Quality evaluation of edible beef skin produced using different singeing methods

Abstract

This study investigated some nutrient components, concentrations of some heavy metals and sensory properties of processed edible beef skin (*ponmo*). The edible beef skin were processed using different singeing methods (wood, gas oven, tyre, shaving stick). The results of some of the nutrient components (moisture, crude protein, ether extract, ash) determined showed the moisture content in the range of 45.73-51.42% with the shaved *ponmo* having the highest moisture content of 51.72% .The shaved edible beef skin had the highest crude protein content of 8.27% while the sample that was singed using local oven had the lowest crude protein content of 7.12%. The ether extract and ash contents of the processed edible beef skin were in the range of 1.16 -1.45% and 1.75 – 1.99% respectively. Heavy metal contents in the processed samples ranged from Fe/ 22.28 - 3.37mg/100g, Mn/12.34 - 48.8mg/100g, Pb/10.11 – 14.23mg/100g, Cr/10.23 – 38.41mg/100g respectively. The shaving treatments recorded significantly lower ($p<0.05$) heavy metals compared to the other singed treatments. The results of the sensory profile of the edible beef skin (*ponmo*) had the shaved samples and those from gas oven as the most preferred with mean values of 7.05 and 7.30 respectively which translates to moderately liked on the nine point hedonic scale.

Key words: quality, edible beef skin, *ponmo*, heavy metals, gas oven, wood, shaving stick,tyre

Introduction

“Meat is a valuable livestock product and for many people serves as their first-choice source of animal protein. It is either consumed as a component of kitchen-style food preparation or as processed meat products. Proteins in human diet are derived from two main sources, namely animal proteins (e.g. egg, milk, meat and fish) and plant proteins (e.g. pulses, cereals, nuts, beans and soy products). Animal proteins are more “biologically complete” than vegetable proteins with regards to their amino acid composition” (Sanusi, *et al* 2016) .

Skins of animals such as cows, goats, and sheep are utilized as raw materials in the manufacturing of leather goods, including shoes, bags, and belts. However, animal skins are considered edible in many parts of the world when further processed. In the United States, pork rind is a popular snack food manufactured from pork skins(Mikkilineni, 2021). In Jamaica, cow skin is traditionally used in soups and stews. Bender(1992) reported that cow skin soup is used to cure a hangover in Jamaica. In West Africa, cow skin is also used in soups and stews. The cow skin soup in West Africa is called Sopa Canja (Mikkilineni, 2021).

Foods from processed edible beef skin are extremely popular in South-Western Nigeria and southern Ghana. Processed edible beef skin popularly known as "*ponmo*" in South Nigeria, and "welle" in Southern Ghana serve as food delicacy in several parts of Africa (Okiel*et al.*, 2009; Akweteye*et al*, 2013) and it has become a preferred alternative for some consumers."The edible beef skin hair is traditionally removed from the hide by tenderizing the rawhide in hot water and then scraping by using sharp knives or razor blades" (Okafor*et al*., 2012). "There are two types of *ponmo*, the finished product due to dehairing the hide by shaving is called white *ponmo*, and the finished product due to dehairing by singeing is called brown *ponmo"* (Dada *et al*., 2018).

"Ponmo provides bulk to food, contribute to satiety value and provides some protein to the body system, though it does not have full complement of essential amino acids as in carcass meat" (Sanusi*et al*., 2016). However, there are controversies concerning its production. There have been several attempts by government to ban the production of *ponmo*due to health reasons as well as loss of revenue by processing of the hides into leather (Mikkilineni, 2021).
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Removal of hair from cattle hide in Nigeria is traditionally done by tenderization in hot water followed by scraping to obtain "*ponmo*" (Okiel*et al*., 2009). "In recent times however, singeing in processing of the cow hides is most preferred because it maintains the carcass hide for consumption and evokes meat flavors that are highly acceptable" (FAO, 1985).

The National Agency for Food and Drug Administration and Control (NAFDAC) in July 2019 warned the general public in Nigeria to minimize the consumption of *ponmo*, made of imported raw hides from other countries citing reasons that imported hides were pre-treated with chemicals for the manufacturing of shoes, bags, and belts; and, therefore, not suitable for human consumption. The leather industry has been facing troubles in Nigeria due to the consumption of contaminated *Ponmo* (Mikkilineni, 2021). This study seeks to evaluate the levels of nutrients, heavy metals and sensory properties of edible beef skin "*ponmo*" processed using different singeing methods.

