Journal of Asian Scientific Research
ISSN(e): 2223-1331
ISSN(p): 2226-5724
DOI: 10.18488/journal.2.2019.912.217.226
Vol. 9, No. 12, 217-226.

URL: www.aessweb.com

SENSORY ATTRIBUTES OF GOAT MEAT UNDER THE INFLUENCE OF GLYCOGEN

Shahnawaz Fazlani[1]
Asad Ali Khaskheli[2+]
Abdul Samad Magsi[3]
Gul Bahar Khaskheli[4]
Ghulam Shabir Barham[5]
Haque Nawaz Fazlani[6]

[1,3,4,5]*Department of Animal Products Technology, Sindh Agriculture University, Tandojam, Pakistan.*
[1]*Email: fazlanishahnawaz@gmail.com Tel: +923322637187*
[3]*Email: asamad_magsi@yahoo.com Tel: +923023090850*
[4]*Email: khaskhelig@gmail.com Tel: +923032166285*
[5]*Email: shabir_dr2010@yahoo.com Tel: +923013618136*
[2]*Department of Animal Nutrition, Sindh Agriculture University, Tandojam, Pakistan.*
[2]*Email: khaskhelias@gmail.com Tel: +923123676239*
[6]*Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University, Tandojam, Pakistan.*

(+ Corresponding author)

Article History
Received: 21 August 2019
Revised: 27 September 2019
Accepted: 29 October 2019
Published: 4 December 2019

Keywords
Flavor
Glycogen
Juiciness
Palatability
Sensory
Tenderness.

ABSTRACT

Current study was conducted in order to evaluate glycogen level and its influence on the sensory characteristics of goat meat of different age groups such as A (6-12 m; age), B (13-18 m; age) and C (>18 m; age) slaughtered at Tandojam market. Goat meat of all three age groups were examined for glycogen level and characteristics including juiciness, tenderness, colour, overall palatability and flavor were examined. Average glycogen level of goat meat of group A and B were statistically non-considerable. Average score rated for flavor, juiciness, tenderness, overall palatability and colour of group A and B goat meat were relatively similar, but comparatively higher compared to group C. Glycogen level possessed no prominent (P>0.05) effect on colour score. The relationship of glycogen with flavor was found positive in goat meat of group A but negative for group B and C. The relationship was found to be negative between glycogen and juiciness of group A and positive to group B and C. The influence of glycogen on tenderness was found to be strong in group A and weak in group B, while it was noted modest incase of group C. The relationship was found to be negative between glycogen and overall palatability of group A and C but the positive in group B. Despite, the goat meat of group A and B were found to be statistically similar in physical and sensory characteristics, the results varied slightly, and group B goat meat concluded to be better among all groups.

Contribution/ Originality: This study contributes to the existing literature by evaluating glycogen level and its influence on the sensory characteristics of goat meat of different age groups such as A (6-12 m; age), B (13-18 m; age) and C (>18 m; age) slaughtered at Tandojam market.

1. INTRODUCTION

Goat is considered an important meat animal throughout the throughout the world now days. In Pakistan, they are commonly reared for multi-purposes like meat, milk and hair production. It is assumed that none of breeds seems to specially be developed as a dairy or meat type, but they serve as multi-purpose animals with low performance level [1]. There are no religious or cultural limitations on the utilization of goat meat that results goats to be commonly available in every society where eating beef, pork or other meat types are prohibited. It is has

been studied that the quality of goat meat is much superior to sheep and cattle meat due to lower fat content [2]. Compositional studies show that the meat of goat possess fat percentage 50 to 65 % less than beef, 42-59 % less compared to lamb and 25 % less compared to veal [3]. Further, goat meat contain saturated fat which is 40 % less than poultry meat; 85 % less than beef while, 90 % lesser in contrast to lamb. It has been observed that the goats of very young age (kids), old, culled, diseased or injured are commonly used for meat production. The production and processing conditions possess substantial effect on glycogen level and thus play vital role in the quality regulation of meat [4]. Glycogen is actually the chief storage form of carbohydrate in animal body. It is found nearly in all types of cells in animal body. Glycogen is stored into two main sites in the body like liver and muscles. The liver is involved in maintaining the blood glucose levels within the required range [5] while the muscles act as a reserve fuel for the creation of Adenosine Triphosphate (ATP) [6].

