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Sensory characteristics of meat from rabbits fed concentrate diets containing *Brassica oleracea* outer leaves and M*usa paradisiaca* leaves

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ABSTRACT

Two separate experiments were conducted to investigate the effect of incorporating levels of Brassica oleracea outer leaves and Musa paradisiaca leaves on sensory characteristics of rabbit meat. In each experiment, forty-eight (48) eight-week-old rabbits were randomly allotted to four treatments of concentrate diets with 0, 10, 20 and 30% inclusion levels of Brassica oleracea outer leaves and Musa paradisiaca leaves. Six rabbits were randomly selected from each treatment group and used for sensory evaluation at the end of a 12-week feeding period. Muscle samples were collected from the longissimus dorsi of the carcasses, pan-fried using 300 ml of Frytol® vegetable oil at 170°C for 10 minutes. Thirty evaluators conducted the sensory evaluation according to the consumer acceptance and preference testing technique on a nine-point hedonic scale comprising appearance, flavour, colour, mouth-feel, taste, texture and overall acceptability. Generally, the sensory characteristic scores for the meat samples support the evaluators' acceptability of the meat from rabbits fed the various diets. However, in specific terms, meat from rabbits fed diets containing 10 and 30% Brassica oleracea outer leaves and 20% Musa paradisiaca leaves tended to have higher sensory scores over meat from rabbits fed diets of the other inclusion levels of the leaves in the sensory attributes measured. The results of the study also suggest that feeding concentrate diets containing Brassica oleracea outer leaves and Musa paradisiaca leaves at 30% inclusion level resulted in the production of rabbit meat at a lower cost than feeding concentrate diets alone and acceptable to consumers.

Key words *Acceptability, leaves, rabbit meat, sensory characteristics.*

INTRODUCTION

The special attributes of the rabbit, *Oryctolagus cuniculus*, a lagomorph, such as low-cost input requirement, short generation interval, high fecundity, rapid growth rate, ability to utilize forage and agricultural by-products, excellent feed conversion ratio and adaptability to a wide

range of ecological environments (Abu et al., 2008) render it an ideal animal that could make a significant contribution towards bridging the gap between domestic production and demand for meat in Ghana (Osei et al., 2012).

Rabbit meat is healthier than the other common meat types as it is rich in calcium and phosphorus and lower in fat and cholesterol than chicken, lamb, beef and pork (Nistor et al., 2013). Meat is considered by consumers for its attractive sensory characteristics (Gašperlin et al., 2006) which include tenderness, flavour (Dalle Zotte, 2002; Palazzo et al., 2015; Gašperlin et al., 2006) colour (Apata et al., 2012) and juiciness (Christensen et al., 2000). Meat color, flavour and tenderness are the major attributes of consumers' choice of meat (Apata et al., 2012; Chodová et al., 2019). The colour of meat can be affected by many factors including pigment myoglobin content which is dependent on primary production factors such as nutritional status, age of animal and stress just before and during slaughter (Bizkova and Tumova, 2010). Flavour may be differentiated into taste, smell and flavour (Dalle Zotte, 2002), while tenderness varies with muscle age and changes in the proportion and type of conjunctive tissue supporting the muscle fibres (Palazzo et al., 2015). The younger the rabbits are slaughtered the more tender the meat will be. On the other hand, flavour tends to develop with age. These attributes and juiciness depend largely on the fat content of the carcass (Palazzo et al., 2015). The overall appearance of a product is important for priming consumers' expectations before consumption (Fiorentini et al., 2020).

Rabbit farming has been accepted in Ghana based on various reasons including the absence of social or religious taboos affecting the consumption of meat. However, the feed provided to rabbits by some farmers in the country is inadequate qualitatively and quantitatively resulting in substandard growth and poor reproductive performance of the animals (Osei et al., 2012), low meat yield and high cost of production. Incorporating crop residues and forages, with less cost implication in composite diets, could improve the nutritive quality of rabbit feed, cut down on the cost of producing rabbits and encourage more people to go into production and consumption of the meat. This study was undertaken to evaluate the sensory characteristics of meat from rabbits fed concentrate diets containing two major crop residues, *Brassica oleracea* (cabbage) outer leaves and *Musa paradisiaca* (plantain) leaves, considered waste materials and readily available at low cost in most of the ecological zones of Ghana and suitable as animal feed.

