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Consumer acceptance, Carcass and sensory characteristics of meats of farmed and wild cane rats (*Thryonomys swinderianus*)

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ABSTRACT

The cane rat, popularly called grasscutter in Ghana, is noted for the supply of a significant proportion of game meat consumed in Ghana. Its hunting from the wild is however, associated with several environmental hazards as well as a threat to their survival as species. Grasscutters are presently being farmed to minimize some of the harmful effects associated with harvesting from the wild. Some local consumers have however, expressed reservations that the meat of wild cane rat is more tender and leaner than meat of farmed ones. This study therefore sought to compare the consumer acceptance of meats from farmed and wild cane rats amongst consumers in Mankessim, in the Mfantsiman Municipality of the Central Region of Ghana, as well as determine some carcass and sensory characteristics of the meats by trained panellists. The study was performed with 250 consumers of cane rat meat, whilst sensory and proximate characteristics were determined by a 25-member trained sensory panel. From the results, 78% of the respondents preferred meat from wild to farmed grasscutters, due to perceived better flavour, tenderness and lower fat content. Sensory panellists indicated that meat of the wild grasscutter was darker, more tender, had higher flavour intensity and higher acceptability than that of the farmed grasscutter. The meat of the wild grasscutter also had higher crude protein (25.72%) than the farmed (24.61%). In addition, meat of the wild grasscutters had lower fat (5.74%) contents than the farmed (9.49%). Aerobic plate counts of the wild cane rat meat was 2.48$\log_{10}$CFU/g, whilst that of the farmed was 1.87 $\log_{10}$CFU/g after 21 days of storage. It is recommended that meat from the wild cane rats harvested in Ghana, should be cooked to a minimum core temperature of 72°C, to minimize possible incidence of food-borne infections amongst consumers.

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Introduction

The cane rat or grasscutter (*Thryonomys swinderianus*) is a wild rodent widely distributed in the African sub-region, and utilized in most areas as a source of animal protein [3,16,18]. Being the most preferred and most expensive meat in Ghana and West Africa in general, it contributes to both local and export earnings of several countries. Steel [23] reported that the price of wild grasscutter meat in some countries in West Africa is 3 - 4 times the price of beef. Jori, et al. [11] estimated the value of the West African grasscutter meat market to be worth in excess of $1103 million (US Dollars). Consequently, the authors estimated the total number of wild grasscutters hunted in West Africa to be over 80 million, the equivalent of 300,000 tonnes of meat. The Canadian National Research Council [17] consequently included the grasscutter in its list of mini-livestock with a promising economic future; however, the survival of the species is threatened by aggressive hunting.

Grasscutter harvesting from the wild is almost synonymous with destruction of the environment, through use of unsustainable hunting methods such as setting of wild fires, and the use of poisonous substances as bait to trap animals, which pose health hazards to unsuspecting consumers. To alleviate these problems, efforts have been made to farm them at home. This is expected to reduce the negative effects on the environment as well as welfare aspects of hunting animals in the wild. Such efforts are yielding positive results as grasscutter farming is now a growing business in certain parts of Africa [11]. An advantage in the farming of the grasscutter is the fact that the species does not require much space for rearing, and can even be raised by people with little or no land in their backyards, and on flat rooftops. Additionally, grasscutters produce only small quantities of body waste, that is odourless and can easily be disposed-of, or used as manure in backyard gardens.

In recent years, there have been anecdotal evidence to suggest that some consumers are less likely to choose meat of the farmed grasscutter because it is perceived to be less tasty in comparison with that of the wild grasscutter. This has the tendency to reduce the popularity and marketability of meat from the farmed species, negating the potential environmental, employment and health benefits. This study was therefore conducted in the Central Region of Ghana (a popular market for grasscutter meat), to compare consumer preference and acceptability for meats from the wild and farmed grasscutters. The study also involved sensory and proximate analyses of the two types of meat to determine characteristics they possess that might affect consumer preference or acceptability. It was hypothesized in this study that there would be no differences in consumer preference, as well as carcass and sensory characteristics of meats of farmed and domesticated grasscutters.

