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Replacement of mechanically deboned chicken meat with its protein hydrolysate in mortadella-type sausages

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Abstract

Mortadella-type sausage manufactured using mechanically deboned chicken meat were reformulated replacing MDCM with increasing amounts of MDCM protein hydrolysates (10%, 20%, and 30%), and their physicochemical, microbiological, and sensorial characteristics were evaluated for 60 days of storage at 4 °C. The higher substitutions resulted in sausages more susceptible to lipid oxidation with higher TBARS values during storage; however, these values were lower than the organoleptic perception threshold. The sausages were darker and less red, with lower lightness (L^*) and redness (a^*) values than those of the control treatment. They had soft texture, which was evidenced by both the instrumental and sensory analysis. Therefore, the formulation containing 10% of MDCM protein hydrolysates proved to be the most suitable for mortadella-type sausage elaboration.

Keywords: protein hydrolysates; mortadella-type sausage; mechanically deboned chicken meat; TBARS; texture properties.

1 Introduction

Mechanically deboned chicken meat (MDCM) is a commonly ingredient used in the formulation of cooked meat products. According to the Brazilian legislation, it is possible to use up to 60% of MDCM in cooked meat sausages (Brasil, 2000). However, there may be some drawbacks to the use of this kind of meat as raw material such as a rapid onset of oxidation resulting in off-flavors and off-odors in the final product (Mielnik et al., 2002).

Protein hydrolysates may possess physicochemical characteristics and bioactivities not found in the original proteins, such as antioxidant activity and higher water-holding capacity (Cumby et al., 2008). The generated peptides could inhibit the harmful changes induced by lipid oxidation due to the presence of certain amino acid residues, such as tyrosine, methionine, histidine, tryptophan, and proline. Several studies have demonstrated the antioxidant potential of protein hydrolysates from many raw materials, such as potato (Wang & Xiong, 2005), whey (Contreras et al., 2011), soy (Peña-Ramos & Xiong, 2003), fish (Dekkers et al., 2011), and shrimp waste (Dey & Dora, 2014). Furthermore, a study has shown that shrimp shell hydrolysates can inhibit human cancer cell proliferation (Kannan et al., 2011).

Studies involving the use of meat protein hydrolysates in meat products are still scarce. Some studies have been carried out using non-meat as raw materials such as soy, potato, and dairy proteins. However, the use of MDCM, which is an ingredient commonly used by the meat industry, has not been studied yet. Thus, the aim of this study was to produce mortadella-type sausages with increasing amounts (10%, 20%, and 30%) of MDCM protein hydrolysate replacing MDCM and to analyze its effect on product properties during storage at 4 °C for 60 d.

2 Materials and methods

2.1 Production of MDCM protein hydrolysate

Previous tests have been carried out to define the best time and temperature conditions for the hydrolysis process. After thawing overnight in a cold room (4 °C), 250 g of MDCM were minced using a cutter (G. Paniz, Caxias do Sul, Brazil) and mixed with distilled water in the ratio of 1:2 (w/v). Then, 1 mL (0.4% in relation to the meat amount) of the Alcalase® 2.4 L enzyme (Novozymes, Bagsvaerd, Denmark) was added, and the mixture was held at 60 °C for 60 min in a water bath (Marconi, Piracicaba, Brazil). The pH was not adjusted during the hydrolysis process with the purpose to keep the original MDCM pH. The hydrolysis reaction was finished by placing the mixtures in boiling water for 15 min. The degree of hydrolysis was calculated according to Hoyle & Merritt (1994), and the value obtained was 14.38%. The proximate composition of MDCM protein hydrolysates was: 87.61% of moisture, 4.37% of protein, 7.68% of fat and, 0.34% of ashes. The MDCM protein hydrolysates were not subjected to any drying process or fat content removal.

