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RESEARCH ARTICLE

Replacement of Fat by Natural Fibers in Chicken Burgers with Reduced Sodium Content

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Abstract:

Introduction:

Due to its practicality in preparation and to have nutrients that satisfy hunger quickly, hamburger has become a product consumed by all popular classes. However, due to the considerable contents of saturated fat and sodium, consuming too much of this type of food can be harmful to human health.

Methods:

Aiming at the development of a healthier meat product with reduced saturated fat, a chicken burger with green banana biomass flour and passion fruit peel flour was formulated using herbal salt (a blend of coarse sea salt and herbs) as a substitute for sodium chloride. The influence of these substitutions on the physical and physicochemical characteristics of the developed product was evaluated. The flours produced were evaluated according to the analysis of: granulometry, water content, water activity and color.

Result and Conclusion:

The hamburger formulations were analyzed for quality parameters: texture profile, color, water content, ash, pH, acidity, lipids, chlorides, cooking yield and percentage of shrinkage. The hamburger enriched with green banana biomass flour was characterized by the lower lipid content but presented higher values for firmness and chewability. The addition of passion fruit peel flour as a partial fat substitute provided higher yields, while the green banana biomass meal resulted in a smaller shrinkage to the burger after cooking. The green banana biomass flour hamburger presented as a viable alternative for the ingestion of processed meat with reduction of sodium and fat.

Keywords: Meat products, Healthy, Fat substitutes, Herbal salt, Sodium chloride, Texture.

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1. INTRODUCTION

The past years have been marked by the development of stratetcies that enrich meat. Generally, this occurs through research that makes processed food healthier [1, 2] and food that produces netcative appeals on Health, are widely divulged in scientific works and, especially, by the specialized media [3]. The change in consumer demand, the acceleration of urban rhythm and increasing global competition are encouraging the meat products industry to develop new technologies and use new ingredients [4].

The number of people seeking a healthier, more balanced lifestyle, opting for foods with reduced levels of sodium, fat and enriched with ingredients with functional properties has increased in recent years. The scientific and industrial community in meat sector has been investing in developing new products that meet the demand for products that are easy to prepare and that are healthy [5].

Depending on the type of product under consideration, a change in composition may have greater or lesser technological, organoleptic and expiry date implications. There are two types of intervention that are performed when changing the constitution of a meat or meat derived products. The first involves reducing a component normally present in the food to more appropriate amounts (fat, salt, nitrite, *etc*.); the second is to incorporate ingredients beneficial to health [6].

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Due to its practicality in preparation and to have nutrients that satisfy hunger quickly, hamburger has become a product consumed by all popular classes [7]. It is an industrialized meat product, obtained from butchered animal meat, added or not of adipose tissue and ingredients, moulded and submitted to appropriate technological process. “It is a raw product, semi-fried, cooked, fried, frozen or cooled” according to its classification [8].

The increase in the consumption of chicken meat was influenced by four main factors: replacement of red meat, growing concern with human health, improved coordination of agroindustrial chain of broiler chicken and appearance of new products and brands [9]. Chicken meat stands out as lean meat, which has few saturated fats (about 30% *vs.* 40-50% in red meat) and high proportion of unsaturated fatty acids and polyunsaturated fatty acids (ometca 6), which our body needs. The consumption of chicken meat in Brazil reached 13.6 million tons in 2016 [10].

Due to their functional and technological properties, dietary fiber has been used as a substitute for fat in various meat products [11, 12] with the purpose of adopting intetcrated stratetcies that generate production of accessible products, and at the same time healthy formulations, with properties beneficial to the consumer’s health. Furthermore, the addition of dietary fiber helps to modify general technological and sensory characteristics of a meat system, such as Water Holding Capacity (WHC), fat retention capacity (ORC), and Texture Profile [13].