Meat which possess normal pH range possess about 10-20mg (1-2%) glycogen. However, the muscles acidification occurring during post-mortem may result break down of glycogen to lactic acid. It has been reported that if the glycogen is depleted by long term stress prior to slaughter then lactic acid formation is lesser and the meat does not acidify normally, resulting high pH. Reduction in the glycogen < 8 mg per gram results in elevation of ultimate pH, and the greater the reduction, the higher the pH [7]. Meat colour, taste, tenderness are assumed to be most important sensory attributes that affect the meat quality and acceptability [8]. Ante-mortem depletion of glycogen may results meat quality defects which are of great importance for consumers at the time of purchasing. Dark Firm Dry (DFD) condition in meat is one of the major quality problems faced by the meat industry. This condition may impair the colour of meat which either becomes too dark or too pale [9]. Further, the DFD meat has poor processing characteristics and high spoilage potential, so the meat possess a very short shelf life [10]. Additionally, nutritive status of meat directly influences the flavor and eventually possess significant impact on eating characteristics [2, 11]. From growth to slaughter, there are some other factors like ageing, breed, stress, and age that may also influence the meat quality. No doubt there are various factors which may impair the goat meat quality but amongst all glycogen level of utmost importance. Goat meat possess lot of popularity especially in the developed countries and its quality is well studied from different aspects [4, 12]. However, in Pakistan goat meat is still processed by traditional methods, and needs lot of attention in term of its quality. In this regards current investigation was carried out in order to assess the effect of glycogen on sensory characteristics of goat meat.

2. MATERIALS AND METHODS

2.1. Experimental Procedure

Experiment was conducted to observe the glycogen level and its influence on sensory properties of goat meat slaughtered at Tandojam market during the year. Goat meat was categorized into three age groups viz. A (6 to 12 m; age), B (13 to 18 m; age) and C (>18 m; age). A total of thirty (30) goat meat samples including 10 from each group were examined for glycogen level and properties like overall palatability, flavor, juiciness, colour and tenderness at the Laboratory of meat chemistry, department of Animal Products Technology Sindh Agriculture University, Tandojam.

2.2. Analysis of Glycogen Level

Glycogen level in the meat was analyzed by reported method Kemp, et al. [13]. Samples were transferred to centrifuge tubes having deproteinizing solution (5ml), 100mg Silver Sulphate and 5g Trichloroacetic acid. Tubes were filled up to 100 ml with distilled water and transferred in water bath (15 min), then cooled using running water and finally centrifuged at 3000rmp (4°C) till 5 min. Thereafter 1ml of clear supernatant and 3ml of H_2SO_4 was transferred to wide test tube and vigorously shacked to mix well. To heat, resultant blend was placed in the water bath for 6min and then using tap water it was cooled. Colour intensity was observed using spectrophotometer, while the glycogen level in term of glucose equivalents was noted from the standard curve.

2.3. Sensory Analysis

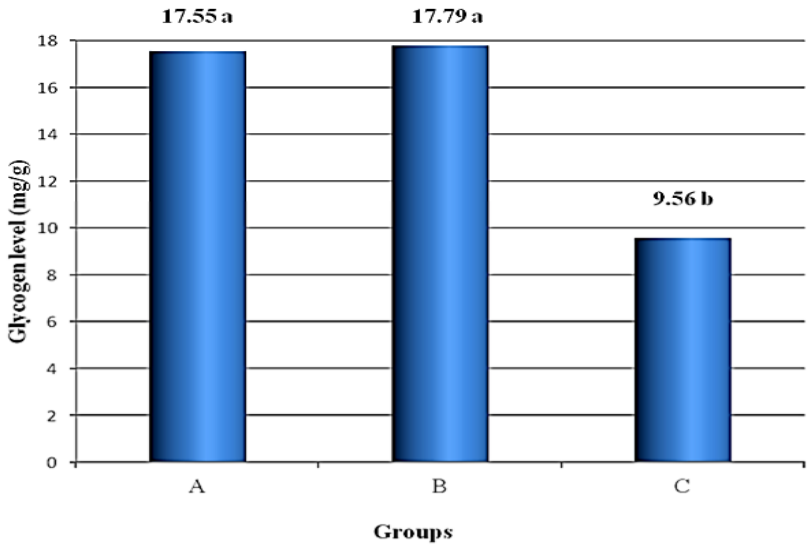
Cooked meat samples were analyzed for sensory parameters like odor, colour, tenderness, overall palatability and juiciness. Panel consisting of 5 panelists using 5 as standard point on Hedonic scale was used the evaluation. Value recorded as 5 was graded excellent, 4 Good, 3 Fair, 2 Poor and 1 Very poor

2.4. Statistical Analysis

Collected data was analyzed using statistical package i.e. Student Edition of Statistics (Copyright 2005, Analytical Software, USA), whereby Analysis of variance (ANOVA) was applied on groups of all age. Incase of considerable variation observed among the means, the least significant differences were computed.

3. RESULTS

Glycogen level: Goat meat samples were analyzed for glycogen level, and the findings are given in the Figure 1. The concentration of glycogen was found between 14.57 to 21.95, 14.74 to 23.21 and 7.96 to 13.34 mg/g in meat of goat with age group of A, B and C, respectively. However, glycogen level was found to be slightly higher in group B (17.79±0.85 mg/g) contrast to group A (17.55±0.75 mg/g). The differences among them were statistically non considerable (P>0.05). Whilst the glycogen level in meat of older group i.e. group C (9.56 ± 0.49 mg/g) was found prominently (P<0.05) lower compared group A and B.

