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Effect of Early Shearing on The Nutritional Metabolism, Growth Performance and Carcass Traits of Barki Lambs

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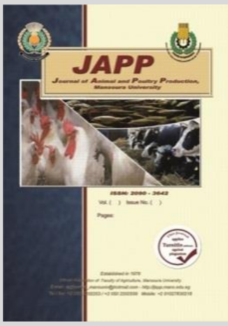

ABSTRACT

This study was planned to investigate the effects of early shearing on the performance and certain metabolic and carcass parameters of growing Barki lambs. Eighteen lambs (23.18± 0.69 kg weight and 4 months of age) were divided into equal two groups. One group was left unshorn and served as a control group (C) while the other group was completely shorn (S) and both groups were housed in shaded pens. All animals were fed concentrate mixture to cover their maintenance requirements otherwise clover hay was offered *ad lib* to cover growth requirements for a period of 110 days. Results showed that total feed intake increased after shearing and improved by 8.37% over the C group. Shearing increased (P<0.01) daily gain of lambs by 12.87% over than of C group. However, shearing had no effects on the indicators of feed conversion. The shorn group recorded a higher growth rate of net clean wool (5.54g/d) than the control group (3.47g/d). Nutrients digestibilities were generally improved in S group, however, insignificance was observed for CF and EE digestibility values. The rumen pH, NH_3-N and VFA were significantly higher in S than C group. The shorn group achieved higher retained N and sulfur. Shorn lambs were more economical efficient in utilizing water than C group. Shearing did not affect dressing percentage; notwithstanding it has a positive financial gain. This study provided clear evidence that under local conditions; the early shearing of growing Barki lambs improved their body weight gain as well as achieved high revenue.

Keywords: Shearing, Barki lambs, body and wool growth rate, Nitrogen and Sulfur metabolism, Carcass.

INTRODUCTION

Under Egyptian conditions, sheep producers face great challenges represented in low wool price and low animal performance for mutton production. Furthermore, the economic value of wool is greatly lower than that of mutton. Therefore, enhancing wool production has become a negligible matter for sheep producers. The local Barki lambs, however, are shorn first in their life, when they reach at least about 12 months old. The shearing process is usually practiced for breeding flock including ewes, ewe lambs, rams where they are subjected to the natural high ambient temperature of the summer season. However, such a practice is not applied for fattening male lambs as their lifetime is usually less than 12 months.

Fleece is important for sheep under both hot and cold conditions to maintain homeothermy. However, shearing stimulates nervous responses to modify the energy-saving mechanisms and thermoregulation that relating to adaptability to climate (Aleksiev, 2009). Shearing may evoke metabolic responses to maintain mechanisms of thermoregulation (Piccione *et al.*, 2008), motivates feed consumption (Avondo *et al.*, 2000) and stimulate the growth of lamb and might have positive reflects on lamb's performance (Mclean *et al.*, 2015). On the other hand, Hristov *et al.* (2012) concluded that, shearing is regarded as one of the major effective sheep stressors.

Shearing is a usual process and practiced especially under stressful environments for lamb hygiene and health, which can also influence animal survival and productivity under that conditions. Generally, there is scanty information about the influence of the early shearing for fattened Barki lambs, therefore, this study was planned to investigate the effects of early shearing on the performance and certain metabolic parameters as well as the carcass performance of fattened Barki lambs.

MATERIALS AND METHODS

This work was developed from August to November 2016 in the Animal Production Section of the Maryout Research Station, Desert Research Center, Cairo, Egypt.

Animals, management and feeding

A total number of twenty-six Barki lambs aged about four months and ranged of 21.0- 24.1 kg of live body weight (LBW), was divided into two groups. The first group consisted of twelve lambs and was less in their average LBW than the second group (fourteen lambs) by about one kg. Three lambs were taken from the first group, have the same average LBW and slaughtered before starting the experiment to record the data of the carcass at day zero and monitor the changes in carcass characteristics. The remaining nine lambs of the first group were left unshorn and served as control group (C). All fourteen lambs of the second group were shorn, and nine lambs were selected to be almost similar to the control group in their average LBW and represent the treatment group (S). The remaining five shorn lambs of the second group, which had extreme LBW values, were excluded from the experiment.

The two groups; un-shorn (control) and shorn (S) were housed in shaded pens. The animals of each group were distributed to be in three pens (3 lambs/ pen). Both

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groups of lambs were fed a concentrate portion to meet their maintenance requirements in accordance with Kearl (1982) otherwise clover hay was offered *ad lib* to cover growth requirements all over the experimental period that lasted for 110days. The concentrate feed mixture (CFM) consisted of 47% wheat bran, 29 % cottonseed meal, 15% crushed yellow corn, 3% rice bran, 3% limestone, 2% molasses, 1% salt. The chemical composition of CFM and clover hay is given in Table (1). Live body weight was recorded at the start, at biweekly intervals thereafter and at the end of the experiment. Body weight was estimated in the morning after an overnight holding of feed and water. Water was offered twice a day 11:00AM and 6:00PM.

Table 1. Chemical components of the experimental concentrate mixture and clover hay roughage

Item	Concentrate mixture	Clover hay roughage
DM%	90.95	88.93
OM%	86.59	90.95
Ash%	13.41	9.05
CP%	13.80	12.65
CF%	20.63	31.01
EE%	2.13	2.68
NFE%	50.03	44.62
Sulfur %	0.22	0.28
Nitrogen/ sulfur (N/S) ratio	10.04	7.23
Sulfur/ nitrogen (S/N) ratio	0.10	0.14

Metabolism trial and collection of rumen samples

Five animals from each group were randomly selected for conducting metabolism trial to determine the digestibility of nutrients as well as nitrogen (N), sulfur and water metabolism. This trial lasted for 17 days; 10 days for adaptation followed by 7 days for samples' collection. Water was daily offered *ad-libitum* and consumption was recorded for each animal. Total excreted feces, urine and feed refusal (if any) were weighted in each animal and a 10% subsamples was saved. Representative samples from feeds, feces and urine were kept for later analysis.

Rumen fluid samples (50 ml) were collected from four animals in each group at day 17 of the metabolism trial. A stomach tube was used to collect rumen samples at zero, 3 and 6h post-feeding. Rumen pH was recorded immediately using a pH-meter with glass electrode. Rumen digesta was strained by using four layers of cheesecloth then rumen filtrate were acidified with 10% HCl and frozen at -20 ºC until analyzed for the organic volatile fatty acids (VFA) and the nitrogen of ammonia (NH_3-N).

Wool measurements

At day zero of experiment (before shearing S group) and to make base line of comparison between the two experimental groups, an area of 10 cm^2 on the right mid-side of each animal in two groups was clipped and the weight of greasy wool was recorded. To determine clean wool weight, greasy patches were washed in hot water (65°C) for 20 min and scoured by heavy-duty compound; then samples dried for 72h before weighing. The whole-body clean wool at day zero of the experiment was calculated as described previously by Kewan (2013a):

The whole-body clean wool, g/head = clean wool weight (g/cm²) × total body surface area (BSA).

Where BSA of the Barki sheep = (4024.42 + (154.6× kg LBW)).

On the day of slaughter, wool was shorn very closely to the skin, and the final weight of greasy fleece and clean wool were determined. The growth rate of net clean wool equals the difference between the final clean wool weight and the first weight at day zero then divided by the experimental period in days. The values of clean wool growth rate (g/day) was used to estimate the whole-body wool N, S accretion (g/day) and the energy retained in wool (MJ/day). The part of feed energy retained in greasy wool (MJ/day) was calculated by multiplying the greasy wool mass (g/day) by its energy content, which is defined by McDonald *et al.* (2002) to be 20.99 MJ/ kg greasy wool.

