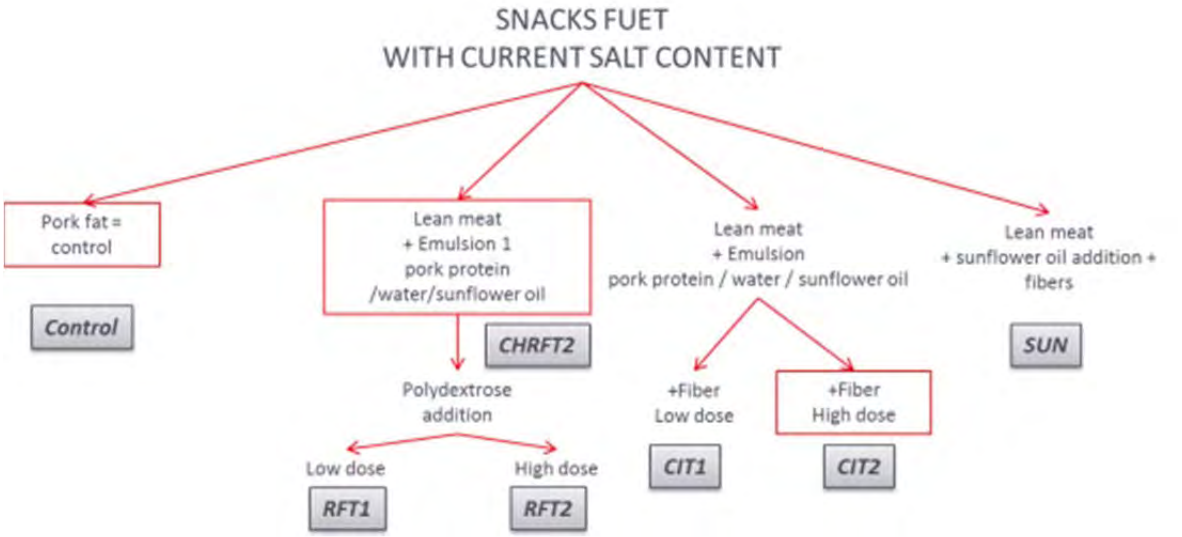
The aim of these trials was to assess the capacity of chorizo and snack fuet formulations to reduce SFA by 60% in the final products. Results from the task 2.1 demonstrated that the SFA reduction by 60% is allow thanks to a formulation without addition of pork backfat and addition of unsaturated fat from vegetable oils. Sunflower oil had been chosen because of their high content in monounsaturated fatty acids (75 – 85% of MUFA) and content in polyunsaturated (PUFA) not too excessive (7-19%), to limit oxidation degradation of fat.

The two strategies tested to incorporate sunflower oil into the meat batter consist in producing:

- emulsion of pork protein/water/sunflower oil and polydextrose or fiber addition.
- sunflower oil and fibres

The experimental plan designed (figure 6) includes 6 trials for fuets and 3 trials for chorizo.

Figure 6 : Experimental plan designed to test the SFA reduction strategies on snack fuets (5 trials and 1 control) and on chorizo (only Control, CHRFT2 and C1T2 trials were tested)



Thus, 6 trials were done to produce snack fuet:

- Control : current snack fuet made with pork shoulder and pork backfat.
- RFT1 : snack fuet with lean meat and emulsion pork protein/water/sunflower oil + low dose of polydextrose.
- RFT2 : snack fuet with lean meat and emulsion pork protein/water/sunflower oil + high dose polydextrose.
- CIT1 : snack fuet with lean meat and emulsion pork protein/water/sunflower oil and fibers at low dose.
- CIT2 : snack fuet with lean meat and emulsion pork protein/water/sunflower oil and fibers at high dose.
- SUN : snack fuet with lean meat andsunflower oil + fibers

Each meat batter (control and the 5 trials) contained the same rate of nitrite salt, colouring, ingredient mix, and KNO_3.

Snack fuet process was managed to achieve a total weight losses of 45%, a final DPH of 39%, a pH of 5 to 5.2 and a water activity to 0.870.

The details of recipes used for the 6 trials to produce Snack fuet are presented in table 5.

Table 5 : Recipes tested in the 6 trials for snack fuet production reduced in SFA.

Snack fuets recipes						
	Control	RFT1	RFT2	CIT1	CIT2	SUN
Meat (%)						
Pork shoulder	☑	☑	☑	☑	☑	☑
pork backfat	☑					
Emulsion1		☑	☑			
Emulsion2				☑		
Emulsion3					☑	
Sunflower oil						☑
Starter	☑	☑	☑	☑	☑	☑
Ingredients (g/kg)						
Nitrite salt (0.6% sodium ni	same dose of each ingredient in all recipes					
Colouring						
Ingredients mix						
KNO3						
Water						
Fibers						☑
Polydextrose		☑ **low dose**	☑ **high dose**			
Water losses (%)	***45***	***50***	***50***	***50***	***50***	***50***
Batter lipids level (%)	***23,1***	***12,3***	***12,1***	***12,4***	***12,3***	***11,8***
Snack fuets lipids (%)	***42,0%***	***24,6%***	***24,3%***	***24,7%***	***24,6%***	***23,6%***
Batter SFA level (%)	***9,2***	***4,3***	***4,3***	***4,4***	***4,3***	***3,6***
Snack fuets SFA level (%)	***16,8***	***8,7***	***8,5***	***8,7***	***8,7***	***7,2***
SFA reduction(%)	***12,0***	***54,7***	***55,3***	***54,4***	***54,6***	***62,3***
Batter PUFA level (%)	***2,8***	***2,6***	***2,6***	***2,6***	***2,6***	***2,7***
Snack fuets PUFA level (%)	***5,0***	***5,2***	***5,1***	***5,2***	***5,1***	***5,3***
	Emulsion 1	Emulsion 2	Emulsion 3			
Pork protein	☑	☑	☑			
Sunflower oil	☑	☑	☑			
Water	☑	☑	☑			
Pork backfat	☑	☑	☑			
Fiber (CFi)		☑ low dose	☑ high dose			
Fat content (%)	***42,7***	***42,0***	***41,3***			
% SFA content	***10,7***	***10,5***	***10,3***			
% PUFA content	***17,2***	***16,9***	***16,6***			
HPD target : 39%	***Average SFA content (SPAIN) :***			***19,1***		
pH target : 5 / 5.2						
aw : 0.870						

Calculated from the recipes and theoretical weight losses, the SFA reduction expected was between 55 to 62% in trials (12% in control).

For chorizo extra, only 3 trials were realized:

- Control: current chorizo extra made with pork shoulder and pork backfat.
- CHRFT2: chorizo with lean meat and emulsion pork protein/water/sunflower oil
- CIT2: chorizo with lean meat and emulsion pork protein/water/sunflower oil and fibre.

Each meat batter (control and the 2 trials) contained the same rate of nitrite salt, colouring, ingredient mix, spices, and KNO_3.

Chorizo process was managed to achieve a total weight losses of 30%, a final DPH of 56%, a pH of 4.8 and a water activity to 0.910.

The details of recipes used for the 3 trials to produce Chorizo are presented in table 6.

Table 6 : recipes tested in the 3 trials for chorizo production reduced in SFA

Chorizo recipes			
	Control	CHRFT2	CIT2
Meat			
Pork shoulder	☑	☑	☑
pork backfat	☑		
Emulsion soja	☑	☑	☑
Emulsion1		☑	
Emulsion3			☑
Starter	☑	☑	☑
Ingredients			
Nitrite salt (0.6% sodium nitrite)	same dose of each ingredient in all recipes		
Starter Prot.			
Ingredients mix			
KNO3			
Water			
Spice			
Coloring			
Water losses (%)	***28***	***33***	***33***
Batter lipids level (%)	***16,2***	***11,0***	***10,9***
Chorizo lipids (%)	***22,6%***	***16,4%***	***16,2%***
Batter SFA level (%)	***6,5***	***3,8***	***3,8***
Chorizo SFA level (%)	***9,0***	***5,7***	***5,7***
SFA reduction(%)	***5,8***	***40,4***	***40,8***
Batter PUFA level (%)	***1,9***	***2,4***	***2,4***
Chorizo PUFA level (%)	***2,7***	***3,6***	***3,5***
	Emulsion 1	Emulsion 3	
Pork protein	☑	☑	
Sunflower oil	☑	☑	
Water	☑	☑	
Pork backfat	☑	☑	
Fiber (CFi)		☑	
Fat content (%)	***42,7***	***41,3***	
% SFAcontent	***10,7***	***10,3***	
% PUFA content	***17,2***	***16,6***	
HPD target : 56%		***Average SFA***	
pH target : 4.8		***content (SPAIN) :***	***9,58***

4.1.1.2.2 Experimental plan for salt reduction

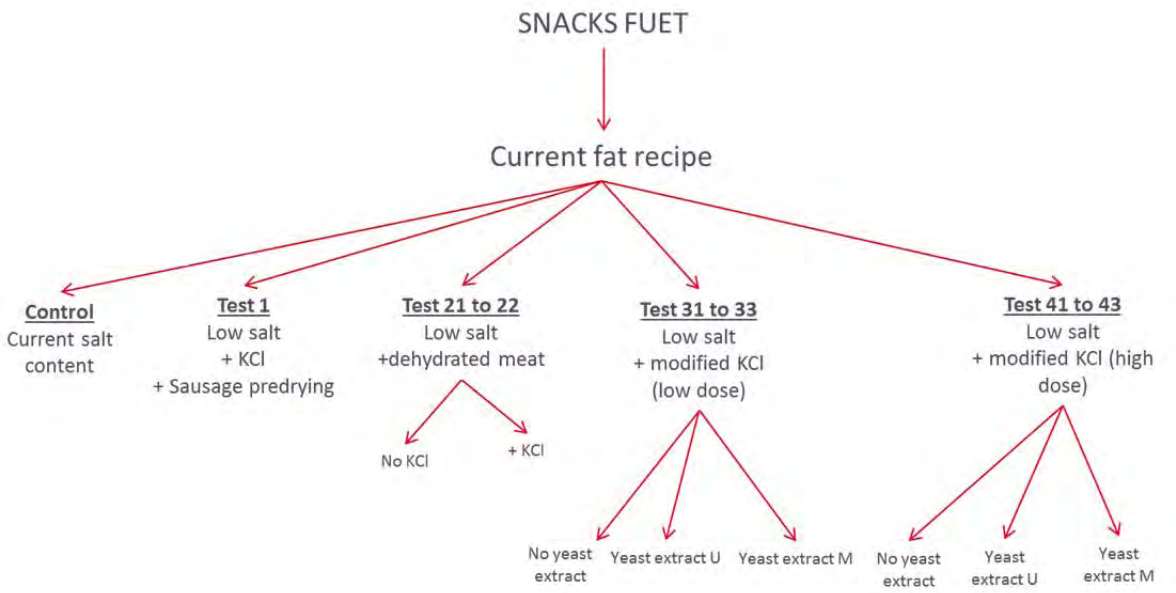
The aim of these trials was to assess the capacity of snack fuet formulation and process strategies to reduce salt by 30% in the final products. Results from the task 2.1 demonstrated that the salt reduction by 30% needs the combination of meat or dry sausage pre-drying with KCl addition and formulation corrections have to been given to get the same acidification profile than current snack fuet and avoid negative impact on sensory characteristics.

The strategies tested to reduce salt content were:

- KCl addition
- cold predrying of snack fuet
- dehydrated meat use
- modified form of KCl addition
- yeast extract

The experimental plan designed (figure 7) includes 10 trials for fuets.

Figure 7: Experimental plan designed to test the salt reduction strategies on snack fuets (9 trials and 1 control)



Thus, 10 trials were done to produce snack fuet:

- Control: current snack fuet made with pork shoulder and pork backfat, with current salt
- T1: snack fuet with lean meat and pork backfat, with low salt + KCl addition and snack fuet cold predrying
- T21: snack fuet with lean meat and pork backfat, with low salt and dehydrated meat
- T22: snack fuet produce as T21 + KCl addition
- T31: snack fuet with lean meat and pork backfat, with low salt + modified KCl addition (low dose)
- T32: snack fuet produce as T21 + Yeast extract U
- T33: snack fuet produce as T21 + Yeast extract M

- T41: snack fuet with lean meat and pork backfat, with low salt + modified KCl addition (high dose)
- T42: snack fuet produce as T41 + Yeast extract U
- T43: snack fuet produce as T41 + Yeast extract M

Each meat batter (one for control and one for the 8 trials) contained the same rate of colouring, ingredient mix, KNO_3 and starter. Modified KCl corresponds to KCl at 93%.

The details of recipes used for the 10 trials to produce Snack fuet reduced in salt are presented in table 7.

Table 7: Recipes of snack fuet reduced in salt

Snack fuets recipes					30% substitution			40% substitution		
	Control	T1	T21	T22	T31	T32	T33	T41	T42	T43
Meat (%)										
Pork shoulder	☑	☑	☑ % adapted according to dehydrated meat level	☑ % adapted according to dehydrated meat level	☑	☑	☑	☑	☑	☑
pork backfat	☑	☑	☑ % adapted according to dehydrated meat level	☑ % adapted according to dehydrated meat level	☑	☑	☑	☑	☑	☑
Starters	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Ingredients										
Nitrite salt (0.6% sodiu	25	15	15	15	15	15	15	15	15	15
Carmin Ingredients mix KNO3 Water	same dose of each ingredient in all recipes									
KCl		☑		☑						
Dehydrated meat			☑	☑						
modified KCl					☑ low dose	☑ low dose	☑ low dose	☑ high dose	☑ high dose	☑ high dose
Yeast extract U						☑			☑	
Yeast extract M							☑			☑
Water losses (%)	***45***	***45,2***	***39,3***	***38,7***	***45***	***45,2***	***44,7***	***45,2***	***44,7***	***44,7***
Batter lipids level (%)	***23,1***	***23,2***	***24,1***	***23,9***	***23,1***	***23,1***	***23,1***	***23,0***	***23,0***	***23,0***
Snack fuets lipids (%)	***42,0%***	***42,3%***	***39,7%***	***39,0%***	***42,1%***	***42,1%***	***41,8%***	***42,0%***	***41,5%***	***41,6%***
Batter SFA level (%)	***9,2***	***9,3***	***9,6***	***9,6***	***9,3***	***9,2***	***9,2***	***9,2***	***9,2***	***9,2***
Snack fuets SFA level (%	***16,8***	***16,9***	***15,9***	***15,6***	***16,8***	***16,8***	***16,7***	***16,8***	***16,6***	***16,6***
Salt level (%)	***4,25***	***2,57***	***2,34***	***2,29***	***2,56***	***2,56***	***2,54***	***2,55***	***2,52***	***2,52***
Sodium level (%)	***1,67***	***1,01***	***0,92***	***0,90***	***1,00***	***1,00***	***1,00***	***1,00***	***0,99***	***0,99***
Sodium reduction(%)	***/***	***33***	***39***	***40***	***33***	***33***	***34***	***34***	***34***	***34***

Calculated from the recipes and theoretical weight losses, we expected a NaCl substitution by 30% with KCl or modified KCl in the tests T1, T22 and T31 to T33. In the tests T41 to T43, NaCl is substitute by 40% by modified KCl.

4.1.2 Products analysis

For each trials of the experimental plan for SFA reduction, we did physical, chemical, nutritional and microbial analysis:

- Lipid (norm NF V-04 403) and humidity content (norm NF V-04 401) on dry products: 2 measurements / trial,

- The lipid and humidity content were used too to calculate DPH ratio (Defatted Product Humidity) that quantifies humidity or drying level of the lean part of a meat product. It is calculated thanks to formula: DPH (%) = 100 x Humidity (%)/(100-lipids (%)). For example DPH of fresh meat is about 77%. In France, DPH of meat products is regulated. For example, for current dry sausages, DPH should not exceed 54%. Lipids and humidity were used to calculate another ratio that is lipids / DPH77. This indicator is used in French regulation, like DPH. It corresponds to lipid content of the fresh batter. For a given meat batter formulation, its calculation gives almost the same result at any stage of dry sausage process. Its formula is: (23 x lipids (%)) / (100 – humidity (%) -0.77 x lipids (%)).
- Fatty acid profile (norm NF EN ISO 5508/12996-2) to quantify saturated, monounsaturated and polyunsaturated fatty acids on dry products: 2 measurements / trial,
- Weight loss measurement on 10 products at days 3, 4, 6, 7, 13 (end of drying for snack fuet), 19, 20 (end of drying for chorizo) (day 0: stuffing day). Weight loss at day n is calculated thanks to the formula: weight loss $_{(day\ n)}$ (%) = 100 x (weight $_{day\ n}$ (kg) –weight$_{day\ 0}$ (kg))/ weight$_{day\ 0}$ (kg)
- pH measurement (norm NF V-04 408) on 1 products at days 3, 4, 6, 7, 13, 20 (day 0 : stuffing day) at the core of the product with pH-meter Knick©,
- a_w measurement (norm NF ISO 21807) on dry sausages during processing : before drying and at the end of drying (2 repetitions/trials). A dew point a_w-meter Aqualab© was used. On dry sausages, measurements were done on cylindrical cross sections without casing.
- TBARS (oxidation index) (ADIV's method) on dry sausages during processing: at the start of drying (day 6), at the end of drying (day 20) and after storage (day 76).
- Visual aspect of dry sausages during processing : after stuffing (day 0), at the end of drying (day 20)
- Textural characteristics of dry sausages at the end of drying (day 20) by TPA test to measure hardness, adhesion, fragility, elasticity and cohesiveness (8 repetitions/trials).
- Informal sensorial evaluation of dry products (day 20) by the both ADIV and BOADAS teams.

For each trials of the experimental plan for salt reduction, we did physical, chemical, nutritional and microbial analysis:

- Lipid (norm NF V-04 403) and humidity content (norm NF V-04 401) on dry products: 2 measurements / trial,
- DPH ratio (Defatted Product Humidity) and lipids / DPH77 ratio were calculated as previously described.
- Sodium chloride content on dry products was estimated by calcul approach based on the NaCl content of ingredients and proportion of each of it in the recipes and weight loss,
- Weight loss measurement on 1 product at days 3, 4, 6, 7, 13, 20 (day 0 : stuffing day). Weight loss at day n is calculated thanks to the formula: weight loss $_{(day\ n)}$ (%) = 100 x (weight $_{day\ n}$ (kg) –weight$_{day\ 0}$ (kg))/ weight$_{day\ 0}$ (kg)
- pH measurement (norm NF V-04 408) on 1 product at days 3, 4, 6, 7, 13, 20 (day 0 : stuffing day) at the core of the product with pH-meter Knick©,
- a_w measurement (norm NF ISO 21807) on dry sausages during processing : before drying and at the end of drying (2 repetitions/trials). A dew point a_w-meter

Aqualab© was used. On dry sausages, measurements were done on cylindrical cross sections without casing.

- Informal sensorial evaluation of dry products (day 20) by the both ADIV and BOADAS teams.
- Microbial countings of *Pseudomonas* (norm NV V-04 504) and *Enterobacteriaceae* (norm ISO 21528-2) at 0, 2, 5, and 26 days of drying (2 repetitions/trials).

4.2 Results of the technological tests for SFA reduction

4.2.1 Weight losses and pH evolution

Process of snack fuet extra was managed to reach a weight loss of 45% in control at the end of drying step. Results demonstrated quicker and higher weigh losses (50%) for reduced SFA snack fuet compared to control (figure 8). This is due to the higher content of water in trials given by water contained in the oil emulsions.

The same difference between control chorizo and SFA reduced chorizo were observed (28% v. 33%, respectively; figure 9).

pH evolution of control snack fuet is different than fuet reduced in SFA : a higher increase of pH between 4 and 20 days in chorizo reduced in SFA represents a microbial risk (figure 10). Formulation will have to be adapted to correct this risk, particularly by adapting the sugar composition.

For chorizo, there is no difference of pH evolution between current sausages and SFA reduced sausages (figure 11).

Figure 8: Weight losses evolution of snack fuet according to the strategy used to reach a SFA reduction of 60% and compared to the control

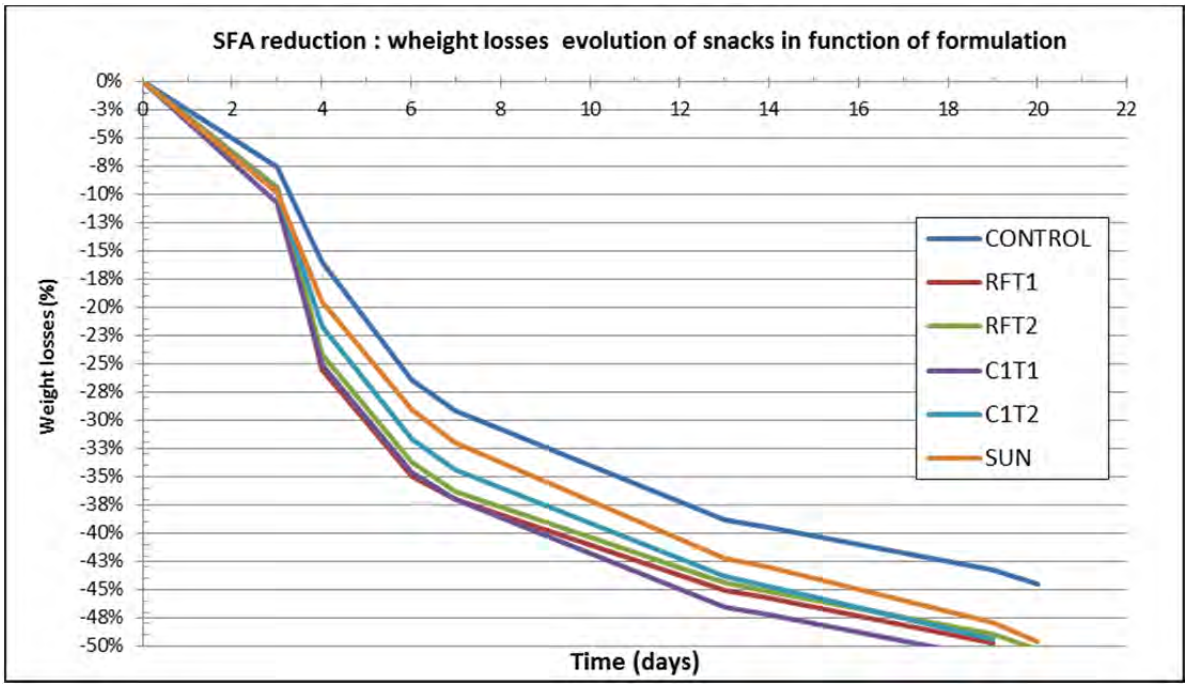


Figure 9: Weight losses evolution of chorizo according to the strategy used to reach a SFA reduction of 60% and compared to the control

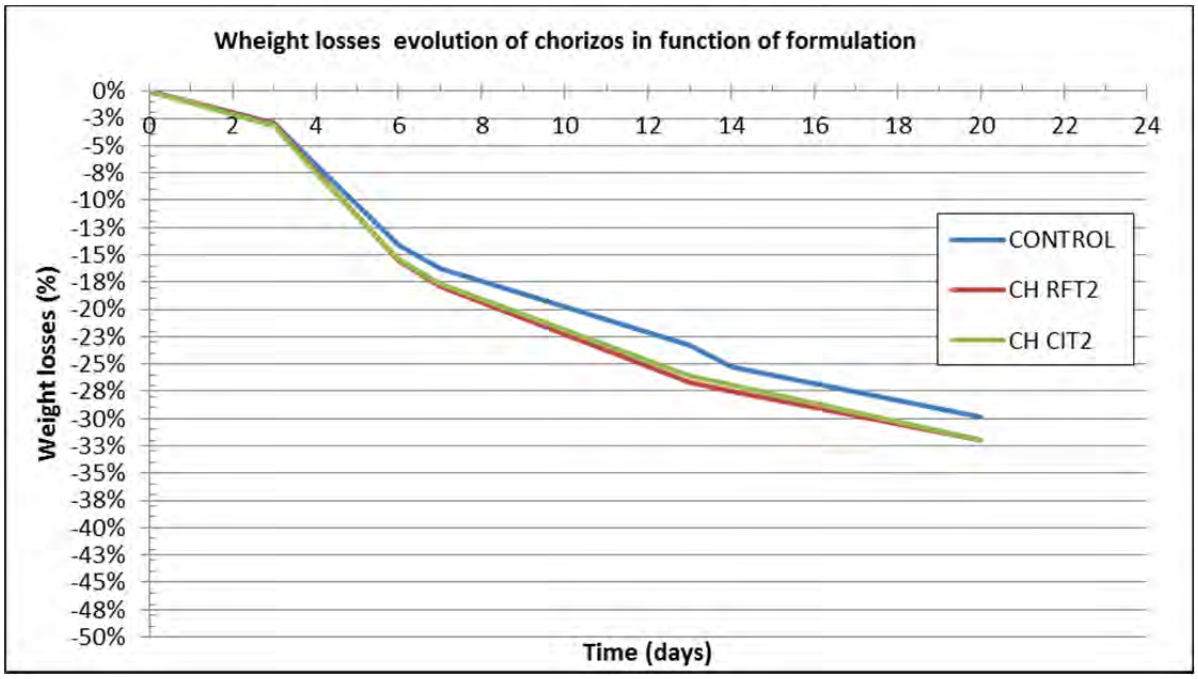


Figure 10: pH evolution of snack fuet according to the strategy used to reach a SFA reduction of 60% and compared to the control

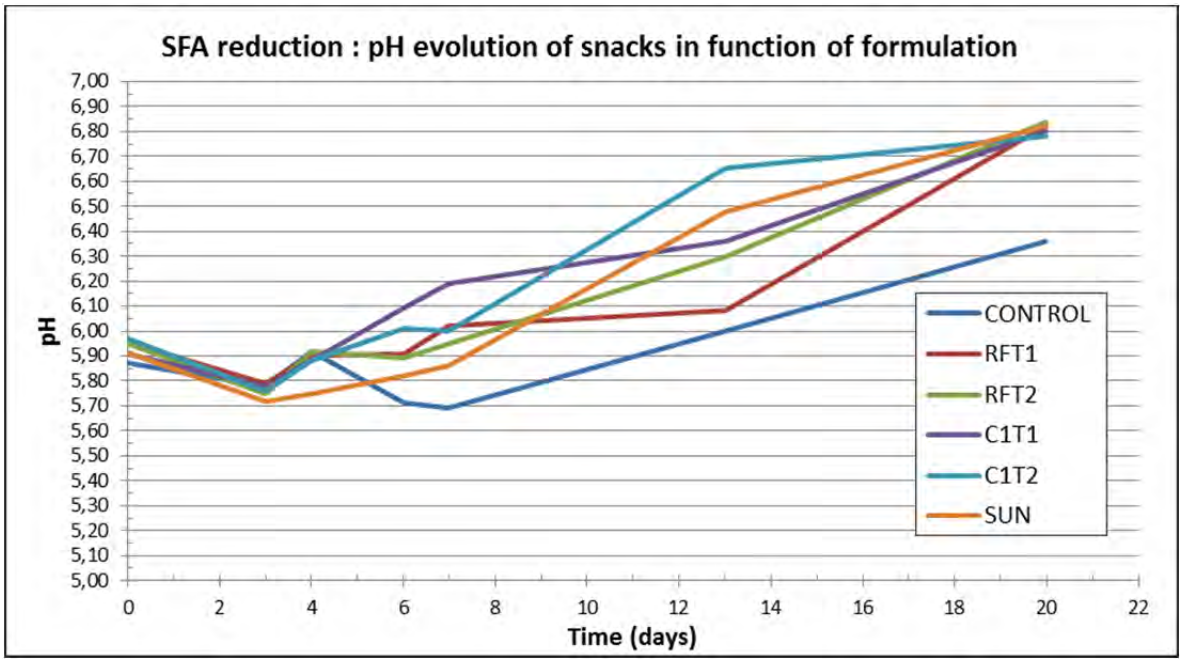
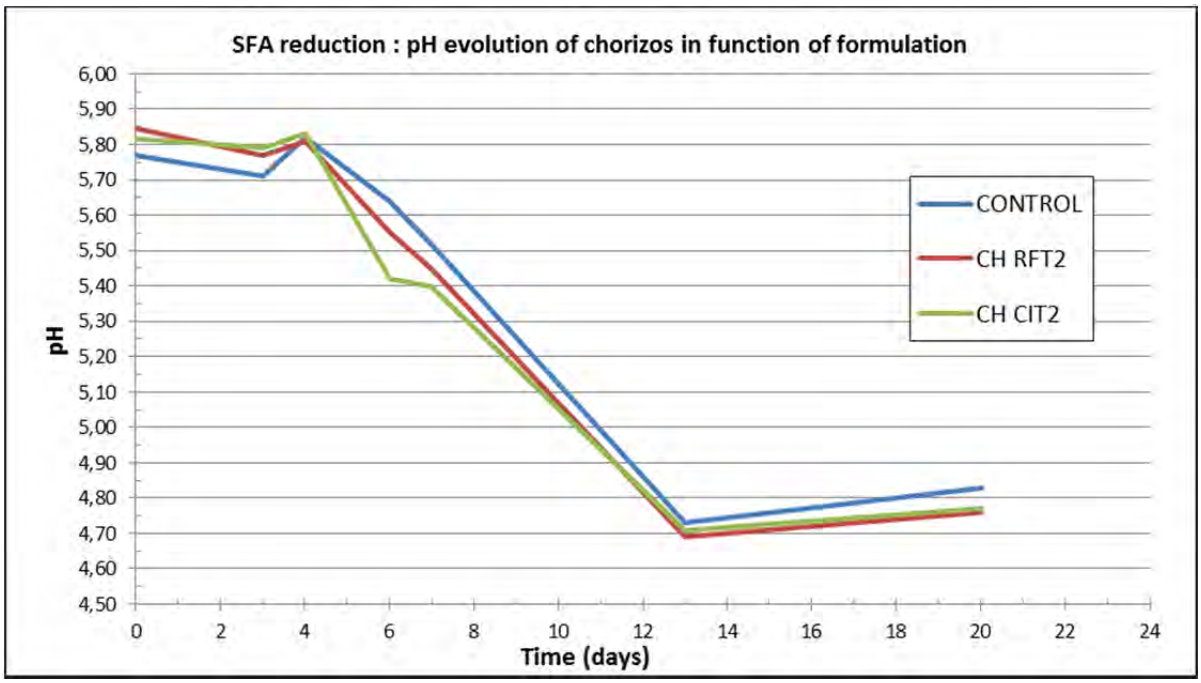


Figure 11: pH evolution of chorizo according to the strategy used to reach a SFA reduction of 60% and compared to the control



4.2.2 aw evolution

Water activity of control snack fuet decrease between the start (0.971±0.001) and the end of drying (0.861±0.001). aw of fuet reduced in SFA is similar than control before drying,

but higher than control after the drying, particularly with the CIT2 (aw=0.898±0.009) and SUN trials (aw=0.911±0.001) (figure 12). For these both trials, chemical analysis of products (humidity and DPH values) demonstrated that products have a higher humidity than others.