Materials and methods

A total cut of twenty (20) edible beef skin were used for this experiment. The edible beef skin were collected from the cattle skin immediately after flaying before singeing at the abattoir in NkwoOgidi market, Idemili North Local Government Area Anambra State, Nigeria. Each fresh edible beef skin divided into four-quarters. Each piece of edible beef skin from the four quarters were randomly allocated to four treatments for processing using either singeing with wood, tyre , shaving or gas oven. Samples of the processed edible beef skin were taken from each treatment. Fresh clean water with sponge was used to wash off the charred surface to reduce the level of contamination on the carcass. The samples were stored in a freezer at -18°C prior to sample analysis.

Chemical and nutrient analysis

Moisture, Ash, fat, protein of the processed edible beef skin samples were determined according to AOAC (2000).

Determination of moisture

The moisture content was determined by the gravimetric methods as described by James (1995).

A known weight of 5g of each sample was dried at 105^{o}C in an oven for about 5 hours. The determination was done using a dish that had been previously

dried at above 105^{o}C and reweighed, after drying the dish and the sample was weighed after cooling. The weight of the moisture lost was determined by differences and expressed as a percentage. It was calculated as shown below;

$$\%Moisture = \frac{W_2 - W_3}{W_2 - W_1} \times 100\%$$

Where: W_1= weight of empty moisture dish

W_2= weight of dish and sample before drying

W_3= weight of dish and sample after drying

Determination of Total Ash

The ash content was determined using the furnace incineration gravimeter methods (AOAC,1990). Five grammes of each of the samples were weighed into porcelain crucible, which had previously been ignited and cooled before weighing. The crucible and sample are ignited first and gently and then at 500^{o}C. The ashing was carried out in a muffle furnace for about 5 hours. The crucible and the ash were cooled in a desiccator. The weight of the ash was obtained and expressed as a percentage given by the formula below;

$$\%\ Ash = \frac{W_2 - W_1}{Wt\ of\ sample} \times 100$$

Where:

W_1= weight of empty crucible

W_2= Weight of crucible + ash

Determination of Fat Content

Fat content of the samples were determined by the continuous solvent extraction methods using a Soxhlet apparatus. The method of Pearson (1976) and James (1995).

Five grammes of each of the sample were wrapped in a porous paper. The wrapped samples were placed in a Soxhlet reflux flask containing 200 ml of petroleum ether. The upper end of the reflux flask was connected to a condenser by heating the solvent in the flask. It evaporated and condensed into the reflux flask soon, the wrapped samples were completely immersed in the solvent and remained in contact with the solvent until the flask is filled up. This process was repeated for 4-5 hours before the defatted sample was removed and reserved for crude fibre analysis.

The solvent was recovered and the extracting flask with its oil content was dried in the oven at 60oc for 3 minutes to remove any residual solvent. After cooling in a desiccator, the flask was reweighed. The weight of Fat (oil) extraction were determined and expressed as a percentage of the sample weights.

$$\% \text{ fat} = \frac{W_2 - W_1}{\text{Wt of sample}} \times 100$$

Where:

W_1= Weight of empty extraction flask
W_2= Weight of flask and oil

Determination of Protein

This was determined by Kjeldahl digestion method described by James (1995). The total nitrogen was determined and multiplied with the factor 6.25 to obtain the protein. About 0.5g of the sample was mixed with 10mls of concentrated sulphuric acid, in a Kjedahl digestion flask. A Tablet of selenium catalyst was added to it and the mixture was digested under a fume cupboard until a clear solution was obtained. The acid and other reagent were digested but without sample to form the blank control. All the digests were carefully transferred to 100ml volume flask using distilled water and made up to a mark in the flask. A 100ml portion of each digest was mixed with equal volume of 45% NaoH solution in Kjedal distilling unit. The mixture was distilled and the distillate collected into 10ml of 4% boric acid solution containing three(3 drops mixed indicator Bromo cresol green and methyl red). A total of 50 ml distillate was obtained and titrated against 0.02N H_2SO_4 solution. The end point is from the initial green colour to a deep red point. The nitrogen content was calculated as shown below;

$$\% \text{ Nitrogen} = \frac{100 \times N \times 14 \times V_f}{Va} \times \frac{T}{W}$$