Carcass measurements

On the final day of the experiment, five lambs from each group randomly chosen were shorn and after 12 hours of fasting, their live body weight was recorded and then slaughtered for carcass data. Slaughtering procedures and recording data of carcass were followed as described in a previous study of Kewan (2013b). Eye muscle area was measured with a Planimeter in square centimeters and fat thickness was measured using calipers as described by USDA (1975). Dressing percentage was calculated by dividing the hot carcass weight by shorn final live weight and multiplying by 100. Carcass gain was calculated by deducting the initial carcass weight (at day zero) from the final hot carcass weight (at day 110).

Economic indicators

Net economic benefit (NEB) was calculated as described by (Xu *et al*., 2017).

$$\mathrm{NEB} = \frac{\text{Total live weight gain; kg} * \text{Unit price of live animals; LE/kg}}{\text{Period in days} * \text{DMI; kg/d} * \text{Unit price of diet; LE/kg}} - 1$$

Chemical analysis:

Feed and feces samples were dried at 60°C to a constant weight. The official methods of AOAC (2005) were used for proximate analysis of feeds, feces and refusal feed samples. Urine and clean wool samples were analyzed for N as described in AOAC (2005). Total Sulfur concentration was determined in the feeds, feces, urine and clean wool sample as described by Okalebo *et al.* (2002).

Rumen liquor samples were analyzed for total VFA according to AOAC (1997). Rumen NH_3-N was assessed calorimetrically using commercial chemical reagent kits (Bio-diagnostic product Kit, Egypt) with slight modification of diluting sample by 24 times with distilled water and subtracting the distilled water blank values.

Chemical components (moisture, protein, fat and ash) of the *Longissimus dorssi* samples was determined as described in a previous study of Kewan (2013b).

Statistical analysis:

The results of measured parameters were statistically analyzed with the GLM procedure of SAS (2004) and compared differences between means by *t*-test. The statistical model of the present study was as follows:

$$\mathbf{Yij = \mu + Ri + eij.}$$

Where: Yij: measured parameter; μ: overall mean; Ri: fixed factor effect (i = 1, 2); eij: residual error term. Significance was declared at *P* < 0.05 unless otherwise declared.

RESULTS AND DISCUSSION

Growth performance and efficiency of feed utilization:

Data of Table (2) illustrate the growth performance, feed intake and the utilization efficiency of energy and protein for gain of lambs in the experimental groups. Shearing increased (P<0.01) total weight gain and daily gain of lambs by 13.27 and 12.87%, respectively over that of the control lambs. This might because of an induced improvement in metabolic rate (Mclean *et al.*, 2015) and/or increase feed intake (Keady and Hanrahan, 2012). Bray (2002) found positive relationship (P< 0.001) between BW gain and feed consumed. This is in line with the results obtained by Herrig *et al.* (2006). Similar trend of improvement in body gain was obtained on shorn Awassi (Younis *et al.*, 1977) Ossimi (Marai *et al.*, 1987) male and female Ossimi lambs (Saddick and Abdel Rahman, 1992), male and female Suffolk cross Mule lambs (Salman and Owen, 1981), and two local Egyptian goat breeds (Abdel-Fattah, 2014). However, Shearing did not increase (P>0.05) lamb weight gain (Moslemipur and Golzar-Adabi, 2017), Valle del Belice pregnant ewes (Piccione *et al.*, 2010) and male of Abou-Delik sheep (Badawy *et al.*, 2008). Finally, Moslemipur and Golzar-Adabi (2017) concluded that shearing of housed Dalagh lambs during heat- stress periods could induce growth by reducing the energy loss of some physiological processes such as breathing activity.

Intake of CFM, roughage and their total increased (P<0.05) after shearing and improved by 5.93, 13.41 and 8.37% over the un-shorn group (Table 2). A higher level of feed intake achieved by shorn group was claimed to be more efficient in metabolic processes than control group. This observation is consistent with the previous studies (Masters and Ferguson, 2019). These results are mostly compatible with previous studies. A higher live body weight is linked to increased feed intake (Saddick and Abdel Rahman, 1992 and Mastersa and Ferguson, 2019). Removing the fleece leads to increased feed intake in order to meet the energy demands of additional heat production (Symonds *et al.*, 1988). In addition, (Manika, 1964) concluded that shearing improved the appetite of shorn animals and the digestible DMI during warm and cool seasons and led to a higher LBW gain, moreover, heat dissipation from the body surface increases and the core body temperature is therefore lowered. This phenomenon can be regarded as a heat stress defensive action (Marai *et al.*, 2007), while Siqueira *et al.* (1993) hypothesised an increase in feed consumption in shorn Merino could be a result of an increased energy demand linked to increased thermal stress caused by shearing. Nevertheless, certain studies have demonstrated that shearing in autumn and winter can increase feed consumption (Aleksiev, 2008), as well as in summer (Avondo *et al.*, 2000). However, Moslemipur and Golzar-Adabi (2017) found no impact on feed intake or weight gain during the study for lambs kept protected under conditions of heat stress.

Table 2. Growth performance, feed intake and efficiency utilization of energy and protein in growing Barki lambs

Item	Control (C)	Shorn (S)	SEM	P value
	Live body weight changes			
Initial live body weight, kg	23.32	23.05	0.36	0.619
Final live body weight, kg	42.09^b	44.31^a	0.42	0.021
Total weight gain, kg	18.77^b	21.26^a	0.35	0.008
Daily weight gain, g	171^b	193^a	3.21	0.008
	Feed intake on DM basis			
Concentrate, g/h/d	893^b	946^a	9.82	0.018
Roughage; RI, g/h/d	410^b	465^a	4.03	0.001
TDMI, g/h/d[1]	1302^b	1411^a	10.8	0.002
RI/ BW, %[2]	1.25^b	1.38^a	0.02	0.008
TDMI/ BW, %	3.98^b	4.19^a	0.02	0.001
RI/ TDMI, %	31.45^b	32.95^a	0.31	0.026
	Feed conversion ratio (FCR), g/g			
DMI/ BW gain	7.64	7.30	0.12	0.125
TDNI/ BW gain	5.10	5.08	0.08	0.895
DCPI/ BW gain	789	806	12.91	0.413
DMI/ Greasy wool	203^a	169^b	0.88	0.001
TDNI/ Greasy wool	135^a	118^b	0.58	0.001
DCPI/ Clean wool	40.83^a	28.63^b	0.48	0.001
	Efficiency utilization of energy			
Average BW, $Kg^{0.73}$	12.75	13.03	0.1	0.118
TDNI, g/d	866^b	985^a	7.52	0.001
TDN for maintenance[3]	459^b	469^a	2.93	0.114
TDN for gain	407^b	516^a	4.86	0.001
Efficiency, %	46.98^b	52.37^a	0.13	0.001
	Efficiency utilization of protein			
DCPI, g/day	135^b	156^a	1.05	0.001
DCP for maintenance[3]	27.93	28.54	0.22	0.120
DCP for gain	107^b	127^a	0.88	0.001
Efficiency, %	62.53^b	65.77^a	0.99	0.036

[1]TDMI: total dry matter intake; [2]RI/BW: roughage intake/ body weight; [3]Calculated for Barki sheep as 36 g TDN/$kg^{0.73}$ and 2.19 g DCP/$kg^{0.73}$ (Farid *et al.*, 1983).

