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Development of functional beef meatball using landrace common bean flour as a substitute for meat and textured soy protein

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Abstract

The aim of this study was to develop a formulation of beef meatball using landrace common bean flour (*Phaseolus vulgaris* L.) to partially replace meat and to fully replace soy protein. The bean flour, beef, test meatball (TMB) and commercial meatball (CM) were all analyzed in terms of centesimal composition, microbiological analysis, sensory profile of fatty acids and amino acids and optical microscopy. Significant differences regarding chemical composition were observed between the TMB and the CM except for moisture and protein. The TMB showed reduced fat content (4.2%) compared with the standard (18%) and therefore could be classified as a light product. The protein content was significantly higher than the required minimum (12%) and the TMB could therefore be considered a functional product because it also met the standards established by the legislation due to a high content of dietary fiber. It was found that the TMB contained both linoleic and linolenic essential fatty acids and it also presented a good n6/n3 ratio. The TMB contained no limiting essential amino acids when compared to the FAO/WHO standard. The meatballs that were developed received good acceptance in sensory evaluation, showing that the partial replacement of meat and the full replacement of soy protein by common bean flour is feasible.

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Introduction

Recent increases in the demand for functional products offer great opportunities for the meat industry. These new trends are in line with the fact that consumers are seeking healthier meat and meat products with reduced fat and cholesterol, a better fatty acids profile, lower salt and nitrite content, and the inclusion of functional ingredients (Khan *et al*., 2011).

Some studies have investigated alternative sources of protein in order to develop functionality, e.g. forming emulsions and adding nutritional value to processed foods (Castilho *et al*., 2010). In this context, the use of common beans (*Phaseolus vulgaris* L.) in the form of flour represents an opportunity to develop foods with improved nutritional composition because the end product has a low content of fat and sodium, has no cholesterol, is rich in protein (20% to 25%) with a high content of lysine, high dietary fiber content (20.85% to 31.35%), with its hypoglycemic and hypocholesterolemic effect, significant content of complex carbohydrates, presence of vitamins B as riboflavin, niacin and falocina, and also contains polyphenols with antioxidant and anticancer activities (Hosfield, 1991; Morrow, 1991; Araujo *et al*., 1996; Londero *et al*, 2008; Xang and Xu, 2008; Gallegos-Infante *et al*., 2010).

The beans are an important source of minerals highlighting primarily in calcium, iron, copper, zinc, phosphorus, potassium and magnesium (Yokoyama and Stone, 2000). It is worth mentioning that the amount of iron found in beans is similar to beef, despite having lower bioavailability simultaneous addition of cystine and ascorbic acid improves iron absorption bean, equaling it to the iron absorption beef (Moura and Canniatti-Brazzaca, 2006).

Commercially, in Brazil there are not many ways to add value to this protein legume, whose annual domestic production is about 3.70 million tonnes (CONAB, 2014). There is virtually no processing of beans in Brazil; when the beans get over maturity (from one crop to another) they lose sensory quality, making them difficult to market and to use. Thus, using beans in the form of flour presents the possibility of obtaining differentiated technological properties and the opportunity to use it as an ingredient in the food industry. It is an abundant raw material in

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Brazil easy access to all socioeconomic classes, due to its low cost when compared to animal protein sources. The proteins of the beans treated by heat are generally more digestible than the natural protein isolates (Damodaran, 2010). Beans have about half the protein content of soybean but they have higher protein digestibility (Pires *et al*., 2006). The bean flour usage comes to meet the demands of vegetarian and vegan consumers.

Meatballs are widely consumed in Brazil and they are an excellent choice of protein ingestion in feeding infants. However, their formulation usually contains soy protein, which is a source of the phytoestrogens daidzein and genistein, which are not suitable for infants (Bennetau-Pelissero *et al*, 2004; Rieu *et al*., 2006). Furthermore, soy protein adversely alters the color of meat products, turning them darker (Youssef and Barbut, 2011) and the development of "off-flavours" may also occur (Hsu and Sun, 2006). The addition of polysaccharides such as carrageenan and maltodextrin in the formulation can interfere with the lightness of the product, since there is a decrease in the concentration of myoglobin, which results in an opaque product (Youssef and Barbut, 2011). Soy affect the taste, which can generate bitter taste due to peptides and raw grain flavour.

