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Probiotic salami with fat and curing salts reduction: physicochemical, textural and sensory characteristics

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Abstract

This work was evaluated the physicochemical, textural and the sensory properties of meat products fermented with traditional or probiotic cultures with lower fat and curing salt content. Chemical composition was evaluated in T30 and instrumental texture was determined during the experimental protocol. A sensory profile evaluation was carried out using the quantitative descriptive analysis (QDA) and the acceptance test. The lowest fat content was found in the salamis processed with reduced pork fat. Texture profile analysis the F5 exhibited the lowest mean value of hardness. In QDA, the results showed that the F1 exhibited the highest mean value of regularity of the border, brightness, softness and smoked, due to the greater amount of fat in their composition. The results revealed that, in T30, there was good acceptance for all formulations and during the storage period, the mean values remained high. The consumers demonstrated a positive purchase intention for all formulations.

Keywords: probiotic salami; chemical composition; texture profile; sensory properties.

Practical Application: Potentially probiotic fermented meat product using cultures with hypolipidemic properties.

1 Introduction

Currently, consumers are searching for safe and nutritious products, besides being innovative and attractive, as functional foods are. In this sense, meat products have been criticized by their large amount of animal fat, nitrite and nitrate. Thus, the search for new products to be developed has aroused great interest, so as to meet the consumer's needs and obtain products that are healthier from a nutritional point of view (Rubio et al., 2014a).

The total or partial replacement of traditional starter cultures for probiotic ones can contribute to the safety of the final product and offer sensory advantages, as well as technological, nutritional and health benefits, representing an attractive alternative for the food industry (Pidcock et al., 2002; Muthukumarasamy & Holley, 2007; Rubio et al., 2014b)

In the meat industry, the use of probiotics proved to be most promising for fermented products, such as salami, which are usually processed and consumed without heating (Työppönen et al., 2003; Ammor & Mayo, 2007; Sidira et al., 2016).

Moreover, the use of olive oil as a partial replacement for animal fat has shown to be effective in getting obtaining meat products with low fat content (Severini et al., 2003; Bolumar et al., 2015), which would promote a repositioning of the product on the market.

The probiotic cultures *E.faecium* CRL 183 and *L.acidophilus* CRL 1014 have been extensively studied for its health benefits. Previous results demonstrated their ability to remove cholesterol *in vitro* (Rossi et al., 1994). The *E. faecium* CRL 183 strain was able to modulate the intestinal microbiota (Bedani, 2008; Cavallini et al., 2011) and the lipid profile (Cavallini et al., 2016) reduce the risk of colon (Sivieri et al., 2008) and breast cancer developing (Kinouchi, 2006) and alleviate the symptoms of ulcerative colitis (Celiberto et al., 2015). To the present time, such strains and their beneficial properties were evaluated only in soy-based products.

Therefore, this study was aimed producing a potential probiotic fermented salami with fat and curing salts reduction. Effects on sensory properties were studied, as well as the influence on texture and chemical composition.

2 Materials and methods

2.1 Development of fermented salami

The fermented salamis were produced in seven different formulations, according to the Italian salami manufacturing procedures proposed by Severini et al. (2003), Koutsopoulos et al. (2008), Macedo et al. (2008) with a few modifications. All formulations were processed in three batches on different days.

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Formulation F1 (control formulation) was produced without fat and curing salts content reduction (0.015% nitrite and 0.005% nitrate), and with traditional cultures (*Pediococcus pentosaceus*/*Staphylococcus xylosus*).

The other six formulations (F2 to F7) were produced with 8% pork fat, representing a replacement of approximately 60% in pork fat used in traditional formulations (T1: 20 g/100 g) (Terra, 1998). Extra virgin olive oil, pre-emulsified with sodium caseinate (2 g/100 g), was used to preserve the sensory characteristics of the salami. The formulation 2 (F2) with traditional cultures and without curing salt reduction. The formulation 3 (F3) with traditional cultures and with curing salt reduction (0.007% nitrite and 0.003% nitrate). The formulations 4 and 5 (F4 and F5) with probiotic culture (*E. faecium* CRL183) and without and with curing salt reduction, respectively. The formulations 6 and 7 (F6 and F7) with probiotic culture (*L. acidophilus* CRL1014) and without and with curing salt reduction, respectively.

The remaining ingredients were added in the following amounts: 61.5% pork meat, 28.5% cow meat, 8.0% pork fat, 2.0% olive oil, 2.5% sodium chloride, 0.5%, sodium ascorbate, 0.5% sucrose, 0.7% lactose, 0.05% garlic powder, and 0.13% white pepper. The starter cultures (probiotic and traditional ones) were added in a sufficient amount to reach at least 8 log CFU/g. Probiotic cultures were propagated in M17 broth (Himedia, India) for 24 hours at 37 °C (*E. faecium* CRL183) or an MRS medium (Man Rogosa Sharpe, Accumedia, USA) for 72h at 37°C (*L. acidophilus* CRL1014), and the cells were precipitated by centrifugation (1173 x g/15 min, 4 °C) and washed with phosphate water.

The salamis were maintained in a chamber for 7 (fermentation – temperature: 25-18 °C) and for 23 days (ripening- temperature: 15 °C), with controlled temperature and humidity, totaling 30 days (Koutsopoulos et al., 2008; Macedo et al., 2008). After this period, the salamis were vacuum-packed and stored under refrigeration for 90 days.

2.2 Chemical composition

Moisture, ash, protein and fat contents were determined according to the Association of official analytical chemists (Association of Official Analytical Chemists, 2005). The determination of total carbohydrates was performed by difference (Fuchs et al., 2005). The total calorie value (TCV) content of the products was calculated based on the content of proteins, carbohydrates and lipids, follow de equation bellow: TCV (kcal) = [proteins (g) x 4)] + [carbohydrates (g) x 4] + [fat (g) x 9].

2.3 Instrumental measurement of texture

The texture profile was determined using a Universal TA-XTplus Texture Analyzer (Stable micro systems, United Kingdom), by a test known as TPA (Texture Profile Analysis) (Bourne, 1978). The parameters determined hardness (g), elasticity, cohesiveness (g x mm), gumminess (g) and chewiness (g x mm) (Liaros et al., 2009).

2.4 Sensory analysis

Sensory analyzes were carried out in a climatized (22 °C) individual cabins, and evaluated under white light, thereby ensuring comfort and privacy for the assessors. The sessions were held in the Laboratory of Sensory Analysis (Department of Food and Nutrition, UNESP). Water was provided for palate cleansing.

This research project was submitted and approved by the Research Ethics Committee from the Faculty of Pharmaceutical Sciences, under number CAAE 0657.4912.2.0000.5426. A Consent Term containing information about the research was prepared and presented to the assessors.

2.5 Quantitative descriptive analysis

The sensory profile evaluation of all seven salami samples was conducted by the quantitative descriptive analysis (QDA) according to the methodology proposed by Stone et al. (2012). This technique has been adopted to analyze various food products, and its principles and measures are well established (Gonzalez et al., 2011; Volpini-Rapina et al., 2012).