Green bananas (*Musa spp.*) have a high content of resistant starch and fibers, and a considerable mineral content, since the banana flour is a source of potassium, phosphorus, magnesium, copper, manganese and zinc, when compared to other types of flour available on market [14, 15]. The passionfruit peel (*Passiflora edulis*) is rich in soluble fibers, such as pectin, important in controlling blood levels of glucose and lipids [16]. It may aid in preventing gastrointestinal diseases, diabetes and obesity [17]. The reduction of sodium intake is a priority issue in the fight against chronic non-communicable diseases in the country, due to its relationship with the risk of hypertension, cardiovascular and renal diseases, among others [18]. The high salt (NaCl) content in meat products can be explained because of its key role in the functionality, microbial stability and sensory properties of the product. NaCl improves water and fat binding characteristics in the formation of a stable gel structure, contributes to the conservation of the product, reducing its water activity, besides increasing perception of salty taste of the product, which is an important factor for acceptance of meat products [19].

From the above, and considering the great consumption of hamburger, it became necessary to develop new formulations with addition of green banana biomass flour and passion fruit peel flour as a substitute for fat and herbal salt (a blend of coarse sea salt and herbs) as a substitute for sodium, aiming to develop a healthier meat product. The influence of these substitutions on physical, chemical and physicochemical characteristics of the developed product was evaluated.

2. MATERIAL AND METHODS

The experiments were carried out at the Food Engineering Laboratories (LEA) of the Center of Technology and Natural Resources (CTRN), campus Campina Grande-PB, belonging to the Federal University of Campina Grande.

2.1. Raw Materials and Supplies

For the experiment, the meat used was chicken breast purchased from a supermarket in the city of Campina Grande / PB. Meat was ground in a meat grinder using a 7 mm disc (PCL 10, METVISA, Santa Catarina, Brazil) reserved in polyethylene containers. The inputs used, such as textured soy protein, brand “Camil”, dehydrated condiments (garlic, onion and black pepper powder), monosodium glutamate, herbal salt (mixture of equal parts of oretcano, basil, rosemary, light salt) were purchased in the retail market of Campina Grande, PB, being careful to select those within validity period and in good conditions of storage and packaging. For the production of flour in the laboratory, passion fruit peel (*Passiflora edulis*) and green banana (*Musa spp*) biomass were also purchased.

2.2. Preparation of Green Banana Biomass Flour

Initially, a manual selection was made and the bananas that had a higher green tone and greater rigidity were chosen. Subsequently, they were cut and then washed in running water to remove soil and sanitized with sodium hypochlorite solution 1% (74.44 g/mol, 1.11 g/ cm^3, Maltex) (50ppm) for 15 minutes, and then the excess chlorine was removed under running distilled water (free of soluble salts).

To obtain pulp, about 1000 g of bananas were placed in a pressure cooker and covered with water. The atmospheric pressure at sea level is 1 atm and, within the pressure cooker, it reaches values between 1.44 and 2.0 atm, resulting in boiling temperatures of around 120 °C. Since it is under a pressure greater than atmospheric pressure, the water does not boil at 100 °C, but at higher temperatures, which makes the food cook faster. They were cooked for 20 minutes, and then kept inside the pan for another 10 minutes for the pressure to cease completely. After that time, the banana peels were removed. The bananas, already shelled, were blended, obtaining pulp.

Afterwards, they were placed in trays and taken to the dryer with forced air circulation (Model 0314M242, Quimis, São Paulo, Brazil) with a temperature of 60° C for 24 hours. After the drying process, the sample was ground in a knife mill, sieved and packed in polyethylene packages at room temperature (25 ± 3)°C.

2.3. Preparation of Passion Fruit Peel Flour

Passionfruit peels were washed with running water, manually cut into strips, immersed for 10 min in sodium hypochlorite at 50 ppm, rinsed with running water and distributed in a tray, brought to a dryer with forced air circulation with 60° C for 24 hours. The shells were then crushed in a knife mill, sieved and packed in polyethylene packages at room temperature (25 ± 3)°C.

2.3.1. Physical and Physicochemical Analyzes of Green Banana Biomass Flour and Passion Fruit Peel Flour

2.3.1.1. Granulometric Analysis

Granulometry was carried out in triplicate by sieving 50 g of flour, characterized by the weights of the sieves with the fractions by direct measurements, using a series of standardized sieves in the range of 16 to 200 Mesh, with electromagnetic stirrer (model 3671, Bertel, São Paulo, Brazil) for round sieves The total sieving time was 10 minutes and the analysis was performed in triplicate [20].

