Journal of Agriculture, Food, Environment and Animal Sciences
Tarım, Gıda, Çevre ve Hayvancılık Bilimleri Dergisi
http://www.jafeas.com, ISSN: 2757-5659

J. Agric. Food, Environ. Anim. Sci.
4(2): 230-242, 2023

Development and Assessment of Quality Attributes of Chevon Bacon *Capra aegagrus hircus* (Goat)

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Research Article

Article History:
Received: 12 September 2023
Accepted: 18 November 2023
Published online: 15 December 2023

Keywords:
Chevon
Bacon
Quality
Acceptability
Sensory

ABSTRACT

To help goat farmers in value addition and improve return on their farming activities, a study was carried out to develop and study the acceptability of chevon bacon. Thigh, loin and rump muscles from goat carcasses were trimmed, injected with brine solution and cured for three days at 2-5°C. The muscles were drained and smoked before being placed in a preheated oven at 60-70°C for one hour. Pork bacon was bought from the market to compare with chevon bacon. Analyses for crude protein, fat, calcium, phosphorus, iron, zinc and residual nitrate/nitrite content were carried out. Microbial analyses for total bacterial count, *Escherichia coli* and *Staphylococcus aureus* were done. Sensory evaluation was also conducted using a 9 point hedonic scale. Results were analysed using the Statistical Analysis System (SAS) version 9.4 (SAS, 2012). Pork had four times more fat than chevon bacon. Iron content of chevon was fourfold that of pork at 2.95 mg and 0.72 mg respectively. Zinc content of pork was half that of chevon. Both bacons were negative for *Escherichia coli* and *Staphylococcus aureus*. Chevon bacon had lower modal scores on aroma and mouthfeel than pork bacon. On the basis of the odds ratios, the panelists were 3.77 times more likely to prefer chevon bacon for its overall flavour. Using the principal component analysis results, mouthfeel and initial juiciness were the main determinants of preference for chevon bacon. Valorisation of goat meat has the potential to drive farmers to rear more goats and increase their incomes and livelihoods.

To Cite : Rusike J, Hamandishe VR., Saidi PT, Imbayarwo-Chikosi VE., 2023. Development and Assessment of Quality Attributes of Chevon Bacon *Capra aegagrus hircus* (Goat). Agriculture, Food, Environment and Animal Sciences, 4(2): 230-242.

INTRODUCTION

Traditionally, bacon used to be produced from pork. Lately, in Zimbabwe, a few beef bacon lines have been introduced. Bacon consumption used to be associated with affluence. This perception is fast changing due to diverse consumer habits, rural to urban migration, improved disposable incomes, availability of varied product range and valorisation of raw materials (Chigudu and Chavunduka, 2021). Market acceptability of chevon bacon as an alternative to pork bacon will be a remarkable change to the normal daily menu. A range of products are offered on chevon menu except bacon.

Zimbabwe is faced with a thrust to improve household and farmers' returns through value addition, VISION 2030. When the word bacon is mentioned, it is associated with processed pork. However, this definition has since changed to include any cured and smoked meat product due to changes in consumer preferences and industrial technological advancement (Chalupa-Krebzdak and Bohrer, 2020).

There are 4.3 million goats and 5.5 million cattle in Zimbabwe (Masuka 2021). Eighty-nine percent of the goats are indigenous breeds owned by smallholder farmers (Sikosana et al., 2015). Goats are slaughtered and consumed as raw-cooked chevon. Various dishes are prepared from goat meat. Chevon, usually mixed with beef or pork, is used to produce sausages and other product lines except for a cured smoked product. Production of bacon from chevon would be an opportunity for producers or processors to increase product diversity offered to the market and improve plant utilisation capacity as well.

Goats are not expensive animals to rear compared to cattle or pigs. They thrive even in arid and semi-arid regions IV and V of Zimbabwe. The feeding behavior of goats is influenced by the presence and abundance of available feeds and vegetation. The goats possess the capability to transition between grazing and browsing behaviors, contingent upon the presence and abundance of vegetative resources. With good animal husbandry and support, goats multiply rapidly and give good returns to investors. Communal farmers' livelihoods are positively impacted by rapid returns from goat rearing and selling. Processing will offer lucrative returns to the producers.

