ECRONICON OPEN ACCESS

EC VETERINARY SCIENCE

Research Article

Effect of Community-Based Buck Selection and Production System on Growth Performance, Carcass and Meat Quality Characteristics of indigenous Malawian Goats

Steven Richard Mussah[1,2]*, Richard Phoya[1], Liveness Banda[1], Jonathan Tanganyika[1] and Gregory Chingala[1]

[1]Lilongwe University of Agriculture and Natural Resources, Lilongwe, Malawi

[2]Malawi Defence Force Headquarters, 2nd Battalion, Kamuzu Barracks, Lilongwe, Malawi

***Corresponding Author**: Steven Richard Mussah, Lilongwe University of Agriculture and Natural Resources, Lilongwe, Malawi.

Received: February 28, 2020; **Published:** April 29, 2020

Abstract

The objective of this study was to evaluate the effect of community-based buck selection of indigenous Malawian goats under different feeding systems on growth performance, carcass and meat quality characteristics. Forty castrated male goats (20 sired by community selected bucks and the remainder from 20 unselected ones), one-year-old and weighing (16.68 ± 2.02) at the commencement of the study were randomly allocated to either semi-intensive or free-range production system in a 2×2 factorial treatment structure. The four treatment combinations were: (1) selected goats + grazing + supplementation; (2) selected goats +grazing only; (3) unselected goats +grazing +supplementation; (4) unselected goats +grazing only. Goats were allowed to graze for eight hours (07:00 - 15:00hrs) daily while supplementation (500g of concentrate/day/goat supplying 160 g/kg DM crude protein) was done after grazing. The concentrate consisted of soybean meal (18%), maize meal (20%), maize bran (59.3%), lime (1%), MCP (1%) and salt (0.7%). The goats were tagged and dewormed before the trial. The goats were weighed on day 0, 15, 30, 45 and 60 of the experiment to determine the weight gain and thereafter slaughtered for carcass and meat quality evaluation. Buck selection in combination with semi-intensive system produced goats which had significantly higher final weight, total and daily weight gain than the rest of the treatments. However, there were no differences ($P > 0.05$) in the final body live weight, total gain and average daily gain between goats born to unselected bucks raised in both semi-intensive and free range. The same pattern was observed for slaughter weight, hot and cold carcass weights. Regardless of the production system, meat from selected goats had higher a* values than unselected. Selected goats raised under semi-intensive system had lower mean values of cooking losses than the other treatments. It was concluded from this study that community-based buck selection and production system had significant effects ($P < 0.05$) on growth performance, carcass and meat quality characteristics of indigenous Malawian goats. Therefore, it was recommended that for optimal performance of indigenous Malawian goats in terms of growth, carcass and meat quality, selection should be accompanied by grazing and supplementation.

Keywords: *Average Daily Gain; Grazing; Indigenous Goats; Supplementation*

Introduction

The Small East African Goat (*Capra hircus*) is one of the small ruminant species kept for meat production by many smallholder farmers in Malawi. According to DAHLD [1] there were 8.4 million goats in Malawi representing 5.4% of the total livestock population and accounted for 96.3% of all ruminant national population. Mahgoub., *et al*. [2] reported that goats play an important role in the socio-economic involvement of human civilisation around the world. In addition, goat production is particularly important in the tropics and sub tropics where it is used as a major source of meat, milk, fibre, skin, and manure in many traditional societies.

Goats are able to adapt to seasonal and geographical changes and utilise low quality range lands to produce high quality protein, which is extremely important. As mixed feeding opportunists, goats have become important livestock in arid and semi-arid regions of the world because of their characteristics of versatility in harvesting forage and their ability to survive adverse foraging conditions. A higher population of goats than other ruminant livestock in Malawi is because goats do not require huge capital investment, large grazing area and thrive better on natural grasslands because of their browsing ability. Furthermore, goats are prolific breeders with shorter gestation period than cattle and possibility of twining is high [3]. As a result, goat production is attractive to the smallholder farmers in Malawi who form the largest bulk of livestock producers. The Malawi's National Statistical Office [4] estimated that most households keeping livestock in Malawi have at least a goat.

Most goats kept in Malawi are indigenous and are kept on communal grazing areas. In general, goat production in Malawi is characterised by low productivity because of inbreeding due to lack of a breeding structure leading to depressed growth performance and survival of kids. Conventional breeding structures are often difficult in smallholder production systems because of the small flock sizes and communal herding [5]. The community-based breeding programme (CBBP) has shown to be a viable and more sustainable genetic improvement of indigenous livestock under smallholders farming system [6]. Community based breeding programmes based on bottom-up participatory approach typically relate with the farmers of low-input production systems within the certain geographical areas with those having a common interest to work together for the improvement of their genetic resources [6].