MATERIALS AND METHODS

Study sites

The rabbits used in the study were kept at the Rabbitry Unit of the Council for Scientific and Industrial Research (CSIR) - Animal Research Institute Frafraha Station, and the sensory evaluation of the meat samples was conducted at the CSIR-Food Research Institute Sensory Evaluation Laboratory in Accra, Ghana.

Experimental diets

Milled dry *Brassica oleracea* outer leaves and *Musa paradisiaca* leaves were incorporated into diets containing maize, soymeal, wheat bran, corn cob, oyster shell, salt, lysine, methionine and premix, at 0, 10, 20 and 30% inclusion levels respectively (Table 1 and Table 2).

TABLE 1. **Gross composition of concentrate diets containing different inclusion levels of *Brassica oleracea* outer leaves**

Ingredient	*Brassica oleracea* inclusion levels (%) in diet			
	(0)	10	20	30
Maize	52.00	47.00	47.00	45.00
Soymeal	21.00	14.00	11.00	8.00
Wheat bran	5.00	16.00	10.00	5.00
Dicalcium phosphate	0.90	0.90	0.90	0.90
Oyster shells	2.00	2.00	2.00	2.00
Iodated salt	0.50	0.50	0.50	0.50
Lysine	0.20	0.20	0.20	0.20
Corn cob	18.00	9.00	8.00	8.00
Methionine	0.15	0.15	0.15	0.15
Premix[1]	0.25	0.25	0.25	0.25
B. oleracea	0.00	10.00	20.00	30.00
Total	100.00	100.00	100.00	100.00

[1]Premix composition per kg diet: Vit.A - 12,000,000 IU; Vit.E - 15000 mg; Vit.B1 - 1500 mg; Niacin - 30,000 mg; Vit.B6 - 1500 mg; Vit.D3 - 4500,000 mg; Vit. K3 - 3,000 mg; Pantothenic acid - 12000 mg; Vit.B12 - 10,000 mg; Vit. B2 - 6000 mg; Folic acid - 800 mg, Iron - 60,000 mg; Copper - 75,00 mg; Iodine - 750 mg; Manganese - 130,000 mg; Zinc - 70,000 mg; Selenium - 300mg; Calcium -17.50%, Lysine -1,330 mg; Methionine - 1,075 mg; B-Corotenic acid - 350 mg.

Table 2: Gross composition of concentrate diets containing different inclusion levels of *Musa paradisiaca* leaves

Ingredient	*Musa paradisiaca* inclusion levels (%) in diet			
	(%)	10	20	30
Maize	52.00	41.50	44.50	44.00
Soymeal	21.00	14.50	11.50	10.50
Wheat bran	5.00	20.00	15.00	6.00
Dicalcium phosphate	0.90	0.90	0.90	0.90
Oyster shells	2.00	2.00	2.00	2.00
Iodated salt	0.50	0.50	0.50	0.50
Lysine	0.20	0.20	0.20	0.20
Corn cob	18.00	10.00	5.00	5.50
Methionine	0.15	0.15	0.15	0.15
Premix[1]	0.25	0.25	0.25	0.25
M. paradisiaca	0.00	10.00	20.00	30.00
Total	100.00	100.00	100.00	100.00

[1]Premix composition per kg diet: Vit.A - 12,000,000 IU; Vit.E - 15000 mg; Vit.B1 - 1500 mg; Niacin - 30,000 mg; Vit.B6 - 1500 mg; Vit.D3 - 4500,000 mg; Vit. K3 - 3,000 mg; Pantothenic acid - 12000 mg; Vit.B12 - 10,000 mg; Vit. B2 - 6000 mg; Folic acid - 800 mg, Iron - 60,000 mg; Copper - 75,00 mg; Iodine - 750 mg; Manganese - 130,000 mg; Zinc - 70,000 mg; Selenium

- 300mg; Calcium -17.50%, Lysine -1,330 mg; Methionine - 1,075 mg; B-Corotenic acid - 350 mg.

Animals and housing

A total of 96 eight-week-old clinically healthy population of mixed-breed and mixed-sex of local, California, New Zealand White and Chinchila rabbits, weighing between 745.2 to 920.8 g, were fed the experimental diets. Two rabbits of same-sex were housed in a wire mesh cage with a wooden frame, measuring 40 x 40 x 50 cm (width x length x height), equipped with a plastic feeding trough and an automatic watering facility. Six hutches, with three rows of six cages each, used in housing the rabbits, were placed 70 cm above ground level under *Azadirachta indica* canopy in an area with natural ventilation and lighting.

