

Physicochemical characteristics and sensory properties of spent laying hen burgers formulated with cashew pomace flour

Abstract

Objective: The objective of this work was to evaluate the effect of adding different proportions of cashew flour on the quality characteristics of burgers from spent laying hens' meat. **Methods:** Spent laying hens (~ 60 weeks old) were used to prepare hamburgers containing different proportions (0, 5, 10 and 15%) of cashew flour, which were evaluated for chemical and nutritional composition, pH, retention capacity of water, instrumental color, cooking yield and sensory aspects. The addition of cashew flour significantly increased the levels of total fiber, carbohydrates and minerals (calcium, iron and phosphorus) and decreased the levels of moisture, fat, protein, caloric value and percentage of shrinkage proportionally when compared to the other formulations. **Results and Discussion:** The burger formulation with up to 5% had greater acceptance and greater purchase intention in relation to the other formulations, with the increase in cashew fiber flour up to 10% making the samples darker, with an aftertaste and a more brittle texture. **Conclusion:** Thus, it was concluded that the use of cashew fiber flour as a dietary supplement increases the nutritional value and acceptance of hamburgers made from meat from discarded laying hens, making them a source of mineral and dietary fiber.

Keywords: Hamburger, Spent hen meat, Cashew fiber flour, Sensory profile.

1. INTRODUCTION

Increased demands for industrialized meat products have conquered worldwide consumer's market due to drastic changes in life style. Burgers are some of the industrialized meat processed product that meets specific advantages, such as: the ease of preparation and the short time for preparation. The burgers as industrialized meat products, obtained from ground meat from botched animals, with or without added fatty tissue and ingredients, molded and subjected to an appropriate technological process; "It is a raw, semi-fried, cooked, fried, frozen or chilled product" according to its classification (Barasil, 2000). Although the most common raw meat

material that is extensively used for burger production is beef ([Abdel-Naeem and Mohamed, 2016](#)); the increasing price of the beef as raw meat materials required for manufacture of meat products has encouraged the food processors to evaluate the possibility of utilization of other low cost and high quality meat source such as meat from spent hens ([Freeman et al., 2009](#)). As started by [Fan and Wu \(2022\)](#), spent hen is a rich source of animal proteins and lipids, which are suitable starting materials for developing valorized products, combined to that the industrialization of culled carcasses in processed meat products is a strategy to stimulate the consumption of the meat of older animals ([Massingue et al. 2018](#)).

Hens are intended for the production of eggs which are considered to have high nutritional value, and after their useful life their carcasses have been commonly underutilized for human feed ([Fan and Wu, 2022](#)). However, spent hen meat carcass could be used as raw material for the production of meat products with good nutritional and sensory characteristics ([Fan and Wu, 2022](#), [Lawrie, 2005](#); [The Poultry Site \(2019\)](#)). Human consumption of hen meat is dissembling their healthy and low-cost meat, and researches was carried out utilizing hen meat compared with that of chicken, like that carried out by [Nunes \(2006\)](#), who reported meat of laying hens provided less loss during cooking, extended shelf life, delayed oxidation, protect meat from dehydration and frostbite during freezing.

Cashew is a cultivated tropical fruit. It's economic potential in Mozambique is valuable noted, since the country is the one of the greatest production and exportation of cashew nut. However, there is a lower industrialization of the cashew apple, which has a wide variety of product alternatives including juice, which is widespread consumed ([Nhampulo, 2022](#)). Various authors ([Owiredu et al., 2014](#); [Guedes-Oliveira et al., 2016](#); and, [Adegunwa et al., 2020](#)) demonstrated the utilities of cashew apple as a good raw material with good technological properties to its industrialization. Furthermore, fruit co-products have demonstrated to be a suitable source of bioactive molecules for meat industry; fibers were utilized as fat replacement capable of improving cooking yield, texture, and reduce formulation costs ([Pinho et al., 2011](#); [Guedes-Oliveira et al., 2016](#)). Then, producing laying hen burgers with cashew apple pomace is in line with the consumption of functional foods, since the addition of cashew apple pomace provide amounts of fiber and its use as a burger ingredient is considered a feasible option ([Mandlate,](#)

2021). Therefore, the purpose of the present study was to evaluate the effect of adding cashew flour on the technological characteristics of spent hen meat burgers.

