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PAPER

ITALIAN-TYPE SALAMI WITH PROPOLIS AS ANTIOXIDANT

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ABSTRACT

There is a world trend of replacing synthetic additives with natural ones. Thus, the purpose of this study was to evaluate the use of propolis, both free and microencapsulated, as a natural antioxidant in salami. For this, salamis were added with free propolis, propolis microencapsulated and other with sodium erythorbate (control). Weight loss, colour, pH, A_w, lipid oxidation, microbial spoilage and sensory acceptance were examined. Products containing propolis showed similar results to the control for colour, pH, weight loss and A_w. Propolis prevented the oxidation of salami during storage; however, it led to a lower sensorial acceptance.

- Keywords: antioxidant, bee glue, microencapsulation, quality, salami

INTRODUCTION

Salami is a product made with comminuted meat and fat that is embedded and subjected to fermentation and drying (CAMPAGNOL *et al.*, 2011). The lipids present in this product give it desirable sensory characteristics and nutritional and technological properties; however, they are easily oxidised, especially the linoleic (18:2, n-6) and oleic (18:1, n-9) acids (CHASCO *et al.*, 1993) included in this type of sausage. Oxidation degrades these compounds into secondary products, affecting the sensory attributes and nutritional value of the final product (OSAWA *et al.*, 2005).

To control this deterioration, in addition to the synthetic antioxidants currently used by the meat industry, it is possible and desirable to use natural antioxidants. Many natural compounds in bee products have significant antioxidant activity (NAGAI *et al.*, 2006), including propolis.

Propolis is a complex mixture of resinous material collected by honeybees from various plant sources (GUO *et al.*, 2011). Several studies have shown that propolis has biological properties such as antimicrobial, antifungal, antiviral and antioxidant activities (PENA, 2008). Attributed to the flavonoids and phenolic acids, most of the biological activities observed for propolis (FUNARI and FERRO, 2006).

Thus, propolis has potential to be used as a food additive because of its natural antioxidant and antimicrobial properties. However, due to its strong flavour and relative insolubility, the use of propolis in foods has been limited (NORI *et al.*, 2011). Microencapsulation can solve this limitation because of its ability to mitigate undesirable flavours; reduce volatility, hygroscopicity and reactivity; and increase solubility and stability in adverse conditions (FAVARO-TRINDADE *et al.*, 2008). A study by our research group demonstrated the feasibility of microencapsulating propolis by a complex coacervation method using isolated soy protein and pectin as a coating. The process yields an alcohol-free, stable powder with antioxidant activity and antimicrobial activity against *Staphylococcus aureus*, and it provides controlled release in food (NORI *et al.*, 2011).

Thus, the objective of this work was to use both free and microencapsulated propolis in Italian-type salami to evaluate their potential as a natural additive in this type of product.

MATERIALS AND METHODS

Salami sausage formulation and processing

The formulation followed the Brazilian legislation for Italian-type salami (BRASIL, 2000). Fresh boneless pork shoulder (600 g/kg), beef rib (200 g/kg) and pork backfat (200 g/kg) were obtained from a local supermarket. The following non-meat ingredients were added as a proportion of the total raw meat material: sodium nitrate (0.4 g/kg), sodium nitrite (0.1 g/kg), salt (25 g/kg), dextrose (7.5 g/kg), sodium tripolyphosphate (3.0 g/kg), monosodium glutamate (1.0 g/kg), white pepper (2.5 g/kg), garlic powder (2.0 g/kg), coriander (1.0 g/kg), nutmeg (0.5 g/kg), smoke aroma (0.3 g/kg) and starter culture (0.125 g/kg) Bactoferm F-1 (Chr.Hansen®, Valinhos, Sao Paulo, Brazil) containing *Staphylococcus xylosus* DD-34 and *Pediococcus pentosaceus* PCFF-1.

Salamis were divided into three treatments: treatment SE (control) with sodium erythorbate (0.5 g/kg), a synthetic antioxidant commercially used in salami production; treatment FP with free propolis (0.14 g/kg) prepared from the dehydration of ethanolic extract of propolis in a spray dryer and dissolved in 1 g/kg of propylene glycol; and treatment MCC with microencapsulated propolis with pectin and isolated soy protein (2.29 g/kg) prepared by complex coacervation according to methods described in NORI *et al.* (2011). All treatments with propolis were calculated to have the same amount of propolis solid in the final product. The propolis was prepared from green propolis, type 12, according to Brazilian classification (PARK *et al.*, 2002), and had its antioxidant activity and stability confirmed (NORI *et al.*, 2011).

