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Sheep Breed Variations: Effects on Growth Performance and Nutrient Digestibility

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ABSTRACT

Background: In Saudi Arabia, sheep are the majority of the livestock population, although it imported by large numbers to meet their people demands. The shortage between production and consumption in order to reduce the import proportions of sheep meat is our aim in this study through the evaluation effect of Saudi sheep breeds on feed intake, growth performance, digestibility and nitrogen utilization.

Methods: Forty-five intact male sheep, comprising the Awassi, Harri and Najdi breeds (approximately 23.4 ± 2 kg), were used in this research. Three breed sheep groups, each consisting of 15 animals, were established. At the end of the 12-week growth period, five animals from each group were selected for digestibility and nitrogen balance trials.

Result: The results indicated that sheep breed significantly ($p<0.05$) affected final live weight, average daily feed intake, average daily gain and feed conversion ratio. However, there was no significant effect ($p>0.05$) of breed on the digestibility coefficients of dry matter, organic matter, crude protein, crude fiber, nitrogen-free extract, neutral detergent fiber and acid detergent fiber. Similarly, no significant differences were observed between breeds in terms of digestible organic matter, digestible crude protein, total digestible nutrients and nitrogen retention. In conclusion, the sheep breeds influenced average daily feed intake, average daily gain and feed conversion ratio, with the Awassi breed demonstrating the best performance regarding average daily gain and feed conversion ratio.

Key words: Awassi, Digestibility, Growth performance, Harri, Najdi, Nitrogen retention.

INTRODUCTION

Cattle, camels, sheep and goats are the primary livestock species producing red meat in Saudi Arabia, with estimated populations of 354,276 cattle, 471,704 camels, 9,055,438 sheep and 3,563,017 goats (GASTA, 2021). Notably, sheep make up approximately 72% of the livestock population. Despite this substantial number, Saudi Arabia imports significant quantities of sheep to meet domestic demand (BMI, 2013).

Evaluating the potential of Saudi sheep breeds in terms of growth performance and nutrient digestibility efficiency could significantly enhance productivity, leading to improved satisfaction in the livestock sector. Understanding the growth performance of different sheep breeds enables farmers to select those that convert feed into body mass more efficiently, which can increase meat production overall (Jaapar *et al.*, 2023). Moreover, assessing nutrient digestibility helps in formulating diets that maximize the utilization of available feed resources (Barman *et al.*, 2023). By identifying breeds that digest nutrients more effectively, farmers can tailor feeding strategies to boost growth rates and feed efficiency (Roba *et al.*, 2022). Additionally, evaluating nutrient digestibility can contribute to more sustainable livestock production systems by optimizing feed use and reducing waste, thereby minimizing the environmental impact of sheep farming (Roba *et al.*, 2022). Moreover, evaluating the feeding practices of farmers and those managing livestock projects is crucial for optimizing overall costs and promoting environmental conservation (Al-Mutairi *et al.*, 2025).

Numerous studies (Samara *et al.*, 2013; Abdoun *et al.*, 2014; El-Waziry *et al.*, 2015) have indicated that digestion, daily weight gain and growth rates vary among breeds. Despite the prominence of the Awassi, Harri and Najdi breeds in Saudi Arabia-favored by the local

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population (Suliman *et al.*, 2021)-there is limited information regarding their performance and efficiency of nutrient's utilization. Furthermore, recent studies comparing these breeds in terms of digestion, performance and nutrient digestibility are lacking. Consequently, this study was conducted to investigate the effects of sheep breeds on growth performance, digestibility coefficients, nutritional values and nitrogen utilization.