2. MATERIAL AND METHODS

2.1. Laying hens and cashew flour acquisition and processing

The spent laying hens (at approximately 60 weeks old) were purchased from egg producers in Munavalate, Vilankulo City. The animals were transported to the Laboratory of Food Processing (Lab. 3) at ESUDER and left to rest during 5 hours of fed on hydric diet before slathered. The slaughter was carried out without stunning but 5 minutes bloodletting. The plucking was made using an electric pluckier for 5 minutes. The legs and viscera were removed, washed, and manually deboned. The deboned meat was placed in plastic bags and stored at -18°C prior processing.

The cashew was acquired in the district of Bilene and transported in a stalk to the tasting room, where the entire cashew was received free of attacks or physical damage, selection and cleaning followed by peeling, disintegration and filtration through sieves. Plastic, followed by manual pressure with the aid of clean cloths, to remove excess moisture (Lima, 2007), the subsequent layer was packed in previously identified plastic bags and subjected to freezing at -18°C, finally Frozen dough was crushed using a blade mill and blender present in ESUDER's (Lab. 3), filtered and stored in vacuum polyethylene packaging at room temperature until used as flour in the preparation of hamburgers.

2.2. Burgers processing

For burgers formulation the hen meat was ground using brand meat grinder (Moulinex HV-1300) and then four different treatments (CONT, CF5, CF10 and CF15) were reached by manually mixing with 0, 5, 10 and 15 % of cashew flour as hen meat replacer, respectively. Initially 72% disposal hen meat was used to produce a control treatment (CONT), and thereafter, meat concentration was replaced by cashew flour (CF) as previously stated. Salt (2%), ground pork fat (18%), egg white (5%) and seasonings (3%) were then mixed and manually homogenized. After burgers batter forming, about 80 g portions were manually shaped using an inox burger maker

machine, to give the dimensions of 8.0 cm diameter and approximately 1.0 cm thickness. The raw burgers were then placed in polyethylene packages and stored per 24 hours under -18 °C until further analysis and cooking treatment.

Burgers samples of each treatment were individually weighed and grilled in a preheated (180 °C) clam-shell grill electric oven for 2 minutes for each side to achieve a core temperature of 71°C monitored with help of thermocouple probe. Samples were cooled at room temperature (25°C) per 15 minutes before reweighing for cooking loss determination.

2.3. Physicochemical analysis and Proximate composition

The physicochemical analyses were performed in raw burgers. Moisture, ash, lipid (Soxhlet), and protein (Kjeldahl, N × 6.25) were determined according to [AOAC \(2012\)](#), and the available carbohydrates were calculated by difference of total percentage and sum of all other components, as follow: % Carbohydrates = 100% - (%moisture + %protein + %fat + %ash). Dietary fiber content was quantified according to the enzyme-gravimetric method described by the Instituto Adolfo Lutz ([2008](#)).

For grilled burgers, pH, cooking loss, reduction of diameter and color were evaluated. The pH of the products was measured using a digital pH meter after homogenization of 5 g of sample in 50 mL of distilled water. The pH meter calibrated with standard solutions (4.00 and 7.02 pH buffers) at a temperature of 20 °C ± 1 °C. Diameter and thickness of the raw and cooked burgers were recorded using a digital caliper rule and calculated using the following expression: Sortening (%) = [(raw chicken burger diameter – grilled chicken burger diameter)/raw chicken burger diameter] × 100. Cooking loss was determined by calculating the weight differences before and after grilling as follows: Cooking loss (%) = [(weight of raw chicken burger (g) – weight of grilled chicken burger (g))/weight of raw chicken burger (g)] × 100.

Color of raw and cooked burgers was also determined using a colorimeter (Konica Minolta, Chroma Meter, CR-400) with a measurement area of 8 mm in diameter, observation angle of 10° and illuminant D65 ([Ramos and Gomide, 2017](#)). Five measurements were taken from each sample. Lightness (L^*), redness (a^*) and yellowness (b^*) were recorded.

For both raw and cooked burgers, pH, color and diameter were analyzed, where it was possible to analyze the percentage of shrinkage. Analysis of protein, fat, ash, carbohydrates and fiber was also carried out on the raw dough.