The frozen beef and pork meat were cut and grounded separately using a grinder (Hobart, HB22-2 Troy, Ohio, USA) with stainless steel disks of 5 and 10 mm holes, respectively, and pork backfat was 8 mm hole. In the mixer (Beccaro, MB-25, São Paulo, Brazil), pork and beef were added first, followed by the pork backfat. After mixing of the raw meats, the non-meat ingredients were added, and the pre-hydrated starter culture and the propolis or sodium erythorbate were added last. , The meat batter was stuffed into collagen casings 55 mm in diameter and 250 mm in length (Viscofan Brazil, São Paulo, Brazil).

The salami sausages were hung from metal rods and randomly placed in a fermentation chamber for 32 days with controlled temperature and relative humidity (RH) and protected from light. Fermentation was carried out at 23°-25°C, 88-90% RH for 24 h to reach a pH between 5.0-5.2. Then, the temperature and RH were reduced to 15-17°C and 1-2% daily until reaching 75% respectively, where it remained until the 32nd day of the process when the salamis reached water activity less than 0.90. After the end of the process, the casings were removed manually and the final product was vacuum-packaged. The packages (Cryovac, Sao Paulo, Sao Paulo, Brazil) were composed of an ethylene vinyl acetate (EVA) multilayer (55 μm, O_2 trans. rate <30 $cm^3/m^2/24$ h/atm). The salami was stored away from light at ambient temperature (25°C) for 90 days.

This process was repeated three times, and each time, a sample of raw material (150 g) and three sausages from each treatment were randomly selected for analysis of quality and shelf life (1, 30, 60 and 90 days of storage).

Determination of lipid oxidation

Lipid oxidation was evaluated by measuring thiobarbituric acid reactive substances (TBARS) according to the method described by BRUNA *et al.* (2001). The results were expressed as mg of malonaldehyde per kg of a sample (mg MDA/kg). To obtain these results, the water content (% water) of the samples was quantified (PREGNOLATTO and PREGNOLATTO, 1985).

Measurement of pH, water activity (A_w) and instrumental colour

The pH was determined directly from samples (three measurement of each sample) using a potentiometer (Oakton pH 300 series 35618, Vemon Hills, Illinois, USA) with automatic temperature compensation and a glass penetration electrode (Digimed, Presidente Prudente, Sao Paulo, Brazil).

The water activity was measured at the temperature of 25.0°±0.3°C in salami slices approximately 3 mm thick which were placed in capsules suitable for analysis. The water activity was determined using the analyzer Aqualab CX2T (Decagon Devices Inc., Pullman, Washington, USA). This determination was performed on the raw sausage during the drying to identify the end of the process and during the storage for 90 days, with three measurements of each sample.

Colour was monitored (three measurements of each sample) using a Minolta colorimeter (Konica Minolta, Chroma Meter, 150 CR-400, Mahwah, New Jersey, USA). Measurements of L* and a* colour values (lightness and redness respectively) were carried out in 9 pieces of each treatment on the CIELab system. The colorimeter was standardized against a white tile (Y=93.7, x=0.3160 and y=0.3323), using D65 and 10° illuminant standard observer (CIE, 1978).

Weight loss

During the drying step, three salamis from each treatment were randomly selected from different locations in the drying chamber (front, right and left) were weighed daily until the end of the process. The Equations 1 and 2 were used to calculate the daily percentage of weight loss:

$$\%W_x = (mW_x \times \%W_{x-1})/mW_{x-1} \quad \text{(Eq. 1)}$$

$$\%WL_x = 100 - \%W_x \quad \text{(Eq. 2)}$$

Where $\%W_x$ is the total weight (%) remaining on day x, where $\%W_1$ is the weight at the first day of drying (100%); mW_x is the mean weight of 3 pieces of the same treatment on day x; $\%W_{x-1}$ is the total weight (%) remaining of the pieces on day x-1; mW_{x-1} is the average weight of 3 pieces of the same treatment on day x-1; $\%WL_x$ is the weight lost (%) of each treatment on day x in relation to the start of processing. Weight loss (WL%) was expressed as the percentage of the initial weight that was lost.

