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Meat quality of West African dwarf sheep fed garlic supplemented diets

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Abstract
The study assessed the effect of dietary garlic powder supplementation on qualitative characteristics of mutton of West African Dwarf (WAD). Garlic powder, a natural antioxidant was fed at different levels of inclusion. Forty yearlings WAD rams of average weight of 15kg were randomly allocated into five treatment groups of garlic powder inclusion: 0% (control), 2%, 4%, 6% and 8%. Three WADS rams were randomly selected from each treatment after 14 weeks of feeding trials. The animals were slaughtered and muscles dissected to determine meat pH, meat colour at different days of display, water holding capacity, chilling and cooking loss. The results shows that $pH_{45minutes}$ and pH_{24hr} values of cut-parts were not significantly ($p>0.05$) influenced by dietary treatments but varied numerically. Meat colour for lightness (L*), redness (a*) and yellowness (b*) at different display days were significantly ($p<0.05$) influenced by dietary treatments. The study also showed that dietary treatments influenced ($p<0.05$) significantly water holding capacity, chilling loss and cooking loss in cut-parts of rams fed dietary treatments. The shear force value of *Longissimus dorsi* (LDM) was lower than *Bicep femoris* (BP) muscle. Dietary garlic powder supplementation up to 8% delayed discolouration of the loin muscle L* (lightness), a*(redness) and b* (yellowness); enhanced water retention and tenderness, reduced chilling and cooking loss in the cut parts of WAD rams.

Keywords: Mutton, garlic powder, antioxidant, cut-parts, post-mortem

1. Introduction

Meat is a desirable edible portion of animal flesh and vital source of animal protein in human diets (Forrest *et al.*, 2001)[1]. Meat meant for consumption must be of high quality to meet consumers'acceptability. Several factors such as physicochemical, microbial, nutritional and sensorial characteristics are necessary for quality assessment of meat (Allen *et al.*, 1998)[2]. The best way to ascertain meat quality was to measure the pH, evaluate the water retention capacity and chemical contents (Fakolade and Omojola, 2008; Gustavson *et al.*, 2011)[3,4]. However, the quality of meat is highly diversified such that it can be evaluated from many perspectives (Bogosavljević-Bošković *et al.*, 2010)[5]. Assessment of meat quality depends greatly on the consumers' judgments (Fortomaris *et al*., 2006)[6]. In an attempt to improve qualities of meat the consumer's health and acceptability should be in focus. Garlic (*Allium sativum*) powder and its extracts are known to possess antioxidant properties and had been used as food flavour and medicinal purposes (Sallam *et al*., 2004)[7]. These antioxidant properties offer garlic for investigation in animal diets of its beneficial impacts on meat quality. Therefore, the study was designed to investigate the effect of feeding garlic supplements on meat quality of West African Dwarf Sheep.

Materials and Methods

Location of the study

The study was conducted at Teaching and Research Farm of Ekiti State University, Ado-Ekiti, Nigeria.

Experimental design, experimental animals and their management

Forty yearling West African Dwarf (WAD) rams of average weight 15 kg were subjected to a Completely Randomized design. WAD rams were randomly allocated into five dietary treatments of garlic powder supplemented at 0% (control), 2%, 4%, 6% and 8% (Table 1). Experimental animals were tagged, weighed for initial body weight, housed individually in the pen and then allowed to acclimatize for the period of three weeks during which they were quarantined. Feeds and water were provided *ad-libitum* for 14 weeks. Animals were weighed for final body weight after 14 weeks.

Slaughter procedures

Animals were weighed, mechanically immobilized and exsaguinated. The head was detached at the atlanto-occipital joint. The fore and hind feet were separated at the carpal-metacarpal and tarsal-metatarsal joints, respectively (Garcia-Valverde *et al.*, 2008)[8]. The left and right side half carcasses were separately weighed then stored in room temperature for 8 hours and thereafter chilled at 4ºC overnight prior analysis.