The diameter was determined using a 15 cm ruler where three edges of the raw and roasted burger were measured. Shrinkage percentage was calculated by the difference between the diameter of the raw and baked sample.

The fiber content was also determined using the Hennberg technique, which consists of acid (H_2SO_4) and basic (NaOH) digestion of the sample, followed by drying in an oven (105°C , 2 hours) and finally incineration in a muffle furnace (550°C) at 3 hours).

Mineral contents were also determined using the molecular absorption spectrophotometric method (UV-Vis) for iron and volumetric method, consisting of precipitation of calcium by oxalate ion in acidic medium for calcium.

2.4. Sensory analysis

Sensory analysis was carried out based on the acceptability test using a structured 9-point hedonic scale. The points and/or ratings were based on the evaluation of appearance, flavor, texture, overall impression and purchase intention. Prior the sensory evaluation panel, the burgers were subjected to the cooking process in an electric oven at a temperature of 180°C , where the consumers were randomly served four (4) samples on disposable plates with their respective three digits based codes. The panelists filled out the table presented to them according to the hedonic scale, along with the terms they perceived. It should be noted that the comments were considered. Thereafter, to describe the sensory characteristics of each product, questions were defined by 8 untrained participants, consisted of graduate students and their supervisors whom were working in their experiments in the laboratory. All participants were frequent consumers of burgers and other meat products. Cubes of approximately 25 mm edge of each sample were presented in a single testing session (Repertory Grid technique), and judges used an open-ended question to establish the appropriate terms for describing their appearance, flavor and texture. The most mentioned terms for each attribute were chosen to compose the Exploratory Multivariate Analysis (Table 1) to analyze by the Principal Component Analysis (PCA) data projection method.

Table 1. Terms surveyed for Principal Component Analysis (PCA) terms of each sensory attribute

Appearance	Flavor	Texture
Brownish	Cooked taste	Firm
Uniform	Salty taste	Juicy
Dark	Taste of spice	Crambly
Greasy	Aftertaste	Fibrous
	Chicken taste	Granulated
	Pleasant flavor	

Secondly, the sensory panel was composed of 50 untrained panelists, aged from 18 to 60 years, of which 12 (24%) were male and 38 (76%) female, were randomly recruited at ESUDER. All participants declared to be burger consumers. The sensory analysis was performed in a single testing session conducted in individual cardboard voting table booth style under the room white light. Sample cubes of approximately 20-25 mm edge were labeled with a 3-digit code and were offered to the panelist randomly and balanced in a monadic sequence. Mineral water was offered to the panelists for mouth rinsing between sample trials. The panelists received the sensory evaluation form (acceptance test) and evaluated the samples using a hedonic scale of 1 (disliked very much) to 9 (liked very much) for each attribute (flavor, texture and overall impression). In the same form, the panelists were asked to check all the fifteen terms of PCA analysis (as previously defined, [Table 1](#)) considered appropriate to describe each attribute.

2.5. Statistical analysis

To carry out the analysis of variance [ANOVA and Tukey's test], the SPSS statistical package was used, including the data from the acceptability test. All data analysis was performed at a significance level of 5%. The EMA and PCA biplot graph were performed in the SensoMaker statistical software (Lavras, MG, Brazil), version 1.92.

3. RESULTS AND DISCUSSION

3.1. Hen meat qualities

Hen meat was pH mean of 6.84. This pH value is acceptable for human immediate consumption (Terra and Brum, 1988; Hautrive *et al.*, 2008). Color parameters were $L^*=21.26$, $a^*=20.35$ and $b^*=17.55$. Its proximate composition was given as follow: moisture (63.84%), fat (15.50%), protein (17.15%) and ash (2.90%); and carbohydrates (0.23%). Despite the slight lower protein content, spent hen composition utilized in this experiment was similar to that found other researches (Safder *et al.*, 2019; Fan and Wu, 2022). The mineral content was 6.12 mg/100g of iron and 0.21% (w/w) of calcium.

3.2. Burgers qualities

The processed burgers from spent laying hens' meat were molded using plastic plate molds where they were flattened and pressed by hand, until a smooth shape was obtained in a polyethylene plastic film and kept at -18°C freezing (Figure 1).