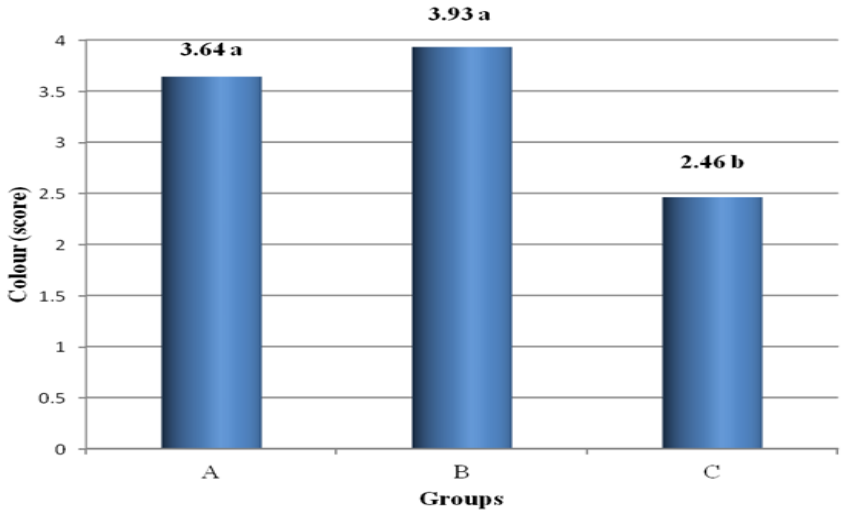


LSD (0.05) = 2.088
SE± = 1.016
Group A = Goat meat of age group 6-12 months.
Group B = Goat meat of age group 13-18 months.
Group C = Goat meat of age group >18 months.

Figure-1. Glycogen level (mg/g) of goat meat of different age groups.

3.1. Influence of Glycogen Level on Sensory Characteristics of Goat

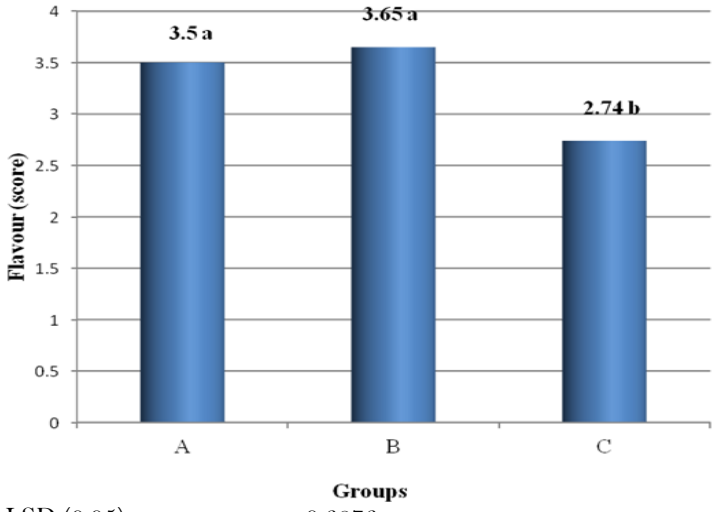
Colour of meat: Colour of goat meat of group A, B, and C was evaluated by a judges' panel, and rated score is depicted in the Figure 2. The goat meat of different age groups perceived score with ranging from 3.2 to 4.2 in meat of group A, 3.4 to 4.6 of group B and 2.0 to 2.8 of group C. Regardless, meat of group B, rated colour score was higher (3.93 ± 0.13) compared group A (3.64±0.11), variation among them was non-considerable (P>0.05). While, the LSD (0.05) comparison of means showed that the colour score for groups A and B were prominently (P<0.05) higher contrast to group C (2.46 ± 0.08).



LSD (0.05) = 0.3327
SE± = 0.1621
Group A = Goat meat of age group 6-12 m.
Group B = Goat meat of age group 13-18 m.
Group C = Goat meat of age group >18 m.

Figure-2. Colour (score) of goat meat of different age groups.

Flavor: Goat meat of group A, B and C was rated for flavor score, and the results are presented in Figure 3. The goat meat of different age groups received score for flavor ranging from 3.0 to 3.8, 2.8 to 4.2, and 2.2 to 3.4 for group A, B and C, respectively. Group B possessed higher average score (3.65±0.16) compare to group A (3.5±0.08) and C (2.74±0.13). However, LSD (0.05) comparison of means illustrated non-prominent variation (P>0.05) among group A and B against flavor, whilst both of these groups perceived considerably (P<0.05) value for flavor score contrast to group C.

