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# Physicochemical characteristics of goat "buchada" added with meat from discarded animals

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**Abstract**

The aim of this research was to evaluate the effects of adding meat from waste animals on the physicochemical and sensory characteristics of goat buchada. Four treatments were prepared: one control (no meat added) and three with 15, 30, and 50% of the viscera replaced by meat from waste goats. Eight goat buchadas, each weighing approximately 70 g, were used for the sensory analysis. The variables ashes, lipids, and proteins showed significant differences ($p < 0.05$) depending on the addition of goat meat to the buchada. The factors meat addition and storage time had a significant effect ($p < 0.05$) on 2-thiobarbituric acid reactive (TBAR) values, so increasing the levels of meat in the buchada decreased the levels of lipid oxidation, while increasing the storage time increased this same parameter in the buchada. The sensory attributes of the smell of buchada, the smell and taste of goat meat, and juiciness showed a significant difference ($p < 0.05$) depending on the addition of goat meat to the buchada. Three main components were needed to explain 71.15% of the variation in the data relating to physicochemical analysis and sensory attributes. In conclusion, reformulating buchada by partially incorporating meat from waste goats improves the nutritional and sensory quality of the product, as well as adds value to the meat of waste animals.

**Keywords:** byproduct; cooking; storage; sheep viscera.

**Practical Application:** The use of edible by-products from the slaughter of sheep in the formulation of blood sausage is viable because it uses low-cost raw materials.

## 1 INTRODUCTION

Slaughtering and processing meat generate a significant amount of solid and liquid by-products. Wholesalers, retailers, and representatives can also produce large quantities of by-products. In this way, millions of tons of waste are produced every day, and their ongoing disposal is a problem as the treatment of these by-products and waste comes at a considerable cost. Despite the existence of industrial systems for treating by-products, there is a growing awareness that most by-products are underutilized and represent a valuable resource if treated correctly (Toldrá et al., 2012).

The consumption of processed products based on offal and blood such as Morcilla de Burgos in Spain (Santos et al., 2003), Cavourmas in Greece (Arvanitoyannis et al., 2000), Morcela de Arroz, Chouriço, and Beloura in Portugal (Pereira et al, 2015; Silva et al., 2014; Todorov et al., 2010), and Krvavica in Slovenia (Gasperlin et al., 2014) is common in several countries. All these products are good alternatives for adding value to meat production and reducing the environmental impact caused by the disposal of by-products (Toldrá et al., 2012). The use of organs and viscera in the preparation of typical dishes, such as goat buchada, is an economically viable alternative for the use of by-products, as well as adding value and increasing the profitability of production (Madruga et al., 2005).

Buchada is a traditional meat product made with minced meat and blood from goats or sheep, whose main ingredients are organs such as the heart, lungs, liver, intestines, and stomach (Brasil et al., 2014; Queiroz et al., 2013). Buchada is a highly sought-after product that can be prepared at home and sold in restaurants, bars, or street markets. However, one of the main disadvantages of preparing buchada is its limited shelf life, a problem mainly related to the use of offal. Several studies have sought alternatives to increase the shelf life and improve the quality characteristics of buchada through the use of suitable packaging (Domínguez et al., 2018; Nikmaram et al., 2018; Pereira et al., 2015), the addition of antioxidants (Albuquerque et al., 2018; Fernandes et al., 2016; Lorenzo et al., 2018a, 2018b; Munekata et al., 2017), or the use of new technologies (Gómez et al., 2018). In addition, the incorporation of beef or goat meat in the preparation of buchada is a common practice carried out in order to improve the sensory characteristics of the final product by improving the flavor and reducing the odor and taste of the viscera.

One of the main problems encountered in goat farming is the difficulty in marketing meat from animals over 12 months old. The meat from these animals can be a source of raw material for processed products since processing modifies the sensory properties of the product, reducing these undesirable

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characteristics (Lima et al., 2022; Madruga et al., 2007). The addition of meat from culled goats to partially replace the viscera can help improve the nutritional characteristics and shelf life of buchada caprina, as well as add value to the meat from culled animals. The aim of this study was to evaluate the effects of partially replacing viscera with meat from waste goats on the physicochemical and sensory characteristics of goat buchada.

