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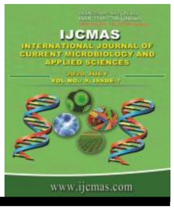

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# Partial Replacement of Berseem Hay by *Atriplex halimus* and *Atriplex nummularia* Nutrients Utilization in Barki Sheep

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The deficiency of animal feed in semi-arid places leads to using of non-traditional resources, like saline plants, as animal feed. Therefore, this experiment was conducted to compare the consequences of replacing berseem hay (BH) with various proportions of *Atriplex halimus* (AH) and *Atriplex nummularia* (AN). Two trials were conducted to determine salt surfing digestion, growth performance, and feed efficiency. Twenty-one adult Barky lambs were used in the first trial. Also, thirty-five growing Barki lambs were used in the second trial. In both trials animals were divided into seven groups and each group received one of seven dietary treatments. The present results reported that leaves and twigs of AN contained higher levels of CP, FAT, and NFE than in AH treatments. They had significant ($P< 0.05$) effects on dry matter intake (DMI), lambs' body weight, and digestibility. In contrast, Degradability, higher gas production and *in vitro* fermentation range of BH to that these substrates had a higher nutritional value than the other browse species. Lambs receiving BH consumed ($P< 0.05$)more feed compared to those received AH or AN. Lambs weight, which fed a diet contained 50% or 25% of AH or AN increased compared with those feed 100%*Atriplex* only. The containing diets up to 50% of AN had no adverse effects on DMI and digestibility. In comparison, supplementing over 25% AH in diets decreased ($P< 0.05$) the digestibility of dry matter and organic matter. BH had the best relative feed value (203.92%), while AH had the lowest (123.37%). Economic efficiency criteria supported a conclusion that favored the 50% AN (T4) than other treatments. In conclusion, up to 50% of BH can be replaced with AN without adverse effects on feed intake and dry matter digestion.

## Introduction

Feed shortage is a challenge in developing countries, thus imposing a big burden on human food costs, especially when increasing population. In Egypt, The hole among the requirement and availability for feeding cattle of feed resources four million tons TDN according to FAO (2008). In semi-arid areas, the availability of conventional feed resources is declining as the livestock population increases.

In this area in Egypt, particularly during hot summer and early autumn seasons, over there a great shortage in animal feedstuffs, also, recently the price of energy sources had dramatically increased with the elevating requirements for animal feeding. So the inflation of feed prices encouraged animal nutritionists to search for cheap high-energy feed ingredients. Therefore the scarcity of animal feed in semi-arid places leads to the use of salt plants as animal feeds.

In Egypt, salty plants are common because there are many brackish areas. Several attempts have made to get used to alternative forages, especially in the summer season, when green forages are lack and animals are underfed. *Atriplex halimus* (AH) and *Atriplex nummularia* (AN) have great potential because they are known to withstand salinity and dehydration in addition to the high content of crude protein, fibers, and mineral contents. Drought resistance allows browsing during the annual dry season when no other feed sources are available (El-Shaer, 2005). Saltbush shrub could use in the rations of cattle, sheep, and goats (Aganga *et al.*, 2003).Obeidat *et al.*, (2016)reported that the potential of inserting the AH up to 150 g / kg in the fattening rations of Awassi sheep without any harmful influences on growth rate and reducing feeding cost.

Also, Hintsa *et al.*, (2018) reported that replacing concentrate feed with *Atriplex nummularia* insect up to 20% did not alter DMI, body weight gain, and carcass components. So, using this plant as an alternative feed resource for livestock may mitigate the shortage of feed sources for smallholder farmers. Therefore, it was the main goal of the present study to illustrate the effect of replacing BH by specific proportions of AH and AN on growth performance and feed utilization of Barki lambs.

## Materials and Methods

This study conducted in the Animal Production Research Station Borg El-Arab. Which stretches along 525 km on the Mediterranean Sea, west of Alexandria city at latitudes 21° and 31° north 21° and 31° north and longitudes 25 degrees and 35 degrees East, the average air temperature ranges from 13 °C (56 °F) in December and January to 26°C (79 °F) in July and August.

### Ethical approval

All animal procedures performed following the standards set forth guidelines for the care and use of experimental animals by the Animal Ethics Committee of Animal Production Research Institute (APRI), Agricultural Research Centre (ARC), Ministry of Agriculture, Egypt. Especially, cannulated Barki sheep well treated under good veterinary care.

The cannulas have been installed by APRI ethical approval to the animals after sterilization and anesthesia well with the provision of all appropriate conditions and remained under intensive veterinary care during the experimental period in Animal Production Research Station Borg El-Arab.

### Animal welfare statement

All animals were kept under the same management and hygienic conditions. Lambs were kept in a ventilated barn and housed separately in shaded pens with concrete flooring, in addition to natural lighting through windows along either side of the building. The pens cleaned in the morning and afternoon after feeding. Diets provided at 8 am and 3.00 pm. and refusals were collected 24 h later. Freshwater and mineral licks provided to animals as free choices.

## Experimental design

In the first trial, twenty-one Barki adult lambs were used (weighed 35.26±0.66 kg); they were randomly assigned into equal seven groups (3 each) as a digestion trial to determine digestibility and feeding value. Each group received one of seven dietary treatments according to NRC (1985) as follows:60% concentrate feed mixture (CFM) and 40% chopped BH and served as control (T1), 60% CFM and 40% dried AN foliage (T2), 60% CFM and 40% dried AH foliage (T3), 60% CFM and 25% BH plus 25% AN (T4), 60% CFM and 25% BH plus 25% AH (T5), 60% CFM and 30% BH plus 10% 25% AN (T6) and 60% CFM and 30% BH plus 10% AH (T7). Animals kept in metabolic cages and weighted at the beginning and final of the digestibility trial that continued for 21 days (14 days as an adaptation period followed by seven days as a collection period). Feed amounts, residuals, fecal output, and urine volume and recorded daily. Daily feed intake of diets (the difference between the offered feeds and refusals) recorded for each animal for 18 weeks, and representative samples of diets recorded daily.

In the second trial, thirty-five Barki lambs were used (singles born, aged three months and weighed 12.16±0.11 kg), randomly assigned into the same experimental groups (5 each). Animals were weighed biweekly for 20 weeks, the first two weeks were an adaptation period, and the other 18 weeks were feeding period. Feeds were offered in two balanced meals at 07:00 and 18:00 h, respectively.

## Preparing experimental forages

AH and AN tree fodder (leaves and twigs) were harvested from the northwest coast, west of Alexandria. Samples from each type of herb were dried (up to 200 g) at 55 °C for 48 hours and passed to a 1 mm screen for subsequent chemical and laboratory analysis. Likewise, the pooled samples collected from AH&AN plus BH (i.e., control fodder) for analysis of all feed components, fecal, and urine samples, according to AOAC (2000).

## Macro and micro-mineral

Mineral content was determined by sample dry ashing at 550°C in a muffle furnace; the ash was dissolved in 10% HCl and filtered (Oshodi, 1992). Sodium (Na) and potassium (K) were measured using a flame model (Jenway PFP7) photometer; Ca, Mg, Zn, Fe, Pb, and Cu were determined using atomic absorption spectrophotometer model (Unicam929) in all dietary while condensed tannins were determined according to the procedures of Porter *et al.*, (1985).