Materials and methods

The study involved the administration of questionnaires to consumers in the Mankessim township in the Mfantsiman Municipality in the Central Region of Ghana to determine their acceptance for the meats of wild and farmed grasscutters. In addition, carcasses of the wild, and live domesticated grasscutters were purchased for sensory and laboratory evaluation in the University of Cape Coast, Ghana. This study had prior ethical approval from the Institutional Review Board (IRB) of the University of Cape Coast, Ghana (UCCIRB/CES/2017/03)

Study area

The study was conducted from May to July 2018 at Mankessim, in the Mfantsiman Municipality of the Central Region of Ghana. The town is located approximately 85 km west of Accra, on the Accra-Takoradi highway, and is regarded as the traditional headquarters of the Fante community of Ghana. The study area is located on latitude 5^0 5′ 60.00″ N of the equator and longitude -1^0 00′ 60.00″ W of the Greenwich Meridian. This area was chosen because it is famous for the "game meat" business. In addition, there are a large number of grasscutter farmers/keepers in this area. The vegetation of the area varies from Coastal Savannah to Deciduous forest, with annual rainfall of between 1200 mm – 1800 mm. Fig. 1 indicates the location of the Mfantsiman Municipality of the Central Region of Ghana.

Questionnaire administration

All respondents were meat consumers from Mankessim, in the Mfantsiman Municipality of the Central Region, Ghana. The stratified sampling method was used to select 250 households: 50 each, from the Eastern, Central, Western, Northern and Southern parts of the Municipality (as designated by the Municipal Assembly). In each household, those in charge of making food purchasing decisions (as indicated by the family) were interviewed. Respondents were issued with content-validated questionnaires to indicate their reactions, based on experience from consuming the two meat types.

Sensory and laboratory evaluation of carcasses

A total of twenty undressed carcasses (2.1 ± 0.4 kg) of wild grasscutters, killed with hunters' guns, were obtained early morning from hunting expeditions the night before. In addition, a similar number of farmed grasscutters (1.9 ± 0.2) were obtained from the Teaching and Research Farm of the University of Cape Coast, Ghana and slaughtered. Carcasses from both groups were dressed, for sensory and laboratory analyses to compare the carcass characteristics in the Meat laboratory of the School of Agriculture, University of Cape Coast.

