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Textured soy protein, collagen and maltodextrin as extenders to improve the physicochemical and sensory properties of beef burger

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Abstract

Non-meat ingredients have been added as extenders to variety of meat products, such as beef burger, to improve some properties. Textured soy protein (TSP), collagen (CL) and maltodextrin (MD); and their combinations (TSPCL, TSPMD, CLMD and TSPCLMD) were added to beef burgers and then the effect on physicochemical and sensory properties was evaluated. MD and TSPMD presented higher yield and TSPMD showed lower value for the shrinkage analysis; these results showed the positive influence of the maltodextrin in reducing water loss. CL and TSPCL were harder than the control treatment. CLMD had higher approval in sensorial acceptance than MD and TSPCL. The addition of these extenders in the beef burgers improved the cooking properties, texture and sensorial acceptance, showing the importance of the addition of these ingredients to the final product.

Keywords: meat products; physicochemical properties; sensory evaluation; protein-polysaccharide interactions.

Practical Application: Non-meat ingredients added in beef burger to improve physico-chemical characteristics.

1 Introduction

During the manufacture of meat products, some ingredients are used to provide variety and improve cooking properties (Trevisan et al., 2016; Telis & Nicoleti, 2009; Tekin et al., 2010) and sensory characteristics, increase stability and reduce production costs (Akwetey & Knipe, 2012; López-Vargas et al., 2014; Ramadhan et al., 2011). The heat treatment during product preparation provides physical, chemical and structural changes to its components by the effect of heat (Borba et al., 2013) and can change the quality and yield due to the composition of product. To alleviate the negative effects of heat on the burger, extenders from protein or carbohydrate sources have been widely used by the food processing industry.

Textured soy protein has been used in meat products in order to increase water hold capacity and protein contents, improve the sensorial characteristics such as texture and reduce the production cost due to the substitution of a portion of the meat (Cassini et al., 2007).

Collagen and its fractions can play a significant role in human diets by containing essential amino acids, nutritive fibers and a source of animal protein. The addition of collagen in meat products can provide biological value and improve important characteristics in the product (Ferraro et al., 2016). Even in low quantities, collagen promotes a stabilizing effect enhancing the gelling and water holding capacities due to its affinity for water and improves the springiness and consistency (Brewer, 2012; Sousa et al., 2017; Telis & Nicoleti, 2009).

Maltodextrin is a polysaccharide composed of D-glucose molecules. It is obtained by the partial hydrolysis of starch. Maltodextrin has a dextrose equivalent (DE) ranging from 3 to 20, i.e. from almost sugarless to moderately sweet. This is because the higher the DE value, the shorter the glucose chains, making it sweeter and more soluble (Brewer, 2012; Lucca & Tepper, 1994). Long chain maltodextrin has affinity for water molecules, making it a gel that has some similar characteristics to fat, enhancing the juiciness and tenderness of meat products. So it is widely used as a fat replacer (Crehan et al., 2000; Telis & Nicoleti, 2009).

Akwetey & Knipe (2012) produced beef burgers using gari (a precooked product obtained from cassava root) to substitute beef. Chevance et al. (2000) studied oat fiber, tapioca starch and maltodextrin as fat-replacers in beef burgers, salami and frankfurters. Kassama et al. (2003) investigated the effect of the addition of soy protein flour and textured soy protein as protein extenders in beef patties. Seabra et al. (2002) studied cassava starch and oatmeal as fat replacers of lamb burger.

Beef burger, a convenience food product, which helps consumers minimize time as well as the physical and mental effort required for food preparation, consumption, and cleanup (Brunner et al., 2010) can have extenders added with interesting combinations that not only reduce the cost, but also improve the quality characteristics. And so, it is interesting to know which characteristics are modified by the different extensors or combinations of them.

Due to the lack of information regarding the effect of the addition of these extenders to beef burgers, the aim of this work was to evaluate the addition of protein (textured soy protein and

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collagen) and non-protein (maltodextrin) extenders to improve the quality of the cooked beef burger.