2.2 Mortadella-type sausage elaboration

Each batch of mortadella-type sausages was formulated with different amounts of MDCM protein hydrolysate as follows: 0% (CT); 10% (T1); 20% (T2); and 30% (T3). The other ingredients were used according to a typical Brazilian formula as follows:

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MDCM (CT – 60%; T1 – 50%; T2 – 40%; T3 – 30%), pork meat (30%), pork fat (10%), ice/water (CT – 29%; T1 – 26.14%; T2 – 23.27%; T3 – 20.22%), salt (1.9%), cassava starch (5%), isolated soy protein (2%), spices (1%), sodium nitrate/nitrite (0.35%), sodium erythorbate (0.25%), and black pepper (0.1%). The amount of ingredients was determined based on the amount of meat. Due to the high moisture level of the MDCM protein hydrolysate, the ice/water amount added to the mortadella-type sausages was adjusted. The mass was stuffed using 80-mm-diameter water-impermeable plastic casings in pieces with approximately 300g. The sausages were cooked at 80 °C for 90 min, until reaching a core temperature of 72 °C. Afterwards, they were cooled under running water and stored at 4 °C.

2.3 Physicochemical analyses

Proximate composition

Moisture, protein (total nitrogen), and ash analyses were carried out according to Association of Official Analytical Chemists (1997). Total fat was extracted according to the method proposed by Bligh & Dyer (1959), and carbohydrates were calculated from the difference. The energy value (kcal) was calculated using the values corresponding to fat (9 kcal/g), protein (4 kcal/g), and carbohydrates (4 kcal/g).

TBARS

Lipid oxidation was assessed using the thiobarbituric acid reactive substances' (TBARS) method (Raharjo et al., 1992). TBARS were calculated and expressed as mg malonaldehyde (MDA) per kg of sausage.

Color parameters

The determination of CIE $L^*a^*b^*$ color parameters was performed using a Chroma Meter CR-300 (Minolta Camera Co. LTD, Osaka, Japan). The color parameters were also converted into Chroma (C^*) and hue angle (h^o).

Texture profile analysis

Texture profile analysis (TPA) was performed using a TA-XT.plus Texture Analyzer and a Texture Expert Exponent Software (Stable Micro Systems Ltd., Surrey, England) in a double compression cycle test according to Bourne (1978). The textural attributes calculated were hardness, springiness, cohesiveness, gumminess, and chewiness.

2.4 Microbiological analysis

Two sausages per batch were used to evaluate the microbiological characteristics according to the method described by Vanderzant & Splittstoesser (1992). The Total viable counts (TVC), lactic acid bacteria (LAB), *Enterobacteriaceae*, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella*, and sulfite reducing clostridia were analyzed.

2.5 Sensory analysis

This study protocol was approved by the Ethics in Research Committee of The Federal University of Santa Maria under the number 01228612.6.0000.5346. The sensory parameters evaluated were color, aroma, taste, texture, and appearance using a seven-point scale, and purchase intention in a five-point scale (Meilgaard et al., 1999).

2.6 Statistical analysis

Proximate composition analysis was performed in triplicate; TBARS and color analyses were performed in quintuplicate; texture profile analysis was performed in nine replicates; microbiological analysis was performed in quadruplicate, and 52 untrained panelists performed the sensorial analysis. The entire experiment was conducted twice. Data were analyzed using the statistical package SPSS 17.0. A completely randomized experimental design with four levels of MDCM protein hydrolysate (0, 10, 20, and 30%) was used. Analyses of variance (ANOVA) were performed with confidence interval of 95%, followed by the *post-hoc* Tukey test to establish statistical differences between treatments.

3 Results and discussion

3.1 Proximate composition

Mortadella-type formulations differed in moisture, protein, fat, ash and, calorific value levels ($P < 0.05$, Table 1). The moisture content of the sausages made with MDCM protein hydrolysate was between 65.41 and 66.98%, and it was

Table 1. Proximate composition (g/100g) and energy value (kcal/100g) of mortadella-type sausages produced with different levels of MDCM protein hydrolysates[1].