Beans are the most popular legume in Brazil, and the state of Rio Grande do Sul landrace common bean is important to meet the rising demand for more diverse, natural, healthy and organic food. In contrast, most of the studies mentioned in the literature used commercial cultivars for the development of meatballs (Serdaroğlu *et al*., 2005) and there are few studies evaluating the use of landrace common bean flour in product development. The aim of this study was to develop a formulation of beef meatball with the partial replacement of meat and the total replacement of soy protein by common bean flour.

Materials and Methods

Raw materials, formulation and processing of meatball

The "Carioca" landrace common bean from the municipality of Ibarama, RS, Brazil (29° 25'10"S, 53°08'05" W, altitude: 317 m) was used to obtain the bean flour. To prepare the flour, the grains were washed in distilled water at room temperature and then dried in an oven with forced air circulation at 65°C for 24 h (Marconi, model MA 035 Piracicaba, São Paulo, Brazil). The whole grains were then ground in a micro-mill (Marconi, model MA 360 Piracicaba, São Paulo, Brazil) and the flour that was obtained was classified in sieves with an opening of 500 µm (35 mesh) and packed in plastic bags at -18°C.

To develop the meatball formulation, Ordinance number 1004 (ANVISA, 1998) was followed. The raw material consisted of frozen beef shoulder. In order to define the proportion of flour in the meatball formulation, some preliminary tests (results not shown) were performed using black beans, other colored beans (white, red and Carioca) and with different proportions of meat and flour in the formulations. The best results were found by replacing up to 30% of meat by common bean flour and by totally replacing the soy protein (results not shown).

The test formulation was named TMB and raw material consisted of beef, previously thawed under refrigeration (8°C), which was ground with a grinder with a 5 mm disc (Jamar model PJ22, Tupã, SP, Brazil) and blended with the following ingredients and additives detailed in Table 1. After mixing, the meatballs were shaped (approximately 30 g) and they underwent a curing period of 8 hours under refrigeration at 4°C and were then frozen at -18°C. For formulation testing, three replicates were performed.

For comparison purposes, a sample of commercially produced meatball (beef, water, wheat flour, seasoning, salt, sodium lactate, sodim polyphosphate, monosodium glutamate, sodium erythorbate and natural aroma of black pepper). Was purchased locally and kept as well at -18°C until the time of analysis.

Proximate composition

The determination of the proximate composition of common bean flour (CBF), beef (B), test meatball (TMB) and commercial meatball (CM) was performed according to the techniques described in the AOAC (1995) as following: analysis of moisture gravimetrically in an oven at 105°C; analysis of ash by incineration in a muffle furnace at 550°C; analysis of protein by the Kjeldahl method (N x 6.25); analysis of ether extract in a Soxhlet apparatus with ethyl ether. The fraction of total carbohydrates was calculated by difference.

The levels of total dietary fiber, soluble fiber and insoluble fiber were measured according to the enzymatic-gravimetric method, Nos. 985.29 and No. 991.42 (AOAC 1995), which analytically determines the levels of total and insoluble dietary fiber, and also quantifies, by difference, the soluble fiber content of samples. The enzymes used in the enzymatic methods were α-amylase (Termamyl® 2X), protease (Alcalase 2.4 L FG®) and amyloglucosidase (AMG 300 L®),

Table 1. Formulation used for the development of meatballs using landrace common bean flour as a substitute for meat and textured soy.