## 2 MATERIAL AND METHODS

### *2.1 Experimental site and preparation of buchadas*

The experiments were performed at the Universidade Federal da Paraíba (UFPB) located in the city of Bananeiras, Paraíba, Brazil (6°41′ 11″ S and 35° 37′ 41″ W).

This study was approved by the Animal Ethics Committee of the Federal University of Paraiba (UFPB), Brazil (protocol no. 2305/14).

Palette and leg meat from mixed-breed goats over 5 years old was used. Ten buchadas were made per treatment (40 Buchadas), each weighing 70 g. There were four treatments: buchadas with no added meat (T1), buchadas with 15% added meat (T2), buchadas with 30% added meat (T3), and buchadas with 50% added meat (T4). Meat was added instead of offal.

The formula used in the preparation of the buchadas was determined based on the methodology established by Silva et al. (2013). Therefore, the following percentages of ingredients were used in their preparations: 9% liver, 26% blood, 6% lungs, 2.5% heart, 1.5% kidneys, 47% digestive tract, and 8% condiments and fresh seasonings (onion, garlic, green pepper, cilantro, meat coloring powder, and Sazón®) (Ajinomoto, São Paulo, Brasil). The acids were added to the chopped offal, and the buchadas were precooked in water (750 mL) and salt (5 g) at 80°C until the temperature of the geometric center reached 75°C. The buchadas prepared were vacuum packed and stored at 4°C for the evaluation of the microbial load and centesimal composition. The samples for sensory analysis were frozen (for 24 h) until they were checked to see if the microbial load was in compliance with the RDC Resolution Number 12 of January 2, 2001 (Agência Nacional de Vigilância Sanitária [ANVISA], 2015).

### *2.2 Microbiological analyses*

These samples were analyzed in duplicate. The microbial analysis was performed according to recommendations by the RDC Resolution Number 12 of January 2, 2001, and the samples were analyzed according to the methodology described by the American Public Health Association (APHA, 2001) to determine total coliforms, thermotolerant coliforms, viable aerobic mesophilic bacteria, coagulase-positive Staphylococcus, and Salmonella sp. The analyses of total and thermotolerant coliforms were performed following the technique of the most probable number. The analysis of viable aerobic mesophilic bacteria was performed by the depth plate technique by using plate count agar and incubation at 35 ± 2°C for a period of 48 h. Coagulase-positive Staphylococcal analyses were performed by direct plate counting. The plates were incubated in an oven at 36°C for 48 h, and then the plates were collected for counting the colonies. For the analysis of Salmonella sp., the procedure was as follows: A pre-enrichment of the samples with lactose broth and incubation at 42 ± 2°C for 24 h was carried out, and then a selective enrichment with tetrathionate and selenite cysteine broth followed by incubation on xylose lysine deoxycholate agar and enteric agar was done.

### *2.3 Physical–chemical analysis*

In order to perform the physicochemical analysis of moisture, ashes, and proteins, the same *buchadas* of Section 2.2 were used and the methodology described by the Association of Official Analytical Chemists (AOAC, 2010) was carried out. For the lipid oxidation analysis, the 2-thiobarbituric acid reactive substances test (TBARS) assay was used in which the *buchadas* were analyzed during four storage periods (weeks) with intervals of 7 days (Tarladgis, Watts, Younathan, & Dugan, 1960). To determine lipids, the method previously described by Folch et al. (1957) was used to extract fat from the food using chloroform and methanol in a 2:1 proportion. A digital pH meter (Jonhis, model IPHPJ, São Paulo, Brazil) was used to determine the pH.

### *2.4 Sensory analysis*

The work was submitted to the Ethics and Research Committee of the Universidade Federal da Paraíba (No. 72189817.5.0000.5188) based on the analysis of the report and resolution CNS n 466 of December 12, 2012. The research was carried out with the free and informed consent of the tasters in accordance with section III.3, letter "g" of the said Resolution.

