Food Science and Technology
ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.02019

Effect of the addition of rabbit meat on the technological and sensory properties of fermented sausage

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Abstract

Rabbit meat has a low-fat content when compared to other meat traditionally used as raw material in the processing of fermented sausages. In addition, it has high levels of essential amino acids in its composition. Thus, the objective of this study was to evaluate the technological properties and sensorial acceptance of a fermented sausage produced with pork and rabbit meat. Three formulations were made: C1 (80% fresh lean pork + 20% pork back fat), T1 (40% fresh lean pork + 40% rabbit meat + 20% pork back fat) and T2 (80% rabbit meat + 20% pork back fat). Samples were evaluated for composition, texture profile, instrumental color, pH, weight loss, lipid oxidation and sensorial acceptance. The samples did not present significant differences between them for moisture, fat and protein contents. Regarding the aroma, flavor, hardness and overall acceptance, all samples presented similar mean values (P>0.05). The study showed that up to 40% of rabbit meat could be substituted in a fermented pork sausage without altering any of the sensorial attributes evaluated and with minimal effect on the technological parameters.

Keywords: rabbit sausage; fermented products; texture profile analysis; sensory acceptability.

Practical Application: Incorporation of rabbit meat in fermented sausage formulation with a good sensory acceptance.

1 Introduction

The fermented sausage represents a high percentage of the consumption of meat products all over the word because of its remarkable sensorial characteristics, practicality of preparation, versatility of use and ease of conservation (Pérez-Burillo et al., 2019).

Rabbit meat is considered healthier than the other raw materials traditionally used in the meat products industry. It has specific nutritional characteristics, being low in fat with a favorable proportion of saturated, monounsaturated and polyunsaturated fatty acids with low cholesterol and sodium levels (Mattioli et al., 2017; Cullere et al., 2018). In addition, rabbit meat can provide proteins with essential amino acids having a high biological value (Wang et al., 2018; Li et al., 2018). It is also rich in potassium, phosphorus, selenium and vitamin B (Cullere & Dalle Zotte, 2018; Dalle Zotte & Szendrõ, 2011).

In addition, the production of rabbit meat is interesting from an economic point of view because of its short life cycle, short gestation period and being notably very prolific. I It also has a high feed conversion capacity (Lebas et al., 1997). The consumption of rabbit meat has been recommended as a healthier source of dietary protein in the developing countries (Amer et al., 2019). In Brazil, this consumption is still small when compared to other meat in the production system and is most unimpressive when compared to the consumption of the same meat in other parts of the world such as Europe and China. The addition of rabbit meat in traditional meat product could help to increase its consumption, due to the mischaracterization of the animal shape (Marino et al., 2015). Besides, the incorporation of a healthier meat material could encourage the consumers to try a new product. An increasing tendency towards healthy products and changes in the behavior of consumers have encouraged researchers to look for new alternatives for healthy meat products (Bis-Souza et al., 2018). Consequently, the use of raw materials with lower cholesterol and different nutritional characteristics may be an alternative in the reformulation of meat products. Exotic meats are being well accepted by the consumer for their nobility and healthiness, making it a product with sophisticated features attributed by the consumer (Pegg et al., 2006). Thus, the purpose of the study was to evaluate the technological processing and sensory characteristics of a fermented sausage produced using pork and rabbit meat.

2 Materials and methods

2.1 Rabbit fermented dry sausage processing

Three different batches of the fermented dry sausage were manufactured in the Meat and Meat Products Laboratory pilot plant at the Institute of Biosciences, Humanities and Exact Sciences of São Paulo State University (São José do Rio Preto Campus).

Fresh lean pork (moisture 72.25%; fat 6.78%), rabbit meat (moisture 74.59%; fat 4%) and pork back fat (moisture 25.02%;

Received 16 Mar., 2019
Accepted 09 Sept., 2019
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fat 61.84%) from the local market in São José do Rio Preto- SP were ground using 10 mm and 8 mm plates respectively.