2.6 Pre-selection of assessors

Participants were recruited among FCFAr/UNESP undergraduates, graduates and employees, who presented themselves as salami consumers and expressed interest in becoming members of the sensory group to be trained. In the pre-selection, 30 candidates were submitted to sequential analysis proposed by Wald, using triangle tests (Amerine et al., 1965; Meilgaard et al., 1999), being approved only 22 candidates. The parameters used in the sequential analysis were: P=0.45 (maximum unacceptable ability), $P1$=0.70 (minimum acceptable ability), α=0.05 (likelihood of accepting a candidate without sensory acuity) and β=0.05 (likelihood of rejecting a candidate with sensory acuity). Based on these parameters, the sensory panelists were selected according to the number of triangular tests and the cumulative number of judgments. In this stage, two samples of commercial Italian salamis (Aurora and Sadia, Brazil) were used and the volunteers were asked to evaluate only the aroma and flavor of the products.

2.7 Descriptive terminology development

For the development of descriptive terminology, Repertory Grid technique according to Kelly's Method (Moskowitz, 1983) was used. All samples were presented in pairs, and the assessors described the similarities and differences between them. The 22 pre-selected volunteers evaluated the descriptive terms of the salamis and, by consensus, decided that 16 attributes would be sufficient to characterize the products. The descriptive terms were defined and the references for the maximum and minimum intensity of each attribute of the scale were provided by the pre-selected candidates (Table 1).

Training sessions to develop sensory memory and equalization among assessors team were held by direct contact of the individuals with maximum and minimum intensity references used for each attribute (Cadena & Bolini, 2011). The sessions were conducted in four days, with two to three daily sessions.

Table 1. Descriptors used for sensory profiling of Italian style salami.

Attributes	Definition	Reference
	Appearance	
Red color (COR)	Color characteristic of dry salami meat	Weak: Ketchup Hellmann´s Strong: Red Methyl
Amount of fat (QG)	The presence of fat globules in salami	Low: Salami Seara (slice: 0.3mm de thickness) Lot: Salami Aurora (slice: 0.3mm de thickness)
Uniformity fat (UG)	Regular size of fat particles in the salami surface (slice)	Low: Salami Seara (slice: 0.3mm de thickness) Lot: Salami Aurora (slice: 0.3mm de thickness)
Regularity of the border (RB)	Rough appearance of edge salami (slice)	Low: Salami Seara (slice: 0.3mm de thickness) Lot: Salami Aurora (slice: 0.3mm de thickness)
Brightness (B)	Characteristic related to the presence of fat in the salami surface (slice)	Low: Salami Seara (slice: 0.3mm de thickness) Lot: Salami Aurora (slice: 0.3mm de thickness)
	Aroma	
Spiced (CO)	Characteristic aroma of the presence of spices (garlic, pepper, salt)	Weak: Broth garlic and pepper (Siamar) dilute (10%) Strong: Broth garlic and pepper (Siamar)
Meat (CA)	Characteristic aroma of salami type salami.	Weak: Liquid meat extract (Maggi) diluted (10%) Strong: Liquid meat extract (Maggi)
Oxidized (OX)	Characteristic aroma of used vegetable oil	Weak: Soybean oil (Liza) Strong: Soybean oil (Liza) heated in an oven
	Texture	
Softness (MA)	Ease of chewing	Low: Hamburguer Seara (roast at 180°C and cut into portions of 2x2 cm) Lot: Salami Sadia (baked in boiling water for 10 min)
Succulent (SU)	Characteristic related to the presence of moisture in the product	Low: Hamburguer Seara (roast at 180°C and cut into portions of 2x2 cm) Lot: Salami Sadia (baked in boiling water for 10 min)
	Taste	
Salty (SA)	Aroma stimulated by sodium chloride (kitchen salt)	Low: 1% NaCl solution Lot: 10% NaCl solution
Spiced (CD)	Aroma related to the presence of spices (garlic, pepper, salt)	Weak: Broth garlic and pepper (Siamar) dilute (10%) Strong: Broth garlic and pepper (Siamar)
Acid (AC)	Acidity characteristic of fermented salamis	Low: *citric acid* diluted *solution* (0.01%) Lot: *citric acid solution* (5%)
Rancidity (RA)	Characteristic Aroma of aged fat	Weak: Soybean oil (Liza) Strong: Soybean oil (Liza) heated in an oven
Smoked (DF)	Characteristic Aroma of meat products subjected to the smoking process	Weak: common mortadella (Seara) (slice: 0.2mm de thickness) Strong: smoked mortadella (Seara) (slice: 0.2m de thickness)
Spicy (PI)	Aroma related to the presence of pepper	Weak: diluted pepper sauce (Siamar) diluído (10%) Strong: Pepper sauce (Siamar)

2.8 Selection of subjects for the QDA

The selection of the final team was based on their power of discrimination between samples ($p<0.30$), repeatability ($p> 0.05$) and consensus between the assessors (Damásio & Costell, 1991). The samples were evaluated in monadic sequence with three replicates, following a balanced complete block design (Wakeling & MacFie, 1995).

Evaluation by the quantitative descriptive analysis (QDA)

The selected assessors evaluated the seven salami samples according to the previously determined references for all attributes. They received portions of 15 g of salami sample and were asked to rate the intensity of each attribute using a continuous 9-cm unstructured line scale with anchors "weak" or "none" on the left and "strong" on the right. The samples were submitted to analysis and coded with three-digit random numbers in monadic sequence and four replications (Macfie et al., 1989).

2.9 Acceptance test

An acceptance testing evaluated the samples' appearance, color, aroma, texture, flavor and overall impression using a structured 9-points hedonic scale (Stone & Sidel, 1993). Samples were presented in a randomized complete block, coded with three-digit numbers in monadic sequence. The team consisted of 60 untrained volunteers which were regular consumers of salami.

2.10 Statistical analysis

QDA results were analyzed by ANOVA using two factors (assessors and sample) and their interaction, followed by a Tukey's test ($p > 0.05$). Principal Component Analysis (PCA) was also conducted to analyze the QDA results. These analyses were carried out using the Statistical Analysis System SAS 9.1.2. The acceptability results were analyzed by the ANOVA and Tukey's test ($p < 0.05$) using the BioEstat 5.0.

3 Results and discussion

3.1 Centesimal composition

With respect to the chemical composition of the samples (Table 2), the results at the end of the ripening period - salamis ready for consumption - are in accordance with Annex V of Normative Instruction # 22 of the Ministry of Agriculture and Supply of July 31 (2000), which recommends the following contents: moisture (max.) 40.0%, fat (max.) 35.0%, protein (min.) 20.0% and total carbohydrates (max.) 4.0% (Brasil, 2000).

Del Nobile et al. (2009) analyzed the effect of fat substitution by extra virgin olive oil on the chemical composition of an Italian-type salami and found the following mean values for the different formulations: moisture content between 27.50% and 37.40%, fat content between 23.6% and 29.84%, proteins ranging from 30.88% to 38.48%, and ash content between 5.73 and 6.85%. These results are consistent with the values found in this study, i.e. the products ready for consumption.