Eight goat *buchadas*, each weighing approximately 70 g, were used for the sensory analysis. The sensory analysis was performed using the methodology adapted from Silva et al. (2013). After cooking, the samples were split into equal portions of 30 g into polystyrene cups (70 mL), topped with foil, and marked with a random three-digit code. The samples were kept warm in a heater at 55°C until needed for analysis. In order to avoid the possible effects of the order of presentation, the samples were presented to panel members following different orders (Macfie et al., 1989). Sensory analysis was performed in individual booths having controlled environmental conditions at a temperature of around 23°C (ISO, 1988). The panel included eight UFPB agricultural science students who were duly selected and trained (ISO, 1993). The tests took place in one session and eleven trained tasters. The tasters analyzed four attributes on the Abuse Disability Questionnaire (ADQ) test sheet, namely, the general appearance, odor (typical of buchada and typical goat meat), flavor (typical of buchada/typical goat meat), and juiciness.

### *2.5 Statistical analysis*

Data were subjected to analysis of variance (ANOVA), and the averages were compared using the t-test at 5% probability, through the PROC GLM of the SAS statistical package (SAS, 2001). The orthogonal contrast was also used between the control and the treatments that received acids. The means of the sensorial attributes were compared by the test Ryan–Einot–Gabriel–Welsch at 5% probability.

After standardization, multivariate analyses were carried out in accordance with Sneath and Sokal (1973) to allocate the animals into groups according to similarity and verify the discriminatory capacity of the original variables. The principal component analysis (PCA) allows the assessment of overall variance; on the other hand, the discriminant analysis describes the variation among groups and identifies the variables with greater discriminatory power between groups. The PCA was performed by the PRINCOMP procedure, separately for each population.

## 3 RESULTS

The variables ashes, lipids, and proteins showed significant differences ($P < 0.05$) as a result of the addition of goat meat to the buchada (Table 1). The results for ashes and lipids showed a linear regressive effect, with ashes increasing and lipids decreasing. The pH showed a quadratic effect. In general, there was a decrease in the lipid content and an increase in the protein levels of the buchadas as the meat was added.

The TBAR value showed a significant effect ($P < 0.05$) for meat addition and storage time (Table 2), but there was no interaction effect ($P > 0.05$) between the two factors. TBARs showed a decreasing linear regression effect with meat addition and an increasing effect with shelf life. According to the results observed, increasing levels of meat reduced the intensity of lipid oxidation in buchadas, while increasing storage time led to a progressive increase in TBAR indices.

In relation to the microbiological analyses (Table 3), no growth was detected in the goat patties with the addition of meat from waste goats; this result was also found in the control group.

The sensory attributes of the smell of buchada, the smell and taste of goat meat, and juiciness showed a significant difference ($P < 0.05$) depending on the addition of goat meat to the buchada (Table 4). It was observed that the smell of buchada decreased with a 50% addition of meat and, consequently, the smell and taste of goat meat increased with the addition of meat to the buchada. Juiciness, on the other hand, decreased in the 15 and 30% treatments compared to the control treatment (0%). The appearance and flavor of the buchada showed no significant difference ($P > 0.05$) between the samples evaluated. The flavor of the buchada had higher average scores than the appearance, with the latter being a variable of low importance.

Three main components were needed to explain 71.15% of the variation in the data relating to physicochemical analysis and sensory attributes (Table 5). The percentage of variance accumulated in the first factor was 38.97%, represented by the variables: lipids, odor, and meat flavor, with meat flavor being the variable with the greatest weight in factor 1. Lipids proved to be inversely proportional to the other two variables, i.e., as the lipid value decreases, the flavor and aroma of the goat meat in the buchada decreases. The second factor accounted for 18.48% of the total variation in the variables and is made up of the flavor of the buchada and its juiciness. The third factor accounted for 13.70% of the total variation in the data and is represented by humidity and pH. Ash, protein, TBARS, appearance, and odor were not represented in any of the three factors, showing less importance among the characteristics studied in this experiment. Figure 1 confirms an inverse relationship between lipids, the smell and taste of goat meat, and the low importance of moisture, ash, pH, and protein as they are close to the zero point of the axis.