The different treatments were: Control formulation (C) using 80 $g.100g^{-1}$ of lean pork and 20 $g.100g^{-1}$ of pork back fat; Blended formulation (T1) using 40 $g.100g^{-1}$ of lean pork, 40 $g.100g^{-1}$ of rabbit meat and 20 $g.100g^{-1}$ of pork back fat; Rabbit formulation (T2) using 80 $g.100g^{-1}$ of rabbit meat and 20 $g.100g^{-1}$ of pork back fat. All the treatments were produced using sodium chloride (2.5 $g.100g^{-1}$), sucrose (2 $g.100g^{-1}$), sodium nitrite (0.015 $g.100g^{-1}$), sodium nitrate (0.015 $g.100g^{-1}$), garlic (0.4 $g.100g^{-1}$), white pepper (0.6 $g.100g^{-1}$), nutmeg (0.3 $g.100g^{-1}$), clove (0.2 $g.100g^{-1}$), sodium erythorbate (0.3 $g.100g^{-1}$), and a starter culture (0.025 $g.100g^{-1}$ Bactoferm T-SPX, Chr. Hansen, Hoersholm, Denmark) consisting of *Pediococcus pentosaceus* and *Staphylococcus xylosus*.

All ingredients were mixed with the raw material using an automatic blender (Frigomaq, Chapecó, Brazil) for approximately 5 minutes. After, the treatments were stuffed in cellulose cases (50 mm diameter and 20 cm long - approximately 250 g). Each sample was soaked in a solution of potassium sorbate (20%) and ripened, in a fermentation/maturation chamber, for 15 days. The dry fermented sausages were ripening according to the following procedure (Temperature/ Relative humidity %): 25 °C/90% (day 0 to 3); 23 °C/89% (day 3 to 6); 20 °C/85% (day 6 to 8); 18 °C/80% (day 8 to 11) and 15 °C/75% (day 11 to 15).

Two sample from each batch were randomly taken at days 0, 3, 7, 11 and 15 f ripening to perform the technological analysis. Three different batches already mentioned were manufactured twice with the same ingredients, formulation and technology process in October and November of 2018.

2.2 pH, weight loss and composition

The pH was measured using a digital pH meter PG 1800 (Gehaka, São Paulo, Brazil) with a penetration probe. Moisture percentage was calculated by a weight loss experiment keeping the sample in a laboratory oven at 105 °C until constant weight. The weight loss was calculated by the difference between the initial weight and the final weight of the samples (n =6). Those analyses were performed during ripening, 0, 3, 7, 11 and 15 days after stuffing. All analyses were performed in triplicate.

All the treatments were characterized for protein content according to Association of Official Analytical Chemists (2007) and the fat content was determined according to Bligh & Dyer (1959) on day 0 and day 15 of ripening time (n=3).

2.3 Instrumental color and texture profile analysis

The color evaluation was performed using a ColorFlex45/0 spectrophotometer (Hunterlab, Reston, USA), observation angle of 10º, illuminant D65 and Universal software version 4.10. The CIELAB color specification system was used and the color coordinates determined were lightness (L*), redness (a*) and yellowness (b*). Each sample was cut into 2 cm pieces and kept at room temperature for 15 minutes before the analysis (n=30).

The instrumental texture analysis was performed at room temperature (25 °C) usinga TA-XT/Plus/50 texture analyzer (Stable Micro Systems, Godalming, UK) equipped with a cylindrical probe 36 mm in diameter. The parameters determined were hardness (N), cohesiveness, springiness (mm) and chewiness (N mm^{-1}) as described by Bourne (2002). The samples of fermented sausage were cut into slices of 2 cm and were axially compressed in two consecutive cycles of 50% of compression, at a constant test speed of 1 mm s^{-1} (n=30).

2.4 Lipid oxidation value

The substance reactive with 2-thiobarbituric (TBARS) values were measured to determine the degree of lipid oxidation (Vyncke, 1970). The TBARS value was expressed as mg of $malondialdehyde.kg^{-1}$ of sample (n=6).

2.5 Microbiological analysis

Thermotolerant coliforms, coagulase-positive *Staphylococci* and the presence of *Salmonella sp*. in 25 g (Association of Official Analytical Chemists, 2007) were analyzed according to the norms established by Brazilian Legislation (Brazilian Health Surveillance Agency – ANVISA) (Brasil, 2001). The microbiological analysis was performed at the end of the ripening process, previously to the sensory analysis.