Microbiological analysis

Bacterial counts of coagulase-positive *Staphylococcus*, *Salmonella* spp. and thermotolerant coliform at 45°C were performed in the raw mixture and the salamis (1st day) in duplicate to evaluate the health and safety of the process as well as the effects of processing. Lactic acid bacteria were monitored to evaluate their resistance to processing and the propolis treatments employed.

For the presumptive analysis of *Salmonella* spp., the VIP® kit from Biocontrol for processed foods was used as indicated by the manufacturer. To count thermotolerant coliforms Petrifilm™ from 3M was used and coagulase-positive *Staphylococcus* was counted by inoculating samples onto the surface of sterile plates with Baird-Parker agar (LANCETTE and TANINI, 2001). Lactic acid bacteria were counted using MRS agar (DeMan, Rogosa, Sharpe Agar) and incubating the plates. The colonies were counted after 72 h of incubation at 37°C (GROSSO and FAVARO-TRINDADE, 2004).

Sensory analysis

An acceptance test was performed with 50 habitual salami consumers (selected according to willingness to participate) to determine whether the addition of propolis affects the sensory properties of salami. The sensory analysis was carried out in the Sensory Analysis Laboratory of Agro-industry, Food and Nutrition at São Paulo University in individual tasting booths under a fluorescent white light with 50 assessments per treatment in each period (1, 30, 60, and 90 days). The samples were presented in random order. The consumer acceptance test was conducted according to MEILGAARD *et al.* (1999) for the evaluation of taste, aroma, appearance and overall acceptance.

The slices of 2 mm thick were presented one at a time in disposable white plastic plates coded with random three-digit numbers. A nine-point structured hedonic scale was used, ranging from "disliked extremely" (1) to "liked extremely" (9).

Statistical analysis

TBARS, L*, a*, A_w and pH analyses were evaluated according to a completely randomised design (CRD) in a 3x4 factorial array according to the model specified in Equation 3:

$$Y_{ijk} = \mu + G_i + T_j + GT_{ij} + e_{ijk} \quad \text{(Eq. 3)}$$

Where, Y_{ijk} = value observed for the variable studied (TBARS, L*, a*, A_w and pH) in repetition k [k=1 (process 1), k=2 (process 2) and k=3 (process 3)] at storage day j [j=1 (1 day), j=2 (30 days), j=3 (60 days) and j=4 (90 days)] in comparison group i [i=1 (SE - control), i=2 (FP - free propolis) and i=3 (MCC - microencapsulated propolis)]; μ = a constant inherent in all observations (average); T_j = effect of the *j*th storage day; G_i = effect of the *i*th comparison group; GT_{ij} = effect of the double interaction of comparison group i with storage day j; e_{ijk} = experimental error associated with the variable studied in repetition *k* at storage time *j* and in comparison group *i*, assuming NID (0, σ_e^2).

Weight loss during the drying process of the salami tests was evaluated following the statistical model in Equation 4:

$$Y_{ijkl} = \mu + G_i + T_j + P_k + GT_{ij} + GP_{ik} + TP_{jk} + e_{ijkl} \quad \text{(Eq. 4)}$$

Where, Y_{ijkl} = value observed for the weight loss variable in repetition I [l=1 (process 1), l=2 (process 2) and l=3 (process 3)] of material processing k (k=1 to 3) at drying time j (j=1 day to j=32 days) and in comparison group i [being i=1 (SE - control), i=2 (FP - free propolis), i=3 (MCC - microencapsulated propolis)]; μ = a constant inherent in all observations (average); G_i = effect of the *i*th comparison group; T_j = effect of *j*th drying time; P_k = effect of *k*th processing where; GT_{ij} = effect of the double interaction of comparison group *i* with drying time j; GP_{ik} = effect of the double interaction of comparison group *i* with material processing *k*; TP_{jk} = effect of the double interaction of drying time j with material processing k; e_{ijkl} = experimental error associated with repetition *l* of material processing *k*, drying time *j* and comparison group *i*, assuming NID (0, σ_e^2).

For sensory analysis, which evaluated the attributes of appearance, aroma, flavour and overall quality, a mixed model was used according to the fixed effects used in the previous model, and the random effect of the consumer was included according to the recommendations of O'Mahony (O´MAHONY, 1986).