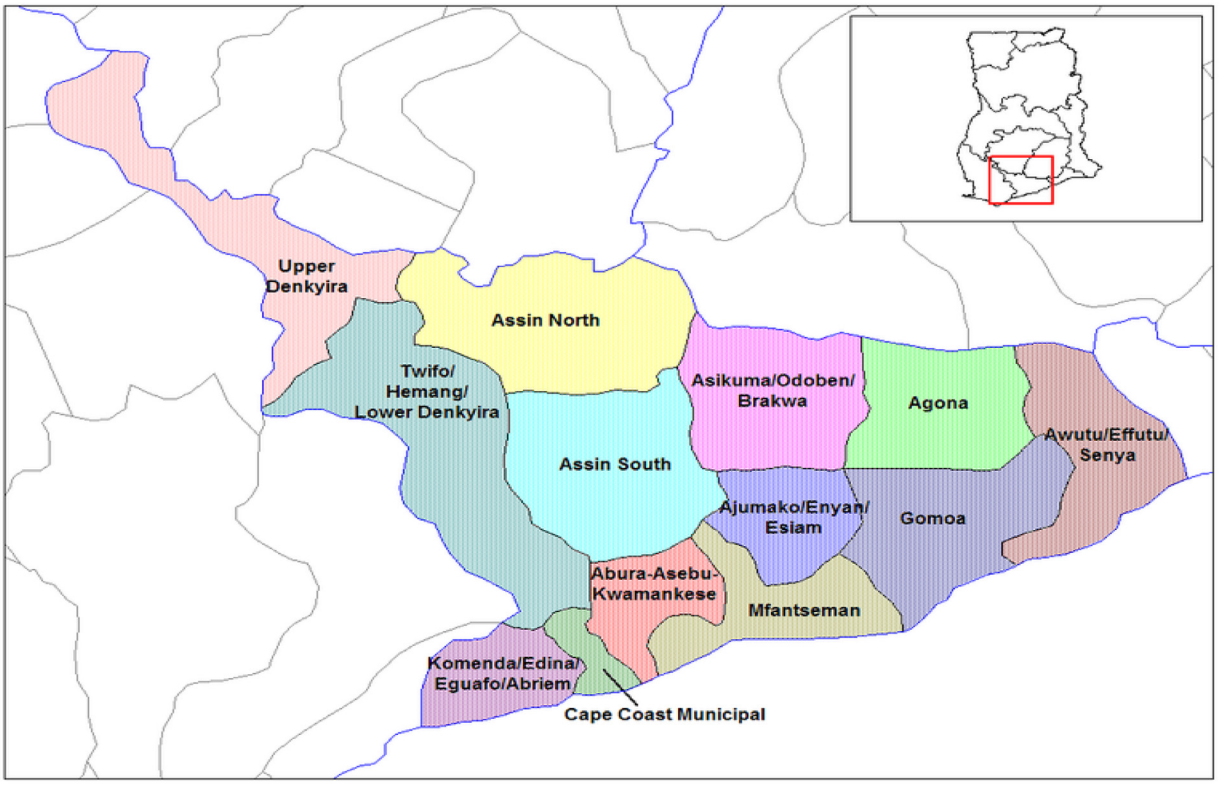

Fig. 1. Map of the Central Region of Ghana, showing the location of Mfantsiman Municipality, where participants in the study were recruited from. Source: https://en.wikipedia.org/wiki/Mfantsiman_Municipal_District.

Carcass dressing and evaluation

In order to minimize pain, farmed grasscutters were stunned with a captive bolt pistol (Matador SS3000, Termet, France) prior to slaughter, followed by a ventral neck incision with a sharp knife (GIESSER, Germany). Carcasses were then bled for about 2 min, scalded in warm water at a temperature of about 80^0C for about a minute, and the coarse and bristly furs scraped off with sharp knives. The de-furred carcasses were washed and eviscerated, after which they were again washed with clean water. The dressed carcasses were weighed and stored in a refrigerator at 4°C, and re-weighed after 24 h of chilling, to determine chilling losses. The pH of the carcasses was determined before refrigeration, according to the methods described by Chen and Lu [6]. The *Semitendinosus, Semimembranosus*, and *Biceps femoris* muscles were obtained from the hind limbs and ground together, using a domestic blender, to determine the proximate composition of the carcasses; the *Longissimus dorsi* muscles were separated and used for the sensory evaluation. The crude protein content of the samples was determined by the Kjeldahl method, ether extract by the Soxhlet method, as well as moisture and ash contents, all according to the methods described by the AOAC [2]. The *Longissimus dorsi* muscles were weighed and grilled in an electric oven (Turbofan Blue Seal, UK), to a core temperature of about 72°C; they were again weighed after cooking to determine cooking losses. The forequarters of the carcasses were stored in chest freezers at −18 °C for Aerobic Plate Counts (APCs) on days 1, 7, 14 and 21 of storage, to determine microbial load in storage, according to the methods described by Teye and Teye [24]. All analyses were conducted in triplicate.

Sensory evaluation of the meat

Sensory evaluation of the products conducted, was adapted from Teye et al. [26], with few modifications. A total of twenty panelists, comprising staff and students of the University of Cape Coast, were selected and trained, according to the British Standard Institution [5] guidelines, to evaluate meat products. Preliminary screening of panelists was done using the duo-trio test to assess sensitivity of their taste buds. They were then trained over a period of three weeks using beef products with known differences in composition, till panelists could indicate differences amongst the products. The previously grilled *Longissimus dorsi* muscles of the carcasses, were sliced into uniform sizes (about 2 cm in length) and wrapped with coded aluminium foils, before presenting to the trained panellists. Each panellist was provided with a private booth, to avoid influences from other panellists. In addition, panellists were provided with water and pieces of bread to serve as neutralizers, in-between tasting of products. The sensory evaluation was conducted on four different days by the same pan-