2.6 Sensory analysis

The sensory study was conducted by 94 untrained panelists recruited among students, faculty and staff members from São Paulo State University, São José do Rio Preto campus (SP, Brazil), previously selected by a questionnaire. The sensorial attributes analyzed were appearance, color, odor, flavor, hardness and overall acceptability using a structured 9-point hedonic scale.

Each sample was coded with a three-digit number and randomly presented in a sequential monadic way, following a balanced complete block design (Meilgaard et al., 2007). The tests were performed in individual booths under white light and at a temperature of 22 °C. This project was approved by the Ethics in Research Committee of São Paulo State University (São José do Rio Preto, Brazil) (nº 3.003.949). The sensory analyses were performed at the end of the ripening process.

2.7 Statistical data analysis

Three batches (C, T1, T2) during five ripening times (0, 3, 7, 11 and 15 days) in two different manufacturing times (October and November 2018) were analyzed for different dependent variables.

One-way ANOVA randomized complete block design using the generalized linear model (GLM) was performed to determine any significant differences between the physicochemical data. Ripening time and formulation were included as fixed effects in the model and the manufacture time was a random effect. The results were expressed as the mean values and the standard error of the mean. Mean comparisons were assessed by the Tukey test at a confidence level of 95% (P>0.05).

The same statistical evaluation was also used for the sensory analysis. The treatments were accepted as a fixed effect and panelists as a random effect.

Principal component analysis (PCA) determined the correlation between the variables related to the technological characteristics of the fermented dry sausage with rabbit meat added, using a correlation matrix. The software used in these analyses was STATISTICA (StatSoft, Inc. version 7.0).

3 Results and discussion

3.1 pH, weight loss and composition

The pH values (Table 1) at the beginning of the ripening time showed a significant difference between the treatments. This could be explained by the addition of different raw material (rabbit meat), since T2, pH value of 5.95 (formulations using only rabbit meat) show a different pH value (P<0.05) compared to C, pH value of 6.23 (formulation using only pork meat). On the day 3 of ripening, the pH value of all formulations decreased (4.97), and no significantly difference (P>0.05) was observed. This stage is characterized by the fermentation, which consists of the production of lactic acid from the fermentation of the sugars available in the meat mixture. The microorganisms responsible for this stage are the lactic acid bacteria, mainly the *Pediococcus pentosaceus* (from the commercial starter culture).

The pH of all treatments decreased during the ripening time (6.23 to 4.92; 6.15 to 4.89 and 5.95 to 4.89 in **C**, **T1** and **T2**, respectively, comparing day o to day 15 of ripening. This pH is recommended when ripening occurs at room temperature (Cruxen et al., 2018). Similar results were reported by Campagnol et al. (2011) when using "Marcela" extract in salami. This latter study connected values of pH (4.95) to the accumulation of the lactic acid produced in the fermentation.

Regarding weight loss and moisture content, an opposite behavior is observed between these characteristics (Table 1). No significant difference (P>0.05) was observed in moisture content between all treatments. The maturation process is performed in an enclosed environment with a relative humidity of 75%, which causes loss of water from the system to the medium. During the ripening time is normal to obtain significant difference between all treatments regarding the weight loss, as observed in Table 1 after 3 and 7 days (Cruxen et al., 2018). In the end of the process C, T1 and T2 reaches 32% of weight loss, which is considered normal for this type of meat product. Similar values of weight loss were reported by Rubio et al. (2014), Ruiz et al. (2014), Dalla Santa et al. (2014), Alamprese et al. (2016) and Bağdatli & Kundakci (2016).

The variation in the moisture content may be related to a low pH value because, when the pH reaches the isoelectric point of the proteins, water loss from the system becomes easier due to the reduction in its water retention capacity (Ruiz et al., 2014).

3.2 Fermented sausage composition

The addition of rabbit meat to the fermented sausage formulation showed no significant effect (P>0.05) on the protein and fat composition of the final product (Table 2). The same amount of pork back fat was added to all formulations, so the fat content in the initial analysis did not present any significant difference.