2 Materials and methods

2.1 Material and beef burger manufacture

Fresh beef (18.5% of protein, 66.9% of moisture content, 12.9% of fat) beef fat (10,6% of protein, 40% of moisture content, 47.8% of fat) and collagen (at least 99% of protein content) were donated by JBS S/A (Lins, SP, Brazil and Guaiçara, SP, Brazil, respectively). The granulated textured soy protein (53% of protein, 32% of carbohydrates, 1% lipid, 2% of dietary fiber) Bremil® (Arroio do Meio, RS, Brazil) and the maltodextrin N Hance SR® (89% carbohydrates content, DE ≤ 5) Ingredion Brasil Ingredientes Industriais Ltda. (São Paulo, SP, Brazil). The burger seasoning and additives (sodium tripolyphosphate, monosodium glutamate and sodium erythorbate) for preparing the beef burgers were provided by Doremus Alimentos Ltda (Guarulhos, SP, Brazil).

The beef burgers were made in two batches at the Meat and Meat Products Laboratory, Department of Food Technology and Engineering, Institute of Biosciences, Humanities and Exact Sciences, UNESP. Beef burgers of eight treatments (seven with extenders added and a control treatment) were prepared in each batch. All the treatments were prepared with 69% of fresh beef, 13% of beef fat, 1.2% of salt, 0.75% of monosodium glutamate, 0.6% of burger seasoning, 0.4% of sodium tripolyphosphate and 0.05% of sodium erythorbate and the quantities of cold water, TSP, CL and MD of each treatment are shown in Table 1. The addition of CL, TSP and MD in the treatments was done in a way that their actions could be evaluated alone, the interactions between them and of all three.

The amount of extender was adjusted by reduction of water in the each formulation, following the procedure used by Baldin et al. (2016) and Schmiele et al. (2015). First, the fresh beef and beef fat were ground using a pre-cut disc (25 mm) followed by a cut disc (3 mm). Texturized soy protein, collagen and maltodextrin were pre-hydrated with distilled water in a ratio of 1:3, 1:6 and 1:3 (extender: water) respectively, for five minutes, and the water was discounted from the total formulation. Then, they were added to the ground beef and beef fat and thoroughly mixed for about ten minutes at cooling temperature (4-8 °C). Finally, portions of 70 g of the mixture were pressed into a form to obtain each beef burger and then they were frozen at -18 °C. Prior to each analysis, the beef burgers were cooked in an industrial oven (PASSIANI, Itajobi, Brazil) at 150 °C for 15 minutes, ensuring that the geometric center of the burger reached at least 72 °C. The temperature was measured with a thermometer.

Table 1. Quantities of cold water, TSP, CL and MD of all treatments.

Treatment	Ingredients quantities (%)			
	Cold water	TSP	CL	MD
CT	15	0	0	0
TSP	13	2	0	0
CL	14	0	1	0
MD	14	0	0	1
TSPCL	12	2	1	0
TSPMD	12	2	0	1
CLMD	13	0	1	1
TSPCLMD	11	2	1	1

CT: Control treatment no added of TSP, CL and MD; TSP: with 2% of TSP; CL: with 1% of CL; MD: with 1% of MD; TSPCL: with 2% of TSP and 1% of CL; TSPMD: with 2% of TSP and 1% of MD; CLMD: with 1% of CL and 1% of MD; TSPCLMD: with 2% of TSP, 1% of CL and 1% of MD.

2.2 Cooking characteristics

Ten beef burgers from each treatment were weighed before and after cooking, and then cooled at room temperature, before each measurement. The cooking yield and shrinkage were obtained using the Equations 1 and 2, respectively:

$$CY = \frac{m_{ac}}{m_{bc}} \times 100 \quad (1)$$

$$SH = \frac{D_{bc} - D_{ac}}{D_{bc}} \times 100 \quad (2)$$

where *CY* was the cooking yield (%); m_{ac} and m_{bc} were the weight of the cooked beef burgers (g) after and before cooking, respectively; *SH* was the shrinkage (%); D_{ac} and D_{bc} were the diameter of the burgers (mm) after and before cooking, respectively. Beef burgers were weighed using a semi-analytical scale and the diameter was measured using a caliper rule. The smallest diameter of each burger was considered to determine the shrinkage.