	Treatments[2]			
	CT	T1	T2	T3
Moisture	68.21±0.10^a	66.98±0.25^b	65.41±0.17^c	65.41±0.07^c
Protein	10.63±0.33^c	11.09±0.52^{bc}	12.00±0.20^a	11.49±0.09^{ab}
Fat	10.66±0.33^b	10.41±0.36^b	11.71±0.09^a	11.58±0.24^a
Carbohydrate	7.62±0.58^a	8.40±0.36^a	7.63±0.26^a	8.04±0.31^a
Ash	2.88±0.02^d	3.12±0.00^c	3.25±0.02^b	3.48±0.03^a
Energy value	168^b	171^b	183^a	182^a

[1]Values are given as mean±SD. Same letter within the same row indicates no significant difference. [2]CT – without addition of MDCM protein hydrolysate; T1 – 10% addition of MDCM protein hydrolysate; T2 – 20% addition of MDCM protein hydrolysate; T3 – 30% addition of MDCM protein hydrolysate.

significantly lower ($P < 0.05$) than that of the control samples (68.21%). With regard to the protein content, the values were between 10.63 and 12.00%. Protein content was higher in the treatments with protein hydrolysate, showing that the addition of protein hydrolysates can be an alternative to improve the protein content in meat products. However, the main advantage of the use of protein hydrolysates is not the increased protein levels but the changes in the protein characteristics that can be caused by hydrolysis. Fat values ranged from 10.41 and 11.71% with differences between the treatments. In meat products, the fat content depends on the amount added in the formulation. Thus, even with the differences between the treatments, all of the fat values found were quite similar to the fat level added to the formulation (10%). In addition, the sausages with higher levels of MDCM protein hydrolysates showed higher levels of ash, and all treatments were different from each other ($P < 0.05$). The energy values were between 168 kcal/100 g (CT) and 183 kcal/100 g (T2), and the addition of higher levels of MDCM protein hydrolysate (T2 and T3) significantly increased ($P < 0.05$) these values as a consequence of the higher content of protein and fat in mortadella-type sausages.

3.2 TBARS

Lipid oxidation of mortadella-type sausages was affected by the MDCM addition ($P < 0.05$, Figure 1) during storage. The average TBARS values ranged from 0.240 to 0.688 mg MDA/kg during storage. It should be observed that the treatment T3 showed higher lipid oxidation values since the first day of storage. It is likely that the temperature used during the hydrolysis process increased the MDCM lipid oxidation. Therefore, mortadella-type sausages with higher amounts of MDCM protein hydrolysates show higher TBARS values since the first day of storage. Furthermore, lipid and pigment oxidation is a common problem reported in the literature, especially in the case of meat protein hydrolysates (Bueno-Solano et al., 2009; Klomklao et al., 2013).

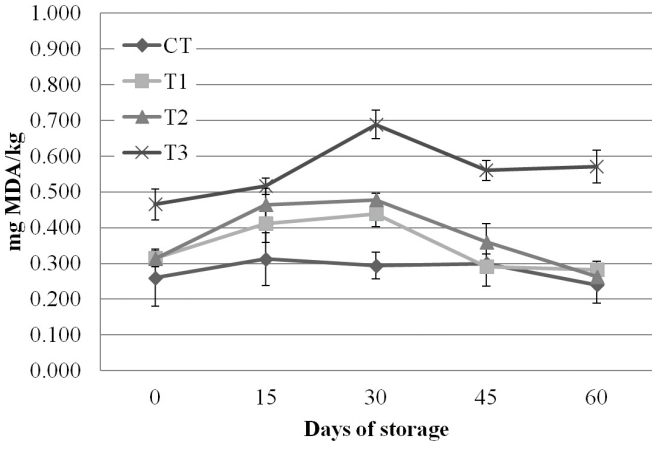

Figure 1. TBARS values of mortadella-type sausages produced with different levels of MDCM protein hydrolysates during storage. CT – without addition of MDCM protein hydrolysate; T1 – 10% addition of MDCM protein hydrolysate; T2 – 20% addition of MDCM protein hydrolysate; T3 – 30% addition of MDCM protein hydrolysate.