For chorizo, water activity of control decrease from 0.963±0.001 to 0.915±0.001 during the drying and there is no statistical differences with the SFA reduced chorizo (figure 13).

At the end of drying, for snack fuet and chorizo, aw is always below 0.92 that is considered as safe regarding to *Listeria monocytogenes* growth capacity (Regulation CE 2073/2005).

Figure 12: aw evolution of snack fuet according to the strategy used to reach a SFA reduction of 60% and compared to the control

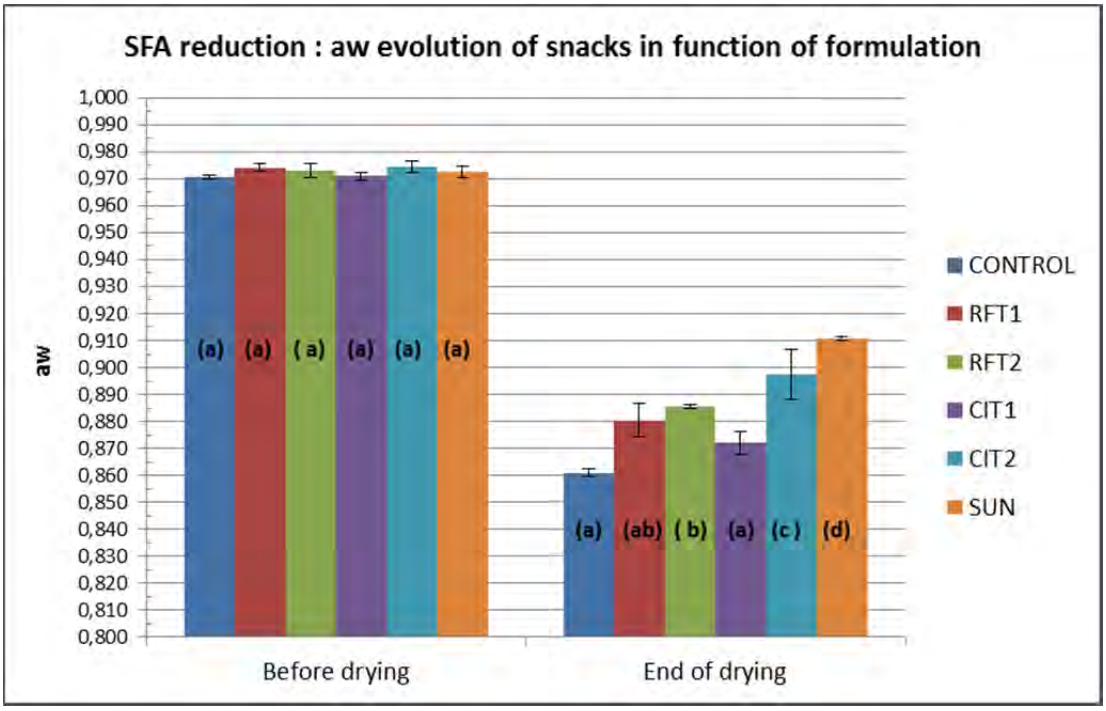
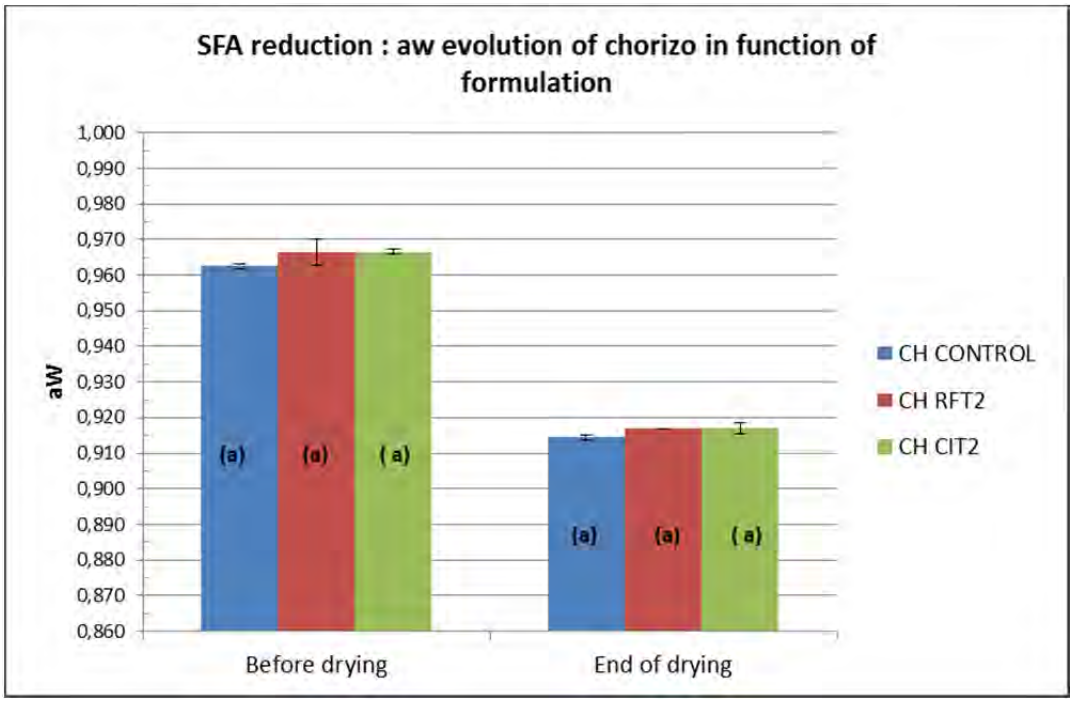


Figure 13: aw evolution of chorizo according to the strategy used to reach a SFA reduction of 60% and compared to the control



4.2.3 Chemical composition

The products were analysed at the end of drying. Results for snack fuet and chorizo are presented in tables 8 and 9, respectively.

- **Snack fuet**

Snack fuet CIT2 corresponding to snacks reduced in SFA and formulated with an oil emulsion and the higher concentration of fibre, and SUN fuet corresponding to SFA reduced sausages and sunflower oil and fibre addition have not the same drying state than control : DPH of 46.4% and 47.4% are higher than control (43.1%).

Concerning the lipid content and quality of fatty acids, because of the formulation used, we expected a SFA reduction by 12% in the control snack fuet comparatively to Spanish reference. Finally, we observed that the control snack fuet produced in this study is less fat than the Spain reference (35.4% vs. 44.3%, respectively), corresponding to a reduction by 25% of SFA (14.3% vs. 19.1%, respectively). This is due to the fat quality of raw material and explains why real SFA reduction is higher than expected reduction for all trials.

In snack fuet reduced in SFA, the reduction varies between 54.4 and 63.4 according to the formulation that is near the 60% targeted. For the trials with polydextrose addition (RFT1 and RFT2), real SFA reduction is higher with the highest polydextrose concentration. For the both snack fuet produced by trials CIT1 and CIT2; there is no difference given by the concentration of fibre added. Snack fuet from CIT2 have the less SFA reduction (57.6%) because of his higher humidity. Conversely, the SUN trial which leads also to products more humid than control allows reaching the targeted SFA reduction (63.3%).

For all trials of SFA reduction using oil sunflower, proportions between the fatty acid classes demonstrated that the SFA reduction was offset by an increase of polyunsaturated fatty acids (% of MUFA is stable).

Table 8: Chemical composition of snack fuet according to the strategy used to reach a SFA reduction of 60% and compared to the control

		SNACKS											
		CONTROL		RFT1		RFT2		CIT1		CIT2		SUN	
		Mean	*Std deviation*	Mean	*Std deviation*	Mean	*Std deviation*	Mean	*Std deviation*	Mean	*Std deviation*	Mean	*Std deviation*
AW	Before drying	0.971	*0.001*	0.974	*0.001*	0.973	*0.003*	0.971	*0.001*	0.975	*0.002*	0.973	*0.002*
	End of drying	0.861	*0.001*	0.881	*0.006*	0.886	*0.001*	0.872	*0.004*	0.898	*0.009*	0.911	*0.001*
Humidity (%)	End of drying	27.9 (a)	*0.1*	33.1 (b)	*0.4*	34.0 (b)	*0.0*	33.2 (b)	*0.8*	35.9 (c)	*0.8*	37.8 (d)	*0.4*
Lipids (%)	End of drying	35.4 (a)	*0.6*	21.8 (b)	*0.9*	19.9 (c)	*0.4*	22.0 (b)	*0.4*	22.6 (b)	*0.6*	20.3 (c)	*0.3*
DPH (%)	End of drying	43.1 (a)	*0.4*	42.3 (a)	*0.0*	42.4 (a)	*0.1*	42.5 (a)	*0.8*	46.4 (b)	*0.6*	47.4 (b)	*0.6*
Lipids / DPH77 (%)	End of drying	18.2	*0.5*	10.0	*0.5*	9.0	*0.2*	10.2	*0.1*	11.1	*0.3*	10.1	*0.2*
SFA (% fatty acids)	End of drying	40.5 (a)	*0.1*	35.2 (c)	*0.4*	35.3 (c)	*0.1*	35.2 (c)	*0.0*	36.0 (d)	*0.1*	34.5 (b)	*0.1*
MUFA (% fatty acids)	End of drying	45.9 (a)	*0.1*	45.7	*0.3*	45.2	*0.1*	44.6	*0.0*	45.3	*0.1*	44.7	*0.1*
PUFA (% fatty acids)	End of drying	13.7	*0.1*	19.1	*0.1*	19.6	*0.1*	20.3	*0.0*	18.8	*0.2*	20.9	*0.1*
SFA (g per 100 g product)	End of drying	14.3 (a)	*0.2*	7.7 (b)	*0.4*	7.0 (c)	*0.2*	7.7 (b)	*0.1*	8.1 (b)	*0.2*	7.0 (c)	*0.1*
MUFA (g per 100g product)	End of drying	16.2 (a)	*0.3*	9.9 (b)	*0.4*	9.0 (c)	*0.1*	9.8 (b)	*0.2*	10.2 (b)	*0.3*	9.1 (c)	*0.1*
PUFA (g per 100g product)	End of drying	5.0 (a)	*0.0*	4.0 (b)	*0.0*	4.0 (b)	*0.0*	4.5 (ab)	*0.7*	4.0 (b)	*0.0*	4.0 (b)	*0.0*
% expected SFA reduction		12.0		54.7		55.3		54.4		54.6		62.3	
% real SFA reduction		*25.0*		*59.9*		*63.4*		*59.5*		*57.6*		*63.3*	

NB : mean of 2 values per cases
DPH : Humidity of Defatted Product

Average SFA content (g/100g of product) for Spanish snacks :19.1 %

- **Chorizo**

For chorizo reduced in SFA, results demonstrated that drying state of products are similar than control (DPH around 57%).

As for snack fuet, control chorizo manufactured in this study have a less content of SFA than the reference Spanish product (-5.1% of SFA). Nevertheless, the levels of SFA reduction reached by the both strategies of oil emulsion addition without or with fibers are under the 60% expected (46% and 48.7% for CHRFT2 and CHCIT2, respectively).

Table 9: Chemical composition of chorizo according to the strategy used to reach a SFA reduction of 60% and compared to the control

		CHORIZO					
		CH CONTROL		CH RFT2		CH CIT2	
		Mean	Std deviation	Mean	Std deviation	Mean	Std deviation
AW	Before drying	0.963	0.001	0.967	0.004	0.967	0.001
	End of drying	0.915	0.001	0.917	0.000	0.917	0.001
Humidity (%)	End of drying	44.2 (a)	0.5	49.0 (b)	0.8	48.7 (b)	0.2
Lipids (%)	End of drying	22.6 (a)	0.1	15.0 (b)	0.9	14.0 (b)	0.2
DPH (%)	End of drying	57.0 (a)	0.6	57.6 (a)	0.4	56.6 (a)	0.4
Lipids / DPH77 (%)	End of drying	13.5 (a)	0.1	8.7 (b)	0.5	8.0 (b)	0.2
SFA (% fatty acids)	End of drying	40.4 (a)	0.1	34.6 (b)	0.6	35.2 (b)	0.5
MUFA (% fatty acids)	End of drying	46.5 (a)	0.2	45.2 (a)	0.6	45.2 (a)	0.5
PUFA (% fatty acids)	End of drying	13.2 (a)	0.1	20.2 (b)	1.2	19.7 (b)	0.0
SFA (per 100 gproduct)	End of drying	9.1 (a)	0.0	5.2 (b)	0.4	4.9 (b)	0.1
MUFA (per 100g product)	End of drying	10.5 (a)	0.1	6.8 (b)	0.5	6.3 (b)	0.0
PUFA (per 100g product)	End of drying	3.0 (a)	0.0	3.0 (a)	0.0	3.0 (a)	0.0
% expected SFA reduction		5.8		40.4		40.8	
% real SFA reduction		**5.1**		**46.0**		**48.7**	

NB : mean of 2 values per cases

Average SFA content (g/100g of product) for Spanish chorizos : 9.58%

DPH : Humidity of Defatted Product

4.2.4 Oxidation risk

The SFA reduction in fuet and chorizo by strategies using addition of sunflower oil can conduct a risk of higher oxidation of fat since fatty acids given by sunflower are more unsaturated than those from pork backfat.

To verify if lipid oxidation occurred in products during the process, TBARS, a chemical indicator that quantify the content of end-products generated by oxidation, was analysed after stuffing (day 0), at the end of drying (day 20) and after storage (day 76).

Globally, with the low values of TBARS (<0.2 mg eq. MDA/kg) measured in snack fuet (figure 14) and chorizo (figure 15), we can conclude there is no evolution of oxidation during the process and the storage and whatever the trial (control and SFA reduced products). Statistically, the products with the highest TBARS level is RFT2 for snack fuet and CIT2 for chorizo, but always under the limit of off-flavour detection by consumers (<1 mg eq. MDA/kg).

Figure 14: Lipid oxidation evolution during processing and storage of snack fuet according to the strategy used to reach a SFA reduction of 60% and compared to the control

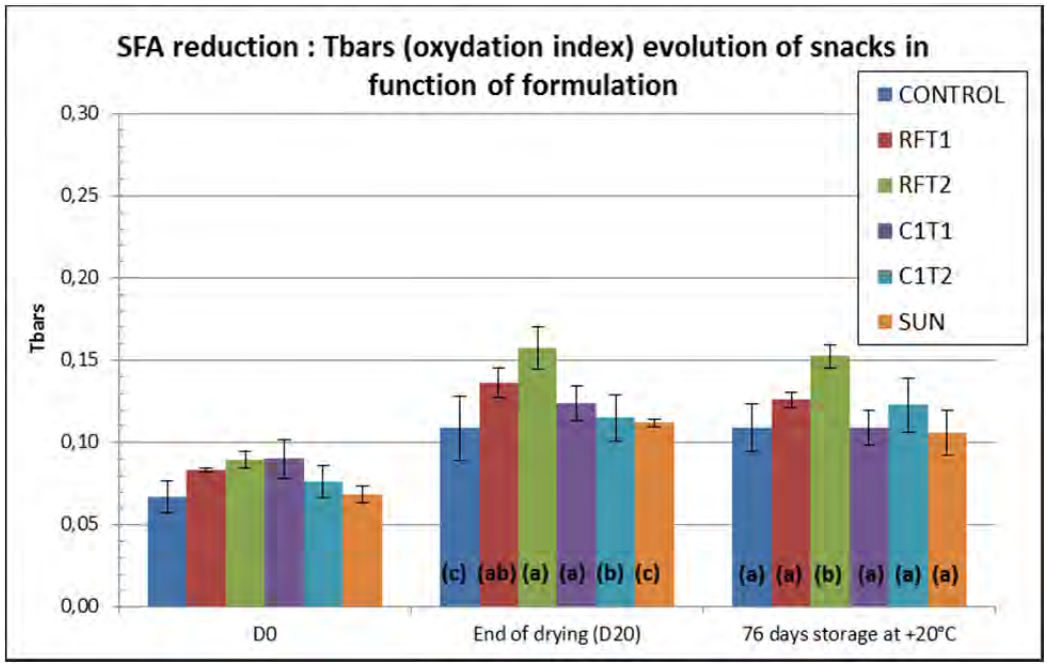
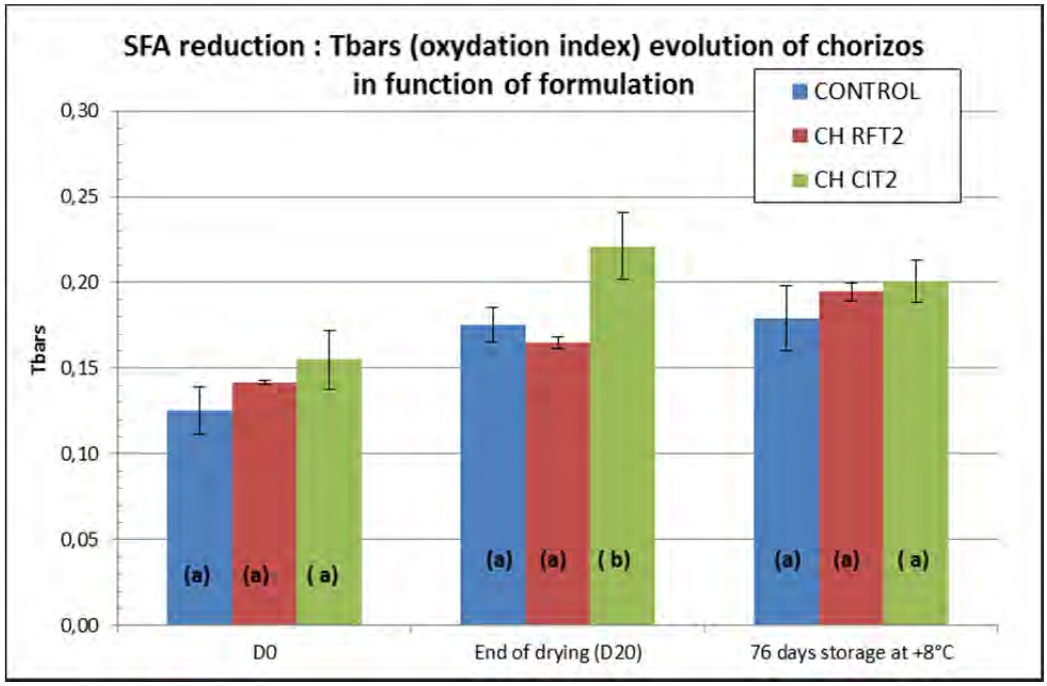


Figure 15: Lipid oxidation evolution during processing and storage of chorizo according to the strategy used to reach a SFA reduction of 60% and compared to the control



4.2.5 Visual aspects of products

Chorizo and snack fuet had been assessed during the processing. After 6 days (figure 16), we observed that for chorizo as for snack fuet, the trials CIT2 give products with an aspect the closest to the control. It was the same at the end of drying (figure 17). For snack fuet, we note that trials RFT1, RFT2 and SUN conduct to products with a leaner aspect than control. This is a positive effect from the consumer point of view and becomes a good argument to communicate and sale these nutritional products.

Figure 16: Visual aspect of snack fuet and chorizo after 6 days of drying according to the strategy used to reach a SFA reduction of 60% and compared to the control

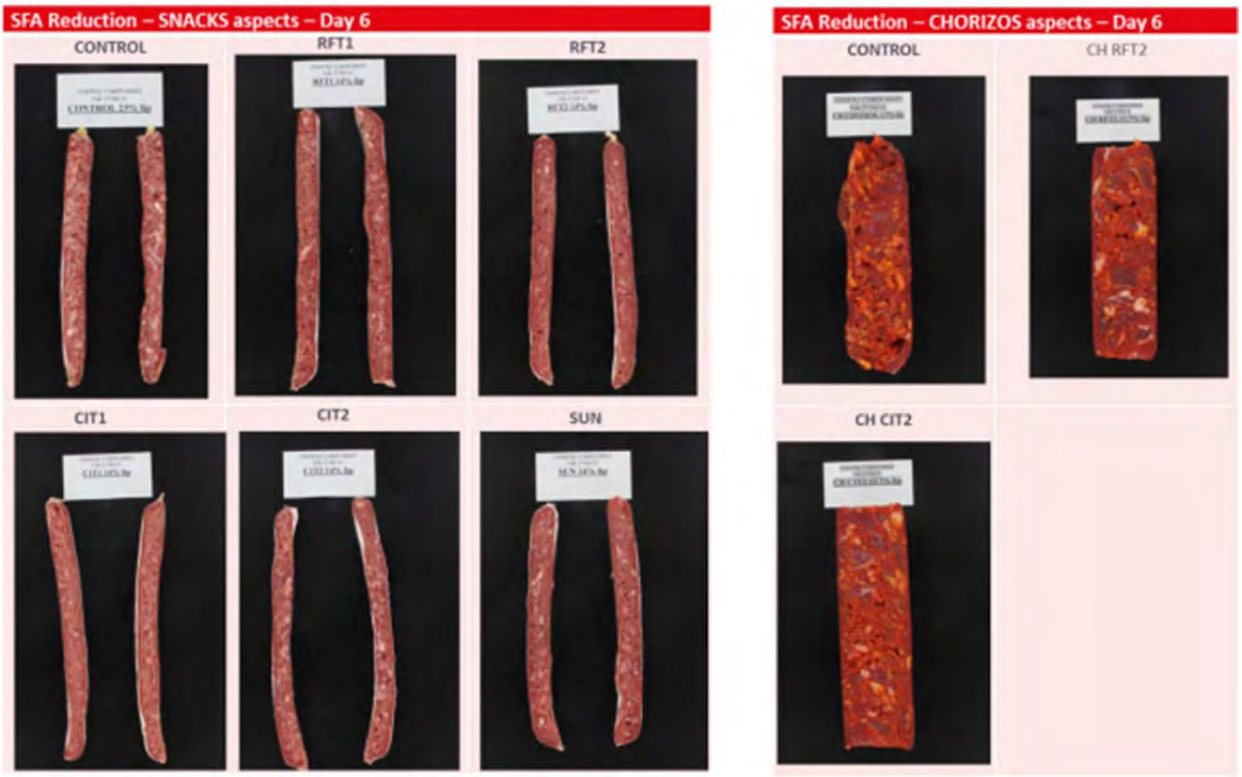


Figure 17: Visual aspect of snack fuet and chorizo after 20 days of drying according to the strategy used to reach a SFA reduction of 60% and compared to the control

4.2.6 Sensorial assessment

A sensorial evaluation of products was performed by the ADIV's team and by the BOADAS's team, independently. Informally, an appreciation of products has been qualified compared to the control (the color, oily aspect, fat repartition, taste, aroma), as presented in tables 10 and 11, for snack fuet and chorizo, respectively.

Using of fat emulsion leads to tougher textures for chorizos and lower flavor and spicy tastes (pepper for snacks, paprika for chorizos) for both kinds of dry sausages. Acid taste increases for chorizos what means that dextrose level has to be adjusted.

Using of polydextrose (RFT1 and RFT2) gives to products a leaner aspect probably because the lack of consistency of fat emulsions. It is a positive point from BOADAS point of view in order to promote fat or SFA reduction towards consumers. The using of fibers in the recipe (SUN trial) gives an intermediate fatty aspect with regular fat grains. Nevertheless, aftertaste is perceptible when fibers are added to the batter.

The best results in terms of aroma were succeeded with sunflower oil and fibers (SUN) even if global aroma is different from control. From ADIV point of view, the fat substitution is more relevant on chorizos than on snacks.

Table 10: Sensorial assessment of snack fuet after drying according to the strategy used to reach a SFA reduction of 60% and compared to the control

Snacks reference	Observations	ADIV overall liking	Boadas overall liking
Control	/	++	++
RFT1	Oily and lightening aspect. Lean aspect. Darker colour than control Fat grains do not have a regular shape Taste : lower aroma than control and perceptible peppery taste	+	+
RFT2	Oily and lightening aspect. Lean aspect. Darker colour than control Fat grains have a more regular shape than RFT1 Taste : lower aroma than control and perceptible peppery taste	+/-	+/-
CIT1	Clear colour Fat grains do not have a regular shape Taste : lower and different aroma than control / perceptible peppery taste	-	+/-
CIT2	Clear colour Fat grains do not have a regular shape Taste : lower and different aroma than control / perceptible peppery taste	-	+/-
SUN	Nice aspect. Dark colour but tough texture Taste : lower aroma than control / perceptible peppery taste but **the better test in term of aroma**	++	++

Table 11: Sensorial assessment of chorizo after drying according to the strategy used to reach a SFA reduction of 60% and compared to the control

Snacks reference	Observations	ADIV overall liking	Boadas overall liking
Control	Fatty aspect. Regular shape of fat grains Sweet and aromatic taste	++	++
CH RFT2	Fat emulsion does not appear. Leaner aspect **Tougher texture** and more spicy taste than control	--	--
CH CIT2	Intermediate fatty aspect compared to control and CHRFT2 **Tougher texture** and more spicy taste than control	+/-	+/-

4.2.7 Textural properties

At the end of drying, chorizo were analysed for their textural characteristics: hardness and adhesion in figure 18, and fragility, elasticity and cohesiveness in figure 19.

Surprisingly, there is no difference of texture evaluated by physical parameters whereas sensorial assessment revealed a tougher texture when oil emulsion was added.

Figure 18: textural properties (hardness and adhesion) of chorizo after drying measured by TPA test and according to the trial

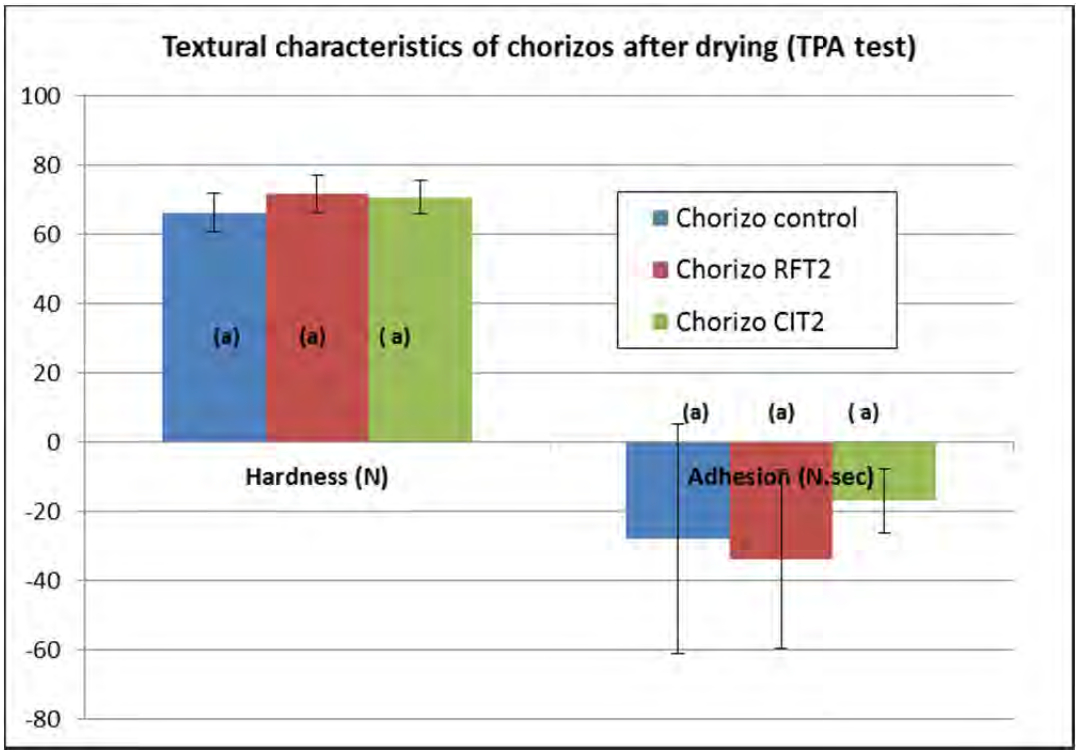
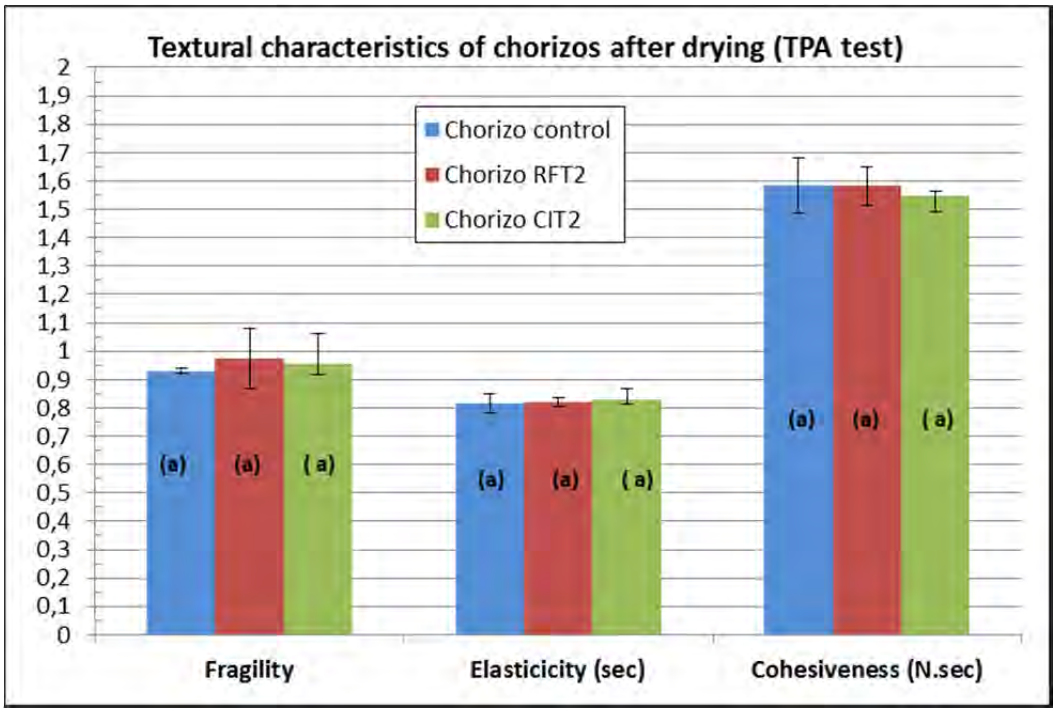


Figure 19: textural properties (fragility, elasticity and cohesiveness) of chorizo after drying measured by TPA test and according to the trial



4.2.8 Conclusion of the technological tests for SFA reduction

- 60% SFA reduction can be achieved thanks to fat emulsion addition. Nevertheless, tests have higher aw values and higher increase of pH during snack process compared to control what represents a significant microbial hazard. Tests CIT2 and SUN have particularly high water activity level due to higher humidity content but it is an artefact due to sampling.