2.3 Physicochemical analysis of cooked beef burger

Approximate composition

Moisture, protein, lipid and ash content were determined in beef burgers, after cooking and cooling at room temperature, in triplicate (except for protein that was determined in duplicate), by Association of Official Analytical Chemists (1995). Protein (g protein/100 g sample) was analyzed according to the Kjeldahl method (*N* x 6.25). Lipid content (g lipid/100 g sample) was determined as described by Bligh & Dyer (1959). Ash content was determined by incineration of the samples. Carbohydrate content was calculated by difference.

Colour analysis

The colour of the beef burgers was evaluated in a previously calibrated spectrophotometer (Konica Minolta, CM-5, Sakai, Osaka, Japan). Five cooked beef burger at room temperature from each treatment were used. The analysis was based on the L^* (lightness), a^* (redness), b^* (yellowness) parameters.

Texture profile analysis (TPA)

Texture profile analysis (TPA) was performed in ten beef burgers at 25 ± 2 °C from each treatment, after cooking and cooling at room temperature, with a Texture Analyzer (Stable Micro Systems, TA-XT/PLUS/50, Godalming, Surrey, UK). The software Texture Exponent 32 (Stable Micro Systems, Godalming, Surrey, UK) was used. Cylindrical samples were cut from beef burgers, with a 10 mm diameter and a height of 12 mm, and subjected to a two-cycle compression test. Samples were compressed to

50% of their original height with a cylindrical aluminum probe (25 mm diameter), with a test speed of 1 mm·s^{-1} and post-test speed of 10 mm·s^{-1}. The parameters were evaluated as defined by Bourne et al. (1978): hardness, in N, is the maximum force necessary to compress the sample; cohesiveness is the range over which the sample can be deformed; springiness, in mm, is the ability of the sample to resume its original shape when a deforming force is removed; and chewiness, in N.mm, is the energy required to chew a sample for swallowing.

2.4 Sensory analysis

Sensory analysis was performed at the Sensory Analysis Laboratory, Department of Food Technology and Engineering, Institute of Biosciences, Humanities and Exact Sciences, UNESP, using individual booths illuminated with white light. This study was approved by the Research Ethics Committee of the same institution (Decision 864959).

Two different scales were used to evaluate the sensory acceptance (appearance, colour, flavour, texture, taste, juiciness and overall acceptance) of the samples: (1) a hedonic scale of 9 points (9 = extremely liked; 5 = neither liked nor disliked; 1 = extremely disliked), to assess how much the panelists liked the aroma of the products; and (2) a purchase intention scale of 5 points (5 = I certainly would buy this product; 3 = I have doubt if I would buy this product; 1 = I certainly would not buy this product) (Meilgaard et al., 2006).

The sensory analysis was performed by 63 panelists. Each panelist analyzed eight samples of beef burgers (seven with extenders added and a control treatment). The samples were presented randomly, in a balanced manner (Macfie et al., 1989), in complete blocks and in monadic form. Burgers were cooked as previously described and maintained at about 60 °C until the analysis.

2.5 Statistical analysis

The means were compared using appropriate statistical inferences: (a) ANOVA followed by Tukey's test; (b) Kruskal-Wallis (nonparametric ANOVA) followed by Dunn's test; and (c) Mann-Whitney test. In all cases, differences were considered significant at $p \leq 0.05$. The Minitab 16 software (Minitab Inc., Pennsylvania, USA) was used for parametric analysis and GraphPad Instat version 5.3 (GraphPad Software Inc., La Jolla, USA) was used for nonparametric analysis.

All the results relating to the variables were subjected to principal component analysis (PCA) to investigate correlations among them. The means of the variable were entered in columns (variables) and the different treatments of beef burger in rows (cases), and the data were standardized before analysis. The PCA analysis was performed using the Statistica 7.0 software (StatSoft Inc., Oklahoma, USA), applying a correlation matrix, without factor rotation.

3 Results and discussion

3.1 Cooking characteristics

MD and TSPMD presented higher yield ($p < 0.05$) than treatments CL and TSPCL (Figure 1), which shows an important influence of the maltodextrin in reducing water loss, leading to an increased cooking yield.

