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 colour, cooking yield and sensory aspects. The addition of cashew flour significantly increased the levels of total fiber, carbohydrates and minerals (calcium, iron and phosphorus). It decreased the levels of moisture, fat, protein, caloric value and percentage of shrinkage proportionally compared to the other formulations. **Results and Discussion:** The burger formulation with up to 5% had greater acceptance and intention 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 using 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 the worldwide consumer ~~'s~~ market due to drastic ~~changes in~~ life style changes. Burgers are ~~some of the~~ industrialized meat processed product~~s~~ that ~~meets~~ have specific advantages, such as: the ease of the preparation and the short ~~time for~~ preparation times. The burgers as industrialized meat products, obtained from ground meat from botched animals, with or without added fatty tissue and ingredients, mo~~u~~lded 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). Al~~tg~~hough the most

Commented [A1]:

Commented [A2]:

Commented [A3]: about

Commented [A4]:

Commented [A5]:

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 the 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~~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~~that 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 carcasses could be used as raw material for ~~the production of~~producing ~~-~~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. Its~~'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~~ widelyconsumed (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~~ excellant raw material with good technological properties to its industrialization. Furthermore, fruit co-products have been demonstrated to be a suitable source of bioactive molecules for the meat industry; fibers were utilized as fat replacement capable of improving cooking yield, texture, and reducing~~e~~ 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 provides 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 a hydric diet before being slathered. The slaughter was carried out without stunning but 5 minutes of 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 to processing.

Commented [A6]:
Commented [A7]: for
Commented [A8]:

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 a brand meat grinder (Moulinex HV-1300). ~~and then f~~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~~after that, 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 the burgers batter formed~~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 71ºC monitored with the help of a 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~~ on 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 the difference of total percentage and sum of all other components, as follows: % 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 colour were evaluated. The pH of the products was measured using a digital pH meter after ~~homogenization of~~homogenising 5 g of sample in 50 mL of distilled water. The pH meter wascalibrated with standard solutions (4.00 and 7.02 pH buffers) at ~~a temperature of~~ 20 °C ± 1 °C. The ~~D~~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.

The ~~C~~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.

Formatted: Font color: Auto

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~~were analysed 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. The difference between the diameter of the raw and baked sample calculated shrinkage percentage.~~Shrinkage percentage was calculated by the difference between the diameter of the raw and baked sample.~~

Formatted: Font: (Default) Times New Roman, Not Bold

Formatted: Font: (Default) Times New Roman

The fiber content was also determined using the Hennberg technique, which consists of acid (H_2SO_4) and ~~basic~~ essential (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 thevolumetric method, consisting of precipitation of calcium by oxalate ion in an 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~~ and ratings were based on ~~the evaluation of~~ evaluating appearance, flavor, texture, overall impression and purchase intention. Prior to 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 panellists filled out the table presented to them according to the hedonic scale, ~~along with the~~and the terms they perceived. It should be noted that the comments were considered. ~~Thereafter,~~After that to describe the sensory characteristics of each product, questions were defined by 8 untrained participants, consisting~~ed~~ 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~~ using 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 panellists, 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 labelled with a 3-digit code and were offered to the panellist 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 (flavour, texture and overall impression). In the same form, the panellists 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.

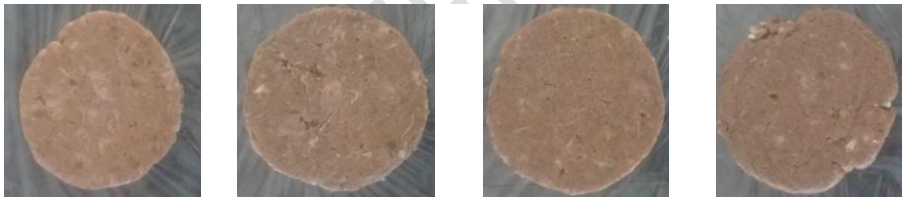
3. RESULTS AND DISCUSSION

3.1. Hen meat qualities

Hen meat ~~was~~ had pH mean of 6.84. This pH value is acceptable for ~~human~~ immediate human 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 ~~fallow~~follows: moisture (63.84%), fat (15.50%), protein (17.15%) and ash (2.90%); and carbohydrates (0.23%). Despite the slight lower protein content, the spent hen composition utilized in this experiment was similar to that found by 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 moulds ~~where they were~~ flattened and pressed by hand, until a smooth shape was obtained in a polyethylene plastic film and kept at -18ºC freezing (Figure 1).