Where:W= Weight of sample analysed

N= Concentration of H_2SO_4

V_f= Total volume of digest

V_a= Volume of digest distilled

T= Titre value- blank

% Crude protein = % N x 6.25

HEAVY METALS ANALYSIS

The dried cowhides rolls were ashed at 500^oC and digested with2-3 cm^3 concentrated HNO_3 (nitric acid) and prepared for Atomic Absorption Spectrophotometer (AAS) analysis on a Perkin Elmer atomic absorption spectrophotometer, the solution was made with concentrated

HNO_3 and 10 mil distilled water. The heavy metals determined were lead, chromium, zinc, iron, manganese. Samples of the same cowhides were boiled for about one hour ashed and prepared for AAS analysis. The determination of the heavy metal level was carried out in duplicates.

Apparatus

Flame AAS

- AAS- 30 Carl Zeiss Jena (Germany) spectrophotometer with pneumatic nebulisation and mono- element lamps with hollow cathode made by photronNavva
- Electrodes; hanging mercury working micro electrode, silver- silver chloride reference electrode.
- Jenny muffle furnace
- Statistiza 5.5 plstatsoft for window 98 software.

Reagents/ solutions;

One-tenth N ammonium buffer. PH = 9.3, 0.2 N acetate buffer, PH=4.7 and PH= 3.5, 0.1 N Solution of dimethylglyoxine in 96% ethanol.0.2 N solution of hydroxyl quinoline in CCL_4,tin chloride(II)- 10% in HCL. Four grammes potassium- peroxydisulphate(VI) acid

Hydrochloric acid sp pure 98%. Working solutions of examined ions (lead, chromium, zinc, iron, manganese).

Sensoryevaluation

The sensoryproperties were determined using the method of Iwe (2010). The acceptability test of the edible beef skin samples were conducted using 20 member test panelists, comprising students of the University community who are conversant with edible beef skin consumption. The processed edible beef skin samples were prepared for sensory analysis by soaking in water for 24 h to make tender. The samples were evaluated for parameters such as taste, general acceptability, appearance, aroma, mouth feel, and chewiness. A descriptive 9 points hedonic scale rating as described by Iwe (2010) was used. They were instructed to score 9 for a parameter 'like extremely' and score 1 for 'dislike extremely'. The score of 5 represented neither like nor dislike.

STATISTICAL ANALYSIS

The experimental design used in this analysis was Completely Randomized Design (CRD) and the data was subjected to analysis of variance (ANOVA) at 0.05% level of significance to determine the statistical significance difference using Duncan Multiple range Tests (SPSS 1999).

Results and Discussion

The effect of singeing methods on the nutrient composition of edible beef skin samples is shown in Table 1.Shaved and wood singed edible beef skin samples were significantly ($P<0.05$) higher in crude protein content (8.27% and 7.85%) than samples singed with gas oven (7.12%) and tyre (7.16%) respectively. The crude protein values obtained in this study compared closely with those of Ademola *et al*. (2022) but did not agree with values reported by Sanusi *et al.* (2016) and Akweteye*et al.* (2013). These values are lower than values reported by Sanusi *et al*. (2016) in their study on the physico-chemical characteristics of edible hide (58.86%) and Akweteye*et al*. (2013) who reported protein value of 85.60 – 93.60% in chemical and nutrient composition of cattle hide ("*welle*") using different processing methods. The low protein value of the *ponmo* samples reported in this study could be attributed to lack of proper feeding as a result of open grazing being practiced in Nigeria. It has been reported that what Nigerians consume as meat is nothing but fibrous as the protein has been lost to trekking (Obansam, 2021) as a result of not embracing ranching which helps cows remain healthy, produce more proteinous meat and more milk. Moving cows from place to place as mostly practiced in Nigeria, stress the cows, make them lean and hardly produces nutritious meat and milk. Ani *et al*. (2018) reported crude protein value of 27.70 – 31.53% in their study on the effect of singeing methods on carcass qualities and sensory properties of red sokoto buck muscle.However, Ademola *et al*. (2022) reported "crude protein value of 8.77% in black singed *ponmo* using *Parkiabiblobosa* wood but reported 30.75% in white scaled *ponmo* using hot water at 100^{o}C. Cattle hide contains collagen which is one of the few proteins which has hydroxyproline (12.8%) in its primary repeating structure; glycine-proline-hydroxyproline (Lawrie, 1991), which is responsible for the thermal stability of the collagen and hence the extent of heat processing has little effect on it and the amino acid contents and availability". Cross and Overby (1988) and Lawrie (1991) suggested that "heat treatment influences the protein content of food substances". The heat intensity from the singeing process as indicated by Girard (1992) results “in the degradation of essential amino acids and also presumably vitamins. Cow hide is mostly made up of collagen and elastin and therefore have different amino acid profile”. “Cow hide is subjected to high level of heat processing, hence the meat is said to be deficient in essential amino acids like lysine because it is mainly made up of collagen and further high temperature treatment reduces the protein quality” (Essumang*et al*., 2007). “Meat cuts of cow hide are richer in connective tissue and have lower protein quality” (Bender, 1992).