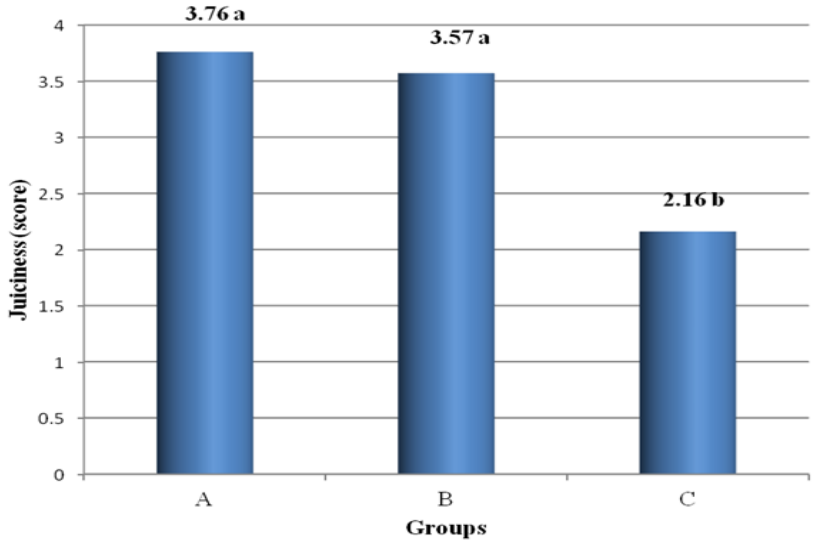


LSD (0.05) = 0.3873
SE± = 0.1887
Group A = Goat meat of age group 6-12 m.
Group B = Goat meat of age group 13-18 m.
Group C = Goat meat of age group >18 m.

Figure-3. Flavour (score) of goat meat of different age groups.

Juiciness: Goat meat of A, B and C groups was evaluated for juiciness by a taste panel, while the results are given in Figure 4. The score was ranked in a range between 3.2 to 4.8 for group A, 2.6 to 4.0 for B and 1.6 to 2.8 for C. However, higher juiciness score was perceived by group A (3.76 ± 0.17) and B (3.57 ± 0.15) as compared to

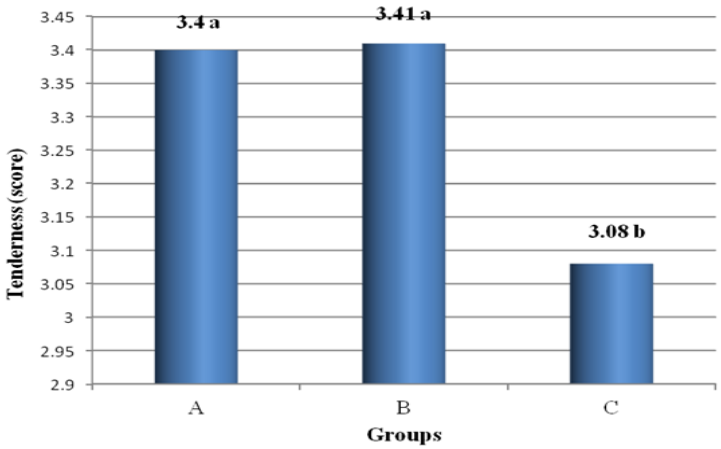
group C (2.16 ± 0.11). Variation in juiciness score of goat meat among them were considerably prominent (P<0.05). Whilst the mean score of group A and B (LSD; 0.05) was non-prominent (P>0.05) compared to each.



LSD (0.05) = 0.4329
SE± = 0.2110
Group A = Goat meat of age group 6-12 m.
Group B = Goat meat of age group 13-18 m.
Group C = Goat meat of age group >18 m.

Figure-4. Juiciness (score) of goat meat of different age groups.

Tenderness: Tenderness score in goat meat of group A, B, and C rated by a taste panel are depicted in Figure 5. It was observed that the score for tenderness ranged from 3.0 to 3.8 for group A, 2.8 to 4.0 for group B and 2.6 to 3.6 for group C. The average tenderness score was rated higher to group B (3.41 ± 0.11) and A (3.40 ± 0.08) compared to that of group C (3.08 ± 0.11). A and B groups possessed significantly (P<0.05) higher tenderness score compared to group C, but contrast to one another no significant variation (P>0.05) was noted.

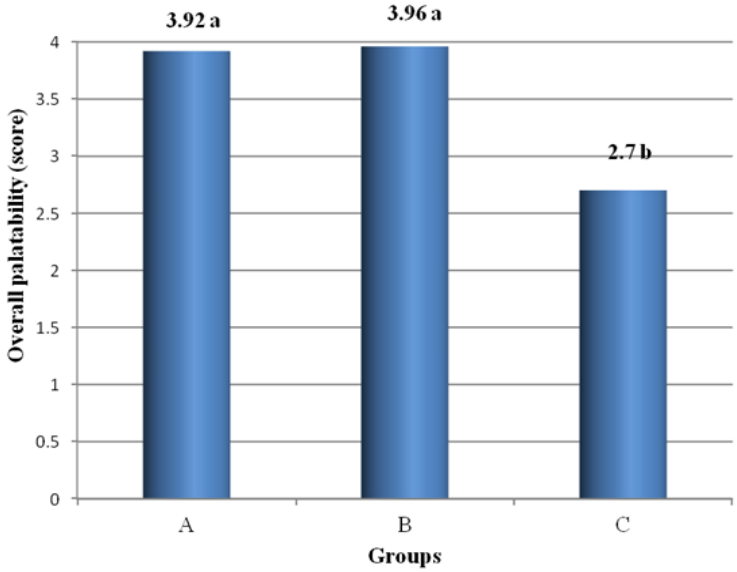


LSD (0.05) = 0.2980
SE± = 0.1453
Group A = Goat meat of age group 6-12 m.
Group B = Goat meat of age group 13-18 m.
Group C = Goat meat of age group >18 m.