To compare groups regarding the main effect the multiple comparisons procedure of Student's *t*-test was used. In the case of significant interactions, the F test was used and, when necessary, regression analysis was also performed for stability studies. All tests were performed with the aid of the Statistical Analysis System© (SAS, 1995) using the PROC MIXED procedure.

RESULT AND DISCUSSION

It was possible to produce salami with either free (pure propolis powder obtained by atomizing) or microencapsulated propolis incorporated into it. However, the microencapsulated form was easily dispersed in the material, whereas the pure for clumped.

Lipid oxidation analyses

There was no significant difference between the TBARS values (approximately 0.47 mg MDA/kg) measured in the raw mixture and those of the salamis on the first storage day. Therefore, the presence of propolis (free and microencapsulated) and sodium erythorbate was effective and/or the conditions used in processing did not promote the oxidation process.

There was also no significant difference between the treatments with respect to TBARS values throughout the storage period under the conditions employed in this study (Fig. 1). This result allowed us to infer that, with respect to lipid oxidation, both free and microencapsulated propolis performed as well as sodium erythorbate. This result proves that the microencapsulated propolis was released from the microcapsule, because it acted as effectively as an antioxidant as the other additives used.

Fig. 1 shows a significant increase ($p<0.05$), although very small, in TBARS values with storage time that is independent of the treatment applied. The TBARS values, even after 90 days of storage, were considerably less than values close to 1 mg MDA/kg of fermented and dry meat sausages observed in another study (MARCO *et al.*, 2008). This result suggests that the conditions employed in the processing and storage together with the presence of erythorbate or free or microencapsulated propolis prevented lipid oxidation in the products, contributing to their preservation.

Microbiological analysis

The Italian-type salamis were within the standards of microbiological quality (BRASIL, 2001) for coliforms at 45°C, *Staphylococcus* co-

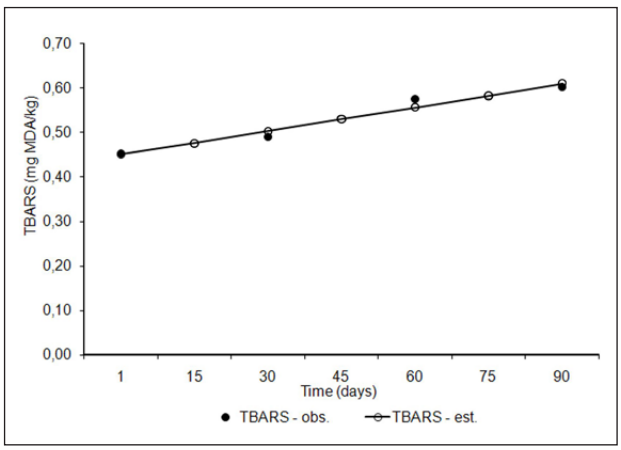

Fig. 1 - Results observed (obs.) and estimated (est.) for TBARS values (y = 0,4492 + 0,001783x) in Italian-type salami during 90 days of storage.

Table 1 - Microbiological evaluations of the raw mixture and prepared salamis (Day 1).

Microorganism	Sample	Treatments		
		SE	FP	MCC
Coliforms at 45°C (CFU/g)	Raw mixture	$1.7x10^2$	$1.7x10^2$	$3.0x10^1$
	Salami	<10	<10	<10
S. coagulase-positive (CFU/g)	Raw mixture	$<10^6$	$<10^6$	$<10^6$
	Salami	<10	<10	<10
Salmonella spp. (per 25 g)	Raw mixture	Absent	Absent	Absent
	Salami			
Lactic acid bacteria (CFU/g)	Raw mixture	$2.3x10^6$	$8.0x10^6$	$1.7x10^6$
	Salami	$1.3x10^7$	$2.4x10^7$	$2.2x10^7$

SE = control salami with sodium erythorbate; FP = salami with free propolis; MCC = salami with microencapsulated propolis.

agulase positive and *Salmonella* spp. (Table 1). Thus, it is observed that the sausages were produced properly in respect to good manufacturing practices for food and is suitable for use in sensory evaluation.

Considerably lower coliform counts were observed in the salami than in the raw mixture. This reduction can be attributed to the action of lactic acid bacteria, which can inhibit competing microorganisms by producing bacteriocins and by reducing the pH through the production of organic acids (HUGAS and MONFORT, 1997). Other factors are likely to have been responsible for the reduction of undesirable microbes, such as reduced A_w, the presence of nitrite and sodium nitrate and the presence of propolis that have antimicrobial properties.

