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Descriptive Sensory Characteristics of Meat from Grower Rabbits Fed on Fermented Ground Mature *Prosopis juliflora* Pods Based-diets

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Abstract: The effect of inclusion of graded levels of fermented ground mature *Prosopis juliflora* pods (FGMPP) replacing maize grain in grower rabbits' diets on sensory attributes was investigated. Thigh muscles were obtained from 12-week-old rabbits fed on five diets comprising: control (formulated standard grower diet), 15% UGMPP, 30% UGMPP, 15% FGMPP and 30% FGMPP replacing maize in standard grower diets. Deep-frozen meats from the rabbits were thawed and boiled in different aluminium pots, cut into small pieces of about 2 cm^3 placed in ceramic plates and presented to 12 panellists. Questionnaires were used for sensory attribute profiling. Data were analysed using SPSS Statistics 25.0.0 and the general linear model (GLM) of Statistical Analysis Systems (SAS) softwares for Principal Component Analysis (PCA) and analysis of variance (ANOVA) respectively. Tukey's range procedure was used to separate means at ($p<0.05$) significance. The PCA indicated that grittiness, particles, oiliness, colour, salty taste and oily taste contributed greatest to the observed variability. According to ANOVA, there was no treatment effect ($p>0.05$) in overall rating, appearance, flavour and colour of the meat. However, there was treatment effect ($p<0.05$) on beefy taste, tenderness, salty taste and grittiness. The study concluded that 30% maize grain in the diets of grower rabbits can be replaced with FGMPP as it did not affect consumer preference of the meat.

Keywords: Carcass, Fermentation, Mature *Prosopis juliflora* Pods, Grower Rabbits, Sensory Evaluation

1. Introduction

The steady increase in human population in African countries has resulted in sub division of available land for human settlement. This has caused a decrease in land available for food production while the demand for food continues to rise [1, 2]. The economic reality for these countries is to reduce food importation by increasing production of livestock species that are easy to rear and cost-effective, given the available land and resources [1]. Among the available options, rabbit production and rabbit meat consumption has been identified as a suitable sustainable alternative animal protein source [3]. Rearing rabbits is attractive in terms of their feed consumption which is low and diverse, ease of rearing and home consumption; a rabbit can be eaten in one meal, presenting no conservation problems [4]. Rabbit production and meat consumption is therefore, a feasible option to meet the demands of consumers and ensure animal protein supply thereby preventing malnutrition [3]. However, rabbit performance is low. This is due to fluctuation in feed quality and prices as a result of the use of cereals and agricultural by-products as feed ingredients. They are mostly rain-fed and also food for man resulting in inadequate supply especially during periods of scarcity [5].

There have been efforts to explore and use non-conventional feed ingredients such as mature Prosopis pods with positive results on livestock growth performance [6]. There was no significant (p>0.05) effect on consumer preference of meat from indigenous chicken fed mature *Prosopis juliflora* pods [7]. Also, toxicological tests done on rats by Wamburu et al. [8] reported that mature Prosopis pods exhibited LD_{50} that exceeded 5000mg/kg and was therefore safe for use by humans and animals with a degree of safety and tolerance. However, reports by Odero-Waitituh et al. [9] indicated that high tannins (8%) and crude fibre (CF) (17%) in the pods interfered with livestock performance with recommendations that treatment could reduce the concentrations of tannins and CF and therefore improved livestock performance could be realised. Several studies have reported improvement in nutritional value and reduction in anti-nutritional compounds. According to Yusuf et al. [10] and Odero-Waitituh et al. [11], spontaneous fermentation of decorticated *Prosopis africana* seed meal and mature *Prosopis juliflora* pods enhanced crude protein (CP) and essential amino acids while CF was reduced resulting in improvement of broiler and rabbit growths were respectively.

Generally, sensory attributes of meat are influenced by animal genetics and prevailing animal environment, with feed factors forming the larger part of the environmental effect [12]. Proper animal nutrition management not only affects livestock health, welfare and productivity but also the quality and safety of animal products. It also safeguards consumers against diseases and poor health. It is therefore important to observe and practice all animal management aspects and practices that will ensure that product quality and safety is not compromised [13]. Studies indicate that consumer food choices for meat and meat products are influenced by the understanding of the effects of the meat on their health, descriptive sensory attributes of the products and reasonable prices [14]. Evaluation of sensory attributes of meat allow producers to develop more precise knowledge about consumer attitudes and perceptions related to food products and ensure that the animal product produced is acceptable to consumers [15, 16]. This study evaluated descriptive sensory characteristics of meat from grower rabbits as affected by feeding fermented ground mature Prosopis pods-based diets.