Young does and wethers, usually referred to as kids (less than one year old), produce good quality chevon. Upon slaughtering beasts of the same grades, the following cold dressing weights were obtained: goat 56.6%, cattle 43.3% and sheep 49.6% (Akpa, et al., 2017). Goats therefore had better yield than cattle. With better multiplication rate and better carcass dressing weight than cattle, goats are an idle draw card for the community. Cattle take long to mature and multiply whilst pigs' feeds are expensive. Some customers shun pork products for religious reasons, leaving goats as a preferred alternative.

Selling raw goat meat does not entice farmers to rear goats as the prices are depressed. Price distortions from raw product consumers and middlemen affect industrial supply

chain. An improvement in goat numbers supplied to the processing plants is a welcome development for depressed industrial slaughtering capacity. The nation has excess slaughtering capacity for cattle, which may be used for goat processing as well. Limited quantities of chevon and its products are seen in retail shops and major retail outlets in Zimbabwe do not have cured goat products on display.

Webb (2014) established that goats have red lean meat with favourable nutritional attributes. Acceptability of chevon bacon to the Zimbabwean market has a positive bearing on both farmers through increased throughput and consumers through improved product diversity and improved nutritional attributes. The market has been saturated with raw red meat products, processed and cured pork products. Not much attention is being given to goat meat products even if they are a source of wealth and livelihood for the farmers. Without value addition, the rural population will remain poor even if they have abundant goats. Value addition increases return on investment. Improved returns encourage farmers to improve goat rearing. The nutritional benefits of low fat content, high iron and zinc content, may only be harnessed through processing and consumption of chevon in multiple product range. The overall objective therefore was to develop and assess the quality and acceptability of chevon bacon, *Capra aegagrus hircus*.

MATERIALS and METHODS

Brine Preparation

Brine solution was made from 1.3 kg of Instant Cure from Freddy Hirsh with 6.25% sodium nitrite, mixed with 10 litres of ice-cold water (0-2) ℃. The brine was kept refrigerated in vats. The refrigeration temperature was kept at a temperature range of 1-5℃.

Chevon Meat Selection and Injection

Loins and legs of commercial grade goat carcasses were bought from a butchery. Loins and legs were deboned with stainless steel deboning knife on a deboning board. Each deboned primal was trimmed to shape and size. Individually trimmed cuts were limited to less than 3 kg and thickness to less than 40 mm. Injection needles were used to pump 20-50 ml of curing brine into each primal. The injected primals were submerged in curing brine for 72 hours at 5℃ in 10 litres curing containers.

Primal Draining

Each cured piece was placed on a rack and allowed to drain in a chiller at 5℃.

Smoking

Liquid smoke was used to smoke the muscles. It had the same effect on meat as application or use of smokehouses. Each cured primal was independently brushed

with liquid smoke. To be effective, the liquid smoke was generously applied to the cured product.

An oven was preheated to 60°C. Cured-liquid-smoked primals were placed in the preheated oven for 1 to 1.5 hours to enable adequate smoke adsorption and absorption. After smoking, the bacon was allowed to cool to room temperature.

Storage

Cooled bacon was frozen at -10°C for a minimum of 24 hours. The product was stored frozen to enable product firming and avoid loss of the smoked bacon flavor.

Bacon Preparation

Frozen bacon was drawn from the freezer and allowed to thaw in a chiller at 5°C prior to slicing and storage in a chiller. A sharp knife was used to produce thin bacon slices. A pan was placed on a stove whose temperature was set at 110°C. Cooking oil (40 ml) was added to the frying pan. Chevon bacon slices were fried in the pan for 5 minutes. Control bacon slices from the market (pork bacon) were treated the same.