The TBARS values of mortadella-type sausages with MDCM protein hydrolysate increased until the 30th day of storage and decreased until the end of storage. According to Smith & Alford (1968), some microorganisms can decompose MDA, and/or further oxidation of MDA in other compounds, such as alcohols and acids, which cannot react with the TBA test may occur (Fernández et al., 1997). This can be considered as a normal phenomenon, and some studies have already reported similar results in other meat products (Georgantelis et al., 2007; Kittiphattanabawon et al., 2012).

Overall, the mortadella-type sausages showed good oxidative stability during 60 days of storage (maximum TBARS value = 0.688 mg MDA/kg). According to Wu et al. (1991), when the TBARS value is higher than 1.0 mg MDA/kg, off-odors are usually formed and it is considered as the beginning of organoleptic perception of lipid oxidation. Thus, taking this value as the rancidity detection threshold, it can be said that none of the treatments reached it until the 60th day of storage.

Several studies have shown that protein hydrolysates have an important antioxidant capacity (Dong et al., 2008; Khantaphant et al., 2011; Klompong et al., 2007). The antioxidant properties of protein hydrolysates typically result from their capability to stabilize or terminate radicals, donate a hydrogen atom, and/or chelate pro-oxidative metal ions, including Fe^{2+} (Kittiphattanabawon et al., 2012). According to Raghavan & Kristinsson (2008), the ability of different protein hydrolysates to chelate metal ions depends on the enzymes used in hydrolysis and the degree of hydrolysis of the hydrolysate. In order to obtain protein hydrolysates with better antioxidant capacity, it is necessary to apply methods that select and concentrate peptides that possess this function.

In meat model systems, Nasri et al. (2013) reported lower TBARS values in cooked turkey meat sausages added with different amounts of Goby (*Zosterissessor ophiocephalus*) fish protein hydrolysates (0.01%, 0.02%, 0.04% and, 0.2%), when compared to those of the control samples. On day 3 of storage, all concentrations reduced meat lipid oxidation by more than 50% if compared to that of the control treatment. After the 12th day of storage at 4 °C, gradual decreases in TBARS values were also observed. Kittiphattanabawon et al. (2012) also reported that cooked comminuted pork meat with addition of higher levels of gelatin hydrolysate from blacktip shark (*Carcharhinus limbatus*) could inhibit lipid oxidation exhibiting lower TBARS values during storage. However, in this study, the synthetic antioxidant used showed a better preventive effect on lipid oxidation. Peña-Ramos & Xiong (2003) and Wang & Xiong (2005) could also inhibit lipid oxidation in cooked meat patties using soy and whey and potato hydrolysates, respectively. Since the antioxidant properties of protein hydrolysates depend on the raw material, the enzyme, and the degree of hydrolysis, further studies are needed to confirm that MDCM protein hydrolysates have peptides with antioxidant action. Some studies have already reported antioxidant activity in protein hydrolysates from chicken liver (Chou et al., 2014), chicken skin (Onuh et al., 2014), and chicken breast (Sun et al., 2012). Nevertheless, these studies were carried out using separation (centrifugation and ultrafiltration) and drying (lyophilization) methods for the protein hydrolysates.

3.3 Color measurements

The addition of MDCM protein hydrolysates affected the color attributes of mortadella-type sausages (Table 2). As for the lightness (L^*) index, the T3 means indicate that the products were darkest ($P < 0.05$) at days 0 and 30 of storage. There is a negative correlation between lightness and the TBARS values (Hernández-Hernández et al., 2009). In other words, as oxidation increased, lightness decreased (the samples became darker). This relation was observed only at the days 0 and 30 of storage since T3 showed the lowest lightness values and higher TBARS values (Figure 1). The lightness values were between 63.36 and 58.66, with T2 lighter ($P < 0.05$) than those of the other treatments in the end of storage. Moreover, there was a significant decrease in this index in the CT during storage, ranging from 63.04 (day 0) to 58.66 (day 60).