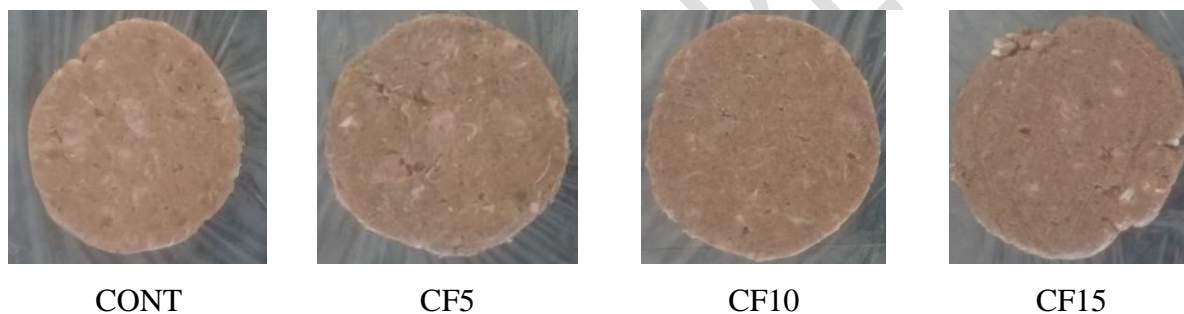


Figure 1: Raw burgers formulated with spent hen meat replaced by 5% (CF5), 10% (CF10) and 15% (CF15) cashew pomace flour.

The reduction in diameter of the burgers using 8.1 cm diameter mold was 23.46%, 13.21%, 14.57% and 6.02% accordingly to Formulations CONT, CF5, CF10 and CF15, respectively. These results are correlated with that of shrinkage of the burgers during grilling with the data stated as follow: CONT (24.87%); CF5 (13.12%); CF10 (13.04%) and CF15 (4.21%). The percentage of shrinkage was inversely proportional to the increase in cashew fiber flour due to the characteristics of the flour. Treatment CF15 showed lower shrinkage (4.21%), having differed significantly ($p < 0.05$) with the other formulations, however, there were no significant differences ($p > 0.05$) between CF5 (13.12%) and CF10 (13.04%). Similar results were reported by Libório (2019) who evaluated laying hen burgers added with oat bran as a fat substitute.

However, [Borba \(2013\)](#) found higher values than this study when evaluated the effect of different cooking methods of beef burgers.

3.2.1. Chemical composition and physicochemical characterization of raw burgers

The proximate composition of raw burgers is given in the [Table 2](#). Moisture, fat and protein content values decreased ($P<0.05$) as cashew pomace flour was added. These tendencies were also reported by [Pinho et al. \(2011\)](#) in hamburgers with partial substitution of the meat with cashew apple residue powder.

Table 2. Proximate composition, pH and shortening characteristics of raw spent hen meat burgers with cashew flour.

Parameters	Formulations			
	CONT	CF5	CF10	CF15
Moisture (%)	55.03±1.20 ^a	50.40±1.73 ^b	48.80±0.69 ^b	45.50±0.40 ^c
Fat (%)	21.25±0.25 ^a	20.75±0.25 ^a	17.50±0.50 ^b	15.89±0.35 ^b
Protein (%)	15.13±0.50 ^a	13.08±0.64 ^a	11.50±0.37 ^{bc}	9.50±0.50 ^c
Ash (%)	5.25±0.25	5.65±0.05	5.00±0.001	5.00±0.001
Calcium, % (w/w)	0.24±0.02 ^a	0.27±0.01 ^a	0.29±0.01 ^a	0.33±0.03 ^a
Iron (mg/100g)	12.00±2.94 ^a	38.02±1.02 ^b	50.14±1.24 ^c	54.76±0.76 ^d
Carbohydrate (%)	1.49±0.06 ^d	7.20±0.18 ^c	11.47±0.19 ^b	15.89±0.12 ^a
Total Fiber (%)	0.72±0.28 ^c	1.77±0.10 ^c	5.21±0.19 ^b	8.51±1.02 ^a
pH	6.38±0.01 ^a	5.96±0.02 ^b	5.57±0.01 ^c	5.24±0.03 ^d
Shortening (%)	24.87±1.13 ^a	13.12±0.63 ^b	13.04±0.58 ^b	4.21±0.61 ^c

CONT is control (without cashew flour added) and CF5, CF10 and CF15 are formulations in which hen meat was replaced by 5, 10 and 15% cashew flour samples, respectively.

