

Full Length Research Paper

Physicochemical and microbiological characteristics of Italian salami made of lamb and enriched with pequi (*Caryocar brasiliense*, Cambess)

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The purpose of this study was to evaluate and compare the inclusion of different levels of pequi (*Caryocar Brasiliense*, Cambess) pulp in the processing of Italian salami made of lamb for the evaluation of their physicochemical and microbiological characteristics. Six formulations of Italian salamis were processed: no pequi pulp (control - treatment 1); 4% pequi pulp (treatment 2); 8% pequi pulp (treatment 3), 12% pequi pulp (Treatment 4), 16% pequi pulp (treatment 5) and 20% pequi pulp (treatment 6). During the maturation period, all Italian salamis made of lamb enriched with pequi presented similar behaviors; and acidity (pH) and water activity (aw) results showed stable end values. For protein, the Italian salami made of lamb without pequi pump presented a higher content. For one of the lowest contents of fat, treatment 3 showed the highest content of humidity. The contents of fat and ashes did not present any significant difference when comparing the Italian salami formulations. A color tending to dark, yellowish and reddish shades was observed in the Italian salamis made of lamb and enriched with pequi. All Italian salamis were microbiologically satisfactory, showing ideal sanitary conditions for consumption. Pequi is a typical fruit from the Brazilian cerrado region, with characteristic color, odor and flavor, and it is an option for inclusion in Italian salamis, but additional studies should be conducted to inspect the sensory acceptability of these products.

Key words: Cerrado fruit, fermented stuffed meat sausages, physicochemical parameters, microbiological parameters.

INTRODUCTION

The lamb meat is a source of protein similar to other species; however, consumption is restricted due to factors involving the dark color, and the flavor and sharp odor. Lima (2009) states that lamb consumption in Brazil (0.7 kg/inhabitant/year) is still lower than farmer's expectation, justified by Brazilians, not used to consume

lamb and the supply is irregular as it costs a little higher than bovine meat.

An alternative to trade and increase lamb consumption would be through industrialization, for instance, stuffed lamb sausages (Pelegri et al., 2008). The market for fermented sausage has shown significant growth and

high competitiveness; these foods are part of the food habits of a considerable portion of Brazilian consumers (François et al., 2009).

Caryocar Brasiliense, Cambess is a fruit of high nutritional value, rich in vitamins A, E, C, polyunsaturated fatty acids, phosphorus, potassium and magnesium, which are substances responsible for the proper functioning of the body (Sousa et al., 2012), in developing new meat products are attractive to consumers as nutritional value, antioxidant activity (Roesler et al., 2007), color, flavor with unique and intense aroma. Although the consumption of fruits from the cerrado region has grown substantially in recent times, they are still not commercially exploited, either by lack of knowledge or lack of incentives for their commercialization and market consolidation (Silva et al., 2014).

According to Lima et al. (2007), the yellow pulp of pequi (*C. brasiliensis*, Cambess), due to its exotic flavor, strong and characteristic aroma, is greatly appreciated and consumed by the population of several states in the North, Northeast and Central West regions of Brazil as a condiment when cooking rice, chicken and meats, and in liqueur production.

Therefore, the development of salami flavored with pequi fresh pulp may make the product have high nutritional value and provide increased consumption of lamb meat. Thereby, the aim of this study was to develop Italian type salami lamb flavored with pequi (*Caryocar brasiliense*, Cambess), and to assess its physicochemical and microbiological characteristics.

MATERIALS AND METHODS

The research was experimentally conducted at the Food Engineering Unit at Instituto Federal Goiano –Rio Verde Campus, GO.

Ingredients and starter culture

Lamb was used in Italian salamis, containing 28.89 g/100 g protein, 2.7 g/100 g fat, 70.06 g/100 g humidity, 7.2 g/100 g ashes and 5.95 pH, and bacon with 9.03 g/100 g protein, 47.38 g/100 g fat, 36.41 g/100 g humidity, 1.5 g/100 g ashes and 7.2 pH. The pequi pulp had 4.04 g/100 g protein, 15.7 g/100 g fat, 65.86 g/100 g humidity, 6.6 g/100 g ashes and 6.3 pH, as well as salami condiment and starter culture.