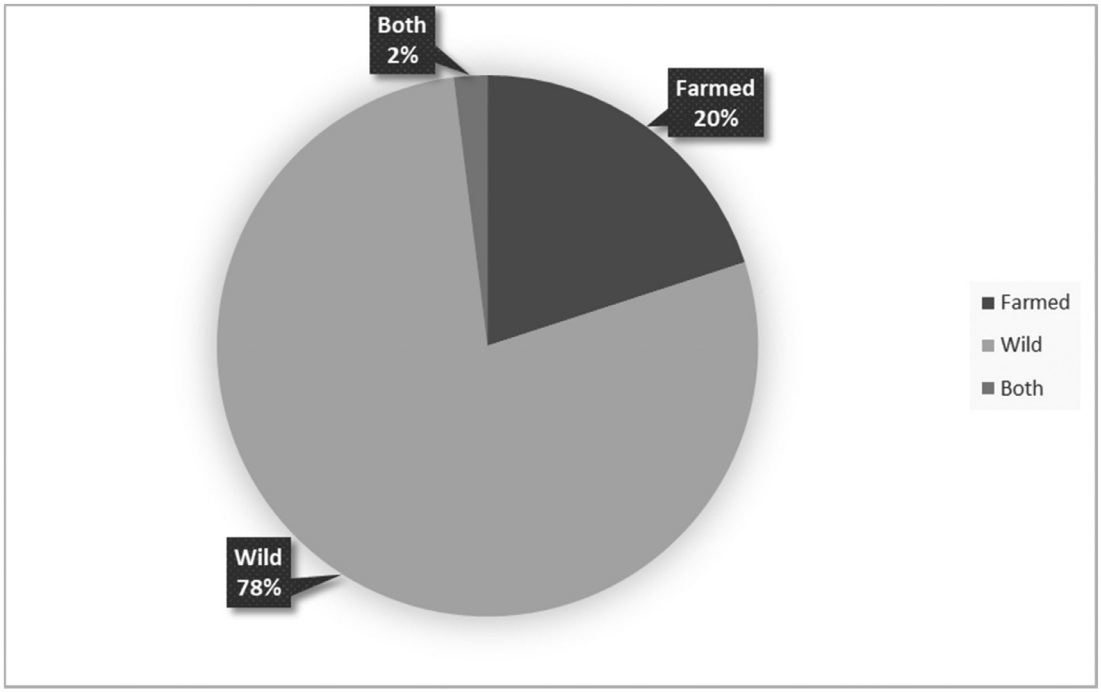

Fig. 2. Consumer preference for meats of Wild and Farmed grasscutters.

ellists, to check for consistency in rating of products. A five-point category scale, as described by Teye et al. [27] with few modifications, was used to describe the products as follows:

Colour: very pale (1), pale (2), intermediate (3), dark (4), very dark (5)
Off-odour: very weak (1), weak (2), intermediate (3), strong (4), very strong (5)
Tenderness: very tough (1), tough (2), intermediate (3), tender (4), very tender (5)
Juiciness: very dry (1), dry (2), intermediate (3), juicy (4), very juicy (5)
Flavour intensity: very weak (1), weak (2), intermediate (3), strong (4), very strong (5)
Overall acceptability: dislike very much (1), dislike (2), intermediate (3), like (4), like very much (5)

Data analysis

The demographic data on the respondents were organized and presented in frequency tables and graphs, whilst data from the sensory and carcass parameters were analysed using Analysis of Variance (ANOVA) of the Minitab Statistical Package (Minitab® Inc. version 15). Where significant differences were found, the means were separated using the Least Significant Difference (LSD).

Results and discussion

Demographic characteristics of the meat consumers

Majority (74.8%) of the respondents indicated they belong to the Christian faith, whilst the rest were either adherents of Islam or Traditional African religion. The respondents with an Islamic background didn't patronize meat of grasscutters hunted from the wild, because bleeding-out of such carcasses is delayed or not done at all in some cases; consumption of such meat, is forbidden by their religion.