Proximate and Nitrite Analysis

Chevon bacon and pork bacon samples were subjected to proximate analysis using AOAC methods of 2005. The samples were analysed for dry matter (DM), ash, fat, crude protein and crude fiber (AOAC, 2005). For nitrite determination, the Association of Official Analytical Chemists method 973.31 procedure was used (AOAC 2000).

Microbiological Analyses

Twenty gram samples of bacon were cut into small pieces using a sterile sharp blade. The shredded pieces were placed in sterile distilled water in a test tube. The suspension was thoroughly mixed. Ten milliliters were pipetted and placed in a sterile test tube. Four serial dilutions were made, taking 1 ml from each sequential test tube.

Total Viable Counts (TVCs) were cultured on nutrient agar at 37°C for 48 hours before colony counting was done. *Escherichia coli* was detected on MacConkey agar and incubated at 35°C. Colony counting was done after 48 hours. For *Staphylococcus aureus*, Mannitol Salt agar was used as a selective and differential medium for the isolation and identification of the bacteria. Incubation was done at 35°C for 48 hours.

Sensory Testing

According to ISO 5495 (1983) a sample size of more than one hundred is acceptable when untrained assessors are used. A sample of 210 untrained sensory evaluation assessors was randomly picked. The sample included willing ordinary customers, university students and staff members.

Chevon bacon and pork bacon were prepared by frying and served to the assessors. For religious and health reasons, the assessors were pre-informed about the presence of chevon and pork bacon. A 9-point hedonic test was used to conduct the assessment.

The scale had 1 as the least acceptable score and 9 as the extremely acceptable score. Attributes of aroma, juiciness, colour, bite, mouth feel and overall flavor were assessed.

Statistical Analysis and Experimental Design

The experimental design used was a completely randomized design. The data from the experiment was analyzed using Statistical Analysis System (SAS) (2012) where Chi-square, Principal Component Analysis and Analysis of Variance (ANOVA) were applied to the data.

Data analyses were in three stages which were descriptive statistics, effect of treatment on sensory parameters and Principal Component Analysis (PCA). The Analysis of Variance (ANOVA) was used to test if there was a statistical difference between means of group data set. Covariance matrix was calculated before determination of eigenvectors and eigenvalues. The data was recast along the principal component axis.

RESULTS

Nutritional Composition of Bacons

The proximate composition and chemical analyses results of chevon bacon and pork bacon are shown in **Hata! Başvuru kaynağı bulunamadı.**1. The results showed that there was a significant difference between pork bacon and chevon bacon on fat, iron and zinc ($p<0.05$). Fat from pork bacon was fourfold that of chevon bacon. Chevon bacon had more iron and zinc compared to pork bacon. The protein content was the same. Calcium and phosphorus were not significantly different. The nitrite results for both chevon and pork were not significantly different ($p > 0.05$).

Table 1. Comparison of nutritional composition (g/100 g meat sample), mineral content and residual nitrites levels (mg/kg meat sample) in chevon and pork bacon

	Chevon bacon	Pork bacon	SEM
Crude fat	2.49^{b}	11.45^{a}	±0.036
Crude protein	25.17	25.45	±0.143
Calcium	13.44	15.03	±0.030
Iron	2.95^{a}	0.72^{b}	±0.0158
Phosphorus	158.97	187.12	±1.899
Sodium	68.03	49.3	±1.864
Zinc	4.17^{a}	1.89^{b}	±0.192
Residual nitrite	8.65	11.35	±0.111

a,b Within a row, means with different superscripts differ ($p < 0.05$)

Microbiological Quality of Bacons

The microbial evaluation of chevon and pork bacon showed no statistically significant difference between the two. Table 2 shows the results obtained against the standards.