- Using of fat emulsion leads to tougher textures for chorizos and lower flavor and spicy tastes (pepper for snacks, paprika for chorizos) for both kinds of dry sausages. Acid taste increases for chorizos what means that dextrose level has to be adjusted.

- Using of polydextrose (RFT 1 and 2) gives compared to control products, leaner aspect probably because of the lack of consistency of fat emulsions. That is a positive point for BOADAS in order to promote fat or SFA reduction towards consumers. Using of fibers gives an intermediate fatty aspect with regular fat grains. Nevertheless, aftertaste is perceptible when fibers are added to the batter. The best results in terms of aroma were succeeded with sunflower oil and fibers (SUN) even if global aroma is different from control.

- SFA reduction thanks to fat emulsion addition gave better technological and sensorial results on chorizo than on snacks.

To conclude, using of fat emulsion and fibers can be kept for the later industrial tests, but the addition level of fiber will be reduced in order to avoid aftertastes. Dextrose content (for chorizos) and spices formulation (for chorizos and snacks) correction will be performed. Also, addition of sunflower oil with fiber can be tested too at industrial level. For both conditions, formulation adjustment will have to be done in order to preserve microbial safety of products and low water activities of dried sausages (cf. “salt reduction”).

4.3 Results of the technological tests for salt reduction

Strategies for salt reduction were only tested with the snack fuet sausages.

4.3.1 Weight losses and pH evolution

For control snack fuet, the weight losses reach 45.4% at the end of drying (figure 20). Quicker weigh losses is measured in the T1 trial due to the pre-drying of sausages realized at low temperature. Conversely, slower weight losses are observed for snack fuet integrating dried meat (T21 and T22 trials) since dry matter content in these products is higher than control at the beginning of the process. T21 and T22 trials conduct to the lowest total water losses (around 39.3%).

pH evolution for pre-dried snack fuet (T1 trial) was lower than control and other trials. At the end of drying, the pH of 5.89 for T1 trial is a better opportunity to obtain an efficient microbial protection.

Figure 20: Weight losses evolution of snack fuet during the process according to the strategies used to reach a salt reduction by 30% and compared to the control

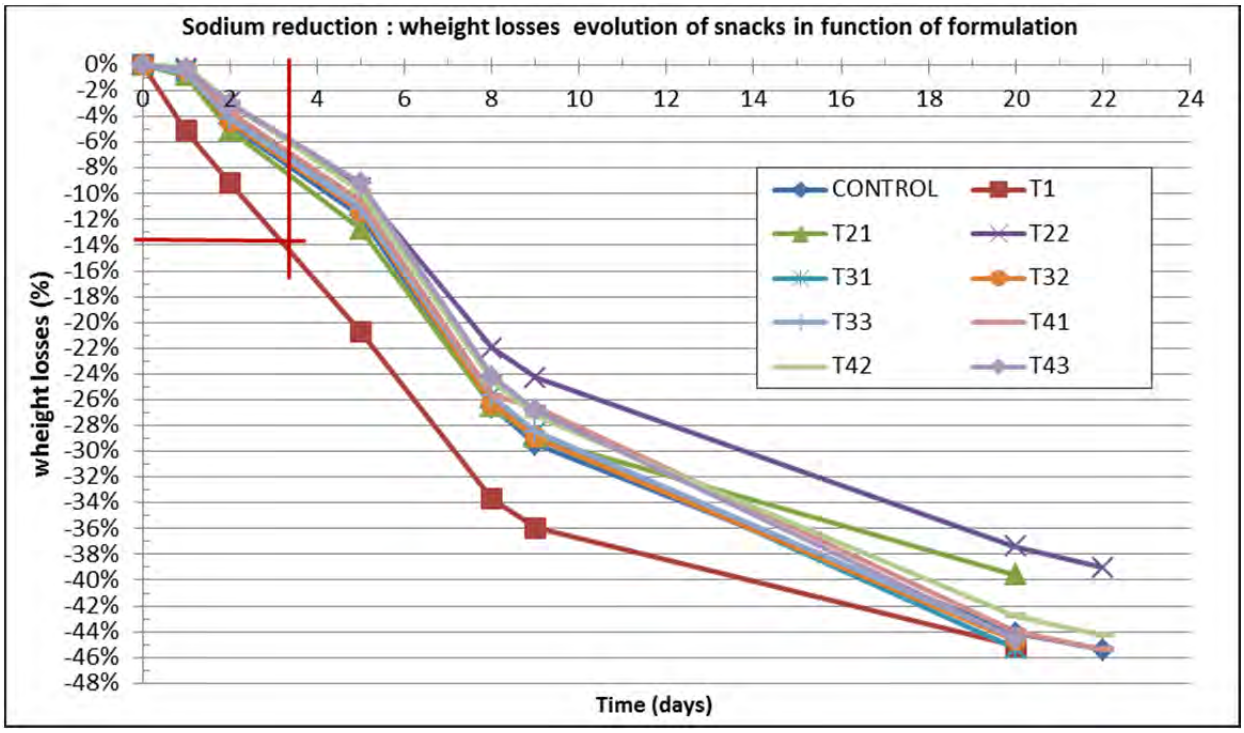
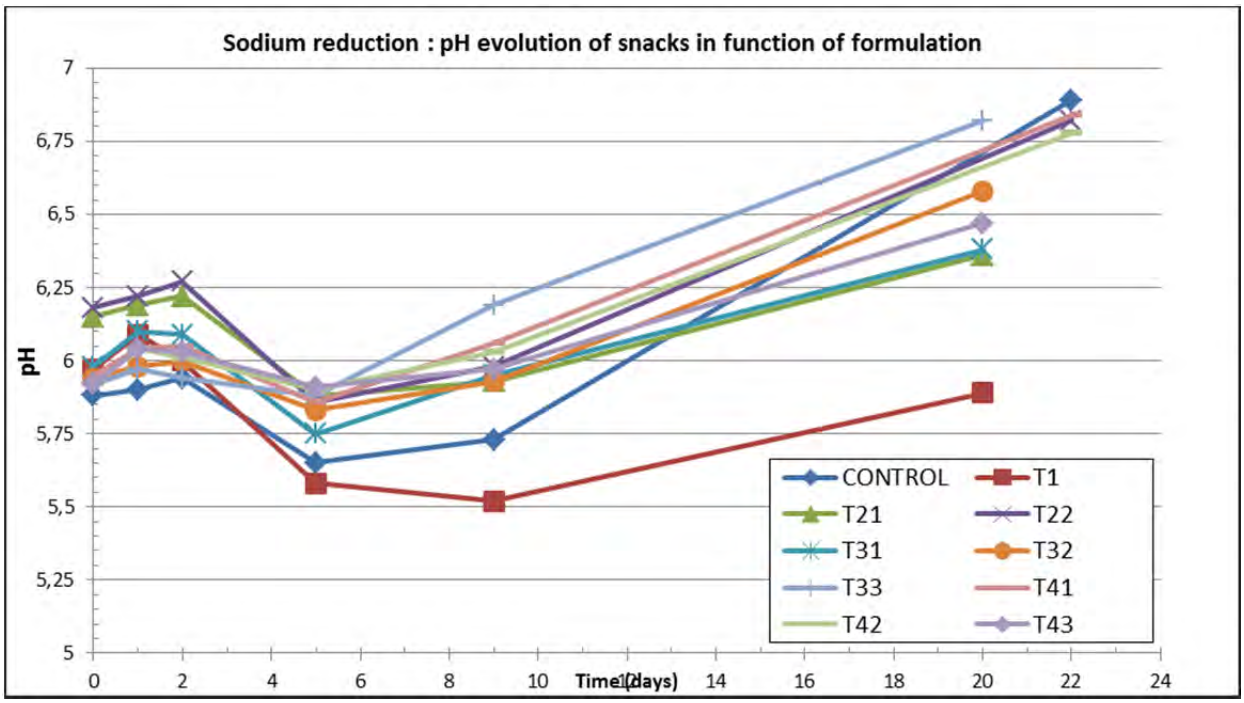


Figure 21: pH evolution of snack fuet during the process according to the strategies used to reach a salt reduction by 30% and compared to the control

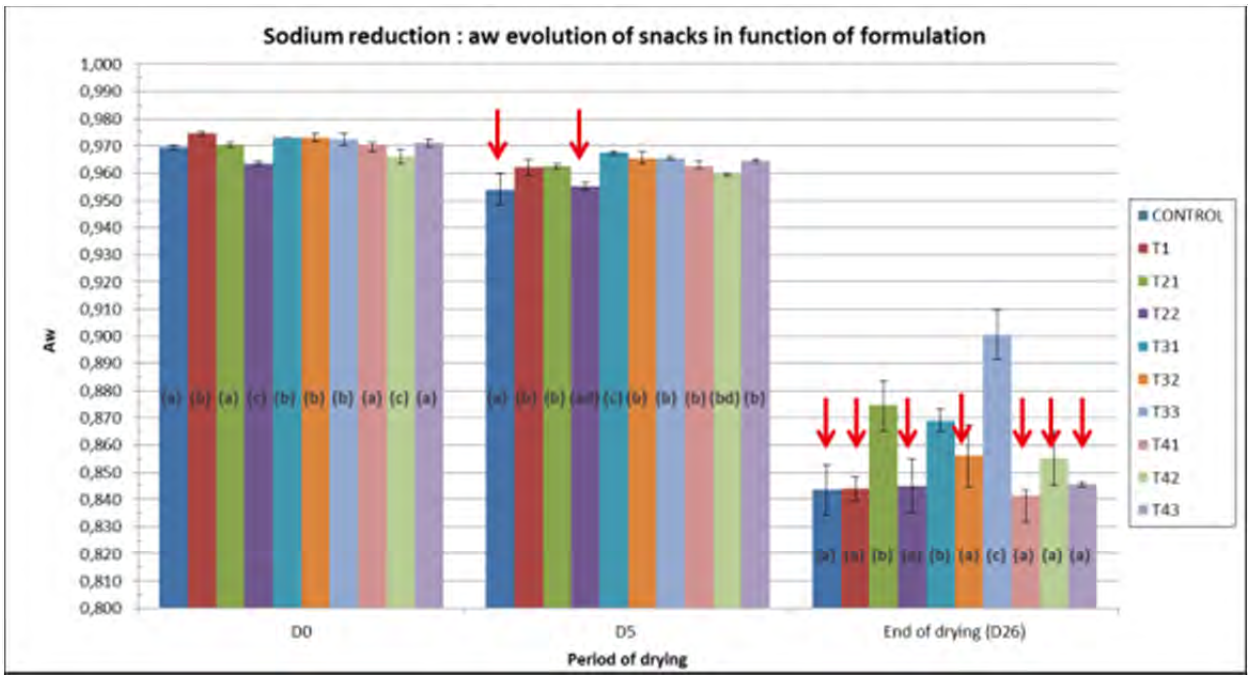


4.3.2 aw evolution

After 5 days of drying, only T22 test (dehydrated meat + KCl) keeps the same aw than control. Other tests have higher water activities (figure 22).

At the end of the drying period, T41 to T43 tests integrating the highest levels of KCl, T1 test with cold predrying with KCl addition and T22 test integrating dehydrated meat and KCl have the same aw level than control (roughly 0.845). Tests with intermediate KCl content (T31 to T33) or dehydrated meat without KCl have higher water activities (0.856 to 0.901).

Figure 22: Water activity evolution of snack fuet during the process according to the strategies used to reach a salt reduction by 30% and compared to the control



4.3.3 Chemical composition

As shown if table 12, chemical characteristics of snack fuet reduced in salt are closed to control except for the test T33, that is more humid (higher DPH value but not significant) and T1 and T21 trials seem dryer (not significant). For all trials, expected sodium reduction (-30% compared to the reference value of Spanish snack fuet) is achieved (sodium content calculated).

Table 12: Chemical composition of snack fuet according to the strategies used to reach a salt reduction by 30% and compared to the control

		CONTROL		Cold pre drying +KCl (low dose)		Dehydrated meat addition				30 % substitution by KCl (low dose of KCl)						40 % substitution by KCl (high dose of KCl)					
				T1		T21 (no KCl)		T22 (+KCl at low dose)		T31		T32 (+ yeast extract U)		T33 (+ yeast extract M)		T41		T42 (+ yeast extract U)		T43 (+ yeast extract M)	
		Mean	Std deviation	Mean	Std deviation	Mean	Std deviation	Mean	Std deviation	Mean	Std deviation	Mean	Std deviation	Mean	Std deviation	Mean	Std deviation	Mean	Std deviation	Mean	Std deviation
Wheight losses (%)	End of drying	-45.4%		-45.1%		-39.6%		-39.0%		-45.3%		-44.7%		-44.5%		-45.4%		-44.3%		-44.6%	
Aw	Before drying	0.970	0.001	0.975	0.001	0.971	0.001	0.964	0.001	0.973		0.973		0.973		0.971		0.966		0.971	
	End of drying	*0.844*	*0.009*	*0.844*	*0.004*	*0.875*	*0.009*	*0.845*	*0.010*	*0.869*	*0.004*	*0.856*	*0.011*	*0.901*	*0.009*	*0.842*	*0.002*	*0.855*	*0.010*	*0.846*	*0.001*
Humidity (%)	Before drying	57.6 (a)	*0.7*	57.8 (a)	*0.6*	52.5 (b)	*0.4*	53.0 (b)	*0.2*	57.4 (a)	*0.1*	57.4 (a)	*0.1*	57.2 (a)	*0.8*	56.8 (a)	*0.2*	55.9 (c)	*0.0*	57.9 (a)	*0.3*
	End of drying	*25.1 (a)*	*1.9*	*24.7 (a)*	*0.2*	*26.3 (a)*	*1.3*	*24.6 (a)*	*0.1*	*25.7 (a)*	*0.4*	*26.7 (a)*	*2.5*	***29.4 (b)***	*1.6*	*24.4 (a)*	*0.1*	*27.1 (a)*	*0.8*	*25.0 (a)*	*0.4*
Lipids (%)	Before drying	21.1 (a)	*1.1*	20.9(a)	*2.0*	23.4 (a)	*0.3*	21.7 (a)	*0.4*	21.3 (a)	*0.4*	21.3 (a)	*0.6*	21.9 (a)	*0.8*	21.6 (a)	*0.1*	22.9 (a)	*0.1*	19.9 (a)	*1.0*
	End of drying	*37.4 (a)*	*1.2*	*36.6 (a)*	*1.3*	*35.0 (a)*	*1.1*	*33.8 (a)*	*0.1*	*38.9 (a)*	*0.1*	*35.6 (a)*	*1.5*	*33.1 (a)*	*4.7*	*36.3 (a)*	*2.7*	*35.0 (a)*	*0.7*	*37.4 (a)*	*1.8*
DPH (%)	Before drying	73.0 (a)	*0.3*	73.1 (a)	*1.2*	68.5 (b)	*0.2*	67.6 (b)	*0.5*	72.9 (a)	*0.4*	72.8 (a)	*0.6*	73.3 (a)	*0.3*	72.5 (a)	*0.4*	72.6 (a)	*0.2*	72.4 (a)	*0.5*
	End of drying	*40.0 (a)*	*2.3*	***38.1 (a)***	*0.8*	*40.4 (a)*	*1.3*	***37.2 (a)***	*0.4*	*41.9 (a)*	*0.7*	*41.3 (a)*	*3.0*	***44.1 (a)***	*5.4*	*38.4 (a)*	*1.3*	*41.7 (a)*	*0.8*	*39.9 (a)*	*0.4*
Salt level (%) *(estimations)*	Before drying	2.5		1.5		1.5		1.5		1.5		1.5		1.5		1.5		1.5		1.5	
	End of drying	*4.2*		*3.0*		*2.3*		*2.3*		*2.6*		*2.5*		*2.5*		*2.5*		*2.5*		*2.5*	
Sodium level (%) *(estimations)*	*End of drying*	*1.7*		*1.0*		*0.9*		*0.9*		*1.0*		*1.0*		*1.0*		*1.0*		*1.0*		*1.0*	
Sodium reduction(%) (estimations)	***End of drying***	*/*		***33***		***39***		***41***		***33***		***34***		***34***		***34***		***36***		***34***	

NB : mean of 2 values per cases

Average salt content (g/100g of product) for Spanish snacks: *3.84 %*

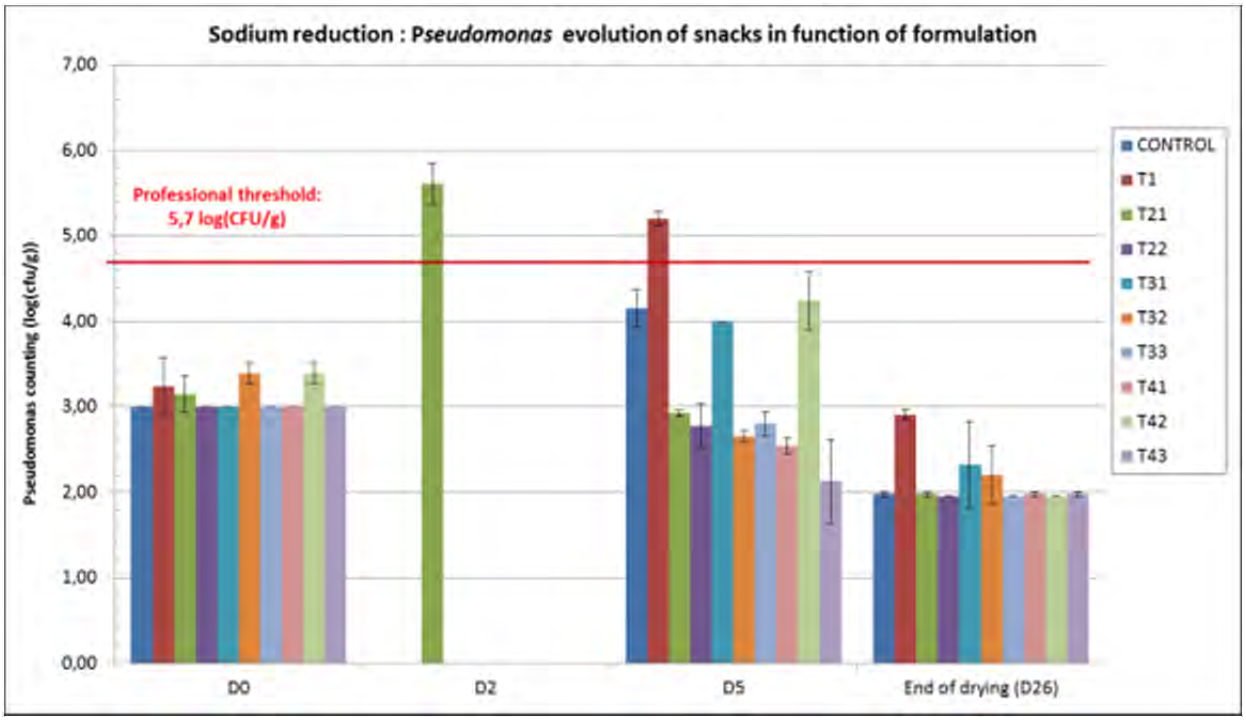
4.3.4 Microbial evolution

In control snack fuet, *Pseudomonas* evolution is characterized by an increase at day 5 and a decrease until the end of drying to reach around 3 log cfu/g (figure 23).

After 5 days of drying, *Pseudomonas* population in test T1 increase significantly due to more propitious conditions for their growth (cold temperature) during the 3-day cold pre-drying stage. Level exceeds the 5.7 log cfu/g considered as the threshold by meat professional.

At the end of the process, *Pseudomonas* counting is similar for every test except T1 that keeps a higher population, but under the threshold.

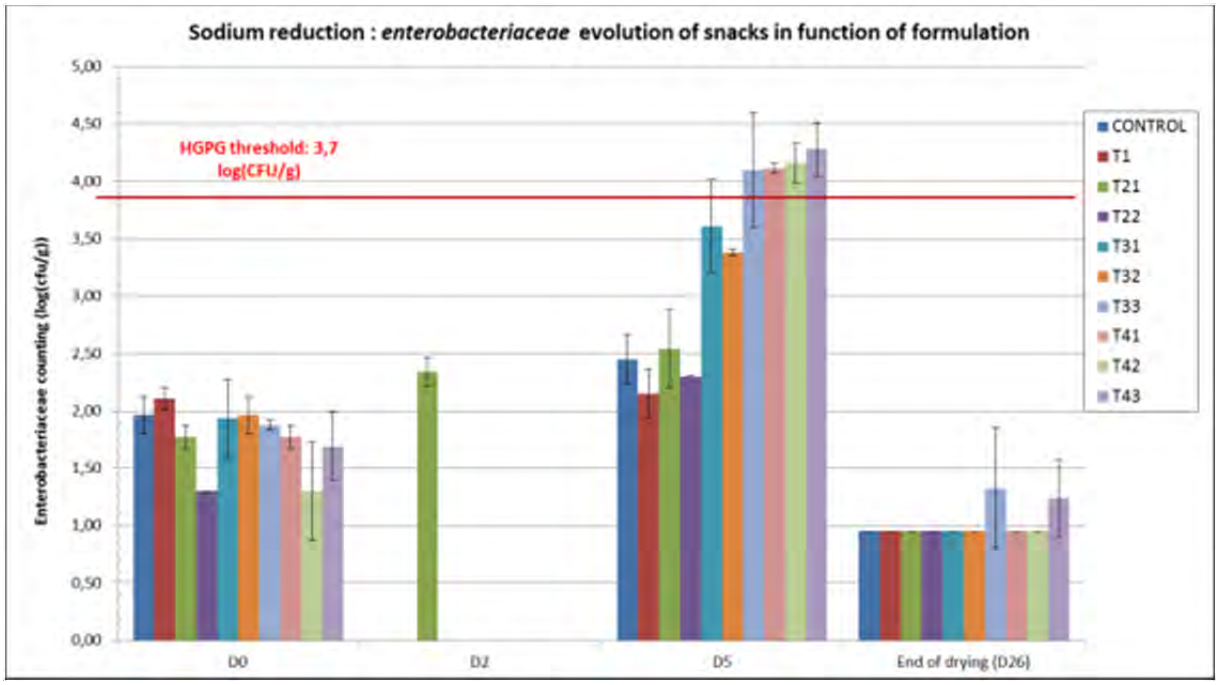
Figure 23: *Pseudomonas* **evolution of snack fuet during the process according to the strategies used to reach a salt reduction by 30% and compared to the control**



After 5 days of drying, only tests T21 and T22 (dehydrated meat addition) and T1 (KCl+cold predrying) keep the lowest *Enterobacteriaceae* populations close to control (figure 24). For the other tests, the lower salt content favours the growth of *Enterobacteriaceae* that exceeds the threshold defined by the French Hygienic Good Practise Book (HGPB).

At the end of the process, *Enterobacteriaceae* countings are lower than 1 log cfu/g for every test except T33 because of high DPH and high aw values, and test 43, potentially due to the effect of yeast extract M added in these both trials.

Figure 24: *Enterobacteriaceae* **evolution of snack fuet during the process according to the strategies used to reduce salt by 30% and compared to the control**



4.3.5 Sensorial assessment

Globally, tests for salt reduction are very satisfying in terms of sensorial appreciation (table 13). Neither metallic nor bitter tastes were detected in the different trials. Dry sausage pre-drying at low temperature (T1) and yeast extract U addition (T32 and T42) gave the best results from ADIV point of view whereas for Boadas, yeast extract M is more pleasant (T33 and T43).

The different appreciation between ADIV and BOADAS teams is probably due to the habits of Spanish population who consume snack fuet while French consumers are accustomed to the French dry sausages that is drier.

Table 13: Sensorial assessment by ADIV and BOADAS's teams of snack fuet according to the strategies used to reduce salt by 30% and compared to the control

Snacks reference	Observations	ADIV overall liking	BOADAS overall liking
Control	/ - Peppery taste – Pleasant overall aroma	+++	+++
T1	Peppery taste - Swetter taste than control	+++	+++
T21	Texture different from control (more floury). Different unpleasant taste	-	--
T22	/ - Peppery taste – Good overall aroma	+	+/-
T31	Low overall aroma - Insipid	-	++
T32	/ - Peppery taste – Pleasant overall aroma- Really close to control	+++	+/-
T33	Soft texture. Unpleasant taste (lipolysed)	- -	+++
T41	Low overall aroma - Insipid	-	+/-
T42	/ - Peppery taste – Pleasant overall aroma- Really close to control	+++	--
T43	Soft texture. Unpleasant taste (lipolysed)	- -	+++

4.3.6 Conclusion of the technological tests for salt reduction

- Cold predrying associated with KCl addition (T1) represents a good compromise in term of flavour and safety. It controls *Enterobacteriaceae* growth and allows a final water activity at low level (0.844) on dry snack fuet.
- Dehydrated meat addition alone (T21) does not provide adequate results in term of water activity (0.875). KCl (T22) has to be added in order to achieve results comparable to control. Nevertheless, flavour differences can be perceived compared to control.
- 30% salt substitution alone (T31 to T33) with or without yeasts extract have higher water activity than control (0.856 to 0.901) at the end of the process. A 40% salt substitution by KCl (T41 to T43) has to be achieved in order to keep the same water activity levels on dry products. However, even at his level, KCl does not control *Enterobacteriaceae* growth during the first 5 days of the process. Concerning flavour, yeast extract M (Tests 33 or T43) provides pleasant overall aroma.

To conclude, cold predrying associated with KCl addition (T1) and 40% salt substitution by KCl associated with yeast extract M addition (T43) can be kept for the later industrial tests and challenge tests.

Listeria growth hazard during these conditions of recipes and process has to be validated for later microbial tests (challenge tests)

4.4 Conclusion of technological tests

Technology tests demonstrate the capacity to reduce SFA or salt content in dry sausages by the formulation and/or by the process management.

Backfat substitution by vegetable oils can be used because of his high proportion in unsaturated fatty acids. Oil incorporation in recipes should be done by emulsion and fibers to manage product aspects and texture. However, the addition level of fiber will be reduced in order to avoid aftertastes. Dextrose content (for chorizos) and spices formulation (for chorizos and snacks) correction will be performed. Also, addition of sunflower oil anf fiber is another strategy to reduce SFA content. For both conditions, formulation adjustment will have to be done in order to preserve microbial safety of products and low water activities of dried sausages.

30% substitution of NaCl by KCl in the recipe associated to a 3 days period of cold predrying of sausages to reach a 15% water losses is an efficient strategy to reduce salt content without microbial hazard. Also, 40% of salt substitution by KCl associated with yeast extract addition for a flavour adjustment can be applied by industrial companies.

5. PART III: Industrial technological tests at pilot plant

5.1 Materials & methods

5.1.1 Strategies of salt and SFA reductions at pilot scale

5.1.1.1 Experimental plan for SFA and salt reduction in snacks of fuet (final tests)

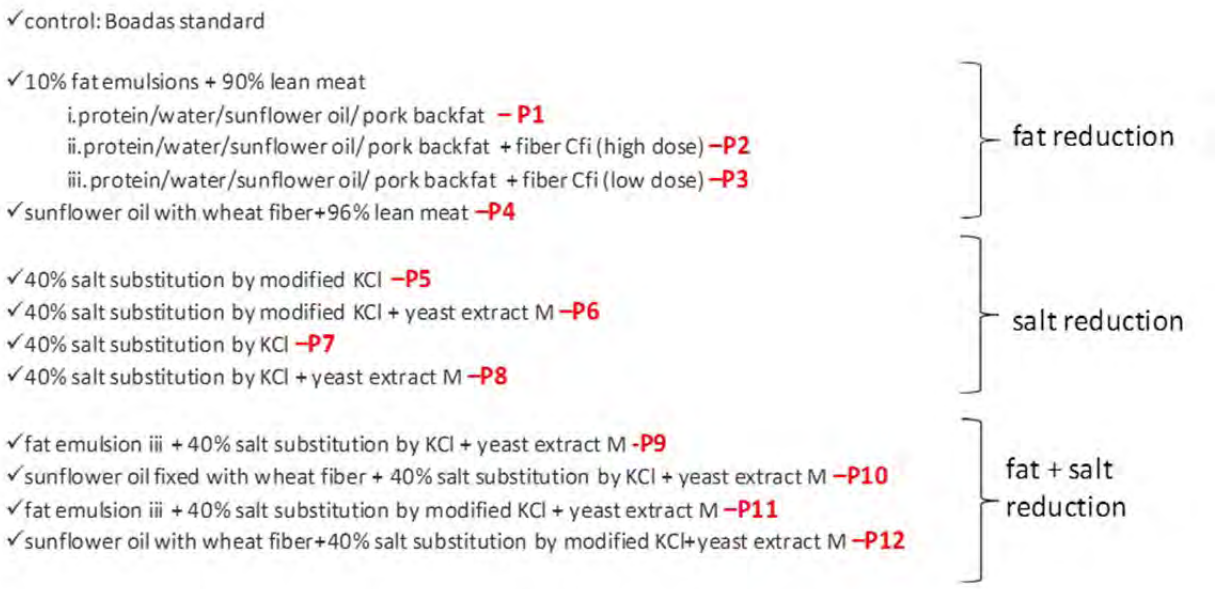
All tests are based on the results obtained previously by Boadas and ADIV and taking in account the best techno-functional qualities by monitoring the following parameters: texture, aw, pH, dry matter, microbial phenomena (technological flora and spoilage flora), peroxidation stability and sensorial properties.

Concerning the fat rate reduction, 5 different strategies have been tested in ADIV on fuet snacks and 2 of them have been selected in order to be tested in Boadas pilot plant facilities: addition of oil and fibers and addition of fat emulsions integrating sunflower oil with soluble or insoluble fibers (4 tests).