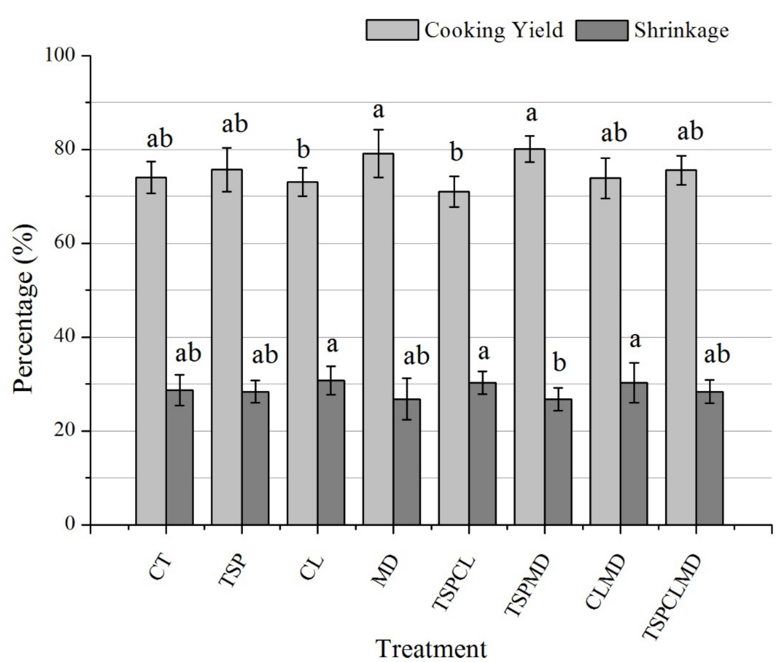

Figure 1. Cooking yield and shrinkage (%) of cooked beef burger. Error bars are expressed as mean ± SD with n = 10. CT: Control treatment no added of TSP, CL and MD; TSP: with 2% of TSP; CL: with 1% of CL; MD: with 1% of MD; TSPCL: with 2% of TSP and 1% of CL; TSPMD: with 2% of TSP and 1% of MD; CLMD: with 1% of CL and 1% of MD; TSPCLMD: with 2% of TSP, 1% of CL and 1% of MD. Different letters (a and b) in the same column indicate significantly different means ($p < 0.05$), using Kruskal-Wallis followed by Dunn's test.

A study reducing fat level, from 30 to 5%, in frankfurters formulated with maltodextrin showed significantly lower cooking losses than controls with no added maltodextrin (Crehan et al., 2000). Moreover, the tertiary structure of proteins can be altered by heat, modifying their water holding abilities (Brewer, 2012) in beef burgers containing protein extenders (CL and TSPCL). Seabra et al. (2002) found similar cooking yield for lamb burger with cassava starch and oatmeal as fat replacers and Angor & Al-Abdullah (2010) obtained lower yields (ranging from 59.9 to 71.1%) when studying low-fat beef burgers with other extenders added (carrageenan, textured soy protein and trisodium phosphate).

Concerning shrinkage, the TSP, TSPCL and CLMD treatments showed higher reductions than the TSPMD treatment, confirming the role of maltodextrin in the improvement of cooking characteristics of the beef burger, mainly together with textured soy protein. According to Brewer (2012), in ground beef, soy protein can increase moisture retention and decrease cooking shrinkage. Borba et al. (2013) studied several methods of preparation of commercial beef burgers and they obtained a reduction in the diameter of 16.87%, lower than the control treatment of this work (28.7%).

3.2 Physicochemical properties of cooked beef burgers

Table 2 shows the results for the approximate composition of the cooked beef burgers.

The moisture ranged from 55.2 to 59.9%, where TSPCL presented the lowest moisture content and MD the highest. The maltodextrin (DE ≤ 5), which was added to MD, presents a longer glucose chain which probably increases the binding affinity with water (Crehan et al., 2000; Telis & Nicoleti, 2009; Chronakis, 1998), and it contributed in reducing water loss, confirming the best results for yield. The lipid content of CT and TSP (18.1 and 18.6%, respectively) was higher than TSPCLMD (14.9%). Ash content of the TSP was higher than CL (4.1 and 3.7%, respectively), which may be attributed to the composition of the textured soy protein that can contain up to 7% ash while collagen in general does not exceed 2%. No treatment showed any significant difference ($p < 0.05$) for the protein and carbohydrate contents.