Community-based buck selection is underway in selected villages in the South, Central and Northern regions of Malawi. Farmers in these communities are encouraged to select good bucks among the flock based on body weights, breeding soundness and other traits that are of interest to them. The undesirable bucks are castrated, fattened and sold for goat meat production. While several studies have been undertaken evaluating the framework of the programme and genetic gains, no studies have evaluated the effect of community-based breeding programmes on growth performance, carcass and meat quality characteristics of kids born from community selected bucks under different production systems in Malawi. Hence, this study was conducted to evaluate growth performance, carcass and meat quality characteristics of offspring of bucks selected through community-based goat breeding programme under two different production systems.

Materials and Methods

Experimental design

All animal procedures used in this trial were approved by the Ethics Committee on Experimental Animal Use and Care of the Lilongwe University of Agriculture and Natural Resources. The trial was conducted from August to September 2019 and involved 40 goats (20 community selected and 20 unselected goats) which were individually housed after grazing at the Sakhula Farm, Bunda College, of the Lilongwe University of Agriculture and Natural Resources, Malawi located on 14°35'S, 33°50'E, with an average annual rainfall of 900 mm. The forages in the rangeland consisted of the following: *Hyparrhenia rufa*, *Chloris gayana*, *Cynodon nlemfuensis* and mixed browse shrubs.

Twenty castrated male goats aged 12 months old were purchased from farmers practicing the community-based buck selection. The bucks were selected by the farmers in the community, based on body weights, breeding soundness and other traits that were of interest to them. In addition, another twenty castrated unselected male goats were purchased from a nearby community that was not involved in community-based breeding programme. The goats were tagged and dewormed before being received at the Sakhula Farm, Lilongwe University of Agriculture and Natural Resources. The goats weighed (16.68 ± 2.02) at the commencement of the experiment.

Either of the goats were randomly assigned to one of the production systems (free-range or semi-intensive) to achieve a 2 x 2 factorial experimental design, with the following four sub-treatment combinations: selected goats + grazing +supplementation; selected goats +

grazing only; unselected goats + grazing + supplementation; and unselected goats + grazing only. All goats were allowed to graze on an open rangeland around the farm for 8 hours daily (07:00hrs - 15:00hrs), followed by a concentrate supplementation (only those animals on semi-intensive system). The chemical composition of the concentrates and forages sampled from the rangeland are shown in table 1.

Chemical analysed, g/kg DM	Rangeland grasses (August-September)	Concentrate supplement
Dry matter	902	881
Crude protein	69	157
Crude fat	5.6	19
Ash	86	101
Neutral detergent fibre	781	271
Acid detergent fibre	678	124
Non-fibrous carbohydrate	58.4	452

Table 1: *Chemical profile of rangeland forages and concentrate.*

Chemical analyses of forages and concentrate

The dry matter (DM), crude protein (CP) and ash were analysed following the AOAC [7] procedures. The Kjeldahl method was used for the determination of CP. Neutral detergent fibre was determined using the ANKOM Fibre Analyser (Ankom Technology, Macedon NY, USA) using the heat-stable α-amylase and sodium sulphite and was expressed inclusive of ash. The analysis for acid detergent fibre (ADF) was also done using the ANKOM Fibre Analyser and was expressed inclusive of ash.

Growth performance measurements

Before the commencement of the experiment, the goats were put through an adaptation period of seven (7) days [8], then initial live-body weights of individual goats were recorded using a weighing scale. Thereafter, the live-body weights were recorded on day 15, 30, 45 and 60. During the entire feeding period, each goat in semi-intensive system was supplemented with 500g of concentrates per day [9]. To determine cumulative weight gain, the initial weight of each goat was subtracted from the final weight of the goat at each data point. Average daily gain (ADG) of an individual animal was determined by dividing final weight of each goat by 60 (total number of days of the experiment).

Carcass characteristics measurements

After the feeding trial, all goats were slaughtered at Bunda Small Animal Unit Abattoir for evaluation of carcass characteristics. The goats were starved (only water was given) for 12 hours before slaughter afterwhich, slaughter weight was recorded, stunned using a captive bolt stunner then slaughtered, flayed and eviscerated. Soon after evisceration, hot carcass weight, and weight of non-carcass parts which included head, feet, skin, full gut, empty gut, heart, liver and spleen were recorded. The non-carcass components were expressed as a percentage of the slaughter weight. The carcasses were then chilled for 24 hours at 4°C. The measurements performed on the carcasses after 24h of chilling included weights for cold carcass and primal cuts (Leg chump, Loin, Rack, Neck and Breast) and their proportion to the cold carcass weight. The proportions of these parts were calculated as the ratio between the individual parts and the cold carcass weight.