CONT CF5 CF10 CF15

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 an 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 follows: 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., ~~h~~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±001^{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 food matrix 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~~ decreased ~~the of~~ moisture content. It was expected since ~~the addition~~ adding ~~of~~ CF was made

additively, not as a substitute. All treatments exhibited similar tendencies in ~~contents of~~ fat, protein and ash content. As overall stated, the greater the fiber addition the lower the lipid content.

A 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~~to be 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 (CIE *b**)	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]

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 differences (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~~must 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.

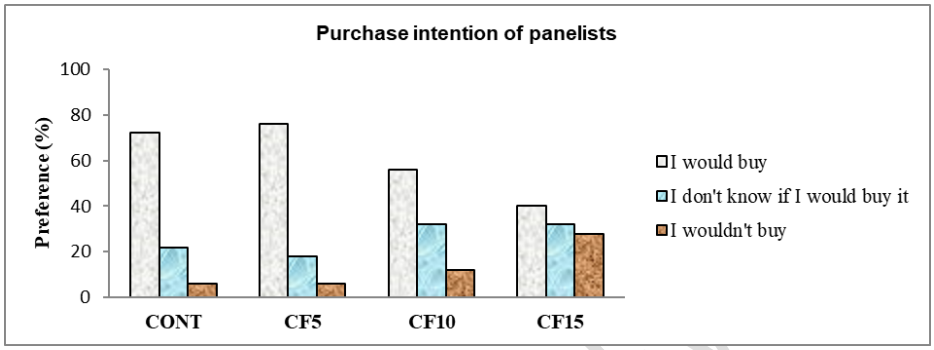


Figure 2. Purchase intention of the hen burgers containing cashew flour by the consumers. CONT is control (without cashew flour added) and CF5, CF10 and CF15 are formulations in which hen meat was replaced by 5, 10 and 15% cashew flour samples, respectively.

3.4. Principal Components Analysis (PCA)

The PCA was generated from the number of times ~~that t~~he 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, t~~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 considered that the panellist 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 having a 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,~~After that the PC2 could be ~~considered~~ regarded as 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.