The results observed for the lactic acid bacteria counts, approximately 10^7 CFU/g, are consistent with other studies whose counts were 10^6 for the raw mixture and 10^3 to 10^9 CFU/g in fermented sausages (DEL NOBILE *et al.*, 2009, ARO ARO *et al.*, 2010).

The sausages produced with propolis had the same lactic acid bacteria counts as those produced with erythorbate. This result suggests that the propolis used had no antimicrobial action against the starter culture, which is one more factor favouring its use as an additive in sausages.

Weight loss

Weight loss was significantly affected by the drying time ($p<0.05$) (Fig. 2) in a nonlinear manner. By the 8th drying day, the salamis had already lost about 20% of their weight, reaching a total of nearly 41% at the 32nd day. This drying behaviour differs from the linear weight loss observed by GARCIA *et al.* (2000) in Italian-type salami, even with a weight loss of 44%, higher than observed in this experiment. No differences were observed with respect to treatment ($p>0.05$).

Even with the non-linear weight loss of the salami, no crust formation was observed on its surface. This result shows indirectly that the amount of water removed from the product is dependent on the temperature and RH of the ripening chamber and the processing time (GARCIA *et al.*, 2000); thus, it appears that the procedures were conducted in a standardised manner. Other explanation is related to the increased acidification and is related to the lower pH found in the treatments, reducing the water retention capacity of the salami. Other study has reported weight loss of until 30% (GØTTERUP *et al.*, 2008), showing large variations between the processing of fermented and dry sausages, which may be due variables such as the formulation, the raw materials and the processing conditions.

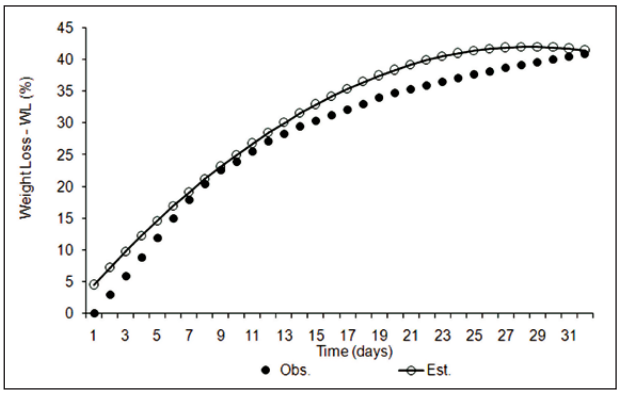

Fig. 2 - Observed (obs.) and estimated (est.) weight loss (%) results ($y = 1,7852 + 2,8163x - 0,04929x^2$) of Italian-type salami during 32 days of drying.

The above results indicate that the incorporation of propolis affected neither the drying process of Italian-type salami nor the materials used as coating agents, such as pectin and isolated soy protein.

pH

The pH measurements of the sausages (Fig. 3) showed a statistically significant interaction ($p<0.05$) between storage time and treatment.

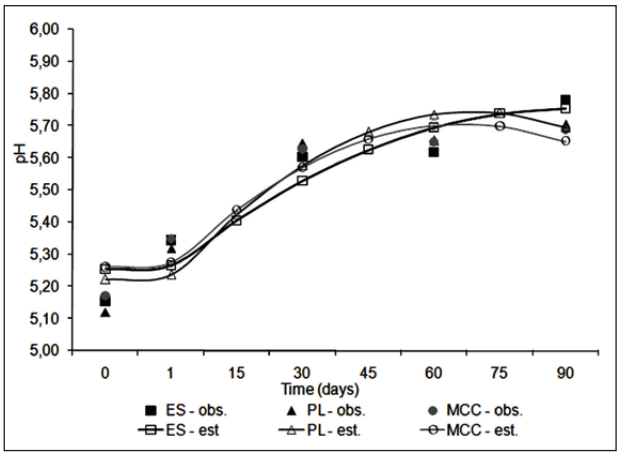

Fig. 3 - Observed (obs.) and estimated (est.) pH of Italian-type salami of different treatments during storage (SE: y = 5,2541 + 0,01095x – 0,00006x²; FP: y = 5,2219 + 0,01516x – 0,0001x²; MCC: y = 5,2605 + 0,01335x – 0,00011x²).
SE = control salami with sodium erythorbate; FP = salami with free propolis; MCC = salami with microencapsulated propolis.