Concerning the salt rate reduction, ADIV has also tested 9 strategies on fuet snacks. Among them, 2 have been selected in order to be validated by Boadas with its industrial process: modulation of fermentation parameters by adding KCl, modified KCl or just combining addition of KCl and a flavor enhancer (yeast extract) or savory flavor (4 tests).

Also Boadas has tested different interactions between these combinations to get the project target reductions: 60% for fat and 30% for salt (4 tests)

In summary, 13 tests with repetition were elaborated. 2 identical tests were done due to the high variability of the dry cured products (variability of meat, variability in drying process…). If both tests do not present significant differences, could be concluded that results are quite reliable.



Each meat batter (control and 12 trials) contained the same rate of nitrite salt, colouring, ingredient mix and KNO_3.

Snacks of fuet process was managed to achieve a total weight loss of 45%.

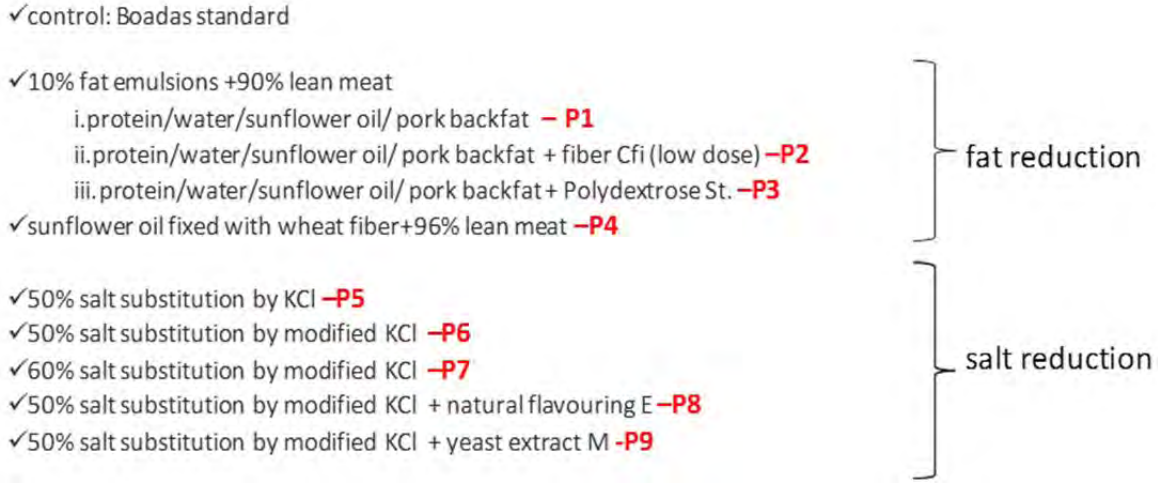
5.1.1.2 Experimental plan for SFA and salt reduction in chorizo (first tests)

Taking in account the ADIV results in fuet snacks and in chorizo, Boadas designed several new tests.

Concerning the fat rate reduction, 4 different strategies have been tested: addition of oil and fibers and addition of fat emulsions integrating sunflower oil with soluble or insoluble fibers.

Concerning the salt rate reduction, 5 different strategies have been tested: modulation of fermentation parameters while adding KCl, modified KCl or just combining addition of KCl and a flavor enhancer (yeast extract) or savory flavor.

In summary, 10 initial tests with repetition were elaborated. 2 identical tests were done due to the high variability of the dry cured products (variability of meat, variability in drying process…). If both tests do not present significant differences, could be concluded that results are quite reliable.

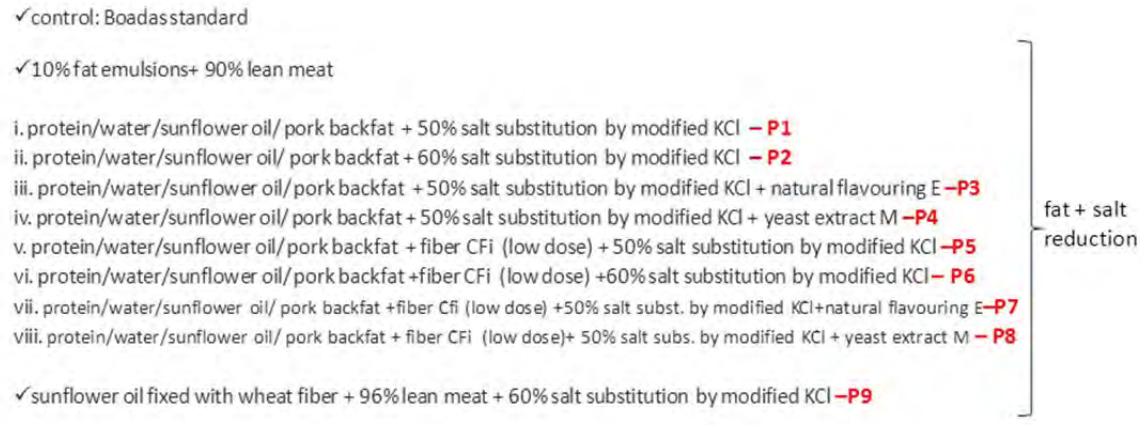


Each meat batter (control and 9 trials) contained the same rate of nitrite salt, colouring, ingredient mix and KNO_3.

Chorizo process was managed to achieve a total weight loss of 35%.

5.1.1.3 Experimental plan for SFA and salt reduction in chorizo (final tests)

After these first results, 10 final tests with repetition with the best combination results of both reductions were done. 2 identical tests were done due to the high variability of the dry cured products (variability of meat, variability in drying process…). If both tests do not present significant differences, could be concluded that results are quite reliable.



Each meat batter (control and 9 trials) contained the same rate of nitrite salt, colouring, ingredient mix and KNO_3.

Chorizo process was managed to achieve a total weight loss of 35%.

5.1.2 Products analysis

For each trials of the experimental plan for snacks of fuet and first and final chorizo tests, physical, chemical and nutritional analyses were done:

- Lipid (norm B.O.E. 29-08-1979) and humidity content (norm UNE 34552) on dry products: 1 measurement / trial (corresponding to the SFA reduction plan)
- Fatty acid profile (norm AOAC 963.22) to quantify saturated, monounsaturated and polyunsaturated fatty acids on dry products: 1 measurement / trial (corresponding to the SFA reduction plan)
- Sodium and NaCl content (norm AOAC 969.23, 990.23, 985.35) on dry products: 1 measurement / trial (corresponding to the salt reduction plan)
- Weight loss measurement on 3 pieces per test at different days until end of drying. Weight loss at day "n" is calculated thanks to the formula: weight loss $_{(day\ n)}$ (%) = 100 x (weight $_{day\ n}$ (kg) –weight$_{day\ 0}$ (kg))/ weight$_{day\ 0}$ (kg)
- pH measurement on 2 pieces per test at different days at the core of the product with pH-meter Hanna© HI 99163,
- a_w measurement on dry sausages at the end of drying. A dew point a_w-meter IC-500 AW-LAB© was used. On dry sausages, measurements were done on cylindrical cross sections without casing.
- Visual aspect of dry sausages at the end of drying
- Informal sensorial evaluation of dry products by the both ADIV and BOADAS teams.

Microbiological analyses were done to evaluate the shelf life of snacks of fuet and chorizo. Both products were packed in protective atmosphere and analysed along its shelf life.

- ✓ fuet snacks : at the beginning of the shelf life, after 2 months and after 4 months
- ✓ chorizo: at the beginning of the shelf life, after 3 months and after 5 months

Microorganisms analyzed on dry products:

- *Salmonella spp* (ISO 16140) on dry products
- *Listeria monocytognes* (ISO 16140) on dry products
- Sulphite-reducing clostridia (ISO 15213:2003) on dry products
- *Escherichia coli* (ISO 16140) on dry products
- Enterobacteria (ISO 16140) on dry products
- *Staphylococcus aureus* (ISO 6888-1) on dry products

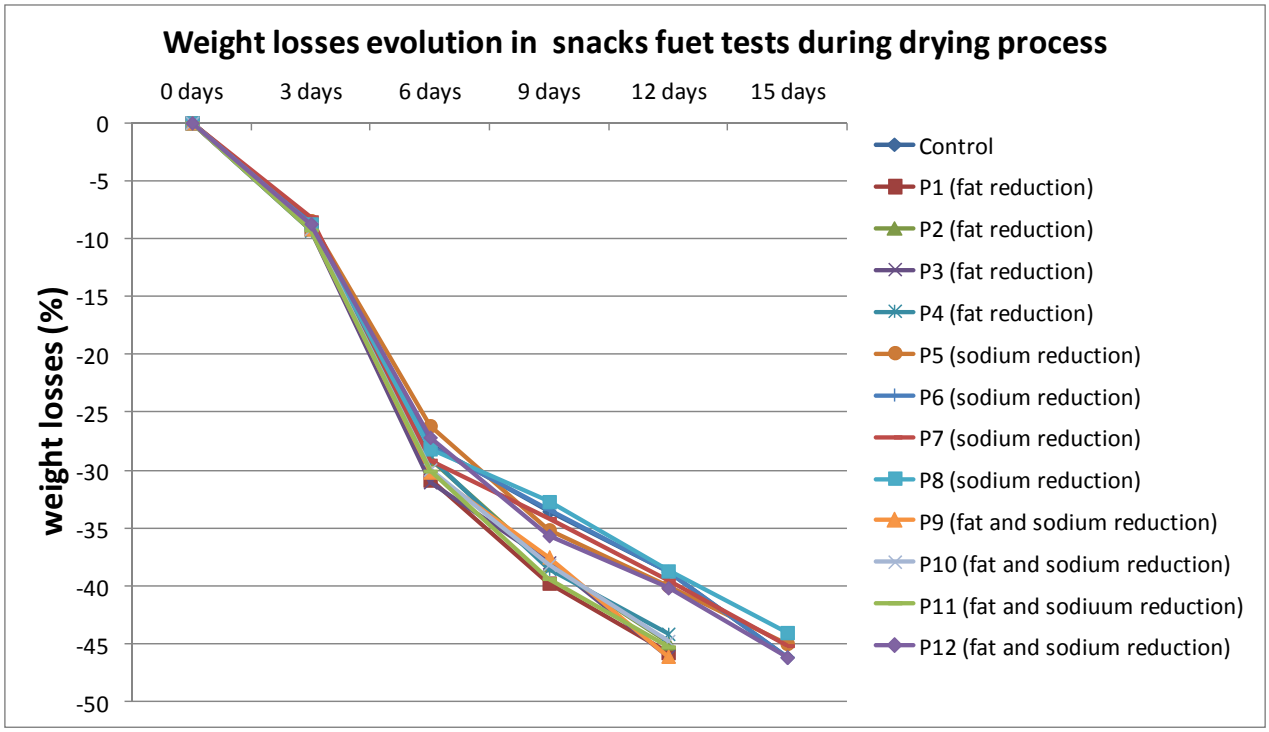
5.2 Results of the final industrial technological tests for snacks of fuet

All results are an average of the 2 performed tests (initial and repetition)

5.2.1 Weight losses evolution and a_w

In reference to the weight losses of snacks of fuet (figure 25), the results shown quicker water losses for fat reduction tests and for tests with combination of fat and salt reduction. This is due to the higher water content in test batters. However, an exception was found (P12) which water loss is similar to control.

Figure 25: Weight losses evolution of snacks of fuet tests and control during drying process



About a_w there is a bit higher a_w in salt reduction tests and in the combination sunflower oil + wheat fiber + KCl test (see table 14)

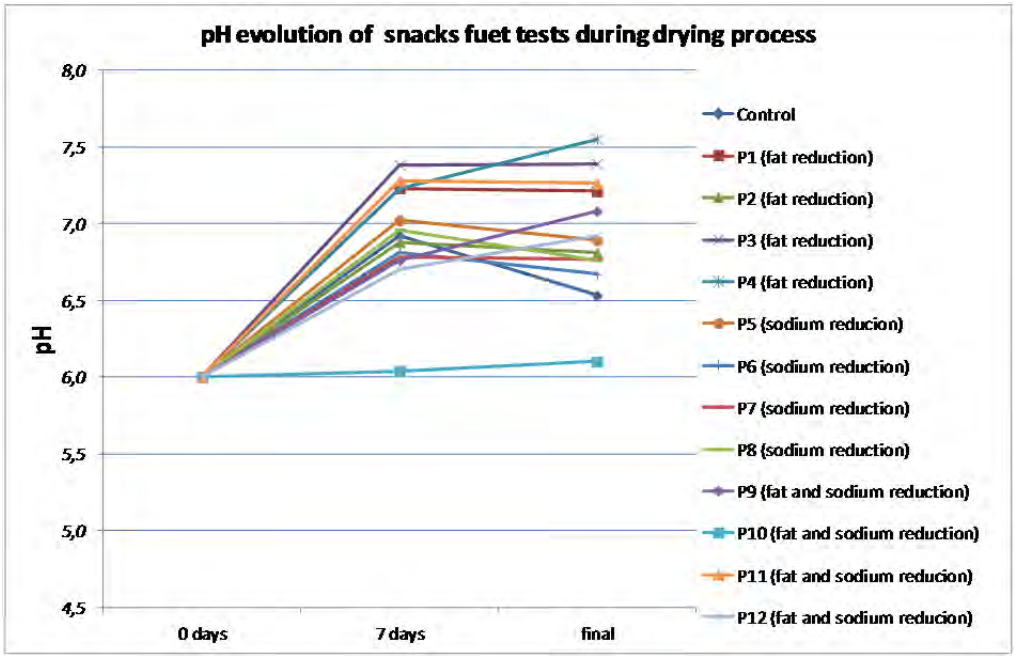
Table 14: a_w of snacks in function of formulation

TEST	TEST DESCRIPTION	a_w
control	Boadas standard	0,707
P1	fat emulsion without fiber	0,72
P2	fat emulsion + fiber Cfi (high dose)	0,707
P3	fat emulsion + fiber Cfi (low dose)	0,724
P4	sunflower oil + wheat fiber	0,716
P5	modified KCl	0,759
P6	modified KCl + yeast extract M	0,767
P7	KCl	0,745
P8	KCl + yeast extract M	0,751
P9	fat emul + fiber Cfi (low dose) + KCl + yeast extract M	0,722
P10	sunflower oil + wheat fiber + KCl + yeast extract M	0,764
P11	fat emul + fiber CfFi (low dose) + modified KCl + yeast extract M	0,721
P12	sunflower oil + wheat fiber + modified KCl + yeast extract M	0,756

5.2.2 pH evolution

The results of pH evolution for snacks of fuet tests (figure 26) demonstrate a higher increase of pH in all tests compared to control, what represents a microbial risk. But there is an opportunity to have efficient microbial results with the pre dried process at low temperature.

Figure 26: pH evolution of snacks of final tests during drying process



5.2.3 Chemical analysis

In the chemical analysis of snacks of fuet tests at the end of the drying process, we could see simultaneous reductions: more than 70% reduction in SFA and more than 35% reduction in sodium (see table 15).

Table 15: Chemical analysis results for snacks of fuet tests compared with average of market and target project

TEST	TEST DESCRIPTION	FAT	% FAT reduction	SFA	% SFA reduction	NaCl	% NaCl reduction	SODIUM	% SODIUM reduction
P1	fat emulsion without fiber CFi	34,36	-22,44	8,72	-54,35				
P2	fat emulsion + fiber Cfi (high dose)	32,82	-25,91	8,42	-55,92				
P3	fat emulsion + fiber Cfi (low dose)	20,99	-52,62	5,07	-73,46				
P4	sunflower oil + wheat fiber	24,88	-43,84	5,67	-70,31				
P5	modified KCl					2,57	-33,07	1,03	-34,81
P6	modified KCl + yeast extract M					2,45	-36,20	0,98	-37,97
P7	KCl					2,37	-38,28	0,95	-39,87
P8	KCl + yeast extract M					2,66	-30,73	1,06	-32,91
P9	fat emul fiber Cfi (low dose) + KCl + yeast extract M	20,99	-52,62	5,07	-73,46	2,66	-30,73	1,06	-32,91
P10	sunflower oil + wheat fiber + KCl + yeast extract M	24,88	-43,84	5,67	-70,31	2,66	-30,73	1,06	-32,91
P11	fat emul Fiber Cfi (low dose) + modified KCl + yeast extract M	20,99	-52,62	5,07	-73,46	2,45	-36,20	0,98	-37,97
P12	sunflower oil + wheat fiber + modified KCl + yeast extract M	24,88	-43,84	5,67	-70,31	2,45	-36,20	0,98	-37,97
Average of market		**44,30**		**19,10**		**3,84**		**1,58**	
Target of project		**31,01**		**13,37**		**2,88**		**1,18**	

5.2.4 Sensorial assesment

Globally in sensorial evaluation, all the tests have good sensory quality (table 16). In the combination tests of fat and salt reduction P10 and P12 obtained good evaluation. Especially P12 is very close to control in every criteria and besides it has the characteristic taste of fuet.

Table 16: Sensorial assessment of snacks of fuet tests and control by ADIV and Boadas team

TEST	TEST DESCRIPTION	ADIV and BOADAS sensorial evaluation	OVERALL EVALUATION	
Control	Boadas standard	Boadas standard		
P1	fat emulsion without fiber CFi	very tough texture and spicy taste, lean aspect	--	fat reduction
P2	fat emulsion + fiber Cfi (high dose)	better than P1 and P3, because the texture is close to the control. Taste is also spicy, lean aspect	+/-	
P3	fat emulsion + fiber Cfi (low dose)	better than P1 but also with tough texture and spicy taste, lean aspect	-	
P4	sunflower oil + wheat fiber	the best test of fat reduction, very good taste and texture, lean aspect	+++	
P5	modified KCl	good overall aroma	++	salt reduction
P6	modified KCl + yeast extract M	good overall aroma	+	
P7	KCl	KCl is worse than K5 in terms of taste	--	
P8	KCl + yeast extract M	better than P7, with hezelnut notes	-	
P9	fat emul fiber Cfi (low dose) + KCl + yeast extract M	lean aspect and tough texture. Perceptible bitter taste	--	fat + salt reduction
P10	sunflower oil + wheat fiber + KCl + yeast extract M	better than P9 and P11, soft texture and pleasant taste	++	
P11	fat emul fiber Cfi (low dose) + modified KCl + yeast extract M	slightly tougher texture, lean aspect and flavor close to French dry sausages	+/-	
P12	sunflower oil + wheat fiber + modified KCl + yeast extract M	very close to control on every criteria. Characteristic taste of fuet	+++	

5.2.5 Shelf life evaluation (microbiological analysis)

All the microbiological results of the fuet snacks during its shelf life are according to the legal limits. Nevertheless, the enterobacteria levels are slightly high in the reduced product (but no *Escherichia coli* growth is detected)

Table 17: Microbiological results evolution of snacks of fuet (control and reduced) during its shelf life

	Time 0 months		Time 2 months		Time 4 months (end shelf life)	
	Control (cfu/g)	Reduced (cfu/g)	Control (cfu/g)	Reduced (cfu/g)	Control (cfu/g)	Reduced (cfu/g)
Sulphithe-reducing clostridia	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 4{,}0 \times 10^{*1}$
Enterobacteria	$< 10^{*1}$	$9{,}6 \times 10^{*4}$	$< 10^{*1}$	$1{,}2 \times 10^{*2}$	$< 10^{*1}$	$< 10^{*1}$
Escherichia Coli	$< 10^{*1}$	$< 10^{*2}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$
Salmonella spp	absence/25g	absence/25g	absence/25g	absence/25g	absence/25g	absence/25g
Staphylococcus aureus	$< 10^{*2}$	$< 10^{*2}$	$< 10^{*2}$	$< 10^{*2}$	$< 10^{*2}$	$< 10^{*2}$
Listeria monocytogenes	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$

5.2.6 Conclusion of tests for snacks of fuet

- ✓ The different initial assays and repetitions didn't show significant differences, so it could be concluded that the results are quiet reliable.
- ✓ 70% reduction in saturated fatty acids (SFA) and more than 35% in sodium can simultaneously be obtained.
- ✓ Higher pH for best test compared to control, so increase of microbial risk. But unable to support the growth of *L. monocytogenes* due to lower aw (0,76).
- ✓ Possibility to have efficient microbial results with the pre-dried process at low temperature (ADIV conclusion). It will be tested at industrial scale. However, the results for microbiological pathogens throughout the shelf life of packaged snacks in protective atmosphere are correct.
- ✓ Sensorial attributes of snacks of fuet tests are very close to control in every criteria. Characteristic taste of fuet was achieved.
- ✓ The reduced fuet snacks packed in protective atmosphere have a shelf life of 4 months according to the legal limits and the microbiological test results.
- ✓ P10 and P12 are selected for sensory evaluation of product quality and consumer acceptance

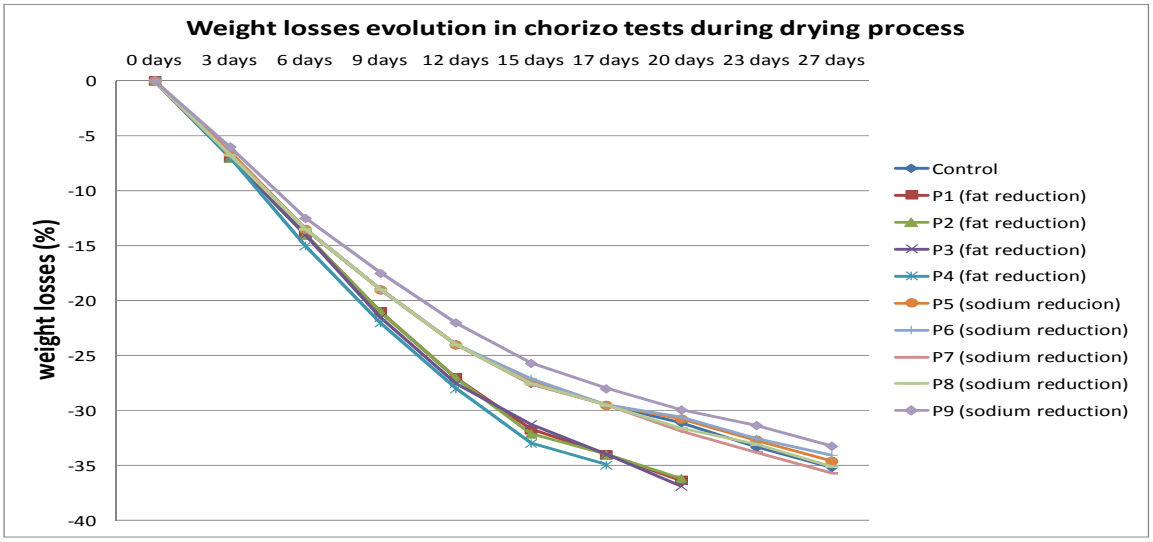
5.3 Results of the first industrial technological tests for chorizo

All the results are an average of the 2 performed tests (initial and repetition)

5.3.1 Weight losses evolution and a_w

In reference to the weight losses of chorizo tests (figure 27), the results show quicker water losses for fat reduction tests. Especially with sunflower oil and fiber due to higher water content in test batters.

Figure 27: Weight losses evolution of chorizo tests and control during drying process



About a_w there is a bit higher a_w in fat reduction tests especially in the combination sunflower oil + wheat fiber + KCl test (see table 18)

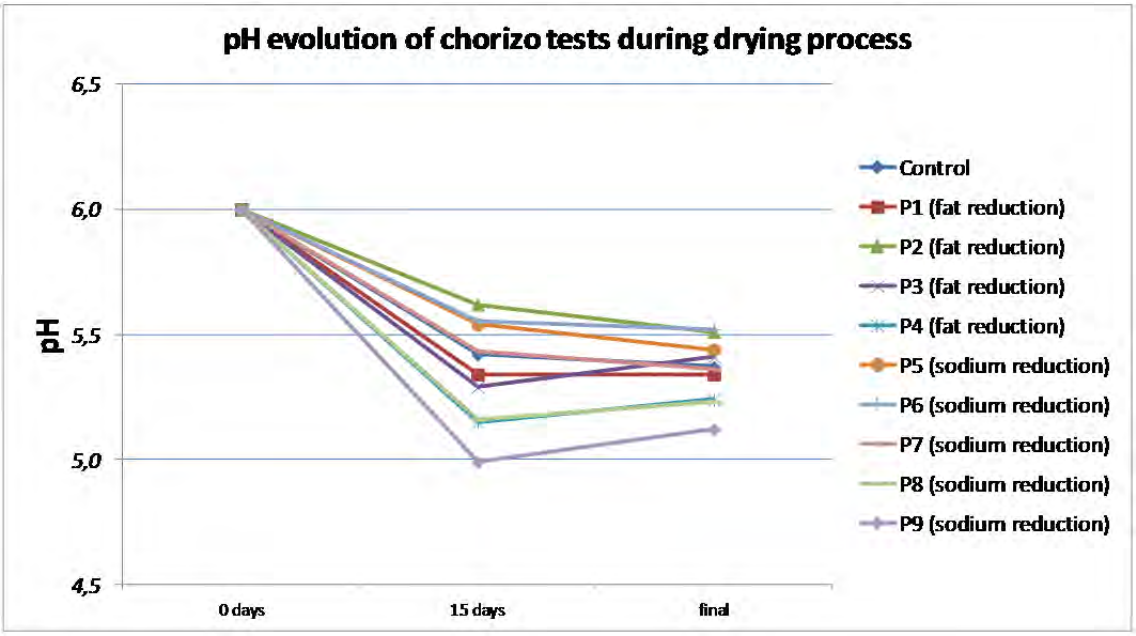
Table 18: a_w of chorizo in function of formulation

TEST	TEST DESCRIPTION	aw
control	control	0,880
P1	fat emulsion without fiber CFi	0,902
P2	fat emulsion + fiber Cfi (low dose)	0,899
P3	fat emulsion + Polydextrose St.	0,907
P4	sunflower oil + wheat fiber	0,925
P5	KCl-50%	0,877
P6	Modified KCl -50%	0,889
P7	Modified KCl -60%	0,870
P8	Modified KCl -50% + natural flavouring E	0,882
P9	Modified KCl -50% + yeast extract M	0,892

5.3.2 pH evolution

The pH results of chorizo tests during drying process (figure 28) demonstrate no significant difference between tests and control. These results cannot be compared to the ADIV ones because Boadas used a different starter less acidifying to improve the taste.

Figure 28: pH evolution of chorizo tests and control during drying process



In order to decrease pH a little bit there is the possibility to optimize the curing process or also use a pre-dried process at low temperature.

5.3.3 Chemical analysis

Table 19 shows chemical analysis results for chorizo tests after drying process compared with market average and project target. We can get more than 70% reduction in SFA reduction tests and more than 45% reduction in sodium reduction tests.

Table 19: Chemical analysis results for chorizo tests compared with market average and project target

TEST	TEST DESCRIPTION	FAT	% reduction of FAT	SFA	% reduction of SFA	NaCl	% reduction of NaCl	SODIUM	% reduction of SODIUM
P1	fat emulsion without fiber Cfi	21,68	-12,97	3,87	-59,60				
P2	fat emulsion + fiber Cfi (low dose)	22,57	-9,39	3,88	-59,50				
P3	fat emulsion + Polydextrose St.	13,29	-46,65	2,19	-77,14				
P4	sunflower oil + wheat fiber	14,92	-40,10	2,44	-74,53				
P5	KCl-50%					1,74	-49,57	0,7	-49,28
P6	modified KCl-50%					1,75	-49,28	0,7	-49,28
P7	modified KCl-60%					1,73	-49,86	0,69	-50,00
P8	modified KCl-50% + natural flavouring E					1,82	-47,25	0,73	-47,10
P9	modified KCl-50% + yeast extract M					1,61	-53,33	0,65	-52,90
Average of market		24,91		9,58		3,45		1,38	
Target of project		17,44		6,7		2,58		1,03	

5.3.4 Visual aspect of products

In relation with the visual aspect of chorizo, figure 29 shows the different aspect of the tests and control. The trials P1, P2, P3 and P4 have a leaner aspect than control.

Figure 29: Visual aspect of chorizo test at the end of drying

5.3.5 Sensorial assessment

In sensorial evaluation, in general, all the tests have good sensory quality (table 20). In fat reduction tests, two tests have good overall aroma (fat emulsion with and without fiber CFi). In salt reduction tests, three tests have good results (with modified KCl and also with yeast extract).