[a,b] In the same row, means have different superscript small letters differ significantly at a level of P<0.05.

Shearing have no effects (P>0.05) on the indicators of feed conversion (g/g) to body gain; like DM, TDN and DCP (Table 2) due to increased DMI without appropriate increase in body weight gain. Similar results were obtained by Salman and Owen (1981) who found that shearing Suffolk cross Mule lambs increased significantly the DMI from 1516 to 1625 kg/d but decreased feed conversion ratio from 8.18 to 7.70 g DM/ g gain. Also, Lane and Kemp (1990) found poorer FCR in shearing lot-fed lambs in summer because of increased DMI without an increase in body weight gain. Conversely, Al-Jaryan (1991), Saddick and Abdel Rahman (1992) and Moslemipur and Golzar-Adabi (2017) showed an improvement in FCR by shearing fattening Awassi lambs, female Ossimi lambs and male fattening Dalagh lambs, respectively.

Efficiency of energy and protein utilization for gain showed significant differences between groups (Table 2).

The efficiency utilization of energy to body gain was 46.98 and 52.37% for control and shorn lamb groups, respectively, which represent enhancement by 11.47% because of shearing. In addition, efficiency utilization of DCP was higher in shorn (65.77%) compared with unshorn lambs (62.53) that revealed a 5.18% increment. The energy and protein efficiencies for growth in shorn group, might support the point that lambs after shearing have capacities to utilize by-passed energy or protein feed for growth purpose. In other word, it seems possible to state that dietary energy in the form of VFA is more utilizable for growth in S group than C group. Symonds *et al.* (1986) reported that shearing increased energy demand as demonstrated by increasing heat production by 28 % over than the unshorn animals. Shearing seems to lead to induce energy retention by reducing certain vital activities such as breathing and loss of heat leading to improved feeding efficiency, otherwise, decrease the excretion of blood metabolites via urine (Moslemipur and Golzar-Adabi, 2017).

Wool yield, gain, composition and relation to feed intake

Wool yield: Wool production per unit area is usually expressed in greasy wool area (GWA) or clean wool area (CWA). Both of them were found to be positively correlated to the total greasy fleece weight and were concluded to be taken as the most indicative criteria for the fleece weight in Barki sheep (El-Gabas, 1999). In addition, Sahoo and Soren (2011) concluded that, wool production depends on available nutrients like energy, protein, minerals and vitamins. Therefore, feed intake, wool growth can be stimulated by altering the protein balance relative to energy in the fermentative digestion products (Preston, 1995). Results in Table (3) show that shorn lamb group had significantly higher (P<0.05) net clean wool yield than control group. This finding might be due to higher feed intake, digestible dry matter intake and/or protein absorbed which was indicated by N retained (Kewan, 2013a). El-Gabas (1999) reported values of 0.067 and 0.032 g for GWA and CWA per unit of mid-side position in Barki ewes. Taha (2019) reported that clean wool production of shorn Barki ewes (613g) did not significantly differ from that of control group (555g), representing percentage of 43.04 *vs.* 37.89%, respectively.

Table 3. The effect of early-shearing on wool production, composition and feed conversion in growing Barki lambs

Item	Control (C)	Shorn (S)	SEM	P value
Clean wool production and growth rate				
Initial weight, g/h[1]	360	373	8.67	0.338
Net yield, g	381^{b}	610^{a}	6.61	0.001
Yield %	54.08^{b}	66.41^{a}	0.76	0.001
Growth rate, g/h/day	3.47^{b}	5.54^{a}	0.03	0.001
Clean wool composition				
Wool Sulfur				
Clean wool-S, %	3.43^{b}	3.84^{a}	0.08	0.019
Clean wool-S, mg/d	119^{b}	213^{a}	3.37	0.001
Wool Nitrogen				
Wool-N%	15.22	15.70	0.11	-
Clean wool-CP, %	95.1^{b}	98.1^{a}	0.33	0.003
Clean wool-CP, g/d	3.30^{b}	5.44^{a}	0.04	0.001
Sulfur and nitrogen ratios to each other				
Sulfur/nitrogen ratio	0.226^{b}	0.245^{a}	0.01	0.041
Nitrogen/Sulfur ratio	4.44	4.09	0.09	0.052
Wool Energy				
GWE, Kcal/d[2]	35.25^{b}	45.85^{a}	0.28	0.001
Feed conversion				
DMI/ Greasy wool, g/g	203^{a}	169^{b}	0.88	0.001
TDN/Greasy wool, g/g	135^{a}	118^{b}	0.58	0.001
DCP/Clean wool, g/g	40.83^{a}	28.63^{b}	0.48	0.001
Wool-CP/ DCPI, %	2.35^{b}	3.32^{a}	0.03	0.001

[1]determined based on patch sample from the mid side area (10 cm^2) as described by Kewan (2013a); [2]GEW: Greasy wool energy.
[a,b] In the same row, means have different superscript small letters differ significantly at a level of P<0.05.

Wool gain: The shorn group recorded higher growth rate of net clean wool (5.54g/d) compared to the control group (3.47g/d) as illustrated in Table (3). Bray (2002) found that wool growth rate was 16.3 *vs.* 23.4 g/d fed low (0.9 M; maintenance requirement level) and high level of intake (1.8M), respectively. Furthermore, Lee and Williams (1994) concluded that, clean wool growth per skin unit area was linearly related to N intake, but was not influenced by diet *per se*. Generally, growth depends on the composition and quantity of available nutrients under regulation by endocrinological controls and biochemical mechanisms. Pehlivan *et al*. (2020) found that metabolic hormones such as T4 and T3 concentrations in blood decreased because of increasing temperature, however, this decrease was higher in the unshorn control group, this attributed increase the metabolic rate in shorn animals (Squires, 2003 and Pehlivan *et al*., 2020). The rate of production in different tissue depends mainly on the competition or cooperation of nutrient between tisses and controlled by physiological, environmental and endocrine factors (Black and Reis, 1979). Hynd and Masters (2002) assumed that the digestible CP leaving the stomach (DPLS) is used for wool growth with efficiency of 11.6% and that wool growth is determined until the DPLS/MEI ratio exceeds 12 g per MJ. Du Plessis and De Wet (1981) reported that clean wool per day is in accordance with the genetic potential of sheep, where the Merino lambs produced considerably more clean wool per day than the Dohne Merino and the SAMM; the values were 8.66, 9.71 and 25 g/d for Dohne Marino, SAMM and Marino lambs, respectively. Reis (2012) added that growth of wool could vary due to changes in nutrient supply and can double to four-fold. The main nutrient limitation to wool growth is the amount and composition of amino acids (particularly the S-containing amino acids) that available to wool follicles. Maximum wool growth can be achieved on maintenance intakes of energy with 150 g of amino acids given as casein via the abomasum (ideal protein available) for intestinal digestion. In the same direction, Hynd and Masters (2002) reported highly positive relationship between feed intake (e.g. dry matter, digestible dry matter, and digestible organic matter) and growth rate of wool.