It was also found, as expected, a lower total fat content in fermented salamis processed with 60% pork fat reduction. In these formulations, the pork fat was replaced by extra virgin olive oil, which had been pre-emulsified with sodium caseinate (2%), to preserve the sensory characteristics and improve the fatty acid profile of the products. Consequently, the caloric content of the reduced fat formulations (T2 to T7) was lower ($p < 0.05$). It was also observed an increase in ash content, proteins and lipids as a function of storage time ($p<0.05$), as a result of moisture reduction in the salamis.

3.2 Instrumental texture

Table 3 shows the results of the Texture Profile Analysis.

The parameters hardness and gumminess exhibited an increase over the course of the analysis times, while chewiness increased at the end of the ripening period (T30) in all formulations. The elasticity of the salamis was reduced in the same period, and their cohesiveness remained largely unchanged until T90.

Only in the last period, T120, it was not possible to determine the texture profile of the formulations with fat reduction, indicating that hardness was above (exceeded) the maximum power that the machine can apply to the sample (operate). This result suggests that the partial replacement of animal fat for extra virgin olive oil results in increased hardness, which is a fact that may compromise the sensory quality of the product, especially during the storage period.

It was observed that in T90, between the formulations with reduced fat content, F5 presented the lowest mean value of hardness ($p<0.05$), indicating that this formulation exhibited the higher texture quality.

Andrés et al. (2006) evaluated the effect of different levels of fat on the quality of chicken salamis, and concluded that there was increased hardness with storage (4 °C). Similar results were reported by Candogan & Kolsarici (2003) for salamis with fat reduction and Kunrath & Savoldi (2014) that evaluated the application of propolis in Italian salami. This increase in hardness is probably due to the water loss of the product after being cooled.

Gumminess and chewiness are dependent on the hardness variable, which would explain an increase in these parameters due to the salamis' increased hardness. As the salami becomes harder as storage time passes, there is a reduction of its elasticity.

3.3 Quantitative Descriptive Analysis (QDA)

Volunteers who had the power of discrimination ($p<0.30$), repeatability ($p> 0.05$) and agreement with the other team members were selected. The nine selected assessors conducted the final analysis, once again in triplicate. The results of QDA are represented graphically by the spider and PCA graphs (Figure 1).

Table 2. Mean (±standard deviations) for centesimal composition (g/100g) at the end of the ripening period - salamis ready for consumption.

Formulation	Ash	Protein	Fat	Moisture	Carbohydrates	Calories
F1	$3.27^{c} \pm 0.14$	$28.77^{c} \pm 1.96$	$31.34^{a} \pm 2.85$	$33.16^{ab} \pm 1.23$	$3.46^{a} \pm 0.27$	$410.99^{a} \pm 11.55$
F2	$6.00^{b} \pm 0.28$	$31.19^{bc} \pm 2.51$	$24.47^{b} \pm 0.81$	$34.61^{a} \pm 2.32$	$3.73^{a} \pm 0.41$	$357.65^{b} \pm 12.91$
F3	$6.50^{ab} \pm 0.29$	$36.11^{a} \pm 0.37$	$21.86^{c} \pm 0.55$	$31.62^{b} \pm 1.03$	$3.91^{a} \pm 0.28$	$356.84^{b} \pm 5.10$
F4	$6.17^{b} \pm 0.03$	$35.53^{a} \pm 1.10$	$20.80^{c} \pm 1.10$	$33.84^{ab} \pm 2.14$	$3.66^{a} \pm 0.33$	$366.51^{ab} \pm 54.97$
F5	$6.96^{ab} \pm 0.96$	$32.08^{bc} \pm 3.59$	$23.00^{bc} \pm 1.11$	$33.91^{ab} \pm 1.61$	$4.05^{a} \pm 1.66$	$349.79^{b} \pm 10.31$
F6	$7.49^{a} \pm 1.04$	$34.42^{ab} \pm 0.46$	$22.36^{bc} \pm 1.09$	$31.90^{ab} \pm 1.23$	$3.94^{a} \pm 0.34$	$354.23^{b} \pm 8.03$
F7	$6.38^{b} \pm 0.22$	$33.65^{ab} \pm 0.70$	$22.93^{bc} \pm 0.93$	$33.16^{ab} \pm 0.50$	$3.89^{a} \pm 0.29$	$356.53^{b} \pm 4.84$

F1 - traditional cultures without fat and curing salts reduction (nitrite and nitrate 0.015% 0.005%); F2 - traditional cultures without curing salts reduction; F3 - traditional cultures with curing salts reduction (nitrite and nitrate 0.007% 0.003%); F4 and F5 - probiotic culture (*E. faecium* CRL183) without and with curing salts reduction, respectively; F6 and F7 - probiotic culture (*L. acidophilus* CRL1014) without and with curing salts reduction, respectively. Analysis of formulations: means with the same lowercase letters in the same column do not differ by Tukey test ($P < 0.05$).

Table 3. Mean (± standard deviations) obtained in the test TPA (Texture Profile Analysis), for hardness, cohesiveness, elasticity, gumminess and chewiness to the different formulations and processing steps.