2. Materials and Methods

2.1. Study Site

The feeding experiment was conducted at the rabbit unit, Tatton Agriculture Park, Egerton University, Kenya. The descriptive sensory evaluation was carried out at the sensory room, Guildford Dairy Institute, Dairy, Food Science and Technology Department of Egerton University. Egerton is located at latitude 0° 23'S and longitude 35° 57'E with an altitude of 2,238m above sea level. It has a mean daily temperature of 21°C. There is a bimodal rainfall pattern (March to May and June to September) with a mean annual rainfall of 900 - 1,020mm [17].

2.2. Dietary Treatments, Experimental Design and Meat Sample Collection

The rabbits were fed five diets that were formulated to grower rabbit requirements [18]. They comprised; 30% UGMPP; 15% UGMPP; 30% FGMPP; 15% FGMPP and control. In a randomized complete block design (RCBD), five dietary treatments were randomly allocated to 60 grower rabbits (30 bucks and 30 does) with four replicates per treatment. Each experimental unit comprised 3 rabbits. On the 42^{nd} day of the experimental period, one rabbit from each experimental unit was selected randomly, numbered, and fasted overnight with *ad-libitum* provision of drinking water before slaughter. Slaughtering was done according to the welfare law [19]. The rabbits were slaughtered following the cervical dislocation method, bled then skinned and eviscerated [20]. Good manufacturing practices were observed at all times. The meat was frozen for 2 weeks before analysis.

2.3. Training and Selection of Panellists

Selection of panellists was done by administration of pre-screening questionnaires to 20 candidates. The pre-screening questionnaires included questions about availability, food habits, flavour, texture and aroma of different products and questions about allergenicity to meat-based products. This was done to select candidates who were verbal about sensory properties and able to participate in the rabbit meat sensory evaluation. During the orientation sessions, the panel agreed on the attributes to use for evaluation, evaluated several meat samples from the rabbits offered (control/reference diet, 30% FGMPP and 30% UGMPP inclusion diets) and rated their intensities (agreed upon by consensus by the panellists). The samples were used as warm-up samples and were provided to the panellists to enable them to identify the intensities and develop the sensory lexicon during the tasting sessions. From the pre-screening questionnaires, 12 of the candidates were selected according to the procedure by Meilgaard et al. [21] as verbal concerning sensory properties. They were then trained on both qualitative and quantitative meat discrimination. During the training, the following sensory lexicon with 15 descriptors was developed (Table 1).

2.4. Sensory Evaluation

Frozen meat samples, in different containers, were thawed using running tap water for 6 hours. This was followed by sample preparation by boiling for 40 minutes in different aluminium pots labelled with random three-digit numbers. The boiled meats were then cut into small pieces of about 2 cm^3 using a kitchen knife. Ceramic plates divided into five portions (according to the assigned codes) were used to present the cut meat samples to the panellists. Stainless steel fork and knife were also availed to every panellist. Water was provided for cleansing and rinsing the palate between samples. The panellists evaluated the meat samples for appearance, aroma and flavour using the sensory descriptors developed during training.

Table 1. *Sensory lexicon developed during training of the selected panellists.*

Term	Definition	Rating scale
Colour	Actual colour of the sample	1=White; 7=Brown
Denseness	Compactness of the cross-section	1=Less compact; 7=Very compact
Oiliness	Presence of visible oil	1=None; 7=High
Chicken aroma	Aromatic associated with cooked chicken	1=None; 7=High
Salty taste	Taste associated with iodized salt	1=None; 7=High
Chicken flavour	Flavour associated with cooked chicken	1=None; 7=High
Beefy flavour	Flavour associated with cooked beef	1=None; 7=High
Tenderness	Ease of chewing	1=Tough; 7=Tender
Juiciness	Moisture released by the product in the mouth as a result of chewing	1=None; 7=High
Rubbery	Degree to which sample returns to original shape after some deformation	1=None; 7=High
Grittiness	Amount of small, hard particles between teeth during chew	1=None; 7=High
Oily residual	Degree to which mouth feels oily after swallowing	1=None; 7=High
Particle residuals	The amount of particles left in mouth after swallowing	1=None; 7=Many
Teeth adhesion	Mouth residues that remain stuck on teeth	1=None; 7=High
Metallic after-taste	Metallic flavour similar to the one produced by iron (II) sulphate	1=None; 7=High

2.5. Statistical Analysis

Using SPSS Statistics 25.0.0 software, data were subjected to normality and homogeneity of variance test. Principal component analysis (PCA) was performed on descriptive sensory attributes to identify attributes that explained the greatest amount of the observed variabilities. Data were then subjected to analysis of variance (ANOVA) using the general linear model (GLM) of Statistical Analysis Systems (SAS, 9.1.3) computer package. The differences among treatment means were determined using the Tukey's range test. Probability values of ($p<0.05$) were considered significant.