Test Formulation	
Ingredients and Additives	(%)
Beef	59.30
Bean flour	25.44
Ice	11.00
Sodium cloride	2.000
Parsley	0.500
Maltodextrin	0.300
Garlic powder	0.200
Sodium tripolyphosphate	0.200
Nutmeg	0.200
Marjoram	0.130
Tyme	0.125
Monosodium glutamate	0.100
Kappa carrageenan	0.100
Flavoring	0.100
Sodium erythorbate	0.100
Black pepper	0.100
Red pepper	0.040
Carmine coloring with 3% caminic acid (0.03%)	0.030
Liguid smoke	0.025
Sodium nitrite	0.010
Total	100,00

all produced by Novozymes Latin American Limited (Araucaria, PR, Brazil). The analyses relating to moisture, ash, crude protein, ether extract and total, soluble and insoluble dietary fiber were performed in duplicate and their final values were converted to dry basis.

Fatty acids analysis

To analyze the fatty acid profile, the lipids were extracted using chloroform and methanol, as described by Bligh and Dyer (1959), and subsequently esterified using the method of Hartman and Lago (1973). The esters that were formed were then analyzed using an Agilent Technologies 6890N series gas chromatograph, equipped with a capillary column (Supelco SP2560, Sigma-Aldrich) of fused silica (100 m long x 0.25 mm internal diameter x 0.2 mm film thickness) and a flame ionization detector (FID). The program for heating the column was started at 170°C for 2 minutes and was followed by a gradual increase of 3°C per minute until the final temperature of 240°C, where it remained for 7 minutes. Nitrogen was used as the carrier gas at 0.9 mL min^{-1}. The injected sample volume (split mode) was 1 µL. The temperature used for the detector (FID) was 280°C. The fatty acids were identified by comparison with retention times of reference standards (Supelco 37 FAME Mix ref. 47885-U, Sigma, Bellefonte, USA). The retention times and areas were automatically computed using Agilent ChemStation software.

Amino acids analysis

The determination of the levels of amino acids was performed using high-performance liquid chromatography (HPLC). The samples passed through prior hydrolysis with redistilled 6 N hydrochloric acid (HCl), followed by pre-column derivatization of the free amino acids with phenylisothiocyanate (PITC), and the separation of the phenylthiocarbamide-amino acid derivatives (PTC-aa), in a C18 reverse phase column (Peak-Tag- 3.9x300 mm) with UV detection at 254 nm. The sample quantification was based on the peak height of each amino acid, having used as the reference the peak height of the internal standard with a known concentration of amino acids, with the standard derived under the same conditions and at the same time as the samples. The amino acid contents were transformed into grams per 16 g of N of dried sample.

Microbiological analysis

The microbiological evaluation were performed according to Normative Instruction No. 62 (MAPA, 2003), following the standards established by ANVISA (2001) (Coliforms at 45°C, coagulase positive *Staphylococci, Salmonella* sp. and sulphite-reducing *Clostridium*).

Microscopic analysis

For the light microscopy, three fragments of each treatment (TMB and CM) corresponding to the center of the raw meatballs were sampled. The collected material was processed according to the conventional technique cited by Junqueira and Carneiro (2008). The samples were qualitatively evaluated for the presence of: collagen and muscle fibers; adipose tissue; compact and fibrous connective tissue; edema; aleurone; the presence of starch; cytoplasmic vacuoles, and the breakdown, disorganization and binding of tissues. Three slides were prepared for each treatment. The samples were cut into sections with a thickness of 4 µm and were then stained with hematoxylin and eosin. A Leica microscope (Leica Microscopy Systems, Heerbrugg, Switzerland) was used and Motic Images Plus 2.0 software (Motic Instruments, Inc., Richmond, Canada) was applied to capture the images.

Sensory analysis

The project was approved by the Ethics Committee (CAAE: 07188612.6.0000.5346). Sensory analysis was performed for the meatballs (only for the test formulation) using the tests of acceptability and purchase intent (Dutcosky, 2007; IAL, 2008). Fifty-six untrained testers from the academic community

Table 2. Chemical composition of "Carioca" landrace common bean flour (CBF), beef (B), test meatball (TMB) commercial meatball (CM) and legal limits