## Gas production

Gas production was evaluated *in vitro* by Menke (1988) methods. Rumen fluid collected from three rumina cannulated Barki sheep. Incubation carried out at 39 ˚C and gas production was read at 3, 6, 12, 24, and 48 h. The remaining volume of gas recorded, according to Theodorou *et al.*, (1994). The cumulative gas volume represented as a milliliter of gas produced per 200 mg DM and corrected for blanks. The gas volume of the control ration (i.e.,BH) used as standard.

## Blood sampling and biochemical assay

Blood samples (10 ml) collected at 08:00 am from 12 h fasted animals in non-heparinized tubes *via* the jugular venipuncture from three lambs within each group before feeding and at the end of the growing period to avoid any diurnal effect on the minerals levels. Blood samples centrifuged (4000 rpm for 20 min. / 5 °C). All serum samples analyzed for total protein and albumin, according to Rodkey (1965). Globulin calculated by subtracting, whereas albumin/globulin ratio was estimated. Plasma urea–N, creatinine, ALT, and AST were measured, according to Berthelot (1959), Seelig and Wust (1969), and Wilkinson *et al.,* (1972), respectively.

### Economic efficiency

Economic efficiency was calculated as total output/total input according to the local prices (where one-ton concentrate = 4500 LE; AH= 500 LE; AN = 500 LE; Hay = 3000 LE; Kg live body weight of lambs = 65 LE. Relative feed value (RFV) developed by the Hay Marketing Task Force of American Forage and Grassland Council (Table 1) is the most widely used index for forage quality in the marketing of hays (Rohweder *et al.,* 1978). RFV of legume shrubs was calculated from the estimates of dry matter digestibility (DMD) and dry matter intake (DMI). Metabolizable energy (ME, MJ/Kg DM) and organic matter digestibility (OMD) were estimated at 24 h post gas collection, according to Menke (1988). Following are the used equations:

$$\mathrm{DMD}\ (\%) = 88.9 - (0.779 \times \mathrm{ADF}\ \%)$$

$$\mathrm{DMI}\ (\mathrm{BW}\ \%) = 120 \div \mathrm{NDF}\ \%$$

$$\mathrm{RFV} = (\mathrm{DMD} \times \mathrm{DMI}) \div 1.29$$

$$\mathrm{ME} = 2.20 + 0.136\ \mathrm{GV} + 0.057\ \mathrm{CP}$$

$$\mathrm{OMD} = 14.88 + 0.889\ \mathrm{GV} + 0.45\ \mathrm{CP} + 0.651\ \mathrm{Ash}$$

Where, ADF = Acid detergent fiber (DM %); NDF = Neutral detergent fiber (DM %); BW = body weight; GV = Total gas volume (ml/0.2 g DM); CP = crude protein; CF = crude fibre.

### Statistical analysis

Data were statistically analyzed using SAS procedure (2003) for Windows software. ANOVA was used to test the effect of treatments, and the differences between means detected by Duncan's Multiple Range Test (Duncan, 1955).

## Results and Discussion

### Chemical composition

Data presented in Tables2, and 3 showed the nutrients proximate analyses of Berseem hay (BH), the two *Atriplex* species, and their mixture forage treatments. Data presented in these tables showed that nutrients of the two *Atriplex* species were comparable to those of berseem hay; it observed that CF, FAT, NEF, OM, and ADL content were noticeably higher with BH than the two *Atriplex* species. While these browse of *Atriplex* had significant ($P< 0.05$) higher CP, DM, NDF, ADF, and ash than in BH. On the other hand, chemical compositions percentage for mixtures between BH and two species of *Atriplex* as a mediator between them. The values of dry matter contents of BH and the two *Atriplex* species were relatively close, but the two *Atriplex* species contained lower levels of organic matter. The foliage of AH provided a higher level of ash and Na (25.43%&37008.01ppm) than that of AN (23.80%& 9037.88ppm). A similar trend recorded by Fayed *et al.,* (2010) and Helal *et al.,* (2018).

The two browse of *Atriplex* understudy had CP values above 10%, which are higher than the minimum required in the diet for adequate digestive activities. Results showed that CP content for AH&AN treatments identical to that obtained by Mueller-Harvey (2006) and Gemeda and Hassen (2015). Who determined that feeds, which contain less of 8% CP could not provide the ammonia levels required by rumen microbes for optimum activity. *Atriplex halimus* and *Atriplex nummularia* fall within the range of benefits (12-14%) reported by Chriyaa and Boulanouar (2000) and Aganga *et al.,* (2003).Where CP content of browsing fodders is an indication of its nutritional quality, this justifies their use as supplements to poor quality natural pastures and crop residues (Rubanza *et al.*, 2003).Salem *et al.*, (2005) indicated that browsing is potential as nitrogen supplementation for ruminants fed low-quality fodders through the dry season in semi-arid regions. Moreover, shrubs and multipurpose trees have become a useful feed for ruminants alternative feed in the harsh semi-arid region (Eissa *et al.*, 2015). The slight variation in the chemical composition of salt bushes among the different studies could be attributed to differences in soil characteristics and the stages of plant growth when sampling.

The phytochemical screening of the treatments revealed that they contained condensed tannins, while the BH was utterly devoid of them (Table 2). Condensed tannin (CT) levels ranged from 0.47 to 9.33 % of DM, T2 showed the highest standards of CT followed by T4, T6, T3, T5, and T7, according to the ratio of both types of *Atriplex* in forge. CTs bind to the protein and/or carbohydrates to form under gradable complexes, which may reduce ruminal fermentation metabolism and nutrient digestibility. Therefore, the quantification of tannins was indispensable before using such forages for feeding. AH was less palatable than BH. This result might be due to high ash and Na contents. Moreover, AH contained considerable amounts of total tannin (9.33%), which appeared to be an anti-nutritional factor, reduced its palatability. Getachew *et al.*, (2002) found that total tannin content in browsed plant species was ranged from 7 to 214 g/kg DM *Atriplex halimus* is characterized by high levels of oxalate, tannic phenols, condensed, and hydrolyzable tannins than *Atriplex nummularia*, which explains its low palatability (Abu-Zanat, 2005).

Significant differences were observed in the macro-mineral contents of AH, AN, and BH (Table 3). Among them, Ca and Na were highest (44020.02and 37008.01 ppm) in AH than AN, and BH. Ca requirement for maintenance of dairy animals was 0.27-0.57%, and for lactating animals, it was 0.43-0.77% (NRC, 2001). The concentration of Ca was higher than the recommended levels. However, it was reported that excess Ca can disturb the absorption of trace elements (NRC, 2001). The concentration of Ca and Na were higher than the recommended levels. However, it was reported that excess Ca can disturb the absorption of trace elements (NRC, 2001). While the recommended level of Na in forages is 0.08-0.1% (NRC, 2001).Mg, one of the critical constituent of chlorophyll in green plants, is normally present in abundance in feeds. Its content did not vary much and the mean values ranged from 515.65to 2322.20 ppm. Ruminant animals are generally at risk from hypomagnesemia when Mg in feed and forages is less than the recommended level i.e. 0.12%-0.2% on DM basis (NRC, 1985). So from a nutritional point of view, both Ca and Mg contents were adequate in top feeds to meet the requirement.