Experimental design

The rabbits were randomly allotted on a weight and sex equalization basis to four dietary treatments with 12 rabbits per treatment in a completely randomized design. The treatments were composite diet without forage as control, and concentrate diets of 10, 20 and 30% inclusion levels of *Brassica oleracea* outer leaves. Similar experimental design and conditions were employed for the rabbits fed control and concentrate diets containing *Musa paradisiaca* leaves at 10, 20 and 30% inclusion levels. The animals were acclimated to the experimental conditions and diets for seven days followed by a 12-week feeding regime. Salt-licks were supplied during the experiment, and feed and freshwater were provided *ad libitum*.

Selection of meat cooking method

The cooking method used in the preparation of the rabbit meat for the sensory evaluation was based on the outcome of a survey of the preference of 166 consumers of rabbit meat in Greater Accra region of Ghana of four major methods employed in the preparation of the meat. The methods were cooking in water (soup), smoking with wood fire, pan-frying with oil and grilling with charcoal (Table 3). Majority of the respondents in the survey preferred meat pan-fried with oil.

TABLE 3. **Consumer preference for meat prepared using major cooking methods**

Cooking method	Number	Percentage
Cooking in water	18	10.84
Grilling with charcoal.	55	33.13
Pan fried with oil	86	51.81
Smoking with wood fire	7	4.22
Total	166	100

Preparation of meat samples and sensory evaluation of meat

The sensory evaluation was done using the consumer acceptance and preference testing technique on a 9-point hedonic scale assessment method by the Food Research Institute of the Council for Scientific and Industrial Research, Ghana. Six rabbits, comprising three of each sex, were randomly selected from each treatment group at 21 weeks (147 days) old, starved overnight to clear the guts, stunned and bled by severing the carotid artery and jugular vein at the level of the atlas vertebra with a

sharp knife. The animals were allowed to bleed for 30 min with their heads down, singed with a gas flame, carefully eviscerated and washed. Muscle samples were collected from the longissimus dorsi on the left side of the loin, frozen and stored at -18˚C. On the day of sensory evaluation the meat samples were defrosted in a refrigerator at about 4˚C for 24hours, thawed, coded and washed. Each meat sample was cut into 5 g pieces. The carcass dissection procedures were based on the World Rabbit Science Association (WRSA) recommendations described by (Blasco & Ouhayoun, 1996). One tablespoon of salt was added to 100 ml of water, the pieces of meat were put into the water and steamed for 10 min. The meat samples were pan fried using 300 ml of Frytol® vegetable oil at 170^0C for 10 min, removed into a colander to drain off excess oil from the meat and cool. A panel of 30 trained assessors were asked not to smoke cigarettes, eat or drink anything except water for one hour before the evaluation session. The evaluation was undertaken in a well-lighted ventilated room. The coded meat samples were randomly served to the assessors on clean saucers for sensory evaluation based on a nine-point hedonic scale on which scale 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely) for appearance, colour, flavour, texture, taste, mouth feel and overall acceptability (Apata et al., 2012). Each sample was evaluated independent of the other, and a slice of cucumber and water were used as neutralizers in between sample tasting.

Cost of feed

The cost of feed was calculated as cost of ingredients used in the preparation of one (1) kg feed, plus transportation, milling, mixing and packing costs. The cost of *Brassica oleracea* (cabbage) outer leaves and *Musa paradisiaca* (plantain) leaves, as ingredients incorporated in a diet, comprised harvesting, chopping, drying and transportation costs.

Statistical analysis

Data collected were subjected to Kruskal-Wallis Test as outlined by the Generalized Linear Model of the GenStat Discovery Edition (VSN International, 2010) to determine the median of the scores. The relationship among the sensory parameters were determined by Kendall's rank correlation tests (Kendall, 1970) using Minitab® 20.

RESULTS AND DISCUSSIONS

Cost of concentrate diets containing different inclusion levels of *Brassica oleracea* outer leaves and *Musa paradisiaca* leaves

The cost of concentrate diets containing varying levels of *Brassica oleracea* and *Musa paradisiaca* leaves is shown in Table 4. The cost per kg feed declined from Gh₵1.59 for the control diets to Gh₵1.20 and Gh₵1.23 for concentrate diets containing 30% *Brassica oleracea* outer leaves and *Musa paradisiaca* leaves respectively. Feed accounts for the largest part of rabbit production cost (Maertens, 2010). The decline in the cost per kg feed as the inclusion level of the forages in the concentrate increased, reflects the advantage of using forages of good nutritive value at appropriate levels in concentrate diets for the production of feed of lower cost for rabbit production.