MATERIALS AND METHODS

Animals, Nutrition and Ethics

The experiment was conducted at the Research Farm of the Department of Animal Production, College of Food and Agricultural Sciences, King Saud University, Riyadh, Saudi Arabia (24.8051°N, 46.5203°E) during the period from February to August 2021. Three Saudi sheep breeds; Awassi, Harri and Najdi were utilized. A total of 45 intact male lambs (15 from each breed) were included in the study, with an average age of 2.8 ± 2 months and an average weight of 23.4 ± 2.5 kg. Before the growth trial commenced, the lambs were ear-tagged, treated for internal and external parasites and housed in shaded pens equipped with feeding and watering troughs. The feeding period lasted for 12 weeks, preceded by a two-week adaptation period. All lambs were kept under the same environmental conditions. They were fed ad libitum an iso-nitrogenous and iso-caloric pelleted diet formulated to meet their nutrient requirements (NRC, 2007). The feed ingredients and chemical composition are presented in Table 1. Drinking water and salt licks were continuously available. The experiment adhered to the guidelines for animal research and was approved by the Research Ethics Committee; Reference No. (KSU-SE-20-17).

Experimental design and growth performance indicators

The experimental animals were distributed evenly into three groups in a complete randomized block design. During the feeding period all growth performance parameters were recorded. These included initial and final live weights, average daily gain, average daily feed intake and feed conversion ratio. The body weight and feed intake were measured weekly for each growing lamb over the growth period, following a 10-hour feed deprivation before each measurement. Weights were recorded using a digital scale to determine daily weight gain, calculated by taking the difference between final and initial weights and dividing by the number of days. Additionally, the feed conversion ratio was determined by dividing daily feed intake by daily weight gain. This methodology provided a thorough evaluation of the lambs' growth performance and feed efficiency throughout the study.

Digestibility and nitrogen balance trials

At the end of the growth period, five animals from each group were selected for digestibility and nitrogen balance trials. The animals were housed individually in separate pens and equipped for total fecal and urine collection. Throughout the collection period, which lasted in 10 days, precise records of individual feed intake were maintained. Total fecal and urinary excretions were collected daily. Additionally, 10% subsamples of both feces and urine were taken each day and stored at -18°C for further analysis.

Chemical analysis

The experimental diet and feces were analyzed according to AOAC (2007) for dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash content. Nitrogen-free extract (NFE) was calculated by difference using the formula:

$$NFE = Dry\ Matter - (CP+EE+CF+Ash)$$

Nitrogen content in urine was determined using the method outlined by AOAC (2007). Additionally, neutral detergent fiber (NDF) and acid detergent fiber (ADF) were measured according to the techniques described by Van Soest *et al.* (1991).

Statistical analysis

The data were analyzed using analysis of variance (ANOVA) in SPSS® software (version 21). Mean separation was performed using Duncan's multiple range test (1955). Statistical significance was determined at a probability value of $p<0.05$.

Table 1: Ingredients and chemical composition of experimental diet.

Item	DM basis, %
Ingredients:	
Alfalfa hay	25.0
Maize	39.3
Barley	23.8
Soybean meal	9.1
Mineral supplements[a]	2.6
Trace mineral and vitamin premix[b]	0.2
Chemical composition:	
CP	13.50
CF	8.16
ADF	15.00
NDF	49.42
NFE	67.77
EE	2.74
Ash	8.60
Ca	0.56
P	0.29
ME, Mcal/kg[c]	2.73

[a]Supplements composition: 30% sodium bicarbonate; 30% ground limestone; 20% dicalcium phosphate; 20% sodium chloride.

[b]Contained per kg of mineral and vitamin premix: $CoSO_4$, 0.30g; $CuSO_4$, 20.1 g; $FeSO_4$, 10.0 g; ZnO, 50.0 g; $MnSO_4$, 40.2 g; KI, 0.75 g; NaCl, 2.81g; vitamin A, 500,000 IU; vitamin D, 500,000 IU and vitamin E, 10,000 IU.

[c]calculated.