Like macro-minerals, significant differences were also observed in the contents of different micronutrients in the tree species (Table 3). Among the micronutrients, Fe concentration was significant ($P < 0.05$) higher in AH(544.76 ppm) than in BH (471.20 ppm),and its normal requirement is 30-60 ppm on DM basis for ruminant animals (McDowell, 1992). Fe is a vital constituent of blood haemoglobin and cofactor of many enzymes. While deficiency can cause anemia, overabundance might result in nutritional imbalances. Higher Fe might interfere with Cu and phosphate absorption and metabolism. The maximum tolerable of Fe in forages is 1000 ppm, and it is least toxic of all the essential trace elements for livestock (McDowell, 1992). Mn deficiency was reported to cause impaired growth, skeletal, and infant abnormalities in animals (Hussain and Durrani, 2008), but the excessive amount decreases appetite. The level of Mn in both berseem hay and *Atriplex halimus* was quite higher than its required level of 20 ppm. Higher levels of Fe and Mn in feeds are in agreement with other reports (Hussain and Durrani, 2008).

## Relative feed value (RFV)

Table 4 showed that Berseem hay had the best DMD, DMI, and RFV (73.48%, 3.58% &203.92%, respectively), while *Atriplex halimus* had the lowest (57.83%, 2.15% &123.37%, respectively). The grade of browse fodders, Berseem hay and their mixture ranged from 2 to prime in the following order: T2= 2; T3= 1; T4= 1; T5= 1; T6= Prime; T7= Prime, according to the standard assigned by Hay Market Task Force of American Forage and Grassland Council.

Okunade *et al.*, (2014) reported that estimated DMD and DMI of the browse fodders ranged from 61.50% and 2.23% in *D. microcarpum* to 73.53% and3.55% in *A. Africana*, respectively. *A. Africana* had the best RFV value (202.94%), while *E. Africana* had the lowest RFV (114.43%). The grade of the legume browses ranged from 4 to prime in the following order: *D. microcarpum*= 4;*E. Africana*= 3; *P. thonningii*= 2; *D. oliveri*= 2; *P. erinaceus*= 1; A. *Africana*= prime in Nigeria. All the selected six legume browses except *D. microcarpum* may be regarded as having high relative nutritive value for ruminants. At the same time, Zhou *et al.*, (2011) reported that DMD of shrubs ranged from 51.03% in *D. Triangular* to 72.75% in *C. didymobotrya*. DMI ranged from 2.17 in *D. triangula* to 5.68% in *C. didymobotrya*. RFV ranged from 85.9% in *D. triangula* to 321% in *C. didymobotrya*. The grades of *Cratylia argentea, Leucaena leucocephala, Flemingia macrophylla, Cajanus cajan, Dendrolobium triangular, Cassia didymobotrya, Cassia bicapsularis* and *Acacia farnesiana* were 2, prime, 2, 1, 4, prime, prime and prime, respectively, for several tropical legumes in China. Besides, the overall RFV is lower than mean value (181.00) for the quality standard followed the same trend as reported by the same authors.

The predicted metabolizable energy and organic matter digestibility from gas production for BH, browse of AH, NH, and their mixture forage treatments are presented in Table 5.

The predicted ME in seven forages varied widely, being particularly high in Berseem hay and their mixture forage treatments (Table 4). While browse of *Atriplex halimus* and *Atriplex nummularia* had significantly lower values of ME. The data showed that there was no significant difference among T1, T6 and T7. There was a positive correlation between metabolisable energy calculated from *in vitro* gas production together with CP and fat content with a metabolisable energy value of conventional feeds measured *in vivo* (Menke, 1988). Results showed that metabolisable energy values reduced ($P< 0.05$) in T2 compared with other treatments. This result may be attributed to the lower energy content of AH and AN than BH These results are in agreement Shaker *et al.*, (2014). Salem *et al.*, (2005) found that animal performance improved by feeding Atriplex supplemented with sated with barley than those fed *Atriplex* alone.

The organic matter digestibility (OMD)% was higher ($P<0.05$) in BH than AH and AN(Table 4). The OMD differed significantly ($P< 0.05$) among treatments. However, the subtropical feeds contained considerable amounts of secondary plant metabolites, particularly tannins, which are associated with a reduction in OMD (Waghorn and Shelton, 1997).*In vitro* gas measurement and chemical composition are used in multiple regression equations (Van Soest, 1994; Waghorn *et al.*, 1997),who found a high precision in prediction of *in vivo* OMD. This group further used a correlative approach to predict the ME content of feed by *in vitro* gas volume measurements and chemical constituents. It concluded that the prediction of ME is more accurate when based on gas and chemical constituents measurements as compared to calculations based on chemical components only.

## Gas production

The cumulative gas volume at 3, 9, 12, 24, and 48 h after incubation of BH, AH, AN, and their mixture are presented in are shown in Table 5 and Figure 1. They were significant ($P < 0.05$) different among treatments. It can be seen that gas production reached the highest point at 48 h of fermentation. Cumulative gas volume at each sampling time was affected ($P < 0.05$) by a variety of feedstuffs. This finding indicated that the degradability of *Atriplex halimus* and *Atriplex nummularia* browses are different. The low gas production from *Atriplex halimus* could be related to the low feeding value of these feeds. Gas production is directly proportional to the substrate degradation rate (Dhanoa *et al.*, 2000). Menke *et al.*, (1988) suggested that the gas volume after 24 h of incubation has a relationship with metabolizable energy in feedstuffs. Sommart *et al.*, (2000) reported that gas volume is a good parameter to predict digestibility, fermentation end-product, and microbial protein synthesis of the substrate by rumen microbes in the *in vitro* system. Additionally, *in vitro*, dry matter and organic matter digestibility were shown to have a high correlation with gas volume (Sommart *et al.*, 2000). Gas volumes also have a close relationship with feed intake and growth rate in cattle (Blummel and Ørskov, 1993). The initial gas production presented in was highly significant ($P < 0.05$) in berseem hay in comparison with other roughages. The fast initial gas production was significant ($P < 0.05$) in BH in comparison with other treatments, the highest cumulative gas production was observed in T1, which was followed by T7, and the lowest was obtained in T2. Variation in cumulative gas production is due to the high content of the berseem hay from NFE, which has a positive correlation with gas production. On the other hand, cell wall content (NDF & ADF) was negatively correlated with gas production at all incubation times and estimated parameters. This may tend to reduce the microbial activity by increasing the adverse environmental conditions as incubation time progress. Also, the relatively high level of ADL as shown in Table 2 explains in part the limited *in vitro* degradation and therefore the lower amount of gas produced. The final net gas volume at 48 h after incubation was significantly ($P < 0.05$) increased among treatments. Isah *et al.*, (2012) confirmed that the forages degradability within 48 h could consider as equivalent to digestion.

Gas production can be regarded as an indicator of carbohydrate degradation and the low gas production in *Atriplex halimus* is explained by condensed tannin's binding to the carbohydrate and then by the inhibition of enzymes or microorganisms complexing with lignocellulose, and preventing the microbial digestion (Getachew *et al.*, 1998).