Table 4: **Cost of concentrate diets containing different inclusion levels Brassica oleracea outer leaves and Musa paradisiac leaves**

Forage	Forage inclusion level (%)			
	0	10	20	30
Brassica oleracea	1.59	1.40	1.31	1.20
Musa paradisiaca	1.59	1.36	1.29	1.23

Sensory evaluation of rabbit meat

The higher consumer preference for meat prepared by oil frying influenced the choice of the cooking method used in this study as it enhances most of the palatability traits of rabbit meat (Apata et al., 2017). Also, meat from the longissimus dorsi was used for the sensory evaluation as it is considered as the most valuable cut of the rabbit carcass (Dalle Zotte and Szendrő, 2011).

Sensory characteristics of meat from rabbits fed concentrate diets containing different levels of *Brassica oleracea* outer leaves and *Musa paradisiaca* leaves are shown in Tables 5 and 6 respectively. There were no significant differences (P>0.05) between the sensory attributes of the meat from rabbits fed concentrate diets containing different levels of *Brassica oleracea* outer leaves as well as the meat from rabbits fed diets containing different levels of *Musa paradisiaca* leaves. However, the sensory characteristic scores for appearance, flavour and colour tended to be higher for meat from rabbits fed the diet containing 30% *Brassica oleracea* outer leaves than the meat from rabbits fed the other inclusion levels, and mouth feel, taste, texture and overall acceptability tended to be higher for meat samples of rabbits fed concentrate diets containing 10% *Brassica oleracea* outer leaves.

The sensory scores tended to be higher for meat from rabbits fed concentrate diet containing 20% *Musa paradisiaca* leaves with the exception of colour which tended to be at par with meat from rabbits fed the diet containing 10% *Musa paradisiaca* leaves. The difference in the sensory scores of meat from rabbits fed concentrate diets containing different levels of *Brassica oleracea* leaves ranged from 0.3 to 0.8 for mouth feel and colour respectively, while the variations ranged from 0.3 for appearance, flavour and colour to 0.6 for mouth feel for diets containing the different levels of *Musa paradisiaca* leaves.

TABLE 5. **Sensory characteristics of meat from rabbits fed concentrate diets containing different levels of *Brassica oleracea* outer leaves**

Characteristics	*Brassica oleracea* outer leaves inclusion level (%)			
	0	10	20	30
Appearance	7.2 ± 0.2	7.2 ± 0.2	6.9 ± 0.2	7.3 ± 0.2
Flavour	6.5 ± 0.2	6.7 ± 0.2	6.3 ± 0.2	6.8 ± 0.2
Colour	7.2 ± 0.2	7.0 ± 0.2	6.6 ± 0.2	7.4 ± 0.2
Mouth feel	6.3 ± 0.2	6.6 ± 0.2	6.4 ± 0.2	6.3 ± 0.2
Taste	6.5 ± 0.2	6.6 ± 0.2	6.2 ± 0.2	6.3 ± 0.2
Texture	6.7 ± 0.2	7.0 ± 0.2	6.4 ± 0.2	6.3 ± 0.2
Overall acceptability	6.9 ± 0.2	7.0 ± 0.2	6.5 ± 0.2	6.7 ± 0.2

TABLE 6. **Sensory characteristics of meat from rabbits fed concentrate diets containing different levels of *Musa paradisiaca* leaves.**

Characteristics	*Musa paradisiaca* leaves inclusion level (%)			
	0	10	20	30
Appearance	7.2 ± 0.2	7.1 ± 0.2	7.4 ± 0.2	7.2 ± 0.2
Flavour	6.5 ± 0.2	6.6 ± 0.2	6.8 ± 0.2	6.5 ± 0.2
Colour	7.2 ± 0.2	7.3 ± 0.2	7.3 ± 0.2	7.0 ± 0.2
Mouth feel	6.3 ± 0.2	6.1 ± 0.3	6.7 ± 0.3	6.5 ± 0.3
Taste	6.5 ± 0.2	6.3 ± 0.3	6.8 ± 0.3	6.3 ± 0.3
Texture	6.7 ± 0.3	6.3 ± 0.3	6.7 ± 0.3	6.3 ± 0.3
Overall acceptability	6.9 ± 0.2	6.7 ± 0.2	7.2 ± 0.2	6.7 ± 0.2