2.3.2. Water Content

The water content analysis was determined by gravimetric method, using a greenhouse at (105 ± 3)^{o}C until reaching constant weight, in three replications [21].

2.3.3. Water Activity

Performed by the Novacina equipment, with sample at room temperature (25 ± 3)^{o}C. The analysis was performed in triplicate, according to methodology [21].

2.3.4. Color

The colorimetric evaluation of the flour was carried out using a Hunter Lab Mini Scan XE Plus portable spectrophotometer, model 4500 L, obtaining the parameters L *, a * and b *, where L * defines the luminosity (L * = 0 - black and L * = 100 - white) and a * and b * are responsible for the chromaticity (+ a * red and -a * green; + b * yellow and -b * blue).

2.4. Production of Hamburgers

The production of the burgers followed the formulation of Table **1**. The inputs used as textured soybean protein, brand "Camil", dehydrated condiments (garlic, onion and black pepper powder), monosodium glutamate were purchased from the retail market of the same city, being careful to select those within the validity period and in good storage conditions and packaging.

Table 1. Production of hamburgers.

Ingredients	% - (g) chicken breast base*
Chicken meat	75.10% - 751g
Ice water	8.28% - 82.8g
Textured Soy Protein	4% - 40g
Powdered black pepper	0.1% - 1g
Monosodium glutamate	0.2% - 2g
Powder onion	0.2% - 2g
Herbal salt	2% - 20g
Garlic	0.1% - 1g
Flour	10% - 100g
Total	100% - 1000g

Passion fruit peel (*Passiflora edulis*) and green banana (*Musa spp*) were also purchased locally. The herbal salt used was a mixture of equal parts of oretcano, basil, rosemary, dried parsley and light salt (50% sodium chloride and 50% potassium chloride).

Four hamburger samples were produced:

Formulation 1: No added flour (Standard);

Formulation 2: Addition of 10% of green banana biomass flour;

Formulation 3: Addition of 10% of passion fruit flour;

Formulation 4: Addition of green banana biomass flour (5%) and passion fruit peel flour (5%) mix. The proportions of ingredients are shown in Table **1**.

Initially, the ingredients were weighed, and then immediately, the ground partially frozen chicken meat, texturized soy protein and water were mixed manually to obtain a homogeneous mass. The dehydrated condiments (garlic, onion and black pepper powder) were added in the sequence to avoid a possible loss of aroma, along with the herbal salt. Finally, the flour was added following the ratio: 0% flour (F1 standard), 10% green banana biomass flour (F2), 10% passion fruit peel flour (F3) and 5% Green banana biomass flour with 5% passion fruit peel flour (F4). Then, effective mixing of the dough was preceded to ensure good distribution of the ingredients. The burgers were placed in plastic jars with net weight of 80 g each and were wrapped in polyethylene bags, placed in plastic trays and stored in freezer at -18°C.

For the physical and physicochemical analyzes, the frozen hamburgers (24 hours of freezing) were fried in non-stick frying pan, preheated for 15 s, using a temperature of 200°C. The burgers were fried with no added fat, turning every 2 minutes to complete the total time of 8 minutes. The pan was cleaned in every repetition.

2.5. Physical and Physicochemical Analyzes of Hamburgers

2.5.1. Color

The colorimetric evaluation of the samples was performed in a Hunter Lab Mini Scan XE Plus portable spectrophotometer, model 4500 L, obtaining the parameters L *, a * and b *, where L * defines the luminosity (L * = 0 - black and L * = 100 - white) and a * and b * are responsible for the chromaticity (+ a * red and -a * green; + b * yellow and -b * blue).

2.5.2. Water Content

For the analysis of water content, the hamburger was macerated, weighing 3g of the sample in triplicate and using oven at (105 ± 3)^{o}C until reaching constant weight, according to [21].

2.5.3. pH and Acidity

The pH and acidity were determined using 3 grams of each sample (previously macerated). For determination of pH, 100 mL of distilled water was added, and the pH of the resulting suspension was determined using Benchtop Meter Q400MT, pre-calibrated and operated according to the manufacturer's instructions. Samples were filtered on filter paper, and in the resulting liquid were added 2 to 3 drops phenolphthalein indicator and this solution was titrated with 0.1 N NaOH.