Subtropical feeds contain considerable amounts of phenolic compounds that reduced *in vitro* gas production correlation between the change in gas production in the presence of tannin binding agent and phenolic contents of browses were consistent with those of Khazaal *et al.*, (1996).

Table 5 showed the rising of the cumulative gas volume by the browse fodders mixture with increasing berseem hay percentage *in vitro* incubation hour. It is well known that gas production is the result of carbohydrates fermentation to acetate, propionate, and butyrate (Getachew *et al.,* 1998), whereas, protein fermentation does not lead to much gas production (Khazaal *et al.*, 1995). In the current study, browse of *Atriplex halimus* and *Atriplex nummularia* generally had moderate gas production potentials; gas production of the forages *in vitro* indicated that further degradation of DM was still possible beyond 48 h. Many factors such as the level of fibers, the presence of secondary metabolites, and potency of the rumen liquor have reported by Bamikole *et al.,* (2004) to determine the amount of gas to be produced during fermentation. Degradability, higher gas production and *in vitro* fermentation range of berseem hay had a higher nutritional value than the other browse species. In contrast, low-gas production of *Atriplex halimus* could be attributed to its high amount of tannins, in agreement with Isah *et al.,* (2012).

Notably, the absolute value (|a|) can utilize to represent the ideal fermentation of a soluble fraction. The total gas production was highest in BH. The soluble fraction makes it easily attachable by ruminal microorganisms and leads to higher gas production. Gas volumes in asymptote (b) describe the fermentation of the insoluble fraction. The b values ranged from the most elevated T1 to the lowest T2, and the gas volume rate (c) ranked from the fastest T1 to the slowest (T2). The cumulative gas volume created by experimental fodders raised by increasing incubation time *in vitro*, high levels of gas production mentioned in T1, possibly affected by fractions of soluble carbohydrates readily available for ruminal microbes. The potential gas production range (a+b) classified from the highest T1 to lowest T2. Generally, the potential for gas production in current processors was high, due to the high carbohydrate content (especially NDF).

The saltbush hay can be used as a source of protein (13%) and minerals. The *Atriplex* species are characterized by high salt content as well as high levels of Na, Ca, P, Mg, and K components (Aganga *et al.,* 2003). However, it is a poor source of energy, like wheat straw, and should be supplemented with high energy feeds. Salem and Smith (2008) observed a low energy content in AN, which could be a limiting issue to satisfy the animal requirements. The lower feed intake in animals fed the *Atriplex* hay is attributed to its high mineral content. Norman *et al.,* (2008) noticed that the high ash content in AN hay restricted the feed intake.

In this study, the average daily feed intake, growth performance, and feed efficiency are summarized in Table 6. Total and daily DM intake tended to increase significantly ($P< 0.05$) with T1 expressed as 1200 g & 95 g/kg$^{w0.75}$, respectively, for lambs compared to other groups, while the lowest values recorded with T2 (750g & 60 g/kg$^{w0.75}$). Treatments had a significant ($P< 0.05$) effect on voluntary feed intake. Lambs receiving berseem hay consumed higher amounts of feed compared to those fed the AH or AN, and there were significant differences in feed intake between lambs fed AH or AN. Relative intakes of saltbushes to berseem hay averaged 62% and 75% for AH and AN, respectively. The lower DMI of saltbushes as compared to those of berseem hay could be associated with higher salt content and lower organic matter digestibility of the consumed saltbushes. In the present study, embedding *Atriplex nummularia* browse up to 50% in diets maintained OMD slightly above 50%.

On the other hand, there was a significant ($P< 0.05$) decrease in lamb's weight fed on AH alone, which can be attributed to small differences that accumulate over time due to energy restriction, and diminished DM intake. Moreover, the high consumption of ash and Na can cause mineral imbalances when intake is over a long period. Also, AH contained considerable amounts of total tannin (9.33% of DM), which seems to be an anti-nutritional factor and decreased its palatability (Norman *et al.,* 2008). However, the weight of lambs fed 50 % *Atriplex* hay of the roughage amount was not affected despitethe reduced feed intake of these animals. High OMD in AN treatment compared to AH treatment may be due to AH content of elevated levels of secondary chemical compounds and ash, this agreement with Menke (1988) andGemeda and Hassen, (2015).Dry matter intakes of saltbushes in the present study (60 to 65 g DM/kg$^{w0.75}$) were lower than those reported by other researchers (Abu-Zanat, 2005). The daily intake of Barbarian ewes were 117 and 90 g DM/kg$^{w0.75}$ for fresh shrubs of AH and AN, respectively (Le Houerou, 1991). In Spain, daily intake by Segurena ewes under pen feeding conditions averaged 1.5 kg or 88 g DM/kg$^{w0.75}$ for AN and 1.4 kg or 73 g DM/kg$^{w0.75}$ for AH (Abu-Zanat, 2005). However, Wilson (1977) reported that daily DMI of AN by sheep averaged 550 g, which is lower than values obtained in the current study. The variations in DMI of forage treatments could be attributed to many factors, including the ratio of leaves to twigs size, digestibility, salt content, and previous exposure of animals to saltbush (Allison, 1985).

Many studies suggested that the diameters of twigs should be less than 5 mm to be grazable by animals (Roundy *et al.,* 1989). Twigs having diameters more than 10 mm are mostly indigestible. A large proportion of these indigestible substances in the diet could be accumulated in the animals' gut and consequently limited their feed intake (Rehman *et al.,* 1994). Previous experience and adaptation of animals to saltbushes considerably affect the consumption of browse (Abu-Zanat, 2005). Le Houerou (1991) reported that sheep become adapted to saltbush and increased their consumption of forage over 3-5 weeks. During the first two weeks of the experiment conducted by Abu-Zanat (2005), Segurena dry ewes lost weight on saltbush diet (*Atriplex nummularia*) and then live weight improved in the third week. This suggests that during the first two weeks of the experiment, ewes underwent an adaptation process; the animal condition is an essential factor that determines the nutrient requirements, thus DMI of the animal. The significant differences in chemical composition and intake among the different *Atriplex* species in addition to differences in breeds, body weights and body condition of animals are major factors contributing to variability in dry matter intakes of saltbushes in the different studies.

Growth performance of Barki lambs fed experimental rations were presented in (Table 6). The obtained results revealed significant ($P< 0.05$) differences among groups fed different rations in final body weight, total body gain, and daily body gain. Final body weight for sheep, which fed a diet contained 50% or 25% of AHorAN increased compared to those fed control diet. This improvement could be attributed to the increase in DMI in these groups. This disagreement with the finding of Brown *et al.*, (2018), who reported that final body weight where similar in sheep fed a diet contained 50% of dietary shrubs compared with other treatment groups. On the other hand, Aganga *et al.,* (2003) found reduced feed intake and digestibility rate of animals fed halophyte shrub, which led to weight loss. The current results showed a wide range of dietary concentrations of the condensed tannin percentage ranged from 0.47 to 9.33 in seven forage treatments (Table 2), which reflected on the improved daily weight gain of Barki lambs on fresh temperate forages. Concerning ruminant nutrition, specific levels of tannins consider beneficial effects including better utilization of dietary protein, faster body weight or wool growth, higher milk yield, increased fertility, and improved animal welfare and health through the prevention of bloat and reduced worm burdens (Mueller-Harvey, 2006). The present results are in agreement with those reported by many studies (Barry *et al.*, 2001; Salem and Smith, 2008; Gemeda and Hassen 2015; Eissa *et al.*, 2015).