3. Results

Table 2. Illustrates results from principal component analysis (PCA). Principal component (PC) 1 demonstrated that chicken flavour, chicken aroma and oily aftertaste followed the same trend and were negatively correlated to residual particles, grittiness and teeth adhesion. Principal component 2 showed oiliness, juiciness and tenderness were similar but negatively correlated with rubbery taste and teeth adhesion, metallic taste, grittiness and chicken flavour were similar but negatively correlated to denseness in PC 3. Principal component 4 showed the same trend on colour, salty taste and rubbery having a positive correlation. Principal component 5 demonstrated a negative correlation between oiliness and salty taste. Grittiness, particles, oiliness, colour, salty taste and oily taste contributed greatest to the observed variabilities according to the PCA. Mean rankings of the descriptive sensory attributes are presented in Table 3. Only salty taste, beefy flavour, grittiness and tenderness were significantly affected by feeding.

Table 2. *Principal components with factor loadings of descriptive sensory properties of meat from grower rabbits fed FGMPP and UGMPP-based diets.*

Attribute	Principal Components					
	PC1	PC2	PC3	PC4	PC5	PC6
Colour	-.008	.360	-.277	.599	.315	-.221
Denseness	.297	-.268	-.423	.255	.291	.320
Oiliness	.024	.649	.051	.212	.538	-.277
Chicken aroma	-.673	-.343	.298	.120	-.123	-.325
Salty taste	-.029	.365	.144	.469	-.610	-.191
Chicken	-.637	-.225	.431	.264	.067	-.015
Beefy	.446	.382	-.025	.313	-.349	.188
Tenderness	-.379	.479	-.112	-.249	.195	.347
Juiciness	-.117	.535	.312	-.019	-.199	.315
Rubbery	.299	-.458	-.047	.574	-.071	.359
Grittiness	.537	.035	.597	.057	.282	-.170
oily	-.520	.333	.326	.071	.056	.432
Particles	.793	.007	.381	-.015	-.030	-.044
Teeth adhesion	.515	.010	.487	-.292	.054	.089
Metallic	-.172	-.338	.483	.310	.308	.239
Eigenvalues	2.875	2.022	1.745	1.451	1.251	1.037
Variance explained (%)	19.168	13.477	11.633	9.675	8.34	6.913

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization
KMO 0.503
Bartlett's Test: Chi square value 196.229; $p<0.0001$

Table 3. *Effect of feeding grower rabbits FGMPP and UGMPP-based diets on sensory attributes of meat.*

Attribute	30% UGMPP	15% UGMPP	30% FGMPP	15% FGMPP	Control	SEM	p-value
Overall rating							
Overall	4.42	5.5	5.5	4.91	5.08	0.35	0.18
Appearance	5.42	5.25	5.67	4.42	5.33	0.41	0.27
Flavour	5.67	5.58	5.25	4.02	4.83	0.39	0.45
Texture	4.67	5.67	5.58	5.5	4.75	0.37	0.17
Appearance							
Colour	4.33	3.83	4.0	4.58	4.5	0.44	0.71
Oiliness	4.83	3.0	4.08	4.58	4.25	0.47	0.08
Denseness	4.17	3.92	4.25	4.33	4.67	0.51	0.88
Flavour							
Salty taste	2.67^{a}	2.42^{a}	2.58^{a}	4.83^{b}	3.92^{ab}	0.45	0.0008
Oily	4.0	3.08	2.5	3.3	3.58	0.47	0.23
Chicken	4.5	4.17	4.58	4.33	4.17	0.43	0.94
Beefy	3.33^{a}	1.83^{ac}	2.58^{a}	3.9^{ab}	1.75^{ac}	0.44	0.003
Texture							
Particles	3.08	3.17	4.5	3.75	3.91	0.46	0.19
Grittiness	3.67^{a}	1.83^{b}	4.67^{ad}	2.58^{ab}	4.17^{a}	0.45	0.0002
Tenderness	5.58^{a}	4.58^{ab}	3.67^{b}	4.33^{ab}	5.41^{a}	0.47	0.04
Juiciness	4.25	3.5	3.5	4.17	5.0	0.5	0.19
Rubbery	3.17	3.75	4.58	3.67	4.0	0.51	0.4
Aroma							
Chicken	4.58	5.5	4.83	4.58	4.42	0.42	0.4
Residual							
Teeth adhesion	3.42	3.5	4.0	3.67	3.58	0.47	0.91
Metallic aftertaste	3.0	2.83	4.5	3.25	3.0	0.44	0.07

SEM=standard error of means; $^{a, b, c, d}$=means in the same row with different superscripts are significantly different (P<0.05); Trt 1=30% UGMPP (unfermented mature Prosopis pods); Trt 2=15% UGMPP; Trt 3=30% FGMPP (fermented ground mature Prosopis pods); UGMPP; Trt 4=15% FGMPP; Trt 5=control.