Measurements of meat quality

Meat quality evaluation was done on meat samples extracted from *Longissimus thoracis et lumborum* muscle from each goat carcass. Meat quality analyses included colour,drip loss, cooking loss, pH, Warner-Blatzler shear force and flavour. All the analyses were performed in triplicates and the average was recorded.

Carcass pH measurements

Carcass pH measurements were taken on the left side of carcasses at the same point on the *Longissimus thoracis et lumborum* (LL) between the 5th and 6th rib [10]. pH readings were taken 45 minutes, 6, 12 and 24 hours post mortem and were designated as pH45 (initial), pH6, pH12 and pH24 (ultimate pH), respectively. The pH was taken using penetrating electrode of a portable pH-metre (Knick-portamess 911, Germany). The probe was calibrated with pH 4 and 7 standard buffer solutions. Before and after every reading the electrode was thoroughly cleaned with distilled water and cotton towel. Ultimate pH (pHu) was taken after complete glycolysis at 24 hours post mortem.

Meat colour

Colour values of external surface of the *Longissimus thoracis et lumborum* muscles from each goat carcass was determined at 24 hours postmortem using the CIE colour system using Konica Minolta CR400 Chroma Meter, Japan [11,12]. Samples measuring 30 x 30 mm were prepared for the colour measurements. The following colour values were measured: lightness (L*), redness (a*) and yellowness (b*). Three random readings were taken from each sample and averaged [13].

Drip loss

Samples of 50g of the LL muscles from each goat carcass were weighed initially and stored at chilling temperatures of 4°C for 24 hours. The samples were placed in a container on the supporting mesh and sealed to prevent air from entering the container. After 24 hours, the samples were removed from the containers, bloated dry, and weighed again. Drip loss was expressed as a percentage of the initial weights [14,15]:

$$\text{Drip loss} = \frac{\text{Initial sample weight - weight of sample after 24hr chilling (1-5°C)}}{\text{Initial sample weight}} \text{ X } 100$$

Cooking loss

Cooking loss was determined by putting 30 mm x 30 mm of the LL muscles from each goat carcass from each treatment in plastic bags and cook it to an internal temperature of 71°C [16]. The samples were left to cool to internal temperature of 4°C. Twelve hours after cooling to room temperature, the bags were opened and free juice drained [17]. The cooked samples were blotted with a paper towel and reweighed. Cooking loss was determined at 24 hours postmortem by expressing cooked sample (B) weight as a percentage of sample before cooking (A) [18,19]: Cooking loss (%) = [(A-B)/(A)]×100.

Meat tenderness

Warner-Bratzler shear force (WBSF, kg/cm^2) values were measured using the Instron Universal Testing Machine (TA. XT plus Texture analyser). Samples from the *Longissimus thoracis et lumborum* (LL) muscles from each goat carcass were cooked individually in plastic bags immersed in a 75°C water bath for 30 minutes [17] and allowed to cool to room temperature for 30 minutes. From each muscle 0.5

×4.0 mm (ca. 2 cm^2) along the muscle fibre was cut for shear force measurement [20]. The meat samples were placed at right angles to a plunger type blade. Crosshead speed was 100 mm/min and full-scale load 50 kg was used. Average of 3 samples from each muscle at 24 hours postmortem was measured.

Sensory characteristics

Sensory scores of flavour of goat meat was determined by a trained taste panelists who scored the meat using the 9-point - Hedonic scale rating. A total of twelve (6 males and 6 females) taste panelists who were familiar with the taste of goat meat and eat at least once a week or more often were recruited according to their responses to a brief screening questionnaire about their; age, sex and available time to carry out the test. The triangle test where three coded samples were presented at the same time, two were identical and the third sample was the odd [21] by using three samples of sugar solution and three other samples of salt solution for the panelists to identify. After this test, the panelists were provided with three plates containing goat meat. The plates were labeled A, B and C which contained meat from the two treatments so that they taste the palatability factors of goat meat.

Statistical analysis

The data were checked for normality using the Shapiro-Wilk test. Data were analysed using General Linear Model (GLM) procedures of SAS 9.4 (SAS Institute, Cary, NC, USA). The PDIFF option of SAS was used for the mean separation. The significance was declared at $P \leq 0.05$.