Time/ Attributes	Formulations						
	F1	F2	F3	F4	F5	F6	F7
T0							
Hardness	$1.67^{bE} \pm 0.18$	$1.78^{abD} \pm 0.09$	$2.12^{aD} \pm 0.06$	$1.93^{abD} \pm 0.20$	$2.08^{abD} \pm 0.33$	$1.90^{abD} \pm 0.12$	$2.00^{aD} \pm 0.16$
Cohesiveness	$0.53^{abBC} \pm 0.04$	$0.57^{aA} \pm 0.04$	$0.48^{bB} \pm 0.03$	$0.51^{abA} \pm 0.05$	$0.54^{abB} \pm 0.03$	$0.56^{aA} \pm 0.03$	$0.51^{cbB} \pm 0.03$
Elasticity	$1.99^{aA} \pm 0.41$	$1.75^{abA} \pm 0.14$	$1.45^{bA} \pm 0.14$	$1.44^{bA} \pm 0.12$	$1.36^{bA} \pm 0.25$	$1.67^{abA} \pm 0.23$	$1.56^{bA} \pm 0.09$
Gumminess	$0.89^{bF} \pm 0.16$	$0.99^{abD} \pm 0.10$	$1.03^{abE} \pm 0.05$	$0.99^{bD} \pm 0.17$	$1.15^{aE} \pm 0.16$	$1.01^{abE} \pm 0.06$	$1.04^{abE} \pm 0.04$
Chewiness	$1.72^{bcF} \pm 0.08$	$1.99^{aD} \pm 0.10$	$1.47^{cdE} \pm 0.11$	$1.41^{dD} \pm 0.19$	$1.57^{bcdD} \pm 0.06$	$1.51^{dD} \pm 0.14$	$1.73^{bD} \pm 0.16$
T7							
Hardness	$9.44^{bD} \pm 1.74$	$13.86^{aC} \pm 1.83$	$13.42^{aC} \pm 0.79$	$11.57^{abC} \pm 1.58$	$11.25^{abC} \pm 2.17$	$12.71^{aC} \pm 0.19$	$12.79^{aC} \pm 1.04$
Cohesiveness	$0.61^{bA} \pm 0.05$	$0.50^{cdA} \pm 0.05$	$0.54^{bcA} \pm 0.02$	$0.43^{dB} \pm 0.02$	$0.83^{aA} \pm 0.08$	$0.49^{cdB} \pm 0.03$	$0.46^{cdC} \pm 0.02$
Elasticity	$1.23^{bB} \pm 0.07$	$1.32^{bB} \pm 0.12$	$1.32^{bA} \pm 0.18$	$1.26^{bB} \pm 0.03$	$1.17^{bB} \pm 0.06$	$1.29^{bB} \pm 0.05$	$1.56^{aA} \pm 0.13$
Gumminess	$3.61^{dE} \pm 0.25$	$5.83^{cD} \pm 0.52$	$6.54^{bcD} \pm 0.49$	$6.78^{bcC} \pm 1.20$	$8.70^{aD} \pm 1.07$	$7.28^{bD} \pm 0.14$	$6.51^{bcD} \pm 0.27$
Chewiness	$2.62^{dE} \pm 0.16$	$3.71^{abC} \pm 0.08$	$3.92^{aD} \pm 0.37$	$3.46^{bcC} \pm 0.14$	$3.44^{bcC} \pm 0.40$	$3.16^{cC} \pm 0.16$	$3.10^{cC} \pm 0.05$
T30							
Hardness	$26.58^{bC} \pm 1.46$	$47.04^{aB} \pm 10.25$	$45.39^{aB} \pm 9.83$	$54.78^{aB} \pm 6.61$	$47.62^{aB} \pm 7.54$	$50.04^{aB} \pm 7.17$	$47.91^{aB} \pm 9.77$
Cohesiveness	$0.57^{aAb} \pm 0.03$	$0.54^{abA} \pm 0.02$	$0.54^{abA} \pm 0.04$	$0.51^{bA} \pm 0.04$	$0.54^{abB} \pm 0.02$	$0.52^{bB} \pm 0.02$	$0.53^{abAB} \pm 0.02$
Elasticity	$1.09^{aBC} \pm 0.04$	$0.96^{bB} \pm 0.01$	$0.82^{dB} \pm 0.02$	$0.84^{cdC} \pm 0.02$	$0.96^{bC} \pm 0.01$	$0.87^{cC} \pm 0.02$	$0.85^{cdB} \pm 0.01$
Gumminess	$13.20^{bD} \pm 1.72$	$23.95^{aB} \pm 3.55$	$29.05^{aB} \pm 1.86$	$27.86^{aB} \pm 0.64$	$26.34^{aC} \pm 4.73$	$24.89^{aC} \pm 3.57$	$25.92^{aC} \pm 3.44$
Chewiness	$5.15^{cD} \pm 0.03$	$24.25^{abA} \pm 1.30$	$23.62^{bA} \pm 1.70$	$25.80^{aA} \pm 1.83$	$23.46^{bA} \pm 0.52$	$23.37^{bA} \pm 0.53$	$24.11^{abA} \pm 0.68$
T60							
Hardness	$49.06^{bB} \pm 1.48$	$46.64^{bB} \pm 3.53$	$46.05^{bB} \pm 3.31$	$59.54^{aAB} \pm 0.14$	$56.24^{aA} \pm 2.32$	$57.43^{aA} \pm 0.84$	$59.60^{aA} \pm 0.02$
Cohesiveness	$0.50^{bcC} \pm 0.02$	$0.39^{dB} \pm 0.07$	$0.45^{cdB} \pm 0.02$	$0.54^{abA} \pm 0.03$	$0.56^{aB} \pm 0.02$	$0.57^{aA} \pm 0.01$	$0.56^{aA} \pm 0.03$
Elasticity	$0.85^{aC} \pm 0.01$	$0.67^{bD} \pm 0.15$	$0.84^{aB} \pm 0.02$	$0.84^{aC} \pm 0.01$	$0.84^{aC} \pm 0.01$	$0.84^{aC} \pm 0.03$	$0.84^{aB} \pm 0.01$
Gumminess	$24.59^{cC} \pm 1.01$	$18.41^{dC} \pm 3.47$	$22.44^{cdC} \pm 1.94$	$30.71^{bB} \pm 3.67$	$31.17^{bB} \pm 2.33$	$37.60^{aB} \pm 0.39$	$34.19^{abB} \pm 0.22$
Chewiness	$11.14^{aC} \pm 0.34$	$12.01^{bcB} \pm 1.37$	$14.47^{aB} \pm 1.49$	$11.56^{cB} \pm 0.29$	$11.63^{cB} \pm 1.02$	$12.66^{abcB} \pm 1.42$	$13.62^{abB} \pm 0.88$
T90							
Hardness	$50.79^{aB} \pm 0.67$	$60.14^{abA} \pm 0.56$	$61.33^{abA} \pm 0.98$	$60.49^{abA} \pm 0.63$	$55.44^{cA} \pm 3.27$	$62.72^{aA} \pm 1.09$	$59.41^{bA} \pm 0.28$
Cohesiveness	$0.56^{aAB} \pm 0.03$	$0.53^{abA} \pm 0.02$	$0.54^{abA} \pm 0.02$	$0.54^{abA} \pm 0.03$	$0.55^{abB} \pm 0.01$	$0.52^{bB} \pm 0.01$	$0.54^{abAB} \pm 0.01$
Elasticity	$0.84^{abC} \pm 0.01$	$0.85^{aC} \pm 0.01$	$0.83^{abB} \pm 0.01$	$0.82^{bC} \pm 0.02$	$0.84^{abC} \pm 0.01$	$0.82^{bC} \pm 0.02$	$0.84^{abB} \pm 0.01$
Gumminess	$33.51^{dB} \pm 1.73$	$56.43^{bcA} \pm 3.82$	$54.75^{cA} \pm 2.06$	$55.36^{bcA} \pm 0.68$	$59.11^{bA} \pm 2.80$	$56.36^{bcA} \pm 1.25$	$67.83^{aA} \pm 0.82$
Chewiness	$12.81^{aB} \pm 0.15$	$12.43^{bcB} \pm 0.25$	$12.40^{bcC} \pm 0.31$	$12.37^{bcB} \pm 0.35$	$12.15^{cB} \pm 0.36$	$12.87^{abB} \pm 0.21$	$13.31^{aB} \pm 0.50$
T120							
Hardness	$65.30^{A} \pm 0.86$	Nd	Nd	Nd	Nd	Nd	Nd
Cohesiveness	$0.62^{A} \pm 0.01$	Nd	Nd	Nd	Nd	Nd	Nd
Elasticity	$0.95^{BC} \pm 0.01$	Nd	Nd	Nd	Nd	Nd	Nd
Gumminess	$48.44^{A} \pm 1.84$	Nd	Nd	Nd	Nd	Nd	Nd
Chewiness	$13.76^{A} \pm 0.29$	Nd	Nd	Nd	Nd	Nd	Nd

F1 - traditional cultures without fat and curing salts reduction (nitrite and nitrate 0.015% 0.005%); F2 - traditional cultures without curing salts reduction; F3 - traditional cultures with curing salts reduction (nitrite and nitrate 0.007% 0.003%); F4 and F5 - probiotic culture (*E. faecium* CRL183) without and with curing salts reduction, respectively; F6 and F7 - probiotic culture (*L. acidophilus* CRL1014) without and with curing salts reduction, respectively. T0 = initial time; T7 = end of fermentation period; T30 = end of the ripening period; T60, T90 and T120 = storage time at 4 °C. Nd = not determined. Analysis of formulations: means with the same lowercase letters in the same line, in the same time interval, do not differ by Tukey test ($P < 0.05$). Analysis of time: means with capital letters for the same formulation at different times, do not differ by Tukey test ($p < 0.05$).