Regarding colour parameters in beef burger (Table 3), TSP showed a paler hue ($L^* = 46.61$) than TSPCL ($L^* = 41.73$). For the parameters a^* and b^* there was no significant difference among treatments ($p < 0.05$). Low and positive values of a^* and b^* represent a low setting to red and yellow dyes, respectively. Such characteristics were also observed in other studies (Bastos et al., 2014; López-Vargas et al., 2014; Ramadhan et al., 2011).

As presented in Table 3, beef burgers containing protein extenders (CL and TSPCL) presented higher hardness than CT ($p < 0.05$); so the incorporation of collagen on its own or with textured soy protein resulted in increased hardness. According to Brewer (2012), at first, water is held by contractile proteins and, for this reason, a temperature increase or pH reduction can promotes a higher drip and cook losses. Cohesiveness was lower in the treatments in which the extenders were used alone (T1, T2 and T3) and in the treatment using TSP and CL (T4) when compared to CT. According to Kassama et al. (2003), proteins used as extenders increase the water hold ability and improve texture properties, as juiciness. However, in this work, there is a tendency for the structure to maintain cohesiveness when protein extenders are combined with MD. Springiness was higher ($p < 0.05$) in TSPCLMD than in treatments TSP and TSPCL, showing the influence of MD on this characteristic of the product: so MD helped to increase springiness. Chewiness showed no difference among the treatments ($p < 0.05$). Similar values for hardness, cohesiveness and springiness were found by Aleson-Carbonell et al. (2005) in their study about beef burgers with added lemon albedo and by Ramadhan et al. (2012) when they studied duck meat burgers.

3.3 Sensory analysis

Despite CLMD having a higher cooking shrinkage, this presented higher acceptance for all attributes and overall acceptance, ranging from 'liked moderately' to 'liked very much', and for the purchase intent, ranging from 'I would probably buy it' to 'I would certainly buy it' (Table 4).

Appearance, colour and flavour were more accepted for CLMD than MD ($p < 0.05$). According to Chronakis (1998), the addition of maltodextrin is not sufficient to get the desired characteristics, requiring the addition of other carbohydrates or proteins. The use of maltodextrin is related to improved texture and juiciness of the product (Crehan et al., 2000), therefore

Table 2. Centesimal composition (%) of cooked beef burger (mean ± SD).

Treatment	Moisture[1]	Protein[2]	Lipid[1]	Ash[1]	Carbohydrate[3]
CT	57.5 ± 0.4^{ab}	17.1 ± 2.2^{a}	18.1 ± 0.0^{a}	3.8 ± 0.0^{ab}	3.5
TSP	56.7 ± 1.1^{ab}	18.6 ± 1.2^{a}	18.6 ± 0.5^{a}	4.1 ± 0.0^{a}	2.0
CL	57.5 ± 0.1^{ab}	20.1 ± 0.5^{a}	17.2 ± 0.3^{ab}	3.7 ± 0.0^{b}	1.5
MD	59.9 ± 0.1^{a}	17.9 ± 1.1^{a}	16.7 ± 0.5^{ab}	4.0 ± 0.2^{ab}	1.5
TSPCL	55.2 ± 0.3^{b}	22.4 ± 0.5^{a}	17.5 ± 0.3^{ab}	3.9 ± 0.2^{ab}	1.0
TSPMD	57.6 ± 0.2^{ab}	18.8 ± 0.4^{a}	16.8 ± 0.4^{ab}	3.8 ± 0.0^{ab}	3.0
CLMD	57.0 ± 0.3^{ab}	19.9 ± 0.8^{a}	17.2 ± 0.5^{ab}	4.0 ± 0.0^{ab}	1.9
TSPCLMD	56.6 ± 0.2^{ab}	21.2 ± 0.8^{a}	14.9 ± 0.0^{b}	4.1 ± 0.0^{ab}	3.2