Majority of the respondents had a high level of education (46.4%). It was most appropriate to use such respondents for this study, because they could describe more accurately, their observations and experiences from consuming grasscutter meat.

Asked to indicate whether they would prefer the meat of farmed or wild grasscutter (based on previous experience), given the choice, their varied responses are presented in Fig. 2.

Majority (78%) of the respondents indicated that they would prefer meat from the wild to that from the farmed grasscutter. When further asked for reasons behind their choice, 41% of them said their decision was based on the fact that meat of the wild grasscutter has a more intense flavour and is also tastier than that of the farmed grasscutter. Pressed further,

Table 1
Demographic characteristics of the grasscutter meat consumers.

Parameters	**Response**	**Frequency**	**Percentage (%)**
Gender	Male	39	15.6
	Female	211	84.4
Religion	Christianity	187	74.8
	Islamic	46	18.4
	Traditional African religion	17	6.8
Level of education	No formal education	21	8.4
	Basic level education	11	4.4
	Secondary level education	102	40.8
	Tertiary level Education	116	46.4

From Table 1, a majority (84.4%) of the respondents were female. Females dominated this study because in most Ghanaian homes, food purchasing decisions are taken by women. Therefore, in most of the households visited, the researchers were directed to the women to fill out the questionnaires. The few male respondents in the study were either unmarried or divorced, and so managed their own domestic lives.

Table 2
Proximate composition of farmed (FG) and wild (WG) grasscutter meats.

Parameter	FG	WG	SED	P-value
Crude protein	24.61^{b}	25.72^{a}	0.13	0.004
Ether extract	9.49^{a}	5.74^{b}	0.11	0.003
Moisture	76.56	75.09	0.33	0.07
Ash	1.17	1.19	0.04	0.09

Means in the same row with different superscripts are significantly different; SED = Standard Error of Difference; FG = meat from farmed grasscutter; WG = meat from Wild grasscutter.

they could however not give definite reasons as to why the meat of the wild grasscutter possessed such desirable characteristics. This observation is a potential threat to efforts by both government and non-governmental organizations to revamp grasscutter farming as a means of alternative livelihood amongst rural folk, because products from such efforts may receive poor consumer patronage. Other respondents (39%) preferred the meat of the wild grasscutter because it was more tender, such that both children and the aged could easily chew it; meat of the farmed grasscutter according to them, is usually not as tender as that from the wild. The said tenderness of the meat of wild grasscutters could be due to protein breakdown during the process of muscle conversion to meat, which was possibly influenced by the delayed bleeding-out and dressing of the hunted carcasses under hot ambient temperature conditions. Meat of domesticated grasscutters however, are either cooked or kept frozen immediately after slaughter, hence the process of muscle conversion to meat does not take place sufficiently. This could have accounted for the relative toughness of such meat, even though they had higher fat content.

A few of the respondents (20%) however, preferred the meat of the farmed grasscutters to that of the wild ones. These respondents were mostly of the Islamic faith, who shunned wild grasscutter meat because hunters either did not bleed-out the animals, or bleeding-out was delayed after the animals were shot dead. This practice is contrary to the Islamic dietary rules [8]. Others indicated that some hunters were known to use poisonous substances to trap animals, which could be dangerous to consumers of such meat because of the possibility of ingesting residual chemicals in the meat. If this claim is really the case, then consumption of such game meat could be hazardous to the health of consumers, as the poisonous substances used to trap the animals could have deleterious effects on some organs in the body of consumers of such meat.

Results from determination of crude protein, moisture, ether extract and ash contents of the grasscutter meats are presented in Table 2.