Santa Inês lamb and bacon were acquired in local trade, packed vacuum with the seal of Federal Inspection Service, according to Normative Instruction nº3, of January 17, 2000, which regulates the humane methods of livestock slaughter (Brasil, 2000).

As a starter culture, the study used dehydrated Bactoform® T-SPX, comprised of *Staphylococcus xylosose* and *Lactobacillus pentosus*, provided by Chr. Hansen, in the proportion of 1.3 ml of culture for every 1 kg of meat, after hydration in the proportion of 25

Table 1. Formulation of Italian salamis made of lamb and enriched with pequi.

Treatment	Formulation (%)		
	Lamb	Pequi pulp	Bacon
1	80	-	20
2	76	4	20
3	72	8	20
4	68	12	20
5	64	16	20
6	60	20	20

g for every 100 ml of mineral water, according to the manufacturer's recommendations.

The commercial condiment, of brand Aglomax® possessed in its composition the following ingredients: refined non-iodized salt, natural dehydrated spices, maltodextrin, flavor enhancer monosodium glutamate, stabilizer sodium tripolyphosphate, antioxidant sodium erythorbate, preservers nitrite and sodium nitrate.

Pequi pulp was obtained from fruits that came from a farm located in the municipality of Itarumã in the interior of Goiás (0°19'45"S, 51°15'16"O, 863 m altitude) in native forest in the Cerrado biome. The region's climate was classified as megathermal or tropical water activity (aw) according to the Köppen climate classification and is a Tropical Savanna subtype, with dry winters and rainy summers.

The region's average temperature is 25°C, and the average rainfall is approximately 1.600 mm, with the highest rainfall occurring in January and the lowest in June, July and August (< 50 mm month⁻¹). The fruits were screened, sanitized in a sodium hypochlorite solution at 200 ppm, peeled and pulped manually with the help of previously sanitized stainless steel knives.

Italian salami processing

Six formulations of Italian salamis were produced, as indicated in Table 1. Figure 1 shows the flowchart of pequi-based Italian salami processing. Before salami processing, all devices were sanitized by immersion, for 10 min, in a sodium hypochlorite solution at 200 ppm.

Shoulder top and leg cuts were used, with superficial fat and visible connective tissues removed, followed by lamb chopping and grinding. Lamb and bacon grinding was conducted using an 8 mm disc in a Moedor Camargo®. After grinding, all ingredients were manually and aseptically mixed in the following order: meat, bacon, condiment, pequi pulp *in natura* (ground) and starter culture, on plastic trays previously sanitized, identified according to every treatment and submitted to stuffing. 50% meat of top and 50% meat of leg was used in each formulation.

One Embutideira Camargo® stuffer was used to stuff the lamb meat, as well as collagen casings gauge 40, suitable for salami, cut in pieces of around 20 cm length, totaling five strings of around 200 g per treatment. After the stuffing process, the strings were placed in a cooled incubator (BOD) at 25°C and relative humidity of 95% for maturation until they reached 0.90 aw. After the maturation