Despite what has been reported in the literature, the rabbit meat formulation (T2) presents a lower (P<0.05) value for protein content. In a study reported by Cavenaghi & Oliveira (1999), the mean protein content in fermented sausage commercialized in Brazil was 23.98%.

Table 1. pH value, moisture (%) and weight loss (%) during ripening time of the dry fermented sausage.

	Treatments	Ripening time (Dias)				
		0	3	7	11	15
pH	C	6.23^{a}	4.97	4.88	4.92	4.82
	T1	6.15^{ab}	4.95	4.92	4.89	4.84
	T2	5.95^{b}	4.94	4.86	4.89	4.88
SEM		0.04	0.02	0.02	0.03	0.02
P value		0.021	0.787^{ns}	0.444	0.919	0.394
Moisture (%)	C	63.70	58.51	50.91^{ab}	44.63	40.76
	T1	60.23	58.05	48.76^{b}	43.09	40.83
	T2	60.52	58.19	52.27^{a}	44.26	41.66
SEM		0.91	0.43	0.61	0.48	0.42
P value		0.232	0.910^{ns}	0.049	0.406^{ns}	0.642^{ns}
Weight loss (%)	C	-	7.83^{a}	19.35^{a}	25.58	32.67
	T1	-	7.13^{a}	19.19^{a}	25.78	32.90
	T2	-	5.92^{b}	17.15^{b}	25.71	33.04
SEM		0.91	0.26	0.37	0.32	0.59
P value		0.232	0.007	0.011	0.970^{ns}	0.971^{ns}

3.3 Instrumental color and texture profile analysis

The addition of rabbit meat in the formulation increased the lightness (*P*<0.05) (Table 3) during all the ripening process. After 15 days of ripening, T2 had a higher (*P*<0.05) value of lightness compared to C and T1. The variation in the lightness values among the same treatment during the ripening process may be related to the curing process of the fermented sausage and the decrease in pH (Mancini et al., 2017). The opposite behavior was observed in relation to the intensity of red coloration, since the treatment with added only with rabbit meat (T2) presented the lowest (*P*>0.05) a* value (9.36) in day 0. Throughout the ripening process, T2 shows the lowest (*P*>0.05) a* value. This could be related to the lower content of myoglobin compared to pork meat (Wang et al., 2019).

The redness (a*) is considered the most sensitive parameter for measuring color stability (Cavalheiro et al., 2013). Redness decreased significantly with the addition of rabbit meat *(P*<0.05) over all the evaluation time. Some authors relate the decrease in redness to the formation of metmyoglobin produced by myoglobin pigment oxidation due to lactic acid production and water loss (Pérez-Alvarez et al., 1999; Choe et al., 2011; Mancini et al., 2017). This acid might denature partially or totally the myoglobin present in the meat. According to Wang et al. (2019) the lipid oxidation can promote myoglobin oxidation. And as observed in Figure 1, T2 show the higher (P>005) TBARS value after 15 days of ripening time. The same authors reported that, in rabbit meat, the high concentration of

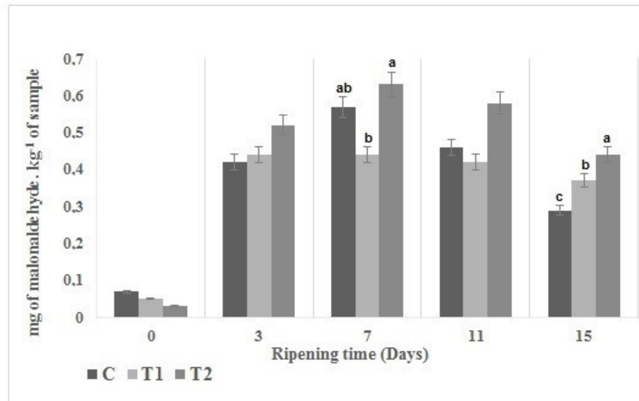

Figure 1. TBARS value during ripening time of dry fermented sausage. C = Control with only pork; T1 = blend of pork and rabbit meat; T2 = only rabbit meat. [a,b,c]Mean values in the same treatment (different ripening time) with different letters presented significant differences (*P*<0.05) in the Tukey test.