Table 20: Sensorial assessment of chorizo tests and control by ADIV and Boadas

TEST	TEST DESCRIPTION	ADIV and BOADAS sensorial evaluation	OVERALL EVALUATION	
Control	Boadas standard	Boadas standard		
P1	fat emulsion without fiber CFi	Lean aspect. Lower spicy taste than control	++	fat reduction
P2	fat emulsion + fiber Cfi (low dose)	Lean aspect. Better than P1 but taste but is also spicy	++	
P3	fat emulsion + Polydextrose St.	Lean aspect and tough texture	+	
P4	sunflower oil + wheat fiber	Lean aspect and very tough texture. Low overall aroma. Difficult slices separation	-	
P5	KCl-50%	Good overall aroma but at the end has perceptible bitter taste	-	salt reduction
P6	modified KCl-50%	Good overall aroma, very close to control but with less acidity than control	+++	
P7	modified KCl-60%	Good overall aroma, very close to control but with less acidity than control	+++	
P8	modified KCl-50% + natural flavouring E	Spicy taste with unpleasant taste at the end of the tasting	+/-	
P9	modified KCl-50% + yeast extract M	Good overall aroma, but is necessary to reduce aroma dosification	++	

5.3.6 Conclusions of first tests for chorizo

- ✓ The different initial assays and repetitions didn't show significant differences, so it could be concluded that the results are quiet reliable.
- ✓ 60% reduction in saturated fatty acids (SFA) and more than 45% in sodium could be achieved
- ✓ Sensorial attributes of chorizo tests are very close to control in every criteria for both tests (fat reduction and salt reduction). Characteristic taste of chorizo was achieved.
- ✓ In order to plan the new tests, combination of fat reduction + salt reduction, the best strategies of the tests done will be selected:
    - Fat emulsion without fiber CFi
    - Fat emulsion with fiber CFi but reducing % of fiber CFi
    - Modified KCl (provides to chorizo good overall aroma than KCl)
    - Addition of natural flavouring E or yeast extract M will be tested too

Possibility to have efficient microbial results with the pre-dried process at low temperature (ADIV conclusion for fuet), it will be tested in industrial scale

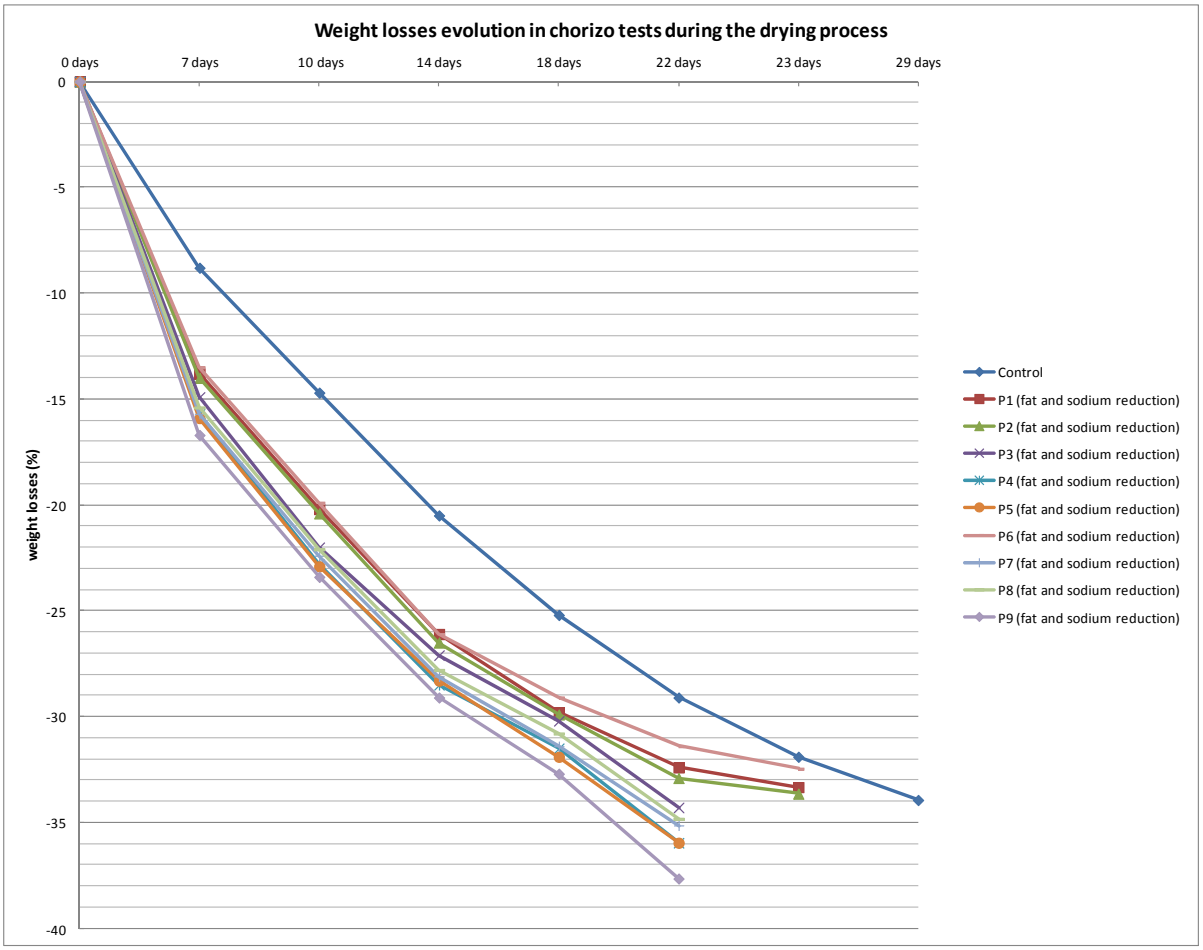
5.4 Results of the final industrial technological tests for chorizo

All the results are an average of the 2 performed tests (initial and repetition)

5.4.1 Weight losses evolution

In reference to the weight losses of chorizo tests (figure 30), the results show quicker and higher water losses for all fat and salt reduction tests. Especially with sunflower oil and fiber due to higher water content in test batters.

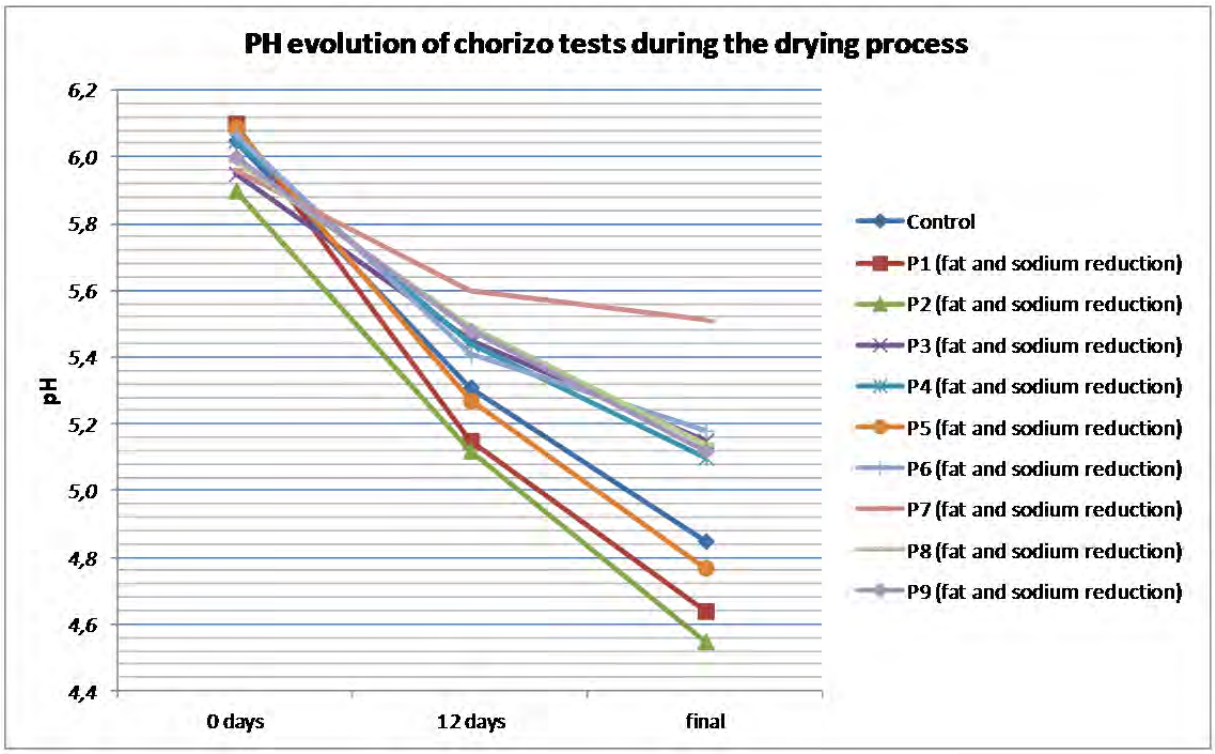
Figure 30: Weight losses evolution of chorizo tests and control during the drying process



5.4.2 pH evolution

In several tests the pH have been lower than 5, specifically the control and P1, P2 and P5 tests. In the rest of the tests the pH value has been over 5, so the microbial risk of products is higher.

Figure 31: pH evolution of chorizo tests and control during the drying process



5.4.3 Chemical analysis

In reference to the chemical analysis after drying process (table 21), we only have analysed the 2 tests with better organoleptic results. We can get more than 60% reduction in SFA reduction tests and more than 40% reduction in sodium reduction tests.

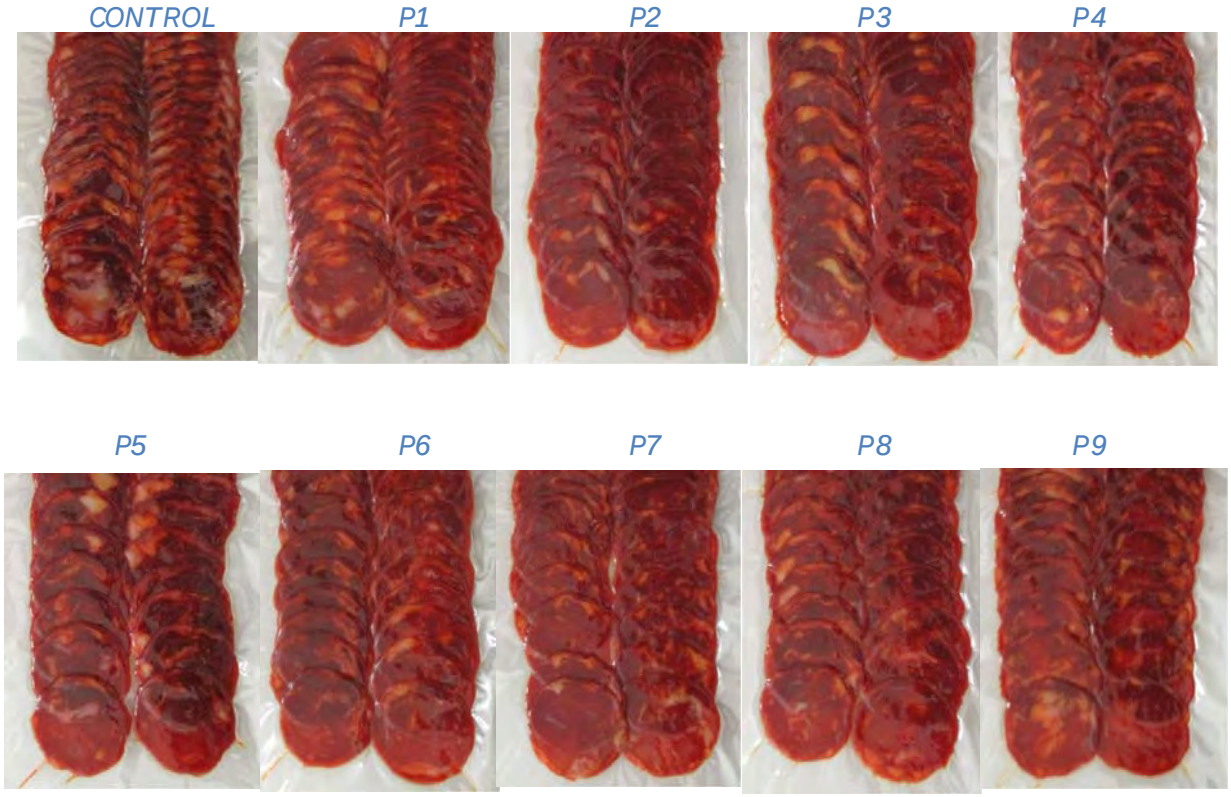
Table 21: Chemical analysis results for best organoleptic chorizo tests compared with market average and project target

Test	Description	Fat (%)	% reduction of fat	SFA (%)	% reduction of SFA	Salt (%)	% reduction of NaCl	Sodium (%)	% reduction of sodium
P1	fat emulsion and modified KCl	12,00	-51,83	3,70	-61,38	1,86	-46,09	0,74	-46,38
P2	fat emulsion and modified KCl (more reduction than P1)	11,08	-55,52	3,31	-65,45	1,35	-60,87	0,54	-60,87
Average similar products from market		24,91		9,58		3,45		1,38	
Terget for project		17,44		6,70		2,58		1,03	

5.4.4 Visual aspect of products

In relation with the visual aspect of chorizo, figure 32 shows the different aspect of the tests and control. All the tests have a leaner aspect than control. This is a positive effect from the consumer point of view and becomes a good argument to communicate and sale these nutritional products.

Figure 32: Visual aspect of chorizo tests at the end of drying process



5.4.5 Sensorial assessment

Globally, in sensorial evaluation, all the tests have good sensory quality (table 22). Firstly, the tests that contain fat emulsion and fiber CFi have worse taste than the tests that contain fat emulsion without fiber CFi. Secondly, the tests that contain natural flavoring or yeast extract are worse than the tests that do not contain them. Thirdly, the best tests from the organoleptic point of view are P1 and P2.

Table 22: Sensorial assessment of chorizo tests and control by ADIV and Boadas

TEST	TEST DESCRIPTION	ADIV and BOADAS sensorial evaluation	OVERALL EVALUATION
Control	Boadas standard	Boadas standard	
P1	Fat emulsion and modified KCl	Good overall in aroma, taste and aspect, good texture but less consistent than the control	+++
P2	Fat emulsion and modified KCl (more reduccion than P1)	Good overall in aroma, taste and aspect, good texture but less consistent than the control (we couldn't find differences between P1 and P2)	++
P3	Fat emulsion, modified KCl and natural flavouring	Good overall in aroma, taste and aspect, but less close to the control than P1 and P2	++
P4	Fat emulsion, modified KCl and yeast extract	Too strong spicy taste at the end of the tasting	+
P5	Fat emulsion with fiber Cfi (low dose) and modified KCl	Better than P4 and close to P1 but with a little bit stronger taste	++
P6	Fat emulsion with fiber CFi (low dose) and modified KCl (more reduccion than P5)	Bad taste, worse than P5	-
P7	Fat emulsion with fiber Cfi (low dose), modified KCl and natural flavouring	The taste is stronger than P5, we think it is not necessary to introduce natural flavouring in that product	+/-
P8	Fat emulsion with fiber Cfi (low dose), modified KCl and yeast extract	Bad and strong taste, this is the worst test	--
P9	Sunflower oil, wheat fiber and modified KCl	Very different taste than the Boadas Control and the other typical chorizos	+/-

5.4.6 Shelf life evaluation (microbiological analysis)

In the chorizo all the microbiological results along the shelf life are within the legal limits (see table 23).

Table 23: Microbiological results evolution of chorizo tests and control during it shelf life

	Time 0 months		Time 3 months		Time 5 months (end shelf life)	
	Control (cfu/g)	Reduced (cfu/g)	Control (cfu/g)	Reduced (cfu/g)	Control (cfu/g)	Reduced (cfu/g)
Sulphithe-reducing clostridia	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 4 \times 10^{*1}$	$< 10^{*1}$	$< 4{,}0 \times 10^{*1}$
Enterobacteria	$< 10^{*1}$	$9{,}6 \times 10^{*4}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$
Escherichia Coli	$< 10^{*1}$	$< 10^{*2}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$
Salmonella spp	absence/25g	absence/25g	absence/25g	absence/25g	absence/25g	absence/25g
Staphylococcus aureus	$< 10^{*2}$	$< 10^{*2}$	$< 10^{*2}$	$< 10^{*2}$	$< 10^{*2}$	$< 10^{*2}$
Listeria monocytogenes	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$	$< 10^{*1}$

5.4.7 Conclusion of final tests for chorizo

- ✓ The different initial assays and repetitions didn't show significant differences, could be concluded that the results are quiet reliable.

- ✓ 60% reduction in saturated fatty acids (SFA) and more than 40% in sodium can simultaneously be achieved
- ✓ Sensorial attributes of chorizo tests are very close to control in every criteria. Characteristic taste of chorizo were achieved
- ✓ The reduced sliced chorizo packed in protective atmosphere has a shelf life of 5 months according to the legal limits and the microbiological test results.
- ✓ P1 and P3 are selected for sensory evaluation of product quality and consumer acceptance

5.5 Conclusion of industrial technological tests at pilot scale

SNACKS OF FUET:

- ✓ The better tests in terms of texture and taste are with oil and fiber addition + KCl or modified KCl + flavor enhancer (yeast extract). The chemical analysis shows that 70% of SFA reduction and 35% of sodium reduction can be obtained. The sensorial evaluation of these tests (performed by ADIV and Boadas) shows that new formulations are very close to the control

CHORIZO EXTRA:

- ✓ The better tests in terms of texture and taste are with fat emulsion + modified KCl + natural flavouring. The chemical analyses show that 60% of SFA reduction and 40% of sodium reduction can be obtained. The sensorial evaluation of these tests (performed by ADIV and Boadas) shows that new formulations are very close to the control

5.6 Sensory evaluation of product quality and consumer acceptance

During the first three years of WP2, different strategies for sodium and fat reduction in dry fermented sausages have been tested, by ADIV and Boadas 1880. Combined reductions of sodium and fat have also been tested, and trials where compensatory actions will be tested have been planned.

Consumer acceptance testing will only be performed on products that have satisfactory sensorial and shelf life properties. For sensory evaluation and consumer acceptance testing, a reference recipe will always be included in order to compare the nutritionally improved dry fermented sausage with today's standard dry fermented product.

5.6.1 Sensory analysis of snacks of fuet made for expert judges (assessors)

5.6.1.1 Material & methods

The sensorial tests have been defined to be done according the task 2.5 "evaluation of product quality and consumer acceptance". We send to the 10 judges (assessors) selected and trained according to ISO 8586-1 and 8586-2, the 2 better tests of reduced snacks of fuet (P10 and P12) and the control, to evaluate the sensory profile (QDA)

OBJECTIVE:

Valuation and comparison of three samples of Snacks of fuet. Verify their perception between 10 qualified tasters, describing and valuating different samples.

OPERATIONAL TECHNIQUE:

The samples to analyzing have been presented to 10 qualified tasters, before selected in agreement with the tests defined by the NORM UNE 87003: Sensory analysis. General guide for the selection, training and judges control.

For the variable response, there are two types of scales of punctuation in use. The used procedures are realized following the dispositions of the NORM UNE 87020: sensory Analysis. Methodology. Evaluation of the food products for methods that use scales:

Descriptive criteria of intensity: Criteria where there describes the degree of perception of the attribute by means of a single-pole / two-pole scale from 1 to 9 (from minimum to maximum):

Aspect/Color (1.Pale - 9.Intense) (1.Greasy- 9.Lean) (1.Not uniform color - 9.Uniform)

Smell (1.Weak - 9.Pronounced) (1.Not balanced - 9.Balanced)

Texture (1.Soft - 9.Firm) (1.Slightly juicy - 9.Juicy)

Flavor (1.Weak - 9.Pronounced) (1. Not balanced - 9. Balanced)

Residual Flavor (1.Weak - 9.Pronounced)

Criteria of valuation: Criteria where an attribute is valued with punctuation from 1 to 9 (from minimal satisfaction to maximum satisfaction):

Valuation of the aspect / color

Valuation of the smell

Valuation of the texture

Valuation of the flavor

Valuation of residual flavor

Global valuation

LEVEL OF SIGNIFICANCE USED:

The significance level is the probability of error (between 0 and 1) on affirming the alternative hypothesis. Otherwise said, the effect of the studied factor exists and the level averages significantly differ. Therefore, if the error is lower than 0.05 we can claim that effect of the factor exists and also that the averages differ significantly with a probability higher of 95 %.

The level of significance used is equal or lower than 0.05.

PRESENTATION OF THE SAMPLES:

The samples appear trivialized, without brands or signs that could be tracks of identification of some brand or product.

Only the samples have been presented to the judges.

PLACE OF THE TEST:

The tests have been realized in a room of degustation provided with cabins or stalls defined by agreement by the NORM UNE 87004.

IDENTIFICATION OF THE SAMPLES:

Figure 33: Sample control

Sample 1:

Mark: CONTROL

Code in the test: 102

Denomination: SNACKS FUET CONTROL

Batch: 036

Expiration date: 05/06/15

Temperature at tasting: Ambient

Preparation: Presentation in codified plate of plastic

Sample 2:

Figure 34: Sample test P10

Mark: PROVA 10

Code in test: 456

Denomination: SNACKS FUET PROVA 10

Batch: 036

Expiration date: 05/06/15

Temperature at tasting: Ambient

Preparation: Presentation in codified plate of plastic

Sample 3:

Figure 35: Sample test P12

Mark: PROVA 12

Code in test: 789

Denomination: SNACKS FUET PROVA 12

Batch: 036

Expiration date: 05/06/15

Temperature at tasting: Ambient

Preparation: Presentation in codified plate of plastic

5.6.1.2 Results

TABLES AND GRAPHICS OF RESULTS:

Table 24: Organoleptic criteria of evaluation

CRITERIA/SAMPLES	CONTROL (102)	PROVA 10 (456)	PROVA 12 (789)	*
ASPECT/COLOR Average Standard deviation DIFFERENT OF: **	**6.20** 1.75	**6.30** 1.25	**6.40** 1.26	**NO**
SMELL Average Standard deviation DIFFERENT OF: **	**5.40** 1.77	**6.10** 1.66	**6.80** 1.03	**NO**
TEXTURE Average Standard deviation DIFFERENT OF: **	**5.10** 2.23	**5.90** 0.87	**5.60** 1.26	**NO**
FLAVOR Average Standard deviation DIFFERENT OF: **	**5.90** 1.91	**6.70** 0.48	**6.80** 0.91	**NO**
RESIDUAL FLAVOR Average Standard deviation DIFFERENT OF: **	**5.10** 2.02 (789)	**6.30** 0.48	**7.00** 0.00 (102)	**YES**
GLOBAL VALUATION Average Standard deviation DIFFERENT OF: **	**5.50** 1.84 (789)	**6.40** 0.51	**7.10** 0.87 (102)	**YES**

* Are there significant differences of valuation between three samples? (Analysis of the variance)

** DIFFERENT OF: valued sample significantly different according to analysis of the variance

ALL THE CRITERIA: Hedonic scale between 1 and 9

The Standard Deviation indicates the dispersion of the information; to minor value of the Deviation it implies more agreement between the tasters with regard to the average note.

Table 25: Descriptive criteria of intensity

CRITERIOS/MUESTRAS	CONTROL (102)	PROVA 10 (456)	PROVA 12 (789)	*
COLOUR (1.Pale - 9.Dark) Average Standard deviation DIFFERENT OF: **	**6.10** 0.87	**6.30** 0.94	**6.50** 1.35	**NO**
ASPECT (1.Greasy - 9.Loin) Average Standard deviation DIFFERENT OF: **	**6.30** 1.25	**5.90** 1.44	**5.70** 1.94	**NO**
COLOUR (1.Not uniform - 9.Uniform) Average Standard deviation DIFFERENT OF: **	**5.90** 1.19	**6.20** 1.03	**6.20** 1.03	**NO**
SMELL(1.Weak - 9.Pronounced) Average Standard deviation DIFFERENT OF: **	**7.50** 0.70	**6.50** 1.08	**6.50** 1.95	**NO**
SMELL (1.Not balanced - 9.Balanced) Average Standard deviation DIFFERENT OF: **	**4.60** 1.50 (789)	**5.60** 1.07	**6.60** 0.51 (102)	**YES**
TEXTURE (1.Soft – 9.Firm) Average Standard deviation DIFFERENT OF: **	**5.00** 1.63	**6.40** 0.96	**5.70** 1.25	**NO**
TEXTURE (1.Slightly juicy – 9.Juicy) Average Standard deviation DIFFERENT OF: **	**5.60** 1.89	**5.80** 1.03	**5.60** 2.06	**NO**
FLAVOR (1.Weak–9. Pronounced) Average Standard deviation DIFFERENT OF: **	**5.60** 1.89	**5.70** 0.94	**6.00** 2.00	**NO**
FLAVOR (1. Not balanced - 9.Balanced) Average Standard deviation DIFFERENT OF: **	**5.00** 1.63	**5.80** 1.31	**6.30** 0.94	**NO**
RESIDUAL FLAVOR (1.Weak - 9.Pronounced) Average Standard deviation DIFFERENT OF: **	**5.20** 1.81 (789)	**6.20** 0.96	**6.90** 0.87 (102)	**YES**

* Are there significant differences between three samples? (Analysis of the variance)

** DIFFERENT OF: described sample significantly different according to analysis of the variance

ALL THE CRITERIA Descriptive Scale of intensity single-pole or two-pole between 1 and 9

GRAPHICS OF VALUATION ORGANOLEPTIC CRITERIA:

Figure 36: Graphics criteria of organoleptic valuation (Average – (Hedonic scale between 1 and 9)

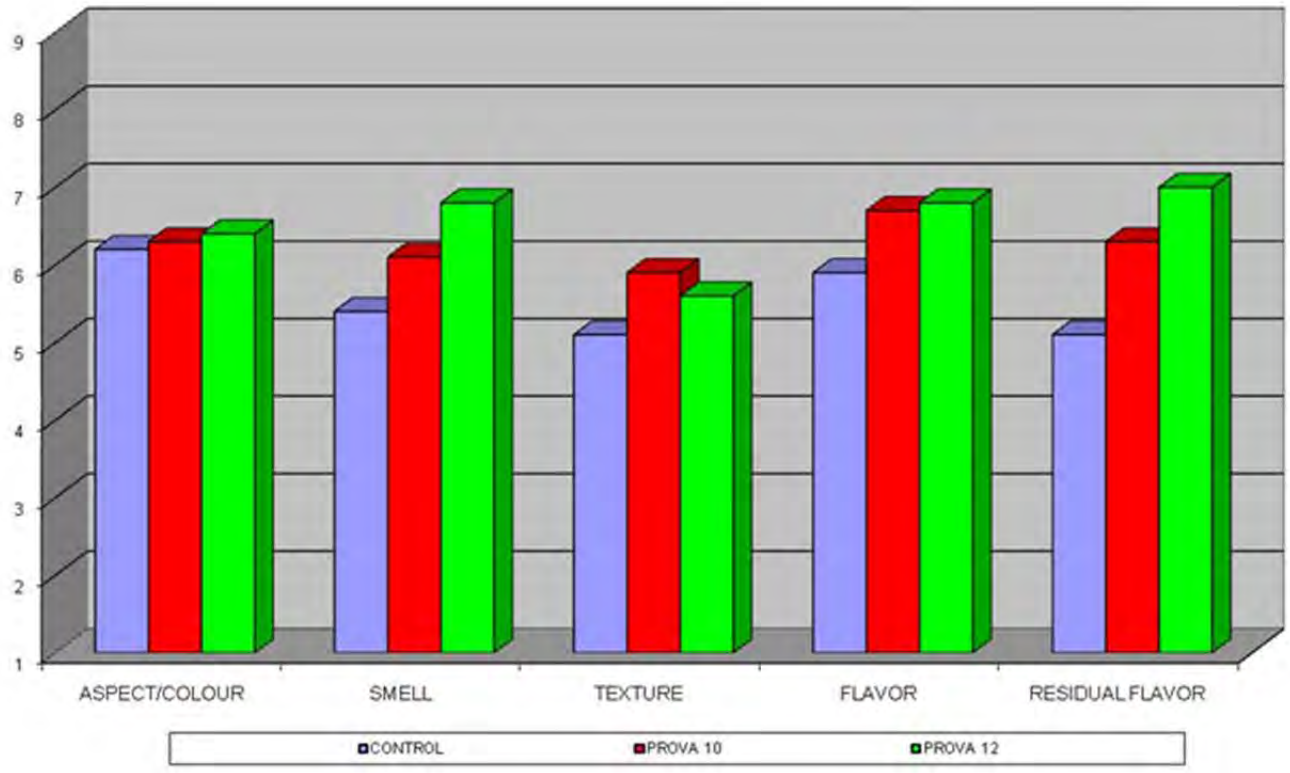


Figure 37: Graphics Global valuation (Average – (Hedonic scale between 1 and 9)

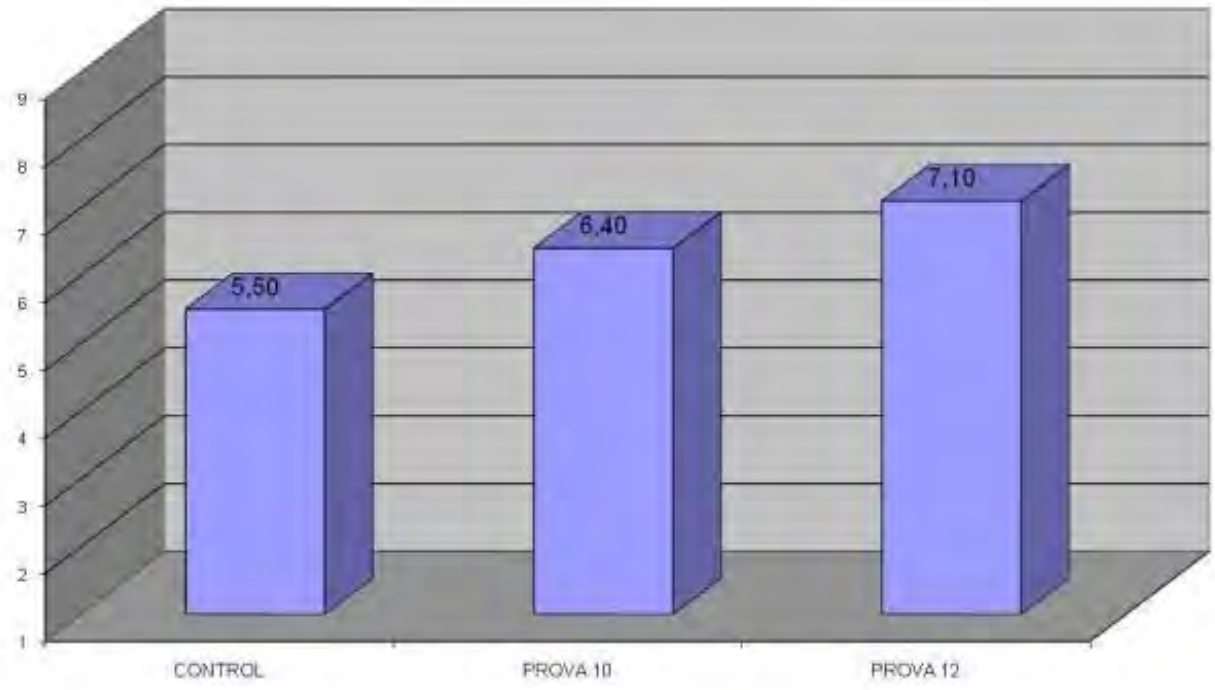
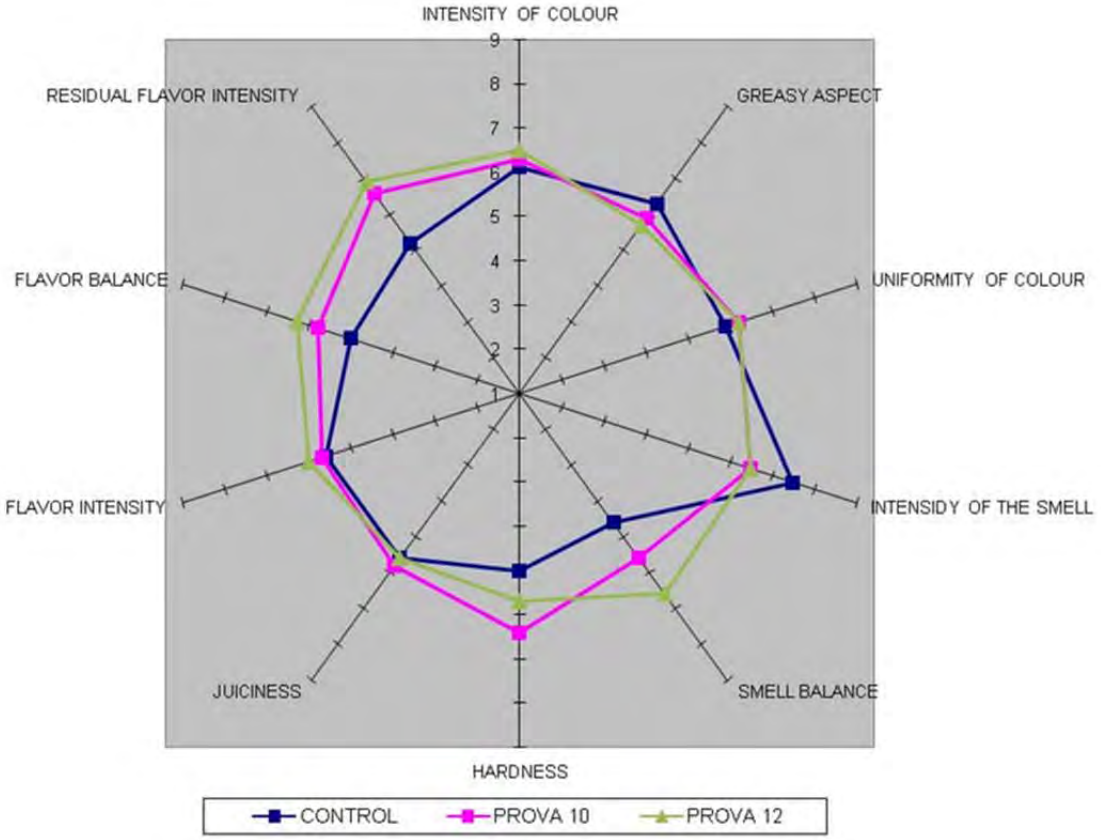


Figure 38: Graphics of description of intensity



5.6.1.3 Conclusions

The results of this comparative study revealed the following assessments:

ASPECT/COLOUR

- ✓ Significant differences have not been detected with regard to the aspect and color between the three samples, which obtain averages between 6 and 6.50
- ✓ Three samples have been considered of typical color, with a color of reddish own lean of the product and uniformly enough
- ✓ As for the proportion greasy/lean they are not considered to have big differences between three samples.