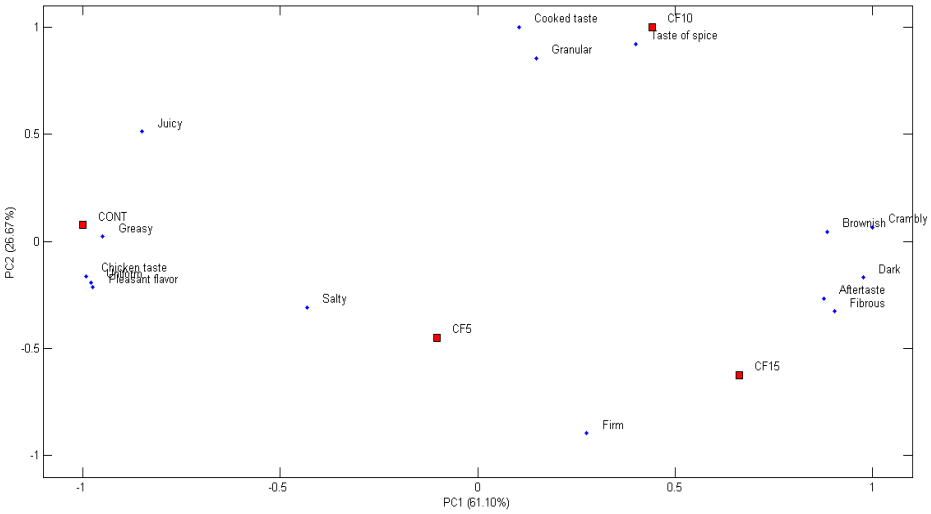


Figure 3. Principal Component Analysis (PCA) of the sensory questionnaire for the spent hen burgers with cashew flour. CONT is control (without cashew flour added); and CF5, CF10 and CF15 are formulations in which spent hen meat was replaced by 5, 10 and 15% cashew flour samples, respectively.

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~~Using cashew pomace flour (CF) asa substitute ~~of~~ forspent hen meat for burgers production slightly affected chemical composition and color parameters, but did not affect the burgers pH and sensory acceptance ~~parameters.parameters of burgers~~. In order,an addition 10 and 15% CF in the burger formulations demonstrated a ~~smaller~~ minor 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~~to prepare hamburgers. Burgers made with meat from spent laying hens have good technological and sensory characteristics when up to 10% cashew fiber flour is added.

References

1. Brazil (2000). Ministry of Agriculture, Livestock and Supply. Approves the Technical Regulations for the Identity and Quality of Meatballs, Ham, Ham, Hamburgers, Kibbeh, Cooked Ham and Ham. Normative Instruction No. 20, of July 31, 2000. Brasília: Official Gazette of the Union of August 3, 2000, Section I, p. 7- 12.

2. Abdel-Naeem, H. H. S., Mohamed, H. M. H. (2016). Improving the physico-chemical and sensory characteristics of camel meat burger patties using ginger extract and papain, Meat Science, vol. 118, pp. 52-60. https://doi.org/10.1016/j.meatsci.2016.03.021

3. Freeman, S. R., Poore, M. H., Middleton, T. F., Ferket, P. R. (2009). Alternative methods for spent of spent hens: Evaluation of the laying efficacy of grinding, mechanical deboning, and of keratinase in the rendering process. Bioresource Technology, vol. 100 (19), p. 4515-4520. https://doi.org/10.1016/j.biortech.2009.01.077

4. Fan, H.; Wu, J. (2022). Conventional use and sustainable valorization of spent egg-laying hens as functional foods and biomaterials: A review. Bioresources and Bioprocess. 9:43, 18p. https://doi.org/10.1186/s40643-022-00529-z

5. LAWRIE, R. A. (2005). Meat Science. 6 ed. Porto Alegre: Artmed.

6. The Poultry Site (2019). Finding the value in processing spent laying hens. Link: https://www.thepoultrysite.com/articles/finding-the-value-in-processing-spent-laying-hens Accessed on: 04/20/2024.

7. NUNES, T. P. (2006). Sensory acceptance of restructured breaded products made with breast fillets from broiler hens and commercial layers. Food Science and Technology., v. 26, p. 841-846.

8. Pinho, L. X., Afonso, M. R. A., Carioca, J. O. B., Costa, J. M. C., & Ramos, A. F. (2011). The use of cashew apple residue as source of fiber in low fat hamburgers. Food Science and Technology, 31, 941e945.

9. Guedes-Oliveira, J. M., Salgado, R. L., Costa-Lima, B. R. C. et al. (2016). Washed cashew apple fiber (Anacardium occidentale L.) as fat replacer in chicken patties. LWT - Food Science and Technology 71 (2016) 268-273. http://dx.doi.org/10.1016/j.lwt.2016.04.005

10. Mandlate, I. A (2021). Technological and sensorial characteristics of hamburgers made from meat from laying hens supplemented with cashew fiber flour. Course Completion Work. Eduardo Mondlane University. 87p.

11. Lima, J. R. (2007). Cashew burger: elaboration and characterization. Embrapa. Brochures: Technical Communication 131. ISSN 1679-6535, pp. 1-4, Fortaleza, CE.