The percentage moisture content of the shaved sample was higher (51.42%) than the other samples. This was closely followed by *ponmo* singed with tyre (50.72%). The lowest moisture content values were recorded. *Ponmo* singed with wood (49.04%) and gas oven (45.73%). Ademola *et al*. (2022) reported moisture content of 23.80% in white scaled *ponmo* and 67.02% in black singed *ponmo*. The moisture content range reported in this study is also in accordance with Maduforo (2016) who reported 72.57% for raw cow hide and 68.08% for cooked cowhide.The high moisture content observed could be as a result of the soaking operation during processing of *ponmo*. Heat processing makes the collagen fibre to shrink and loose more moisture due to high temperature (180^{o}C).

“The mean values reported for fat contents in this study were in the range of 1.16 – 1.45 %. The variations in temperature of the thermal treatments applied may be responsible for fat losses observed due to the degradation of the fatty acid by heat treatment”. (Alflaia et al., 2010)This finding is in agreement with the findings of (Apata, 2014) that reported “lower fat content in meat samples prepared with hot water over those singed with rubber tyre and firewood”. “Meat composition, especially its fat content, combined with specific heat treatment methods is among the factors that mostly affect the final quality of meat products” (Alflaia*et al*., 2010). “Thermal treatments can cause undesirable changes, such as loss of essential fatty acids, mainly due to lipid oxidation, reducing the nutritive value of meat. Several factors may affect the level of fat in a meat sample. In the case of cow hide, one of these factors is processing method. Cow hide processing involves extensive heat treatment which can burn up the fat during the processing period”. (Essumang*et al*., 2007; Essumang*et al*., 2011).

The effects of the singeing methods on some of the heavy metal contents identified in the edible beef skin are presented in Table 2. The sample singed with firewood had the highest value for chromium 38.41mg/100g and lead 14.23mg/100g; this was closely followed by the tyre singed cattle hide samples with lead content value of 13.35mg/00g. The type of wood used for the singeing could have caused the rise in the value of chromium and lead. The shaved samples recorded the lowest values of chromium and lead, 10.23 mg/100g and 10.211mg/100g respectively. The samples recorded zinc and iron content levels within the range of 35.42 – 49.57 mg/100g and 22.28 – 39.37 mg /100g. The observed metal levels in all the processed edible beef skin were far below the maximum permissible levels in meats. These results to some extent support some previous assertions that partially the processing methods used and environmental conditions attributed heavy metals in cattle hide (Ademola *et al*., 2022). It has also been reported that there was a close relationship between heavy metal concentration in cattle tissues with their concentrations in the soil, feed and sources of drinking water (Ademola *et al*., 2022; Cai *et al*., 2008).Singeing with scrap tyres and certain types of wood pose great health challenge as well as an environmental hazard. “These fuel sources may contain potentially toxic substances like furans and benzene which could contaminate the hides and render them unfit for human consumption” (USFA, 1999; Obiri-Danso*et al*.,2008).“Among other environmental pollutants, tyres also contain several metals such as lead, mercury, cadmium, chromium, zinc and arsenic which could contaminate hides when these were used as sources of fuel for singeing” (IAFC, 2000; OECD, 2004).