Statistical model

Statistical analysis on growth performance, carcass and meat quality characteristics used the following model: $Y_{ijk} = \mu + S_i + D_j + (SD)_{ij} + \varepsilon_{ijk,}$ where; Y_{ijk} = Growth performance, carcass characteristics and meat quality; μ = Overall mean; S_i = Effect of Buck selection; D_j = Effect of diet; $(SD)_{ij}$ = Interaction between selection and production system; ε_{ijk} = Random error. Furthermore, time of measurements were fitted in the model as repeated measures for cumulative live body weight gain.

Results and Discussion

Growth Performance

Community buck selection, production system, day of measurement and their interaction had influenced ($P < 0.05$) the cumulative weight gain of the goats. At the start of the experiment, all goats had similar live body weights (Figure 1). However, the goats born from community selected bucks raised under semi-intensive system had the highest cumulative body weight gain throughout the experimental period ($P < 0.05$) followed by the selected goats under free range while unselected goats raised on both systems had the lowest cumulative weight gain. There was no significant difference ($P > 0.05$) in cumulative weight gain between unselected goats raised on both systems. The trend kept on increasing up to the end of the experiment.

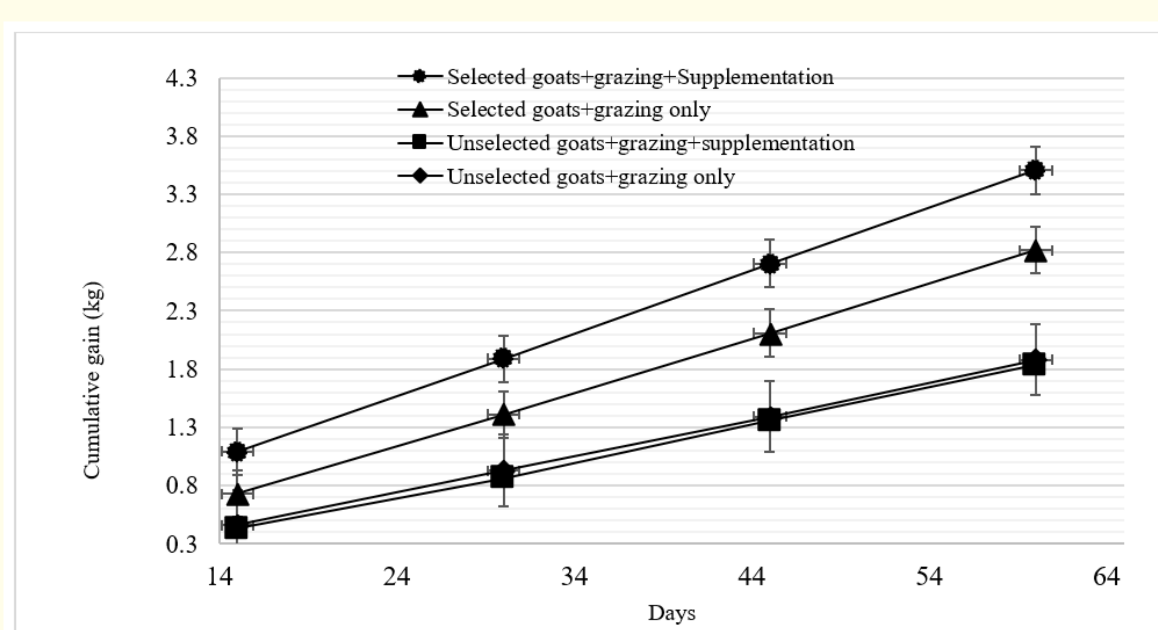

Figure 1: *Cumulative weight gains of selected and unselected indigenous Malawian goats under semi-intensive and free-range systems.*

The higher cumulative weight gains in selected goats raised on semi-intensive system over unselected goats under the same production system may be attributed to better genetic constitution of the selected goats, which led to good feed efficiency, hence rapid growth. Tanganyika., *et al.* [9] reported that supplementation in goats under semi-intensive feeding system results in better growth performance of goats. Similar findings were reported by Gokdal [22] who reported different growth rates in goats with different genotypes fed concentrates (300 g/day/animal) in addition to grazing on rangelands.

Results of effects of community-based buck selection in combination with production system on final weight, total and average daily gain (ADG) are presented in table 2. There were significant interactive effect of buck selection and production system ($P < 0.05$) on the final body live weight, total gain and daily average gain. Buck selection in combination with semi-intensive system produced goats which had the highest ($P < 0.05$) final, total gain and ADG of all treatment. However, there were no significant differences ($P > 0.05$) in the final body live weight, total gain and average daily gain between goats born to unselected bucks raised in both semi-intensive and free range systems. The difference in growth performance between goats born to community selected bucks raised under semi-intensive and other treatment combinations may be attributed to genetic and environmental interaction which led to good feed efficiency, hence rapid growth. The good genotypes in selected goats allowed good utilization of the nutrients provided by supplementation of concentrates. This means that the combination of genetics and environment (nutrition) provided more potential for growth in selected group. Shrestha and Fahmy [23] reported that all performance traits are not only influenced by the genetic variance but also the environment in which the animals are raised.