CT: Control treatment no added of TSP, CL and MD; TSP: with 2% of TSP; CL: with 1% of CL; MD: with 1% of MD; TSPCL: with 2% of TSP and 1% of CL; TSPMD: with 2% of TSP and 1% of MD; CLMD: with 1% of CL and 1% of MD; TSPCLMD: with 2% of TSP, 1% of CL and 1% of MD. Different letters (a and b) in the same column indicate significantly different means ($p \leq 0.05$), using Kruskal–Wallis followed by Dunn's test, except for protein content which was used Mann Whitney test. [1]n = 3; [2]n = 2; [3]Carbohydrate content was calculated by the difference.

Table 3. Colour parameters and texture profile analysis of beef burger (mean ± SD).

Treatment	Colour parameters		
	L^*	a^*	b^*
CT	44.7 ± 3.4[ab]	3.3 ± 0.8[a]	10.6 ± 0.6[a]
TSP	46.6 ± 0.9[a]	3.2 ± 0.6[a]	10.7 ± 0.8[a]
CL	45.0 ± 1.6[ab]	3.6 ± 0.5[a]	10.8 ± 1.1[a]
MD	45.7 ± 1.0[ab]	3.7 ± 0.3[a]	10.1 ± 0.8[a]
TSPCL	41.7 ± 2.7[b]	4.2 ± 0.5[a]	11.2 ± 0.9[a]
TSPMD	42.9 ± 1.4[ab]	3.9 ± 0.7[a]	10.8 ± 0.7[a]
CLMD	42.9 ± 2.4[ab]	4.1 ± 0.6[a]	11.3 ± 0.3[a]
TSPCLMD	43.4 ± 1.1[ab]	4.0 ± 0.6[a]	11.4 ± 0.5[a]

Treatment	Texture profile analysis			
	Hardness (N)	Cohesiveness	Springiness (mm)	Chewiness (N·mm)
CT	15.38 ± 3.34[b]	0.69 ± 0.02[a]	0.78 ± 0.04[ab]	8.23 ± 1.83[a]
TSP	20.55 ± 4.18[ab]	0.64 ± 0.31[b]	0.74 ± 0.06[b]	9.82 ± 2.41[a]
CL	22.06 ± 3.58[a]	0.64 ± 0.42[b]	0.77 ± 0.04[ab]	10.67 ± 1.26[a]
MD	17.06 ± 3.83[ab]	0.64 ± 0.03[b]	0.77 ± 0.05[ab]	8.38 ± 1.90[a]
TSPCL	21.38 ± 3.49[a]	0.64 ± 0.02[b]	0.75 ± 0.04[b]	10.37 ± 1.93[a]
TSPMD	19.93 ± 3.23[ab]	0.67 ± 0.02[ab]	0.81 ± 0.04[ab]	10.64 ± 1.67[a]
CLMD	17.71 ± 3.38[ab]	0.67 ± 0.02[ab]	0.79 ± 0.02[ab]	0.83 ± 0.03[a]
TSPCLMD	19.70 ± 2.37[ab]	0.67 ± 0.03[ab]	0.83 ± 0.03[a]	10.86 ± 1.59[a]

CT: Control treatment no added of TSP, CL and MD; TSP: with 2% of TSP; CL: with 1% of CL; MD: with 1% of MD; TSPCL: with 2% of TSP and 1% of CL; TSPMD: with 2% of TSP and 1% of MD; CLMD: with 1% of CL and 1% of MD; TSPCLMD: with 2% of TSP, 1% of CL and 1% of MD. Different letters (a and b) in the same column indicate significantly different means ($p \leq 0.05$), using Kruskal–Wallis followed by Dunn's test (n = 10).

Table 4. Sensory acceptance and purchase intent of cooked beef burger (mean ± SD).