To calculate the acidity in normal percent solution, the product was carried out between the volume of 0.1N NaOH solution spent in the titration and the correction factor of 0.1N NaOH solution (1.02); then the ratio of the result to the number of grams of the sample used in the titration was performed [21].

2.5.4. Lipids

The determination of the fat content of the hamburgers was carried out by the method of Bligh *et al.* [22]. Previously macerated, 3 g of the samples were weighed into beakers, and 10 ml of chloroform, 20 ml of methanol and 8 ml of distilled water were added. The samples were transferred to hermetically capped glass containers and placed on a rotary shaker for 30 minutes, then 10 ml of chloroform and 10 ml of 1.5% anhydrous sodium sulfate solution were added. Samples were transferred to plastic tubes, capped and centrifuged in a NT-810 micro-processed bench centrifuge at 1000 rpm for 5 minutes to accelerate separation. Filtration was carried out after removal of the supernatant to give a clear solution. From this filtered solution, 4.5 ml (triplicate) were measured in previously tared petri dishes.

Plates were placed in an oven at 80 ° C until solvent evaporated (15-20 minutes). Refrigerated in desiccator, the plates containing the final weight of lipids were weighed in analytical balance. To obtain the percentage of total lipids, Equation 1 was used:

$$\%\text{TotalLipids} = \frac{pX4}{g}\ X\ 100 \qquad \textbf{(1)}$$

in which:

p= weight of lipids (g)

g= weight of samples (g)

2.5.5. Analysis of Chlorides by Volumetry

For chlorides analysis, 5 g of the sample was weighed into a porcelain capsule. Samples were taken to carbonize on electric plate and incinerated in a muff at 550 ° C. After the sample cooled, 30 mL of hot water was added and stirred with glass rod. The solution was transferred with the aid of a funnel into a 100 mL volumetric flask. The capsule, glass stick and funnel were washed with another two 30 mL portions of hot water. The solution and wash water were then transferred to the volumetric flask to cool. The flask volume was completed and then stirred. A 10 mL aliquot was withdrawn from the solution into a 125 mL Erlenmeyer flask. Two drops of the 10% potassium chromate solution were added as an indicator and titrated with 0.1 M silver nitrate solution until a red-brick color appeared [21].

2.6. Texture Profile of Burgers

Fried burgers were subjected to texture analysis in the TA-XT plus universal texturometer model - Texture Analyzer from Stable Micro Systems manufacturer equipped with Exponent Stable Micro Systems software,

using the P-36R probe, under the following conditions: pre-test, during the test and post-test speed of 2.0 mm / s, 5.0 mm / s and 5.0 mm / s, respectively; with distance of 30 mm and time between the two compressions of 5 s. The determined texture parameters were: firmness, elasticity, cohesiveness and chewability.

2.7. Physical Characteristics after Cooking

2.7.1. Cooking Yield

The fried hamburgers were weighed so that the calculation of yield and cooking was performed according to equation (2).

$$\%\ \text{yield} = \frac{\text{Weight of cooked sample x100}}{\text{Weight of raw sample}} \qquad \textbf{(2)}$$

2.7.2. Percent Shrinkage

Using a pachymeter, the diameter of raw and fried hamburgers was measured. The percentage of shrinkage was determined using Equation (3) [23]. This analysis was performed in triplicate.

$$\%\text{Shrinkage} = \frac{(\text{Dam} - \text{Dac})\text{x}100}{\text{Dam}} \qquad \textbf{(3)}$$

In which:

Dam= Diameter of Raw sample

Dac= Diameter of cooked sample

2.8. Statistical Analysis of Results

The experimental design was a completely randomized block with four treatments and three replications, using Assistant version 7.7 beta software. Data were submitted to analysis of variance (ANOVA) and the means comparison was done by the Tukey test at 5% probability.

3. RESULTS AND DISCUSSION

3.1. Physical And Physical-Chemical Characterization of Green Banana Biomass and Passion Fruit Peel Flours

The results obtained for particle size analysis of green banana biomass and passion fruit peel flours observed are shown in Table **2**.