Parameter	Community selected goats		Unselected goats			p-Value		
	Supplemented	Not supplemented	Supplemented	Not supplemented	SEM	Selection (S)	Production system (P)	S x P
Initial wt (kg)	16.2	16.5	16.6	16.7	0.62	0.108	0.742	0.421
Final wt (kg)	20.2^a	19.5^b	18.5^c	18.5^c	0.17	< 0.0001	0.0025	0.0069
Total wt gain (kg)	3.57^a	2.83^b	1.85^c	1.79^c	0.16	< 0.0001	0.0025	0.0069
ADG (g/day)	59.5^a	47.2^b	30.8^c	29.9^c	2.84	< 0.0001	0.0025	0.0069

Table 2: *Effect of community-based buck selection and production on growth performance of Indigenous Malawian goats.*
^{abc}: Means with different superscripts in same rows differ significantly ($P < 0.05$)
ADG: Average Daily Gain; SEM: Standard Error of Mean; S: Selection; P: Production System.

Selected goats performed differently under semi-intensive and free range systems. Selected goats in the semi-intensive system had statistically higher means in terms of final weight, total gain and average daily gain than the free-range ones. The significant difference ($P < 0.05$) in the means may be attributed to the good environment (supplements) provided to the semi-intensive group. Studies by Naga., *et al.* [24], Shrestha and Fahmy [23] reported that all performance traits are not only influenced by the genetic variance but also the environment in which the animals are raised.

No significant differences ($P > 0.05$) in final weight, total gain and average daily gain of goats from unselected buck under semi-intensive and free-range systems were recorded (Table 2). Shrestha and Fahmy [23] reported that animals with poor genotypes, even if exposed to good environment such as nutrition, may not perform beyond their genetic potential. This could be the reason why despite the supplementation of the unselected group of goats did not yield any significant differences from the unselected group on free range.

Carcass characteristics

There were interactions between selection and production system (P < 0.05), between selected and unselected groups reared under semi-intensive and free-range systems, in terms of slaughter weight, hot carcass weight, dressing percentage, cold carcass weight, rack and loin weight (Table 3). The higher means obtain in selected animals may be attributed to the effect of supplementation [9]. Supplementation might have provided enough energy which prompted growth of all the attributes mentioned. In addition, good environment (nutrition/supplementation) enabled the animals in selected groups to express their genetic potential fully, hence good growth and development of the parts mentioned.

Parameter	Selected		Unselected		SEM	p-Value		
	Semi-intensive	Free range	Semi-intensive	Free range		Selection (S)	Production system (P)	S× P
Slaughter wt, kg	20.1[a]	19.5[b]	18.4[c]	18.4[c]	0.17	< 0.0001	0.0136	0.0273
HCW (%)	9.78[a]	8.49[b]	8.19[c]	8.0[c]	0.23	< 0.0001	< 0.0001	0.0337
CCW (%)	9.14[a]	7.66[b]	7.20[c]	7.08[c]	0.22	< 0.0001	< 0.0001	0.0052
Dressing %	45.3[a]	41.2[b]	39.4[c]	38.6[c]	1.07	0.003	< 0.0001	0.0335
Leg chump (%)	28.3[a]	31.3[b]	30.4[b]	30.8[b]	1.11	0.3318	0.0376	0.106
Loin (%)	12.8[a]	11.7[b]	10.5[c]	10.8[c]	0.48	< 0.0001	0.298	0.0429
Rack (%)	6.94[a]	6.59[b]	6.04[c]	6.0[c]	0.34	0.9144	0.007	0.461
Neck (%)	12.9[a]	11.1[b]	10.1[c]	10.0[c]	0.56	< 0.0001	0.135	0.230
Breast (%)	0.66	0.52	0.45	0.45	0.34	0.0700	0.417	0.547
Head (%)	7.56	7.42	7.39	7.40	0.28	0.100	0.523	0.0591
Skin (%)	8.51	8.53	8.64	8.76	0.43	0.4489	0.119	0.261
Liver (%)	0.46	0.46	0.46	0.44	0.03	0.711	0.578	0.578
Heart (%)	0.63	0.66	0.64	0.68	0.08	0.299	0.160	0.447
Full gut (%)	8.8	8.64	7.69	9.45	0.62	0.684	0.070	0.0396
Empty gut (%)	5.29	5.58	4.36	4.98	0.28	0.0007	0.0344	0.421
Spleen (%)	0.58	0.56	0.55	0.58	0.07	0.141	0.377	0.644
Feet (%)	2.67	2.66	2.65	2.61	0.14	0.308	0.170	0.178