Table 2. Protein and fat value of dry fermented sausage (g.100g^{-1}).

Ripening process		Formulations			SEM	*P value*
		C	T1	T2		
Initial	Protein	17.15^{a}	15.32^{a}	11.38^{b}	0.89	0.001
	Fat	6.20	9.85	7.46	0.96	0.322^{ns}
Final	Protein	22.79	22.82	20.61	0.64	0.306^{ns}
	Fat	25.30	23.48	23.55	1.8	0.884^{ns}

C = Control with only pork; T1 = blend of pork and rabbit meat; T2 = only rabbit meat; SEM = standard error of mean; [ns] = not significant *P*>0.05. [a,b]Mean values in the same row with different letters presented significant differences in the Tukey test *(P*<0.05).

Table 3. Color parameters during ripening time (15 days) of the dry fermented sausage.

		Days					SEM	*P value*
		0	3	7	11	15		
L*	**C**	48.14^{cC}	56.18^{bA}	57.84^{bA}	54.33^{B}	52.92^{bB}	0.33	0.000
	T1	50.09^{bC}	56.72^{abA}	57.98^{bA}	54.79^{B}	53.24^{bB}	0.28	0.000
	T2	53.05^{aD}	57.93^{aB}	59.56^{aA}	55.43^{C}	56.34^{aBC}	0.26	0.000
SEM		0.36	0.26	0.27	0.25	0.32		
P value		0.000	0.023	0.016	0.205^{ns}	0.000		
a*	**C**	12.58^{aA}	11.41^{aB}	9.91^{aC}	11.36^{aB}	12.36^{aA}	0.13	0.000
	T1	11.95^{aA}	10.91^{aBC}	10.71^{aC}	10.75^{bC}	11.62^{bAB}	0.10	0.000
	T2	9.36^{bA}	8.86^{bA}	8.66^{bB}	9.04^{cA}	9.22^{cA}	0.07	0.017
SEM		0.20	0.14	0.17	0.13	0.17		
P value		0.000	0.000	0.000	0.000	0.000		
b*	**C**	15.93^{abA}	11.54^{B}	11.13^{BC}	10.74^{C}	10.73^{C}	0.15	0.000
	T1	16.08^{aA}	11.72^{B}	10.97^{C}	11.06^{C}	10.97^{C}	0.15	0.000
	T2	15.44^{bA}	11.67^{B}	11.02^{C}	11.05^{C}	10.82^{C}	0.14	0.000
SEM		0.01	0.08	0.07	0.07	0.08		
P value		0.027	0.608^{ns}	0.629^{ns}	0.115^{ns}	0.446^{ns}		

C = Control with only pork; T1 = blend of pork and rabbit meat; T2 = only rabbit meat; SEM = standard error of mean; [ns] = not significant *P* >0.05. [a,b,c,d]Mean values in the same column (different formulation in the same ripening time) with different small letters presented significant differences; [A-D]Mean values in the same row (same formulation in different ripening time) with different capital letters presented significant differences.

malondialdehyde could lead to an increased in metmyoglobin percentage. Due to the higher presence of unsaturated fatty acids, which are more unstable, rabbit meat is considered more susceptible to metmyoglobin formation.

Regarding yellowness (b*), the treatments showed no difference during ripening, unlike the results found by Cruxen et al. (2018) in their study using mutton in fermented sausage. The variation observed in the color parameters during processing indicates that the color of the final product is influenced by several factors such as the raw material, concentration of salt and the presence of sodium nitrite.

The texture profile (Table 4) showed that only the springiness attribute was not different (P>0.05) between the treatments, indicating that the use of rabbit meat in fermented sausage do not affect this texture parameter.

Regarding hardness (Table 4), the raw material added in the fermented sausage formulation shows no effect at time 0. During the ripening time, treatments C and T1 present no difference (P>0.05) between each other and T2 had the lowest value for this texture parameter.