According to Table **2**, granulometric fractions of green banana biomass flour that had the highest quantitative were in 60 and 100 Mesh sieves, with values of 35 and 27.8%, respectively. It was observed that the lowest quantitative was in the 16 Mesh sieve, corresponding to 0.02% of retained particles. For passion fruit peel flour, 41% were retained in the 60 mesh sieve, which corresponds to a size of 0.250 mm.

A study of Berry [23] observed that the flour made from acerola juice residue showed a larger percentage in ≤0.250 mm granulometry. According to Stork *et al*. [24], particle size directly influences water absorption capacity, mixing time and sensory characteristics, such as appearance, taste and texture. The ability of flour to absorb water is related to the distribution of particle size, with smaller particles of flour absorbing more water, and faster, than larger particles [25].

Table **3** contains results of analyzes of water content, water activity and color of green banana biomass and passion fruit peel flours.

Table 2. Granulometric analysis of green banana biomass and passion fruit peel flours.

Mesh (Tyler)	Opening (mm)	Retained (%)	
		F1	F2
16	1.000	0.02 ± 0.01	1.86 ± 0.05
32	0.500	9.05 ± 0.09	20.5 ± 0.4
60	0.250	35± 1	41 ± 1
100	0.150	27.8 ± 0.4	19 ± 3
200	0.075	21 ± 1	17 ± 3

Table 3. Physical and physicochemical characterization of green banana biomass and passion fruit peel flours.

Analysis**		Flours	
		F1	F2
Water content		8.5 ± 0.2[b]	10.4 ± 0.1[a]
Water activity		0.500 ± 0.002[a]	0.500 ± 0.001[a]
Colour	L*	64.2 ± 0.3[b]	71.0 ± 0.1[a]
	a*	9.1 ± 0.2[a]	4.1 ± 0.1[b]
	b*	19 ± 1[b]	24 ± 1[a]

F1: Green banana biomass flour; F2: passion fruit peel flour. ** average of three replicates (± standard deviation). *** Averages followed by the same letter, in the same row, do not differ statistically at 5% probability, by the Tukey test.

Excess moisture can cause microbial development which compromises the final quality of the product. The samples showed water content (**3**) equal to 8.5 and 10.4% for green banana biomass and passion fruit peel flour, respectively. Based on Brazilian standards, these values are acceptable and do not lead to loss of quality in farinaceous. Values accepted in Brazil are up to 14% [26]. Similar results were evidenced by Brasil [27] and Lima *et al*. [28] in watermelon peel flour (9.55%) and ironwood seed flour (9.38%), respectively.

Retcarding water activity, values were equal for the two flours (0.5) approaching values thus found by Lima *et al*. [29] to 0.5 passion fruit peel flour. Water activity is an important parameter that shows the availability of water for chemical reactions, enzymes and development of microorganisms in food.

The instrumental color analysis showed that the green banana biomass (L * = 64.2) and passion fruit peel flours (L * = 71.0) had values higher than 50, classifying samples as clear.

Retcarding the chromaticity parameters (a * and b *), it is verified that the samples had values of a * = 9.1 and b * = 19 for banana green biomass flour and a = 4.13 and b * = 24 for passion fruit peel flour in the retcions red and yellow, which in instrumental terms of color are characteristic of positive values for both coordinates. A study [30] found values of luminosity (L *) close to 100 (a hundred), parameter a * and b * positive, classifying the yellow albedo passion fruit flour as light, with a slightly red and strongly yellow coloration.

3.2. Physical, Chemical and Physicochemical Characterization of Hamburgers

Results of the physical, chemical and physicochemical analysis of hamburgers are presented in Table **4**.

Table 4. Physical, chemical and physicochemical characterization of low-sodium chicken meat hamburgers formulated with passion fruit peel flour and green banana biomass flour.