Table 3: *Effect of community-based buck selection and production system on carcass characteristics of Indigenous Malawian goats.*

[abc]: Means with different superscripts within rows differ significantly (p < 0.05). HCW: Hot Carcass Weight; CCW: Cold Carcass Weight; SEM: Standard Error of Mean.

The results show that the mean values for full and empty gut was higher in selected and supplemented goats than the other group. This agrees with [25] who reported the same in Small East African goats under different feeding regimes. The higher mean values of a full and empty gut could be due to higher fat content on the surface of the gut of goats under supplementation. However, this is not in agreement with what [26], who reported that goats on high concentrate supplementation have less developed digestive tract due to the less roughage intake compared to those on low concentrate intake. That study further stated that higher roughage intake stimulates gut development that support peristaltic movements during digestion. No significant differences were found in weights of some non-carcass parts. The present study agrees with [9] who reported non-significant differences in some non-carcass parts such as head, feet, heart and empty gut in indigenous Malawian goats supplemented with different amounts of concentrates.

Meat quality characteristics

There were interactions (P < 0.05) between selection and production system as regards to cooking loss, lightness and pH of the meat. There were significant differences (P < 0.05) in some meat quality characteristics between selected and unselected goats kept under semi-intensive and free-range systems. Selected goats had lower mean values in terms of cooking loss percentage and colour (lightness), but with higher mean values for flavour and muscle pH.

Choi., *et al*. [19] reported that difference in diets affected cooking loss of Korean Black goats fed different browses. On the contrary, Lee., *et al*. [27] reported that diet did not affect cooking loss of goats fed three post weaning diets. Studies by De Palo., *et al*. [28] also reported no significant differences (P > 0.05) in cooking losses of dairy goats fed milk replacers.

The results show significant differences (P < 0.05) in colour between selected and unselected goats (Table 4) reared under semi-intensive and free-range systems. Selected goats under semi-intensive system had darker meat than unselected ones. Selected goats registered higher mean values of L*, a* and b* and this may be attributed to the difference in genetic constitution between the two groups as selection may concentrate genotypes which may influence myoglobin levels in the muscles. In line with this, Ivanovic [29] indicated that myoglobin influences the colour of meat.

Parameter	Selected		Unselected		SEM	p-Value		
	Semi-intensive	Free range	Semi-intensive	Free range		Selection (S)	Production system (P)	S×P
Drip Loss (%)	1.05	1.04	1.04	1.03	0.02	0.6871	0.4014	0.9124
Cooking Loss (%)	20.15[a]	24.52[b]	24.61[b]	24.87[b]	0.57	< 0.0001	< 0.0001	< 0.0001
WBSF, kg	3.01	2.97	3.03	3.0	0.05	0.307	0.464	0.883
L*	37.4[a]	39.7[b]	44.5[c]	43.7[c]	1.11	< 0.0001	0.558	0.0237
a*	17.46[a]	17.29[a]	13.09[b]	13.18[b]	0.44	< 0.0001	0.899	0.681
b*	8.83[a]	8.14[b]	8.16[b]	8.00[b]	0.23	< 0.0001	0.651	0.166
pH 45 minutes	6.48[a]	6.33[b]	6.34[b]	6.36[b]	0.04	0.0847	0.0382	0.0047
pH 6hrs	6.3[a]	6.14[b]	6.13[b]	6.13[b]	0.02	< 0.0001	< 0.0001	<0.0001
pH 12hrs	5.6	5.61	5.59	5.6	0.04	0.0566	0.216	0.0877
pH 24hrs	5.6	5.6	5.61	5.6	0.02	0.890	0.579	0.945
Flavour score	8.4	7.7	7.3	7	0.24	0.0011	< 0.0001	0.556

***Table 4:** Effect of community-based buck selection and production system on meat quality characteristics of Indigenous Malawian goats.*

[abc] Means with different superscripts in same rows differ significantly (P < 0.05).

L: Lightness; a*: Redness; b*: Yellowness; SEM: Mean Standard Errors; WBSF: Warner-Blatzler Shear Force.*

No significant differences (P > 0.05) were found in Warner-Blatzler Shear Force between selected and unselected goats kept under semi-intensive and free-range systems. However, the mean shear force value (3 kg) obtained in this study agree with what Webb., *et al*.