Figure-5. Tenderness (score) of goat meat of different age groups.

Overall palatability: Overall palatability score of goat meat of group A, B, and C was evaluated by judges' Panel, whereas results are presented in the Figure 6. Goat meat of different age groups perceived score with

ranging from 3.4 to 4.4 in meat of group A, 3.6 to 4.2 of group B and 2.2 to 3.0 of group C. Regardless the score rated for overall palatability score was prominent B group (3.96 ± 0.06) compared A group (3.92±0.09), the differences among them were non-considerable (P>0.05). However, overall palatability score of group A and B was found considerably (P<0.05) higher contrast to C group (2.70 ± 0.09), when the LSD (0.05) of means was compared.



LSD (0.05) = 0.2305
SE± = 0.1123
Group A = Goat meat of age group 6-12 m.
Group B = Goat meat of age group 13-18 m.
Group C = Goat meat of age group >18 m.

Figure-6. Overall palatability (score) of goat meat of different age groups.

Table-1. Correlation matrix (Pearson) between glycogen and sensory characteristics of goat meat

Attributes	Goat meat of age group		
	6-12 m	13-18 m	>18 m
Glycogen × Colour	-0.2790^{ns}	0.5388^{ns}	-0.2489^{ns}
Glycogen × Flavour	0.4186^{ns}	0.3469^{ns}	-0.4073^{ns}
Glycogen × Juiciness	-0.0639^{ns}	0.2440^{ns}	0.6316*
Glycogen × Tenderness	-0.7712*	0.3904^{ns}	-0.4038^{ns}
Glycogen × Overall Palatability	-0.6127^{ns}	0.5195^{ns}	-0.3693^{ns}

* Significant = P<0.05
ns Non significant = P>0.05.

Influence of glycogen on sensory attributes of goat meat of different age groups: Influence of glycogen on sensory properties of goat meat was assessed, and findings are illustrated in Table 1. Glycogen has no prominent (P>0.05) effect on colour, flavor, juiciness, tenderness and overall palatability score of goat meat of age group 6-12 m, 13-18 m and >18 m except on goat meat of age group 6-12 m and >18 m where significant (P<0.05) relationship was found to be among glycogen x tenderness and glycogen x juiciness respectively. Further, it was noted that the glycogen was negatively correlated with colour of goat meat of age group 6-12 m and >18 m but positively correlated with age group 13-18 m. The relationship among them was weak (r = -0.2790), weak (r = -0.2489) and modest (r = 0.5388), respectively. Moreover, positive correlation was observed between the glycogen and flavour in goat meat of age group 6-12 m and 13-18 m but negatively correlated with age group >18 m. The influence of glycogen on flavour was found to be modest in goat meat of age group 6-12 m (r = 0.4186) and weak in age group 13-18 m (r = 0.3469), while it was noted modest (r = -0.4073) in case of age group >18 m. The relationship was found to be negative between glycogen and juiciness of goat meat of age group 6-12 m and positive to goat meat of age group 13-18 m and >18m. However, this relationship was very weak in case of goat meat of age group 6-12 m

(r = -0.0639) and weak in age group of 13-18 m (r = 0.2440) and modest in age group >18 m (r =0.6316). The influence of glycogen on tenderness was found to be strong in goat meat of age group 6-12 m (r = -0.7712) and weak in age group 13-18 m (r = 0.3904), while it was noted modest (r = -0.4038) in case of age group >18 m. The relationship was found to be negative between glycogen and overall palatability of goat meat of age group 6-12 m and >18 m but the positive in age group 13-18 m. The influence of glycogen on overall palatability of goat meat remained modest (r = -0.6127), weak (r = -0.3693), and modest (r = 0.5195) in age group 6-12m, >18 m and 13-18 m, respectively.

4. DISCUSSION

Current investigation was performed to assess glycogen level and its influence on sensory attributes of goat meat of different age groups i.e. group A (6-12 m; age), B (13-18 m; age) and C (>18 m; age). The average glycogen level appeared slightly higher in group B (17.79 ± 0.77 mg/g) in contrast to A group (17.55 ± 0.66 mg/g). Variation among them was found non-considerable (P>0.05). However, goat meat of group A and B appeared to have prominently (P<0.05) greater glycogen level in comparison to group C (9.56 ± 0.40 mg/g). These findings disagreed with the results of Kannan, et al. [14] who found higher (P< 0.01) muscle glycogen in old (24 to 30 m of age) vs. young (6 to 12 m of age) goats. While, Gracey, et al. [15] agreed with the present results, their reports indicated that the old animals have lower reserve of glycogen than that of younger. In another study [16] observed that eight month old lambs appeared to have greater glycogen level than that of 22 month old sheep. Nevertheless, the concentrations of glycogen in goat meat observed in the present study are in a range of findings reported by Warriss [17] that the muscles which produce meat with normal pH contain about 10-20 mg/g glycogen. Moreover, any type of pre-slaughter stress decreases the glycogen reserves in the muscles [18]. Whilst, regular exercise was known to increase the level of glycogen in the muscle of a variety of animals [19, 20].