Treatment	Appearance	Colour	Flavour	Texture	Taste	Juiciness	Overall acceptance	Purchase intent
CT	6.4 ± 1.5[ab]	6.2 ± 1.6[ab]	6.8 ± 1.4[ab]	6.2 ± 1.7[b]	6.9 ± 1.3[a]	6.6 ± 1.5[ab]	6.7 ± 1.2[ab]	3.6 ± 0.8[ab]
TSP	6.7 ± 1.4[a]	6.6 ± 1.5[a]	7.0 ± 1.4[ab]	6.3 ± 1.7[b]	7.1 ± 1.4[a]	6.7 ± 1.6[ab]	6.8 ± 1.2[ab]	3.7 ± 0.9[ab]
CL	6.6 ± 1.5 [a]	6.5 ± 1.7 [a]	6.7 ± 1.7[ab]	6.4 ± 1.6[ab]	7.0 ± 1.6[a]	6.6 ± 1.6[ab]	6.8 ± 1.5[ab]	3.7 ± 1.0[ab]
MD	5.7 ± 1.5[b]	5.6 ± 1.6[b]	6.3 ± 1.4[b]	6.5 ± 1.8[ab]	7.1 ± 1.5[a]	7.0 ± 1.4[ab]	6.5 ± 1.4[b]	3.4 ± 1.1[b]
TSPCL	7.0 ± 1.5[a]	6.9 ± 1.6[a]	6.8 ± 1.6[ab]	6.2 ± 1.8[b]	6.9 ± 1.5[a]	6.4 ± 1.7[b]	6.6 ± 1.6[b]	3.5 ± 1.1[b]
TSPMD	7.1 ± 1.2[a]	7.0 ± 1.3[a]	7.0 ± 1.3[ab]	6.6 ± 1.5[ab]	7.2 ± 1.6[a]	6.9 ± 1.4[ab]	7.0 ± 1.2[ab]	3.9 ± 0.9[ab]
CLMD	7.1 ± 1.5[a]	7.0 ± 1.5[a]	7.2 ± 1.3[a]	7.3 ± 1.6[a]	7.6 ± 1.2[a]	7.3 ± 1.3[a]	7.3 ± 1.2[a]	4.1 ± 0.9[a]
TSPCLMD	6.6 ± 1.5[a]	6.6 ± 1.4[a]	6.6 ± 1.4[ab]	6.6 ± 1.6[ab]	7.0 ± 1.4[a]	6.7 ± 1.7[ab]	6.7 ± 1.3[ab]	3.6 ± 1.0[ab]

CT: Control treatment no added of TSP, CL and MD; TSP: with 2% of TSP; CL: with 1% of CL; MD: with 1% of MD; TSPCL: with 2% of TSP and 1% of CL; TSPMD: with 2% of TSP and 1% of MD; CLMD: with 1% of CL and 1% of MD; TSPCLMD: with 2% of TSP, 1% of CL and 1% of MD. Different letters (a and b) in the same column indicate significantly different means ($p \leq 0.05$), using ANOVA followed by Tukey's test (n = 63).

maltodextrin associated with collagen, which is a protein extender compatible with meat protein, may have provided a higher acceptance. The degree of polymerization of the maltodextrin is known to influence the retention of volatile components; flavour volatile retention has been shown to be inversely related to the dextrose equivalent of the polymer (Chevance et al., 2000; Le Thanh et al., 1992). In this work, the maltodextrin (DE < 5) could have decreased the release of flavour, when it used on its own in the formulation.

Texture and juiciness were more accepted in CLMD, when compared to TSPCL ($p < 0.05$). Lower moisture and higher hardness can be related to the lower acceptance of these attributes of TSPCL.

Overall acceptance and purchase intent were higher for CLMD than for MD and TSPCL. The combination of carbohydrate (MD) and an ingredient with high protein content (CL) presented the better result when compared to two protein extenders (TSP and CL) or only the carbohydrate (MD). There was no difference in taste among the treatments.

Principal component analysis (PCA)

The principal component analysis (PCA) showed that the first principal component explained 38.4% of the data variation and the second principal component explained 24.7%, thus totaling 63.1% of the total data variation (Figure 2).