Measurement of muscle pH

Muscles pH was measured by using an electrode of a portable digital pH-meter (Knick Portamess ® 910, Germany), at both 45 minutes and 24- hour post-mortem.

Determination of meat colour

The meat colour was determined at interval of storage days by the method of Moawad *et al.* (2013)[9]. Colour evaluation was determined after allowing the loin muscle surface to bloom for 30 min., using a Hunter Lab Scan XE Colorimeter (Hunter Laboratory Inc. Restonva).

Determination of Water holding capacity

This was evaluated according to the procedure of Suzuki *et al*. (1991) [10].

Determination of Chilling loss

Carcasses were chilled after taking their percentage yield at 4°C for 24 hours. The chilling loss was determined as difference between the warm carcass weight and chilled weight expressed as percent of warm carcass weight, as described by Awosanya and Okubanjo (1993) [11]:

$$\% \text{ chilling loss} = \frac{\text{weight of warm carcass - weight of chilled carcass}}{\text{Weight of warm carcass}} \text{ X } 100$$

Determination of cooking loss (CL)

Three replicates of 50 g of meat samples per treatment were placed in tightly sealed polyethylene oven bag and heated in a water bath at 75°C until an internal temperature of 71˚C was achieved. Cook-out was drained and the cooked mass was cooled, dried with filter paper and reweighed. Cooking loss (CL) was expressed as the percentage loss related to the initial weight (Pena *et al*., 2009)[12].

$$\text{Cooking loss (\%)} = \frac{\text{weight of raw cut after thawing – weight of cooked cut}}{\text{Weight of raw cut after thawing}} \times 100$$

Determination of Shear Force (Kg/cm²) of carcass

Measurement for shear force value was determined using Warner Bratzler Shear force (WBS) apparatus to indicate meat tenderness. *Longissimus dorsi* (LDM) and *Bicep femoris* (BP) muscle samples were obtained from each carcass of the treatment groups, cooked in the labelled polyethylene bags placed in a water bath to an internal temperature of 75°C. The samples were removed and cooled to room temperature (27°C) for 10 minutes. The cooked meat samples were reweighed and wrapped in polythene bags and chilled at 4°C for 18 hours. Samples were removed, allowed to cool to room temperature and cores to approximate 1.25cm diameter parallel to muscle fibre (Qiaofen and Da-Wen, 2005)[13]. The muscles were sheared at three locations with Warner – Bratzler V-noch blade (Honikel, 1998)[14].

Statistical analysis

All data were collected in triplicate and statistically analyzed using SAS (2008)[15].

Results and Discussion

Meat pH

Table 2 shows the meat pH of standard cut-parts of West African Dwarf (WAD) rams fed garlic powder supplemented diets after 45 minutes' and 24-hour post-mortem. The study revealed that dietary intake of garlic powder did not significantly influence (p>0.05) pH values at different post-mortem periods. The pH_{45mins} values obtained for rib cut-parts ranged from 6.95±0.10 (treatment 3) to 6.87±0.06 (treatment 5), loin cut-part varied from 6.88±0.03 in treatment 5 to 7.00 in treatment 2, the value of pH_{45mins} of round cut-parts was higher in treatment 5 (7.05±0.18) with least recorded in treatment 4 (6.89±0.05). The pH_{24} value of rib cut ranged from 5.50±0.00 in treatment 3 to 5.67±0.06 in treatment 4. The highest pH_{24} value of 5.80±0.00 was obtained in treatment 4 while the lowest value of 5.50±0.00 obtained in treatment 5 of round-cut of the carcass.

The pH value of cuts at 45 minutes' postmortem ranged from 6.87±0.06 to 7.05±0.18 at a temperature between 26°C and 27°C across cuts parts (rib, loin and round muscles) obtained from WAD rams fed treatment diets were normal for muscle physiological process for meat conversion, this is an indication that the muscle glucose is gradually depleting as it undergoes rigor-mortis which is fully completed at 24-hour post-mortem period, this resulted into lowering of pH value ranging from 5.50±0.00 to 5.70±0.10 in the carcasses.