[30] recommended to be acceptable in goats. Results from the current study also agrees with Lee., *et al*. [27] who found no significant differences in Warner-Blatzler Shear Force in goats fed different rations. Contrary to this, Choi., *et al*. [19] reported significant differences in Warner-Blatzler Shear Force values of goats fed different browses.

Selected and unselected goats indicated differences ($P < 0.05$) in pH readings at 45 minutes and 6 hours. However, the value for ultimate pH for both selected and unselected goats was 5.61 (Figure 2) which falls in the recommended meat pH range of 5.5 to .5.8 as reported by Boughalmi and Araba [12]. The study reported that ultimate meat pH may affect several objective and sensory quality characteristics of meat i.e. color and water-holding capacity. Thus, it is accepted and used to be the main indicator of meat quality at the commercial level.

The results in table 4 did not show any significant differences in drip loss between selected and unselected groups kept under semi-intensive and free-range systems. This may be attributed to myofibrils which were still strong 24 hours post slaughter, bringing about no significant differences in drip loss between the two groups. A study by Budimir., *et al.* [31] reported no significant differences 24 hours post slaughter in lambs slaughtered at 40 and 60 days and attributed this to the strength of myofibrils within 24 hours post slaughter. The study later found significant differences after day three post slaughter and attributed this to the myofibrils which started weakening several hours after slaughter.

There was no selection × production system interaction on meat flavour (Table 4). However, there were significant differences ($P < 0.05$) in flavour between selected and unselected goats with selected goats regardless of production system having more intense flavour than unselected ones. In agreement with this, Ivanovic [29] reported that fats have been implicated to flavour in sheep and goats. This was applicable to this study because selected goats had more weight gain (accumulated more fat) than unselected goats.

Conclusion and Recommendation

This study has shown that community-buck selection, production system and interaction between community-buck selection and production system have significant effect on growth, carcass and meat quality attributes. It was also noted that the performance of goats from selected bucks can be enhanced with the provision of better nutrition. This study has also shown that progeny of unselected buck even when provided with better feed may not perform as good as selected ones. Therefore, the study recommends that for better and efficient production of indigenous Malawian goats, buck selection should be combined with better feeding (i.e. grazing and supplementation) to optimise goat meat production and quality.

Acknowledgement

The authors gratefully acknowledge Dr Fanny Chigwa (Head of Animal Science Department) for purchasing the goats used in the study. The first author would also like to thank the Malawi Defence Force commanders for providing support during the study period.

Many thanks to Mr Fanuel Malaundi, Pettersen Nachanje, David Mankhamba, Kwame Nazombe, Fred Kalengamaliro, Beaumont Mussah, Patrick Malapo, Charles Nyirongo, Maureen Zidyani, Francisco Kachoma, Kefasi Liwinga, Gibson Maliketi, Jonathan Malapo, Mphatso Malombera, Gladson Chiwanda, Dares Kandoje, Steven Lapken, Colonel Msukwa, LT. Colonel Vincent Kandapo, Captain Herbat Kamsuni Msowoya, Captain Andrew Precious Kalulu, Brigadier General Kapalamula, Brigadier Mkaliainga, Colonel Chilenga and Colonel Percy Mitengo for all the support given to the first author during the study period.

Thanks should also go all the workers at Sakhula Farm for raising the goats used in this study.