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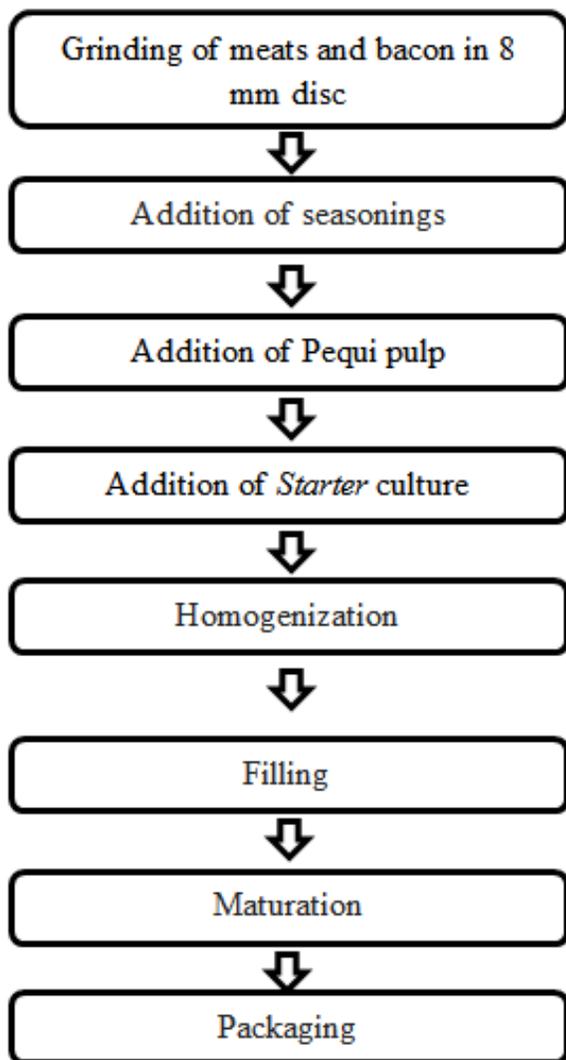


Figure 1. Flowchart of the processing of Italian salamis made of lamb and enriched with pequi.

period, they were vacuumed packed and stored at 10°C for analyses (Figure 2).

Physicochemical analyses

The characterization of raw materials (pequi pulp, Santa Inês lamb and bacon) involved the analyses of humidity, pH, fat, protein and ashes, according to the recommendations of AOAC (2000) and a color analysis that used a colorimeter (ColorQuest II, Hunter LabReston, Canada). The results were expressed in L^* , a^* and b^* , with values of L^* (luminosity or brightness) ranging from black (0) to white (100), values of chroma a^* ranging from green (-60) to red (+60) and values of chroma b^* ranging from blue (-60) to yellow (+60), according to Paucar-Menacho et al. (2008).

During salami maturation, the pH value and water activity were determined at days 1, 5, 9, 13, 17, 21, 25 and 29. The pH value was determined using Hanna® pH bench meter, model H1 221, and the water activity was determined using a Hygropalm, Model Aw1®.

Three samples from each treatment were randomly collected for

the analysis of Italian salamis with pequi; and they were analyzed in terms of protein, humidity, fat and ashes, following the recommendations of AOAC (2000), and color according to Paucar-Menacho et al. (2008). The treatments consisted of three replicates and analyzes in triplicate per replicate, totaling nine results by treatment.

Microbiological analyses

The microbiological analyses were conducted with the lamb, bacon, pequi pulp and Italian salamis with pequi to evaluate the quality of raw materials and Italian salamis with pequi, using the most probable number (MPN) method for total coliform and thermotolerant coliform counts, a classic cultural method of salmonella determination and direct count on plates for *Staphylococcus aureus* analysis, following the recommendations of Silva et al. (2001).

Statistical analyses

The physicochemical analyses of Italian salamis with pequi were conducted using a completely randomized design (CRD), in triplicate, with three repetitions for all analyses. The results were submitted for the analysis of variance (ANOVA) and Tukey's test, with 5% significance level, using Sisvar software (Ferreira, 2003). The pH and water activity results during the maturation period were submitted for the analysis of variance and regression analysis using Sigma Plot 10.1, Jandel Scientific (2010).

RESULTS AND DISCUSSION

Figure 3 shows the pH values of Italian salamis made of lamb and pequi during the maturation period, indicating that all treatments present the same behavior of reduced pH values on the first five days due to released lactic acid, which is created after the fermentation of hexoses by lactic bacteria, with pH increase after this period, due to reactions of decarboxylation and deamination of amino acids, releasing ammonia and increasing pH values.