Data in Table 6 indicated that the economic efficiency (E.E.) was better with T5 compared to other groups, in terms of growth performance of lambs with treatments. In this respect, Eissa *et al.*, (2015) found that E.E. improved significantly by replacing legumes trees with ammoniated wheat straw in sheep rations. Saltbushes mixture recorded a reduction in feed cost of $Kg^{w0.75}$, about 53% for sheep compared to the control group due to the lower price of saltbushes mixture compared to berseem hay. The results are in agreement with those reported by Fayed *et al.*, (2010) and Sadek *et al.*, (2020).

Data of blood parameters shown in Table 7 revealed that the lowest concentrations of total proteins (T.P.), albumin (A.L.) and globulin (G.L.) were detected with T2. These findings are in agreement with those reported by Eissa *et al.*, (2015). This reduction of T.P. in animals fed salt shrubs might be owing to the high content of tannins in these plants. In agreement, Reed *et al.*, (1995) and Mueller-Harvey (2006), since they reported that the high content of tannins in *Acacia* probably decreases the digestibility of crude protein. Coles (1986) found that reduced absorption of dietary constituents from the intestinal tract leads to hypoproteinemia. Mahmoud (2001) reported that a lower globulin concentration in sheep might be due to the presence of a high level of tannins that form complexes with diet. Thus, higher concentrations of T.P., AL, and G.L. in T1 than T2 and T3 might be owing to N concentration. The same trend found in the blood urea-N level. Generally, this can be attributed to the high protein content in T1, which is utilized efficiently by rumen microflora (Shaker *et al.*, 2014). Also, creatinine levels were significant ($P< 0.05$) increased in treatments.

**Table.1** Quality standards of shrubs, grass, and mixture of them

| **Quality standard** [a] | **CP** | **ADF (DM %)** | **NDF (DM %)** | **RFV** [b] |
|---|---|---|---|---|
| **Prime** | >19 | <31 | <40 | **>151** |
| **1** | 17- 19 | 31-40 | 40-46 | **151 - 125** |
| **2** | 14 - 16 | 36-40 | 47-53 | **124 - 104** |
| **3** | 11 - 13 | 41-42 | 54-60 | **102 - 87** |
| **4** | 8 - 10 | 43-45 | 61-65 | **85 - 75** |
| **5** | **<8** | **>45** | **>65** | **<75** |

[a] Standard assigned by Hay Market Task Force of American Forage and Grassland Council;
[b] Relative Feed Value (RFV) – Reference hay of 100 RFV contains 41% ADF & NDF and 53% N, Okunade *et al.*, (2014).

**Table.2** Chemical compositions, fiber fractions, and condensed tannins of the experimental rations

| Treatments | Chemical composition (as DM basis) | | | | | | | Fiber fractions | | | CT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CP | CF | Fat | NFE | Ash | DM | OM | NDF | ADF | ADL | |
| **T1** | 11.35<br>±0.08$^{d}$ | 27.64<br>±0.6 $^{a}$ | 2.45<br>±0.08$^{a}$ | 48.15<br>±0.82$^{a}$ | 10.41<br>±0.98$^{e}$ | 90.00<br>±0.15$^{c}$ | 89.70<br>±0.14$^{a}$ | 33.50<br>±0.33$^{e}$ | 19.80<br>±0.75$^{f}$ | 10.80<br>±0.82 $^{a}$ | Nil |
| **T2** | 12.84<br>±0.02$^{b}$ | 25.03<br>±0.42 $^{c}$ | 1.40<br>±0.04$^{c}$ | 35.3<br>±0.33$^{f}$ | 25.43<br>±0.32$^{a}$ | 92.42<br>±0.25$^{a}$ | 74.84<br>±0.42$^{e}$ | 55.70<br>±0.61$^{a}$ | 40.45<br>±0.32$^{a}$ | 14.50<br>±0.77$^{ab}$ | 9.33<br>±0.002$^{a}$ |
| **T3** | 13.75<br>±0.04$^{a}$ | 22.20<br>±0.25$^{d}$ | 1.80<br>±0.05$^{b}$ | 38.45<br>±0.32$^{e}$ | 23.80<br>±0.36$^{b}$ | 92.53<br>±0.30$^{a}$ | 76.20<br>±0.32$^{d}$ | 52.56<br>±0.52$^{b}$ | 35.31<br>±0.22$^{b}$ | 12.38<br>±0.77 $^{b}$ | 1.89<br>±0.005$^{d}$ |
| **T4** | 12.60<br>±0.03$^{b}$ | 26.34<br>±0.58$^{b}$ | 1.93<br>±0.06$^{b}$ | 41.23<br>±0.36$^{d}$ | 17.90<br>±0.42$^{c}$ | 91.26<br>±0.22$^{b}$ | 82.27<br>±0.14$^{c}$ | 44.60<br>±0.72$^{c}$ | 30.13<br>±0.42$^{c}$ | 12.65<br>±0.79$^{ab}$ | 4.66<br>±0.006$^{b}$ |
| **T5** | 12.01<br>±0.05$^{c}$ | 24.92<br>±0.32$^{c}$ | 2.13<br>±0.07$^{a}$ | 43.81<br>±0.51$^{c}$ | 17.13<br>±0.45$^{c}$ | 91.31<br>±0.20$^{b}$ | 82.95<br>±0.02$^{c}$ | 43.03<br>±0.66$^{c}$ | 27.56<br>±0.35$^{d}$ | 11.59<br>±0.80$^{ab}$ | 0.95<br>±0.007$^{d}$ |
| **T6** | 12.71<br>±0.05$^{b}$ | 26.99<br>±0.55$^{ab}$ | 2.19<br>±0.06$^{a}$ | 43.95<br>±0.75$^{b}$ | 14.16<br>±0.68$^{d}$ | 90.63<br>±0.18$^{c}$ | 85.99<br>±0.15$^{b}$ | 39.06<br>±0.53$^{d}$ | 24.96<br>±0.54$^{e}$ | 11.73<br>±0.81 $^{a}$ | 2.33<br>±0.008$^{c}$ |
| **T7** | 11.95±0.07$^{c}$ | 25.88<br>±0.44$^{b}$ | 2.39<br>±0.08$^{a}$ | 45.92<br>±0.63$^{b}$ | 13.86<br>±0.82$^{d}$ | 90.66<br>±0.17$^{c}$ | 86.33<br>±0.17$^{b}$ | 38.27<br>±0.42$^{d}$ | 23.68<br>±0.65$^{e}$ | 11.20<br>±0.82$^{a}$ | 0.47<br>±0.009$^{d}$ |

**a,b,c,d,e,f means in the same row with different superscripts differ significantly at *P*< 0.05.**

**CP: crude protein, CF: crude fiber, NFE: nitrogen-free extract, DM: dry matter, OM: organic matter, NDF: neutral detergent fiber, ADF: acid detergent fiber ADL: acid detergent lignin, CT: condensed tannins, T1: berseem hay, T2: *Atriplex halimus*, T3: *Atriplex nummularia*, T4: 50% berseem hay + 50% *Atriplex halimus*, T5: 50% berseem hay + 50% *Atriplex nummularia*, T6: 75% berseem hay + 25% *Atriplex halimus*, T7: 75% berseem hay + 25% *Atriplex nummularia*.**