Meat sensory characteristics tend to measure, analyses and interpret the quality of meat, which is, therefore, ranked by the sense of flavor, colour, juiciness aroma and tenderness. These sensory characteristics are highly affected by age [19] breed [21] and species of animal [22]. In the present study goat meat of unknown breed of different age groups were evaluated through panel of Judges and ranked as per score rated by them. It could be argued that colour of meat is of most important impression for consumer acceptance [23, 24] and in the present study it was found that there was no considerable variation (P>0.05) among the meat colour score of A (3.62 ± 0.11) and B (3.93 ± 0.13) group. While, the colour of these both groups were more acceptable (P< 0.05) contrast to C group (2.46 ± 0.08). Further, findings of current research reveals that the colour of group A and C goat meat was inversely related with glycogen concentration of goat meat, whilst in group C goat meat, the relationship was found to be positive. Moreover, present results are relation with study of Pieniak-Lendzion, et al. [25] who reported that the meat of older animals perceived the lower colour score than that of younger goat meat. In another study it has been reported that the average colour score of goat meat was decreased with increase in maturity of goat and meat became darker in colour [26].

Flavor is another important sensory character, which found to be the most important factor affecting the consumers' meat buying habits [27]. Flavor score of goat meat in group A and B (3.5 ± 0.08 and 3.65 ± 0.16, respectively) appeared similar and it was prominently higher (P> 0.05) than group C (2.74 ± 0.13). Present findings are in consistent with that of reported by Dawkins, et al. [28] who reported the significant effect of animal age on the flavour of cooked goat meat. However, Simela, et al. [29] reported that flavour intensity increase with the age of an animal, though disagree on which age group are the most acceptable. Moreover, flavour of goat meat in a group A and B was found to be directly related with glycogen level and in group C, it was inverse. But this relationship between glycogen and flavour attributes was found to be statistically non-significant (P>0.05).

Meat juiciness is found to be major character considered in the evaluation of meat quality [3]. In the present study the average score for juiciness was rated relatively similar (P>0.05) in goat meat of group A (3.76 ± 0.17) and

B (3.57 ± 0.15), whilst both of these groups ranked significantly higher (P<0.05) in juiciness than that of goat meat of group C (2.16 ± 0.11). It has been further observed that in older age group of goat meat (13-18 m, or >18 m), juiciness has direct relationship with glycogen and in younger age group (A) of goat meat it was found to be negative. These results are in agreement with reported results of Simela, et al. [29] who observed that meat of younger age were more juicer than that of older goats. In another study it has been reported that sensation of juiciness in chevon is closely related to the age of the animal [30]. It is of interest to note that meat of younger age goat could be of more marbled than that of older age goat meat as meat juiciness appeared to be high in well-marbled carcasses [21]. While Webb, et al. [31] reported that the juiciness of meat is directly linked to the moisture and intramuscular lipids content of meat.

Meat tenderness is assumed to be important attributes of eating quality that determines the consumers' interest in meat [30]. In the present study the average score for tenderness of group B (3.41 ± 0.15) and A (3.40 ± 0.08) was found to be similar (P> 0.05) but significantly higher (P< 0.05) than that of group C (3.08 ± 0.11) of goat meat. It has been further found that tenderness was inversely related to glycogen level of goat meat of young age group A as well as C, but directly related with age group B. However, this relationship was only significant (P<0.05) in meat of young age group (A). These results are accordance with the work of Bonvillani, et al. [32] who reported the higher score for initial tenderness in young goat and subsequently the lower with the progression of slaughter age. Similarly main effect due to increase in slaughter age in tenderness was observed by Peña, et al. [4]. The findings of current investigation are also in line with those found by McMillin and Brock [33] who reported that the increase in goat age generally decreases the meat tenderness.

Present findings indicate that goat meat of A (3.92±0.08) and B (3.96±0.05) group were similar (P> 0.05) in palatability. However, meat of both of these groups were more acceptable than that of group C (2.70 ± 0.09) goat meat. It could be noted that overall acceptability of meat products is directly affected by certain eating quality attributes like flavour, texture/tenderness, appearance/colour and juiciness [34]. Some of them indicate more influence on the overall acceptability compared to others. For instance, Lawrie [35] rated texture and tenderness as the most important eating quality attributes, whilst Bartholonew and Osualo [36] reported that flavour had more effect on overall acceptability of processed mutton products. However, present findings of overall acceptability correlate with that of other eating attributes (i.e. colour, flavour, juiciness and tenderness) observed in the present study, where group A and B goat meat perceived the higher score than that of group C goat meat. Overall palatability also correlates with level of glycogen. Their relationship was found to be negative in case of goat meat of young age group (A) and the old age group (C), whilst it was positive incase of group B goat meat i.e. 13-18 m age. The relationship of palatability with glycogen level presumed to be modest in goat meat of young age groups i.e. group A and B, where as it was weak in case of goat meat of older age group C i.e. >18 m age.