PARÂMETERS	CBF (%)	B (%)	TMB (%)	CM (%)	Standard (%)***
Moisture*	6.65±0.10	72.65±0.60	57.00[a]±0.30	60.00[a]±0.01	
Ash**	5.00±0.10	2.43±0.11	10.78[a]±0.13	4.87[b]±0.33	
Protein*	19.80±0.97	17.33±0.43	14.90[a]±0.16	14.78[a]±0.28	12.00 (Min.)
Lipids**	1.88±0.40	7.59±0.55	4.20[b]±0.76	16.76[a]±0.90	18.00 (Max.)
Total carbohydrates	66.67±0.98	-	13.13[a]±0.88	3.59[b]±0.78	10.00 (Max.)
Total dietary fiber**	31.48±0.87	0	7.65[a] ±0.89	0.45[b] ±0.85	
Insoluble fiber**	27.76±0.85	0	6.78[a] ±0.88	0.36[b] ±0.83	
Soluble fiber**	3.73±0.98	0	0.86[a] ±0.96	0.09[b]±0.97	

Wet basis; ** Dry basis; ***MAPA (2000). Means followed by different letters in the line differ by Tukey's test at 5% error probability

participated. The meatballs were prepared with sauce containing water (40%), tomatoes (38%), onion (17%), salt (3%) and annatto (2%) and were cooked to an internal temperature of 72°C and then served at 60°C. A seven-point hedonic acceptance test was applied (1 = extremely disliked and 7 = extremely liked) and the following parameters were analyzed: color, odor, flavor and texture. A five-point purchase intent test was also used and all the testers were asked to indicate whether they would buy meatballs made with common bean flour.

Statistical analysis

The results that were obtained were subjected to analysis of variance (ANOVA) and Tukey's test with a significance level ($p< 0.05$). All these analyses were performed using the SISVAR 5.3 software program (Ferreira, 2000).

Results

The proximate composition of the common bean flour, beef, TMB and CM are presented in Table 2. In the analysis of the ash content, there was a higher percentage in the common bean flour (5%) compared to the beef (2.43%). The analysis of ash content provides preliminary information about the mineral content of a food and it is the starting point from which the other minerals are quantified. Thus, it can be seen that the common bean flour had a higher percentage of minerals than the beef.

Furthermore, the common bean flour showed higher contents of crude protein (19.80%) than the beef (17.33%); higher values (22.65%) have been reported by Hautrive *et al*. (2012). The crude protein content of the common bean flour was lower than that found by Prolla *et al.* (2010), Mavromatis *et al*. (2007) and Mavromatis *et al*. (2010), who found levels of 25.69%, 25.40% and 25.25%, respectively.

As expected, the lipid content of the common bean flour (1.88%) was lower than that of beef (7.59%). Regarding the meat, some differences were found if our results are compared with other studies. These differences may have been caused by the production system (handling, food, genetic, etc.) (Zorba and Kurt, 2006). The lipid content of the beans was higher than the average content of 1.15%, which was observed by Mavromatis *et al.* (2010) and close to the average contents of 1.82% and 1.90% observed by Prolla *et al.* (2010). The main constituent of carbohydrate in the common bean flour was dietary fiber, which accounted for 47.22% out of a total of 66.67% total carbohydrates. A similar result (68.61%) was verified by Delfino and Canniatti-Brazzaca (2010).

The total dietary fiber content of the common bean flour was 31.48% and insoluble fiber was 27.76%, values which were above the corresponding averages of 25.35% and 19.50% found by Prolla *et al.* (2010). The soluble fiber content of the common bean flour was 3.73%, which confirmed the values found by Londero *et al*. (2008). However, it is noteworthy that the chemical composition of beans may vary according to the cultivar, growing conditions, climate, and soil fertility.

Comparing the two main ingredients used for the formulation of the test meatballs it was concluded that the common bean flour had a better nutritional profile, which was due to a higher content of ash, protein, dietary fiber and reduced lipid content. Significant differences ($p< 0.05$) were observed between the test meatballs and the commercial meatballs regarding the content of ash, fat, total carbohydrates, dietary

Table 3. Major fatty acids in "Carioca" landrace common bean flour (CBF), beef (B), test meatball (TMB) and commercial meatball (CM)

Fatty acids (%)	CBF	B	TMB	CM
14:0 (Myristic)	0.52	3.24	3.04	3.01
16:0 (Palmitic)	16.45	23.66	23.09	23.01
16:1 (Palmitoleic)	0.43	2.94	2.76	2.44
18:0 (Stearic)	3.70	18.22	17.31	19.27
18:1n9c (Oleic)	11.94	32.7	28.85	33.02
18:2n6c (Linoleic)	33.11	2.06	4.88	2.25
18:3n3c (Linolenic)	19.40	-	2.14	-
∑SFA	20.67	45.12	43.44	45.29
∑MFA	12.37	35.64	31.61	35.46
∑PFA	52.51	2.06	7.02	2.25
n6/n3	1.70	-	2.28	-

SFA: saturated fatty acids; MFA: mono-unsaturated fatty acids; PFA: poly-unsaturated fatty acids.

Table 4. Composition of essential and non-essential amino acids (in grams per 16 g of N of dry matter) of the test meatball (TMB), commercial meatball (CM) and the FAO standard

Amino acids	TMB	CM	FAO(1)
Essential aminio acids			
Lysine	22.64	20.40	5.8
Phenylalanine	9.77	9.94	6.3(2)
Leucine	15.66	13.89	6.6
Isoleucine	8.84	8.57	2.8
Histidine	3.41	3.77	1.9
Valine	9.61	8.74	3.5
Threonine	22.64	15.09	3.4
Methionine	8.53	6.17	2.5(3)
Non-essential amino acids			
Aspartic acid	24.19	29.15	
Glutamic acid	39.07	40.12	
Serine	12.09	13.03	
Glycine	20.31	15.43	
Alanine	17.36	31.03	
Proline	14.88	11.83	
Tyrosine	5.43	6.00	
Arginine	15.81	23.66	
Cysteine	1.55	5.66	

(1) Amounts of amino acids considered sufficient by the FAO (1998) to meet the daily needs of children of pre-school age (2-5 years).
(2) Phenylalanine + tyrosine
(3) Methionine + cysteine

fiber, soluble fiber and insoluble fiber, but there was no significant difference (p> 0.05) for levels of moisture and protein (Table 2).

The ash content of the test meatball (10.78%) was higher than that found for the commercial meatball (4.87%), which was due to the contribution of the common bean flour in relation to mineral content. The intake of foods with a good supply of minerals is essential because they play a vital role in the proper development and good health of the human body (Hardisson *et al*., 2001).

The TMB had a protein content (14.90%) similar to the CM (14.78%) and both were above the minimum value (12%) established by Brazilian legislation for this type of product (MAPA, 2000). Divergent results were found by Dzudie *et al.* (2002), who found that the protein content in beef sausages decreased in line with increasing levels of common bean flour in the formulation. However, Serdaroğlu *et al*. (2005) found that the incorporation of leguminous flour in meatballs increased the percentage of protein.

It was found that the test meatball and the commercial meatball met the standards required by Brazilian legislation regarding lipid content, which establishes a maximum permissible limit of 18% for this class of product (MAPA, 2000). It is noteworthy that the TMB showed a 76.67% reduction in lipids compared to the standard and therefore could be classed as a light product. Current legislation, (Resolution No. 54 of November 12, 2012) states that a minimum reduction of 25% of any ingredient in a product means that it can be considered as light (ANVISA, 2012).

The total carbohydrates in the TMB (13.13%) were higher than in the CM (3.59%) and exceeded by 30% the limit allowed by the legislation (10%). This was mainly due to the incorporation of 25.44% common bean flour and also maltodextrin. In meatballs with 15% added rice bran, Huang *et al.* (2005) found 7.90% of total carbohydrates. This is one of the factors that suggest a revision of the current legislation is required because with the increased demand for functional products the currently established parameters may well not be achieved due to the different characteristics of the formulations of these products.

Comparing the total dietary fiber in the test meatball (7.65%) with the commercial meatball (0.45%) the former could be classified as a functional product and a source of fiber because it meets the minimum 3 g of fiber per serving established by Brazilian legislation (ANVISA, 2012). This is due to the fact that beans are one of the few whole foods that have a balanced content of soluble and insoluble fiber (Hughes, 1991). The fractions that make up the fiber exert different physiological effects on the human body and act to regulate the function of the gastrointestinal tract and the control and/ or

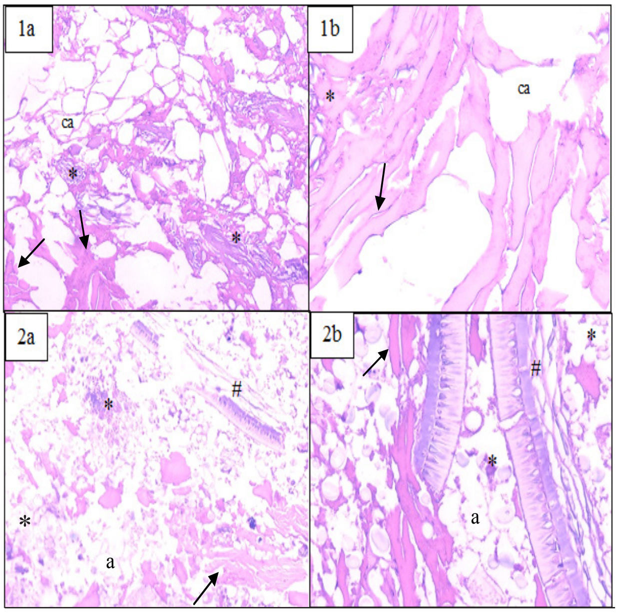

Figure 1. Photomicrographs of commercial meatball (CM) (1a and 1b) and test meatball (TMB) (2a and 2b)

1a) Note the adipose tissue (ca) beside the intact muscle cells (arrows). Disorganized dense connective tissue can be seen (*).

1b) note the detail showing the thin and long muscle cells similar to normal muscle tissue (arrows).

2a) Note the disorganization of the muscle cell (arrows) beside the dense connective tissue (*). Note the starch present in the tissue (a), but this is not integrated to the other tissues and components.

prevention of certain chronic non-communicable diseases.

Table 3 shows the profile of fatty acids for the common bean flour, beef, TMB and the CM. It can be seen that the common bean flour excelled in terms of essential linoleic fatty acids (18:2n6c) and essential linolenic fatty acids (18:3n3c) with a total sum of 52.51%. The beef had a fatty acid profile with a predominance of saturated fatty acids, totaling 45.12% and palmitic acid (16:0) in greater quantity (23.66%).

It was noted that the TMB contained two essential fatty acids, linoleic (18:2n6c) and linolenic (18:3n3c), incorporated in the common bean flour and the sum of the content of these fatty acids was greater than in the CM, which can be explained because the latter did not contain the linolenic fatty acid (18:3n3c) in its composition. The ratio of the n6/n3 fatty acids in the TMB was 2.28. This is an appropriate value as recommended by the World Health Organization (WHO, 1995), which states that this ratio cannot be greater than 10:1. Levels below that ratio demonstrate that a food contains a good balance of essential fatty acids and that it has anti-inflammatory potential. The results of our study indicate that the developed meatball may have anti-inflammatory potential because of the good n6/n3 ratio and high omega-3 content. According to McDaniel *et al*. (2013), foods with low values for the n6/n3 ratio are desirable and are associated with reduced levels of C-reactive protein, a protein which alleviates inflammation.

Regarding the content of amino acids (Table 4), it was found that the TMB showed higher levels of lysine, leucine, isoleucine, valine, threonine and methionine compared to the CM. It can therefore be concluded that the mixture of meat with common bean flour resulted in increased levels of amino acids in the final product, which is a potential alternative use for this type of flour. However, both products contained adequate amounts of essential amino acids to meet the nutritional requirements of the body, according to the standard established by FAO the (1998). Thus, the TMB offers advantages due to its nutritional attributes (primarily fiber) in comparison with commercial meatballs.

With respect to microbiological evaluation, the test meatballs met the standards required by Brazilian legislation (ANVISA, 2001) (results not shown). Figure 1 shows the photomicrographs obtained with hematoxylin and eosin for the commercial meatball (1a and 1b) and the test meatball (2a and 2b). Microscopy was used to study the influence of the total replacement of meat and the partial replacement of soy protein by common bean flour in terms of the structure of the meatball. It showed the distribution of muscle fibers, adipose tissue, compact and fibrous connective tissue, edema, cytoplasmic vacuoles, and the breakdown, disorganization and binding of tissues. The commercial meatball showed the presence of adipose to the side of muscle cells in a slightly disorganized manner (Figure 1a and 1b). The presence of dense and disorganized connective tissue can be seen (Figure 1a) and the absence of tissue bonding (Figure 1b). It was noticed that there was tissue disorganization involving collagen, muscle and adipose tissue, which was probably due to the grinding of the raw material to manufacture the product.

In relation to the test meatball, it was noted that the muscle was more disorganized (Figure 2a) than the commercial meatball (Figure 2a compared to 1a) but the dense connective tissue seemed to be more integral. The presence of starch was observed but it was not integrated to the other tissues and components of the product (Figure 2b). The presence of adipose tissue was also noted, as well as a lesser amount of muscle tissue, which was due to the reduction of the meat and increased interstitial space (Figures 2a and 2b). Clusters of plant cells were noted, which resulted from the use of common bean flour (Figure 2b). The test meatball showed less tissue boding and greater structural disorganization, which may have influenced the bonding and technological properties. The use of the hematoxylin and eosin technique made it possible to observe the addition of the common bean flour and the structural differences in the products. Even with greater disorganization and lesser tissue bonding no problems were observed in molding or in terms of a brittle product. Histology clearly showed the distribution of the common bean flour in the structure and the presence of starch resulting from the composition of the beans. Although the images showed differences, these were not perceived in the sensory analysis.

In the sensory evaluation the color parameter obtained a score of 5.88, odor received 5.73, flavor 5.3, and texture 5.12, which placed the TMB in the range of "liked" in the seven-point verbal hedonic scale. Other studies found similar results for meatballs made with corn flour (Serdaroğlu and Değırmencioğlu, 2004) and bean flour, lentils and chickpeas (Serdaroğlu *et al.*, 2005). In the spaces reserved for comments in the evaluation form, the testers mentioned that the taste of the test meatball was better than that produced with textured soy protein (the commercial meatball). The testers also commented that the test meatball was very similar to a meatball containing beef. This is positive factor because the test product was very close to that which is commonly consumed, but with improved functional and nutritional properties because of the addition of common bean flour. In addition to these factors, the technological quality of common bean flour is also referred to in the literature by Castilho *et al.* (2010), who highlight the good activity and stability for emulsions obtained with this flour, indicating its potential application in the production of sausages.

The results of the purchase intention test showed that 67.85% of the testers "would probably buy or would certainly compare" the test meatball, followed by 26.78%, who said they would "maybe buy/ maybe not buy" and 5.36% who "would probably not buy". None of the 56 testers stated they would "certainly not buy." The acceptance of functional products by consumers largely depends on social, economic, geographical, political and cultural factors (Jiménez-Colmenero *et al*., 2001). The results were satisfactory, demonstrating the ability of the developed product to enter the consumer market.

The incorporation of common bean flour in meatballs reduces the cost of the product because beans are cheaper than beef. It also means that the surplus production of beans can be reused, resulting in a greater appreciation of this culture, which offers potential use by the meat industry.

Conclusion

This study developed a beef meatball formulation with the partial replacement of meat and the total replacement of textured soy protein by common bean flour. The developed product had reduced fat content with a good n6/n3 ratio, as well as high protein and fiber content. The meatball formulation had better nutritional quality than the sample of commercial meatball. The developed product had functional food attributes, was classed as light, and had good acceptability by the testers. It was concluded that it was viable to replace 30% of meat and 100% of textured soy protein by common bean flour.

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