SMELL

- ✓ There have not given significant differences of valuation between three samples as for the smell. Nevertheless, the sample control is the worst valued one with an average of 5.40, whereas prova 12 (P12) obtains 6.80 and prova 10 (P10) 6.10

- ✓ Three samples have been described of a typical smell, intense, clear and spiced to the point. Nevertheless, the sample control has been considered by some judges as less balanced, whereas prova 12 as the most balanced, describing the sample control as too hard as for its intensity

TEXTURE

- ✓ Neither it can be affirmed significant differences of valuation not descriptive between three samples as for its texture

- ✓ The sample prova 10 obtains an average valuation of 5.90, followed by prova 12 with 5.60 and of the sample control with 5.10

- ✓ The three samples have been considered of appropriate texture, relatively juicy and uniform. Nevertheless, for the sample control, is commented by a part of some judges that its texture is slightly softer

FLAVOR – RESIDUAL FLAVOR

- ✓ The judges do not appreciate significant differences of valuation not descriptive between three samples as for the valuation of its flavor. Nevertheless, the sample control obtains an average of 5.90, whereas the prova 12 and prova 10 obtain averages of 6.80 and 6.70 respectively

- ✓ As for the residual flavor, the average valuations are more extreme than those of the flavor. Hereby, the sample control obtains an average valuation of 5.10, differing significantly from the prova 12 that obtains 7. The prova 10 places in an intermediate position with 6.30

- ✓ The three samples have been considered of a typical flavor, of spiced balanced, intense enough and of suitable acidity. On the other hand, for the residual flavor, the sample control has been considered to be too weakly and that disappears too fast, by what it has been penalized, in spite of the fact that initially its flavor can seem to be strong

GLOBAL VALUATION / GLOBAL POSITIONING

- ✓ We can affirm significant differences of global Valuation in favour of prova 12, that it obtains an average of 7.10, followed by the PROVA 10, with an average of 6.40. The sample control has obtained a global average of 5.50, being the worst valued one of significant form.

- ✓ The Global Positioning * of the samples is the following one:

  1ª: PROVA 12

  2ª: PROVA 10

  3ª: CONTROL

*** If the samples are in the same box, it implies that they cannot affirm significant global differences of positioning between them.**

5.6.2 Sensory analysis of chorizo made for expert judges (assessors)

5.6.2.1 Material & methods

The sensorial tests have been defined to be done according the task 2.5 "evaluation of product quality and consumer acceptance". We send to the 10 judges (assessors) selected and trained according to ISO 8586-1 and 8586-2, the 2 better tests of reduced chorizo (P1 and P3) and the control, to evaluate the sensory profile (QDA)

OBJECTIVE:

Valuation and comparison of three samples of chorizo. Verify their perception between 10 qualified tasters, describing and valuating different samples.

OPERATIONAL TECHNIQUE:

The samples to analyzing have been presented to 10 qualified tasters, before selected in agreement with the tests defined by the NORM UNE 87003. Sensory analysis. General guide for the selection, training and judges control.

For the variable response, there are two types of scales of punctuation in use. The used procedures are realized following the dispositions of the NORM UNE 87020: sensory Analysis. Methodology. Evaluation of the food products for methods that use scales:

Descriptive criteria of intensity: Criteria where there describes the degree of perception of the attribute by means of a single-pole / two-pole scale from 1 to 9 (from minimum to maximum):

Aspect/Color (1.Pale - 9.Intense) (1.Greasy- 9.Lean) (1.Not uniform color - 9.Uniform)

Smell (1.Weak - 9.Pronounced) (1.Not balanced - 9.Balanced)

Texture (1.Soft - 9.Firm) (1.Slightly juicy - 9.Juicy)

Flavor (1.Weak - 9.Pronounced) (1. Not balanced - 9. Balanced)

Residual Flavor (1.Weak - 9.Pronounced)

Criteria of valuation: Criteria where an attribute is valued with punctuation from 1 to 9 (from minimal satisfaction to maximum satisfaction):

Valuation of the aspect / color

Valuation of the smell

Valuation of the texture

Valuation of the flavor

Valuation of residual flavor

Global valuation

LEVEL OF SIGNIFICANCE USED:

The significance level is the probability of error (between 0 and 1) on affirming the alternative hypothesis. Otherwise said, the effect of the studied factor exists and the level averages significantly differ. Therefore, if the error is lower than 0.05 we can claim that effect of the factor exists and also that the averages differ significantly with a probability higher of 95 %.

The level of significance used is equal or lower than 0.05.

PRESENTATION OF THE SAMPLES:

The samples appear trivialized, without brands or signs that could be tracks of identification of some brand or product.

Only the samples have been presented to the judges.

PLACE OF THE TEST:

The tests have been realized in a room of degustation provided with cabins or stalls defined by agreement by the NORM UNE 87004.

IDENTIFICATION OF THE SAMPLES:

Figure 39: Sample control

Sample 1:

Mark: CONTROL

Code in the test: 333

Denomination: CHORIZO CONTROL

Batch: 056

Expiration date: 25/06/15

Temperature at tasting: 10ºC

Preparation: Presentation in codified plate of plastic

Figure 40: Sample test P1

Sample 2:

Mark: PROVA 1

Code in test: 221

Denomination: CHORIZO PROVA 1

Batch: 056

Expiration date: 25/06/15

Temperature at tasting: 10ºC

Preparation: Presentation in codified plate of plastic

Sample 3:

Mark: PROVA 3

Code in test: 879

Denomination: CHORIZO PROVA 3

Batch: 056

Expiration date: 25/06/15

Temperature at tasting: 10ºC

Preparation: Presentation in codified plate of plastic

Figure 41: Sample test P3

5.6.2.2 Results

TABLES AND GRAPHICS OF RESULTS:

Table 26: Organoleptic criteria of evaluation

CRITERIA/SAMPLES	CONTROL (333)	PROVA 1 (221)	PROVA 3 (879)	*
ASPECT/COLOR Average Standard deviation DIFFERENT OF: **	**7.20** 0.63	**6.30** 1.25	**6.00** 1.33	**NO**
SMELL Average Standard deviation DIFFERENT OF: **	**6.80** 0.42	**6.00** 0.81	**6.60** 1.17	**NO**
TEXTURE Average Standard deviation DIFFERENT OF: **	**6.20** 2.39	**6.70** 0.48	**6.30** 0.48	**NO**
FLAVOR Average Standard deviation DIFFERENT OF: **	**7.30** 0.82	**6.50** 1.35	**6.10** 1.28	**NO**
GLOBAL VALUATION Average Standard deviation DIFFERENT OF: **	**6.90** 0.87	**6.40** 1.17	**6.20** 1.31	**NO**

* Are there significant differences of valuation between three samples? (Analysis of the variance)
** DIFFERENT OF: valued sample significantly different according to analysis of the variance

ALL THE CRITERIA: Hedonic scale between 1 and 9

The Standard Deviation indicates the dispersion of the information; to minor value of the Deviation it implies more agreement between the tasters with regard to the average note

Table 27: Descriptive criteria of intensity

CRITERIA/SAMPLES	CONTROL (333)	PROVA 1 (221)	PROVA 3 (879)	*
COLOR (1.Pale - 9.Intense) Average Standard deviation DIFFERENT OF: **	**6.50** 1.08	**6.20** 0.42	**6.30** 2.11	**NO**
ASPECT (1.Greasy - 9.Loin) Average Standard deviation DIFFERENT OF: **	**2.90** 1.10 (879)	**4.00** 1.05 (879)	**6.80** 1.03 (333)(221)	**YES**
ASPECT **(1.Regular hash - 9.Irregular hash)** Average Standard deviation DIFFERENT OF: **	**5.50** 1.17	**5.40** 1.50	**5.20** 2.04	**NO**
SMELL (1.Weak - 9.Pronounced) Average Standard deviation DIFFERENT OF: **	**6.70** 0.48	**5.80** 1.03	**5.80** 1.61	**NO**
TEXTURE (1.Soft – 9.Tough) Average Standard deviation DIFFERENT OF: **	**5.80** 1.75	**6.20** 1.47	**6.40** 1.71	**NO**
FLAVOR (1.Insipid – 9.Flavourful) Average Standard deviation DIFFERENT OF: **	**7.40** 0.51	**7.00** 0.00	**6.60** 1.77	**NO**
FLAVOR **(1.Not balanced – 9.Balanced)** Average Standard deviation DIFFERENT OF: **	**7.00** 0.00	**7.10** 0.73	**6.80** 1.39	**NO**

* Are there significant differences between three samples? (Analysis of the variance)

** DIFFERENT OF: described sample significantly different according to analysis of the variance

ALL THE CRITERIA: Descriptive Scale of intensity single-pole or two-pole between 1 and 9

GRAPHICS OF VALUATION ORGANOLEPTIC CRITERIA:

Figure 42: Criteria of organoleptic valuation (Average – (Hedonic scale between 1 and 9)

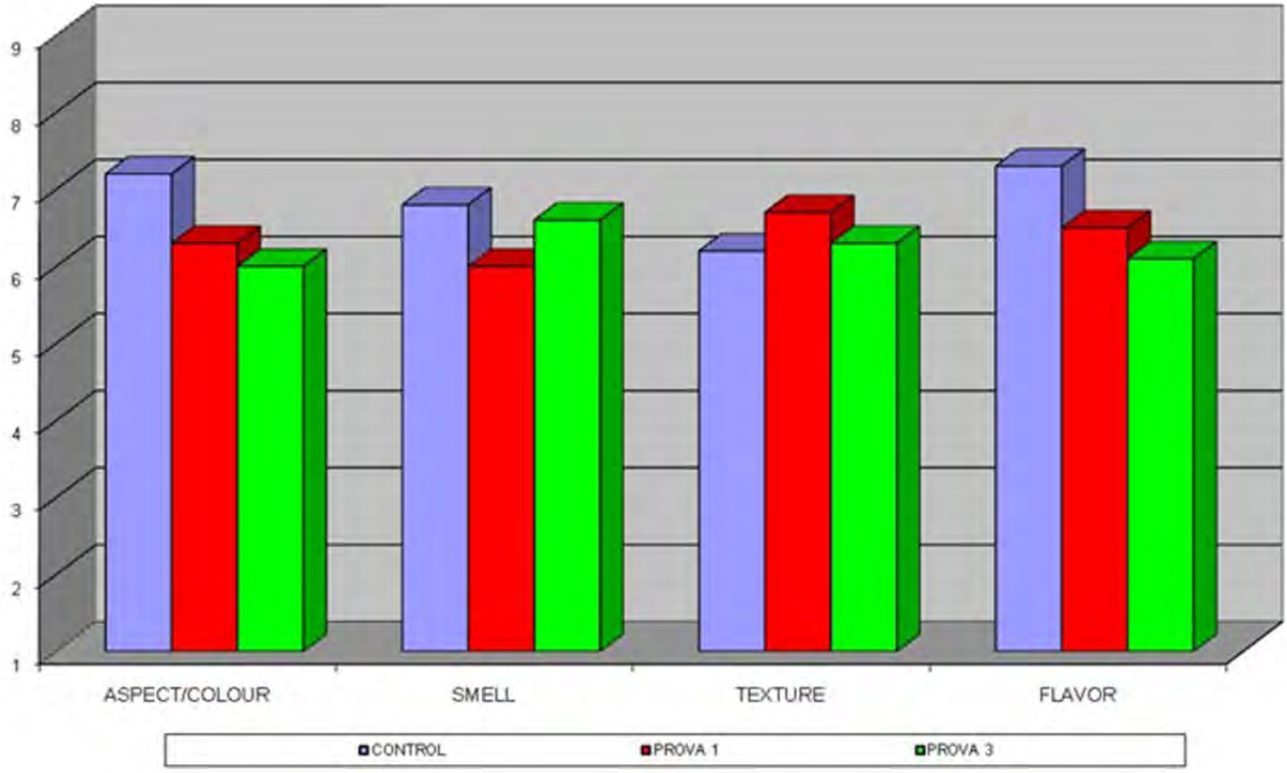


Figure 43: Global valuation (Average – (Hedonic scale between 1 and 9)

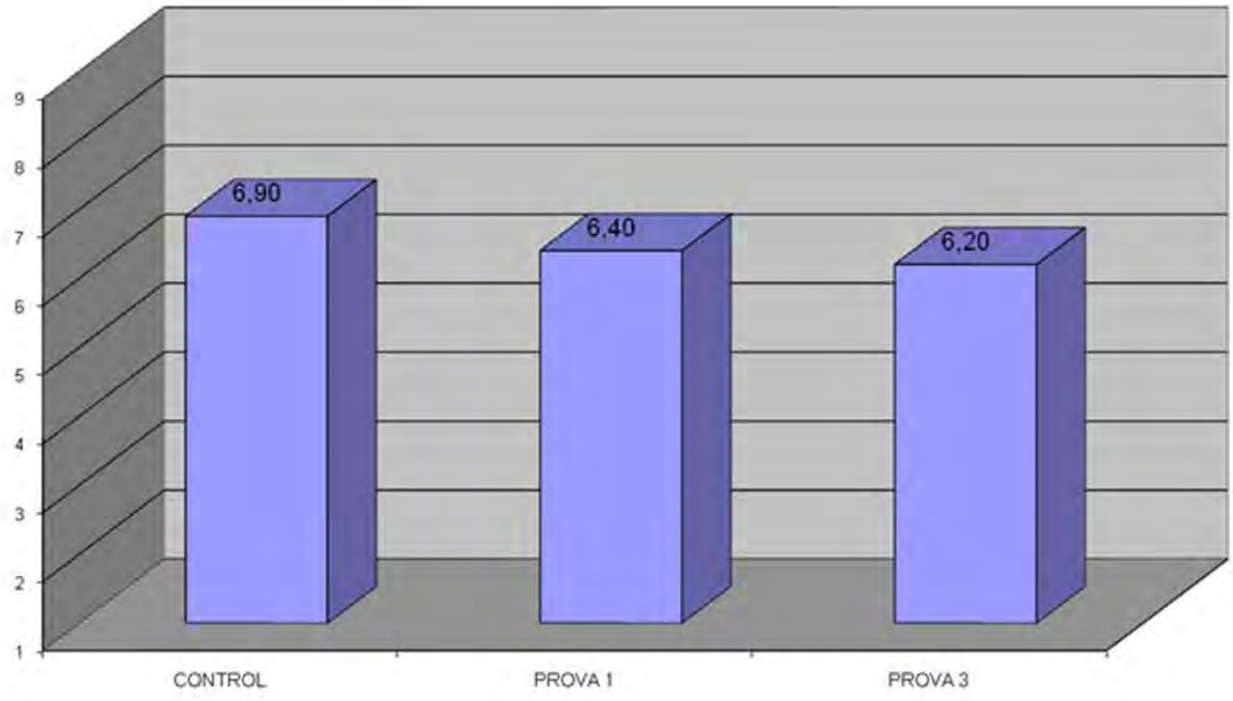
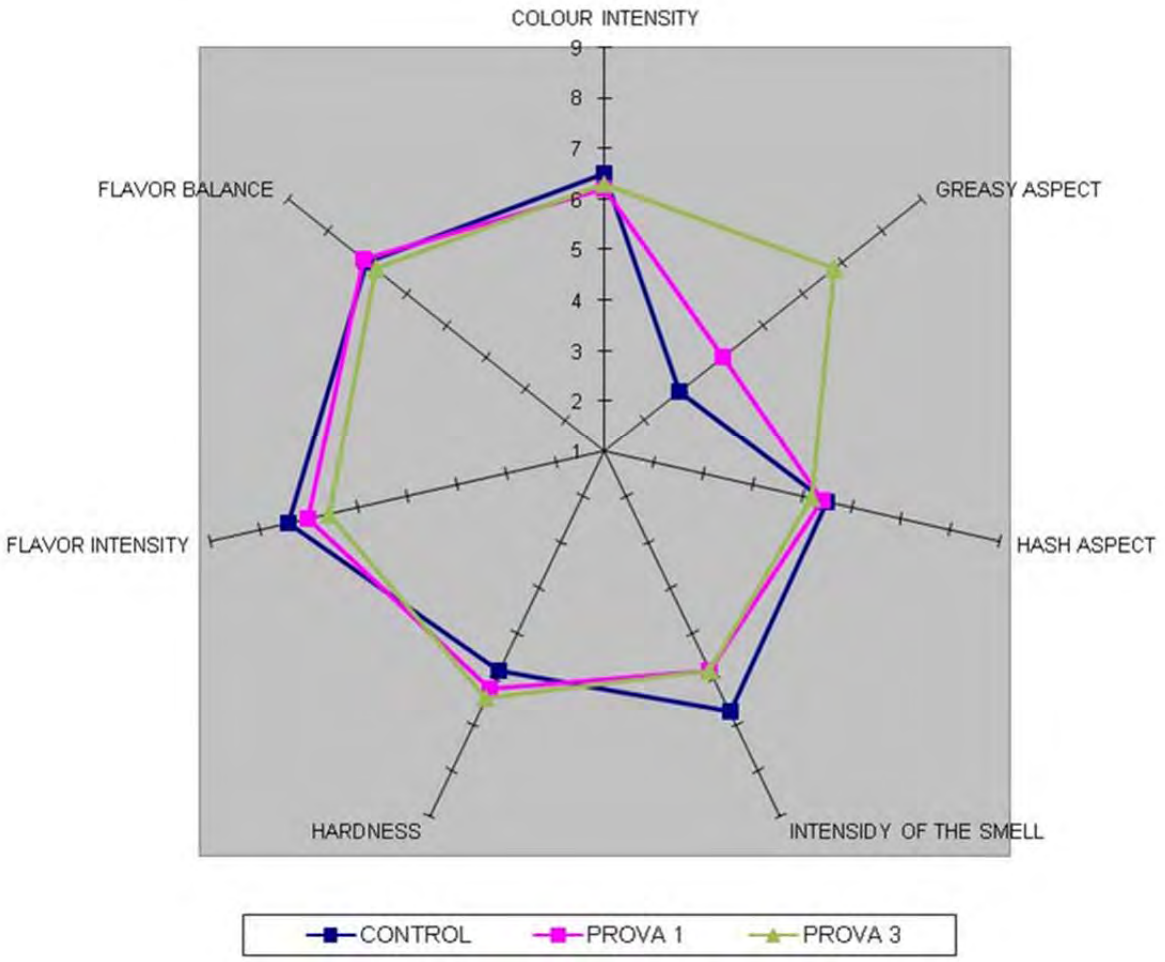


Figure 44: Graphics of description of intensity



5.6.2.3 Conclusions

The results of this comparative study revealed the following assessments:

ASPECT/COLOUR

- ✓ Significant differences of valuation have not been detected with regard to the aspect and color between three samples. The sample control obtains an average of 7.20, the prova 1: 6.30 and the prova 3: 6
- ✓ The three samples have been considered of typical color, of correct intensity with a color of reddish own lean of the product and uniformly enough
- ✓ As for the proportion greasy/lean, the thought is that prova 3 has more quantity of lean, whereas the sample control is greasier

SMELL

- ✓ There have not given significant differences of valuation between three samples as for the smell, obtaining average notes placed between 6 and 7
- ✓ The three samples have been described of a typical smell, clear and spiced to the point. As for the intensity, the sample control has been considered to be something more intense though without significant differences be detected

TEXTURE

- ✓ Neither can be affirmed significant differences of valuation nor descriptive between three samples as for its texture.
- ✓ The three samples obtain averages placed around 6.50
- ✓ The three samples have been considered of appropriate texture, neither very soft nor very firm. Some tasters comment that the sample control has a rather heterogeneous texture with harder zones.

FLAVOR – RESIDUAL FLAVOR

- ✓ Do not appreciate significant differences of valuation not descriptive between three samples as for the valuation of its Flavor
- ✓ Hereby, the sample control obtains an average of 7.30, whereas the prova 1: 6.50 and the prova 3: 6.10
- ✓ Three samples have been considered of a typical flavor, of spiced balanced, intense enough, persistent and of suitable acidity.

GLOBAL VALUATION / GLOBAL POSITIONING

- ✓ We cannot affirm significant differences of global valuation between three samples. The sample control obtains an average of 6.90 and slightly more remote they place the prova 1 with an average of 6.40 and the prova 3 with an average of 6.20
- ✓ The Global Positioning * of the samples is the following one:

  1ª: CONTROL

  2ª: PROVA 1

  3ª: PROVA 3

*** If the samples are in the same box, it implies that they cannot affirm significant global differences of positioning between them.**

5.6.3 Consumer test of snacks of fuet

5.6.3.1 Material & methods

The consumer test has been defined to be done according the task 2.5 "evaluation of product quality and consumer acceptance". It was send to a select group of 100 regular consumers of cured meats, the better test of reduced snacks of fuet (P12) and the control, to do a test of preference for consumers

OBJECTIVE:

Valuation of two samples of snack fuet extra to verify consumer's perception.

Check the suitability of the product to the consumer expectations, valuating the product according to their preferences, both globally and by organoleptic.

CONSUMERS SAMPLE:

The samples under analysis have been presented to 100 Snack fuet ordinary consumers. Profile:

Sex: -45% male

-55% female

Age: -Between 18 and 65 years

METHODOLOGY:

Have followed the guidelines of Briefing provided by the customer.

The procedures are performed following the guidelines or the UNE 87008: Sensory analysis of food. Methodology.

Each consumer has answered to a test score as organoleptic evaluation parameters: APPEARANCE/COLOUR, SMELL (AROMA), TEXTURE, FLAVOR, and RESIDUAL FLAVOR. Also it has realized a GLOBAL VALUATION.

Later, each consumer has answered to opened question about the qualities and faults of the products and has answered to the question of INTENTION OF PURCHASE and PREFERENCE.

The consumer has also completed the profile's identification.

The scale for the organoleptic parameters of valuation is hedonic (of satisfaction) from 0 to 10.

Analyzed samples are presented in a trivialized form (no marks or signs may be clues of identifying a brand or product) to the 100 consumers of this type of product.

The samples are tested separately and in different orders.

The tests are performed in a tasting room equipped with cabins or boxes defined according to UNE 87004.

TREATMENT OF THE RESULTS:

The obtained results were statistically treated by means of:

- T-Student Test for the parameters of ASSESSMENT.

- Wilcoxon Test for PREFERENCE.

- McNemar Test for INTENT TO PRUCHASE.

- Exhibition of comparative graphs.

Software used:

- LE SPHINX LEXICA (Program survey management and data processing).

- SPSS (Statistical Package standard).

STATISTICAL INTERPRETATION OF THE RESULTS:

The level of significance is the error (between 0 and 1) that we do to say that the sample means are significantly different. Therefore, if the error is less than 0.05 we can ensure that the means are significantly different with an accuracy of over 95%.

If the error is more than 0.05 the samples are not considered significantly different because the error is superior to 5%.

The level of significance used is equal or lower than 0.05.

IDENTIFICATION OF THE SAMPLES:

Sample 1:

Mark: CONTROL

Code in test: 478

Denomination: Snack fuet extra

Manufacturer: BOADAS

Figure 45: Sample control

Sample 2:

Mark: P12

Code in test: 619

Denomination: Snack fuet extra

Manufacturer: BOADAS

Batch:

Figure 46: Sample test P12

5.6.3.2 Results

Table 28: Table of statistical results

CRITERIA / SAMPLES	CONTROL	P12	
APPEARANCE / COLOUR			
Average	**6,75**	**6,75**	**NO**
Standard deviation	1,05	1,08	
SMELL (AROMA)			
Average	**6,33**	**6,60**	**NO**
Standard deviation	1,20	1,01	
TEXTURE			
Average	**6,06**	**6,90**	**SI**
Standard deviation	1,35	0,93	
FLAVOR			
Average	**6,28**	**7,03**	**SI**
Standard deviation	1,45	0,93	
RESIDUAL FLAVOR			
Average	**5,95**	**6,91**	**SI**
Standard deviation	1,34	1,02	

VALUATION CRITERIA: Scale between 0 and 10
Test: t-Student

* Are there significant differences between brands? (Assuming a 5% error): Significance Level.

The standard deviation indicates the dispersion of data, a lower value of the deviation involves more agreement among consumers about the middle note.

Table 29: Global opinion and intent to purchase

CIRTERIA / SAMPLES	CONTROL	P12	
GLOBAL OPINION			
Average	**6,16**	**6,85**	**YES**
Standard Deviation	1,30	0,84	
INTENT TO PURCHASE			
If the product had a reasonable price, would you be ready to buy it?			
Yes	31 - 31,0%	57 - 57,0%	**YES**
Probably yes	36 - 36,0%	42 - 42,0%	
Subtotal	*67 - 67,0%*	*99 - 99,0%*	
No	14 - 14,0%	1 - 1,0%	
Probably no	19 - 19,0%	0 - 0,0%	
Subtotal	*33 - 33,0%*	*1 - 1,0%*	
DIFERENT OF:			
PREFERENCE			
Select sample in:			
1st Place	39 - 39,0%	61 - 61,0%	**YES**
2nd Place	61 - 61,0%	39 - 39,0%	

GLOBAL OPINION: Hedonic scale between 0 and 10. Test: t-Student

INTENT TO PURCHASE: Possible answers: YES/NO Test: McNemar Test

PREFERENCE: Scale: 1. 1st place. 2. 2nd place Test: Wilcoxon Test

* Are there significant differences between brands? (Assuming a 5% error)
%: Probability of error in stating significant differences.

The standard deviation indicates the dispersion of data, a lower value of the deviation involves more agreement among consumers about the middle note.