The spider graph (Figure 1) suggests that control formulation (F1), without fat and curing salt reduction, presented a different behavior with higher mean values of brightness, edge regularity, softness and rancidity flavor. The other formulations showed a similar behavior, since the differences between mean values, even though being significant ($p < 0.05$ – Table 4), were numerically lower.

The PCA chart (Figure 2) shows that 54.98% of the variation between the samples was explained by the first axis (PC1) and 14.85% by the second axis (PC2). The PCA clearly separated the formulations with fat reduction, control sample (F1), but it did not manage to separate them according to the starter culture used and the amount of curing salts. Attributes CO, MA, PI, CA, SA and COR contributed with greater weight to the variability associated with the second axis. While the other attributes were those that most contributed to the variability associated with the first axis. The control formulation (F1: without fat and curing salt content reduction and produced with traditional cultures) showed, once more, a different behavior from the others, being characterized by the attributes B, RA, SU, CD, DF and RB (PC1). The other formulations were located in closer regions, exhibiting the following characteristics: F2, F3 and F7 were located next to vectors OX, QG and UG; F4 close to vectors CA, RA and COR;

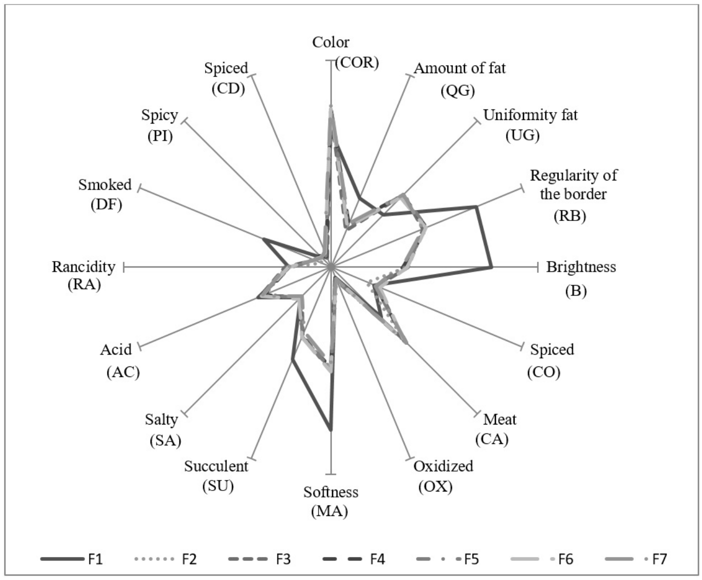

Figure 1. Spider graph with the average of the attributes of salami samples. F1 - traditional cultures without curing fat and curing salts reduction (nitrite and nitrate 0.015% 0.005%); F2 - traditional cultures without curing salts reduction; F3 - traditional cultures with curing salts reduction (nitrite and nitrate 0.007% 0.003%); F4 and F5 - probiotic culture (*E. faecium* CRL183) without and with curing salts reduction, respectively; F6 and F7 - probiotic culture (*L. acidophilus* CRL1014) without and with curing salts reduction, respectively.

Table 4. Results of QDA (mean ± SD) of the different formulations of salamis.

	Attributes	F1	F2	F3	F4	F5	F6	F7
Appearance	**Color**	$4.61^{b} \pm 0.21$	$5.37^{a} \pm 0.24$	$5.32^{a} \pm 0.17$	$5.37^{a} \pm 0.26$	$5.44^{a} \pm 0.25$	$5.40^{a} \pm 0.26$	$5.46^{a} \pm 0.32$
	Amount of fat	$2.52^{a} \pm 0.26$	$1.47^{bc} \pm 0.23$	$1.33^{c} \pm 0.18$	$1.57^{b} \pm 0.20$	$1.51^{bc} \pm 0.28$	$1.46^{bc} \pm 0.26$	$1.60^{b} \pm 0.23$
	Uniformity fat	$2.50^{b} \pm 0.26$	$3.50^{a} \pm 0.24$	$3.47^{a} \pm 0.26$	$3.44^{a} \pm 0.28$	$3.48^{a} \pm 0.29$	$3.33^{a} \pm 0.21$	$3.47^{a} \pm 0.24$
	Regularity of the border	$5.32^{a} \pm 0.25$	$3.39^{b} \pm 0.24$	$3.38^{b} \pm 0.22$	$3.50^{b} \pm 0.20$	$3.50^{b} \pm 0.19$	$3.47^{b} \pm 0.25$	$3.37^{b} \pm 0.30$
	Brightness	$5.41^{a} \pm 0.23$	$2.58^{b} \pm 0.28$	$2.60^{b} \pm 0.18$	$2.44^{b} \pm 0.29$	$2.48^{b} \pm 0.28$	$2.57^{b} \pm 0.28$	$2.41^{b} \pm 0.23$
Aroma	**Spiced**	$1.58^{a} \pm 0.24$	$1.31^{b} \pm 0.22$	$1.67^{a} \pm 0.33$	$1.63^{a} \pm 0.32$	$1.60^{a} \pm 0.32$	$1.78^{a} \pm 0.35$	$1.63^{a} \pm 0.34$
	Meat	$2.39^{b} \pm 0.28$	$3.55^{a} \pm 0.30$	$3.49^{a} \pm 0.27$	$3.62^{a} \pm 0.25$	$3.56^{a} \pm 0.27$	$3.50^{a} \pm 0.31$	$3.60^{a} \pm 0.21$
	Oxidized	$0.38^{a} \pm 0.03$	$0.48^{a} \pm 0.05$	$0.39^{a} \pm 0.04$	$0.40^{a} \pm 0.04$	$0.47^{a} \pm 0.04$	$0.43^{a} \pm 0.04$	$0.43^{a} \pm 0.04$
Texture	**Softness**	$5.51^{a} \pm 0.22$	$3.41^{bc} \pm 0.23$	$3.53^{b} \pm 0.24$	$3.39^{bc} \pm 0.23$	$3.42^{bc} \pm 0.22$	$3.53^{b} \pm 0.22$	$3.29^{c} \pm 0.19$
	Succulent	$3.36^{a} \pm 0.27$	$2.53^{bc} \pm 0.23$	$2.49^{bc} \pm 0.26$	$2.55^{b} \pm 0.26$	$2.53^{bc} \pm 0.23$	$2.56^{a} \pm 0.25$	$2.34^{c} \pm 0.21$
Taste	**Salty**	$1.45^{a} \pm 0.19$	$1.47^{a} \pm 0.19$	$1.39^{a} \pm 0.18$	$1.47^{a} \pm 0.26$	$1.40^{a} \pm 0.18$	$1.52^{a} \pm 0.28$	$1.37^{a} \pm 0.24$
	Acid	$2.67^{a} \pm 0.25$	$2.38^{b} \pm 0.28$	$2.57^{ab} \pm 0.27$	$2.43^{b} \pm 0.26$	$2.57^{ab} \pm 0.30$	$2.54^{ab} \pm 0.31$	$2.54^{ab} \pm 0.29$
	Rancidity	$1.42^{ab} \pm 0.24$	$1.51^{ab} \pm 0.19$	$1.57^{a} \pm 0.21$	$1.41^{ab} \pm 0.24$	$1.36^{b} \pm 0.19$	$1.44^{ab} \pm 0.23$	$1.54^{ab} \pm 0.28$
	Smoked	$2.46^{a} \pm 0.05$	$0.35^{c} \pm 0.04$	$0.63^{b} \pm 0.09$	$0.64^{b} \pm 0.08$	$0.62^{b} \pm 0.09$	$0.64^{b} \pm 0.09$	$0.60^{b} \pm 0.09$
	Spicy	$0.49^{a} \pm 0.04$	$0.50^{a} \pm 0.05$	$0.53^{a} \pm 0.06$	$0.56^{a} \pm 0.11$	$0.51^{a} \pm 0.06$	$0.48^{a} \pm 0.04$	$0.44^{a} \pm 0.04$
	Spiced	$0.46^{ab} \pm 0.04$	$0.44^{ab} \pm 0.05$	$0.34^{b} \pm 0.04$	$0.40^{ab} \pm 0.05$	$0.42^{ab} \pm 0.05$	$0.52^{ab} \pm 0.04$	$0.55^{a} \pm 0.05$