The reduction in the pH values on the first days of fermentation is important for the production of quality salamis through the inhibition of pathogenic and degrading microorganisms, color conversion and stabilization, and production of compounds related to the flavor and aroma characteristics (Terra et al., 2004).

Furthermore, the pH values of Italian-type salami observed in this experiment are similar to those reported by Macedo et al. (2008) in their study of the preparation of sausages fermented by probiotic *Lactobacillus*. Similar results to this study have been reported in fermented cured products (Backes et al., 2013; Lorenzo and Franco, 2012; Cavalheiro et al., 2010; Olivares et al., 2010).

The reduction in the pH values leads to reduced water activity due to reduced water retention capability of meat proteins as pH approaches the isoelectric point, speeding up dehydration and slowing down the water activity (Chasco et al., 1996). Figure 4 shows this behavior, illustrating the water activity of Italian salamis made of lamb and enriched with pequi during the maturation period.

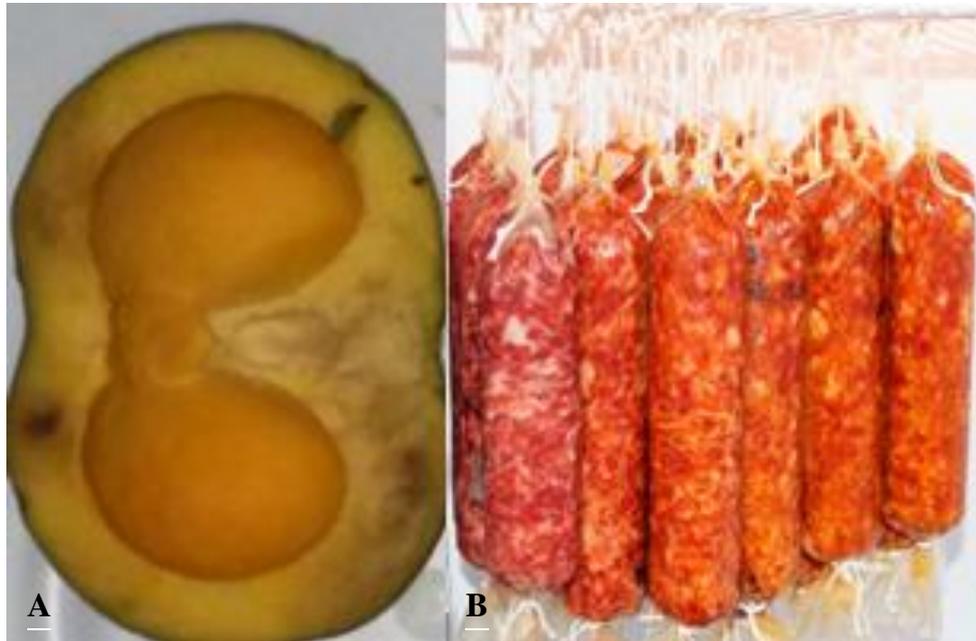


Figure 2. Unpeeled pequi (A) and Italian salami made of lamb enriched with pequi (B).