Time 0, in this case, indicates the salami after the end of the fermentation process, when the pH was reduced to between 5.10-5.20. This decrease is related to lactic acid production by lactic acid bacteria from the starter culture.

The pH increase during the 90 days of storage, also observed by LEE *et al.* (2009), may be related to the concentration of buffering proteins, the formation of ammonia and amines resulting from proteolysis by tissue enzymes or the decreasing dissociation of electrolytes in the middle (ARO ARO *et al.*, 2010).

Thus, it appears that the fermentation process was conducted properly and the desired pH of 5.0-5.2 was achieved at the end of fermentation. These results are consistent with commercial samples of Italian-type salami, which has a pH ranging from 4.86-5.78 (CACCIOPPOLI *et al.*, 2006).

The different treatments showed the same change in pH, as shown by the curves of Fig. 3, although there were points with slightly different results between treatments, as at the 75th and 90th days. However, small differences in pH between certain treatments in some areas are not significant from a technological standpoint.

Water activity

The water activity of the salami varied over time, showing a nonlinear reduction (y = 0.86 – 0.00052x + 0.0000038x²) of A_w during the 90 days of storage.

The reduction of A_w from 0.86 on day 1 to 0.84 90 days later may be a result of free water binding to other compounds present in the material that were not identified. Similar behaviour was observed by LEE *et al.* (2009) in sausages stored for up to 120 days at room temperature of 25°C.

The observed reduction in A_w between the raw mixture (mean 0.97) and the prepared salamis at time point 1 (mean 0.86) is desirable, and it is due to the drying process, wherein the water essential for the growth of microorganisms is removed from the salami.

Salamis of all the treatments met the A_w standard established by the Technical Regulation of Identity and Quality for Italian-type salami, which is a maximum of 0.90 (BRASIL, 2000). The values obtained are also consistent with those of other study (HERRERO *et al.*, 2007). Thus, the incorporation of free or microencapsulated propolis left the A_w behaviour of this product unaffected.

Colour characterisation

For the Italian-type sausages studied, L* decreased linearly (y = 40.90 – 0.01596x) but modestly with storage time ($p<0.05$); however, there was no treatment effect. L* decreased from 40.86 to 39.38 during the storage period.

From the start of processing (raw butter) to the finished product (time 1), the salamis showed a reduction in the mean value of L* from 54.32 to 40.86. This decline seems related to the process of curing, drying and ripening. In particular, the drying process contributes to this decrease by concentrating the solids in the product by dehydration.

The L* value is highly variable in Italian-type salami sold in Brazil (CAVENAGHI and OLIVEIRA, 1999), and in typical Italian-type salami, L* values of 45.70 are observed (DEL NOBILE *et al.*, 2009). Thus, the L* values obtained herein are consistent with those obtained for similar products. This suggests that the incorporation of neither free nor microencapsulated propolis interfered with the lightness of the salami during its shelf life.

With respect to the a* parameter, only time contributed to the statistically significant linear increase (y = 15.15 + 0.01772x) in redness. In this case, a* increased from 15.23 to 16.77. Because it is an instrumental measure, this small difference of less than two units cannot be visually perceived by humans.

The increase in a* values may be related to the presence of viable lactic acid bacteria in the salami at the end of processing. *Staphylococcus xylosus*, which comprises the starter culture, shows nitrate reduction activity at the optimum temperature of 30°C, which is close to the storage temperature (25°C). This may have contributed to the formation of nitrosomyoglobin by residual nitrate reduction in the salami. Furthermore, the L* reduction observed may have helped to increase the intensity of the redness. The packaging used had an oxygen barrier and, together with storage away from light, was sufficient to prevent oxidation of the meat pigments, be-

cause the rate of reddening is more affected by oxygen than by light (MARCHESI *et al.*, 2006).

The a* values obtained also showed that there was no oxidation of nitrosomyoglobin of the salami during storage, unlike other studies that have indicated a significant correlation between the parameters of lipid oxidation (which increased with respect to time) and colour in vacuum packaged sausage (ZANARDI *et al.*, 2002).