Hardness increased (*P*<0.05) for all treatments during ripening because of moisture loss and decreasing water activity (Ayyash et al., 2019). In another study to optimize the structural properties in a fermented sausage, the authors reported a significant correlation between hardness and moisture content (Bağdatli & Kundakci, 2016). Other interesting data in our study was that the hardness values for C (after the 7th day) presented no significant difference until the end of the process on the 15th day. On the other hand, in formulations T1 and T2 the increase in hardness is subtler, showing that rabbit meat has different behavior during the ripening process from pork. Differences between the treatments were also reported by Cruxen et al. (2018) that added different concentrations of mutton in fermented meat sausage.

Similar values of hardness were reported by Corral et al. (2016) who obtained 135 – 175 N for this texture parameter for a dry fermented sausage formulation. In a study using camel meat in fermented sausage, the authors reported a higher value of hardness for the camel formulation compared to the beef formulation. They justified those results due to the distinct myofibril protein structure and gel formed during fermentation in camel sausages relative to those of beef (Ayyash et al., 2019).

Regarding at cohesiveness, the addition of rabbit meat in the fermented sausage formulation (T1 and T2) increased (P<0.05) this texture parameter after 3 days of ripening time, comparing to C. After 7 days of ripening, the addition of a different raw material shows no affect (*P*>0.05) on this texture parameter.

For chewiness values, the treatments show no difference (*P*>0.05) until 7 days of ripening. After 11 days, C and T1 present

Table 4. Texture profile of dry fermented sausage during ripening time.

		Days					SEM	*P value*
		0	3	7	11	15		
Hardness (N)	**C**	11.48^{C}	93.59^{aB}	152.89^{aA}	156.87^{aA}	161.66^{abA}	6.25	0.000
	T1	12.13^{D}	89.99^{aC}	131.89^{abB}	146.04^{aB}	172.35^{aA}	6.25	0.000
	T2	10.81^{D}	76.78^{bC}	117.92^{bB}	129.51^{bAB}	138.25^{bA}	5.08	0.000
SEM		0.25	2.04	5.73	2.67	4.38		
P value		0.101^{ns}	0.001	0.044	0.000	0.004		
Springiness (mm)	**C**	0.53^{B}	0.68^{A}	0.71^{A}	0.69^{A}	0.67^{A}	1.34	0.000
	T1	0.48^{B}	0.71^{A}	0.74^{A}	0.68^{A}	0.67^{A}	0.01	0.000
	T2	0.49^{B}	0.71^{A}	0.72^{A}	0.62^{A}	0.63^{A}	0.15	0.000
SEM		0.01	0.01	0.02	0.02	0.01		
P value		0.109^{ns}	0.494^{ns}	0.790^{ns}	0.167^{ns}	0.447^{ns}		
Cohesiveness	**C**	0.31^{bC}	0.64^{bA}	0.62^{A}	0.60^{AB}	0.56^{B}	0.02	0.000
	T1	0.30^{bC}	0.68^{aA}	0.59^{B}	0.61^{B}	0.58^{B}	0.01	0.000
	T2	0.36^{aD}	0.70^{aA}	0.64^{B}	0.59^{C}	0.58^{C}	0.01	0.000
SEM		0.01	0.01	0.01	0.03	0.01		
P value		0.000	0.000	0.089^{ns}	0.664^{ns}	0.527^{ns}		
Chewiness ($N.mm^{-1}$)	**C**	1.90^{C}	38.53^{B}	67.32^{A}	65.23^{aA}	60.36^{abA}	2.82	0.000
	T1	1.77^{C}	43.01^{B}	57.17^{A}	60.28^{aA}	67.70^{aA}	2.73	0.000
	T2	1.93^{C}	38.46^{AB}	55.86^{A}	48.54^{bA}	50.40^{bA}	2.38	0.000
SEM		0.07	1.21	3.08	2.00	2.07		
P value		0.654^{ns}	0.225^{ns}	0.248^{ns}	0.002	0.002		

C = Control with only pork meat; T1 = blend of pork meat and rabbit meat; T2 = only rabbit meat; SEM = standard error of mean; ^{ns} = not significant *P*>0.05. ^{a,b}Mean values in the same column (different formulation in the same ripening time) with different small letters presented significant differences; $^{A-E}$Mean values in the same row (same formulation in different ripening time) with different capital letters presented significant differences.

similar (P>0.05) results, both higher than T2. As expected, chewiness presented behavior similar to hardness during ripening.