RESULTS AND DISCUSSION

Growth performance trials

The three sheep breeds (Awassi, Harri and Najdi) were used in this study and distributed into three groups. All animal started the experimental period of growth that extend for 84 days with mean average of initial live weight (ILW) about 24.56 kg (Table 2, Fig 1). The final live weight was ranged on average between 44.51 and 50.52 kg. Average total feed intake (ADI), average total gain (ADG) and feed conversion ratio (FCR) were shown in Table 2 and Fig 1. The values were ranged between 118.3 and 141.8 kg for ADI; 19.81 and 26.21 kg for ADG and 5.42 and 6.01 for FCR.

Table 2: Growth performance of the three breeds of sheep fed the experimental diet[1].

Item	Breeds[2]			SEM[3]	*p*
	AW	HA	NA		
Initial, kg	24.31	24.70	24.68	0.215	0.7391
Final, kg	50.52[a]	44.51[b]	48.54[a]	0.863	0.0041
Total Gain, kg	26.21[a]	19.81[b]	23.68[a]	0.849	0.0009
Total Feeds, kg	141.8[a]	118.3[b]	137.3[a]	3.141	0.0002
Intake, g^{-d}					
0 - 28 d	1402.4[a]	1241.0[b]	1363.1[ba]	28.713	0.0425
28 - 56 d	1578.9[a]	1233.7[b]	1516.7[a]	44.987	<0.0001
56 - 84 d	2083.9[a]	1749.4[b]	2025.2[a]	26.68	0.0023
0 - 84 d (ADI)[4]	1688.4[a]	1408.0[b]	1635.0[a]	16.12	0.0443
Gain, g^{-d}					
0 - 28 d	280.9	256.6	254.1	7.516	0.2941
28 - 56 d	320.9[a]	193.0[b]	296.6[a]	17.479	0.0005
56 - 84 d	334.2	257.9	301.2	17.423	0.2083
0 - 84 d (ADG)[4]	312.0[a]	235.8[b]	284.0[a]	10.108	0.0009
Intake: Gain					
0 - 28 d	5.07	4.85	5.39	0.147	0.3497
28 - 56 d	4.98[b]	6.50[a]	5.14[b]	0.240	0.0056
56 - 84 d	6.33	7.57	6.83	0.527	0.6581
0 - 84 d (FCR)[4]	5.42[b]	6.01[a]	5.77[ba]	0.113	0.0955

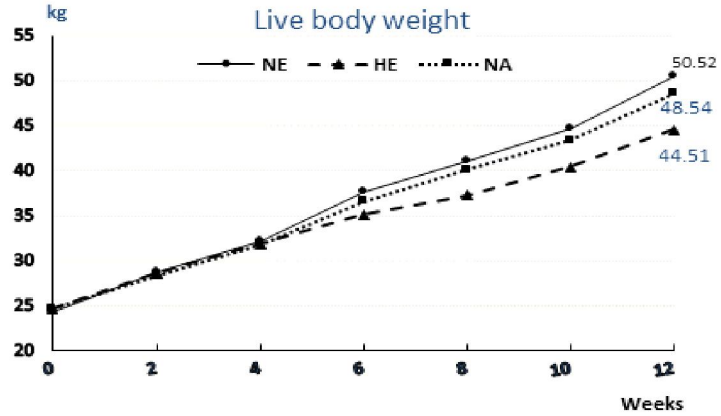
[1]Values represent means of 5 pens, 3 lambs each per treatment. Feeding period lasted 84 days.

[2]Breeds: AW=Awassi; HA=Harri; and NA=Najdi male lambs.

[3]Pooled standard error of means.

[4]ADI= Average daily intake; ADG= Average daily gain; FCR= Feed conversion ratio.

[a, b] Means within rows not sharing the same letter (s) differ (P<0.05).



Values are means (n=15 lambs/treatment). Breeds: (AW=Awassi; HA=Harri; NA=Najdi male lambs).

Pooled standard error of means at d0, 14, 28, 42, 56, 70 and 84 were 0.22, 0.23, 0.26, 0.42, 0.55, 0.58 and 0.86, respectively.