The addition of fruit fibers on meat products usually increases the water holding capacity of the food matrix and consequently the moisture content ([Elleuch et al., 2011](#); [Pinero et al., 2008](#)). Nonetheless, in the present study, the addition of cashew apple flour induced a decrease of moisture content. It was expected since the addition of CF was made additively, not as a substitute. All treatments exhibited similar tendencies in contents of fat, protein and ash. As overall stated, the greater the fiber addition the lower the lipid content.

Decrease in protein content was already expected, as fruits are not typically sources of this nutrient. However, laying hen burger added with oat bran as a fat substitute (Libório, 2019) resulted in higher values than to those observed in the present work. There was no significant difference ($p > 0.05$) between all formulations in terms of ash, but several variations (min. 0.54% to max. 1.49%). An increase in fiber and carbohydrate content values was observed (Table 2).

Minerals calcium (Ca) and iron (Fe) contents are shown in Table 4. Iron content increased significantly as the amount of cashew fiber flour in the burger formulations increased ($p < 0.05$) from mean of 12.0 up to 54.76mg/100g), but did not varied to calcium content (mean of 0.28%). Barros et al. (2012) observed higher contents of minerals in hamburgers formulated and supplemented with cashew fibers.

Regarding the percentage of shrinkage, it was observed that this was inversely proportional to the increase in cashew fiber flour. Where F15 (15% cashew pomace flour) showed lower shrinkage (4.21%), having differed significantly ($p < 0.05$) with the other formulations, however, there were no significant differences ($p > 0.05$) between CF5 (13.12%) and CF10 (13.04%), as illustrated in Table 2.

3.2.2. CIE color characteristics of hamburgers

There are expected differences of color characteristics among raw and grilled burgers (Table 3). Older animals tend to accumulate myoglobin in their muscle tissues, darkening the meat color (Oliveira, 2015). The similar tendencies were observed by Frizzell et al. (2017) on spent laying hens' meat and Souza et al. (2011) for raw burgers.

Table 3. CIE color of raw and grilled burgers

Characteristics	Cooking		Formulations			
	Raw	Grilled	CONT	CF5	CF10	CF15
Lightness (CIE L^*)	18.52±0.76 ^a	10.03±0.56 ^b	19.98±1.56 ^a	14.84±0.72 ^b	11.51±0.21 ^c	10.70±0.17 ^d
Redness (CIE a^*)	17.85±0.62 ^a	9.64±0.51 ^b	20.07±1.52 ^a	14.2±0.71 ^b	10.88±0.23 ^c	9.98±0.48 ^d
Yellowness	9.84±0.51 ^a	5.52±0.24 ^b	11.07±1.02 ^a	8.2±0.26 ^b	6.07±0.14 ^c	5.76±0.10 ^c

(CIE b^*)

CONT is control (without cashew flour added) and CF5, CF10 and CF15 are formulations in which hen meat was replaced by 5, 10 and 15% cashew flour samples, respectively.

3.3. Sensory analysis

The sensory analysis of grilled spent hen burgers formulated with cashew pomace flour is presented in the [Table 4](#). There were no significant difference ($P>0.05$) among the samples. It can be seen that almost all formulations showed good acceptability, since the formulations evaluated presented scores of the means of 6 (“I liked it slightly”) to 8 (“I really liked it”) in the hedonic scale. Similar behavior was observed by [Oliveira and Lobato \(2020\)](#) in hamburguers added with 9.5% of cashew fiber.

Table 4. Sensory parameters of grilled spent hen burgers formulated with cashew pomace flour (CF).

Parameters	Formulations			
	CONT	CF5	CF10	CF15
Appearance	7.16±1.91 ^a	7.50±1.67 ^a	6.76±2.24 ^a	6.22±1.86 ^a
Flavor	7.50±1.59 ^a	7.46±1.96 ^a	6.82±2.25 ^a	6.04±2.38 ^a
Texture	7.32±1.90 ^a	6.89±1.73 ^a	6.64±2.27 ^a	6.26±2.11 ^a
Overall impression	7.82±1.45 ^a	7.50±1.56 ^a	6.76±2.02 ^a	6.68±1.90 ^a

CONT is control (without cashew flour added) and CF5, CF10 and CF15 are formulations in which hen meat was replaced by 5, 10 and 15% cashew flour samples, respectively.