**Table.3** Macro & Micro - mineral composition of specific tree and shrubs species (as DM basis)

| Treatments | Macro-mineral (ppm) | | | | | Micro-mineral (ppm) | | |
|---|---|---|---|---|---|---|---|---|
| | Na | Ca | K | P | Mg | Fe | Mn | Zn |
| **T1** | 4210.67$^{g}$ | 2564.11$^{e}$ | 10889.92$^{e}$ | 1015.05$^{e}$ | 515.65$^{e}$ | 471.20$^{b}$ | 31.94$^{c}$ | 30.38$^{b}$ |
| **T2** | 37008.01$^{a}$ | 44020.02$^{a}$ | 12961.01$^{c}$ | 2030.02$^{d}$ | 1750.22$^{d}$ | 544.76$^{a}$ | 43.09$^{a}$ | 35.61$^{a}$ |
| **T3** | 9037.88$^{f}$ | 2528.05$^{e}$ | 14541.77$^{b}$ | 1031.80$^{e}$ | 531.83$^{e}$ | 215.42$^{e}$ | 10.87$^{e}$ | 23. 05$^{d}$ |
| **T4** | 28109.34$^{b}$ | 26292.17$^{b}$ | 31366.98$^{a}$ | 2712.54$^{b}$ | 2212.24$^{b}$ | 507.98$^{a}$ | 37.61$^{b}$ | 33.00$^{a}$ |
| **T5** | 14124.28$^{e}$ | 5546.19$^{f}$ | 12715.85$^{c}$ | 2213.43$^{c}$ | 1773.45$^{c}$ | 343.31$^{d}$ | 21.41$^{d}$ | 31.61$^{b}$ |
| **T6** | 23660.00$^{c}$ | 17428.09$^{c}$ | 11407.69$^{d}$ | 3053.79$^{a}$ | 2250.70$^{a}$ | 489.59$^{b}$ | 34.66$^{b}$ | 31.69$^{b}$ |
| **T7** | 16667.47$^{d}$ | 7055.09$^{d}$ | 11802.88$^{d}$ | 2804.24$^{b}$ | 2322.20$^{b}$ | 407.26$^{c}$ | 22.94$^{d}$ | 28.55$^{c}$ |

a,b,c,d,e,f,g Means in the same row with different superscripts differ significantly at *P*< 0.05.
Na: Sodium, Ca: Calcium, K: Potassium, P: Phosphor, Fe: Ferric, Mn: Manganese, Ze: Zinc, T1: Berseem Hay, T2: *Atriplex halimus*, T3: *Atriplex nummularia*, T4: 50% berseem hay + 50% *Atriplex halimus*, T5: 50% berseem hay + 50% *Atriplex nummularia*, T6: 75% berseem hay + 25% *Atriplex Halimus*, T7: 75% berseem hay + 25% *Atriplex nummularia*.

**Table.4** Dry matter digestibility, dry matter intake, metabolizable energy, organic matter digestibility, and relative feed value prediction of selected browses

| Treatments | DMD (%) | DMI (% of BW) | OMD (%) | ME (MJ/Kg DM) | RFV | Quality standard |
|---|---|---|---|---|---|---|
| **T1** | 73.48$^{a}$ | 3.58$^{a}$ | 54.27$^{b}$ | 7.99$^{a}$ | 203.92$^{a}$ | **Prime** |
| **T2** | 57.38$^{f}$ | 2.15$^{d}$ | 47.65$^{e}$ | 6.81$^{d}$ | 123.37$^{g}$ | **2** |
| **T3** | 61.93$^{e}$ | 2.28$^{d}$ | 49.11$^{d}$ | 7.04$^{c}$ | 141.20$^{e}$ | **1** |
| **T4** | 65.42$^{d}$ | 2.69$^{c}$ | 61.67$^{a}$ | 7.43$^{b}$ | 136.42$^{f}$ | **1** |
| **T5** | 67.43$^{c}$ | 2.79$^{c}$ | 51.45$^{c}$ | 7.48$^{b}$ | 145.77$^{d}$ | **1** |
| **T6** | 69.46$^{b}$ | 3.07$^{b}$ | 53.06$^{b}$ | 7.75$^{a}$ | 165.29$^{c}$ | **Prime** |
| **T7** | **70.45$^{b}$** | **3.14$^{b}$** | **61.11$^{a}$** | **7.75$^{a}$** | **171.24$^{b}$** | **Prime** |

a,b,c,d,e,f,g Means in the same row with different superscripts differ significantly at *P*< 0.05.
DMD: Dry matter digestibility (%), OMD: Organic matter digestibility, DMI: Dry matter intake (% of body weight), ME: Metabolisable energy, RFV = Relative feed value, T1: Berseem Hay, T2: *Atriplex halimus*, T3: *Atriplex nummularia* T4: 50% berseem hay + 50% *Atriplex halimus*, T5: 50% berseem hay + 50% *Atriplex nummularia*, T6: 75% berseem hay + 25% *Atriplex halimus*, T7: 75% berseem hay + 25% *Atriplex nummularia*

**Table.5** Accumulative gas production and estimated parameters for a variety of roughages incubated with rumen fluid *in vitro*

| Treatments | Accumulative gas production (Incubation times, h) | | | | | Estimated parameters | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3h | 6h | 12h | 24h | 48h | c | A | b | a+b |
| **T1** | 6.90 ±0.07$^{a}$ | 15.50 ±0.22$^{a}$ | 25.71 ±0.63$^{a}$ | 37.80 ±0.47$^{a}$ | 47.60 ±0.45$^{a}$ | 0.070 ±0.006$^{a}$ | 3.60 ±0.09$^{a}$ | 45.04± 0.87$^{e}$ | 48.49 ±0.78$^{a}$ |
| **T2** | 4.20 ±0.03$^{c}$ | 8.60 ±0.87$^{e}$ | 18.90 ±0.76$^{e}$ | 28.50 ±0.62$^{e}$ | 32.70 ±0.63$^{e}$ | 0.052 ±0.007$^{a}$ | 2.20 ±0.04$^{e}$ | 33.04 ±0.33$^{f}$ | 35.24 ±0.35$^{g}$ |
| **T3** | 5.80 ±0.06$^{b}$ | 10.25 ±0.45$^{d}$ | 20.20 ±0.85$^{d}$ | 29.80± 0.65$^{d}$ | 35.90 ±0.68$^{d}$ | 0.061 ±0.008$^{b}$ | 2.50 ±0.04$^{d}$ | 37.01 ±0.53$^{e}$ | 39.51 ±0.52$^{f}$ |
| **T4** | 5.55 ±0.05$^{b}$ | 12.05 ±0.65$^{c}$ | 22.31 ±0.75$^{c}$ | 33.15 ±0.45$^{c}$ | 41.15 ±0.75$^{c}$ | 0.065±0.007$^{a}$ | 2.80 ±0.03$^{c}$ | 39.04 ±0.65$^{d}$ | 41.84 ±0.48$^{e}$ |
| **T5** | 6.35 ±0.05$^{a}$ | 12.88 ±0.75$^{c}$ | 24.46 ±0.92$^{b}$ | 33.80 ±0.61$^{c}$ | 41.75 ±0.78$^{c}$ | 0.066 ±0.008$^{a}$ | 3.12 ±0.05$^{b}$ | 41.03 ±0.72$^{c}$ | 44.15 ±0.65$^{d}$ |
| **T6** | 6.23 ±0.04$^{a}$ | 13.78 ±0.42$^{b}$ | 24.01 ±0.82$^{b}$ | 35.48 ±0.53$^{b}$ | 43.88 ±0.76$^{b}$ | 0.068 ±0.008$^{a}$ | 3.25 ±0.07$^{ab}$ | 42.04 ±0.80$^{b}$ | 45.29 ±0.43$^{c}$ |
| **T7** | 6.63±0.87$^{a}$ | 14.19 ±0.33$^{b}$ | 24.33 ±0.66$^{b}$ | 35.80 ±0.57$^{b}$ | 44.68 ±0.62$^{b}$ | 0.069±0.007$^{a}$ | 3.45 ±0.03$^{a}$ | 43.03 ±0.85$^{b}$ | 46.63 ±0.65$^{b}$ |