F1 - traditional cultures without fat and curing salts reduction (nitrite and nitrate 0.015% 0.005%); F2 - traditional cultures without curing salts reduction; F3 - traditional cultures with curing salts reduction (nitrite and nitrate 0.007% 0.003%); F4 and F5 - probiotic culture (*E. faecium* CRL183) without and with curing salts reduction, respectively; F6 and F7 - probiotic culture (*L. acidophilus* CRL1014) without and with curing salts reduction, respectively. Means with the same letter on the same line do not differ by Tukey test ($p < 0.05$).

F5 and F6 were located in the positive region of the PC2, next to vectors PI and MA.

The results of the analysis of variance and the Tukey test (Table 4) showed no significant difference between the formulations for attributes oxidized, salty and smoked ($p < 0.05$). Formulation F1 (control formulation) showed the highest intensity for attributes regularity of the border, amount of fat, brightness, softness and rancidity and the lowest mean values for color, uniformity fat and acid, therefore differing from all other formulations ($p < 0.05$). Formulation F2 showed the lowest mean values for aroma and spicy flavor. On the other hand, the salami fermented with *E. faecium* CRL 183 and curing salt reduction (F6) was the most succulent, without significantly differing from the control formulation ($p < 0.05$). Finally, formulation F3 (traditional cultures, fat and curing salt reduction) exhibited the highest mean value for acid taste, only differing from formulation F5, and the lowest mean value for spicy flavor, only differing from the probiotic salami, F7 ($p < 0.05$).

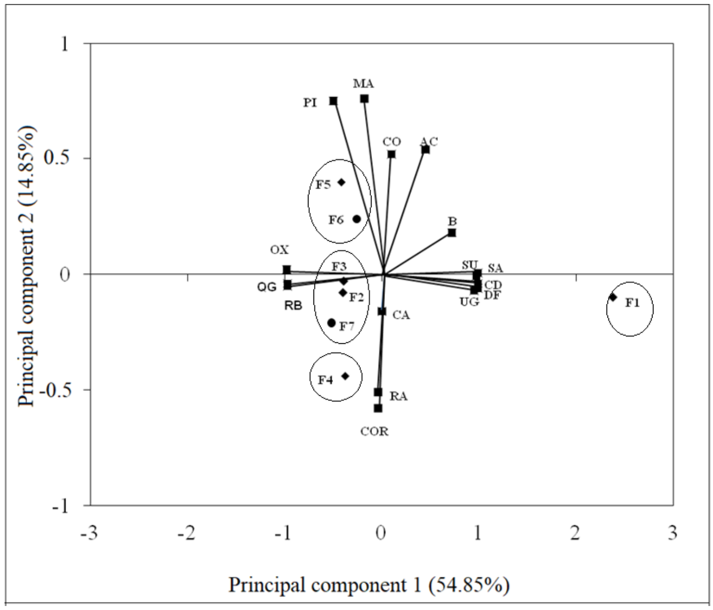

Figure 2. PCA chart of different formulations. APPEARANCE: Color (COR), amount of fat (QG), uniformity fat (UG), regularity of the border (RB), brightness (B); AROMA: spiced (CO), meat (CA), oxidized (OX); TEXTURE: softness (MA), succulent (SU); TASTE: salty (SA), spiced (CD), acid (AC), rancidity (RA), smoked (DF), spicy (PI). F1 - traditional cultures without fat and curing salts reduction (nitrite and nitrate 0.015% 0.005%); F2 - traditional cultures without curing salts reduction; F3 - traditional cultures with curing salts reduction (nitrite and nitrate 0.007% 0.003%); F4 and F5 - probiotic culture (*E. faecium* CRL183) without and with curing salts reduction, respectively; F6 and F7 - probiotic culture (*L. acidophilus* CRL1014) without and with curing salts reduction, respectively.

The results obtained in the QDA were as expected since the fat content reduction is directly affects the product's texture (softness and succulence), which can be confirmed by the instrumental data of texture.

Gómez & Lorenzo (2013) evaluated the effect of fat reduction on a typical Spanish product, the chorizo. The results showed significant differences in cohesiveness, odor intensity, pepper odor and hardness between the samples produced with and without reduction in pork fat.

The results of this study indicate that the reduction in nitrite content and the replacement of traditional cultures for probiotic ones did not alter the aroma and taste of the samples. Despite the presence of nitrite be related to the characteristic red color of cured meats (Fox & Ackerman, 1968; Sebranek & Fox, 1985) there was no change in the perception of this attribute in this study due to the reduction of curing salts. Mora-Gallego et al. (2013) also evaluated the effect of reducing and replacing animal fat in sensory and instrumental properties of fermented salamis. Formulations with a minimum reduction of 70% animal fat (5% addition of animal fat, sunflower oil or diglycerides) demonstrated similar behavior to the control formulation (no fat reduction). Nevertheless, the addition of sunflower oil still improved the aroma, taste and texture of the products.

3.4 Acceptance testing

Table 5 shows the values of appearance, color, aroma, texture, flavor and overall impression obtained in the acceptance test of the 7 formulations in 30 (product ready for consumption), 60, 90 and 120 days (of storage time).

The different formulations showed good acceptance for all attributes, as well as fat and curing salt reduction, and replacing traditional starter cultures for probiotic ones did not influence the hedonic impression of consumers by the end of the ripening period (T30) ($p<0.05$).