Table 2. Microbiology of chevon and pork bacon

Test	Standard	Chevon bacon	Pork bacon
Total viable count (cfu/g)	$<1x10^6$	$1x10^2$	$1x10^3$
E. coli (cfu/g)	< 10	0	0
S. aureus (cfu/g)	< 20	0	0

Sensory Evaluation

The results from sensory analysis showed that the scores were not normally distributed. Therefore, the descriptive statistics were presented as median and mode scores as shown in Table 33. The modal score enabled easy assessment as it depicted the most frequently scored point for that attribute. Pork bacon had more scores than chevon bacon in terms of aroma and mouth feel.

Table 3. Scores for sensory evaluation

Treatment	Variable	n	Median score	Modal score	Minimum score	Maximum score
Chevon bacon	Aroma	210	7	6	3	9
	Initial juiciness	210	7	8	2	9
	Colour	210	7	8	3	9
	Bite	210	7	8	2	9
	Sustained juiciness	210	8	8	2	9
	Mouth feel	210	7	6	1	9
	Overall flavour	210	8	8	1	9
Pork bacon	Aroma	210	8	8	5	9
	Initial juiciness	210	8	8	6	9
	Colour	210	8	8	5	9
	Bite	210	8	9	5	9
	Sustained juiciness	210	8	9	6	9
	Mouth feel	210	8	8	6	9
	Overall flavour	210	8	8	5	9

Association between Age, Gender and Sensory Parameters

The associations between gender, age, and sensory parameters were evaluated using the nominal logistic regression. Table 4 reveals the overall results of the logistic regression for all the sensory parameters. All sensory parameters were significantly influenced by treatment (P<0.05). Colour of the sample, bite, sustained juiciness and overall liking were negatively associated with the age of panelists (P<0.05). There was no association between the gender of the panelists and all the sensory parameters that were evaluated in this study (P>0.05).

Table 4. Association between sensory parameters, age and gender of panellists

Sensory parameter	Regressor variable	β-value	s.e.	P-value
Aroma	Age	0.050	0.0988	0.6132
	Gender	-0.049	0.1765	0.7832
	Treatment	-0.111	0.1826	<0.0001*
Initial juiciness	Age	-0.156	0.1001	0.1189
	Gender	-0.161	0.1783	0.3663
	Treatment	-1.069	0.1842	<0.0001*
Colour	Age	-0.454	0.1023	<0.0001*
	Gender	-0.336	0.1786	0.0603
	Treatment	-1.309	0.1874	<0.0001*
Bite	Age	-0.287	0.1005	0.0042*
	Gender	-0.291	0.1778	0.1019
	Treatment	-1.035	0.1830	<0.0001*
Sustained juiciness	Age	-0.228	0.1007	0.0238*
	Gender	-0.280	0.1790	0.1171
	Treatment	-0.945	0.1834	<0.0001*
Mouthfeel	Age	-0.097	0.0997	0.3298
	Gender	-0.345	0.1787	0.0537
	Treatment	-1.439	0.1890	<0.0001*
Overall flavor	Age	-0.297	0.1033	0.0041*
	Gender	0.048	0.1823	0.7907
	Treatment	-1.322	0.1943	<0.0001*

*Significant at P<0.05

Odds for Preference

On the basis of the odds ratios, the panelists were 3.77 times more likely to prefer chevon bacon over pork bacon for its overall flavour. The odds for preferring chevon bacon over pork bacon for all the other sensory parameters ranged from 2.92 (initial juiciness) to a high of 4.22 (mouth feel).

The patterns of preference according to age group were varied but generally, when compared to age class 5 (50+ years), panelists in age class 3 (31-40 years) were more likely to prefer chevon bacon than pork bacon on the basis of overall flavour.

Principal Component Analysis

The PCA was carried out to determine the main components that influenced preference for the two types of bacon. Figure 1, shows the loadings for the chevon bacon (Treatment 1). According to the panelists that were used in this trial, the main drivers of preference for chevon bacon were aroma, initial juiciness and mouth feel. These constituted the principal component 1 (One). On a minor scale, the major determinants of preference for chevon bacon were overall flavour, sustained juiciness and bite.