Mortadella-type sausages with no MDCM protein hydrolysates addition (CT) had higher ($P < 0.05$) redness (a^*) during all days of storage. Nevertheless, the values at the end of storage were lower ($P < 0.05$) than that at day 0. The red color of mortadella-type sausages with MDCM protein hydrolysates addition was less intense than that of the CT, but it was more stable since there was no difference in the redness parameter between days 0 and 60 of storage. During the hydrolysis process, the hydrolysate can turn brownish yellow, probably due to the oxidation of myoglobin pigment of the meat (Benjakul & Morrissey, 1997). The heat used during the hydrolysis process produced a prooxidant effect oxidizing the myoglobin to metmyoglobin, which is associated with a reduction in reddish color.

With regard to the yellowness parameter (b^*), the CT showed more stable values when compared to the treatments with MDCM protein hydrolysate addition. There was no difference in the b^* values between the beginning and the end of storage, while T1, T2, and, T3 had increased b^* values ($P < 0.05$) in the same period. An increase in these values may be related to a fading of the color of cured meats (American Meat Science Association, 1991), but, a decrease in a^* values would be necessary, which was not observed in the treatments with addition of MDCM protein hydrolysate.

Chroma (C^*) and hue angle (h^*) are both based on a^* and b^* values and, consequently, are influenced by both. The CT had a higher chroma and lower hue angle, indicating a more intense reddish color than that of the treatments containing MDCM protein hydrolysates. Another study also reported that myoglobin oxidation to brown metmyoglobin was associated with a reduction in reddish color in beef patties (Sánchez-Escalante et al., 2003).

3.4 Texture profile analysis

The addition of MDCM protein hydrolysates affected ($P < 0.05$) the texture profile of mortadella-type sausages (Table 3). All parameters in the control treatment (CT) were higher than those of the other treatments with MDCM protein hydrolysate. Hardness values were lower in the products with

Table 2. Colorimetric parameters (L^*, a^*, b^*, C^*, and h^o) of mortadella-type sausages produced with different levels of MDCM protein hydrolysates during storage.[1]