3.4 Lipid oxidation value

Lipid oxidation (Figure 1) seems to be influenced by the added raw material since, at the end of processing, all the treatments showed a significant difference (P<0.05) with T2 having the highest value. This is possibly because rabbit meat has higher percentages of polyunsaturated fatty acids, which are more susceptible to the oxidation process, than pork.

The difference between batches could justify the difference (P<0.05) in TBARS values in the same treatment throughout the ripening time (De Paula et al., 2017). Moreover, the high concentration of polar products resulting from the oxidation of secondary compounds can react with malondialdehyde, causing a lower quantification of this compound in the method used (Gatellier et al., 2007).

In a study using species of game in the processing of salami, the authors reported no difference compared to a pork formulation. This can be explained by the major source of lipids in the salami formulation being from pork back fat (Chakanya et al., 2018). It should be noted that TBARS values < 1.0 mg malondialdehyde equivalent/kg are considered to be in an acceptable condition (Ospina et al., 2015).

3.5 Microbiological analysis

The microbiological analysis for all the dry fermented sausage treatments were within the limits established by Brazilian legislation for fermented sausages (Brasil, 2001). *Salmonella* sp. was absent in 25g of sample. Regarding the growth of coliforms at 45 °C, the result was < 2 NMP.g^{-1} and coagulase positive *Staphlococci* was < log 1 CFU.g^{-1}.

3.6 Sensory analysis

The use of rabbit meat in the formulation of fermented sausage showed no effect (P>0.05) on sensory attributes (Table 5) such as odor, flavor, hardness and global acceptance. Similar results were reported by Campagnol et al. (2011), Backes et al. (2013) and Rubio et al. (2014) in fermented sausage made with pork meat. A fermented sausage elaborated with up to 50% of ostrich meat also show no difference to control treatment (with pork meat) for the parameter of aroma, flavor and texture (Cavalheiro et al., 2013).

Regarding of the appearance and color attributes, T2 score decreased significantly (P<0.05) compared to C and T1. This result matches with the instrumental color reported, considering that the red color is the most wanted visual parameter to consumers.

This shows that, even with the consumer noticing a difference for the color and appearance attributes between T2 and the other samples, that difference was not enough to influence the overall acceptance. Demonstrating great market potential, since average overall evaluation was higher than 7, being in agreement with that obtained by Cruxen et al. (2018) when using mutton in fermented sausage reformulation.

The appearance attribute is influenced by the color attribute, which, when analyzed instrumentally, presented a value of a * (red color) significantly lower than C and T1. These results were reinforced by the correlation evaluation that pointed strong positive correlation between appearance and color.

3.7 Correlation

The correlation analysis showed that the sensory parameters appearance, color, odor and flavor had a strong positive correlation (P < 0.05) with the global acceptance of the dry fermented sausage. Regarding the technological parameters, the pH, TBARS value, weight loss and lightness (L*) have a strong negative correlation (P<0.05) with the global acceptance of the dry fermented sausage. The intensity of the red coloration (a*) is positively correlated with the global acceptance and hardness of this meat product (P<0.05). Hardness can be negatively correlated (P<0.05) to pH, moisture value and lightness (L*).

The two principal components of the PCA explained 100% of the data variation, wherein the first principal component explained 82.81% of the data variation, the second principal component explained 17.19% (Figure 2A). The data presented allowed the separation of the results into three 3 groups (Figure 2B). Each treatment can be explained by a different group of responses. C can be related to all sensory parameters which is confirmed by the highest sensory acceptance score. T1 could be related to hardness and chewiness. T2 can be explained by lightness (L*), moisture (U%) and pH. This confirms that the addition of the rabbit meat in the processing of a fermented sausage changes the luminosity and the water loss kinetic during processing.