Fig 1: Effect of Experimental diet on live body weight of breeds lambs.

Digestibility and nitrogen balance trials

Dry matter intake, digestibility coefficients and nutritive values of the experimental diet fed to the three breeds of sheep are presented in Table 3. The lowest value of DMI was recorded with Harri followed by Najdi and Awassi and the values were 1186.3, 1783.7 and 1808.9 g/day for Harri, Najdi and Awassi, respectively. The digestibility coefficients of dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), nitrogen free extract (NFE), neutral detergent fiber (NDF) and acid detergent fiber (ADF) are shown in Table (3).The values were on average from 60.87 to 64.69% for DM; 65.19 to 69.10% for OM; 52.42 to 56.22% for CP; 86.13 to 89.97% for EE; 40.16 to 46.52% for CF; 73.30 to 76.93% NFE; 54.65 to 60.79% for NDF and 41.66 to 47.04% for ADF.

Nitrogen utilization of three breeds of sheep fed the experimental diet is shown in Table 4. The values of nitrogen intake were 25.11, 37.76 and 38.29 g/day for Harri, Najdi and Awassi breeds, respectively. The values of absorbed nitrogen were 14.07, 19.82 and 20.45 g/day for Harri, Najdi and Awassi breeds, respectively. The values of nitrogen retention were 5.61, 7.98 and 7.98 g/day for Harri, Najdi and Awassi breeds, respectively.

The ILW between the group animals did not differ significantly (p>0.05). There were significant differences among the groups with the final live weight (FLW). The highest (p<0.05) FLW was recorded with Awassi breed followed by Najdi then Harri (Table 2, Fig 1). Average daily feed intake (ADI), average daily gain (ADG) and feed conversion ratio (FCR) were significantly (p< 0.05) different among the group breeds (Table 2). The Awassi sheep breed attained the highest (p<0.05) ADI followed by Najdi and Harri, respectively. The best (p<0.05) ADG and FCR was reported with Awassi sheep contrasted to the other two sheep breeds (Table 2) and this agrees with the report of Hassanin *et al.* (2013). The greater FLW of Awassi sheep is ascribed to ADG and FCR over Najdi and Harri breeds, where this agrees with the results of Aller *et al*. (2012) and Kridi *et al*. (2006). The Harri breed had the lowest (p<0.05) values of final weight, total gain, average daily feed intake, average daily gain during 84 days (Table 2) compared to Awassi and Najdi breeds and this was attributed to the less amount of DMI consumed by Harri breed (Suliman *et al.,* 2021). The significant difference between Awassi and Najdi in final weight, total gain, average daily intake and average daily gain during 84 days was not detected (p >0.05) and this may due to the similar amount of average daily feed intake consumed by them (Suliman *et al.,* 2021). Therefore, the best feed conversion ratio was recorded by Awassi followed by Najdi and Harri (Table 2). Conclusively, the discrepancies in FBW can be ascribed to the effect of the breed; besides effects of DMI and body fat. Several studies have indicated that breed is one of the primary factors affecting FBW (NRC, 2007; AOAC, 2007; BMIIR, 2021; Al-Owaimer*et al.,* 2014; Wilhelm *et al.,* 2010; Culler *et al.,* 1978; Ayele *et al.,* 2019).

For digestibility and nitrogen balance trials, there was significant (p<0.05) difference between Harri breed compared to Awassi and Najdi breeds in dry matter intake (DMI). There was no significant (p> 0.05) difference between Najdi and Awassi in DMI. These results were parallel with the results of DMI in the growing trail in the present study. There were no significant (p>0.05) differences among the three breeds of sheep of digestibility coefficients in dry

Table 3: Dry matter intake, digestibility coefficients and nutritive values of the experimental diet fed to the three breeds of sheep[1].