5. CONCLUSION

Study concludes that the meat obtained from goat having age of 6-12 months and 13-18 months possess similar sensory attributes, however at the age of >18 months goat changes significantly in term of all sensory characteristics.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Acknowledgement: Authors and co-authors are thankful to the department of Animal Products Technology including all staff members for providing research facility and favorable environment.

REFERENCES

[1] B. B. Khan and G. B. Issani, *Breeds and types of livestock in Pakistan. In: Animal Husbandry (S.I. Shah)*, 2nd ed. Islamabad: National Book Foundation, 1994.

[2] H. E. Warren, N. D. Scollan, M. Enser, S. Hughes, R. I. Richardson, and J. D. Wood, "Effects of breed and a concentrate or grass silage diet on beef quality in cattle of 3 ages. I: Animal performance, carcass quality and muscle fatty acid composition," *Meat Science*, vol. 78, pp. 256-269, 2008. Available at: https://doi.org/10.1016/j.meatsci.2007.06.008.

[3] V. Muchenje, K. Dzama, M. Chimonyo, P. Strydom, A. Hugo, and J. Raats, "Some biochemical aspects pertaining to beef eating quality and consumer health: A review," *Food Chemistry*, vol. 112, pp. 279-289, 2009. Available at: https://doi.org/10.1016/j.foodchem.2008.05.103.

[4] F. Peña, A. Bonvillani, B. Freire, M. Juárez, J. Perea, and G. Gómez, "Effects of genotype and slaughter weight on the meat quality of criollo cordobes and anglonubian kids produced under extensive feeding conditions," *Meat Science*, vol. 83, pp. 417-422, 2009. Available at: https://doi.org/10.1016/j.meatsci.2009.06.017.

[5] P. J. Roach, "Glycogen and its metabolism," *Journal of Current Molecular Medicine*, vol. 2, pp. 101-120, 2002. Available at: http://doi:10.2174/1566524024605761.

[6] D. L. Nelson and M. M. Cox, *Lehninger principles of biochemistry*, 4th ed. New York: W.H. Freeman and Company, 2005.

[7] P. Warriss, "The effects of live animal handling on carcass and meat quality," *Meat Science: An Introductory Text*, pp. 131-155, 2000. Available at: https://doi.org/10.1079/9780851994246.0131.

[8] M. S. Madruga, E. J. L. D. Medeiros, W. H. D. Sousa, M. d. G. G. Cunha, J. M. Pereira Filho, and R. d. C. R. D. Queiroga, "Chemical composition and fat profile of meat from crossbred goats reared under feedlot systems," *Brazilian Journal of Animal Science*, vol. 38, pp. 547-552, 2009. Available at: https://doi.org/10.1590/s1516-35982009000300021.

[9] D. Wachholz, R. Kauffman, D. Henderson, and J. Lochner, "Consumer discrimination of pork color at the market place," *Journal of Food Science*, vol. 43, pp. 1150-1152, 1978. Available at: https://doi.org/10.1111/j.1365-2621.1978.tb15257.x.

[10] K. Newton and C. Gill, "The microbiology of DFD fresh meats: A review," *Meat Science*, vol. 5, pp. 223-232, 1981. Available at: https://doi.org/10.1016/0309-1740(81)90005-x.

[11] A. Taylor and B. Shaw, "Hie effect of meat pH and package permeability on putrefaction and greening in vacuum packed beef," *International Journal of Food Science & Technology*, vol. 12, pp. 515-521, 1977. Available at: https://doi.org/10.1111/j.1365-2621.1977.tb00136.x.

[12] V. Santos, A. Silva, J. Cardoso, A. Silvestre, S. Silva, C. Martins, and J. M. T. D. Azevedo, "Genotype and sex effects on carcass and meat quality of suckling kids protected by the PGI "Cabrito de Barroso"," *Meat Science*, vol. 75, pp. 725-736, 2007. Available at: https://doi.org/10.1016/j.meatsci.2006.10.003.

[13] A. Kemp, J. M. Adrienne, and K. V. Heijningen, "A colourimetric micro-method for the determination of glycogen in tissues," *Journal of Biochemistry*, vol. 3, pp. 646-647, 1953.

[14] G. Kannan, B. Kouakou, T. Terrill, and S. Gelaye, "Endocrine, blood metabolite, and meat quality changes in goats as influenced by short-term, preslaughter stress," *Journal of Animal Science*, vol. 81, pp. 1499-1507, 2003. Available at: https://doi.org/10.2527/2003.8161499x.

[15] J. F. Gracey, D. S. Collins, and R. J. Huey, "Anatomy, meat composition and quality," *Journal of Meat Hygiene*, vol. 10, pp. 601-602, 1999.

[16] E. N. Ponnampalam, D. L. Hopkins, K. L. Bulter, and R. D. Warner, "Muscle glycogen in sheep: Genotype and gender effects," *Journal of Production Australia Society Production*, vol. 6, pp. 105-114, 2008.