12. AOAC (2012). Official methods of analysis of AOAC International. Gaithersburg, MD: Association of Official Analytical Chemists.

13. IAL (2008). Adolfo Lutz Institute. Physico-Chemical Methods for Food Analysis - 4th Edition 1st Digital Edition. Sao Paulo, Brazil.

14. Ramos EM, Gomide LAM. Meat Quality Assessment: Fundamentals and Methodologies. Viçosa: Editora UFV; 2017.

15. LIBÓRIO, P. T. (2019). Preparation of a laying hen burger with oat bran added as a fat substitute, GARANHUNS – PE.

16. Borba, C.M.; Oliveira, V. R.; Montenegro, K. R. et al. (2013). Physicochemical evaluation of beef and chicken burgers subjected to different thermal processing. Brazilian Journal of Food and Nutrition, v.24, n.1, p.21-27.

17. GALVÃO, A. M. P. (2006). Use of cashew fiber (Anacardium occidentale, L.) in the formulation of a hamburger-type product. 75 f. Dissertation (Master's in Food Technology) Federal University of Ceará, Fortaleza.

18. OLIVEIRA, L. G. L (2015). Integration of the cashew agribusiness production chain with sustainable development.

19. Frizzell, K. M.; Lynch, E.; Rathgeber, B. M. et al. Effect of housing environment on laying hen meat quality: Assessing Pectoralis major pH, color and tenderness in three strains of 80–81 week-old layers housed in conventional and furnished cages. British Poultry Science, v.58, n.1, p. 50-58, 2017. https://doi.org/10.108 0/00071668.2016.1236364
20. SOUZA, K.M.R., ARAUJO, R.B., SANTOS, A.L. (2011). Adding value to the meat of spent laying hens manufacturing sausages with a healthy appeal. Brazilian Journal of Poultry Science, v.13 n.1 p 57-63.
21. Barros…
22. TEIXEIRA, E., MEINERT, E., BARBETA, P. A. (1987). Sensory analysis of food. Florianópolis: UFSC.
23. DUTCOSKY, S. D. (2007). Sensory analysis of foods. 2nd ed. Curitiba: Champagnat,. 123 p. 33. DWY
24. Nhampulo, A. (2022). Design and dimensioning of a machine for processing cashew stalks to obtain juice. Degree work. Engineering College. Eduardo Mondlane University (UEM), Mozambique. Evaluable at: http://monografias.uem.mz/handle/123456789/316
25. Owiredu, I., Laryea, D. and Barimah, J. (2014), "Evaluation of cashew nut flour in the production of biscuit", Nutrition & Food Science, v. 44, no. 3, p. 204-211.
26. Adegunwa, M.O., Kayode, B.I., Kayode, R.M.O. et al. Characterization of wheat flour enriched with cashew apple (Anacardium occidentale L.) fiber for cake production. Food Measure 14, 1998–2009 (2020). https://doi.org/10.1007/s11694-020-00446-9
27. Leon, K., Mery, D., Pedreschi, F., Leon, J., 2006. Color measurement in L* a* b* units from RGB digital images. Food Res. Int. 39 (10), 1084–1091.
28. Safder M, Temelli F, Ullah A (2019) Extraction, optimization, and characterization of lipids from spent hens: an unexploited sustainable bioresource. J Clean Prod 206:622–630
29. Oliveira Rosa, M.Y. and Lobato, F.H.S. (2020). Cashew burger: elaboração e análise sensorial de hambúrguer à base de caju (anacardium occidentale l). Research, Society and Development, v. 9, n.8, e615985958.
30. Pinho, L.X. et al. (2011). The use of cashew apple residue as source of fiber in low fat hamburgers. Ciência e Tecnologia de Alimentos, Campinas, 31(4): 941-945.

31. Hind, B and Outname, S. N. (2022). Principal Component Analysis applied to survey data: Methodological aspects and application. International Journal on Optimization and Applications, v. 2 (3), p. 25-33.