The first principal component was explained by the L^* value and one group of variables composed of the b^* value, colour, appearance, flavour, purchase intent and overall acceptance (variables in bold in Figure 2A). Variables in the same group were correlated positively, while the L^* value correlated negatively with the group of variables. The second component was explained by moisture and juiciness (variables underlined in Figure 2A) that were correlated positively.

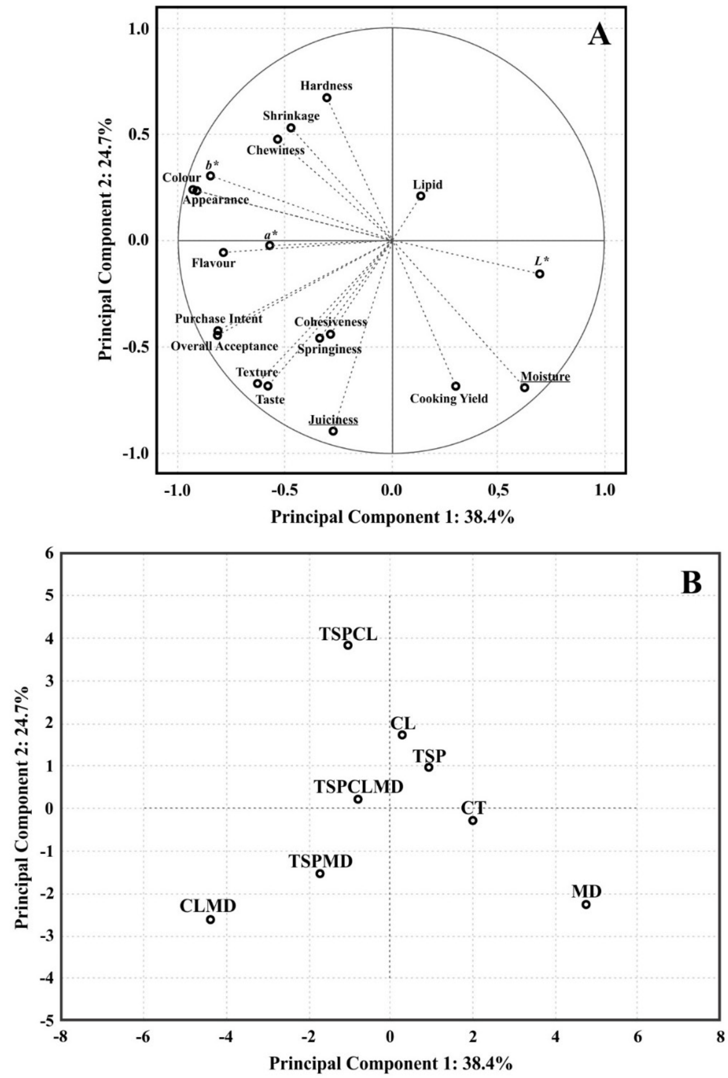

Figure 2. Principal component analysis on variables of the cooked beef burger (A- variables projection; B- samples projection). CT: Control treatment no added of TSP, CL and MD; TSP: with 2% of TSP; CL: with 1% of CL; MD: with 1% of MD; TSPCL: with 2% of TSP and 1% of CL; TSPMD: with 2% of TSP and 1% of MD; CLMD: with 1% of CL and 1% of MD; TSPCLMD: with 2% of TSP, 1% of CL and 1% of MD.

The beef burgers to which a combination of collagen and maltodextrin had been added (CLMD) had higher purchase intent and overall acceptance due the higher acceptability of appearance, flavour and colour, and the colour was more accepted due the higher b^* value (more yellowish) and lower L^* value (Figure 2B).

On the other hand, beef burgers with the addition of only maltodextrin (MD) had a higher acceptance of juiciness due to its higher moisture (Figure 2B).

4 Conclusions

The present study showed the importance of the addition of extenders to beef burgers. The addition of maltodextrin positively affected cooking properties of the beef burgers, such as yield and shrinkage, but it negatively influenced the appearance, colour and flavour. Textured soy protein as an extender didn't show any improvement in the physicochemical and sensory properties of beef burger. The collagen in beef burger increased the hardness. However, collagen as an extender together with maltodextrin resulted in best results in the sensorial acceptance of beef burgers.

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