According to [Teixeira, Meinert and Barbeta \(1987\)](#) and [Dutcosky \(2007\)](#), for the product to be considered accepted, in terms of its sensory properties, it is necessary for it to obtain an Acceptability Index (AI) of at least 70%. However, CF10 and CF15 (samples with 10 and 15% cashew fiber flour, respectively) had lower preference by the consumer ([Figure 2](#)) described as consumer purchase intention. Therefore, the purchase intention test estimates the consumer's willingness to buy the product; and at least 50% of consumers would purchase the spent hens burgers formulated with cashew apple flour up to 10% ([Figure 2](#)). There is getting that greater cashew apple flour content the reduced consumers willing to buy the product.

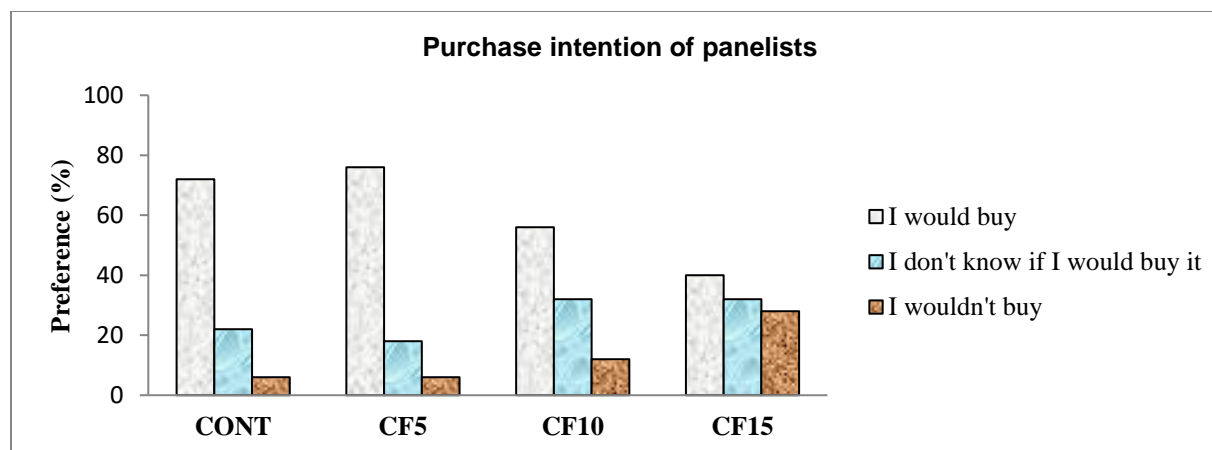


Figure 2. Purchase intention of the hen burgers containing cashew flour by the consumers. CONT is control (without cashew flour added) and CF5, CF10 and CF15 are formulations in which hen meat was replaced by 5, 10 and 15% cashew flour samples, respectively.

3.4. Principal Components Analysis (PCA)

The PCA was generated from the number of times that the consumers associated each of the 15 sensory terms (Table 2) with the samples. Two principal components (PC1 and PC2) were considered valid to generate the PCA graphic (Figure 3). The PC biplots show the relative positions of the samples and factor loadings indicate the attributes that best describe the dimensions of the perceptive space. Combined, the PC1 and PC2 accounted for 87.77% of the total variance in the data after fitting by the Autoscale processing technique with the PC1 explaining 61.10% and PC2, 26.67% of variance.

PC1 consider that the panelist related the CONT sample as greasy, juicy, chicken taste, uniform and with perceived with a pleasant flavor. Nevertheless the sample CF5 was a little hard and perceived as salty taste, these trends could be the main reasons that the Control (CONT) and CF5 demonstrated to be the preferred samples to been bought by the consumers. Sample CF15 was considered with aftertaste, dark, brownish, crumbly, fibrous and hard (firm) characteristics. Thereafter, the PC2 could be considered extremely correlated with the sample CF10 properties. It was evaluated with perceived cooked taste and taste of spice; and granulated texture. The results shown that the sensory panel had a good tendency to evaluate the samples if the PCA is correlated with that data of the sensory acceptability.