Item	Breeds[2]			SEM[3]	*P*
	AW	HA	NA		
Dry matter intake (DMI,g/day)	1808.9[a]	1186.3[b]	1783.7[a]	92.36	<0.0001
Digestibility coefficients (%):					
Dry matter (DM)	61.61	64.69	60.87	0.952	0.2359
Organic matter (OM)	65.81	69.10	65.19	0.919	0.1796
Crude protein (CP)	53.30	56.22	52.42	1.280	0.4911
Ether extract (EE)	86.13[b]	89.97[a]	88.52[ba]	0.679	0.0569
Crude fiber (CF)	44.28	46.52	40.16	1.704	0.3321
Nitrogen free extract (NFE)	73.30	76.93	73.51	0.860	0.1530
Neutral detergent fiber (NDF)	57.02	60.79	54.65	1.437	0.2261
Acid detergent fiber (ADF)	43.38	47.04	41.66	1.585	0.4051
Nutritive value (%):					
Digestible OM (DOM)	58.92	61.86	58.36	0.823	0.1796
Digestible CP (DCP)	7.05	7.44	6.94	0.170	0.4911
Total digestible nutrients (TDN)	63.02	66.15	62.58	0.835	0.1665

[1]Values represent means of 4 lambs / treatment;

[2]Breeds: AW=Awassi; HA=Harri; and NA=Najdi male lambs.

[3]Pooled standard error of means.

[a, b]Means within rows not sharing the same letter (s) differ (P<0.05).

Table 4: Nitrogen (N) utilization of the three breeds of sheep fed the experimental diet[1].

Item	Breeds[2]			SEM[3]	*P*>
	AW	HA	NA		
Nitrogen balance					
N intake g^{-d}	38.29[a]	25.11[b]	37.76[a]	1.955	<0.0001
N excretion:					
Fecal g^{-d}	17.84[a]	11.04[b]	17.94[a]	1.107	0.0013
Urinary g^{-d}	12.47	8.46	11.84	0.873	0.1252
Absorbed N g^{-d}	20.45[aa]	14.07[b]	19.82[a].82[a]	1.005	0.0023
N retention:					
g^{-d}	7.98	5.61	7.98	1.039	0.6065
%, of N intake	20.77	21.66	21.14	2.942	0.9939
%, of absorbed N	37.79	37.99	40.19	4.991	0.9808

[1]Values represent means of 4 lambs / treatment;

[2]Breeds: AW=Awassi; HA=Harri; and NA=Najdi male lambs.

[3]Pooled standard error of means.

[a, b]Means within rows not sharing the same letter (s) differ (P< 0.05).

matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), nitrogen free extract (NFE), neutral detergent fiber (NDF) and acid detergent fiber (ADF) (Table 3). The three breeds of sheep had no effect (p>0.05) in digestible organic matter (DOM), digestible of crude protein (DCP) and total digestible nutrients (TDN). The present results indicated that the larger DMI depresses the nutrient digestibility and this agrees with NRC (2001). Potts *et al.* (2017) reported that greater intake depresses nutrient digestibility and can expect that residuals feed intake will be negatively correlated with digestibility. A major factor influencing nutrient utilization in dairy cattle is the relationship between feed intake and diet digestibility (Colucci *et al.,* 1982). Thus, the Harri sheep breed had a numerical impact on dry matter intake (DMI), which influenced nutrient digestibility, aligning with the findings of NRC (2001); Potts (2017); Colucci (1982). The lowest value of nitrogen intake was recorded (p < 0.05) with Harri breed compared to other two breeds; this is attributed to the less amount of DMI consumed by animals. There was no significant (p>0.05) difference between Awassi and Najdi in nitrogen intake. There was no significant (p>0.05) difference in nitrogen retention among the three breeds, although Harri breed had the low value of nitrogen intake as mentioned, this due to the lowest value which excreted nitrogen in fecal by Harri breed compared to Awassi and Najdi breeds (Table 4).