**a,b,c,d,e,f,g Means in the same row with different superscripts differ significantly at *P*< 0.05.
Estimated parameters (c, a, b &a+b), T1: berseem hay, T2: *Atriplex halimus*, T3: *Atriplex nummularia*, T4: 50% berseem hay + 50% *Atriplex halimus*, T5: 50% berseem hay + 50% *Atriplex nummularia*, T6: 75% berseem hay + 25% *Atriplex halimus*, T7: 75% berseem hay + 25% *Atriplex nummularia*.**

**Table.6** Growth performance and feed efficiency of Barki lambs fed experimental rations

| **Items** | **Treatments** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **T1** | **T2** | **T3** | **T4** | **T5** | **T6** | **T7** |
| **Feed intake** | | | | | | | |
| **Roughage (g)** | 400 ±0.88$^{a}$ | 150 ±0.33$^{f}$ | 200 ±0.42$^{e}$ | 250 ±0.55$^{d}$ | 300 ±0.64$^{c}$ | 300 ±0.66$^{c}$ | 350 ±0.75$^{b}$ |
| **CFM (g)** | 800 ±0.65$^{a}$ | 600 ±0.55$^{d}$ | 700±0.55$^{c}$ | 750 ±0.60$^{b}$ | 750±0.60$^{b}$ | 800 ±0.65$^{a}$ | 800 ±0.65$^{a}$ |
| **TDMI (g/h/d)** | 1200 ±2.12$^{a}$ | 750 ±0.18$^{g}$ | 900 ±0.36$^{f}$ | 1000 ±0.16$^{e}$ | 1050 ±1.24$^{d}$ | 1100 ±1.22$^{c}$ | 1150 ±1.15$^{b}$ |
| **DMI (g/kg$^{w0.75}$)** | 95 ±2.11$^{a}$ | 60 ±1.01$^{g}$ | 65 ±1.21$^{f}$ | 75 ±1.24$^{e}$ | 80 ±1.55$^{d}$ | 85 ±1.78$^{c}$ | 90 ±2.01$^{b}$ |
| **TOMI (g/h/d)** | 1100 ±1.25$^{a}$ | 750 ±0.55$^{g}$ | 850 ±0.60$^{f}$ | 900 ±0.75$^{e}$ | 950 ±0.80$^{d}$ | 1000 ±0.95$^{c}$ | 1050 ±1.85$^{b}$ |
| **CP intake (g)** | 140 ±0.45$^{a}$ | 75 ±0.48$^{g}$ | 95 ±0.66$^{f}$ | 100 ±0.72$^{e}$ | 115 ±0.65$^{d}$ | 122 ±0.85$^{c}$ | 135 ±0.77$^{b}$ |
| **Growth performance** | | | | | | | |
| **No. of lambs** | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| **Feeding period (week)** | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| **Initial weight (kg)** | 12.08 ±0.46 | 12.12 ±0.17 | 12.32 ±0.29 | 12.32 ±0.29 | 12.02 ±0.06 | 12.32 ±0.29 | 12.28 ±0.11 |
| **Final weight (kg)** | 33.46 ±0.48$^{a}$ | 22.20 ±0.43$^{g}$ | 26.18 ±0.46$^{f}$ | 28.07 ±0.46$^{e}$ | 29.66 ±0.53$^{e}$ | 30.97 ±0.46$^{c}$ | 31.81 ±0.48$^{b}$ |
| **Total gain (kg)** | 21.42 ±0.13$^{a}$ | 10.08 ±0.27$^{e}$ | 13.86 ±0.32$^{d}$ | 10.71 ±0.32$^{e}$ | 15.12 ±0.53$^{c}$ | 18.65 ±0.32$^{b}$ | 19.53 ±0.42$^{b}$ |
| **Daily body gain (g)** | 170 ±0.01$^{a}$ | 80.00 ±0.02$^{f}$ | 110.00 ±0.04$^{e}$ | 125.00 ±0.03$^{d}$ | 140.00 ±0.04$^{c}$ | 148.00 ±0.03$^{c}$ | 155.00 ±0.03$^{b}$ |
| **Feed conversion (Kg CP/Kg gain)** | 0.82 ± 0.003$^{b}$ | 0.94 ± 0.007$^{a}$ | 0.86 ± 0.005$^{ab}$ | 0.80 ± 0.006$^{b}$ | 0.82 ± 0.003$^{b}$ | 0.82 ± 0.003$^{b}$ | 0.87 ± 0.006$^{ab}$ |
| **Feed efficiency** | | | | | | | |
| **Total feeding cost, LE** | 3.39 | 2.33 | 2.24 | 2.77 | 2.79 | 3.08 | 3.12 |
| **Price of daily gain, LE** | 11.05 | 6.56 | 6.82 | 7.15 | 10.01 | 7.67 | 10.46 |
| **Economic efficiency %** | 2.25 | 1.81 | 2.04. | 1.58 | 2.58 | 1.49 | 2.35 |

**a,b,c,d,: Means in the same row with different superscripts differ significantly at *P*< 0.05.**

**T1: berseem hay, T2: *Atriplex halimus*, T3: *Atriplex nummularia*, T4: 50% berseem hay + 50% *Atriplex halimus*, T5: 50% berseem hay + 50% *Atriplex nummularia*, T6: 75% berseem hay + 25% *Atriplex halimus*, T7: 75% berseem hay + 25% *Atriplex nummularia*, TDMI: total dry matter intake, TOMI: total organic matter intake, CFM: concentrate feed mixture.**

**Total price for feeds calculated according to the price of different ingredients available in Egypt.**

**1- The local market prices were; 4500 LE for one ton CFM, 500 LE for one ton *Atriplex halimus*, 500 LE for one ton *Atriplex nummularia*, 3000 LE for one-ton berseem hay and 65 L.E. price for one Kg live body weight of lambs.**