The pH after 45 minutes' post-mortem ($pH_{45)}$ values obtained in all cut- parts were similar to the values reported by Hopkins *et al.* (2000)[16] and Vnućec *et al.* (2014)[17] in loin cut of sheep. The pH_{24} (ultimate) in the current study fell within the quality range of pHu (pH ultimate) below<6.0 in sheep (Miranda-de Lama *et al*. 2009)[18] Meat pH above 6.0 values at 24-Hr post-mortem facilitates rapid spoilage and poor shelf life. The pH values obtained in the study in cut-parts at different post-mortem periods were within normal ranged for keeping quality of carcass (Lawrie, 1991)[19]. Meat pH is a measure of good meat quality (Bello and Tsado, 2014)[20].

Meat colour

The meat colour values of loin muscles of WAD rams fed garlic powder supplemented diets at different display days are presented in Table 3. The study showed that colour values for lightness (L*), redness (a*) and yellowness (b*) at different display days were significantly (p<0.05) influenced by dietary treatments. Meat colour values significantly (p<0.05) reduced as storage days advanced and consequently increased between dietary treatments. Meat colour values obtained in the study for L*, a* and b* were significantly higher in treatment 5 fed rams than control and other treatments irrespective of the time of display. Lightness (L*) and redness (a*) values of treatments 4 and 5 were similar to the findings of Santos-Silva *et al*. (2002)[21] in *Longissimus dorsi* muscles of lamb, but yellowness (b*) value were lower than values obtained in current study.

The meat colour values obtained in the study on day 0, 5 and 14 were lower than L*(50.24) and b*(11.39) values but similar to a*(15.97) value reported by (Atay *et al*., 2011)[22] in cross bred goat, while day 0 value of treatments 4 and 5 values were higher than L*(42.54), a*(10.78) and b*(15.23) values reported by Pena *et al*. (2009)[12]. L* (49.74) and b* (11.11) values were higher and a*(15.58) values were lower in the findings of El-Waziry *et al*. (2011)[23]. Werdi Pratiwi *et al.* (2007)[24] observed similar L* (46.8), a*(19.6) and lower b*(4.7) values. The meat colour was best retained in treatment 5 fed rams as a result of antioxidants potentials of garlic in delaying oxidation of myoglobin (Renerre, 2000)[25].

Chilling and cooking losses in carcass cuts

Table 4 shows the percentages of chilling and cooking loss in primal cuts of West African Dwarf (WAD) rams fed experimental diets. The percent chilling loss were significantly low (p<0.05) in rib cuts of treatments 5, followed by round cut of treatment 5 and round cut of treatment 4 fed rams. The chilling loss values obtained in the study were higher than those reported by Yusuf *et al.* (2014)[26] in Boer goats. The chilling losses obtained from cuts of treatments 4 and 5 were within the range of 2.3 and 8.7% reported by El- Khidir *et al*. (1998)[27]. The percent chilling loss in cuts obtained among diets reduced drastically than those observed by others in meat Sebsibe *et al.* (2007)[28]. The little loss obtained during chilling of carcasses was as result of minimal shrinkage in the muscles which prevented fluid losses (Yusuf *et al.*, 2014)[26]. The percent cook loss was significantly different (p<0.05) among cut- parts obtained from treatment group. Flank cut-part of WAD ram fed treatment 1 had the highest cook loss of 41.03±1.55% while the rib cut of treatment 5 fed had the least value of 32.36±1.54%. The percentage cooking loss in all cuts significantly decreased (p>0.05) as garlic increased in the dietary treatments. This is in line with the observation of Bello and Tsado (2014)[20] in cooked meat of Yankasa rams. The average percentage cooking loss obtained in the study was within the values reported by others in rams fed dietary antioxidants (Karami *et al.,* 2010; Tsegay *et al.,* 2015)[29,30]. Cooking losses resulted by denaturation of myofibrillar protein induced by the heat during cooking thus allowing the release of essential constituents (moisture and fat) in the muscles (Aaslyng *et al.,* 2003)[31] Cooking loss usually reveals the rate of loss in consumable meat mass (Gustavson *et al.,* 2011)[4].