**Table 2**. Value of TBAR as a function of meat addition and shelf life.

| | |
|---|---|
| *Addition of meat (%)* | |
| 0 | 0.44a |
| 15 | 0.41ab |
| 30 | 0.36b |
| 50 | 0.30c |
| *Shelf life* | |
| 0 | 0.28d |
| 7 | 0.34c |
| 14 | 0.41b |
| 21 | 0.47a |
| SEM | 0.070 |
| *P-value* | |
| Addition of meat | < 0.0001 |
| Shelf life | < 0.0001 |
| Addition of meat *Shelf life | 0.7096 |
| *P-value regression* | |
| Addition of meat | |
| Linear | < 0.0001[1] |
| Quadratic | 0.7792 |
| Shelf life | |
| Linear | < 0.0001[2] |
| Quadratic | 0.7604 |

Different letters in the column differ by Tukey's test at the 5% probability level; SEM: standard error of the mean; [1]$Y = 0.44 - 0.002x$ ($R^2 = 0.99$); [2]$Y = 0.28 + 0.009x$ ($R^2 = 0.99$).

**Table 3**. Microbiological evaluation of buchada caprina with different levels of added meat.

| Microorganisms | Meat addition levels (%) | | | |
|---|---|---|---|---|
| | 0 | 15 | 30 | 50 |
| *Coliform 35°C* (MPN $g^{-1}$) | < .0 | < 3.0 | < 3.0 | < 3.0 |
| *Coliform 45°C* (MPN $g^{-1}$) | < 3.0 | < 3.0 | < 3.0 | < 3.0 |
| *Staphylococcus* spp. (CFU $g^{-1}$) | < 0.100 | < 0.100 | < 0.100 | < 0.100 |
| *Salmonella* sp. (25 g) | Absent | Absent | Absent | Absent |

**Table 1**. Physicochemical variables and TBA of goat buchada with different levels of meat added.

| Variable | Levels of added meat (%) | | | | SEM | P-value | |
|---|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 50 | | Linear | Quadr |
| Moisture (%) | 71.89 | 70.25 | 73.36 | 71.05 | 5.02 | 0.9825 | 0.7941 |
| Ash (%) | 2.56ab | 2.34b | 2.62ab | 2.94a | 0.30 | 0.0186[1] | 0.0733 |
| Fat (%) | 8.93a | 5.90b | 5.91b | 3.81c | 0.58 | < 0.0001[2] | 0.0869 |
| Protein (%) | 19.68b | 17.34c | 20.92ab | 22.97a | 1.31 | 0.7746 | 0.6135 |
| pH | 5.07 | 5.21 | 5.20 | 5.14 | 0.11 | 0.4381 | 0.0325[3] |

SEM: Standard error mean; different letters in the line differ from each other by Tukey's test at the level of 5% probability; [1]$Ash = 2.39\text{-}0.009x$ ($R^2 = 0.60$); [2]$Fat = 8.33 - 0.09x$ ($R^2 = 0.88$); [3]$pH = 5.08+0.01x - 0.0002x^2$ ($R^2 = 0.93$).

**Table 4**. Effect of adding meat to buchada caprina on sensory attributes.

| Attribute | Meat addition levels (%) | | | | SEM | P-value |
|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 50 | | |
| Appearance | 6.10 | 4.88 | 5.54 | 5.43 | 1.57 | 0.2438 |
| Odor of buchada | 6.81a | 7.01a | 6.31a | 5.10b | 1.02 | < 0.0001 |
| Odor of meat goat | 1.85c | 5.29b | 5.65b | 6.64a | 0.91 | < 0.0001 |
| Flavor of buchada | 6.44 | 6.16 | 6.52 | 5.64 | 1.38 | 0.3283 |
| Flavor of meat goat | 1.61c | 4.99b | 6.93a | 6.53a | 0.79 | < 0.0001 |
| Juiciness | 7.22a | 6.07b | 6.06b | 6.45ab | 1.12 | 0.0269 |

Different letters in the line differ by the Ryan–Einot–Gabriel–Welsch test at the 5% probability level; SEM: standard error mean.