The result of taste panelist on sensory properties of edible beef skin is presented in Table 3. The result indicated that the processing methods influenced the sensory scores for appearance, taste, aroma, mouth feel, chewiness and overall acceptability of the singed edible cowhide. Appearance (colour) is the first sensory assessment parameter for meat and meat products qualities (Omojola*et al*., 2014). The appearance of the edible cowhide samples were significantly different ($p<0.05$). The shaved samples had the highest mean score of 8.15 which translates to like very much on nine point hedonic scale. This was closely followed by samples singed with wood (7.55) and gas oven (7.15) which were rated as moderately liked. The sample singed with tyre had the lowest mean score of 4.60 (slightly dislike) for appearance. This could have been affected b the chemical components of the tyre. The members of the taste panel rated a score of moderately liked for chewiness for samples singed with wood (7.65) and gas oven (7.70). There were also differences ($p<0.05$) in the panel score for the overall acceptability of the samples. Sample singed with gas oven was rated 7.30 (moderately liked) and was closely followed by the shaved sample which was rated 7.05 (moderately liked).

Conclusion

The edible beef skin samples had protein content values in the range of 7.12 – 8.27% with the shaved sample having 8.27%. The result of the general acceptability of the edible beef skin sample also showed that the edible beef skin processed using gas oven and shaving were most preferred (7.05 and 7.30) by the member of the panel and these values translates to moderately liked. More study should be carried out on the best method of producing edible beef skin in Nigeria using advanced methods free of contamination since it has been established that most people enjoy eating delicacies prepared using edible beef skin.

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Table 1. Nutrient composition of edible beef skin samples (%)

Singeing Methods	Moisture	Ash	Ether Extract	Crude Protein
Wood	$49.04^{a} \pm 0.83$	$1.95^{a} \pm 0.00$	$1.45^{a} \pm 0.00$	$7.85^{b} \pm 0.00$
Gas oven	$45.73^{b} \pm 0.24$	$1.90^{a} \pm 0.01$	$1.22^{c} \pm 0.03$	$7.12^{c} \pm 0.00$
Tyre	$50.72^{a} \pm 1.24$	$1.75^{b} \pm 0.04$	$1.28^{b} \pm 0.01$	$7.16^{c} \pm .00$
Shaving (control)	$51.42^{a} \pm 1.33$	$1.99^{a} \pm 0.99$	$1.16^{c} \pm 0.00$	$8.27^{a} \pm 0.50$

***** Means with the same superscript within each column are not significantly different ($P>0.05$), but means without the same superscripts within each column are significantly different ($P<0.05$).

Table 2. Heavy metal concentrations of edible beef skin samples (mg/100g)

Singeing Methods	Chromium	Zinc	Iron	Lead	Manganese
Wood	$38.41^{a}\pm1.32$	$36.84^{a}\pm3.46$	$22.28^{a}\pm3.71$	$14.23^{b}\pm6.10$	$12.34^{a}\pm1.01$
Gas oven	$10.32^{b} \pm 0.44$	$35.42^{a} \pm 1.12$	$37.40^{b}\pm1.00$	$10.12^{ab}\pm1.26$	$45.66^{b}\pm10.11$
Tyre	$10.44^{b}\pm1.40$	$49.57^{b}\pm1.96$	$39.37^{b}\pm6.39$	$13.35^{a}\pm2.22$	$40.64^{b}\pm12.71$
Shaving (control)	$10.23^{b}\pm0.12$	$39.31^{b}\pm0.11$	$35.32^{b}\pm0.23$	$10.11^{ab}\pm0.56$	$48.98^{b}\pm17.46$

* Means with the same superscript within each column are not significantly different (P>0.05), but means without the same superscripts within each column are significantly different (P<0.05).

Table 3: Sensory profile of edible beef skin samples

Singeing Methods	Taste	Appearance	Aroma	Mouth feel	Chewiness	General Acceptability
Wood	6.80^{a}±1.20	7.55^{ab} ± 1.23	7.10a±1.25	6.95^{a}±1.19	7.65^{a}±0.99	6.35^{b} ± 1.09
Gas oven	7.45^{a}±1.23	7.15^{b} ± 1.39	7.55a±1.19	6.95^{a}±1.43	7.70^{a}±0.80	7.30^{a} ± 1.17
Tyre	5.50^{b}±0.95	4.60^{c} ± 1.00	5.30b±1.13	3.30^{b}±1.34	4.20^{c}±0.89	4.15^{c} ± 1.18
Shaving (control)	7.40^{a}±1.23	8.15^{a} ± 0.93	5.45^{b}±0.95	5.45^{b}±1.17	6.45^{b}±1.15	7.05^{ab} ± 1.32

***** Means with the same superscript within each column are not significantly different (P>0.05), but means without the same superscripts within each column are significantly different (P<0.05).