Wool composition: for maximum wool growth, animals require optimal amount of S-amino acids and other amino acids plus energy and minerals in their diets (Qi *et al.* 1994). Clean wool in shorn group had higher (P<0.05) sulfur content (3.84%) than in control group (3.43%) as shown in Table (3). These results are mostly consistent with previous study for Barki lambs (Kewan 2013a) which ranged between 3.23 and 3.37%. However, it was higher than the range recorded for non-pregnant Romney ewes; 2.73-3.26% (Barry and Andrews, 1973) and lactating Naeini ewes; 2.08-2.56% in (Nezamidoust *et al.*, 2014). However, Bray (2002) found that wool sulfur concentration increased (P< 0.01) by increasing sulfur in diet. Wool N concentration was not affected (P>0.05) by shearing and the values were 15.22 and 15.70 for control and shorn groups, respectively (Table 3). Masters *et al.* (2000) reported that, shorn lambs showed higher wool CP content and necessarily had higher fractional protein synthesis in the skin (%/d) and absolute protein synthesis in the skin (g/100cm^2).

The S/N ratio: It represents the animal efficiency of utilizing dietary sulfur for wool synthesis with the allowed quantity of nitrogen. The values in Table (3) show that, shearing process caused a slight increase (P<0.05) of S/N ratio for shorn group than control group. The optimal range of S/N ratio in diets for ruminants is from 1:10 to 1:15 (Osman and El-Husseiny, 1978). The present study was 1: 3.66 for both two groups. Kewan (2013a) reported a range of S and N in wool of Barki lambs fed agro-industrial by-products to be 3.23-3.37 and 10.7-11.53% respectively with S/N ratio 0.29-0.31. Shearing did not affect the N/S ratio in clean wool being values 4.44 and 4.09 for control *vs.* shorn group as shown in Table (3). The ARC (1980), proposed that the dietary N/S ratio should not exceed 14: 1. The NRC (1985) suggested that, dietary DM should contain 0.14 - 0.18% S for adult sheep, 0.18 - 0.26% S for growing sheep, and the N/S ratio should not exceed 10: 1. Additionally, (Qi *et al*. 1994) recommended that the dietary DM should contain a minimum of 0.30% sulfur (N/S maximum of 5 to 6: 1) for wool-type adult sheep; a minimum of 0.25% sulfur (N/S maximum of 6 to 7: 1) for meat-type adult sheep; and a minimum of 0.24 to 0.31 % sulfur (N/S maximum of 8 to 9: 1) for growing sheep. The demand N/ S ratio is higher for growing than for adult sheep, this is not because growing sheep need fewer grams of S, but because they require more N. The N/ S ratio of the majority of feed ingredients was above 10: 1. The sulfur content of protein varies from 0.3 to 1.6% (Church, 1979) causing the N/S ratio to be ranged between 53: 1 and 10: 1, with average vale 16: 1. Qi *et al*. (1994) concluded that, most protein sources have an N/S ratio above 20: 1. Such feeds, when supplemented to satisfy N requirements of animals, it may not correct a deficiency of sulfur, especially for the ruminants that required higher S supplement. Nevertheless, wool production will be enhanced by increasing supply of sulfur for ruminal microbes or ruminal escape S-containing amino acids from such protein supplements.

Feed conversion to wool: The control group showed better-feed conversion to wool (P<0.05) as compared with a shorn group (Table 3). A summary from numerous studies (Sahoo and Soren, 2011) suggests that every 100 g of digestible DM consumed, about 2 g of wool is produced. This value is low as it is associated with net efficiency and is confounded with maintenance costs. Graham and Searle (1982) reported the efficiencies of ME for wool production is from 16 to 19%. Shelton (1998) used these values and suggested that the amount of good quality feed (50% TDN) required to produce 453.6 g of wool is about 11.3 to 13.6 kg. For most of diets consumed by grazing sheep (6-11 MJ/kg DM), at a rates of 800-1500 g DM / day, wool growth rate will be limited by the supply of protein to the intestines. In summary, increasing conversion efficiency of feed into wool is not the result of increasing energy or protein digestibility; it is due to an increase in efficiency of use of absorbed nutrients (Masters and Ferguson, 2019).

Digestibility of nutrients and rumen fermentation parameters

The digestibility of nutrients as affected by shearing in Barki lambs is shown in Table (4). Nutrients digestibilities were generally improved (P<0.05) in shorn group, however, insignificance was observed for CF and EE digestibility values. There is a lack of studies concerning the effects of shearing on the digestibility of diet ingested. The highest digestibility CP and NFE that observed in shorn group (Table 4) could be an indicator of high demand of protein and NFE for body and wool growth (Ryder and Stephenson, 1968), as well as increasing the microbial biomass and therefore to increase the production of protein within the population (Hassaan *et al.*, 2015). In this concern, Sahoo and Soren (2011) concluded that proper growth of wool requires all the important nutrients such as carbohydrates, amino acids, minerals and vitamins. The present results were in harmony with the findings of Sahoo and Soren (2011) who reported that high wool growth is associated with high feed intake and both amounts and composition of protein available for absorption in the intestine. Furthermore, shearing reduces the increased intake of water due to the heat stress, so that the digesta passage rate can be reduced and feed digestibility improves (Silanikove, 1992 and Marai *et al.,* 2007). Alqaisi *et al.* (2020) concluded that shearing had a significant effect (P < 0.01) on total DMI, OMI and DOMI, however, intakes of ADF and NDF were not significantly(P > 0.05) affected. Sulfur containing amino acids from bacterial proteins or those infused into the abomasum stimulate the anabolism of animals, which is observed by weight gain (Sahoo and Soren, 2011).

Another study of Chokla rams, showed an increase in the digestibility of nutrients, immune status of animals and higher wool production with sulfur supplementation of 0.3% in the concentrate diet that contained 19.6% CP. (Sahoo and Soren, 2011). The N/S ration revealed by ingesting the diet was 9.14 (31.18/3.4) and 9.17 (33.02/3.6) for control and shorn group. Krasicka *et al.* (1999) reported that the narrow N/S ratio (4.4) decreased the apparent crude fiber digestibility, however, Morrison *et al.* (1994) and Qi *et al.* (1994) observed that the range 16:1 to 4:1 of N/S ratio did not change the in vivo OM digestibility, but increased the rumen DM degradability. This was not the case in experiment of Krasicka *et al.* (1999). The apparent digestibility of DM, OM and CP was higher in the balance trial but it decreased with progressing time. This phenomenon was associated with the high starch diet that was also observed by Taniguchi *et al.* (1986). Alqaisi *et al.* (2020) reported that shearing had a significant effect (P < 0.01) on total DMI, OMI and DOMI, while a greater significant effect (P < 0.001) was observed on MEI and CPI. Furthermore, shearing had a non-significant effect (P > 0.05) on intakes of ADF and NDF, concentrate OM and DOM, where intakes of OM and DOM in shorn animals were 10% higher than in control animals. Furthermore, intakes of dietary ME, and CP were 10% and 13% greater in shorn animals compared with control animals. Shearing had no significant effect on water intake, and although non-significant, intakes of concentrate OM and DOM were 3% and 9% greater in shorn animals than in control animals. Furthermore, roughage OM and DOM intakes were 9% and 12% greater in shorn animals compared with control animals.

The impact was more obvious with the shearing treatment on both TDN and DCP% comparing with the control (Table 4). Shearing raised the nutritive value of diet from 66.49 to 69.78% as TDN and from 10.33 to 11.03% as DCP, with relative improvement 4.95 and 6.78%, respectively. Shearing normally improves energy exchange between the animal and its surrounding environment (Dikmen *et al.,* 2011 and Alqaisi *et al.,* 2020); the same effect could also result in case of increasing OMI (Revell *et al.,* 2000 and Kenyon *et al.,* 2005) and consequently the OM digestibility in shorn animals. High feed intake revealed by the shorn group could be the reason for enhancing the digestibility of nutrients and the nutritive values. These observations are in accordance with that reported by Masters and Ferguson (2019) who showed that wethers that highly produce clean fleece weight were energetically less efficient at 0.8M (maintenance level) and more efficient at 1.8M.