Hind and Outname (2022) consider principal component analysis (PCA) as an extremely powerful tool for synthesising the information contained in the various data to have a representation that allows easier interpretation.

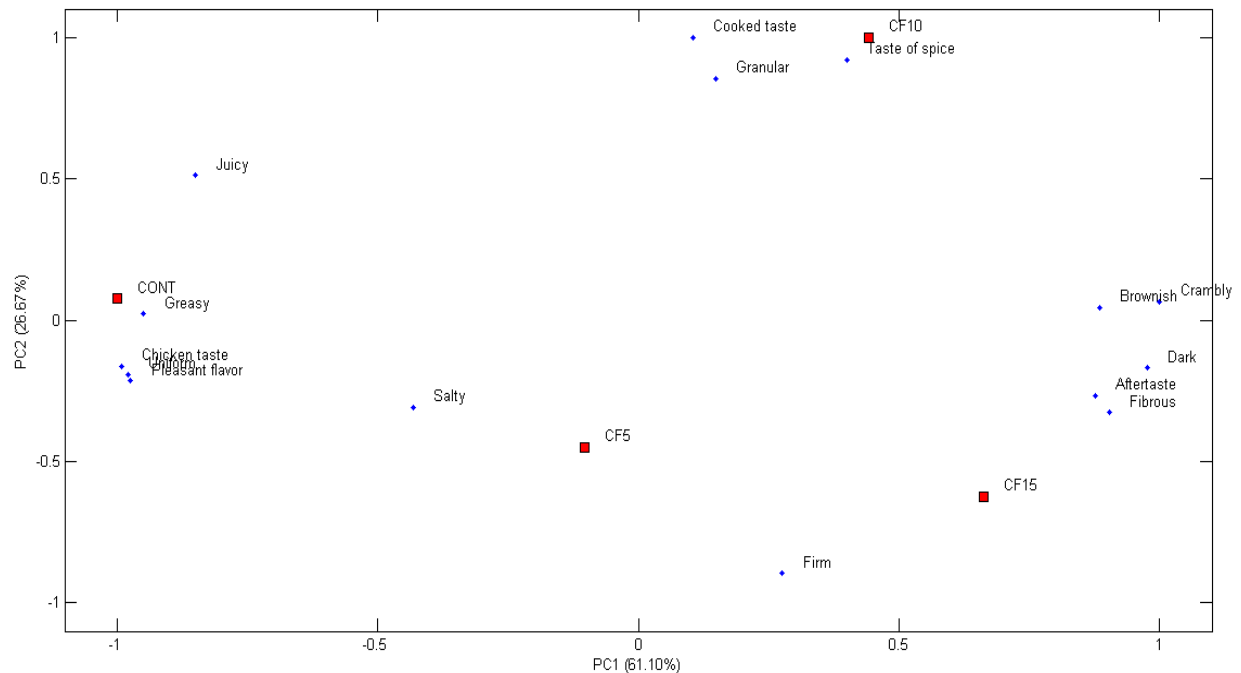


Figure 3. Principal Component Analysis (PCA) of the sensory questionnaire for the spent hen burgers with cashew flour. CONT is control (without cashew flour added); and CF5, CF10 and CF15 are formulations in which spent hen meat was replaced by 5, 10 and 15% cashew flour samples, respectively.

The aspect and color of the food surface is the first quality parameter evaluated by consumers and is critical in the acceptance of the product, even before it enters the mouth. The color of this surface is the first sensation that the consumer perceives and uses as a tool to accept or reject food. Food appearance determined mostly by surface color is the first sensation that the consumer perceives and uses as a tool to either accept or reject food (Leon et al., 2006).

4. Conclusion

The use of cashew pomace flour (CF) as substitute of spent hen meat for burgers production slightly affected chemical composition and color parameters, but did not affect the pH and sensory acceptance parameters of burgers. In order, addition 10 and 15% CF in the burger

formulations demonstrated a smaller rejection regarding purchase intention of burger. Cashew pomace flour is nutritionally rich (high iron content) and can be used as a food supplement in the preparation of hamburgers. Burgers made with meat from spent laying hens have good technological and sensory characteristics when up to 10% cashew fiber flour is added.

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