During the storage period (T60 to T120), the evaluated attributes remained highly graded, with mean values close to 7.0 for the different formulations. At the end of the 120 days of storage, the potentially probiotic samples exhibited lower acceptance mean values for appearance (F5=*Enterococcus faecium* CRL183) and texture (F6=*Lactobacillus acidophilus* CRL1014), without interfering with the overall impression of the samples ($p < 0.05$).

The results of the purchase intention survey (Figure 3) confirmed the results of the acceptance test and, at all analyzed times, over 60% of the consumers would certainly or probably buy the products, with the exception of F3 and F6 formulations in T60 (48% and 47%, respectively, would certainly or probably purchase the product). The partial replacement of animal fats for olive oil was noticed by assessors in the descriptive analysis. However, the identified changes did not affect the overall acceptance of the products.

Other authors evaluated the effect of including vegetable oils to replace animal fat in fermented meat products and the results were similar to those found in this study. Backes et al. (2013) evaluated the effect of the partial replacement of pork fat for emulsion containing canola oil in an Italian salami type. In their study, three formulations were evaluated: a control formulation (100% pork fat without replacing fat);

Table 5. Means (± standard deviations) of acceptance values for each attribute evaluated in different formulations.

Time/Attribute	Formulations						
	F1	F2	F3	F4	F5	F6	F7
T30							
Appearance	$7.55^{abA} \pm 1.24$	$7.60^{abA} \pm 1.08$	$8.07^{aA} \pm 0.72$	$7.53^{abA} \pm 1.07$	$7.43^{bAB} \pm 1.16$	$8.00^{aA} \pm 0.82$	$7.66^{abAB} \pm 1.04$
Color	$7.82^{aA} \pm 1.07$	$7.58^{aA} \pm 1.08$	$8.03^{aA} \pm 0.83$	$7.65^{aA} \pm 1.01$	$7.50^{aAB} \pm 1.19$	$7.75^{aA} \pm 1.02$	$7.63^{aA} \pm 1.02$
Aroma	$6.85^{aA} \pm 1.26$	$7.35^{aA} \pm 1.18$	$7.14^{aA} \pm 1.43$	$6.98^{aA} \pm 1.05$	$7.15^{aA} \pm 1.27$	$7.17^{aA} \pm 1.43$	$7.32^{aA} \pm 1.15$
Texture	$7.53^{aA} \pm 1.17$	$7.52^{aA} \pm 1.00$	$7.51^{aA} \pm 1.17$	$7.50^{aA} \pm 1.17$	$7.62^{aA} \pm 0.96$	$7.28^{aA} \pm 1.25$	$7.42^{aA} \pm 1.07$
Taste	$7.03^{aA} \pm 1.55$	$7.35^{aA} \pm 1.02$	$7.41^{aA} \pm 1.43$	$7.55^{aAB} \pm 1.14$	$7.58^{aA} \pm 1.11$	$7.27^{aA} \pm 1.69$	$7.53^{aA} \pm 1.06$
Overall impression	$7.27^{aA} \pm 1.25$	$7.52^{aA} \pm 0.93$	$7.59^{aA} \pm 1.15$	$7.33^{aAB} \pm 1.17$	$7.55^{aA} \pm 0.98$	$7.38^{aA} \pm 1.22$	$7.56^{aA} \pm 0.99$
T60							
Appearance	$7.32^{abA} \pm 1.19$	$7.37^{abA} \pm 1.07$	$7.90^{aA} \pm 0.99$	$7.20^{bA} \pm 1.40$	$7.62^{abA} \pm 1.12$	$7.72^{abA} \pm 1.45$	$7.63^{abAB} \pm 1.06$
Color	$7.45^{aAB} \pm 1.13$	$7.42^{aA} \pm 1.27$	$7.77^{aA} \pm 1.27$	$7.23^{aA} \pm 1.17$	$7.53^{aA} \pm 1.07$	$7.65^{bA} \pm 1.16$	$7.70^{aA} \pm 1.03$
Aroma	$6.53^{cA} \pm 1.26$	$7.15^{aA} \pm 1.26$	$7.20^{abA} \pm 1.19$	$6.70^{bcA} \pm 1.58$	$7.33^{abA} \pm 1.24$	$7.27^{abA} \pm 1.39$	$7.53^{aA} \pm 1.05$
Texture	$7.07^{abcA} \pm 1.15$	$7.47^{aA} \pm 1.02$	$6.50^{bcB} \pm 1.69$	$7.13^{abA} \pm 1.26$	$7.42^{aA} \pm 1.12$	$6.35^{cB} \pm 1.76$	$7.37^{aA} \pm 1.21$
Taste	$6.72^{bA} \pm 1.17$	$7.20^{abA} \pm 1.33$	$6.82^{abA} \pm 1.53$	$7.00^{abAB} \pm 1.56$	$7.28^{abA} \pm 1.24$	$7.05^{abA} \pm 1.37$	$7.63^{aA} \pm 1.07$
Overall impression	$6.93^{abA} \pm 1.29$	$7.22^{abA} \pm 1.03$	$6.70^{bB} \pm 1.68$	$6.95^{abB} \pm 1.47$	$7.37^{abA} \pm 1.06$	$6.85^{abA} \pm 1.54$	$7.53^{aAB} \pm 1.02$
T90							
Appearance	$7.40^{abcA} \pm 1.21$	$7.73^{abA} \pm 1.23$	$7.92^{aA} \pm 0.91$	$7.47^{abcA} \pm 1.07$	$7.05^{cB} \pm 1.55$	$7.82^{aA} \pm 0.95$	$7.18^{bcB} \pm 1.51$
Color	$7.30^{abA} \pm 1.14$	$7.62^{aA} \pm 1.29$	$7.80^{aA} \pm 0.99$	$7.37^{abA} \pm 1.26$	$6.92^{bB} \pm 1.65$	$7.63^{aA} \pm 1.07$	$6.88^{bB} \pm 1.79$
Aroma	$6.63^{cA} \pm 1.39$	$7.65^{aA} \pm 1.23$	$7.50^{abA} \pm 1.13$	$6.98^{bcA} \pm 1.30$	$7.43^{abA} \pm 1.48$	$7.42^{abA} \pm 1.15$	$7.33^{abA} \pm 1.56$
Texture	$7.32^{abA} \pm 1.35$	$7.57^{aA} \pm 1.41$	$6.92^{abAB} \pm 1.44$	$7.00^{abA} \pm 1.15$	$7.52^{abA} \pm 1.38$	$6.85^{bAB} \pm 1.46$	$7.30^{abA} \pm 1.51$
Taste	$6.68^{bA} \pm 1.46$	$7.38^{acA} \pm 1.30$	$7.30^{abA} \pm 1.34$	$7.32^{abAB} \pm 1.11$	$7.55^{aA} \pm 1.57$	$7.37^{aA} \pm 1.21$	$7.08^{abA} \pm 1.61$
Overall impression	$6.93^{aA} \pm 1.29$	$7.42^{aA} \pm 1.20$	$7.45^{aA} \pm 1.20$	$7.18^{aAB} \pm 1.11$	$7.30^{aA} \pm 1.46$	$7.33^{aA} \pm 1.19$	$7.00^{aB} \pm 1.45$
T120							
Appearance	$7.62^{abA} \pm 1.01$	$7.45^{abA} \pm 1.17$	$7.83^{aA} \pm 0.99$	$7.42^{abA} \pm 1.45$	$7.10^{bAB} \pm 1.12$	$7.76^{aA} \pm 1.04$	$7.75^{aA} \pm 1.08$
Color	$7.72^{aAB} \pm 0.98$	$7.35^{abA} \pm 1.36$	$7.92^{aA} \pm 1.06$	$7.47^{abA} \pm 1.33$	$7.05^{abAB} \pm 1.21$	$7.75^{aA} \pm 1.14$	$7.56^{abA} \pm 1.13$
Aroma	$7.08^{aA} \pm 1.23$	$7.55^{aA} \pm 1.20$	$7.37^{aA} \pm 1.29$	$7.08^{aA} \pm 1.41$	$7.41^{aA} \pm 1.21$	$7.41^{aA} \pm 1.30$	$7.54^{aA} \pm 1.12$
Texture	$7.30^{abA} \pm 1.15$	$7.63^{aA} \pm 1.10$	$6.97^{bAB} \pm 1.50$	$7.50^{abA} \pm 1.12$	$7.36^{abA} \pm 1.23$	$6.95^{bAB} \pm 1.27$	$7.44^{abA} \pm 1.04$
Taste	$7.08^{aA} \pm 1.23$	$7.55^{aA} \pm 1.17$	$7.22^{aA} \pm 1.51$	$7.63^{aA} \pm 1.12$	$7.37^{aA} \pm 1.07$	$7.39^{aA} \pm 1.23$	$7.49^{aA} \pm 1.34$
Overall impression	$7.15^{aA} \pm 1.13$	$7.40^{aA} \pm 1.18$	$7.27^{aAB} \pm 1.45$	$7.55^{aA} \pm 1.24$	$7.27^{aA} \pm 1.13$	$7.34^{aA} \pm 1.21$	$7.59^{aA} \pm 1.02$