Analysis**		Formulations			
		F1	F2	F3	F4
pH		6.4 ± 0.01[a]	6.20 ± 0.06[b]	5.20± 0.03[d]	5.4 ± 0.1[c]
Acidity (v/m)		0.9 ± 0.3[c]	5.2 ± 0.3[b]	6.1 ±0.8[ab]	6.8 ± 0.2[a]
Water content (%)		62 ± 3[b]	41.0 ± 0.2[c]	35 ± 2[d]	73.3 ± 0.7[a]
Ashes		2.40 ± 0.04[bc]	1.94 ± 0.03[c]	3.1 ± 0.6[ab]	3.2 ± 0.1[a]
Color	L*	57.0 ± 0.4[a]	39.0 ± 0.1[d]	55 ± 1[b]	47.8 ± 0.2[c]
	a*	2.7 ± 0.2[d]	6.80 ± 0.01[b]	9.0 ± 0.1[a]	6.2 ± 0.1[c]
	b*	19 ± 1[c]	13.3 ± 0.1[d]	32.3 ± 0.6[a]	25 ± 1[b]
Lipids (%)		1.1 ± 0.2[b]	0.8 ± 0.2[a]	0.90 ± 0.07[a]	0.83 ± 0.07[a]
Chlorides in sodium chloride (%)		0.05± 0.01[c]	0.06 ± 0.01[bc]	0.11 ± 0.02[a]	0.100± 0.006[ab]

* F1, F2, F3, F4 - Standard hamburger, hamburger made with green banana biomass flour, hamburger made with passion fruit peel flour and hamburger made with flour mix respectively. ** average of three (± standard deviation). *** Averages followed by the same letter, in same row, do not differ statistically at 5% probability, by Tukey test.

The mean pH and acidity values of burgers ranged from 6.4 to 5.4 and 0.9 and 6.8 mL of 0.1 N NaOH / 10g, respectively. These values evidenced the increase of these parameters due to the addition of green banana biomass and the passion fruit pee flours.

It was observed that F1 presented higher pH due to the absence of fibers. According to Ferreira *et al*. [31] the determination of pH and acidity provides valuable data in the assessment of the state of conservation of food. Samples F3 and F4 presented values of 5.20 and 5.4 for pH, respectively. This reduction was justified by the presence of passion fruit peel flour, with 10% in formulation 3 and 5% in formulation 4.

The values found for F3 and F4 are below the results of Gonçalves *et al*. [32], who found for beef burger and buffalo burger average pH of 5.50 and 5.49 respectively.

Values found by Silva *et al*. [33] in burgers using pectin as fat substitute ranged from 4.91 to 5.53. These results were similar to those obtained for F3 and F4 hamburgers in this study. Bilek and Turhan [1] studied the effect of oat fiber addition on physicochemical properties of cooked and frozen hamburger with reduced fat and salt and found pH values ranging from 6.02 to 6.30. These results approximate the results obtained for the F2 formulation of this work.

The burgers prepared in this study had water content of 62 and 73.3%, the lowest value assigned to F3 formulation when using flour of passion fruit peel. This difference can be related to the amount of fat that is inversely proportional to water content. Araújo *et al*. [34] found in beef hamburger in natura with 5% flax flour water content equal to 62.95% approaching the values found for the standard formulation F1.

Retcarding ashes, results ranged from 2.40 to 3.2 [35]. Oliveira *et al*. used burgers made from buffalo meat enriched with orange fiber and found values ranging from 2.84 to 3.26.

As for the color analysis, there was a significant difference between all samples. It was observed that hamburger F1 and F3 presented higher values in luminosity (L * = 57.0 and L * = 55, respectively) resulting in a lighter burger. This observation justifies the slight visual similarity of the hamburger enriched with passion fruit peel flour with a standard hamburger with no flour. In relation to chromaticity, the observed values of a * ranged from 2.7 to 9.0 and b * from 13.3 to 32.3 [36]. Sousa *et al*. found a = 9.13 and b * = 10.45 in beef hamburger cooked with partial replacement of pork fat or processing residues of pineapple and canola oil.

The values for lipid content ranged from 0.8 to 1.1%, and are in accordance with MAPA Hamburger Quality and Identity Technical Retculation [37] which recommends a maximum of 23% fat. The reduction of fat content in relation to the standard sample can be explained by the addition of fiber rich flours in formulations. The hamburger enriched with green banana biomass flour was distinguished by its lower content of lipids. Selani *et al*. [38] in buffalo burgers with added orange fiber found a significant increase in fat compared to a standard sample.

Retcarding analysis of chlorides by volumetry, it was verified that the hamburger F3 and F4 differed statically from standard F1 formulation at the 5% probability level, by Tukey's test.