Table 4. Effect of early-shearing on digestibility of nutrients and rumen fermentation in Barki lambs

Item	Control (C)	Shorn (S)	SEM	P value
Nutrients digestibility, %				
DM	71.80[b]	74.59[a]	0.85	0.048
OM	73.1[b]	76.75[a]	0.69	0.041
CP	76.54[b]	81.69[a]	0.37	0.022
CF	73.12	78.71	1.61	0.070
EE	83.29	86.77	1.52	0.182
NFE	71.67[b]	73.98[a]	0.77	0.039
Nutritive values, %				
TDN	66.49[b]	69.78[a]	0.71	0.043
DCP	10.33[b]	11.03a	0.13	0.019
Rumen fermentation				
pH				
0h	6.62[b]	7.13[a]	0.07	0.001
3h	6.60[b]	6.72[a]	0.03	0.016
6h	6.80	6.82	0.06	0.090
Overall mean	6.67[b]	6.88[a]	-	-
±SE	0.03	0.04	-	-
VFA, m.eq/dl				
0h	6.81[b]	7.57[a]	0.11	0.001
3h	11.31	11.33	0.09	0.948
6h	12.26[b]	14.19[a]	0.09	0.049
Overall mean	10.13	10.70	-	-
±SE	0.48	0.47	-	-
NH_3-N, mg/dl				
0h	16.42[b]	18.29[a]	0.57	0.034
3h	26.97	29.58	0.93	0.064
6h	30.48[b]	33.57[a]	0.82	0.017
Overall mean	24.62	27.15	-	-
±SE	1.22	1.37	-	-

[a,b] In the same row, means have different superscript small letters differ significantly at a level of P<0.05.

The rumen fermentation parameters in shorn versus un-shorn Barki lambs are shown in Table (4). The rumen pH, VFA and NH_3-N were significantly different between shorn and un-shorn groups. Shorn group showed higher values at 0, 3 and 6h post-feeding. It can be observed that rumen pH maintained within a physiological range of about 5.5 to 7.0 determined by Wang *et al.* (2016), which assures efficient rumen fermentation. The recorded values of pH is a main index reflecting ruminal fermentation process and producing total acids end product by rumen bacteria (Phillip *et al.,* 2014). The recorded values of VFA is somewhat reflecting the index about the digestibility of DM, the rate of absorption, rumen pH, digesta passage flow rate and microbial population in the rumen and their activities (Kewan *et al.,* 2017). Furthermore, the fluctuation in fermentation parameters revealed in this study with processing time reflects the feeding behavior, microbial protein synthesis and flow rate at the same time. Although there is a lack of studies concerning the effects of shearing on the rumen fermentation parameters, shearing may have an effect on rumen fermentation through increasing the feed intake and promoting the rumen micro-organisms to produce more sulfur containing microbial protein to attain the sulfur-amino acids required for growing wool. These results are mostly consistent with the previous study of Sahoo and Soren (2011) who confirmed these observations, where they found that microbial protein synthesis in the rumen and its availability for digestion and absorption in the intestine is more associated with the intake of digestible energy (DEI) by the animal than to the protein content of the diet. Although wool growth increased with increasing digestible organic matter intake, its affect is consistent with its probable effect on microbial protein synthesis in the rumen. (Yadav and Yadav,1988). Kewan *et al.* (2017) found that increased ruminal NH_3-N concentration might be due to higher N intake and higher CP digestibility, these findings agree well with the present results. Other investigators attributed the increase in NH_3-N concentration in the rumen to a decrease in the efficiency of microbial protein synthesis or to the reduction of NH_3-N absorption by rumen epithelium (Ikwuegbu and Sutton, 1982). In addition, (Sahoo and Soren, 2011) reported that the apparent response in wool growth to an increase in OM or energy intake is to the increased supply of microbial amino acids reaching the intestine. If the supply of ATP, N and sulfur in the rumen is non-limiting, microbial outflow from the rumen will provide about 6.6 g DCP/MJ ME. Thus, microbial protein would provide 0.2 g sulfur amino acids/MJ ME. In the absence of unfermented or escape dietary protein, it appears that the supply of sulfur-amino acids from microbial protein is the primary factor limiting wool growth. The large amounts of feed needed to provide the amino acids for maximum wool growth also provide energy and other nutrients well above maintenance, which might be used for other functions (Hogan *et al.*, 1979). On the other hand, Masters and Ferguson (2019) wondered, if improving the feed conversion efficiency to wool is simply a result of improved digestibility of feed or increased production of microbial protein, then there would be an increased supply of ME and DCP leaving the stomach and an overall increase in available nutrients for growth and production. But the published evidence indicates this is not the case with apparent energy and N digestibility, VFA and NH_3-N concentrations and digesta kinetics remaining unchanged across genotypes differing in wool production. High sulfur ingested may increase VFA concentration in rumen liquor (Table 4), this is in line with the conclusion of Krasicka *et al.* (1999) who found that supplementation of sulfur in low fiber diet increased the acetic acid concentration at the expense of other VFA in the rumen fluid.

Nitrogen metabolism

Table (5) illustrates the data of N metabolism in growing Baki lambs as affected by early shearing. In general view, the shorn group revealed higher (P<0.05) intake and digestion of N than control group. These emphasize that shearing had effective role on N intake and that utilized by micro-organisms in the rumen. The total output N was almost similar between the two groups, notwithstanding, the shorn group achieved higher N retained (NR) being values were 9.36 *vs.* 7.64 g/d for shorn *vs*. control groups, respectively (Table 5). These findings are consistent with higher body and wool daily gains observed in shorn group compared with control group. Shearing consequently increased (P<0.05) feed intake, which significantly affects the retained N and the apparent digestion, this supported by the findings of Bray (2002) who reported that nutrition is the determining factor for N utilization. The shorn lambs retained more N, reflecting a greater amount of N intake and that shared for body protein synthesis (Oddy *et al.*, 1989b). As feed intake increased by lambs, body protein gained at a faster rate due to the reduction of protein degradation in the hind limb (Oddy *et al.*, 1989a). When sheep consumed more feed, more nitrogen was digested and retained so the high proportion of retained N was partitioned to body growth instead of wool growth (Bray, 2002). On the other hand, Sahoo and Soren (2011) reported that higher inorganic Sulfur supplementation could increase nitrogen retained in lambs. Overall, the shorn lambs were claimed to be metabolically more efficient for N utilization. The highest N utilization after shearing could be due to one or more of the following reasons: 1) increased N intake and that partitioned in body protein synthesis (Oddy *et al.*, 1989b), 2) gained body protein at a faster rate due to reduction of protein degradation in the hind limb (Oddy *et al.*, 1989a), and 3) that higher ingested inorganic Sulfur could increase the N retained in lambs (Sahoo and Soren,2011).

The wool N as percentage of N retention was 6.94 and 9.34% for control and shorn groups, respectively (Table 5). These findings were close to that reported for Dohne Marino, SAMM breeds that was 6.50 and 7.3%, respectively however, it was lower than value of 20.1% that cited for Marino lambs (Du Plessis *et al.* ,1981). In addition, Bray (2002) found that when sheep in a high level of intake, only 20% of the N retained was used in the growth of wool and 80% in other body parts. These emphasize that the present results of retained N for wool growth in the local breed (Barki) were highly less than those reported for the fine wool-produced breed (Marino). Furthermore, a greater proportion of the retained N is directed to body growth rather than wool growth, which is in agreement with Bray (2002) conclusion.