	Treat.[2]	Days of Storage				
		0	15	30	45	60
L^*	CT	63.04 ± 1.59^{aA}	59.20 ± 0.70^{bB}	58.98 ± 1.39^{bA}	60.68 ± 0.79^{abA}	58.66 ± 1.26^{bB}
	T1	62.11 ± 0.17^{abA}	62.73 ± 1.15^{aA}	61.03 ± 1.28^{abA}	60.56 ± 1.25^{abA}	60.09 ± 0.66^{bB}
	T2	61.16 ± 0.97^{bA}	60.16 ± 1.48^{bB}	59.86 ± 0.55^{bA}	60.24 ± 0.51^{bA}	63.36 ± 1.20^{aA}
	T3	56.98 ± 0.59^{cB}	59.40 ± 0.57^{abB}	56.15 ± 1.29^{cB}	60.56 ± 1.14^{aA}	58.66 ± 2.10^{abB}
a^*	CT	23.18 ± 0.27^{aA}	21.33 ± 0.20^{cdA}	21.96 ± 0.39^{bcA}	21.23 ± 0.36^{dA}	22.15 ± 0.22^{bA}
	T1	20.37 ± 0.37^{aB}	20.55 ± 0.41^{aA}	20.66 ± 0.31^{aB}	20.14 ± 0.51^{aB}	20.98 ± 0.41^{aBC}
	T2	20.39 ± 0.40^{abB}	19.29 ± 0.41^{cdB}	20.10 ± 0.62^{bcB}	18.93 ± 0.28^{dC}	21.18 ± 0.22^{aB}
	T3	20.43 ± 0.50^{aB}	19.59 ± 0.19^{aB}	19.96 ± 0.51^{aB}	19.97 ± 0.63^{aB}	20.35 ± 0.61^{aC}
b^*	CT	13.50 ± 0.21^{aA}	12.68 ± 0.10^{bA}	13.13 ± 0.23^{aA}	12.44 ± 0.28^{bC}	13.50 ± 0.08^{aBC}
	T1	11.79 ± 0.13^{cC}	12.78 ± 0.21^{bA}	12.81 ± 0.22^{bA}	12.99 ± 0.17^{abB}	13.27 ± 0.26^{aC}
	T2	12.40 ± 0.10^{cB}	12.40 ± 0.23^{cA}	13.16 ± 0.34^{bA}	12.90 ± 0.19^{bB}	14.17 ± 0.14^{aA}
	T3	11.59 ± 0.23^{cC}	12.59 ± 0.19^{bA}	13.24 ± 0.19^{aA}	13.51 ± 0.22^{aA}	13.60 ± 0.09^{aB}
C^*	CT	27.49 ± 0.84^{aA}	24.81 ± 0.22^{cdA}	25.58 ± 0.42^{bcA}	24.60 ± 0.45^{dA}	25.93 ± 0.21^{bA}
	T1	23.53 ± 0.38^{bB}	24.20 ± 0.46^{abAB}	24.31 ± 0.38^{abB}	23.96 ± 0.51^{abA}	24.82 ± 0.48^{bBC}
	T2	23.86 ± 0.31^{bcB}	22.93 ± 0.64^{cC}	24.02 ± 0.70^{bB}	22.90 ± 0.34^{cB}	25.48 ± 0.17^{aAB}
	T3	23.48 ± 0.54^{abB}	23.29 ± 0.34^{bBC}	24.06 ± 0.61^{abB}	24.10 ± 0.64^{abA}	24.47 ± 0.52^{aB}
h^o	CT	30.2 ± 0.3^{cB}	30.7 ± 0.1^{bcC}	30.9 ± 0.4^{abC}	30.3 ± 0.2^{bcC}	31.4 ± 0.2^{aC}
	T1	30.0 ± 0.2^{dB}	31.8 ± 0.2^{bcB}	31.7 ± 0.1^{cB}	32.8 ± 0.4^{aB}	32.3 ± 0.2^{abB}
	T2	31.3 ± 0.7^{dA}	32.7 ± 0.4^{cA}	33.2 ± 0.2^{bcA}	34.3 ± 0.2^{aA}	33.7 ± 0.4^{abA}
	T3	29.5 ± 0.2^{cB}	32.7 ± 0.2^{bA}	33.5 ± 0.4^{abA}	34.1 ± 0.4^{aA}	33.7 ± 0.8^{abA}

[1]Values are given as mean±SD. Same letter within the same row indicates no significant difference. Same capital letter within the same column indicates no significant difference. [2]CT – without addition of MDCM protein hydrolysate; T1 – 10% addition of MDCM protein hydrolysate; T2 – 20% addition of MDCM protein hydrolysate; T3 – 30% addition of MDCM protein hydrolysate.

more than 20% of MDCM protein hydrolysates when compared to those of the other treatments.

The treatment with addition of 10% of MDCM protein hydrolysate (T1) had lower ($P > 0.05$) hardness values than control treatment but higher ($P > 0.05$) than T2 and T3. Springiness represents the extent of recovery of sausage height and, the values showed difference ($P < 0.05$) as the addition of protein hydrolysate was increased in the sausages elaboration (Table 3). The secondary parameters of cohesiveness, gumminess and chewiness have similar results to those parameters, showing a decrease as the MDCM protein hydrolysate levels increased.

The results of the texture profile analysis were in accordance with those found by Sun et al. (2010), who observed a decrease in the texture parameters of Cantonese sausages due to the addition of Maillard reaction products derived from the mechanically deboned chicken residue hydrolysate. Lower values of hardness, gumminess, and chewiness of cooked meat sausages with the addition of MDCM protein hydrolysates may be associated with weaker internal structure of the MDCM protein hydrolysate than that of the MDCM in its traditional form.