CONCLUSION

The present study concluded that the sheep breed affected average daily feed intake, average daily gain and feed conversion ratio. Awassi breed showed the best of average daily gain and feed conversion ratio followed by Najdi and Harri breeds. Harri breed had the lowest average daily gain and feed conversion. The breed of sheep had no effect on digestibility coefficients and nitrogen retention although Harri sheep breed affected numerically dry matter intake and hence the nutrient digestibility nitrogen retention. Therefore, more studies will be needed to achieve for evaluating the three sheep breeds under study considering their performance, carcass characteristics and meat quality to confirm which of them gain higher standing among consumers.

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Ethical approval

The experiment followed the guidelines for animal research and received approval from the Research Ethics Committee, Reference No. (KSU-SE-20-17).

Informed consent

NA

Conflicts of interest

The authors state that there are no conflicts of interest related to this article's publication. Additionally, no funding or sponsorship affected the study's design, data collection, analysis, publication decision, or manuscript preparation.

REFERENCES

Abdoun, K.A., Okab, A.B., El-Waziry, A.M., Samara, E.M., Al-Haidary, A.A. (2014). Dietary Supplementation of Seaweed (*Ulva lactuca*) to alleviate the Impact of Heat Stress in Growing Lambs. Pakistan Veterinary Journal. 34: 108-111.

Aller, J.F., Aguilar, D., Vera, T., Almeida, G.P., Alberio, R.H. (2012). Seasonal variation in sexual behavior, plasma testosterone and semen characteristics of Argentine Pampinta and Corriedale rams. Spanish Journal of Agricultural Research. 10: 345-352.

Al-Mutairi, M.H., Al-Zahrani, K.H., Qassem, H.S., Al-Badwi, M.A., Al-Baadani, H.H., Alhidary, I.A. (2025). Assessment of Animal Feeding Practices by Livestock Farmers in the Kingdom of Saudi Arabia. Indian Journal of Animal Research. 2: 1-9. doi 10.18805/IJAR.BF-1912.

Al-Owaimer, A.N., Suliman, G.M., Sami, A.S., Picard, B., Hocquette, J.F. (2014). Chemical composition and structural characteristics of Arabian camel (*Camelus dromedarius*) m. longissimus thoracis. Meat Science. 96: 1233-41.

AOAC. (2007). Official methods of analysis. In: Herlick K, *et al*., editors. Association of Official Analytical Chemists. 16th ed., Arlington, VA.

Ayele, S., Urge, M., Animut, G., Yusuf, M.J. (2019). Comparative slaughter performance and carcass quality of three Ethiopian fat-tailed hair sheep breeds supplemented with two levels of concentrate. Tropical Animal Health and Production. 51: 187-98.

Barman, K.C., Barman, K., Verma, A.K., Jadhav, S.E., Dutta, P., Singh, N., Chaudhary, P., Jat, S.L. (2023). Determination of *In vitro* Nutrient Digestibility of Silage based Diets with Varying Levels of Crude Fibre using Pig Faecal Inoculum. Indian Journal of Animal Research. 5: 1-6. doi: 10.18805/IJAR.B-5021.

BMI. (2013). The Business Monitor International, Food and Drink Report on Saudi Arabia,http://www.researchandmarkets.com/reports/2364081/saudi_arabi a_food_and _drink_report_q1_2013.

BMIIR. (2021). Business Monitor International – Industry Reports. Saudi Arabia Foodand Drink Report Aug 27, 2016. New York, NY: Alacra Store. Retrieved from: http://www.alacrastore.com/storecontent/Business-Monitor-International Industry, Reports/Saudi-Arabia-Food-and-Drink-Report-2026-454 (accessed March 03, 2021).

Colucci, P.E., Chase, L.E., Van Soest, P.J. (1982). Feed Intake, Apparent Diet Digestibility and Rate of Particulate Passage in Dairy Cattle. Journal of Dairy Science. 65: 1445-1456.