Table 5. Effect of early-shearing on nitrogen metabolism in growing Barki lambs

Item	Control (C)	Shorn (S)	SEM	P value
Total-N intake (TNI), g/d	31.18^b	33.02^a	0.49	0.031
Feces-N, g/d	7.32	6.04	0.35	0.059
Feces-N/ TNI%	23.46^a	18.31^b	0.99	0.022
Digested-N (DN), g/d	23.87^b	26.98^a	0.68	0.031
DN/ TNI, %	76.54^b	81.69^a	0.98	0.022
Urine-N, g/d	16.23	17.62	0.76	0.264
Urine-N/ TNI%	51.95	53.38	4.36	0.499
Total-N output, g/d	23.55	23.66	0.91	0.932
Total-N output/ TNI%	75.41	71.68	1.53	0.159
N-retained (NR), g/d	7.64^b	9.36^a	0.41	0.042
NR/ TNI, %	24.59	28.32	1.53	0.159
NR/ DN, %	32.13	34.64	1.81	0.381
Wool-N, g/d	0.53^b	0.87^a	0.02	0.001
N for body gain (BG), g	7.11^b	8.49^a	0.41	0.047
Wool-N/ NR%	6.94^b	9.34^a	0.41	0.014
N for BG/ NR%	93.06^a	90.66^b	0.41	0.014
N for BG: Wool-N ratio	13.48^a	9.75^b	0.60	0.012

[a,b] In the same row, means have different superscript small letters differ significantly at a level of P<0.05.

The N directed to body gain is folded by 13.48 and 9.75 times that for wool growth in control and shorn groups, respectively (Table 5). These observations were in accordance with that reported by Oddy *et al*., (1989b) who concluded that, reduced wool growth efficiency is associated with an increase in body protein deposition of and consequent reduction in N used for synthesis of wool protein. In addition, partitioning of nutrients for growth of the body tissue, such as wool and muscle, involves complex physiological and metabolic events (Bray, 2002).

Sulfur metabolism

Sulfur is an essential element for synthesis of the sulfur amino acids that required for synthesis of tissue protein, sulfur-containing metabolites and for the normal growth of rumen bacteria that may improve fiber and OM digestibility (Durand and Komisarczuk, 1988; Slyter *et al.*, 1988; Qi *et al.*, 1994 and Krasicka *et al.*, 1999). According to NRC (1985), sulfur should be in the range of 0.1 - 0.3% (on a DM basis) of the ruminant diets and this is why sulfur is often added to ruminant diets, especially those enriched with non-protein nitrogen. Moreover, Alves de Oliveira *et al.* (1996) stated that the rumen ecosystem could resistant high sulfur levels in diets. The effect of dietary sulfur supplement on feed intake, body weight gain, and nutrients digestibilities was early studied in sheep by Slyter *et al.* (1988); Yada and Mandokhot (1980) and Fleck and Shurson (1992). In the present study, CFM and clover hay sustained higher Sulfur level (3.4 *vs.* 3.6 g/h/day) for the experimental growing Barki lambs (Table 6) than the requirement range recommended by NRC (1985). Kewan (2013a) recorded the value of 58.85% as an apparent absorption coefficient for sulfur in growing Barki lambs received CFM plus clover hay, which is lower than the present values (64.30 *vs.* 67.13%) revealed by the control and shorn groups. However, the present data are in accordance with that (64.7%) reported on lambs fed herbage (Powell *et al.*, 1978) and may be attributed to higher inorganic sulfur content that was well absorbed (Krasicka *et al.*, 1999). The amount of sulfur retained was mostly consistent with wool and body gains, where increasing retention by increasing requirements, which was observed in shorn group in the present study (Table 6). The significance positive nitrogen and sulfur retention indicates high correlation between them under the condition of the present experiment.

Silva *et al.* (2014) reported that the presence of sulfur in sheep diet affect directly on feed intake because the synthesis of sulfur-containing amino acids (S-AA) is essential for the maximum microbial growth in the rumen and consequently, DM digestibility. They added that, the N/S ratio in the rumen microbial proteins is 14.5:1, and a sulfur deficiency in sheep diet causes low microbial fermentation and reduces the utilization of lactate by the rumen bacteria, resulting in its accumulation. Consequently, digestion of cellulose is significantly decreased, probably because the microbial growth is reduced. sulfur thus improves the microbial digestion of cellulose and thus contributes to amino acid synthesis in particular methionine and cysteine. Many species of the rumen bacteria need sulfur which can be obtained by several ways (Silva *et al.*, 2014). Some microorganisms are able to convert inorganic sulfur sources into sulfide and incorporating this compound to the amino acids, while others use organic sulfur only (Durand and Komisarczuk, 1988). In an earlier study by Kennedy and Milligan (1978), about 50% of the bacterial organic sulfur in sheep was obtained from sulfate. Sulfur supplements in ruminant diets are complemented by sulfur recycled via saliva, in a mixture of sulfur element that includes organic and inorganic forms (Bird, 1974). Abou-Hussein *et al.* (1977) mentioned that sulfur addition caused a significant increase in the retention of N and sulfur and an increase in wool growth.

Table 6. Effect of early shearing on Sulfur metabolism in growing Barki lambs

Item	Control (C)	Shorn (S)	SEM	P value
Feed-S intake, FSI, g/d	3.40	3.60	0.06	0.113
Fecal-S, g/d	2.21[a]	1.18[b]	0.01	0.019
AA, %[1]	64.30[b]	67.13[a]	0.66	0.038
Urine-S, g/d	1.96	2.09	0.05	0.227
Total-S out, g/d	3.17	3.27	0.07	0.347
Retained-S (RS), g/d	0.23[b]	0.33[a]	0.02	0.002
RS/ FSI, %	6.63[b]	9.13[a]	0.56	0.004
RS/ AS, %[2]	10.32[b]	13.61[a]	0.48	0.009
S-AMBT , mg/d[3]	2.95	2.94	0.07	0.926
Wool-S, %	3.43[b]	3.84[a]	0.07	0.017
Wool-S, g/d	0.119[b]	0.213[a]	0.01	0.001
Body-S, g/d	0.107[b]	0.115[a]	0.01	0.013
Wool-S/ RS, %	53.23[b]	64.91[a]	3.19	0.046
Body-S/ RS, %	46.77[b]	35.09[a]	3.19	0.046

[1]Apparent absorption or Sulfur availability = intake - fecal output x 100/ intake (Reid 1980); [2]AS: Absorbed-S; [3]S-AMBT: Sulfur-apparently mobilized from body tissue = total output – retained.
[a,b] In the same row, means have different superscript small letters differ significantly at a level of P<0.05.

Water utilization

The data of Table (7) illustrates the results of water utilization and efficiency as influenced by shearing the growing Barki lambs. Free water intake was lower in shorn group (120g/ $kg^{0.82}$) compared to control one (142 g/ $kg^{0.82}$). The same trend was observed by Al-Ramamneh *et al.* (2011) who reported that water intake was 2.9 and 2.5 L/d for control *vs.* shearing mutton sheep due to higher evaporative cooling, in contrast, DMI relative to metabolic BW was lower in control than shorn group. Despite shearing having statistically significant effects on feed, metabolic and free water intake (expressed as g/$kg^{0.82}$), the total water output was insignificant (Table 7).