Water holding capacity (WHC)

Table 4 shows the water holding capacity in primal cuts of rams fed treatment diets. Water holding capacity varied significantly (p<0.05) among dietary treatments in rib, loin, round, shoulder and flank cut-parts. WHC was highest in round cut of treatment 5, followed by the rib cut of treatment 2 and flank cut-part in treatment 5. WHC values obtained in the study were above 60% in cuts which reveals that water is the major liquid constituents of the muscles (Borisova and Oreshkin, 1992)[32]. This accounts for meat tenderness and juiciness. High water holding capacity obtained in the cuts shows that mutton could retain water in either prior and post rigor phases (Karakaya *et al.,* 2006)[33]. High WHC value obtained in the study in primal cuts revealed that feeding, pre and post handling of animals did not negatively influence meat pH, which may cause loss of moisture (Shirimaa and Mteng, 2012)[34].

Shear force

The shear force values of *Longissimus dorsi* (LDM) and *Bicep femoris* (BP) muscles were shown in Table 5. Shear force value of both *Longissimus dorsi* (LDM) and *Bicep femoris* (BP) muscles were not significantly different (p>0.05) between dietary treatments. The study revealed that the shear force value of *Bicep femoris* decreases as the level of garlic powder increases in the test diets. Shear force of *Longissimus dorsi* (LDM) muscle obtained was within the range of 2.9 and 3.8 kg/cm^2 reported by Dhanda *et al.* (1999)[35] for less tough meat, while shear force values of *Bicep femoris* (BP) muscle muscle were within 4.3 and 4.6 kg/cm^2 reported by Dhanda et al. (1999)[35] in chevon. The shear force values of *Longissimus dorsi* (LDM) and *Bicep femoris* (BP) muscles obtained were lower than 4.83 kg/cm^2 (Moadwad *et al.,* 2013)[9] but higher than 3.59 kg/cm^2 (El-Waziry *et al.,* 2011)[23] in small ruminants. The shear force value of *Bicep femoris* (BP) muscles obtained, fell within range of 4.6 and 5.5kg/cm^2 (Shackelford *et al*., 1991)[36] for meat tenderness while *Bicep femoris* (BP) muscle of treatment 2 had similar value with 4.1 kg/cm^2 (Huffman *et al.,* 1996)[37] and value of 4.0 kg/cm^2 (Babiker *et al.,* 1990)[38] Also, it was observed that shear force value of *Longissimus dorsi* (LDM) was lower than those obtained from *Bicep femoris* (BP) muscle of WAD ram; this implies that *Longissimus dorsi* was tenderer than *Bicep femoris* due to structural composition of the muscles.

Table 1: Experimental feed composition (%)

Items	composition
Ingredients	
Soybean meal	10.0
Maize	35.0
Rice bran	15.0
Brewer's dry grain	37.5
Bone meal	1.0
Salt	1.0
Vitamin/mineral	0.25
Premix	0.25
Total	100
Calculated protein (%)	16.07
Calculated Energy(kcal/kg)	2605.7

Table 2: Meat pH value of carcass parts of WAD rams fed garlic powder supplemented diets