F1 - traditional cultures without fat and curing salts reduction (nitrite and nitrate 0.015% 0.005%); F2 - traditional cultures without curing salts reduction; F3 - traditional cultures with curing salts reduction (nitrite and nitrate 0.007% 0.003%); F4 and F5 - probiotic culture (*E. faecium* CRL183) without and with curing salts reduction, respectively; F6 and F7 - probiotic culture (*L. acidophilus* CRL1014) without and with curing salts reduction, respectively. T30 = end of the ripening period; T60, T90 and T120 = storage time at 4 °C. Means followed by the same lower case letters in a line and capital letters on the column do not differ by Tukey test ($p < 0.05$). Analysis between formulations: means with lowercase equal on the same line do not differ by means of Tukey test ($P < 0.05$). Analysis between time: means with capital letters for the same formulation at different times, do not differ by Tukey test ($p < 0.05$).

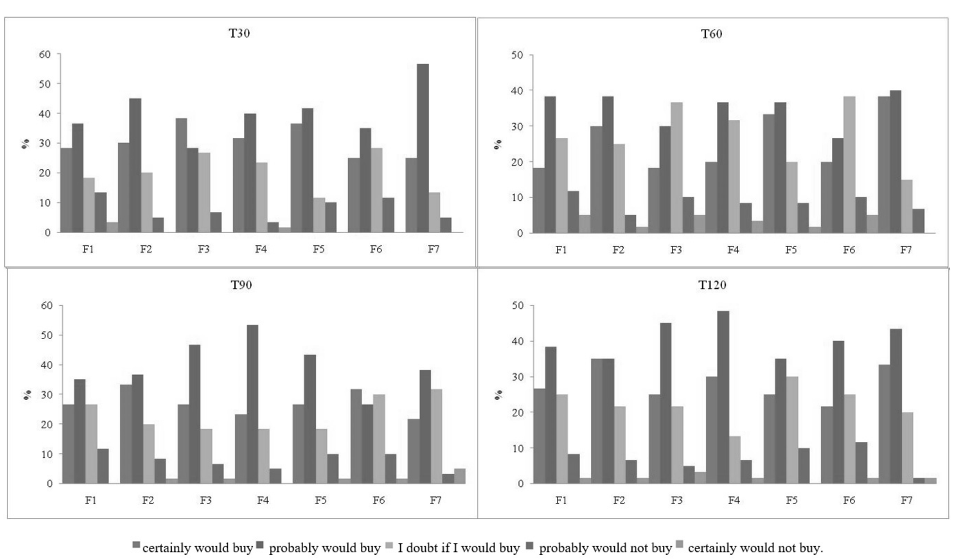

Figure 3. Frequency distribution of the notes corresponding to the scale used to assess the purchase intention of the products ready for consumption (T30) and during the storage period (T60, T90 and T120). F1 - traditional cultures without fat and curing salts reduction (nitrite and nitrate 0.015% 0.005%); F2 - traditional cultures without curing salts reduction; F3 - traditional cultures with curing salts reduction (nitrite and nitrate 0.007% 0.003%); F4 and F5 - probiotic culture (*E. faecium* CRL183) without and with curing salts reduction, respectively; F6 and F7 - probiotic culture (*L. acidophilus* CRL1014) without and with curing salts reduction, respectively.

T1 (15% of pork fat replacement for emulsion containing canola oil) and T2 (30% of pork fat replacement for emulsion with oil canola). The acceptance of the samples was evaluated using a seven-point hedonic scale, ranging from extremely disliked (1) to extremely liked (7). The acceptance values obtained for all formulations and attributes were next to five (5), indicating that the replacement of animal fat for vegetable oil did not affect the acceptance of the product.

Bloukas & Paneras (1993) studied the effect of replacing animal fat for olive oil in dry fermented salamis. Five formulations were produced: A) A control formulation (24% beef, 43% pork and 22% pork fat, B) and C) replacing 10% and 20% animal fat for olive oil, respectively, and D) and E) replacing 10% and 20% animal fat for pre-emulsified olive oil with soy protein isolate, respectively. The sensory characteristic evaluation of the different formulations were carried out using a seven-point scale (7 = excellent; 6 = very good; 5 = good; 4 = acceptable; 3 = fair; 2 = slightly unacceptable; 1 = unacceptable). The salamis produced with pre-emulsified olive oil showed similar sensory characteristics to the control formulation with sensory mean values exceeding five for aroma and taste, wherein the added oil content did not influence the results. On the other hand, the replacement of animal fat for olive oil negatively alters the sensory characteristics of the fermented products as well as the product developed by Menegas et al. (2013) using corn oil as a substitute.

4 Conclusion

The results indicate that it was possible to obtain a potentially probiotic fermented salami, and that, the replacing of the animal fat, the reduction in curing salts content and replacement of traditional cultures for probiotic ones does not compromise the chemical composition or the acceptance of salamis, besides the QDA and texture profile differences between formulations with reduced fat and control. All formulations showed a positive purchase intention, indicating that the functional sausages exhibit potential to be inserted in the market.

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