Our results indicated that shorn lambs ingested significantly 15.5% less water than the control lambs, and this can be attributed to the remarkable water economy of the first one. This is in agreement with the results presented by Al-Ramamneh *et al.* (2011) who reported that shearing increased the turnover of water and the control sheep consumed water by 25% over than shorn animals. In this concern, early study conducted by Dikmen *et al.* (2011) revealed that the shorn lambs could maintain their body temperature below the control lambs during hot conditions. However, Ternouth and Beattie (1970) attributed this observation to shift water to increase the cooling system via the extra cellular fluid more than to evaporative cooling system via respiration. Furthermore, shearing reduces the increased intake of water that induced by the thermal stress, this may decrease the digest passage rate and leading to enhance the digestibility (Silanikove, 1992 and Marai *et al.*, 2007). Contrary to current figures, Alqaisi *et al.* (2020) found shearing had no significant effect on any measured water intake criteria because of the short experimental periods or the small difference of DMI (6 g/kg $BW^{0.75}$) that found between shorn and control animals, but when water intake was expressed in L/kg $BW^{0.75}$, the value was slightly higher in the shorn animals.

Efficiency of water utilization expressed as free water intake for either kg DM ingested or producing one ton of live weight gain showed that shorn lambs were more (P<0.05) economy efficient in utilizing water than the control group (Table 7). These findings were confirmed by the early study of Al-Ramamneh *et al.* (2011) who found that the ratio of water intake to DMI was 2.6 and 2.8 for control vs. shearing mutton sheep received 1.10 vs. 1.0 kg DM/d, respectively.

Table 7. Effect of early shearing on water metabolism in growing Barki lambs

Item	Control (C)	Shorn (S)	SEM	P value
MBW[1], kg $^{0.82}$	19.65	19.30	0.33	0.486
Water utilization (g/kg$^{0.82}$):				
Free water intake FWI	142[a]	120[b]	1.84	0.001
Feed combined water	7.77[b]	8.53[a]	0.19	0.049
Metabolic water	29.31[b]	33.17[a]	0.70	0.018
Total water intake TWI	179[a]	162[b]	1.47	0.001
Fecal water	20.32[b]	26.03[a]	1.17	0.026
Fecal water/ TWI, %	11.45[b]	16.15[a]	0.64	0.007
Urine water	30.97[a]	27.76[b]	0.42	0.006
Urine water/ TWI, %	17.26	17.23	0.26	0.939
Total water output TWO	51.19	53.87	1.05	0.146
TWO/TWI, %	28.63[b]	33.33[a]	0.46	0.002
IWL[2]	128[a]	108[b]	1.03	0.001
IWL/TWI, %	71.37[a]	66.67[b]	0.46	0.002
Efficiency of water utilization:				
FWI /DMI, L/kg	1.93[a]	1.51[b]	0.04	0.002
FWI/ weight gain, m^3/Ton	13.92[a]	9.84[b]	0.33	0.010

[1]MBW: Metabolic body weight. [2]IWL: Insensible water loss.
[a,b] In the same row, means have different superscript small letters differ significantly at a level of P<0.05.

Carcass data

Data presented in Table (8) show that, some carcass traits were affected by shearing process. Animals in shorn group expressed slightly heavier (P<0.05) fasted weight (FW), empty weight (EW) and hot carcass weight (HCW) as compared to un-shorn animals. However, no differences (P>0.05) were detected between the experimental groups regarding the high price cuts as a percentage of HCW, the external (% of FW) or internal (% EW) offal and total carcass fat (% HCW) (Table 8).

Table 8. Carcass data of shorn lambs versus control one

Item	Control (C)	Shorn (S)	SEM	P value
FW, kg[1]	42.09[b]	44.31[a]	0.48	0.001
	Carcass weight			
Empty weight; EW, kg	31.48[b]	33.49[a]	0.66	0.008
HCW, kg[2]	17.23[b]	20.70[a]	0.32	0.002
	Sale cuts, % of hot carcass			
Neck	4.56	4.00	0.79	0.448
Shoulders	19.51	19.03	0.56	0.224
Round	33.24	34.37	1.62	0.956
Rack	29.67	30.1	1.17	0.899
Loin	6.12	7.12	0.29	0.118
Brisket	3.19	2.74	0.3	0.910
Flank	2.75	2.10	0.22	0.913
	Offal and fat percentages			
External offal/ FW, %[3]	18.13	17.82	0.97	0.521
Internal offal/ EW, %[4]	6.40	6.38	0.31	0.385
Carcass fat/ HCW, %[5]	5.09	5.21	0.65	0.612
	Physical parameters of eye muscle			
Fat thickness, mm	2.46	2.15	0.43	0.628
Area, square cm	22.31[b]	30.82[b]	1.62	0.02
Meat,%	69.60	70.20	3.407	0.921
Fat, %	10.2	9.75	1.37	0.172
Bone, %	20.48	20.05	1.72	0.554
	Chemical composition of eye muscle			
Moisture%	68.47[a]	66.47[b]	0.23	0.003
CP%	20.97[b]	23.66[a]	0.38	0.008
EE%	8.71	8.75	0.25	0.584
Ash%	1.14	1.02	0.08	0.392

[1]FW: Fasting weight of lambs that were shorn before slaughtered; [2]HCW: Hot carcass weight without offal; [3]External offal = head+ feet+ pelt; [4]Internal offal = liver +heart + spleen + kidneys + testis; [5]Carcass fat = omental fat + kidney fat + tail.
[a,b] In the same row, means have different superscript small letters differ significantly at a level of P<0.05.

Physical parameters of eye muscle were not significantly different except for the area in cm^2 which was high in shorn group than control one.

Furthermore, the chemical composition of eye muscle showed superiority (P<0.05) for shorn group in CP content but lower in moisture content comparing with control group. On the other hand both EE and ash% were not affected (P>0.05) by shearing the lambs. The same trend was observed by Marai *et al.* (1987) on shorn Ossimi lambs. However, in contrast Al-Jaryan (1991) found that shearing had no effect on slaughtering parameters on Awassi lambs. Also, Mclean *et al.* 2015) detected no significant effects for winter shearing on hot carcass weight (HCW), meat yield or proportion slaughtered. The lack of significant differences between groups is due to the highly differences among lambs within the same group. Li *et al.* (2007) found the Merino wethers that high producing clean fleece with high level feeding, grew faster and had greater fat depth of eye muscle.

Carcass evaluation

Despite achieving high rate (P<0.05) of carcass gain by shorn group, the dressing percentage or coefficient of meat were insignificant (Table 9). Shearing did not affect (P<0.05) dressing percentage (Table 9). The present values of dressing percentage were lower than that reported by Abdel – Moneim (2009) for Barki lambs weighted 25.8 kg, which was 53.3%. Salman and Owen (1981) found that shearing Suffolk cross Mule lambs increased dressing percentage (CCW/FW %) from 42.7 to 43.8% but with no significant differences Furthermore, Hassan *et al.* (2016) found that shorn Awassi lambs had higher (P< 0.05) dressing percentage compared to unshorn lambs In addition, Cam *et al.* (2007) who found that winter shearing increased hot carcass yield and dressing percentage. Keady and Hanrahan (2007) and Keady *et al.* (2009) concluded that shearing male lambs in winter could have a beneficial effect on daily weight gain and dressing percentage without affecting performance. Furthermore, Hassan *et al.*(2016) found that shorn Awassi lambs had higher (P< 0.05) dressing percentage compared to unshorn lambs. In addition, Cam *et al.* (2007) found that winter shearing increased hot carcass yield and dressing percentage. Keady and Hanrahan (2007) and Keady *et al.* (2009) concluded that shearing male lambs in winter could have a beneficial effect on daily weight gain and dressing percentage without affecting performance.