The loadings for treatment 2 (pork bacon) are illustrated in Figure 2. The main determinants of preference for pork bacon were identified as initial juiciness, sustained juiciness and mouth feel. For both pork and chevon bacon, mouth feel and initial juiciness were the main determinants of preference.

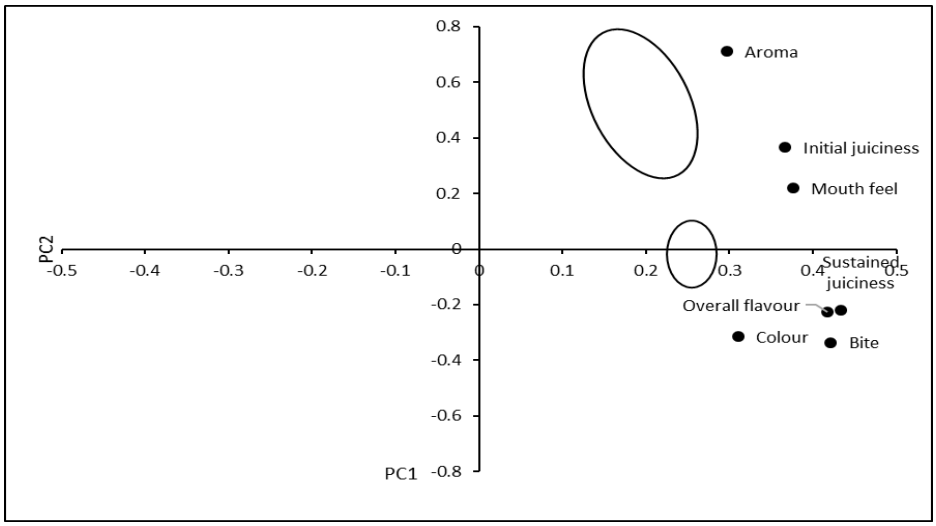

Figure 1. PCA Loadings for treatment 1(chevon bacon)

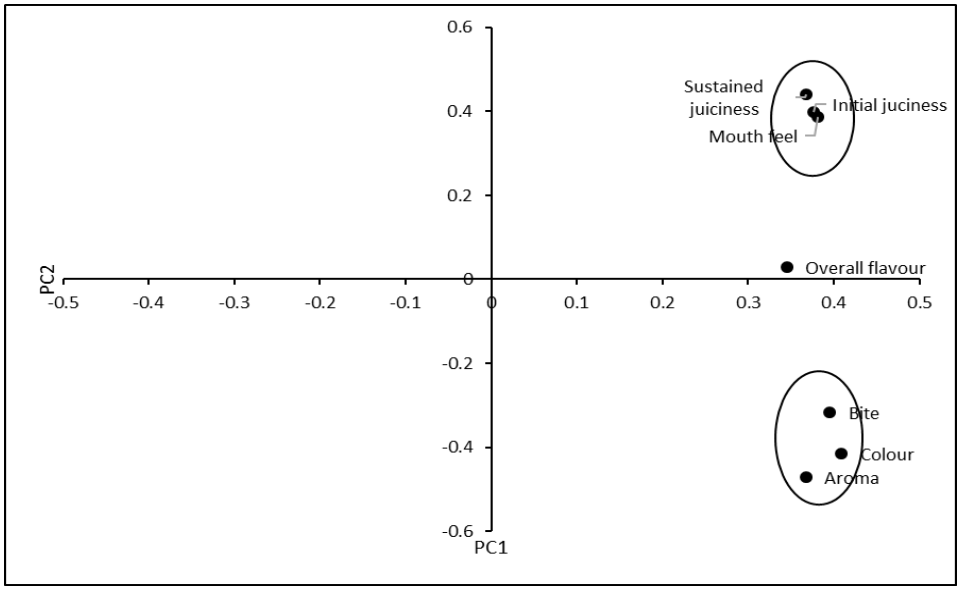

Figure 2. PCA Loadings for treatment 2 (pork bacon)