[17] P. D. Warriss, "The effect of live animal handling on carcass and meat quality," *Hand book of Meat Science. School of Vet. Sci. Uni of Bristol UK*, pp. 144-146, 2000.

[18] T. Grandin and Gallo, *Welfare requirements of handling facilities. In: Farm animal housing and welfare. Eds. Baxter, S.H., M.R. Baxter and J.A.C. MacCormack, N. Martinus.* Netherlands: The Hague, 2007.

[19] M. Tan, A. Bonen, W. Watson-Wright, D. Hood, M. Sopper, D. Currie, A. Belcastro, and G. Pierce, "Muscle glycogen repletion after exercise in trained normal and diabetic rats," *Journal of Applied Physiology*, vol. 57, pp. 1404-1408, 1984.

[20] D. R. Topliff, G. P. Poter, J. L. Krieder, T. R. Dietson, and G. T. Jessup, "Diet manipulation, muscle glycogen metabolism and aerobic work performance in the equine," in *Proceeding 9th Equine Nutri. and Physi. Sci. Synp*, 1985, pp. 224-229.

[21] V. Muchenje, K. Dzama, M. Chimonyo, P. Strydom, A. Hugo, and J. Raats, "Sensory evaluation and its relationship to physical meat quality attributes of beef from Nguni and Bonsmara steers raised on natural pasture," *Animal*, vol. 2, pp. 1700-1706, 2008. Available at: https://doi.org/10.1017/s1751731108002802.

[22] H. Stone and J. L. Sidel, *Sensory evaluation practices*, 2nd ed. San Diego: Academic Press, 1993.

[23] K. Glitsch, "Consumer perceptions of fresh meat quality: Cross-national comparison," *British Food Journal*, vol. 102, pp. 177-194, 2000. Available at: https://doi.org/10.1108/00070700010332278.

[24] R. Mancini and M. Hunt, "Current research in meat color," *Meat Science*, vol. 71, pp. 100-121, 2005. Available at: https://doi.org/10.1016/j.meatsci.2005.03.003.

[25] K. Pieniak-Lendzion, R. Niedziółka, and T. Borkowska, "Some carcass traits and physicochemical composition of white improved breed goat kids slaughtered at 90 and 180 days of age," *Archives Animal Breeding*, vol. 52, pp. 425-431, 2009. Available at: https://doi.org/10.5194/aab-52-425-2009.

[26] A. Argüello, N. Castro, J. Capote, and M. Solomon, "Effects of diet and live weight at slaughter on kid meat quality," *Meat Science*, vol. 70, pp. 173-179, 2005. Available at: https://doi.org/10.1016/j.meatsci.2004.12.009.

[27] B. Sitz, C. R. Calkins, D. M. Feuz, W. J. Umberger, and K. M. Eskridge, "Consumer sensory acceptance and value of domestic, Canadian, and Australian grass-fed beef steaks," *Journal of Animal Science*, vol. 83, pp. 2863-2868, 2005. Available at: https://doi.org/10.2527/2005.83122863x.

[28] N. Dawkins, K. Mcmillin, O. Phelps, S. Gebrelul, A. Beyer, and A. Howard, "Palatability studies as influenced by consumer demographics and chevon characteristics," *Journal of Muscle Foods*, vol. 11, pp. 45-59, 2000. Available at: https://doi.org/10.1111/j.1745-4573.2000.tb00414.x.

[29] L. Simela, E. C. Webb, and M. Bosman, "Acceptability of chevon from kids, yearling goats and mature does of indigenous South African goats: A case study," *South African Journal of Animal Science*, vol. 38, pp. 247-259, 2008.

[30] L. Simela, "Meat characteristics and acceptability of chevon from South African Indigenous goat," Ph.D. Thesis, University of Pretoria, South Africa, 2005.

[31] E. Webb, N. Casey, and L. Simela, "Goat meat quality," *Small Ruminant Research*, vol. 60, pp. 153-166, 2005.

[32] A. Bonvillani, F. Peña, G. De Gea, G. Gómez, A. Petryna, and J. Perea, "Carcass characteristics of criollo cordobés kid goats under an extensive management system: Effects of gender and liveweight at slaughter," *Meat Science*, vol. 86, pp. 651-659, 2010. Available at: https://doi.org/10.1016/j.meatsci.2010.05.018.

[33] K. W. McMillin and A. P. Brock, "Production practices and processing for value added goat meat," *Journal of Animal Science*, vol. 83, pp. 57-68, 2005.

[34] B. D. Sharma, "Eating quality and sensory evaluation of meat food products," *Meat and Meat Products Technology*, vol. 11, pp. 82-87, 2000.

[35] R. A. Lawrie, *Eating quality and sensory evaluation of meat food products, meat sci*, 3rd ed.: Oxford Pergamon Press, 1979.

[36] D. T. Bartholonew and C. L. Osualo, "Acceptability of flavour, texture and appearance in processed meat products," *Journal of Meat Science*, vol. 51, pp. 1560-1562, 1986. Available at: https://doi.org/10.1111/j.1365-2621.1986.tb13861.x.