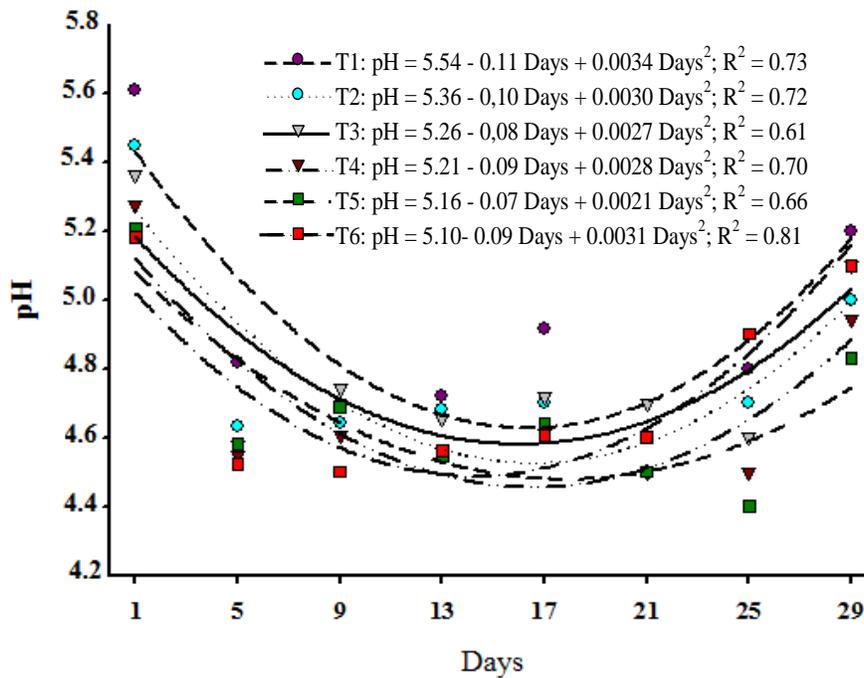


Figure 3. pH of Italian salamis made of lamb and enriched with pequi during the maturation period if Italian salamis made of lamb and enriched with pequi during the maturation period.

The reduction in the pH values and water activity of Italian salamis made of lamb and enriched with pequi during the maturation period agree with the behavior

reported by Cirolini et al. (2010) when analyzing an Italian salami produced with native starter cultures, and by Macedo et al. (2008), when studying the production of

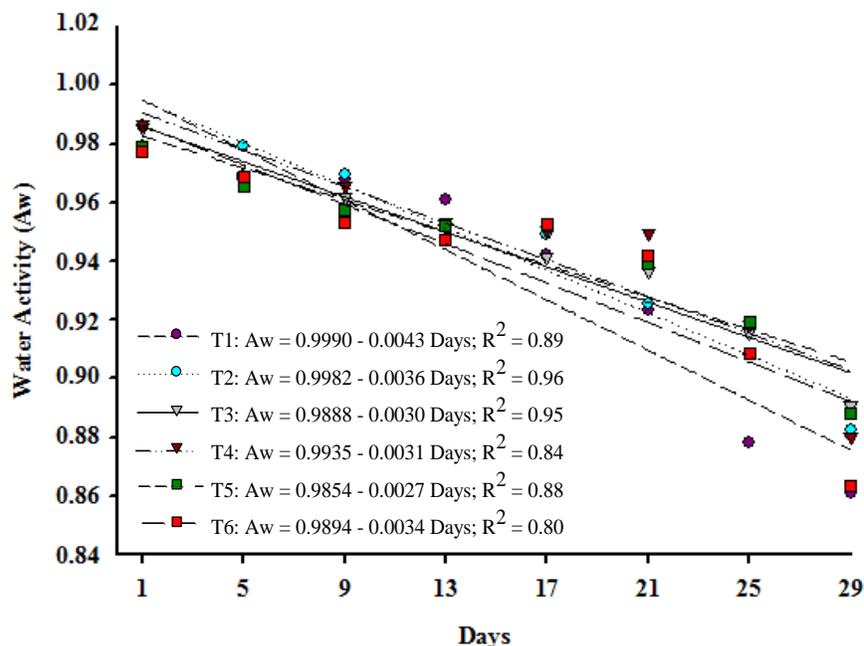


Figure 4. Water activity of Italian salamis made of lamb and enriched with pequi during the maturation period.

Table 2. Results from pH and water activity (Aw) analysis of Italian salamis made of lamb and enriched with pequi.

Parameter	Treatment						CV (%)	F value
	1	2	3	4	5	6		
pH	4.70 ^a	4.91 ^a	4.75 ^a	4.94 ^a	4.83 ^a	4.81 ^a	3.56	0.331 ^{ns}
Aw	0.87 ^a	0.88 ^a	0.88 ^a	0.88 ^a	0.89 ^a	0.87 ^a	5.55	2.09 ^{ns}

Mean values on the same line, with the same letter, do not present differences when compared with each other. ^{ns}Not significant.

stuffed meat sausages fermented with probiotic *Lactobacillus*.