Items	Treatment 1 0% GP*	Treatment 2 2% GP	Treatment 3 4% GP	Treatment 4 6% GP	Treatment 5 8% GP
pH_{45mins}					
Rib	6.89±0.07	6.94±0.04	6.95±0.10	6.91±0.02	6.87±0.06
Loin	6.95±0.09	7.00±0.10	6.97±0.03	6.95±0.01	6.88±0.03
Round	6.93±0.08	7.03±0.03	6.95±0.04	6.89±0.05	7.05±0.18
pH_{24hrs}					
Rib	5.60±0.10	5.53±0.06	5.50±0.00	5.67±0.06	5.53±0.06
Loin	5.47±0.06	5.63±0.06	5.53±0.06	5.50±0.00	5.53±0.06
Round	5.70±0.10	5.67±0.12	5.80±0.00	5.53±0.06	5.50±0.00

Mean ± standard deviation, GP-garlic powder

Table 3: Colours of loin muscles displayed at different day's interval in WAD rams fed garlic powder supplemented diets

No of days	traits	Treatment 1 0% GP*	Treatment2 2% GP	Treatment 3 4% GP	Treatment 4 6% GP	Treatment5 8% GP
0	L*	38.79±0.01^d	39.31±0.02^d	40.41±0.02^c	42.82±0.50^b	44.60±0.10^a
	a*	18.42±0.02^c	18.53±0.06^c	18.57±0.08^c	19.85±0.05^b	20.71±0.33^a
	b*	9.70±0.01^b	9.75±0.01^b	9.77±0.02^b	10.17±0.06^a	10.22±0.01^a
5	L*	38.72±0.05^c	39.39±0.53^b	39.40±0.01^b	39.51±0.01^b	40.01±0.04^a
	a*	15.31±0.01^c	15.67±0.01^b	15.89±0.01^b	15.91±0.01^a	15.96±0.03^a
	b*	9.08±0.02^c	9.09±0.01^c	9.13±0.02^c	9.26±0.04^b	9.70±0.35^a
14	L*	37.33±0.02^b	37.23±0.57^b	36.65±0.05^b	38.20±0.02^a	39.84±0.01^a
	a*	15.22±0.02^c	15.27±0.01^c	15.31±0.02^b	15.37±0.03^a	15.39±0.01^a
	b*	8.09±0.01^d	8.13±0.0^c	8.17±0.02^c	8.31±0.02^b	8.52±0.03^a

Mean ± standard deviation; L* -lightness, a* - redness, b*- yellowness; a, b,c, d means of different superscripts on same row are significantly (P<0.05) different, GP- garlic powder

Table 4: Water holding capacity, chilling loss and cooking loss of primal cuts of WAD rams fed garlic powder supplemented diets (%)

Items	Treatment 1 0% GP*	Treatment 2 2% GP	Treatment 3 4% GP	Treatment 4 6% GP	Treatment5 8% GP
WHC (%)					
Rib	68.00±1.80^{d}	81.00±1.30^{a}	76.00±0.56^{b}	71.67±0.66^{c}	67.33±0.81^{d}
Loin	76.33±0.03^{a}	74.67±0.64^{a}	77.67±0.97^{a}	78.00±0.72^{a}	66.33±1.32^{b}
Round	63.33±1.73^{c}	64.33±1.69^{c}	64.33±1.01^{c}	74.33±1.11^{b}	81.67±1.64^{a}
Shoulder	68.33±0.64^{c}	72.33±0.86^{b}	68.00±0.55^{c}	75.67±1.8^{a}	71.33±0.61^{b}
Flank	69.33±1.79^{b}	64.67±1.81^{c}	76.33±1.02^{a}	79.33±1.37^{a}	60.67±1.60^{d}
Chilling loss (%)					
Rib	12.65±1.26^{a}	11.28±1.47^{b}	10.00±1.5^{b}	8.17±1.18^{c}	6.17±1.84^{d}
Loin	9.50±1.58^{a}	8.35±1.11^{b}	8.13±0.77^{b}	7.73±1.39^{c}	7.38±0.40^{c}
Round	9.03±0.36^{a}	8.28±0.38^{a}	7.85±0.40^{b}	7.18±0.46^{b}	7.15±0.53^{b}
Shoulder	12.90±1.88^{a}	11.48±1.80^{a}	10.32±1.28^{b}	9.50±1.95^{b}	7.85±1.20^{c}
Flank	16.83±1.40^{a}	16.22±1.28^{a}	15.98±1.82^{a}	15.17±0.71^{a}	14.17±1.29^{b}
Cooking loss (%)					
Rib	33.82±1.96^{a}	32.62±1.50^{a}	32.20±1.18^{a}	26.24±1.43^{b}	25.91±1.32^{b}
Loin	34.35±0.56^{a}	33.06±0.93^{a}	32.54±0.27^{b}	32.20±0.60^{b}	31.00±0.08^{b}
Round	36.56±0.95^{a}	34.62±0.21^{a}	34.28±0.23^{a}	33.84±0.99^{b}	32.70±0.49^{c}
Shoulder	37.72±1.48^{a}	37.16±1.20^{a}	35.97±1.33^{b}	35.86±1.77^{b}	30.08±1.22^{c}
Flank	41.03±1.55^{a}	38.19±1.74^{a}	37.28±1.89^{b}	35.85±1.07^{b}	32.36±1.54^{c}