The crude protein content of meat from the wild grasscutters was higher ($p = 0.004$) than that from farmed grasscutters (Table 2). This is consistent with findings of Ajayi and Tewe [1] who reported very high protein levels in carcasses of wild grasscutters. Grasscutters from the wild are killed, but not usually bled-out immediately. Gregory et al. [9] showed that delayed bleeding-out in cattle resulted in high levels of residual blood in the forequarters. According to Warriss [29], blood is a rich source of protein, thus its presence in the muscles could have resulted in the higher crude protein content in the meat from the wild grasscutters. The nutrient-rich nature of blood, according to Lawrie and Ledward [14] however, makes it a good medium for microbial proliferation, and so poorly bled carcasses tend to have shorter shelf-life than properly bled ones. Such carcasses need to be stored well to reduce microbial activities, and minimize possible food-borne infection/illness amongst consumers. That notwithstanding, higher crude protein content in meat is said to be advantageous, because protein is required for several essential functions such as growth and repair of worn-out tissues in humans [14].

Table 3
pH, Cooking and Chilling losses of carcasses of farmed (FG) and wild (WG) grasscutters.

Parameter	FG	WG	SED	P-value
pH	6.15[b]	6.89[a]	0.24	0.004
Cooking losses	18.38[b]	20.23[a]	0.31	0.000
Chilling losses	2.13[b]	2.96[a]	0.12	0.000

Means in the same row with different superscripts are significantly different; SED = Standard Error of Difference; FG = meat from farmed grasscutters; WG = meat from wild grasscutters.

The meat from the wild grasscutters had lower ($p = 0.003$) levels of ether extract, than that of the farmed grasscutters. This could have resulted from differences in feeds consumed, or possibly due to the more sedentary nature of farmed grasscutters resulting from inadequate space in cages as well as absence of other facilities to express their normal behaviour patterns as done in the wild; this will result in less energy expenditure [22]. This finding corroborates that of Pethick and Rowe [21] who investigated the effects of exercise and feed types on fat score of sheep carcasses. They concluded that regular exercise reduced the fat content of meat; as well, the type of feed fed had a marked effect on the fat content of meat. Fats in meat improve its tenderness, juiciness and flavour [25,28]. Drewnowski [7] observed that, the sensory properties of fat help to make diets flavourful, tender and palatable. Conversely, meat with low fat content present technological difficulties during further-processing. Keeton [13] outlined some problems associated with processing meats with low fat content as reduced cook yield, poor binding ability, short shelf-life, rubbery skin formation and excessive purge in vacuum bags. However, regular intake of meat with high fat content has been associated with the development of hypertension, cardio-vascular diseases and obesity [12]. A number of health establishments, including the World Health Organization, have recommended reduced daily fat intake for improved health . Grasscutter farmers are therefore advised to provide adequate space for farmed grasscutters to enable them exercise, and possibly reduce fat contents of their meat.

The moisture and ash contents of the meats were however, not different ($p>0.05$), on analyses.

The pH, cooking and chilling losses of the carcasses are presented in Table 3.

The pH of the meat from wild grasscutters was higher ($p = 0.004$) than that from the domesticated ones (Table 3). The lower pH of the domesticated grasscutter meat might be due to higher rates of lactic acid production from pre-stunning handling stress in the course of conveying animals to the slaughterhouse. It is worth noting that though the animals were farmed, they still exhibited some aggressive characteristics in the presence of humans. According to Warriss [29], when animals feel threatened, or are stressed prior to slaughter, defensive mechanisms come into play; as a result, glycolysis takes place to produce energy for escape. However, the absence of oxygen (following the death of the animal) results in the production of lactic acid, instead of energy. The wild grasscutters were however, shot unexpectedly with a gun. If the shots directly hit the head, it is possible this caused immediate loss of normal brain function; and lactic acid production post-mortem would not be as rapid as in stressed animals. This might result in the significantly lower pH levels in the meat of the farmed grasscutters.