Live body constituents; i.e. water, fat, protein and ash determined as the difference between the final and beginning carcass of experiment were also shown in Table (9). The gain of live body composition (CP) that based on the initial carcass composition was superior for shorn group comparing with control group. However, EE and ash were not significantly affected by shearing process on growing lambs. The retained energy (NEg) for shorn group was biologically higher by 24.3% based on the control group. These findings were early confirmed by Minson and Ternouth (1971) who found that shearing increased the energy requirements of sheep. Furthermore, Alqaisi *et al.* (2020) reported that, intakes of dietary CP and ME were 13% and 10% higher in shorn animals compared with control animals. On the other hand, El-Badwy and Gado (1996) concluded that body composition is more affected by the dietary regimen and always with the limitation of voluntary intake.

Table 9. Carcass evaluation for early shorn Barki lambs versus control one

Item	C	S	SEM	P value
Carcass values indicators				
Rate of carcass gain, g/d[1]	64.8[b]	92.43[a]	2.91	0.002
Dressing, %[2]	40.93	45.70	0.64	0.121
Dressing, %[3]	54.73	60.45	0.59	0.165
Coefficient of meat[4]	3.95	3.99	0.22	0.686
Gain of live body composition[5]				
Water gain, kg	51.93[a]	50.18[b]	0.36	0.026
CP gain, kg	3.66[b]	5.35[a]	0.258	0.010
EE gain, kg	2.33	2.52	0.11	0.294
Ash gain, kg	0.21	0.19	0.03	0.703
NEg, Mcal[6]	42.99[b]	54.43[a]	1.32	0.003

[1]Calculated based on the carcass weight for initial carcass that was 10.10kg; [2]Dressing % based on FBW = HCW/FW%; [3]Dressing % based on EBW = HCW/EW%; [4]Coefficient of meat = (meat + fat) / bone. [5]Calculated as the difference between the final and initial carcass composition; [6]Net energy for gain where each g of fat and protein is equivalent to 9.5 and 5.7 Kcal, respectively.
[a,b] In the same row, means have different superscript small letters differ significantly at a level of P<0.05.

Economic indicators

Shorn group showed higher revenue as compared to the other control group (Table 10). Shearing has positive financial gain expressed as revenue based on either body weight gain or carcass weight being improvement percent was 19.0 and 22.2%, respectively.

Table 10. Calculated economic indicators* for shorn versus un-shorn growing Baki lambs.

Item	C	S	Improvement, %
Economic indicators based on animal live weight:			
Shearing cost, LE/head	0	10	-
Price of wool, LE	0	Neglected	-
Cost of concentrate intake, LE/110d	605	643	6.3
cost of roughage intake, LE/110d	152	173	13.7
Total feeding cost, LE/110d	757	795	5.0
Total variable cost, LE	757	815	7.7
Selling price of net gain, LE	1314	1488	13.3
Revenue, LE/h/110d	557	663	19.0
Net economic benefit	0.74	0.87	18.5
Economic indicators based on empty carcass weight:			
Initial empty carcass weight, kg	18.69	18.69	-
Final empty carcass weight, kg	31.48	33.49	6.4
Net gain of empty carcass weight, kg	12.79	14.8	15.7
Price of net gain of empty carcass weight, LE	1535	1776	15.7
Revenue, LE/h/110d	778	951	22.2

***Calculated based on the prices of 2021. Unit price of concentrate and roughage are 5.6 and 3.0 LE/kg, respectively; Market unit price of live animals and carcass are 70 and 120 LE/kg, respectively.**

Salman and Owen (1981) found a small marginal profit (£0.57) per shorn Suffolk cross Mule lamb fed *ad lib.* Lucerne, so that, shearing in autumn is financially worthwhile. Mclean *et al*. (2015) indicated that while shearing improved lamb growth rates, there was no economic benefit associated with lamb carcass weight or time to slaughter.

CONCLUSIONS

This study adds to our knowledge of the nutritional characteristics of growing Barki lambs, and their responses to the shearing. Early shearing has provided clear evidence that enhancement of feed intake, daily lamb growth; metabolism of nitrogen, sulfur and water as well as economy efficient in utilizing water and higher carcass mass can occur. Accordingly, a high financial profit is gained from the final marketing live weight or carcass mass.

As a general conclusion, early shearing is recommended for Barki lambs just after weaning or before starting the fattening process.

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تأثير الجز المبكر على التمثيل الغذائي وكفاءة النمو وصفات الذبيحة في الحملان البرقي

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أجريت هذه الدراسة لمعرفة تأثير الجز المبكر للحملان البرقي على كفاءة النمو والتمثيل الغذائي وصفات الذبيحة. تم تقسيم ثمانية عشر حمل برقي (متوسط وزن 23.18 ± 0.69 كجم) إلى مجموعتين (9 في كل مجموعة). تركت إحدى المجموعتين دون جز واعتبرت كمجموعة مقارنة (م1) بينما تم جز المجموعة الأخرى بالكامل (م2) وتم إيواء المجموعتين في حظائر مظللة. تم تغذية جميع الحيوانات على مخلوط علف مركز لتغطية احتياجاتهم الحافظة مع تقديم دريس البرسيم حتى الشبع لتغطية متطلبات النمو لمدة 110 يوم. اظهرت النتائج ما يلي: ان المأكول الكلي زاد معنويا (مستوى 5%) بعد الجز وتحسن بنسبة 8.37٪ في المجموعة م2 عن مجموعة المقارنة. أدى الجز الى زيادة معنوية (مستوى 1%) في معدل النمو اليومي للحملان بنسبة 12.87٪ عن المجموعة المقارنة، ومع ذلك لم يؤثر الجز معنويا (مستوى 5%) على مؤشرات كفاءة تحويل العلف. سجلت مجموعة المعاملة (م2) أعلى قيمة (مستوى 0.1%) لمعدل نمو الصوف النظيف (5.54 جم / يوم) عن مجموعة المقارنة (3.47 جم / يوم). تحسن هضم العناصر الغذائية بشكل عام (مستوى 5%) في المجموعة المعاملة (م2)، ولكن لوحظ عدم تأثر هضم الألياف الخام والدهن الخام. كانت الأس الهيدروجيني لسائل الكرش ، الأمونيا ، و الأحماض الدهنية الطيارة أعلى معنويا (مستوى 5%) في م2 عن مجموعة المقارنة. حققت المجموعة المعاملة (م2) قيما أعلى في كل من النيتروجين والكبريت المحتجز. أدى الجز الى تحسين (مستوى 5%) كفاءة استخدام ماء الشرب في م2 عن م1. أدى الجز الى زيادة وزن الذبيحة الساخن ولكن لم يؤثر على نسبة التصافي في الذبيحة. حققت مجموعة المعاملة (م2) عائدا ماديا أفضل عن مجموعة المقارنة (م1). نستنتج من هذه الدراسة أن الجز المبكر (بعد الفطام) للحملان البرقي قد أدى إلى زيادة الوزن الحي عند التسويق و وزن الذبيحة وبالتالي تحقيق ربح أكبر في كلتا الحالتين مقارنة بالحملان الغير معاملة.