4. Discussions

In PC 1, the inverse relationship between chicken aroma, chicken taste and oiliness to beefy taste, grittiness, particles and teeth adhesion is an indication of the attributes that constitute beef and chicken meats. Chicken meat has different but specific attributes from beef that are negatively correlated. In PC 2, the positive correlation between juiciness, tenderness and oiliness is an indication of their contribution to the overall rating of the meat, and therefore their positive contribution to meat quality. The negative correlation (inverse relationship) of these attributes with the rubbery attribute is an indication of poor meat quality. These results indicate the overall relationship between beef and chicken meats with regards to quality where chicken meats are considered of higher quality by consumers. Similar results were reported by Trout et al. [22] and Ruiz-Carrascal et al. [23] when relationships between texture, appearance, presence of moisture and intramuscular fat content of meat were studied. There was a direct relationship between these attributes, meat quality and meat preference as reported by consumers. In this study, feeding FGMPP or UGMPP did not affect the relationships of the attributes that represent consumer preference and quality. Similar results were reported by Wanjohi et al. [7] when indigenous chicken were fed ground mature Prosopis pods based-diets.

Out of the nineteen attributes evaluated, only four were significant according to ANOVA, Table 3. This substantiates several similar studies that highlighted that meat sensory attributes are less influenced by diet, when indigenous chicken were fed Prosopis pods [7]; when broilers were fed soaked Prosopis seeds [24]; when chicken were fed enzyme-treated and untreated Prosopis pods [25]; when pigs were fed fermented food waste [26] and when broiler chicken were fed fermented rapeseed meal [27]. Generally, large amounts of changes in the diet composition are needed to cause minute changes in sensory attributes [28]. According to Tasić et al. [29], grittiness is an inverse indicator of meat quality. The similarity in the grittiness of meat of the rabbits fed the control diet and 30% FGMPP inclusion diet is an indication of similar meat quality. In the present study, it was shown that feeding UGMPP at 30% did not cause significant differences in grittiness. However, when fed at low levels (15%), whether fermented or not, ground mature *Prosopis juliflora* pods reduced the grittiness of the rabbits' meat. Thus, 15% UGMPP can be used to improve meat quality as grittiness inversely affects meat quality [29]. In this study, meat from the rabbits offered treatment with 30% FGMPP had lower ($p<0.05$) salt content. This is desirable to the consumers. Daily salt intake in humans is high due to diets consisting of processed foods with high salt content. This predisposes people to cardiovascular diseases like high blood pressure. Low salt diets are important in reducing blood pressure of hypertensive individuals [30]. In this study, the meat from the rabbits fed on diets with 30% FGMPP inclusion would be ideal for preventing and reducing cardiovascular diseases in humans due to the low salt content [31]. Although analysis by PCA reported beefy taste and tenderness with a low contribution to the observed variabilities, they were significant ($p<0.05$) in ANOVA analysis. They are important descriptive sensory attributes that indicate consumer preference for meats and therefore their purchasing-decision process [32]. Tenderness is an important attribute to the older population compared to younger people and unlike juiciness, it rarely determined consumer buying decisions [26].

According to Guerrero et al. [33], meat quality is affected by several factors like diet, production system, age with meat from goats reared with milk replacers as opposed to dams' milk exhibiting differences in sensory attributes [34]. In this study, age and production system was the same across all treatments. The only effect investigated on descriptive sensory attributes was therefore the diets. According to Guerrero et al. [35], some of the dietary factors that determine differences in quantitative and qualitative properties of meat are physical properties, chemical properties, use of additives and composition of the diets. Many of the nutrients in meat are also involved in flavour formation. There is therefore a linear relationship between the nutritional aspect of meat and its flavour [36]. In this study, similar sensory attributes in the overall ratings exhibited by meat in all the treatments is an indication that all the diets provided adequate nutrients to allow for normal metabolism in muscular tissues. According to Font-i-Furnols and Guerrero [37], the overall rating of meat as appearance, flavour and texture were more important in consumer buying decisions of meat. In this study, differences in these individual descriptive sensory attributes did not affect the overall rating of the meat from rabbits in all the treatments.

5. Conclusions

Based on the results of this study, it is concluded that up to 30% of maize grain in grower rabbits' diets can be replaced with fermented ground mature Prosopis pods. The meat had a lower salty taste and was similar to the control in the overall rating. This inclusion did not affect descriptive sensory characteristics. The prevailing price of maize as compared to the price of FGMPP will determine the cost-benefit of the replacement as these prices are subject to seasonal fluctuations.

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