DISCUSSION

A rich golden brown pleasant smelling chevon bacon product was produced. The proximate analyses showed more fat in pork bacon than chevon bacon because as pigs mature, they deposit more fat than muscles, in their body. According to Mazhangara et al. (2019) and Nuhriawangsa et al. (2021), chevon has low fat and cholesterol but high polyunsaturated fatty acids (PUFA) compared to other red meats and pork. Foods with high fat content like pork bacon are associated with cardiovascular diseases, high blood pressure, diabetes, fatty liver and cancer while chevon bacon with low cholesterol and saturated fat content, improve blood cholesterol and ease inflammation (Kazhybayeva et al., 2019). Modern consumers are more health conscious hence chevon bacon becomes a favorable alternative.

Iron plays a major role in blood oxygen transportation as hemoglobin and as myoglobin which provides oxygen to the muscles. With a fourfold yield from chevon bacon compared to pork, chevon is a better option on iron supply upon consumption. Zinc is key for thyroid functioning, immune functioning, wound healing and blood clotting (Bhowmik et al., 2010). Zinc is able to compete between host and pathogen, a concept called nutritional immunity (Haase and Rink 2014). With chevon bacon providing double the quantity being yielded by pork, this may be a better source of the nutrient. The residual nitrite levels obtained were below maximum permissible levels of 120 ppm showing that the nitrite levels were within safe limits for human consumption (Ferysiuk and Wójciak 2020). Residual nitrite, is key to meat preservation, colour, taste and toxicology (Bedale et al., 2016).

Sensory evaluation of food products is key as it reflects the consumer's feel and perceptions of the product. Upon assessment of the modal classes, which is the

maximum occurring frequency, chevon was less preferred in terms of the aroma and mouthfeel which scored a modal class of 6 compared to pork with a class of 8. For goat meat products, aroma may be influenced by the release and emission of 4-methyloctanoic acid, a natural compound mainly responsible for the characteristic goaty sheepy flavour of sheep and goat milk (Apata et al., 2016, Watkins et al., 2021). As goat meat for the trials was bought from a retail outlet, the sex and age of the goat could not be ascertained. 'Goaty flavour' is associated with old uncastrated goats. To counter that unpleasant aroma drawback, young castrated bucks or females are to be used for commercial chevon bacon production.

The relationship between age of panellists and sensory attributes showed that the colour, bite and sustained juiciness of the bacons was negatively affected by age. A study carried out in South Africa concluded that age of consumer negatively influenced goat meat consumption and that older people were less willing to consume goat meat (Ibrahim et al., 2020). Chevon bacon was accepted by younger individuals showing that there is potential for acceptance if commercially launched.

Gondekova et al. (2014) and Popoola et al. (2021) noted a difference in gender preference when tests were done on meat consumption patterns. However, gender did not have an effect on acceptability of chevon bacon. These results concur with findings by Aslam et al. (2022), who concluded that there is no gender bias in mindful eating habits amongst adult students.

The higher likelihood for preference of chevon bacon over pork bacon for its overall flavor showed that overall flavour has a strong bearing on acceptability and desire to purchase a product (Xu et al., 2023). From PCA analysis for both pork and chevon bacon, mouth feel and initial juiciness were the main determinants of preference. It is important to maximize on such attributes when producing and marketing chevon bacon.

CONCLUSIONS and RECOMMENDATIONS

The study showed that chevon bacon has the same protein, calcium, potassium and sodium content compared to pork. It has however superior attributes in the form of low fat content and high iron and zinc than pork bacon. The sensory evaluation results of chevon bacon showed that there is potential of acceptability of chevon bacon by customers. There is need to do further research using castrated bucks or does to eliminate the 'goaty flavour' drawback from aroma evaluation. With the abundance of goats in Zimbabwe showing a positive growth trajectory, it is imperative that chevon valorization is taken seriously. This has the potential to drive farmers to rear more goats and increase their incomes and livelihoods.

Conflict of Interest

The authors declare that there are no competing interests.

Authors Contribution

The authors contributed equally to the manuscript

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