Mean ± standard deviation; a, b, c, d means of different superscripts on same row are significantly (P<0.05) different, GP- garlic powder

Table 5: Shear force value of muscles of WAD rams fed garlic powder supplemented diets (kg/cm^{2})

Items		Treatment1 0% GP*	Treatment2 2% GP	Treatment3 4% GP	Treatment4 6% GP	Treatment5 8% GP
Muscle type	LDM*	3.87±0.37	3.74±0.40	3.77±0.52	3.91±0.08	3.80±0.17
	BP*	4.49±0.32	4.45±0.15	4.35±0.10	4.14±0.15	4.08±0.08

LDM- *Longissimus dorsi*, BP- *Bicep femoris*: mean ± standard deviation, GP- garlic powder

Conclusion

The results of this study indicate that the inclusion of garlic powder supplementation in the diet of West African Dwarf (WAD) rams improved meat qualitative properties. It is concluded that garlic powder at 8% could be used as supplements in ruminant nutrition for the retention of meat colour pigments, enhancement of high water holding capacity, reduction of drip and cook losses and texture improvement in mutton.

References

1. Forrest JC, Aberle ED, Gerrard DE, Mills WE, Hedrick HB, Judge MD, Merkel RA. The Principles of Meat Science.2001. Kendall/Hunt Publishing Company: U.S. 4th Edition.
2. Allen CD, Fletcher DL, Northcutt JK, Russell SM. The relationship of broiler breast color to meat quality and shelf-life. Poult. Sci. 1998, 77:361-366.
3. Fakolade PO, Omojola AB. Proximate composition, pH value and microbiological evaluation of 'Kundi' (dried meat) product from beef and camel meat. Conference on International Research on Food Security, Natural Resource Management and Rural Development. Meat Science Laboratory, Animal Science Department, University of Ibadan. Nigeria, 2008, 7-9.
4. Gustavson J, Cederberg C, Sonesson U, van Otterdijk R, Meybeck A. Global Food Losses and Food Waste. Food and Agriculture Organization of the United Nations, Rome, 2011.
5. Bogosavljević-Bošković1 S, Pavlovski Z, Petrović MD, Dosković V, Rakonjac S. Broiler meat quality: Proteins and lipids of muscle tissue. Afr. J. of Biotech. 2010; 9(54):9177-9182.
6. Fortomaris P, Arsenos G, Georgiadis M, Banos G, Stamataris C, Zygoyiannis D. Effect of meat appearance on consumer preferences for pork chops in Greece and Cyprus. Meat Sci. 2006, 72:688-696. doi:10.1016/j.meatsci.2005.09.019
7. Sallam KH, Ishioroshi MI, Samejima K. Antioxidant and antimicrobial effect of garlic in chicken sausage. Lebensm. Wiss. Technol. 2004, 37:849-855.
8. Garcia-Valverde R, Barea R, Lara L, Nieto R, Aguilera JF. The effect of feeding level upon protein and fat deposition in Iberian heavy pigs. Liv. Sci. 2008; 114(2-3):263-273. https://doi.org/10.1016/j.livsci.2007.05.005
9. Moawad RK, Mohamed GF, Ashour MMS, El-Hamzy EMA. Chemical Composition, Quality Characteristics and Nutritive Value of Goat Kids Meat from Egyptian Baladi Breed. J. of Appl. Sci. Res. 2013; 9(8):5048-5059.
10. Suzuki A, Koima N, Nkeuchi Y. Carcass Composition and meat quality of Chinese pure bred and European X Chinese Cross bred pigs. Meat Sci. 1991; 29:31-41. https://doi.org/10. 1016/0309-1740(91)90021-H
11. Awosanya B, Okubanjo AO. Effect of skinning, scalding or singeing on the physical characteristics of rabbit carcasses. Nig. Food Jour. 1993; 11:147-152.
12. Peña F, Bonvillani A, Freire B, Juárez M, Perea J, Gómez G. Effect of breed ad slaughter weight on the meat quality of Criollo Cordobes and Anglonubuian kid produced under extensive feeding condition. Meat Sci. 2009, 83: 417-422. https://doi.org/10.1016/j.meatsci. 2009.06.017
13. Qiaofen C, Da-Wen S. Application of PLSR in correlating physical and chemical properties of pork ham with different cooking methods. Meat Sci.2005,70: 691 – 698. https://doi.org/10.1016/j.meatsci. 2005.03.004