**Table 5**. Factor loading for the physicochemical and sensory attributes evaluated in the goat *buchada*.

| Variable | PC 1 | PC2 | PC3 |
|---|---|---|---|
| Moisture (%) | -0.0124 | 0.1931 | **0.8533** |
| Ash (%) | 0.2775 | 0.0235 | 0.1073 |
| Fat (%) | **-0.8566** | 0.3483 | -0.2093 |
| Protein (%) | 0.0394 | -0.3204 | 0.5941 |
| pH | 0.2625 | -0.1424 | **0.8625** |
| TBARs | -0.5064 | 0.1204 | -0.6048 |
| Appearance | -0.0290 | 0.5404 | -0.5137 |
| Odor of buchada | 0.0228 | 0.6292 | -0.1501 |
| Odor of meat goat | **0.9396** | 0.1051 | 0.0412 |
| Flavor of buchada | 0.1078 | **0.8453** | 0.0302 |
| Flavor of meat goat | **0.9671** | 0.0773 | 0.0936 |
| Juiciness | -0.3686 | **0.7141** | -0.2561 |
| Eigenvalues of the correlation matrix (λ) | 4.6770 | 2.2179 | 1.6432 |
| Total variance explained by components (%) | 38.9752 | 57.4585 | 71.1521 |

## 4 DISCUSSION

The values found for the concentration of protein in the buchada with added meat were on average 20% higher than the control group and also higher than those found by Melo et al. (2021), who in their research observed an average of 19.8 g/100 g of protein in buchadas sold in restaurants in the state of Piauí, Brazil. Considering that goat meat has higher average protein levels (20.6 g/100 g) (USDA, 2019) compared to viscera (18 g/100 g) (Queiroz et al., 2017), it is valid to conclude that increasing the levels of meat in the buchadas' formulation increased the protein content of the products. These results show that the addition of meat from waste goats adds nutritional value to the product by increasing protein levels and also gives a destination to meat from old animals that would not have commercial market value. The pH values were higher than those found by Albuquerque et al. (2018).

The average fat content of the buchada with added meat was lower than the average of 8.93% found in the control treatment without added meat from waste goats. The lower fat content of goat meat compared to viscera probably made it possible to reduce the fat concentration in the reformulated buchadas. Madruga et al. (2007) found total fat values ranging from 7 to 16% in traditional buchadas prepared without the addition of goat meat. Once again, the addition of meat from waste goats improved the nutritional characteristics of the buchada by reducing the fat levels of the final product, a beneficial factor in protecting against the onset of cardiovascular diseases and obesity.

According to Díaz et al. (2008) in meat products with a TBARS value of less than 0.5 MDA $kg^{-1}$, it is not possible for consumers to detect any odors or flavors caused by oxidative rancidity. Treatments with higher quantities of meat showed lower lipid oxidation values. This may have been due to the lower lipid content of the reformulated products caused by the addition of meat, which has a lower fat percentage than viscera. Goats deposit large amounts of fat in the abdominal cavity and viscera, which can reach 60% of the total fat content (Madruga, 1999).

All the treatments were considered suitable for consumption according to current legislation (APHA, 2001). Good manufacturing practices, vacuum packaging, precooking, and refrigeration were probably determining factors in preserving the microbiological quality of the buchada caprinas prepared in this study.

Regarding the sensory attributes, the goat sausage was positively evaluated by the tasters, achieving scores above 4.88 on the hedonic scale for all the attributes evaluated. A similar result was observed by Albuquerque et al. (2018) who found scores above 6 for color, juiciness, texture, flavor, and aroma in smoked goat blood sausage. According to the PCA, the goat meat odor and flavor variables can be considered very important for the total variation in the data. The variables that are located farthest from the zero point of the x- and y-axis are the most important for total variation.

## 5 CONCLUSION

In this study, meat from waste goats was used as a partial substitute for viscera in the preparation of buchada. The incorporation of goat meat reduced the lipid content and increased the protein concentration of the reformulated buchada, improving the nutritional characteristics of the product. In addition, the lower rate of lipid oxidation observed in the reformulated products can be considered a technological advantage for better preservation of goat buchada. The sensory changes observed in the reformulated buchadas are, in general, positive as they attribute the flavor and aroma of goat meat without modifying the traditional taste of buchada. In conclusion, reformulating buchada by partially incorporating meat from waste goats improves the nutritional and sensory quality of the product, as well as adds value to the meat from waste animals.

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