Bibliography

1. Department of Animal Health and Livestock Development, 2017/18. APES Report. Ministry of Agriculture. Department of Animal Health and Livestock Development (DAHLD), Lilongwe, Malawi (2018).
2. Mahgoub O., *et al*. "Goat meat production and quality". CAB International (2012).
3. Sheradin R., *et al*. "Meat quality of Boer goat kids and Mutton Merino lambs 2 sensory meat evaluation". *Animal Science* 76.1 (2003): 73-79.
4. National Statistical Office (NSO). Third Integrated Household Survey, Zomba: Malawi (2012).
5. Gizaw S., *et al*. "Breeding programmes for smallholder sheep farming systems: II. Optimization of cooperative village breeding schemes". *Journal of Animal Breeding and Genetics* 131.5 (2014): 350-357.
6. Mueller JP., *et al*. "Community-based livestock breeding programs: Essentials and examples". *Journal of Animal Breeding and Genetics* 132.2 (2015): 155-168.
7. AOAC. "Official methods of analysis, association of analytical chemists". 15th edition, Washington (2002).
8. Sun Z., *et al*. "Seasonal variations in voluntary intake and apparent digestibility of forages in goats grazing on introduced *Leymus chinensis* pasture". *Asian Australasian Journal of Animal Science* 27.6 (2014): 818-824.
9. Tanganyika J., *et al*. "Carcass yield and composition of Malawian indigenous goat weathers". *Scholarly Journal of Agricultural Science* 4.10 (2014): 526-535.
10. Shija DS., *et al*. "Chemical composition and meat quality attributes of indigenous sheep and goats from traditional production system in Tanzania". *Asian-Australian Journal of Animal Science* 26.2 (2007): 295-302.
11. Mussah SR and Phoya RKD. "Determination of age at slaughter on meat quality characteristics for indigenous Malawian spotted (kawangi) chickens". *Livestock Research for Rural Development* 29 (2017): 53.
12. Boughalmi A and Araba A. "Effect of feeding management from grass to concentrates feed on growth, carcass characteristics, meat quality and Fatty acid profile of Timahdite lamb breed". *Small Ruminant Research* 144 (2016): 158-163.
13. Pophiwa P., *et al*. "Meat quality characteristics of two South African goat breeds after applying electrical simulation or delayed chilling of carcass". *Small Ruminant Research* 145 (2016): 107-115.
14. Berri C., *et al*. "Increasing Dietary Lysine Increases Final pH and Decreases Drip Loss of Broiler Breast Meat". *Poultry Science* 87.3 (2008): 480-484.
15. Offer G and Knight P. "The structural basis of water-holding in meat". Part 2: Drip losses. In: Developments in meat science, Volume 4. Elsevier Science Publishers, New York (1988): 173-243.
16. Kannan G., *et al*. "Colour changes reflecting myoglobin and lipid oxidation changes in chevon cuts during refrigerated display". *Small Ruminant Research* 42.1 (2001): 67-75.
17. Choi JH., *et al*. "Effects of postmortem temperature on the physicochemical characteristics of prerigor Pekin duck breast muscles". *Poultry Science* 95.3 (2016): 645-650.
18. Yang HS., *et al*. "Textural and sensory properties of low fat pork sausages with added hydrated oatmeal and tofu as texture modifying agent". *Meat Science* 75.2 (2007): 283-289.

19. Choi SH., *et al*. "Effect of feeding browses in growth performance and meat quality of Korean Black Goats". *Small Ruminant Research* 65.3 (2006): 193-199.

20. Ali S., *et al*. "A Comparison of Meat Characteristics between Duck and Chicken Breast". *Asian-Australasian Journal of Animal Sciences* 20.6 (2007): 1002-1006.

21. Heinz G and Hautzinger P. "Meat Processing Technology for Small to Medium Scale Producers". RAP Publication 2007/20. FAO, Bangkok (2007).

22. Gokdal O. "Growth, slaughter and carcass characteristics of Alpine X Hair goats, Saanen X Hair goats and Hair goats male kids fed with concentrates in addition to grazing on rangeland". *Small Ruminant Research* 109.109 (2013): 69-75.

23. Shrestha JNB and Fahmy MH. "Breeding goats for meat production 3. Selection and breeding strategies". *Small Ruminant Research* 67.2-3 (2007): 113-125.

24. Naga AMA., *et al*. "Genetic improvement of Egyptian Nubian goats as sub-tropical dairy prolific breed". *Small Ruminant Research* 102.2-3 (2012): 125-130.

25. Hango A., *et al*. "A study on growth performance and carcass characteristics of Small East African goats under different feeding regimes". *Livestock Research for Rural Development* 19.9 (2007).

26. Priolo A., *et al*. "Effect of grass or concentrate feeding systems on lamb carcass and meat quality". *Meat Science Journal* 62.2 (2002): 179-185.

27. Lee JH., *et al*. "Chemical composition and quality characteristics of chevon from goats fed three different post-weaning diets". *Small Ruminant Research* 75.2-3 (2008): 177-184.

28. De Palo P., *et al*. "Effect of different milk replacers on carcass traits, meat quality, meat colour and fatty acid profile of dairy goats". *Small Ruminant Research* 131 (2015): 6-11.

29. Ivanovic S., *et al*. "The impact of diet on the quality of fresh meat and smoked ham in goats". *Small Ruminant Research* 138 (2016): 53-59.

30. Webb EC., *et al*. "Goat meat quality". *Small Ruminant Research* 60.1-2 (2005): 153-166.

31. Budimir K., *et al*. "Slaughter performance and carcass and meat quality of Bergamasca light lambs according to slaughter age". *Small Ruminant Research* 164 (2018): 1-7.

Volume 5 Issue 5 May 2020