Correlations between sensory characteristics of rabbit meat

Sensory characteristics of meat from rabbits fed diets containing different levels of *Brassica oleracea* outer leaves correlated positively ($r = 0.41$ to 0.99, $p<0.05$) except for appearance and mouth feel, appearance and texture, flavour and mouth feel, flavour and texture, colour and mouth feel, colour and taste and colour and texture (Table 7). The correlations between appearance and mouth feel correlated negatively ($r = -0.14$, $p<0.05$), while appearance and texture, flavour and mouth feel, flavour and texture were not correlated.

Table 8 shows that sensory characteristics of meat from rabbits fed diets containing different levels of *Musa paradisiaca* leaves correlated positively ($r = 0.41$ to 1.00, $p<0.05$) with each other with the exception of appearance and colour ($r = 0.19$, $p>0.05$), while colour and mouth feel had negative non-significant correlation ($r = -0.18$, $p>0.05$). The correlation between taste and overall acceptability was exceptionally high ($r = 1.00$, $p<0.05$)

The high correlations observed between most sensory characteristic scores of the meat samples signify the reliability of sensory characteristics as consumers' acceptance of meat from rabbits fed the various diets containing graded levels of *Brassica oleracea* outer leaves and *Musa paradisiaca* leaves. The extremely high correlation between taste and overall acceptability of the meat samples suggests the reliability of taste as a predictor of consumers' choice of rabbit meat. Nevertheless, meat from rabbits fed concentrate diets containing 30% *Brassica oleracea* and 20% *Musa paradisiaca* leaves tended to have an advantage over the meat from rabbits fed the other diets as they had the highest scores for appearance and colour which are the major attributes that give the first impression consumers have about meat and therefore influences their selection (Apata et al., 2012).

TABLE 7. **Correlation between sensory characteristics of meat from rabbits fed diets containing different levels of *Brassica oleracea* outer leaves**

Characteristics	Appearance	Flavour	Colour	Mouth feel	Taste	Texture	Overall acceptability
Appearance	1.00	0.91	0.96	-0.14	0.53	0.18	0.65
Flavour		1.00	0.81	0.11	0.41	0.14	0.53
Colour			1.00	-0.41	0.32	-0.06	0.46
Mouth feel				1.00	0.52	0.75	0.43
Taste					1.00	0.92	0.99
Texture						1.00	0.86
Overall acceptability							1.00

For statistical significance, a correlation coefficient of 0.35 or larger is required at 5 percent level

TABLE 8. **Correlation of sensory characteristics of meat from rabbits fed concentrate diets containing different levels of *Musa paradisiaca* leaves**

Characteristics	Appearance	Flavour	Colour	Mouth feel	Taste	Texture	Overall acceptability
Appearance	1.00	0.75	0.19	0.92	0.93	0.69	0.93
Flavour		1.00	0.67	0.55	0.80	0.41	0.80
Colour			1.00	-0.18	0.50	0.41	0.50
Mouth feel				1.00	0.71	0.45	0.71
Taste					1.00	0.86	1.00
Texture						1.00	0.86
Overall acceptability							1.00

For statistical significance, a correlation coefficient of 0.35 or larger is required at 5 percent level.

CONCLUSION AND RECOMMENDATIONS

It is concluded from the study that the high sensory characteristics of fried meat samples, in particular appearance and colour, render meat from growing rabbits fed diets containing up to 30% *Brassica oleracea* outer leaves and 20% *Musa paradisiaca* leaves attractive to consumers. Also, the taste of the meat which could be assessed only at consumption correlated highly significant with the overall acceptability. However, it may be necessary to conduct further studies using other cooking methods to confirm the reliability of appearance and colour as the major indicators of consumers' choice of rabbit meat. Furthermore, incorporating *Brassica oleracea* outer leaves and *Musa paradisiaca* leaves at appropriate inclusion levels in the feed will result in a lower cost of producing rabbit meat where the crop residues are readily available.

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COMPETING INTERESTS

The authors would like to declare unequivocally that they have no conflict of interest as far as this article in concerned.

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