**2- Economic efficiency (EE) = net profile / total feeding cost, LE.**

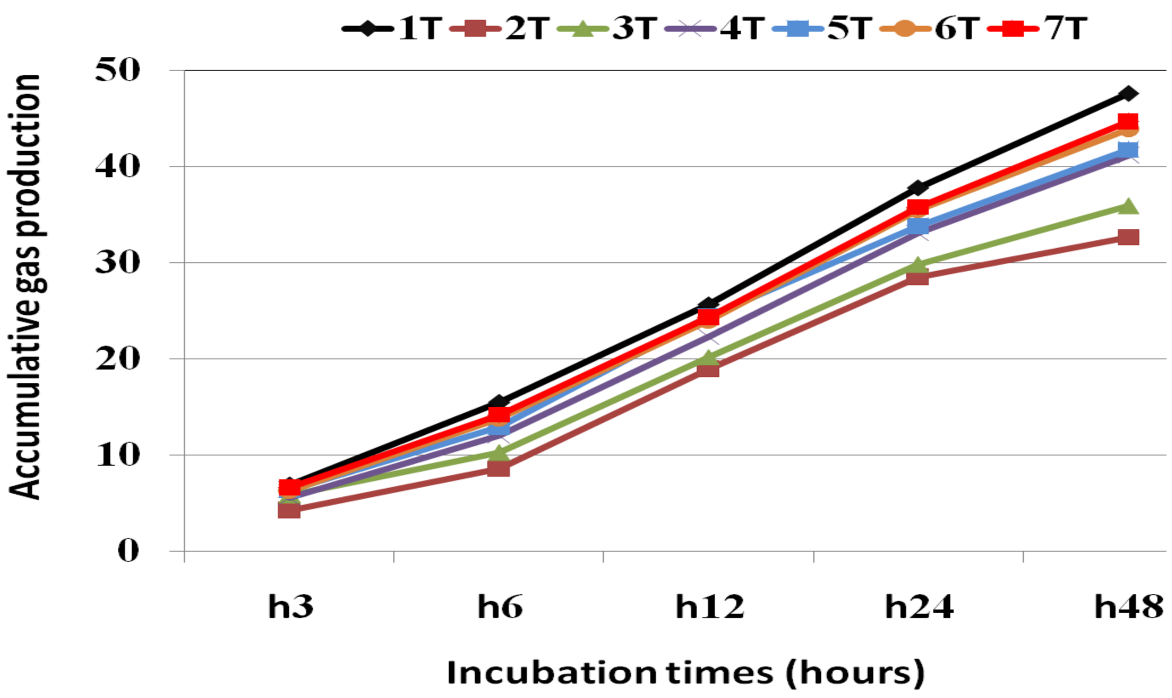
**Table.7** Effect of feeding experimental rations for Barki lambs on some blood serum parameters

| Items | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 | T6 | T7 |
| **Total protein, g/dl** | 8.11 ±0.50$^{a}$ | 6.42 ±0.34$^{b}$ | 7.06 ±0.46$^{ab}$ | 6.55 ±0.51$^{ab}$ | 6.82 ±0.51$^{ab}$ | 7.10 ±0.25$^{ab}$ | 7.45 ±0.25$^{ab}$ |
| **Albumin, g/dl** | 4.61 ±0.38$^{a}$ | 3.50 ±0.19$^{b}$ | 3.87 ±0.23$^{ab}$ | 3.94 ±0.23$^{ab}$ | 3.70 ±0.23$^{ab}$ | 3.63 ±0.29$^{ab}$ | 3.90 ±0.29$^{ab}$ |
| **Globulin, g/dl** | 3.60 ±0.14$^{a}$ | 3.19 ±0.18$^{b}$ | 3.35 ±0.24$^{ab}$ | 3.20 ±0.29$^{ab}$ | 3.30 ±0.29$^{ab}$ | 3.46 ±0.10$^{ab}$ | 3.56 ±0.10$^{a}$ |
| **A/G ratio** | 1.28 ±0.07$^{a}$ | 1.10 ±0.05$^{ab}$ | 1.16 ±0.04$^{ab}$ | 1.23 ±0.07$^{ab}$ | 1.12 ±0.07$^{ab}$ | 1.05 ±0.10$^{b}$ | 1.10 ±0.10$^{ab}$ |
| **Urea-N, mg/dl** | 23.62 ±0.39$^{a}$ | 19.99 ±0.20$^{c}$ | 22.13 ±0.65$^{b}$ | 23.20 ±0.43$^{ab}$ | 21.50 ±0.43$^{ab}$ | 23.19 ±0.52$^{ab}$ | 24.10 ±0.52$^{a}$ |
| **Creatinine, mg/dl** | 1.13 ±0.11$^{d}$ | 1.92 ±0.12$^{a}$ | 1.61 ±0.18$^{b}$ | 1.82 ±0.10$^{a}$ | 1.51 ±0.10$^{b}$ | 1.31 ±0.12$^{c}$ | 1.22 ±0.12$^{c}$ |
| **AST, U/l** | 26.05 ±0.58$^{d}$ | 33.49 ±0.30$^{a}$ | 31.44 ±0.59$^{ab}$ | 30.48 ±0.52$^{b}$ | 29.18 ±0.52$^{c}$ | 30.10 ±0.48$^{ab}$ | 28.15 ±0.48$^{c}$ |
| **ALT, U/l** | 16.28 ±0.29$^{d}$ | 20.90 ±0.32$^{a}$ | 19.46 ±0.32$^{b}$ | 17.90 ±0.40$^{c}$ | 17.64 ±0.40$^{c}$ | 17.81 ±0.45$^{c}$ | 17.70 ±0.45$^{c}$ |

**a,b,c,d Means in the same row with different superscripts differ significantly at *P*< 0.05.**

**T1: berseem hay, T2: *Atriplex halimus*, T3: *Atriplex nummularia*, T4: 50% berseem hay + 50% *Atriplex halimus*, T5: 50% berseem hay + 50% *Atriplex nummularia*, T6: 75% berseem hay + 25% *Atriplex halimus*, T7: 75% berseem hay + 25% *Atriplex nummularia*.**

**Figure 1.**Cumulative gas volume for a variety of roughages incubated with rumen fluid *in vitro*.



Concentrations of AST and ALT enzymes that conventionally used for diagnosing hepatic damage were higher with salt-tolerant shrubs groups, but the differences were significant (*P* < 0.05). Generally, the obtained results indicated that blood components measured showed slight variations due to the source of shrubs, as all levels were within the normal ranges reported by Silanikove *et al.*, (1996).

In conclusion, the nutritional value of leaves and twigs for *A. nummularia* is better than *A. halimus*, and A. *nummularia* can replace up to 50% of BH without adverse effects on the consumption and digestion of dry matter. Fodder shrubs, especially the species of *Atriplex* , are known for their tolerance to drought and salinity. In semi-arid regions where lack of water resources limits BH production, these fodder bushes can use to replace partial BH in the small ruminant diet. *A. nummularia* are exotic species, while *A. halimus* is an indigenous species in the Mediterranean basin. Previous shrubs may be used in certain mixtures with concentrated feed mixtures to enhance the supply of livestock feed and to ensure an acceptable level of production in semi-arid conditions. Economic efficiency criteria supported justified a conclusion that favored the 50% AN (T5)than other treatments.

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