Table 2 shows the end mean values of pH and aw during the maturation period of Italian salamis with pequi. The incorporation of different pequi pulp concentrations in the formulation of Italian salamis made of lamb did not influence ($p > 0.05$) the end values of pH and Aw, as the pH value of the pequi pulp is similar to the pH value of the meat, not showing pH differences as a result of meat replaced with pequi pulp. The end values of Aw reported in this study agree with the values required in the Brazilian legislation (Brasil, 2000), which establishes maximum 0.90 for Italian salamis.

The end pH values of Italian salamis in this study were similar to the values of 4.81- 4.93 mentioned by Scheid et al. (2003) in the physicochemical evaluation of Italian salamis with different concentrations of clove (*Eugenia caryophyllus*). However, lower pH values were reported by Paulsen et al. (2011) in a study that analyzed the

quality characteristics of salami made of wild boar meat, produced with different meat cuts and adipose tissue, with and without bacterial fermentation, whose end pH value was 6.05. However, Ordonez (2005) reported that meat products presenting pH < 5.0 and aw < 0.91 are considered stable.

In agreement with the end content of water activity presented by Italian salamis made of lamb and enriched with pequi, Cavalheiro et al. (2010) observed aw values ranging from 0.85 to 0.88 for cured and fermented stuffed meat sausages with the addition of ostrich meat combined with pork.

Regarding the physicochemical parameters (Table 3), the Italian salamis made of lamb presented fat contents ranging from 49.48 g/100 g to 40.16 g/100 g. The Italian salami made of lamb without pequi pulp (treatment1) presented high protein value (49.48 g/100 g), not showing significant difference ($p \leq 0.05$) when compared to treatments 2 (4% pequi pulp), 3 (8% pequi pulp) and 4

Table 3. Results of physicochemical analyses of Italian salamis made of lamb and enriched with pequi.

Parameter (g/100 g)	Treatment						CV (%)	F value
	1	2	3	4	5	6		
Protein	49.48 ^a	44.86 ^{ab}	44.31 ^{ab}	44.27 ^{ab}	41.60 ^b	40.16 ^b	11.71	3.47 ^{**}
Humidity	24.16 ^{ab}	24.15 ^{ab}	24.75 ^a	21.00 ^b	22.37 ^{ab}	20.93 ^b	10.49	4.47 ^{**}
Fat	39.38 ^a	37.47 ^a	37.98 ^a	39.04 ^a	38.82 ^a	38.10 ^a	5.42	1.10 ^{ns}
Ashes	6.19 ^a	6.40 ^a	6.28 ^a	6.35 ^a	6.49 ^a	6.33 ^a	4.41	1.263 ^{ns}

Mean values on the same line, with the same letter, do not present differences when compared with each other. ^{**}significant at 1% probability level. ^{ns}Not significant.

Table 4. Results of color (L*, a* and b*) of Italian salamis made of lamb and enriched with pequi.

Parameter	Treatments						CV (%)	F value
	1	2	3	4	5	6		
L*	43.17 ^c	45.39 ^b	46.09 ^b	46.00 ^b	46.89 ^{ab}	48.81 ^a	4.64	13.45 ^{**}
a*	10.79 ^a	6.14 ^b	6.07 ^b	4.75 ^c	4.56 ^c	4.53 ^c	13.64	147.507 ^{**}
b*	7.48 ^c	8.69 ^b	8.69 ^b	9.59 ^{ab}	9.84 ^a	9.85 ^a	11.52	13.56 ^{**}

Mean values on the same line, with the same letter, do not present differences when compared with each other. ^{**}Significant at 1% probability level. ^{ns}Not significant.

(12% pequi pulp), and which did not differ from treatments 5 (16% pequi pulp) and 6 (20% pequi pulp).