Table 30: Qualities / Defects

CONTROL					
QUALITIES	Individuals	%	**DEFECTS**	Individuals	%
Pleasant flavor	24	24,5	Spicy flavor	10	18,2
Pleasant aspect	20	20,4	Slightly agreable flavor	7	12,7
Pleasant texture	10	10,2	Slightly agreable aspect	6	10,9
Pleasant smell	7	7,1	Slightly intense smell	4	7,3
Intense flavor	7	7,1	Gummy texture	4	7,3
Nice colour	5	5,1	Residual slightly agreeable flavor	3	5,5
Right size	5	5,1	Unpleasant smell	3	5,5
Texture in his point of juiciness and hardness	4	4,1	Small pieces	3	5,5
Pleasant residual flavor	3	3,1	Dry texture	3	5,5
Spiced flavor	3	3,1	Excess fat	2	3,6
Spicy residual flavor	2	2,0	Less cured	2	3,6
Salty flavor	2	2,0	Meaty texture	2	3,6
Right point of salt	2	2,0	Soft texture	1	1,8
Handicraft aspect	1	1,0	Slightly agreeable texture	1	1,8
Intense colour	1	1,0	Tough texture	1	1,8
Intense smell	1	1,0	Spicy residual flavor	1	1,8
Intense flavor to meat	1	1,0	Too much pepper	1	1,8
			Strong smell	1	1,8
TOTAL	**98**		**TOTAL**	**55**	

RATIO LIKE/DISLIKE 1,782

P12					
QUALITIES	Individuals	%	**DEFECTS**	Individuals	%
Pleasant flavor	34	28,3	Slightly agreeable aspect	6	21,4
Pleasant texture	21	17,5	A little spicy	5	17,9
Pleasant aspect	10	8,3	Strong smell	4	14,3
Pleasant smell	9	7,5	Slightly agreeable smell	4	14,3
Pleasant residual flavor	9	7,5	Residual slightly agreeable flavor	3	10,7
Intense Flavor	6	5,0	Dry texture	3	10,7
Right size	6	5,0	Residual weak flavor	2	7,1
Pleasant spicy point	4	3,3	Slightly intense smell	1	3,6
Nice colour	4	3,3			0,0
Intense smell	3	2,5			0,0
Texture exactly of treatment	3	2,5			0,0
Meat agreeable flavor	3	2,5			0,0
Right point of salt	2	1,7			0,0
Residual lasting flavor	2	1,7			0,0
Uniform aspect	2	1,7			0,0
Handicraft aspect	1	0,8			0,0
Juicy texture	1	0,8			
TOTAL	**120**		**TOTAL**	**28**	

RATIO LIKE/DISLIKE 4,286

GRAPHS OF RESULTS:

Figure 47: Organoleptic criteria of valuation (Average - (Scale between 0 and 10)

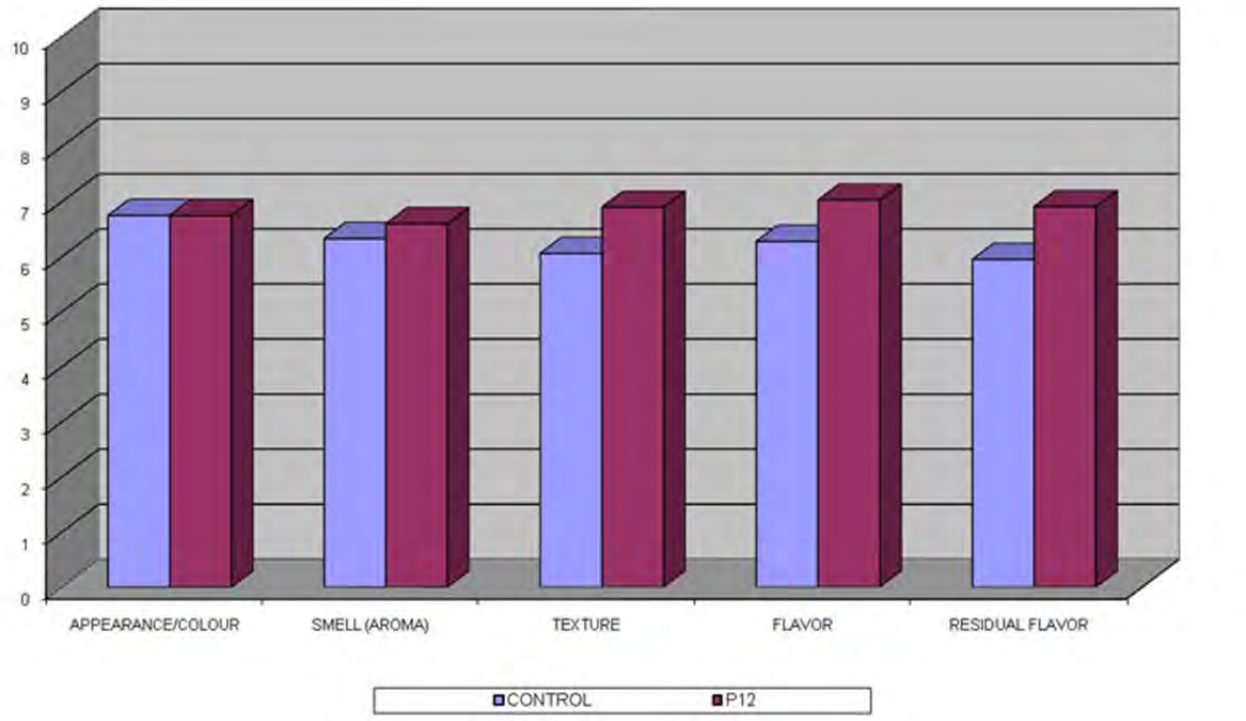


Table 31: Importance that consumers grant to the analyzed criteria

CRITERIA	AVERAGE RANGE	CLASSIFICATION ON ORDER OF IMPORTANCE
APPEARANCE / COLOUR	3.60	4
SMELL (AROMA)	3.75	5
TEXTURE	2.85	2
FLAVOR	1.32	1
RESIDUAL FLAVOR	3.48	3

Figure 48: Global opinion (Average – (Hedonic Scale between 0 and 10)

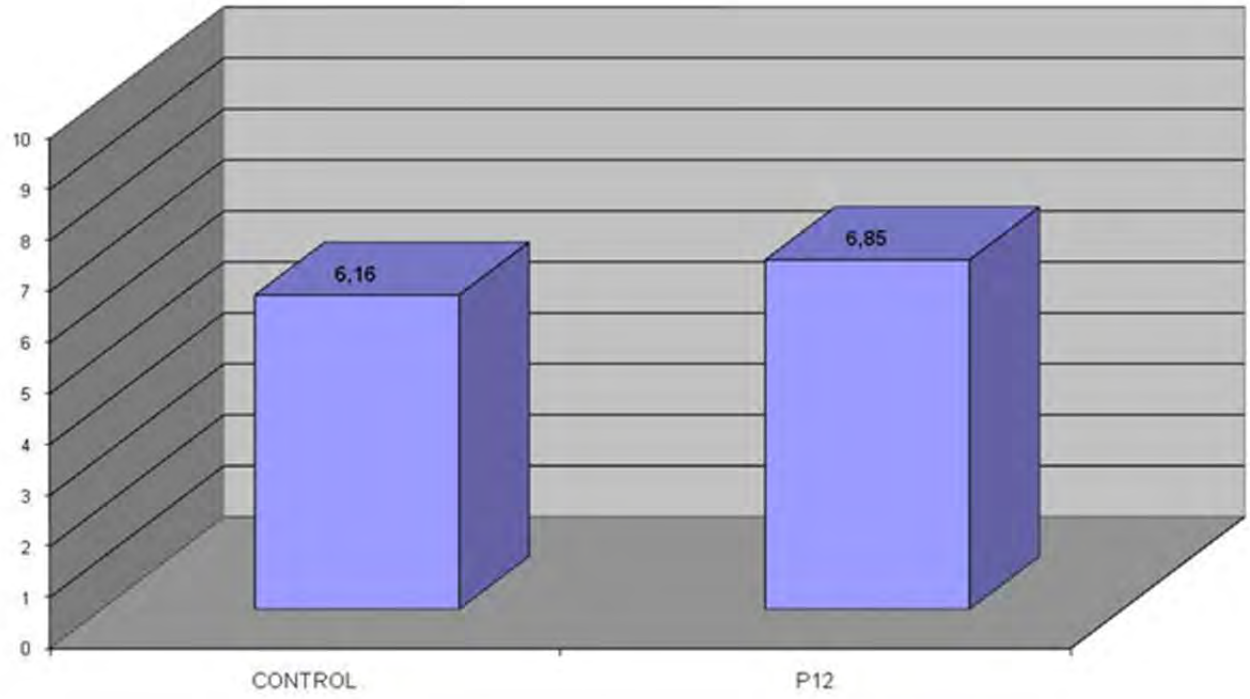


Figure 49: Preference (% place in the classification)

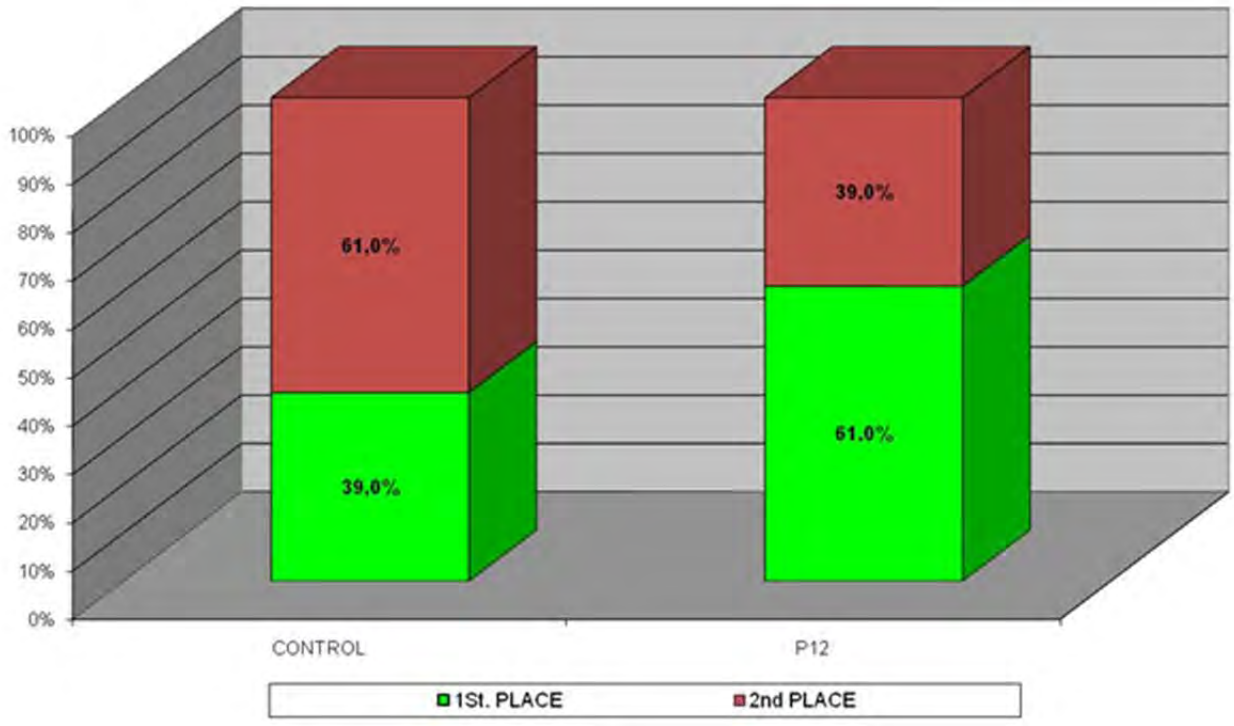


Figure 50: Intent to purchase (¿If the product had a reasonable price, could you be ready to buy it?) - Relative frequency – (%)

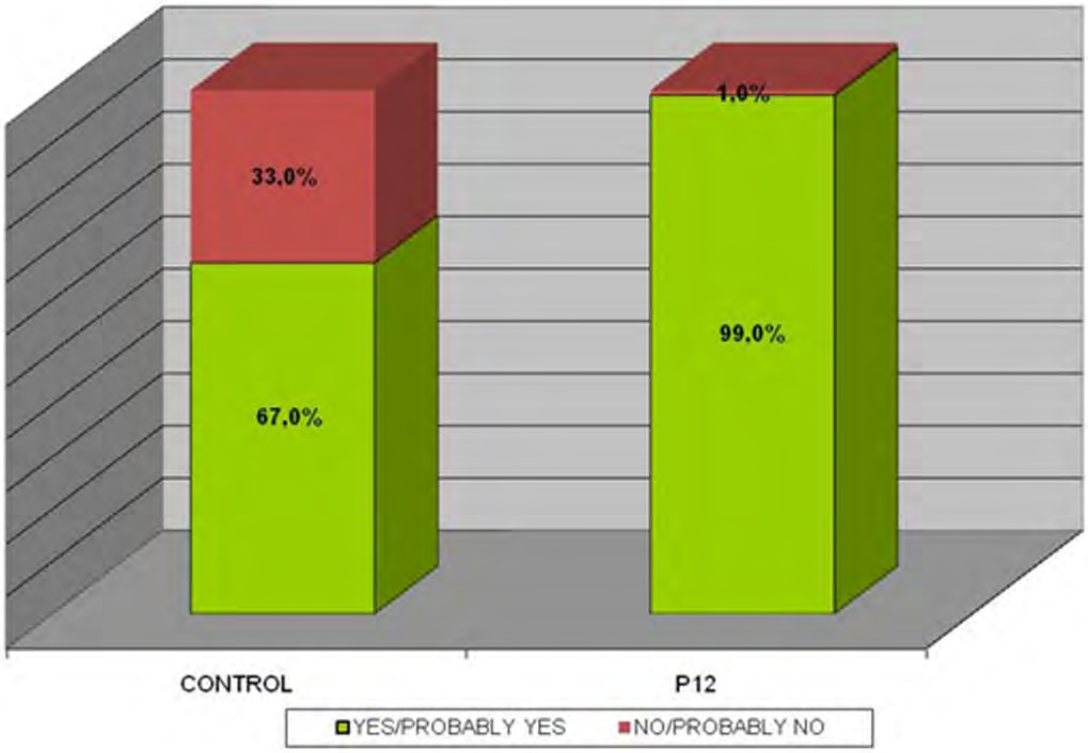


Figure 51: Organoleptic criteria of valuation - Average – (Hedonic Scale between 0 and 10)

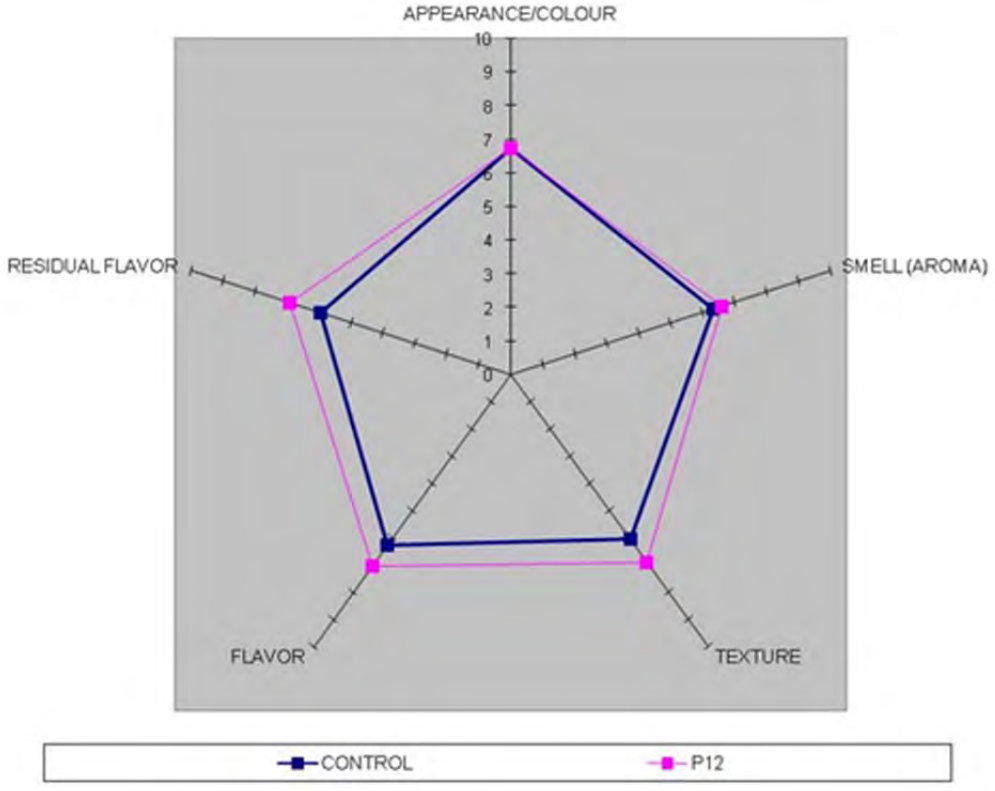
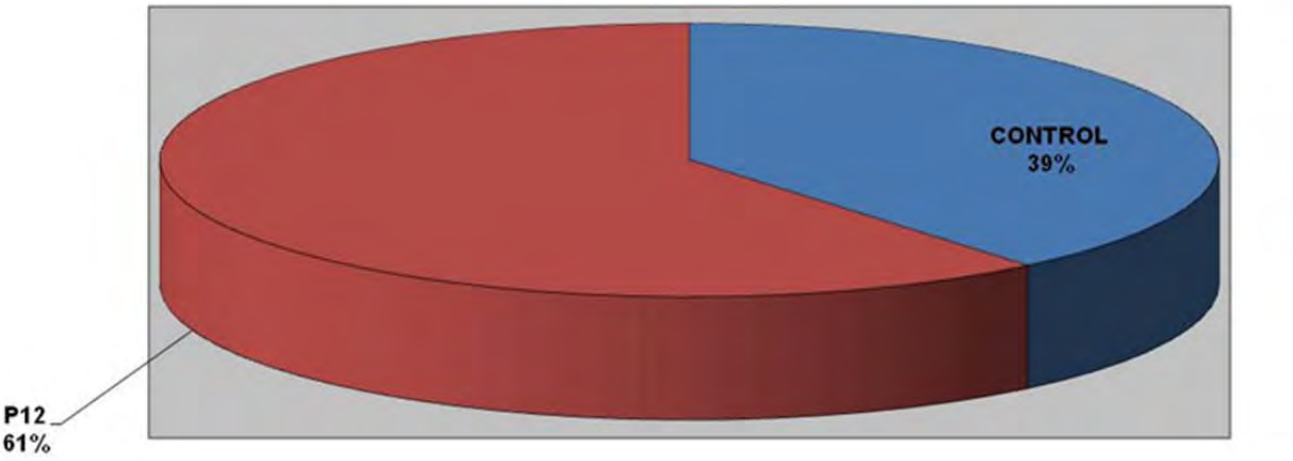


Figure 52: Consumption preferences - Relative frequency – (%)



5.6.3.3 Conclusions

GLOBAL OPINION/INTENT TO PURCHASE/PREFERENCE:

- ✓ It is possible to affirm the existence of significant differences of global Valuation in favour of P12. It obtains an average of 6.85, whereas control obtains 6.16
- ✓ As for the Intention of Purchase of the product, they can also affirm significant differences in favour of P12, of that 99 % affirms that they would or probably would buy it. Of control, 67 % of the consumers affirm that they would or probably would buy it.
- ✓ In reference to the preference, it can also be affirmed significant differences in favour of P12, that is chosen first by 61 % of the consumers, whereas control is chosen first by 39 remaining %
- ✓ The Global Positioning* of the samples is the following one:

1ª: P12

2ª: CONTROL

*** If the samples are in the same box, it implies that they cannot affirm significant global differences of positioning between them.**

5.6.4 Consumer test of chorizo

5.6.4.1 Material & methods

The consumer test has been defined to be done according the task 2.5 "evaluation of product quality and consumer acceptance". It was send to a select group of 100 regular consumers of cured meats, the better test of reduced chorizo (P1) and the control, to do a test of preference for consumers

OBJECTIVE:

Valuation of two samples of chorizo extra to verify consumer's perception.

Check the suitability of the product to the consumer expectations, valuating the product according to their preferences, both globally and by organoleptic.

CONSUMERS SAMPLE:

The samples under analysis have been presented to 100 chorizo ordinary consumers. Profile:

Sex: -49% male

-51% female

Age: -Between 18 and 65 years

METHODOLOGY:

The consumer has followed the guidelines provided in the Briefing.

The procedures are performed following the guidelines or the UNE 87008: Sensory analysis of food. Methodology.

Each consumer has answered to a test score as organoleptic evaluation parameters: APPEARANCE/COLOUR, SMELL (AROMA), TEXTURE, FLAVOR, and RESIDUAL FLAVOR. Also it has realized a GLOBAL VALUATION.

Later, each consumer has answered to opened question about the qualities and faults of the products and has answered to the question of INTENTION OF PURCHASE and PREFERENCE.

The consumer has also completed the profile's identification.

The scale for the organoleptic parameters of valuation is hedonic (of satisfaction) from 0 to 10.

Analyzed samples are presented in a trivialized form (no marks or signs may be clues of identifying a brand or product) to the 100 consumers of this type of product.

The samples are tested separately and in different orders.

The tests are performed in a tasting room equipped with cabins or boxes defined according to UNE 87004.

TREATMENT OF THE RESULTS:

The obtained results were statistically treated by means of:

- T-Student Test for the parameters of ASSESSMENT.

- Wilcoxon Test for PREFERENCE.

- McNemar Test for INTENT TO PRUCHASE.

- Exhibition of comparative graphs.

Software used:

- LE SPHINX LEXICA (Program survey management and data processing).

- SPSS (Statistical Package standard).

STATISTICAL INTERPRETATION OF THE RESULTS:

The level of significance is the error (between 0 and 1) that we do to say that the sample means are significantly different. Therefore, if the error is less than 0.05 we can ensure that the means are significally different with an accuracy of over 95%.

If the error is more than 0.05 the samples are not considered significantly different because the error is superior to 5%.

The level of significance used is equal or lower than 0.05.

IDENTIFICATION OF THE SAMPLES:

Sample 1:

Mark: CONTROL

Code in test: 120

Denomination: Chorizo extra

Manufacturer: BOADAS

Figure 53: Sample control

Sample 2:

Mark: P1

Code in test: 246

Denomination: Chorizo extra

Manufacturer: BOADAS

Figure 54: Sample test P1

5.6.4.2 Results

Table 32: Table of statistical results

CRITERIA / SAMPLES	CONTROL	P1	
APPEARANCE / COLOUR			
Average	**6,58**	**7,45**	**YES**
Standard deviation	1,68	0,90	
SMELL (AROMA)			
Average	**6,26**	**7,31**	**YES**
Standard deviation	1,54	1,03	
TEXTURE			
Average	**6,35**	**6,81**	**NO**
Standard deviation	1,70	1,39	
FLAVOR			
Average	**6,26**	**6,85**	**NO**
Standard deviation	1,88	1,59	
RESIDUAL FLAVOR			
Average	**6,16**	**6,63**	**NO**
Standard deviation	1,75	1,44	

EVALUATION CRITERIA: Scale between 0 and 10
Test: t-Student

* Are there significant differences between brands? (Assuming a 5% error): Significance Level.

The standard deviation indicates the dispersion of data, a lower value of the deviation involves more agreement among consumers about the middle note.

Table 33: Global opinion and intent to purchase

CRITERIA / SAMPLES	CONTROL	P1	
GLOBAL OPINION			
Average	**6,20**	**6,96**	**YES**
Standard Deviation	1,76	1,26	
INTENT TO PURCHASE			
¿If the product had a reasonable price, would you be ready to buy it?			
Yes	19 - 19,0%	47 - 47,0%	**YES**
Probably yes	55 - 55,0%	42 - 42,0%	
Subtotal	*74 - 74,0%*	*89 - 89,0%*	
No	16 - 16,0%	2 - 2,0%	
Pprobably no	10 - 10,0%	9 - 9,0%	
Subtotal	*26 - 26,0%*	*11 - 11,0%*	
DIFFERENT OF:			
PREFERENCE			
Selected sample in:			
1st Place	19 - 19,0%	81 - 81,0%	**YES**
2nd Place	81 - 81,0%	19 - 19,0%	

GLOBAL OPINION: Hedonic scale between 0 and 10. Test: t-Student

INTENT TO PURCHASE: Possible answers: YES/NO. Test: McNemar Test

PREFERENCE: Scale: 1. 1st. place. 2: 2nd place Test: Wilcoxon Test

* Are there significant differences between brands? (Assuming a 5% error)
%: Probability of error in stating significant differences.

The standard deviation indicates the dispersion of data, a lower value of the deviation involves more agreement among consumers about the middle note.

Table 34: Qualities / Defects

CONTROL					
QUALITIES	Individuals	%	**DEFECTS**	Individuals	%
Pleasant aspect	18	20,9	Weak flavor	15	19,0
Pleasant flavor	17	19,8	Many fat	9	11,4
Pleasant smell	12	14,0	Unpleasant aspect	7	8,9
Pleasant texture	8	9,3	Unpleasant texture	5	6,3
Nice colour	8	9,3	Artificial flavor	4	5,1
Residual flavor	5	5,8	Fat	4	5,1
Right size	4	4,7	Hard texture	4	5,1
Soft flavor	4	4,7	Greasy aspect	3	3,8
Succulent	3	3,5	Artificial smell	3	3,8
Flavor to seasoning that has	3	3,5	Residual flavor	3	3,8
Everything	2	2,3	weak smell	3	3,8
Keeps repeat	1	1,2	Very thin slices	2	2,5
Tasty	1	1,2	Soft texture	2	2,5
			Slightly natural aspect	2	2,5
			Greasy texture	2	2,5
			Plastic aspect	2	2,5
			Plastic texture	2	2,5
			Artificial colur	2	2,5
			Unpleasant smell	1	1,3
			Spicy flavor	1	1,3
			Unpleasant colour	1	1,3
			Unpleasant flavor	1	1,3
			Insipid flavor	1	1,3
TOTAL	**86**		**TOTAL**	**79**	

RATIO LIKE/DISLIKE 1,089

Pleasant flavor	5	4,4	Artificial flavor	3	6,0
Residual flavor	5	4,4	The chunks of fat are hard	3	6,0
Natural flavor	3	2,6	Excess of chunks of fat	3	6,0
Everything	3	2,6	Tough fat	2	4,0
Few fat	2	1,8	Reddish colour	2	4,0
Intensity of the natural flavor	2	1,8	Unpleasant textura	2	4,0
Right size	2	1,8	Plastic texture	2	4,0
Not greasy	2	1,8	Unpleasant residual flavor	1	2,0
Soft flavor	1	0,9	Unpleasant aspect	1	2,0
Typical flavor	1	0,9	Unpleasant colour	1	2,0
			Very thun slices	1	2,0
TOTAL	**114**		**TOTAL**	**50**	

RATIO LIKE/DISLIKE 2,28

GRAPHS OF RESULTS:

Figure 55: Organoleptic criteria of valuation (Average – (Scale between 0 and 10)

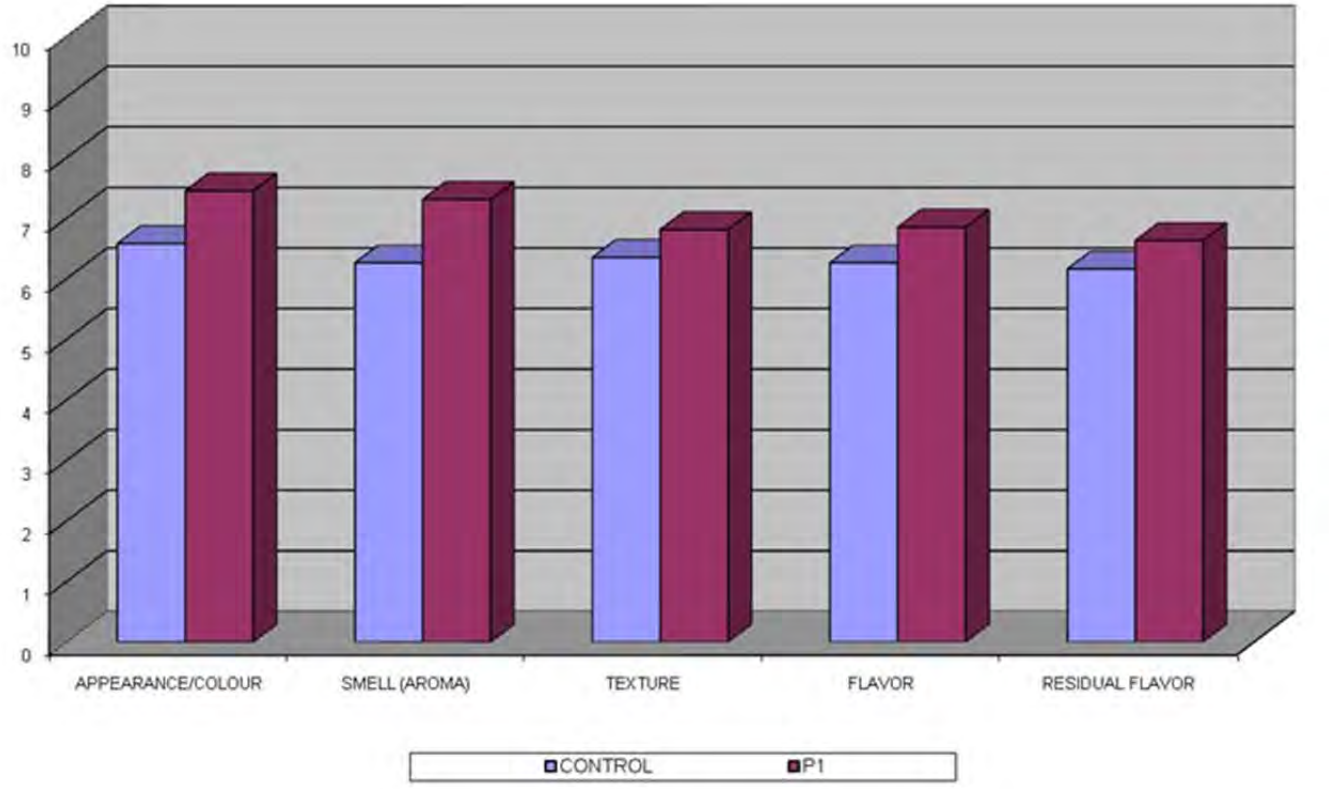


Figure 56: Importance that consumers grant to the analyzed criteria

CRITERIA	AVERAGE RANGE	CLASSIFICATION ON ORDER OF IMPORTANCE
APPEARANCE / COLOUR	3.45	4
SMELL (AROMA)	3.90	5
TEXTURE	3.18	2
FLAVOR	1.33	1
RESIDUAL FLAVOR	3.20	3

Figure 57: Global opinion (Average – (Hedonic Scale between 0 and 10)

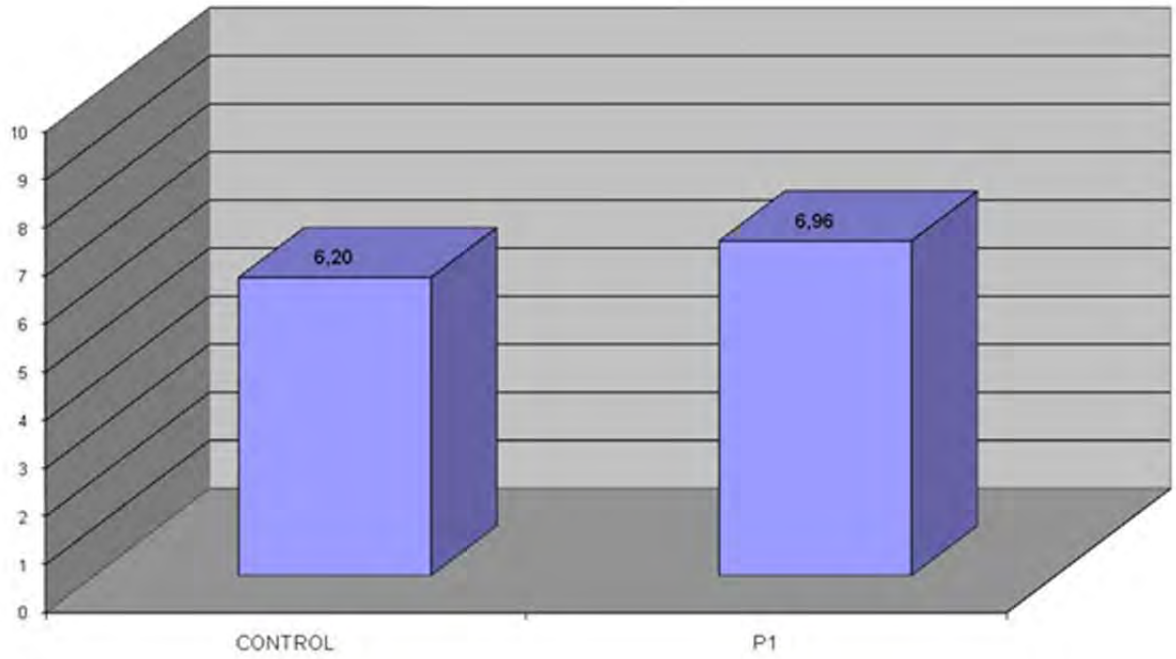


Figure 58: Preference (% place in the classification)