The cooking losses in the meat from wild grasscutters were higher ($p = 0.000$) than those for the farmed ones. This could have resulted, possibly from the carcasses of the wild grasscutters being bled-out and dressed several hours after death, which could have initiated protein breakdown/putrefaction. Omojola [19] in a similar observation, reported high cooking losses in rabbits which were stunned mechanically, and bleeding-out delayed for up to 15 min. Hunters in most parts of Ghana, usually go hunting at night, but all animals killed in the night are neither bled nor dressed till they return from the hunting trip (with the exception of Muslim hunters who are required to bleed hunted animals for religious reasons). This delay likely initiates the process of muscle conversion to meat. As carcasses are handled under relatively high storage temperatures, enzymes and lactic acid bacteria within the muscles act to breakdown rigour mortis and connective tissues in the muscles to make them tender [29]. The protein putrefaction associated with such activity, might have resulted in the muscles becoming more tender, having improved flavour, and also losing their water-holding capacity.

On the other hand, it was realized from Table 2, that the meat from farmed grasscutters, had higher fat contents than those from wild grasscutters. The higher fat content might have been a contributory factor to the lower cooking and chilling losses in the meat, as fat is reported to serve as a barrier to minimize moisture losses from meat products [20].

Similarly, the chilling losses in the meat from wild grasscutters was also higher ($p = 0.000$) than that from farmed ones. The reason for this observation might be similar to those adduced for the higher cooking losses in the meat of wild grasscutters (Table 3).

The sensory characteristics of the farmed and wild grasscutter meats are presented in Table 4.

The meat of the wild grasscutters was darker ($p = 0.000$) than that of the domesticated grasscutters (Table 4). This observation could be due to the delayed bleeding-out of the carcasses of the wild grasscutters. Blood is usually dark in colour, hence poorly bled carcasses appear darker in colour [14]. This could have adverse effects on meat marketing because colour represents perceived freshness, and so is of vital importance to the meat industry [15]. Bell and Weaver [4] indicated that colour is a major indicator of quality of meat, and the appearance of meat and meat products influences consumer

Table 4
Sensory characteristics of farmed (FG) and wild (WG) grasscutter meats.

Parameter	FG	WG	SED	P-value
Colour	3.14^{b}	4.68^{a}	0.13	0.000
Off-odour	1.64	1.98	0.57	0.090
Tenderness	3.42^{b}	4.16^{a}	0.11	0.003
Juiciness	2.59	2.66	0.14	0.089
Flavour intensity	3.13^{b}	4.43^{a}	0.15	0.003
Acceptability	3.27^{b}	4.43^{a}	0.21	0.000

Means in the same row with different superscripts are significantly different; SED = Standard Error of Difference; FG = meat of farmed grasscutters; WG = meat of Wild grasscutters; ***Colour***= very pale (1), very dark (5); ***Off-odour***: very weak (1), very strong (5); ***Tenderness:*** very tough (1), very tender (5); ***Juiciness***: very dry (1), very juicy (5); ***Flavour intensity***: very weak (1), very strong (5); ***Overall acceptability***: dislike very much (1), like very much (5).