3.5 Microbiological analysis

The microbiological characteristics of the mortadella-type sausages made with MDCM protein hydrolysates are shown in Table 4. All of the treatments had good microbiological quality during storage. The CT showed higher ($P < 0.05$) TVC counts but lower LAB counts at the end of storage (60 days). Furthermore, the mortadella-type sausages containing MDCM protein hydrolysates also had higher ($P < 0.05$) LAB counts on days 15 and 45 of storage when compared to those of the CT.

Lazzi et al. (2011) showed that the addition of protein hydrolysate obtained from the poultry industry promoted the growth of a wide range of *Bifidobacterium* species of human origin. Recently, Lazzi et al. (2013) also reported that the growth of *Lactobacillus* species could also be improved by the supplementation with proteinaceous hydrolysates derived from poultry processing leftovers. These studies showed that protein hydrolysates from poultry meat are a promising functional food, and this is probably one of the reasons why the treatments with MDCM protein hydrolysate addition showed higher LAB counts when compared to those of the control treatment.

Zanello et al. (2014) have recently showed that poultry bone and meat trimming hydrolysates do not have *in vitro* antimicrobial activity against *E. coli*, *Listeria monocytogenes*, *Lactobacillus* sp., *Pseudomonas* sp., and *Salmonella* sp. However, the addition of 1.5% of protein hydrolysate to minced turkey meat could inhibit the microbial growth of mesophilic (TVC), psychrophilic, and *Enteterobacteriaceae* groups. In our study, the values of *Enterobacteriaceae*, *E. coli*, *S. aureus*, sulfite reducer clostridia, and *Salmonella* were not detected in all treatments (data not shown) during the entire storage period, and therefore these values are in accordance with the Brazilian legislation requirements (Brasil, 2001).

Table 3. Textural properties of mortadella-type sausages made with different levels of MDCM protein hydrolysates.[1]

Parameters	Treatments[2]			
	CT	T1	T2	T3
Hard (N)	27.13±3.92^{a}	8.33±0.90^{b}	4.68±0.82^{c}	3.93±0.68^{c}
Spring (mm)	0.94±0.03^{a}	0.65±0.07^{b}	0.49±0.11^{c}	0.47±0.06^{c}
Cohes (ratio)	0.76±0.04^{a}	0.36±0.04^{b}	0.29±0.02^{c}	0.30±0.01^{c}
Gumm (N)	20.57±3.57^{a}	3.01±0.59^{b}	1.37±0.22^{b}	1.18±0.23^{b}
Chew (Nmm)	19.24±3.62^{a}	1.99±0.54^{b}	0.69±0.27^{b}	0.56±0.15^{b}

[1]Values are given as mean±SD. Same letter in within the same row indicates no significant difference. [2]CT – without addition of MDCM protein hydrolysate; T1 – 10% addition of MDCM protein hydrolysate; T2 – 20% addition of MDCM protein hydrolysate; T3 – 30% addition of MDCM protein hydrolysate. Hard – Hardness; Spring – Springiness; Cohes – Cohesiveness; Gumm – Gumminess; Chew – Chewiness.

Table 4. Microbiological counts of mortadella-type sausages produced with different levels of MDCM protein hydrolysates.[1]

Microorganisms	Days	Treatments[2]			
		TC	T1	T2	T3
TVC	0	3.33±0.67^{aB}	3.50±0.38^{aA}	3.46±0.48^{aA}	3.75±0.11^{aA}
(log CFU/g)	15	2.82±0.05^{bB}	3.36±0.33^{aA}	3.67±0.13^{aA}	3.52±0.14^{aA}
	30	3.52±0.64^{aB}	3.43±0.02^{aA}	3.58±0.05^{aA}	3.55±0.07^{aA}
	45	2.88±0.15^{aB}	3.57±0.59^{aA}	3.19±0.97^{aA}	3.53±0.07^{aA}
	60	4.71±0.18^{aA}	3.31±0.15^{bA}	3.52±0.10^{bA}	3.62±0.26^{bA}
LAB	0	3.22±0.59^{aA}	2.93±0.08^{aA}	3.22±0.24^{aAB}	3.03±0.05^{aA}
(log CFU/g)	15	2.25±0.09^{bA}	2.95±0.17^{aA}	3.39±0.37^{aA}	2.97±0.12^{aA}
	30	3.33±0.86^{aA}	3.01±0.17^{aA}	3.32±0.15^{aA}	3.32±0.20^{aA}
	45	2.49±0.24^{bA}	3.28±0.85^{aA}	3.39±0.23^{aA}	3.09±0.25^{aA}
	60	2.17±0.08^{bA}	2.58±0.15^{aA}	2.72±0.05^{aB}	2.52±0.17^{aB}