Table 5. Sensory scores for dry fermented sausage.

	Appearance	Color	Odor	Flavor	Hardness	Global Acceptance
C	7.74^a	7.70^a	7.22	7.64	7.17	7.45
T1	7.26^a	7.22^a	7.10	7.48	7.53	7.32
T2	6.73^b	6.55^b	6.99	7.27	7.43	7.09
SEM	0.092	0.100	0.0933	0.091	0.087	0.084
p *value*	0.000	0.000	0.537^{ns}	0.249^{ns}	0.225^{ns}	0.202^{ns}

C = Control with only pork; T1 = blend of pork and rabbit meat; T2 = only rabbit meat; SEM = standard error of mean; ^{ns} = not significant P>0.05. ^{a,b}Mean values in the same row with different letters presented significant differences in the Tukey test (P<0.05).

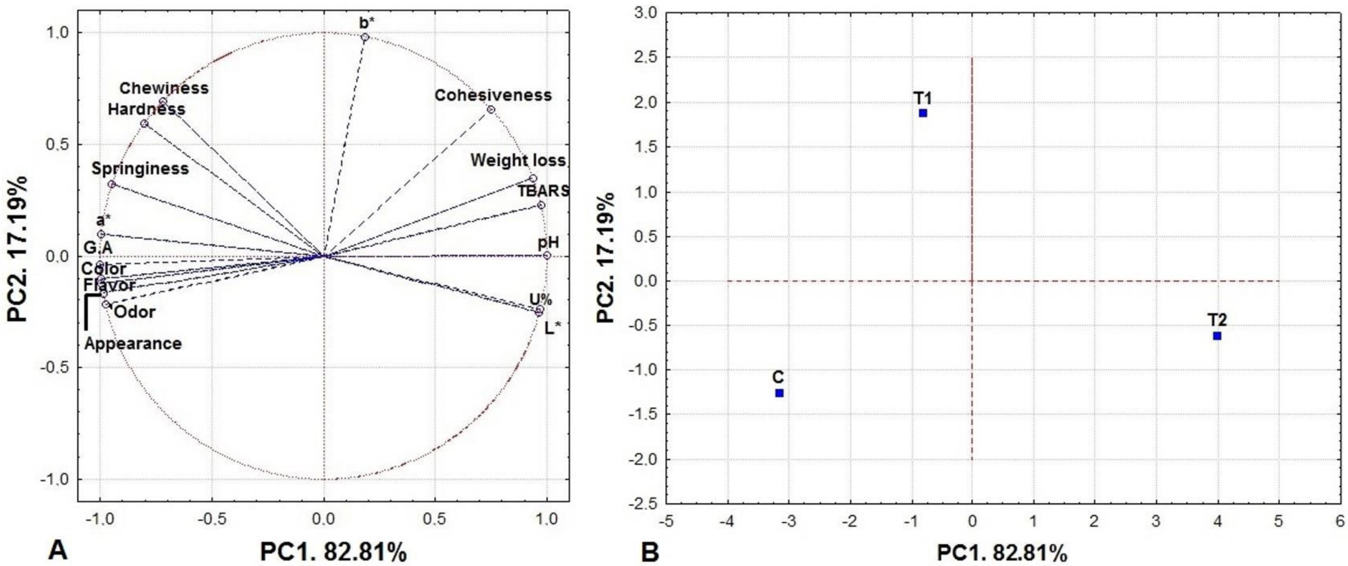

Figure 2. Principal component analysis (A) variables projection; (B) treatments projection. PC1 (80.81%) and PC2 (17.19%), correlating technological and sensory characteristics of dry fermented sausage. C = Control with only pork; T1 = blend of pork and rabbit meat; T2 = only rabbit meat.

4 Conclusion

The introduction of up to 40% of rabbit meat in fermented sausage had a positive effect on the physicochemical, technological and sensory parameters. The use of rabbit meat and pork in fermented meat sausage can encourage the consumption of rabbit meat without compromise sensory acceptance and get value-added products.

Acknowledgements

The authors would like to thank the National Council for the Improvement of Higher Education CAPES (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*) for their financial support.

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