14. Honikel KO. Reference methods for the assessment of physical characteristics of meat. Meat Sci. 1998; 49(4):447-457. https://doi.org/10.1016/S0309-1740(98)00034-5
15. SAS. Statistical Analysis System User's Guide. SAS Institute Inc., Cary, 2008, N.C. 27513 U.S.A.
16. Hopkins DL, Littlefield PJ, Thompson JM. The Effect of Low Voltage Stimulation under Controlled Conditions on the Tenderness of Three Muscles in Lamb Carcasses, Asian-Aus. J. Anim. Sci. 2000; 13:362-365.
17. Vnuičec I, Držaić V, Mioć B, Prpić Z, Pavić V, Antunović. Carcass traits and meat colour of lamb from diverse production systems, Veterinarski Arhiv. 2014; 84(3):251-263.
18. Miranda-de la Lama GC, Villarroel M, Olleta JL, Alierta S, Sanudo C, Maria GA. Effect of the pre-slaughter logistic chain on meat quality of lambs. EAAP Publ. 96, Wageningen, Netherlands, 2009, 177-201.
19. Lawrie RA. Meat Science. 5th edition Pergamon Press, New York, NY, 1986, p22.
20. Bello AA, Tsado DN. Quality and sensory evaluation of meat from Yankasa rams fed sorghum stover supplemented with varying levels of dried poultry droppings based diet. Int. J. of Agric. And Food Sci. Tech. 2014; 5(2):1-8.
21. Santos-Silva J, Mendes IA, Bessa RJB. The effect of genotype, feeding system and slaughter weight on the quality of light lambs: 1. Growth, carcass composition and meat quality, Liv. Prod. Sci. 2002; 76(1-2):17-25. https://doi.org/10.1016/S0301-6226(01)00334-7
22. Atay O, Gökdal Ö, Kayaardi S, Eren V. Fattening Performance, Carcass Characteristics and Meat Quality Traits in Hair Goat (Anatolian Black) Male Kids. J. Anim. and Vet. Adv. 2011; 10(10):1350-1354.
23. El-Waziry AM, Al-Owaimer AN, Suliman GM, Hussein ES, Abouheif MA. Performance,Carcass Characteristics and Meat Quality of Intact and Castrated Ardhi Goat Kids Fed High Energy Diet. J. Anim. and Vet. Adv.2011, 10(16): 2157-2161.
24. Werdi Pratiwi NM, Murray PJ, Taylor DG. Feral goats in Australia: A study on the quality and nutritive value of their meat. Meat Sci. 2007, 75: 168-177.
25. Renerre M.. Oxidative processes and myoglobin. In E. Deker, C. Faustman, & C. J. Lopez-Bote (Eds.), Antioxidants in muscle foods. 2000, 113–133.
26. Yusuf AL, Goh YM, Samsudin AA, Alimon AR, Sazili AQ. Growth Performance, Carcass Characteristics and Meat Yield of Boer Goats Fed Diets Containing Leaves or Whole Parts of *Andrographis paniculata*. Asian-Australasian J. of Anim. Sci. 2014, 27(4): 503-510. https://doi.org/10.5713/ajas.2013.13533