Lamb has more fat than pequi (*C. Brasiliense*, Cambess). However, due to the addition of pequi pulp in the formulations, a lower protein content was observed in Italian salamis made of lamb and enriched with pequi, both observing the values determined in the Brazilian legislation (min 25 g/100 g).

The Italian salamis made of lamb and enriched with pequi presented higher protein contents than the salamis made of Santa Inês lamb produced by Lima (2009) (34.87 g/100 g) and Lappe (2004) (30.83 to 32.50 g/100 g).

Regarding the humidity content, the results agree with the values determined in the Brazilian legislation (max. 35 g/100 g). Treatment 3 (8% pequi pulp) presented greater humidity with 24.75 g/100 g, with significant difference ($p \leq 0.05$) when compared to treatments 4 and 6. The other Italian salamis made of lamb (treatment 1, 2 and 5) did not differ significantly from the treatments above in terms of humidity. The Italian salami humidity is related to the fat content. For presenting one of the lowest fat content, treatment 3 showed the highest humidity level.

The values of salami humidity obtained in this study agree with data reported by Coelho et al. (2010) (31.5 to 28.5 g/100 g) in the production of stuffed meat sausages fermented with probiotic microorganisms.

No significant difference was observed ($p > 0.05$) in fat and ashes when comparing the treatments. Italian salamis may contain up to 32% of lipids in their composition (Brasil, 2000). The Italian salamis made of

lamb and enriched with pequi presented protein contents ranging from 38.48 to 37.47 g/100 g, contents above the values determined in the Brazilian legislation, which may have been influenced by low humidity.

In general, the Italian salamis presented dark (median values of luminosity), yellowish (positive b* component) and reddish color (slightly positive a* component) (Table 4). A higher content of luminosity (L*) and yellow color (b*) was observed in treatment 6 (20% pequi pulp), as well as reduced values of these parameters with lower pequi pulp concentrations. Thus, as pequi pulp increased in formulations, the Italian salamis presented clearer color, with more yellowish pigments, which is directly related to the yellow color of pequi pulp.

Regarding the reddish color, the Italian salamis of lamb without pequi pulp presented more reddish pigments, significantly differing from the Italian salamis of lamb with pequi pulp. The increased values of L* and b* and the reduced values of a* are consistent with the addition of pequi pulp in the formulations. Due to the addition of pequi pulp, different results of luminosity and reddish pigments from this study were reported by Matos et al. (2007) when studying the effect of fermentation type on the end quality of fermented cooked stuffed sausages made of lamb, and by Cirolini et al. (2010), when studying Italian salamis with native starter cultures.

The microbiological quality of Italian salamis made of lamb and enriched with pequi was considered satisfactory, as they presented negative results for total coliform, thermotolerant coliform and *Staphylococcus aureus*, as well as absence of Salmonella, indicating compliance with the Brazilian legislation (Brasil, 2000),

showing proper sanitary standards for consumption. These results are attributed to the quality of raw materials, the sanitization conditions of manufacture and product characteristics, which was confirmed by François et al. (2009), when studying the physicochemical and sensory properties of fermented stuffed sausages made of different proportions of pork and lamb for disposal.

Conclusion

Italian salamis made of lamb with the addition of pequi pulp presented good protein levels and, in general, all Italian salamis made of lamb presented high levels of fat. Studies using lower bacon concentrations should be conducted to meet the standards required by law. The addition of pequi pulp increased luminosity and intensity of yellow color of Italian salamis made of lamb that can be a visual attraction for consumers.

Based on pH and water activity results, the Italian salamis made of lamb and enriched with pequi are stable and can be stored at ambient temperature. Pequi is a typical fruit from the Brazilian cerrado region, with characteristic color, odor and flavor, and it is an option for inclusion in Italian salamis, but additional studies should be conducted to inspect the sensory acceptability of these products.

Conflict of interests

The authors did not declare any conflict of interest.

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