Figure 59: Intent to purchase (¿If the product had a reasonable price, could you be ready to buy it?) – Relative frequency – (%)

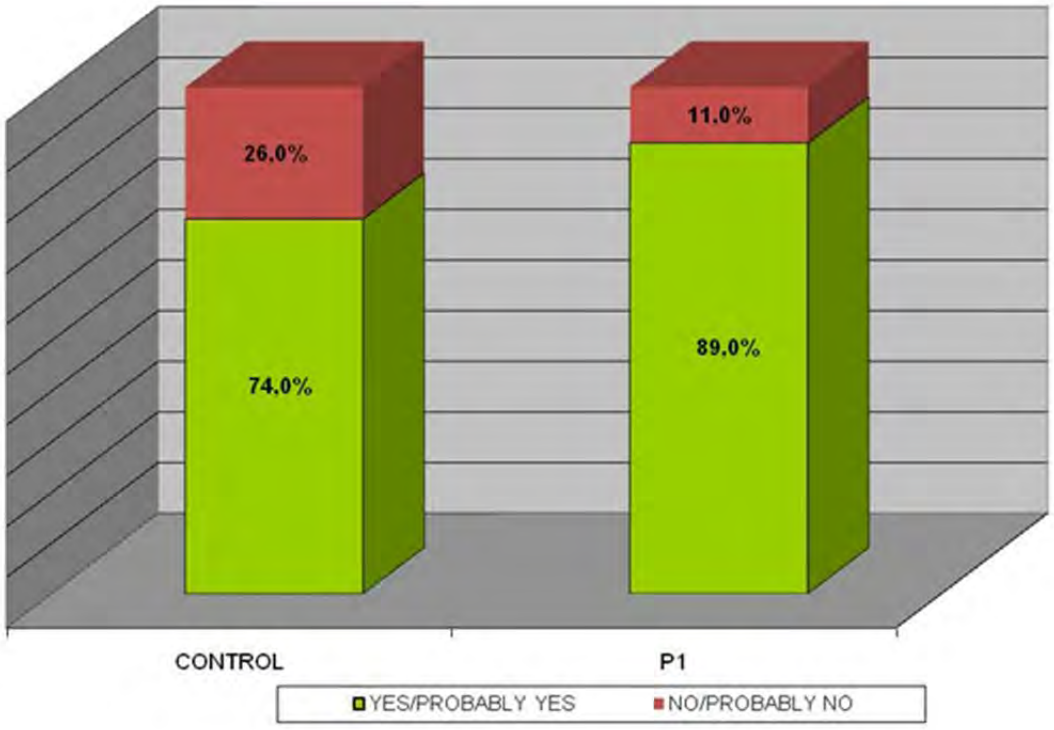


Figure 60: Organoleptic criteria of valuation - Average – (Hedonic Scale between 0 and 10)

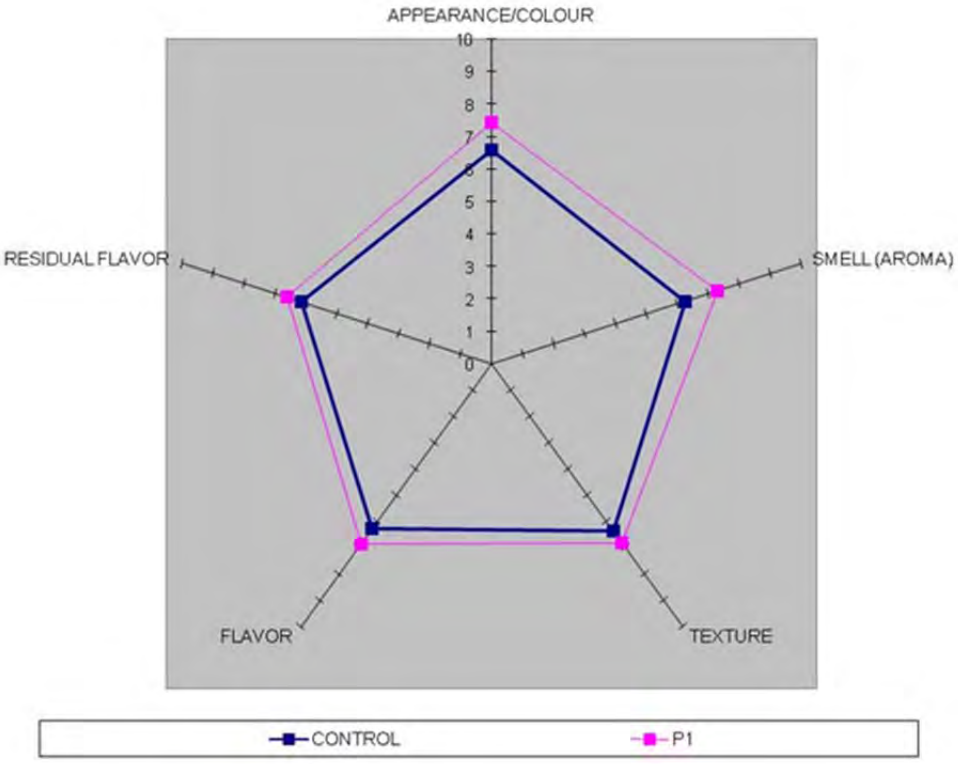
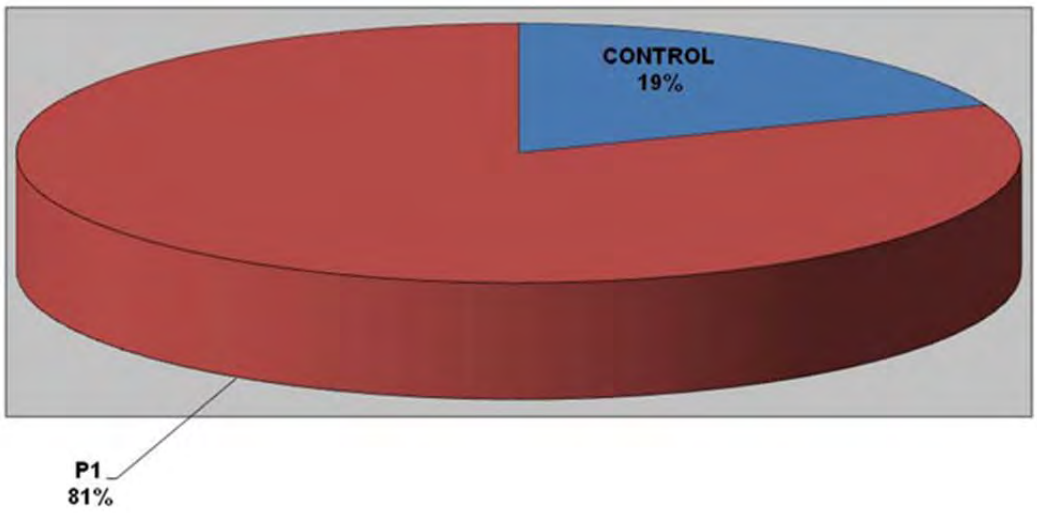


Figure 61: Consumption preferences – Relative frequency – (%)



5.6.4.3 Conclusions

GLOBAL OPINION/INTENT TO PURCHASE/PREFERENCE:

- ✓ It is possible to affirm the existence of significant differences of Global Opinion in flavor of P1, that it obtains an average of 6.96, whereas control obtains 6.20
- ✓ As for the Intention of Purchase of the product, also it can be affirmed significant differences in flavour of P1, of that 89% affirms that they would buy it or probably it would do it. Of control 74% of the consumer affirms that they would buy it or probably would do it
- ✓ In reference to the preference, also they can affirm significant differences in flavor of P1, that is chosen first by 81% of the consumers, whereas control is chosen first by 19% remaining
- ✓ The Global Positioning* of the samples is the following one:

1ª: P1

2ª: CONTROL

*** If the samples are in the same box, it implies that they cannot affirm significant global differences of positioning between them.**

6. PART IV: Challenge tests

Results from the technological tests demonstrated that strategies by the formulation and/or by the process allow reducing SFA or salt content in dry sausages as expected.

- to reduce SFA in dry sausages by 60%, two strategies had been validated :
  - using of fat emulsion and fiber (CIT),
  - addition of sunflower oil and fiber (SUN).
- To reduce salt content in dry sausages by 30%, two other strategies had been validated :
  - KCl addition and cold predrying of products (T1)
  - 40% salt substitution by KCl associated with yeast extract M addition (T43)

Results from the industrial tests demonstrated that binary reduction in SFA and sodium can be achieved simultaneously by combining recipes and process strategies.

In this last step, microbial status of products manufacture by the best technological strategies of combined salt and fat reduction defined for snacks fuet was assess by using challenge test approach.

6.1 Objectives

The challenge test is an experimental technique that involves inoculating, in a product, a known concentration of a microorganism, and to follow the development of it by counts at different points of the shelf-life.

In this study, ADIV implemented the challenge test only on snack fuet manufactured according 3 conditions as described in the table 35. The pathogen germs, *Listeria monocytogenes* and *Salmonella* were assess in individually experiments, thus 18 trials were conducted (1 product x 3 process x 3 batches x 2 germs).

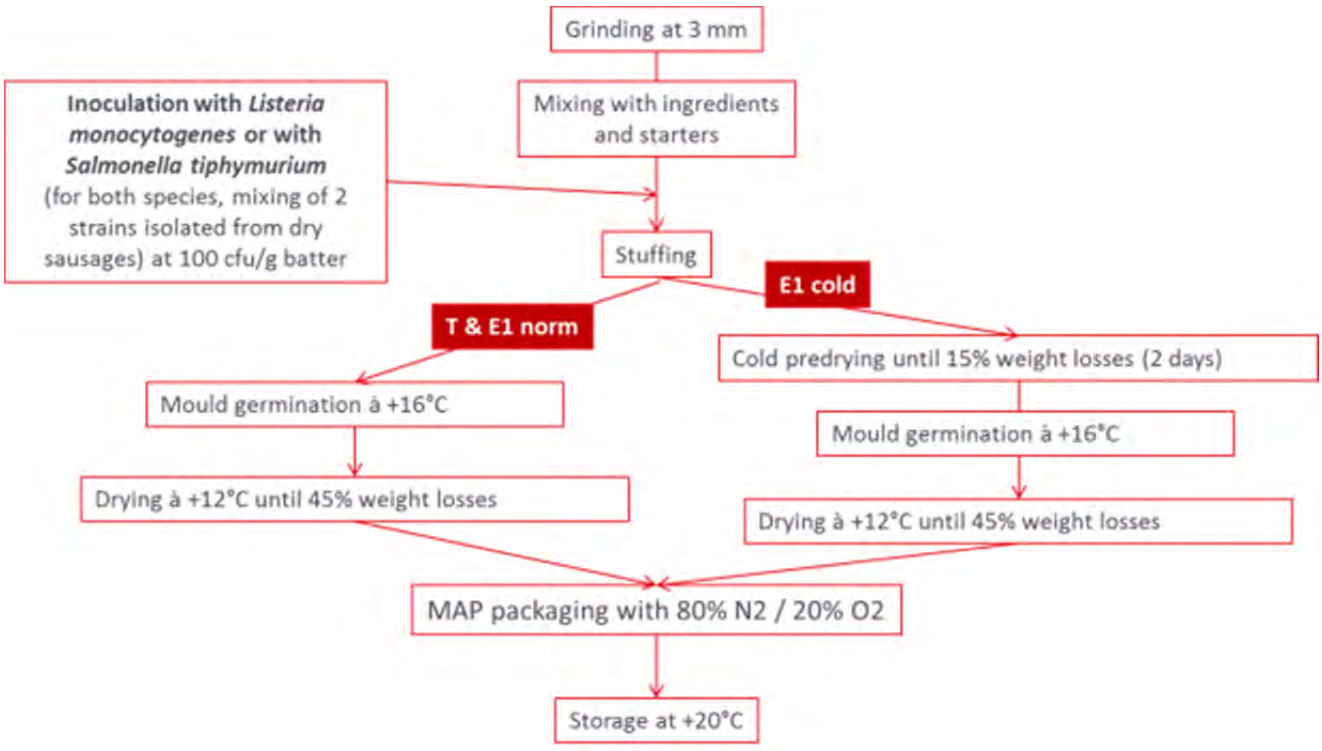
Table 35: Conditions of the 3 challenge tests implemented with snack fuet

Products	Tests
Snacks	T : Control
	E1 Norm : 40% salt substitution by KCl + Sunflower oil + fibers+ Yeast extract addition
	E1 cold : Cold predrying + 40% salt substitution by KCl + Sunflower oil + fibers+ Yeast extract addition

6.2 Material and methods

For each of the 3 challenge tests, 3 batches of meat purchased by 3 different providers were processed individually with the following process (figure 62).

Figure 62: Simplified diagram of snack fuet manufacture during the 3 conditions of the challenge tests



The details of the recipes are described in the table 36.

Table 36: Recipes of snack fuets manufacture during the challenge tests according to the trial

	Snacks fuets	
	Control (T)	E1
Meat		
Pork shoulder	☑	☑
Pork backfat	☑	
Starters	☑	☑
Sunflower oil		☑
Ingredients		
Nitrited salt (10% sodium nitrite)	☑	☑ low dose adapted to KCl substitution
Salt	☑	☑ low dose adapted to KCl substitution
Carmin 21%	same dose of each ingredient in all recipes	
Ingredients mix		
KNO3		
Water		
Fibers		☑
Modified KCl		☑
Yeast extract		☑

Weight losses (%)	***45***	***50***
Batter lipids level (%)	***25,7***	***11,7***
Snack fuets lipids (%)	***46,8%***	***23,4%***
Batter SFA level (%)	***10,3***	***4,0***
Snack fuets SFA level (%)	***18,7***	***7,9***
SFA reduction(%)	***0,0***	***57,6***
Batter PUFA level (%)	***3,1***	***2,7***
SNACKS PUFA level (%)	***5,6***	***5,5***
Salt level (%)	***0,26***	***0,17***
Sodium level (%)	***0,10***	***0,07***
Sodium reduction(%)	***/***	***33***

HPD target : 39%

For the 3 challenge tests where pathogen germs were inoculated, *Listeria* and *Salmonella* were accounting from the stuffing until the end of storage. A snack fuet production was realized without inoculation of meat batter to assess water activity, weigh losses and pH evolution in the same time. Precisions about analysis plan are given in table 37.

Each analysis was carried out on 300g samples except for weight loss for which 1 kg of raw material has been used.

Table 37 : analysis plan for challenge tests on snack fuet

	Inoculated meat		Non inculated meat		
	Inoculated Listeria Mono.	Inoculated Salmonella typhim.	Water activity	Weight loss	pH
Day 0 : Stuffing day	3 analysis	3 analysis	3 measurements	1 measurement	3 measurements
D1				1 measurement	
D2				1 measurement	3 measurements
D3				1 measurement	3 measurements
D4				1 measurement	3 measurements
D6	3 analysis	3 analysis	3 measurements	1 measurement	3 measurements
D9	3 analysis	3 analysis		1 measurement	3 measurements
D11				1 measurement	
D13 (End of drying)	3 analysis	3 analysis	3 measurements	1 measurement	3 measurements
D67 (End of storage)	3 analysis	3 analysis	3 measurements		3 measurements
TOTAL	**15**	**15**	**12**	**9**	**24**

6.3 Results of challenge test

6.3.1 Weight losses and pH evolution

As observed in the "technological test", the weight losses of current snack fuet and sausages from test E1norm (same process than control) were around 45% after 13 days post-stuffing. Quicker weight losses for test E1cold were observed (figure 63) due to cold predrying managed to reach a weight loss of 25% in the 3 first days after stuffing.

Snacks pH evolution with the E1cold test was closed to control (from 6.1 to 6.45 after 13 days) while higher increase of pH was observed for test E1norm, particularly after the day 6 to reach a pH of 6.8 at day 13 (figure 64).

Figure 63: Weight losses evolution of snack fuet during challenge tests according to experimental conditions and compared to the control

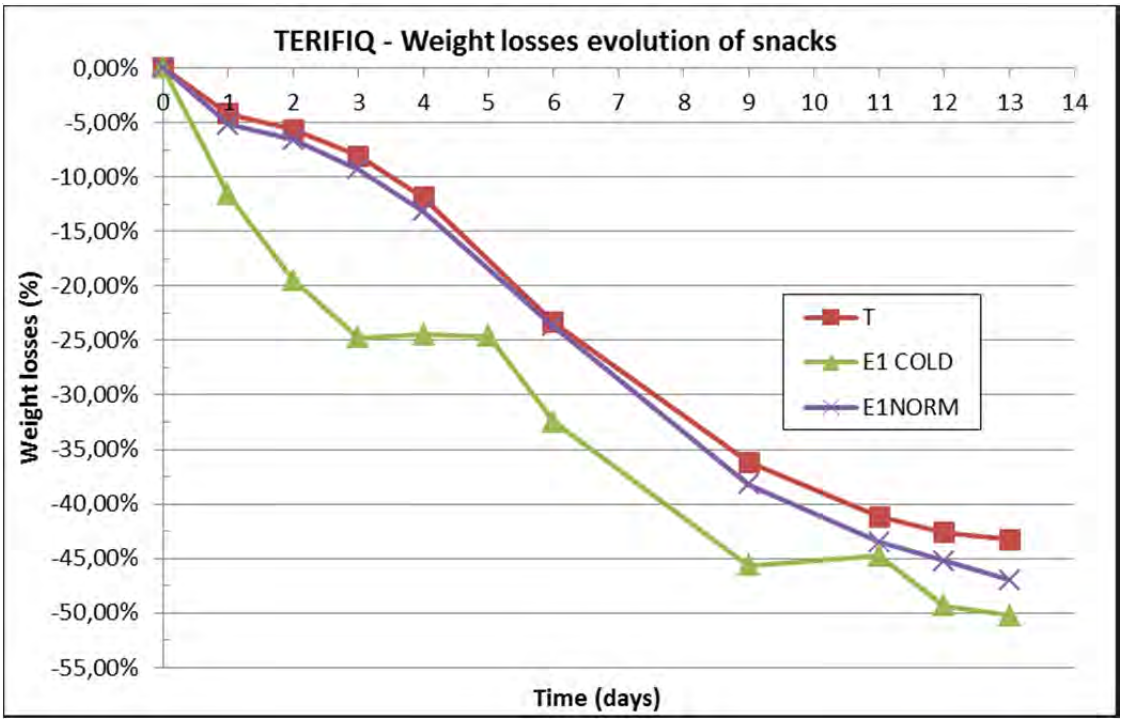
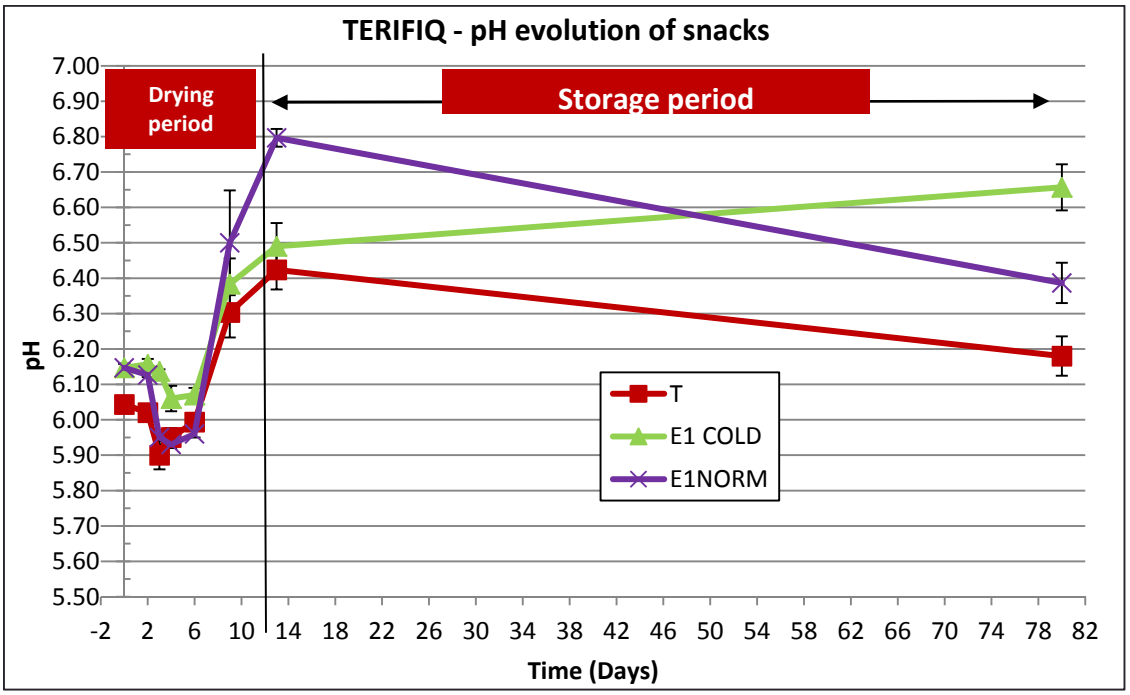


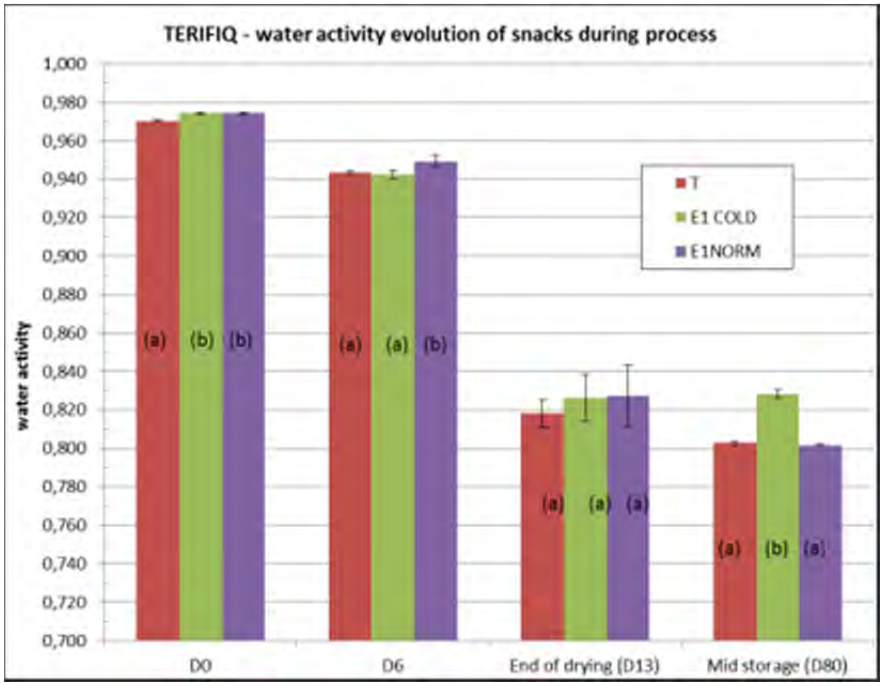
Figure 64: pH evolution of snack fuet during challenge tests according to experimental conditions and compared to the control



6.3.2 aw evolution

As expected, cold predrying allows keeping a low water activity during the first stage of the process (figure 65). For every tests, low aw values (<0.830) at the end of the process are suitable for efficient microbial protection.

Figure 65: water activity evolution of snack fuet during challenge tests according to experimental conditions and compared to the control



6.3.3 Chemical composition

After drying, salt reduction of 27% and SFA reduction of 48% for test E1cold is close to the expected values (table 38).

This level of reduction was not achieved for test E1 norm because of lower DPH (Defatted Product Humidity) and so to higher weight losses of analysed samples (concentration effect of SFA content).

Table 38: Chemical composition of snack fuet from challenge tests according to experimental conditions and compared to the control

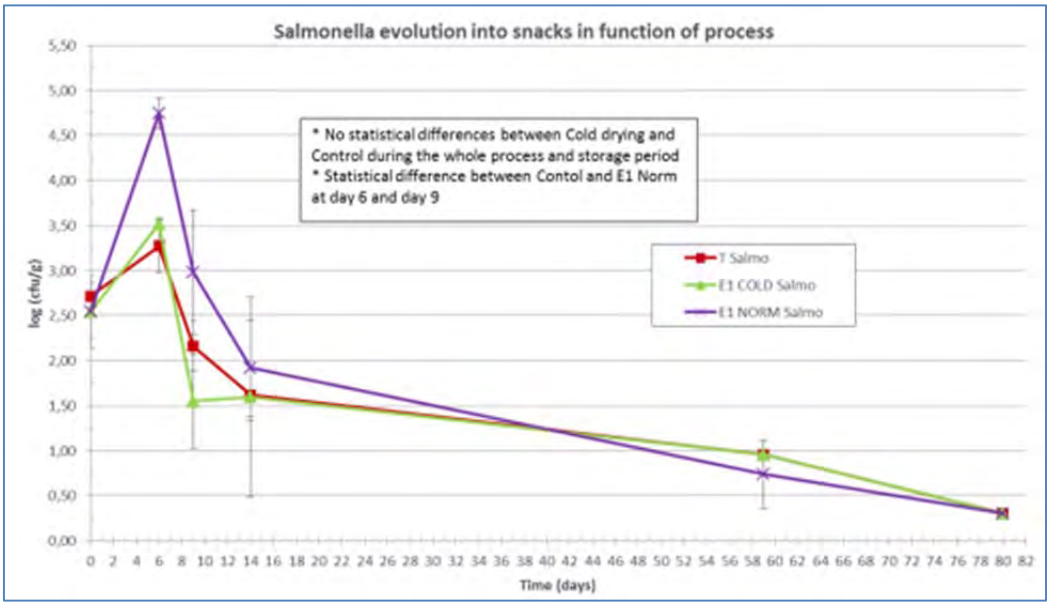
	Sodium (mg / 100 g product)	Humidity (%)	Lipids (%)	Lipids on batter (%)	DPH (%)	Saturated Fatty acids (g/100g product)	Mono Inaturated Fatty acids (g/100g product)	Poly Inaturated Fatty acids (g/100g product)	Sodium reduction (%)	SFA reduction (%)
T	2007	23.2	40.5	20.4	39.0	18.3	17.9	4.3	*0.0*	*0.0*
E1 COLD	1467	32.0	25.1	11.9	42.8	9.6	11.4	4.1	*-26.9*	*-47.7*
E1 NORM	1583	25.8	26.4	11.3	35.0	10.0	12.3	4.2	*-21.1*	*-45.4*

6.3.4 *Salmonella* evolution

Substitution of NaCl and fat with current process (E1norm test) induces high growth of *Salmonella* during the first stages of the process (figure 66). Cold predrying contributes to manage this growth during the whole process. It is the only condition for which *Salmonella* counting are the lowest at the end of the process (day 14). Two samples (among 3 analyzed) have counting lower than 10 cfu/g.

At day 59 (=45 days of storage at 20°C) every tests have *Salmonella* counting below to 10 cfu/g.

Figure 66: Salmonella evolution into snack fuet during process of challenge tests according to experimental conditions and compared to the control

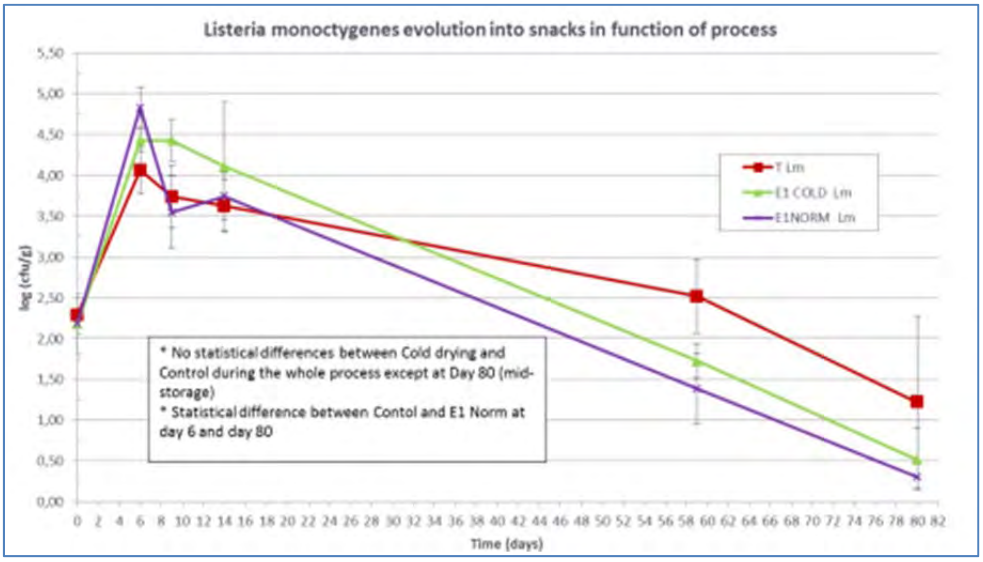


6.3.5 *Listeria* evolution

The 3 conditions induce growth of *Listeria* during the first stage of the process (figure 67), especially both tests with high substitution level of NaCl and fat (tests E1Norm and E1cold) (+0.5 log). For cold predrying, *Listeria* populations are no significantly different than control.

At day 80 (=66 days of storage at 20°C), both tests have the lowest *Listeria* counting.

Figure 67: *Listeria* **evolution into snack fuet during process of challenge tests according to experimental conditions and compared to the control**



6.4 Conclusion of challenge test

- Association of cold predrying with combined strategies of salt and fat reduction (E1 cold) is equivalent to control to manage *Salmonella* and *Listeria* evolution into snacks fuet.

- Combined strategies of salt and fat reduction without cold predryo,g (E1norm) is not efficient enough to control pathogen bacteria growth, especially Salmonella. This behaviour has to be linked to the higher water activities induced by SFA substitution tests (lower fat content) during the first steps of the process

  - Concerning chemical results, salt reduction of 27% and SFA reduction of 48% for test E1cold were achieved that is close to the expected values.

7. Conclusions

The implementation of research activities in WP2 leads to the demonstration that new strategies are efficient to reduce simultaneously the salt and saturated fatty acid contents in dry sausages, respectively by 30% and 60 %. TeRiFiQ activity on dry sausages is successful and will gives solutions to meat companies to offer healthier products for consumer and without lose the product authenticity.

8. References

- **Regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods**