

*Full Length Research Paper*

## Quality indicators of ground beef purchased by bidding in a Brazilian university restaurant

Marilice de Andrade Grácia<sup>1\*</sup>, Renato João Sossela de Freitas<sup>1</sup>, Camila Augusto Perussello<sup>1</sup>, Cátia Nara Tobaldini Frizoni<sup>1</sup>, Rosemary Hoffman-Ribani<sup>1</sup>, Vinícius José Bolognesi<sup>2</sup> and Carlos Eduardo Rocha Garcia<sup>2</sup>

<sup>1</sup>Department of Chemical Engineering, Graduation Program of Food Engineering, Federal University of Paraná, Jardim das Américas, CEP: 81531-980, Curitiba-PR, Brazil.

<sup>2</sup>Department of Pharmacy, Federal University of Paraná, Jardim Botânico, CEP: 80210-170, Curitiba-PR, Brazil.

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The objective of the present study was to evaluate the physicochemical characteristics (moisture, lipids, proteins, collagen, collagen-related protein, fixed mineral residue, pH, water activity and color) of bovine ground meat used in a Brazilian university restaurant for over 60 days to ensure the quality of the products purchased. Some of the results were not in line with legislation and literature, suggesting the supplier was probably delivering ground beef composed of different meat cuts. The results returned to the desired values when the supplier was warned about the problem, which reinforces the need of constant supervision from the food service to ensure the reception of high quality raw material.

**Key words:** Ground beef, bidding process, physicochemical quality, community restaurants.

### INTRODUCTION

The Brazilian population has undergone major social transformation in the recent decades, resulting in changes regarding physical spaces for sharing meals and daily practices of food preparation (Brasil, 2008b). Among some facilities where meals are consumed outside home, university restaurants of the Federal Institutions for Higher Education (IFES) have the responsibility of ensuring the right for adequate and safe food for its students and staff (Brasil, 2008a).

Meats stand out among the foods used in the human diet, often representing the main part of most meals (Teichmann, 2000). They are considered one of the foods most valued by consumers for having exceptional

organoleptic characteristics and high nutritional value. Due to its high protein content, the meat has singular importance in the development of the organism and may also serve as an energy source (Sauvant et al., 2004).

The chemical composition of beef differs as result of factors such as species, age, breed and sex of cattle, type of cattle feed and cuts or muscles analyzed. Beef is mostly composed of water (73.1%), proteins (23.2%) and fats (2.8%) and may contain 11-29% of polyunsaturated fatty acids (PUFA). In addition, it is rich in iron and zinc, providing over two thirds and one quarter of the daily requirement, respectively. It is an excellent source of high biological value proteins, vitamin B12, niacin, vitamin B6,

\*Corresponding author. E-mail: mariandrade71@gmail.com. Tel: +55-41-3361-3232.

phosphorus, endogenous antioxidants and other bioactive substances including taurine, carnitine, carnosine, ubiquinone, glutathione and creatine (Williams, 2007).

In food services, the receipt of raw material is important to guarantee the safety of the final product (Silva and Cardoso, 2011; Associação Brasileira de Normas Técnicas, 2008). Therefore, it is imperative to adopt it in order to comply with the good manufacturing practices, particularly concerning the reception area, process control, supplier evaluation and transport system. This goes beyond technical visits and observation of the adequacy of the transportation system used (Associação Brasileira de Normas Técnicas, 2008; Agência Nacional de Vigilância Sanitária, 2004). The procedures still do not include laboratory tests to establish whether the products are suitable for use, which would ensure that only products that are in good nutritional and safety conditions are used in the preparation of foods (Food and Drug Administration– FDA, 2009). The final quality of the beef is the result of what happened to the animal during the entire production chain, reason why appropriate transportation, storage, handling, display and preparation of meat must be ensured (Marin, 2014).

The ground beef is used in various menus for the production of a wide variety of culinary preparations. Due to the good acceptance of these preparations, observed in the practice of community restaurants, coupled with the reasonable cost, ground beef is an ingredient routinely acquired and constantly present on the menu of these establishments. However, the use of ground meat has inconvenience which is the lack of standardization as a consequence of the composition and characteristics of the various sections of animals that originate from it.

Supplier selection and acquisition of food ingredients have low levels of compliance with the current Brazilian legislation (Medeiros et al., 2012). Obtaining raw material from unreliable sources is a risk factor that contributes to outbreaks of foodborne illnesses (Food and Drug Administration, 2009). A special focus should be placed on raw foods of animal origin, which are considered particularly dangerous (Ebene et al., 2011). Fresh beef, when handled under inadequate sanitary conditions, can be a primary source of infection (Almeida et al., 2010). Thus, the quality of meat depends on the adoption of control measures and monitoring of the pre-slaughter period up to the meat consumption. All parties involved in the supply of meat should ensure the quality of the products (Conceição and Gonçalves, 2009).

Public institutions such as hospitals, barracks, prisons, university restaurants, kindergartens and schools often use bidding for acquiring food genres. In this type of purchase, prices should be compatible with the current market and the maximum cost per period should be considered as defined in specific regulation in order to comply with the management of financial resources (Brasil, 1993). A strategic purchase should therefore combine an effective pricing comparison with the

assessment of consistent quality indices according to the standards designated by the establishment (Brasil, 1993). The sanitary quality of products offered by food services is an important issue for the individual and population health because many food poisoning outbreaks occur when food is prepared for large groups (Codex Alimentarius Commission, 1993). In Brazil, restaurants rank second in number of reported foodborne diseases. An epidemiological analysis of 8451 cases of foodborne illnesses reported by the Ministry of Health between 2000 and 2011 revealed that foods of animal origin were the most commonly involved foods (Brasil, 2011).

In addition, the evaluation of quality parameters by the receiver is an indispensable factor in combating fraud, since a product other than stated in the contract can be delivered, which is not always possible to detect sensorially without the aid of appropriate physico-chemical analysis. In the study of Combris et al. (2009) with pears, it was found that flavor can beat food security, that is why the acceptance of a meal prepared with that raw material by the consumer does not indicate by itself integrity. It is necessary to evaluate certain physical and chemical aspects that are indicators of the quality of the raw material, as established by the Normative Instruction no. 83, from 21/11/03, of the Brazilian Ministry of Agriculture, Livestock and Supply (Brasil, 2003). This normative stipulates minimal quality characteristics for meats, a maximum fat percentage of 15% and a maximum addition of 3% water, the only additive permitted.

Therefore, the aim of this study was to evaluate the physical and chemical characteristics of ground beef purchased through bidding by a community restaurant (CR) for students from a federal public university in the city of Curitiba, in Brazil.

## MATERIALS AND METHODS

The ground beef was received fresh and vacuum packed, in temperatures ranging from 0 to 7°C. The samples were separated and packed in disposable plastic bags and stored between 0 and 2°C until the analyses. Only the samples collected for evaluation of collagen and collagen-related protein were kept frozen (approximately -15°C) until the day of analysis. All other assessments were conducted on the reception day. These analyzes were conducted in triplicate right after receipt of the ground beef by the community restaurant, making a total of 24 samples (8 weeks × 3 batches a week) of 1 kg. All the assessments were carried out between August and October of 2010 in the Departments of Chemical Engineering and Nutrition of the Federal University of Paraná, Curitiba, Brazil.

### Proximate analysis

Moisture, crude protein (micro-Kjeldahl), crude fat (Soxhlet), pH, collagen and collagen-related protein (spectrophotometric hydroxyproline), and ash content as well as water activity ( $A_w$ ) (Hygrometer Aqualab, model AT-2, Decagon Devices Inc., USA)

**Table 1.** Physicochemical characteristics of the ground beef received weekly in the community restaurant.

Week	Characteristic (wet basis)					
	Moisture* (%)	Ash* (%)	Fat* (%)	Protein** (%)	pH**	Aw
1	76.38±1.24 <sup>a</sup>	0.47±0.02 <sup>c</sup>	3.10±0.30 <sup>cd</sup>	19.85±1.05 <sup>a</sup>	5.73±0.01 <sup>ab</sup>	0.996±0.001 <sup>b</sup>
2	70.84±0.28 <sup>d</sup>	0.93±0.04 <sup>ab</sup>	8.55±0.77 <sup>a</sup>	20.41±0.44 <sup>a</sup>	6.02±0.01 <sup>a</sup>	0.998±0.002 <sup>ab</sup>
3	72.93±0.37 <sup>c</sup>	0.97±0.03 <sup>ab</sup>	6.28±0.23 <sup>ab</sup>	20.17±0.13 <sup>a</sup>	5.95±0.01 <sup>ab</sup>	0.999±0.001 <sup>a</sup>
4	73.11±0.27 <sup>bc</sup>	0.86±0.08 <sup>b</sup>	5.67±0.29 <sup>abc</sup>	19.63±0.85 <sup>a</sup>	5.95±0.05 <sup>ab</sup>	0.999±0.001 <sup>a</sup>
5	75.47±0.12 <sup>a</sup>	1.05±0.02 <sup>a</sup>	2.72±0.78 <sup>d</sup>	20.39±0.28 <sup>a</sup>	5.79±0.02 <sup>ab</sup>	0.997±0.001 <sup>b</sup>
6	74.98±0.58 <sup>ab</sup>	1.02±0.01 <sup>a</sup>	3.88±0.25 <sup>bcd</sup>	20.30±0.16 <sup>a</sup>	5.62±0.02 <sup>b</sup>	0.998±0.001 <sup>ab</sup>
7	75.15±0.45 <sup>a</sup>	1.01±0.04 <sup>a</sup>	4.01±1.95 <sup>bcd</sup>	19.83±2.69 <sup>a</sup>	5.93±0.18 <sup>ab</sup>	0.999±0.001 <sup>a</sup>
8	75.39±0.61 <sup>a</sup>	1.03±0.04 <sup>a</sup>	2.75±0.60 <sup>d</sup>	20.42±1.17 <sup>a</sup>	5.71±0.01 <sup>b</sup>	0.998±0.001 <sup>ab</sup>
Average	74.28±1.71	0.92±0.18	4.62±1.92	20.13±0.29	5.84±0.13	0.998±0.001

\*Means followed by the same letter in a column are not significantly different according to the Tukey test ( $p < 0.05$ ). \*\*Means followed by the same letter in a column are not significantly different according to the Kruskal-Wallis test ( $p < 0.02$ ). Observation: The only chemical composition specifications for ground beef as stipulated by the Brazilian food legislation (Normative Instruction n. 83, 2003, from the Brazilian Ministry of Agriculture, Livestock and Supply) are the maximum fat percentage (15%) and maximum addition of water (3%).

were determined using the methods of AOAC (1995), as described by Brasil (1999) and IAL (2005).

#### Color parameters

The color of the tested meat samples was measured using a spectrophotometer Hunter Lab Scan XE Plus Mini (Reston, VA, USA) equipped with illuminant D65/10° and suitable for analysis of meat (Hunter lab, 2008), using the CIELAB system ( $L^*$ ,  $a^*$  and  $b^*$ ) (Hunter lab, 2008). The readings were taken within 10 min after exposure to oxygen. All determinations were done in triplicate.

#### Statistical analysis

All measurements were replicated three times. Analysis of variance (ANOVA) was carried out and the average values were compared with the Tukey test, or the Kruskal-Wallis test followed by nonparametric multiple comparisons (Hollander and Wolfe, 1999). Differences were considered statistically significant at  $p < 0.05$ .

## RESULTS AND DISCUSSION

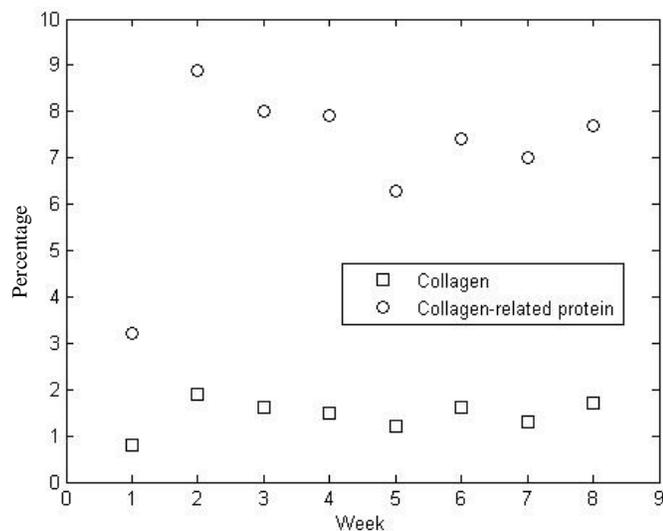
Proximate compositions of the grounded beef samples are presented in Table 1. As indicated, meats showed relatively homogeneous results in all assessments, with the exception of the second week, for which the values of moisture and lipids showed significant differences, as well as the fixed mineral residue for the first week. The moisture content of the samples ranged from 70.84 to 76.38%. The fixed mineral residue content varied significantly in the first and fourth weeks, from 0.47 to 0.86%, respectively. In the other weeks there were no significant variations regarding this analysis, yielding results between 0.93 and 1.05%.

The lipid content, for instance, ranged from 2.72 to 8.55% during the 8 weeks of study. In the 2<sup>nd</sup> and 3<sup>rd</sup> weeks, the contents were 8.55 and 6.28%, respectively,

and in the following weeks there was a clear reduction of these rates, which ranged between 2.72 and 5.67%. The protein content was very homogeneous during all the period of assessment, showing values between 19.63 and 20.42%, with no significant variation.

The pH of the samples varied between 5.62 and 6.02 during the two months of study, showing the higher rate in the second week. The higher percentage of lipids (8.55%) and lower content of moisture (70.84%) that occurred in the same week indicate a probable link between lipids and moisture content. The  $a_w$ , in its turn, only changed significantly in the first week of evaluation, showing a result of 0.996 versus 0.999 for the other weeks.

The percentages of collagen content and collagen-related protein, as shown in Figure 1, showed significant variations between the first week and the others, not only as demonstrated by the graph, but also visually, since the ground beef received in the first week looked exempted of connective or fatty tissues. The collagen content and collagen-related protein in the first week were 0.66 and 3.33%, varying between 1.29 and 1.79, and 6.36 to 8.82%, respectively, during the following periods. These results are evidence that the supplier delivered a better quality product in the first week of the bidding process. Not only the composition of meats is influenced by a number of factors such as age, gender, place of origin and feeding of the animals, but also the collagen content depends on the cleaning phase, when the connective tissue is removed from the meat cuts, which in the case of this study is supposed to be from knuckle (*Quadriceps femoris*). Considering that the meat is already ground when received by the community restaurant, there is no way to ensure the intrinsic characteristics of the meat or the cut used. These values were lower than that recommended in literature in all weeks of testing: 2% of collagen and 15-18% of collagen-related protein



**Figure 1.** Contents of collagen and collagen-related protein.

(Shimokomaki et al., 2006). On the other hand, the excess collagen renders the product less digestible, harder and with reduced nutritional value due to amino acid imbalance and low content of essential amino acids (Ordóñez et al., 2005). In this context, some techniques such as hitting, grinding, chopping, soaking, application of hydrostatic pressure and use of enzymes/softeners are procedures commonly used to tenderize meats (Sun and Holley, 2010; Sullivan and Calkins, 2010; Ha et al., 2012; Lonergan et al., 2010). In addition, the evaluation of collagen-related protein is important for the preparation of meat emulsions from ground beef, inasmuch as this value should not exceed the range of 15 to 18% in order not to harm the mass stability when it comes to systems with high fat content (Shimokomaki et al., 2006).

Variations in the results between different weeks of analysis, as mentioned above, are attributed to the characteristics of the meat delivered by the supplier each week, taking into account that there are many factors that influence the chemical composition and pH of meat products: age, sex, origin and animal feed, cut type, processing (e.g., removal of connective tissues), among others.

Forasmuch as the lipid content of the meat was higher than 5% in the second, third and fourth weeks, the supplier was warned about the fact and informed that should the product should meet the standards of the bidding process (Brasil, 1993) and the technical specification from the nutrition service of the CR. In the following weeks, the value was indeed adjusted to less than 5%, indicating commitment from the butchery in delivering a quality product, most likely due to the warning applied by the CR.

It is worth noting that none of the samples showed lipid content higher than 15%, set as the maximum permitted by the Brazilian law, according to the Technical

Regulation of Identity and Quality of ground beef (Brasil, 2003). Although, lipids have the positive feature of providing juiciness, flavor and aroma for meats, they are easily oxidized and can lead to the formation of toxic and undesirable products (Shimokomaki et al., 2006), therefore should not be present in excess. Flemming et al. (2003) evaluated the fat ground beef sold at a supermarket chain of Curitiba, Brazil, finding a content of 3.43%, that is, less than the average result from the present study, which was 4.62%.

During the 60 days of analysis, the protein levels remained constant, however the fat percentage increased as moisture content decreased. Meats, like most foods, have a pattern of compensation between levels of moisture, lipids and proteins (Shimokomaki et al., 2006). Within the same class of meat products, the protein content is almost constant, whereas for certain fat levels, a reduction of moisture is verified (Shimokomaki et al., 2006). The inverse relationship between moisture, lipids and proteins was also evidenced by Pedrão et al. (2009) when comparing the chemical composition of hump steak (*Rhomboides m.*) and loin (*Longissimus dorsi m.*) of Nellore (*Bos indicus*): 36.70 and 73.34% of moisture, 48.82 and 3.39% of lipids and 12.6 and 21.8% of protein, respectively.

All samples showed pH below 6.1, indicating the absence of early decomposition and meeting the standards of the National Laboratory of Animal Reference (LANARA), which profess meat as proper for consumption when pH ranges from 5.8 to 6.2 (Brasil, 1999). However, there were significant differences between weeks, inasmuch as the pH assumed rates of 5.62 and 5.71 on the sixth and eighth weeks, respectively. Conceição and Gonçalves (2009) found pH values of 6.5 and 7 to ground beef collected in Rio de Janeiro and Niterói, Brazil, which indicate the beginning of bacterial decomposition. The range of  $A_w$  expected for fresh meat is greater than 0.985, which complies with the meat received in the CR, which ranged between 0.996 and 0.999.

The mean values (Table 1) obtained for the chemical composition and pH of bovine ground meat received at the CR can be compared with those found for knuckle beef cut by Della Torre and Beraquet (2005): 74.5, 1.1, 2.8, 21.1, 1.0, 5 and 5.56 for moisture, ash, lipids, proteins, collagen, collagen-related protein and pH value, respectively. The ground meat tested in the current study showed a much higher lipid content, indicating that there may be the possibility that the supplier used another cut of beef, different from knuckle, to obtain the product, such as those with larger content of fats, that is, topside, outside flat and chuck. Table 2 presents the results of color attributes of the ground beef samples during the eight weeks. Significant ( $p < 0.05$ ) differences were observed among meat samples during 8 weeks in lightness ( $L^*$ ) and yellowness ( $b^*$ ). The analysis of variance using ANOVA was performed for all physical

**Table 2.** Color coordinates  $L^*$ ,  $a^*$  and  $b^*$  of the ground beef received weekly in the community restaurant.

Week	$L^*$	$a^*$	$b^*$
1	39.5± 0.42 <sup>ab</sup>	21.11± 2.31 <sup>a</sup>	17.32± 0.94 <sup>ab</sup>
2	40.89± 1.93 <sup>ab</sup>	17.95± 1.68 <sup>a</sup>	15.99± 1.21 <sup>ab</sup>
3	40.58± 0.90 <sup>ab</sup>	17.14± 0.60 <sup>a</sup>	15.58± 0.40 <sup>ab</sup>
4	42.23± 0.69 <sup>a</sup>	18.98± 1.19 <sup>a</sup>	17.47± 0.64 <sup>ab</sup>
5	40.37± 1.62 <sup>ab</sup>	17.26± 0.45 <sup>a</sup>	15.70± 0.66 <sup>ab</sup>
6	41.37± 1.32 <sup>ab</sup>	18.30± 0.20 <sup>a</sup>	15.93± 0.66 <sup>ab</sup>
7	37.91± 1.25 <sup>b</sup>	17.84± 1.16 <sup>a</sup>	15.31± 0.76 <sup>b</sup>
8	42.19± 0.16 <sup>a</sup>	19.49± 0.46 <sup>a</sup>	18.12± 0.26 <sup>a</sup>

Means followed by the same letter in a column are not significantly different according to the Tukey test ( $p < 0.05$ ).

and chemical parameters, however when the assumptions for this analysis were not satisfied, a corresponding non-parametric analysis, the Kruskal-Wallis test, was used and followed by non-parametric multiple comparisons. When the hypothesis  $H_0$  was rejected by the Kruskal-Wallis test, the presence of significant difference was indicated (Hollander and Wolfe, 1999).

The color analysis showed average values of  $L^*$  (lightness) and  $b^*$  (yellow) of 40.63 and 16.43, respectively. Cañeque et al. (2003) suggested that increased brightness may be ascribed to intramuscular fat content. According to Marin (2014), color intensity depends on the quantity of hemoglobin and fat and differs depending on pH and cutting and also on age, sex and activity of the animal. Brightness, in specific, depends on pH and it influences the conformation of proteins within the muscle. Zhang et al. (2005) reported that meat with high pH showed lower values of  $L^*$ ,  $a^*$  and  $b^*$  than meat with normal pH. The mean value obtained for the parameter  $a^*$  (red) was 11.1 to 23.6 according to a survey of Muchenje et al. (2009).

In summary, the beef received by the CR showed color, pH and water activity mostly within the standards established in the literature for ground knuckle, but the levels of collagen and collagen-related protein were smaller than that desired and the lipid content was greater than that prescribed by the bidding process (up to 5%), although always lower than the maximum permitted by the Brazilian legislation (15%) (Normative Instruction n. 83, 2003, from the Brazilian Ministry of Agriculture, Livestock and Supply). Thus, there is the possibility that the supplier is delivering a cut different from knuckle, such as topside, hard cushion and chuck, which have lower cost and higher fat content. However, when warned of lipid content greater than 5% (as specified in the bidding process) in the second, third and fourth weeks of analysis, the supplier adapted the product to the specifications of the CR. Hence, the continuous assessment of the physicochemical parameters of food products obtained by bid enhances the quality of the

products purchased. Such control renders it possible to maintain quality standards of raw materials used in community restaurants.

## Conclusions

The current study evaluated the physicochemical characteristics of bovine ground meat comparing them with legislation and literature in order to facilitate the identification of standards that can be used by public institutions that purchase meat by bidding process. The Brazilian legislation presents the technical regulation of identity and quality of ground beef in its Normative Instruction n. 83, from 2003. Such normative does not stipulate physical and chemical specifications for categories of ground beef, it rather only establishes maximum levels for fat (15%) and addition of water (3%), and prohibits additives other than water. This way, commercial establishments are free to market products with different quality standards, naming them accordingly as special, first and second quality cuts, however these quality standards are not regulated by the Brazilian food legislation regarding the fat and collagen content.

The ground beef received by the community restaurant (CR) was in general adequate in relation to color attributes, moisture content,  $A_w$  and pH, according to the values mentioned in previous studies and the maximum fat content (15%) established by the Brazilian food legislation. Nevertheless, the contents of collagen and collagen-related protein were found to be lower than the ideal. In addition, after the first week of analysis, the lipid content of the product received increased continuously and out of the range prescribed in the bidding contract, which was corrected by the supplier after receiving a warning from the CR, revealed the importance of evaluating the quality parameters continuously and not only in the first weeks of reception of the raw material. The standards set in this study may be used for other institutional food services to ensure the receipt of high

quality meat, consequently raising awareness among local butcheries.

### Conflict of Interests

The authors have not declared any conflict of interests.

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