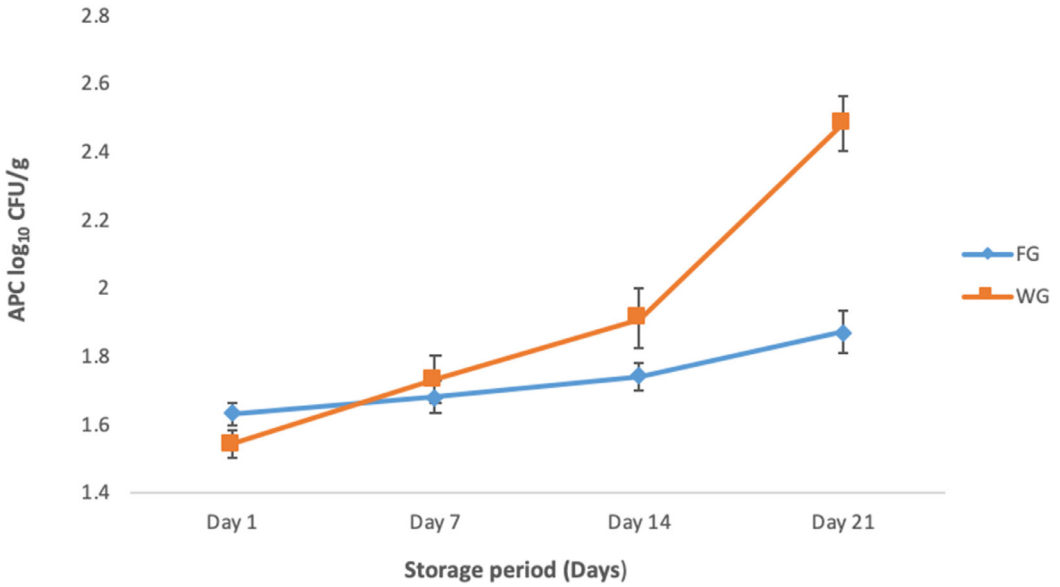

Fig. 3. Weekly Aerobic Plate Counts from carcasses of farmed (FG) and wild (WG) grasscutters during 21 days of storage.

acceptability. This however, did not appear to adversely affect the sensory characteristics of meat of the wild grasscutters, as scored by the panellists.

The off-odour and juiciness scores were not different ($p>0.05$) between the two products.

Tenderness and flavour intensity of the meat from the wild grasscutters were better ($p = 0.003$) than those from farmed grasscutters. These might be due to the keeping of the wild grasscutter carcasses under high ambient temperature conditions over a long period (up to about 12 h) after death. This probably resulted in muscle putrefaction, and a resultant breaking down of connective tissues, thus improving tenderness and flavour intensity of the meat from the wild grasscutters.

The acceptability of the wild grasscutter meat was better ($p = 0.000$), probably due to improved tenderness and flavour intensity [15]. This could have resulted from muscles of slaughtered animals being frozen immediately after slaughter, resulting in possible toughness due to cold shortening. This could have accounted for meat from farmed grasscutters appearing tougher than that from the wild grasscutter, even though the former had higher fat content than the latter. The implication of the higher preference for the wild grasscutter meat is that patronage of meat of farmed grasscutters would be low, thus negating the several benefits in it creating employment for the youth, minimizing environmental hazards associated with hunting for grasscutters, and possible incidence of food poisoning if animals are trapped with poisonous substances. To overcome this challenge, meat processing firms are advised to obtain chilling facilities to ensure proper process of conversion of muscle to meat; hence, in the process improve flavour and tenderness of meat of farmed grasscutters.

The results of Aerobic Plate Counts from the carcasses, determined on days 1,7,14 and 21 of storage (following slaughter), are presented in Fig. 3.

Aerobic Plate Count indicates the general bacterial population in products. This usually provides information on the wholesomeness and product stability in storage [10]. The aerobic plate counts at the start of storage (day 1), was significantly lower in the meat from the wild grasscutters. However, the counts became higher in the meat of wild grasscutters from 14 days of storage and beyond, compared with that of the farmed grasscutters. This observation can be explained by the accumulation of blood in the meat of the wild unbled grasscutters, which served as additional source of nutrients for rapid microbial multiplication. The APCs in all the products were however, significantly lower than $7\log_{10}$CFU/g, which is considered as the maximum threshold for product acceptability [10].

Conclusions

Majority of meat consumers in the study area preferred meat from the wild grasscutter to that of the farmed ones, defeating the hypothesis of this study. Reasons given included higher level of tenderness, higher flavour intensity and lower fat content of the meat of wild grasscutters, in comparison with meat from the farmed grasscutters. The wild grasscutters were not bled for several hours after death; their meat subsequently had higher crude protein content, probably due to the high contribution of blood proteins in the muscles. To improve patronage of the meat of farmed grasscutters, farmers are advised to provide adequate space for caged grasscutters to exercise to reduce fat content in meat. In addition, slaughter plants and individual processors are encouraged to obtain facilities that allow freshly slaughtered carcasses of farmed grasscutters to age for about 36 - 48 h before freezing or smoking; this is likely to improve tenderness and flavour of the meat. Consumers who have access to wild grasscutter meat, are advised to cook them sufficiently before consumption, to avoid contracting possible food-borne diseases.

Declaration of Competing Interest

None

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