27. El- Khidir IA, Babiker SA, Shafie SA. Comparative feedlot performance and carcass characteristics of Sudanese desert sheep and goats. Small Rumin. Res. 1998, 30:147-151. https://doi.org/10.1016/S0921-4488(98)00097-2
28. Sebsibe A, Casey NH, Van Niekerk WA, Tegegne A, Coertze RJ. Growth performance and carcass characteristics of three Ethiopian goat breeds fed grainless diets varying in concentrate to roughage ratios, South Afr. J. of Anim. Sci. 2007, 37 (4): 221-232. http://dx.doi.org/10.4314/sajas.v37i4.4094
29. Karami M, Alimon A, Goh YM, Sazili AQ, Ivan M. Effects of Dietary Herbal Antioxidants Supplemented on Feedlot Growth Performance and Carcass Composition of Male Goats, American J. of Anim. and Vet. Sci. 2010, 5 (1): 33-39
30. Tsegay L, Mohammed B, Sandip B. Meat quality assessment at Hawassa city in Southern Ethiopia, World J. of Multidiscipl. and Contemp. Res. 2015, 1(2):1- 9
31. Aaslyng MD, Bejerholm C, Ertbjerg P, Bertram HC, Andersen HJ. Cooking loss and juiciness of pork in relation to raw meat quality and cooking procedure, Food Quality and Preference.2003, 14:277–288.
32. Borisova MA, Oreshkin EF. On the water conditions in pork meat. Meat Sci. 1992; 31: 257–265. https://doi.org/10.1016/0309-1740 (92)90056-A
33. Karakaya M, Saricoban C, Yilmaz. The effect of mutton, goat, beef and rabbit meat species and state of rigor on some technological parameters. J. Muscle Food.2006, 17: 56-66. https://doi.org/10.1111/j.1745-4573.2006.00035.x
34. Shirimaa EJM, Mtenga LA. Comparative analysis of retail cuts, muscle physico-chemical properties and meat tenderness of indigenous castrate sheep finished off under feedlot conditions RJSITM.,2012, 01(12): 65-73.
35. Dhanda JS, Taylor DG, Murray PJ, McCoSker JE. The Influence of Goat genotype on the Production of Capretto and Chevon Carcasses .2. Meat quality. Meat Sci.1999, 52:363-367.
36. Shackelford SD, Morgan JB, Savell JW, Cross HR. Identification of threshold levels for Warner-Bratler shear force in beef top loin steak. J. of Muscle Foods. 1991,2(4) 289-296. https://doi.org/10.1111/j.1745-4573.1991.tb00461.x
37. Huffman KL, Miller MF, Hoover LC, Wu CK, Brittin HC, Ramsey CB. Effect of beef tenderness on consumer satisfaction with steaks consumed in the home and restaurant. J. Anim. Sci.1996, 74:91−97. https://doi.org/10.2527/1996.74191x
38. Babiker S, Ei Khider AIA, Shafie SA. Chemical composition and quality attributes of goat meat and lamb. Meat Sci. 1990, 28: 273-277. https://doi.org/10.1016/0309-1740 (90)90041-4