[1]Values are given as mean±SD. Same letter within the same row indicates no significant difference. Same capital letter within the same column indicates no significant difference. [2]Control Treatment (CT) – without addition of MDCM protein hydrolysate; T1 – 10% addition of MDCM protein hydrolysate; T2 – 20% addition of MDCM protein hydrolysate; T3 – 30% addition of MDCM protein hydrolysate. TVC – Total viable counts; LAB – Lactic acid bacteria.

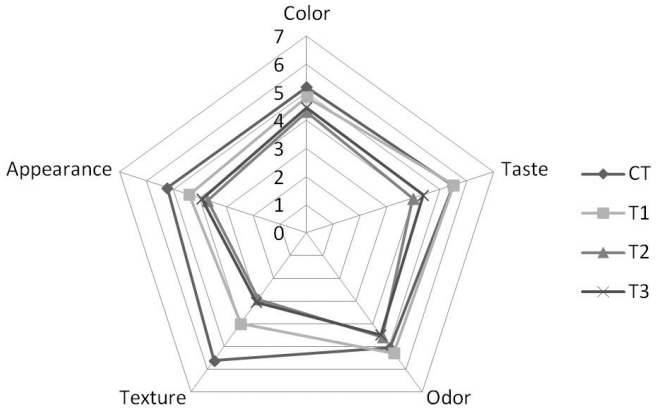

Figure 2. Sensory attributes of mortadella-type sausages produced with different levels of MDCM protein hydrolysates. CT – without addition of MDCM protein hydrolysate; T1 – 10% addition of MDCM protein hydrolysate; T2 – 20% addition of MDCM protein hydrolysate; T3 – 30% addition of MDCM protein hydrolysate.

3.6 Sensory evaluation

The addition of increasing levels of MDCM protein-hydrolysates had a negative effect on the sensory parameters analyzed by the panelists (Figure 2). The CT obtained higher ($P < 0.05$) scores for all attributes. The addition of more than 20% of MDCM protein hydrolysates affected the color, taste, and odor attributes of mortadella-type sausages. It is also known that the hydrolysis of protein produces peptides with brownish color and that the addition of large quantities of protein hydrolysate can affect the color of the product (Bueno-Solano et al., 2009). Moreover, other studies reported that the major disadvantage of the use of protein hydrolysates is the occurrence of bitter peptides (Spellman et al., 2009). It is likely that the bitter taste of these peptides can be experienced in the products and, therefore, this is the reason why T2 and T3 obtained lower scores ($P < 0.05$) for the taste parameter.

The panelists also reported that mortadella-type sausages with higher amounts of MDCM protein hydrolysate (T2 and T3) had softened texture, and consequently these treatments obtained lower scores ($P < 0.05$) than those of the others. It is likely that the addition of higher quantities of protein hydrolysates can be more useful in meat products with soft texture, such as patties. The future purchase intention scores were between 2.37 and 4.16 (data not shown), and as expected, the CT had the highest values ($P < 0.05$).

4 Conclusions

Based on the results of this study, it can be said that MDCM protein hydrolysate is a promising raw material for use in cooked meat products. However, the addition of more than 10% of MDCM protein hydrolysates to mortadella-type sausages affect lipid oxidation, color parameters, taste and texture, and, the addition of more than 10% of MDCM protein hydrolysate has not been recommended so far.

Further studies on different forms of MDCM protein hydrolysates and different meat products should be conducted.

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