The values obtained are lower than the 17.5-17.8 observed by GARCIA *et al.* (2000) and higher than the 7.99 observed by DEL NOBILE *et al.* (2009). This difference can be attributed to the raw meat used, which may have varying amounts of myoglobin, and oxidation of the red pigment.

Sensory analysis

The acceptance showed interaction between storage time and treatment with significant differences ($p<0.05$) in the appearance of the Italian-type salami of different treatments.

In general, the appearance of the sausage was accepted. The FP and MCC salamis received constant evaluations over the 90 days of storage in the range of "like regularly" (mean 7.0), whereas the SE salami showed a linear increase ($y = 6.4 + 0.007x$) in the same period from "like slightly" (mean 6.5) to "like regularly" (mean 7.2). On days 1 and 30, the salamis of treatments FP and MCC were the most accepted ($p<0.05$), whereas on the remaining days, no differences were observed ($p>0.05$) between the treatments applied.

In general, the FP and MCC salami had the most acceptable appearance over the 90 days of storage, and the SE salami was the least accepted. For the panellists, the MCC salami was characterised mainly by presenting a uniform appearance. Thus, in regard to the attribute of appearance, the addition of propolis did not impair the product's acceptance.

Regarding the attribute of aroma, the sausages studied differed only with respect to treatment ($p<0.05$), with no effect of storage time. The SE salamis showed a slightly higher acceptance ($p<0.05$; mean 7.3, in the range of "like regularly") than those from treatments FP and MCC (means of 6.6 and 6.8, respectively, in the range of "like slightly"). The more accepted aromas were described by the judges as characteristic, smooth and pleasant. Some panellists identified the odour of propolis in the FP and MCC salamis, they were unaware of the addition of this additive at the time of the evaluation, which may explain the lower acceptance of these.

However, the MCC salami was more accepted than the FP, which confirms that the encapsulation process was effective at attenuating the aroma of propolis, although incompletely so.

At no time did any consumer comment about the presence of a rancid aroma in the products, even after 90 days of storage. This confirms that the salamis remained stable with respect to lipid oxidation, confirming the results of TBARS.

The flavour of the SE salami increased linearly ($y = 6.8 + 0.0087x$) during the storage period of 90 days, that of the FP salami remained constant (mean 6.6), while the MCC salami's flavour declined between the 1st and 30th days but subsequently increased until the end of the 90 days of storage ($y = 6.7 - 0.026x + 0.00029x^2$). Until the 30th day, the treatments showed no difference between them ($p>0.05$), and subsequently, the SE salami was more accepted for its flavour ($p<0.05$) than the salami of the FP and MCC treatments, which did not differ ($p>0.05$).

The microcapsule incorporation was not effective for softening the flavour of the product, which was comparable to that with propolis incorporated in the free form (FP). Some consumers indicated that the FP and MCC salamis were less acceptable, with a strong residual uncharacteristic flavour that was unpleasant. However, they did not indicate that the flavour was directly from propolis. This suggests that the microcapsules released the compounds responsible for the characteristic propolis flavour during the storage, which was identified in the sensory analysis.

Only an effect of treatment was observed for the overall quality attribute. The control was significantly more accepted ($p<0.05$) than the treatments with propolis, which did not differ from one another. However, in general, the salamis were well accepted, with means that ranged between "like regularly" (mean 7.1 for SE) to "like slightly" (mean 6.7 for the FP and MCC treatments).

The lower acceptance assigned to treatments is possibly due to the aroma and taste of propolis, which persisted in the products. However, the difference in acceptance, although significant, was relatively small and should not be the only factor to consider in choosing or rejecting this additive, because propolis is a natural additive and has several therapeutic properties that may confer functional value to the product (PENA, 2008).

The SE salamis were the most accepted for the tested attributes, except for appearance, for which the MCC treatment was more accepted.

CONCLUSION

It is possible to prepare Italian-type salami using propolis as a replacement for the synthetic antioxidant sodium erythorbate. The products have similar technological characteristics to control products (SE treatment) and slightly lower sensory acceptance with respect to aroma acceptability. The uses of microencapsulated propolis are advantageous with regard to ease of incorporation of the additive to the raw mixture and because this process will be reduce

some strong sensorial characteristic of propolis. Thus, further research is needed with other microencapsulation techniques or even other microencapsulating agents to mitigate the strong aroma of propolis.

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