Culler, R.D., Parrish, F.C Jr., Smith, G.C., Cross, H.R. (1978). Relationship of myofibril fragmentation index to certain chemical, physical and sensory characteristics of bovine longissimus muscle. Journal of Food Science. 43: 1177-80.

Duncan, D.B. (1955). Multiple ranges and multiple F test. Biometrics. 11: 1-15.

El-Waziry, A.M., Al-Haidary, A.A., Okab, A.B., Samara, E.M., Abdoun, K.A. (2015). Effect of dietary seaweed (*Ulva lactuca*) supplementation on growth performance of sheep and on *in vitro* gas production kinetics. Turkish Journal of Veterinaryand Animal Sciences. 39: 81-86.

GASTAT. (2021). Agriculture, water and environment. In: General Authority for NewWorld Camelids;Washington, DC: The National Academies PressStatistics. Statistical Yearbook of 2018. Available online at: https:// www.stats.gov.sa/en /1011 (accessed March 3, 2021).

Hassanin, S.H., Hussein, A.F., Khattab, Y.A., Abdalla, M.A. (2013). Reproductive performance of rams under arid conditions. Life Science Journal. 10: 2546-2606.

Jaapar, M.S., Chung, E.L.T., Nayan, N., Muniandy, K.V., Hamdan, M.H.M., Jusoh, S., Jesse, F.F.A. (2023). Digestibility, Growth Performance, Body Measurement and Hormone of Sheep Fed with Different Levels of Brachiaria decumbens Diets. Tropical Life Sciences Research. 34(1): 67-83.

Kridi, R.T., Abdullah, A.Y., Shaker, M.M., Al-Momani, A.Q. (2006). Age at puberty and some biological parameters of Awassi and its first crosses with Charollais and Romany rams. Italian Journal of Animal Science. 5: 193-202.

NRC. (2001). National Research Council. Nutrient Requirements of Dairy Cattle. 7th ed., Natl. Acad. Press, Washington, DC.

NRC. (2007). Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids and New World Camelids; Washington, DC: The National Academies Press, 384.

Potts, S.B., Boerman, J.P., Lock, A.L., Allen, M.S., Van deHaar, M.J. (2017). Relationship between residual feed intake and digestibility for lactating Holstein cows fed high and low starch diets. Journal of Dairy Science.100: 265-278.

Roba, R.B., Letta, M.U., Aychiluhim, T.N., Minneeneh, G.A. (2022). Intake, digestibility, growth performance and blood profile of rams fed sugarcane bagasse or rice husk treated with Trichoderma viride and effective microorganisms. Heliyon. 1;8(12): e11958. doi: 10.1016/j.heliyon.2022.e11958. PMID: 36478836; PMCID: PMC9720023.

Samara, E.M., Okab, A.B., Abdoun, K.A., El-Waziry, A.M., Al-Haidary, A.A. (2013). The subsequent influences of feeding intact green seaweed Ulva lactuca to growing lambs on the seminal and testicular characteristics in rams. Journal of Animal Science. 91: 5654-5667.

Suliman, G.M., Al-Owaimer, A.N., El-Waziry, A.M., Hussein, E.O.S., Abuelfatah, K., Swelum, A.A. (2021). A Comparative Study of Sheep Breeds: Fattening Performances, Carcass Characteristics, Meat Chemical Composition and Quality Attributes. Frontiers in Veterinary Science. 8: 647-192.

Van Soest, P.J., Robertson, T.B., Lewis, B.A. (1991). Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science. 74: 3583-3597.

Wilhelm, A.E., Maganhini, M.B., Hernández-Blazquez, F.J., Ida, E.I., Shimokomaki, M. (2010). Protease activity and the ultrastructure of broiler chicken PSE (pale, soft, exudative) meat. Food Chemistry. 119: 1201-4.