Texture profile analysis (TPA) indicated firmness, chewing, elasticity and cohesiveness of four hamburger formulations, and the results of each parameter are expressed in Table **5**.

Table 5. Texture analysis of reduced-sodium chicken meat burgers formulated with passion fruit peel and green banana biomass flours.

Formulations	Firmness* (N)	Chewing* (J)	Elasticity* (mm)	Cohesiveness* (Dimensionless)
F1	300 ± 3^b	188 ± 2^a	1.00 ± 0.01^a	0.6 ± 0.3^a
F2	561 ± 1^a	251 ± 4^a	0.7 ± 0.6^a	0.5 ± 0.1^a
F3	455 ± 1^a	229 ± 2^a	1 ± 1^a	0.5 ± 0.4^a
F4	506 ± 1^a	172 ± 1^a	0.7 ± 0.6^a	0.40 ± 0.01^a

F1, F2, F3, F4 - Standard hamburger, hamburger made with green banana biomass flour, hamburger made with passion fruit peel flour and hamburger made with flour mix respectively.

It was observed that formulation F2 (with green banana biomass meal) presented higher firmness and consequently higher chewiness when compared to F1 (standard formulation), since parameters are related to each other, *i.e.*, the higher the firmness the higher the value of chewiness. This increase is explained by the replacement of animal fat with green banana biomass flour, rich in fiber and gives a higher value in the firmness of hamburger. Retcarding elasticity, it was observed that formulations F2 and F4 presented a lower value (0.7) and were, therefore, less elastic when compared to standard formulation. For cohesiveness, it was observed that formulation F4 presented lower value (0.4), while standard formulation had the highest value (0.62).

It was also verified that in chewability, elasticity and cohesiveness there was no significant difference between all samples in relation to standard formulation.

According to Huang *et al*. [39], hardness represents one of the most important parameters of meat product texture, influencing the consumer's preference. The size and number of muscle fibers, as well as their composition and distribution, directly influence the meat texture parameters [40].

Lima *et al*. [28] report that hardness reduces with increasing fat content in hamburgers. For chewability in hamburgers made with 5% of blood plasma Claudino and Bertolini [41] found a value of 5417.02.

López-Vargas *et al*. [42] in boiled pork burgers plus 2.5% albedo of passion fruit, found a cohesiveness of 0.36. Formulation 4 presented a value close to 0.4.

3.3. Physical Characteristics After Cooking

Results obtained for cooking yield and percentage shrinkage are given in Table **6**.

Table 6. Analysis of yield and shrinkage of reduced sodium chicken meat burgers formulated with passion fruit peel flour and green banana biomass flour.

Hamburger	Cooking yield (%)	Percent Shrinkage (%)
F1	81 ± 1^b	38 ± 2^a
F2	84 ± 1^{ab}	4 ± 2^c
F3	88 ± 1^a	6.7 ± 0.2^c
F4	87 ± 2^a	3.5 ± 0.1^b

* F1, F2, F3, F4 - Standard hamburger, hamburger made with green banana biomass flour, hamburger made with passion fruit peel flour and hamburger made with flour mix respectively. ** Averages followed by the same letter, in the same column, do not differ statistically (p≤0,05), by Tukey test.

The F4 hamburger (with the mix of green banana biomass and passion fruit peel flour) presented the highest cooking yield in this study, being 87% when compared to the standard sample that is free of flour. In relation to shrinkage percentage, F2 sample (with green banana biomass flour) presented a lower value for this parameter, which means a great advantage at industrial level [43]. found values of yield and shrinkage of 88% and 25%, respectively, for bovine burger enriched with Brazil nut residues.

CONCLUSION

The hamburger enriched with green banana biomass flour was characterized by lower lipid content, but presented higher values for firmness and chewability. The addition of passion fruit peel flour as partial fat substitute provided higher yields, while green banana biomass flour resulted in a smaller shrinkage to the burger after cooking. Therefore, it was concluded that green banana biomass flour hamburger presented as a viable alternative for the ingestion of processed meat with reduction of sodium and fat, maintaining attractive characteristics in hamburgers.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No Animals/Humans were used for studies that are base of this research.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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