INFLUENCE OF ALL OR PARTIAL REPLACEMENT OF MORINGA FROM BERSEEM ON THE PRODUCTIVE PERFORMANCE OF SHEEP

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SUMMARY

This study was conducted to investigate the effect of inclusion *Moringa oleifera* (MO) to be partially or all replace berseem in sheep ration and its effect on nutrients digestibility, in-sacco effective degradability of dry matter (DM) and crude protein (CP) of fresh berseem (*Trifolium alexandrinum*) against *Moringa oleifera* forage, dietary nitrogen utilization, rumen fermentation activity, productive performance and blood parameters of Barki sheep. Digestibility trials were conducted with Barki rams, while rumen fermentation trials were conducted with fistulated Barki ewes. Feeding trials were applied with thirty male growing lambs. Thirty male Barki sheep (25.37±0.37kg, and 7 months of age) were randomly divided into five similar groups (6 each) for a feeding period of 75 days, where weight was recorded and blood samples were collected at end of the feeding period. Experimental rations based on 60% CFM + 40% fresh berseem (R_1); 60% CFM + 30% berseem + 10% moringa (R_2); 60% CFM+ 20% berseem+ 20% moringa (R_3); 60% CFM + 10% berseem + 30% moringa (R_4) and 60% CFM + 40% moringa (R_5). Results indicated that higher nutrients digestibility associated moringa containing rations, where the R_4 containing (10% berseem + 30% moringa) and R_5 (40% moringa) had the highest ($P<0.05$) digestibility values for all nutrients followed by those of R_3 (20% berseem + 20% moringa). While, the lowest values were recorded with R_1 containing 40% berseem (0% moringa). Nutritive values expressed as TDN was ($P<0.05$) higher for R_4 and R_5 than R_1, while DCP was ($P<0.05$) higher for all moringa rations (R_2, R_3, R_4 and R_5) than R_1. Results of nitrogen utilization as well showed remarkable ($P < 0.05$) increase of N-retained as % of N-absorbed and relative to N-intake or digestible N with moringa containing rations. The results indicated that feeding moringa forage in partial or complete substitution of berseem fodder improved nitrogen utilization with all moringa rations in comparison to R_1. Rumen liquor pH values and NH_3-N concentration were lower ($P<0.05$) with increasing moringa in rations (R_3, R_4 and R_5) than R_1 and R_2, while total VFA's concentration was remarkably higher for R_3, R_4 and R_5 than R_1 and R_2 experimental rations. In similar trend, microbial nitrogen yield was greater with the moringa rations (R_5) than that of R_1 (40% berseem containing ration). Molar proportion % of propionic acid and butyric acid were insignificantly lower with increasing moringa in experimental rations. Acetic acid, acetic: propionic ratio and rumen volume (L) were higher ($P<0.05$) with increasing moringa in rations. Effective degradability of DM and ruminal undegradable protein (RUP) were significantly increased with increasing the level of moringa up to 40%. Economic return and economic efficiency were higher for moringa than berseem. Feeding moringa rations was associated with higher ($P<0.05$) blood glucose concentration, total protein, albumin and globulin with increase moringa in rations compared with the control ration. Moreover, blood cholesterol and urea was decreased ($P<0.05$) with moringa rations, however the effect was more pronounced with 40% moringa ration. Feeding moringa up to 40% of the whole daily ration did not badly affects liver or kidney functions. Under the conditions of this study, it's fair to conclude that; *moringa oleifera* is palatable and highly nutritious fodder. Therefore, the partial or complete replacement of berseem with moringa is highly recommended in the feeding practices of sheep.

Keyword: *Moringa oleifera, sheep, digestibility, rumen fermentation, degradation kinetics, growth performance and blood parameters.*

INTRODUCTION

Livestock plays a very important role as an integral part of farming and rural life in developing countries; providing food and the critical cash reserve and income for many farmers. The lack of sufficient feeds to meet the nutritional requirements of the existing animal population is one of the most critical problems of animal production in Egypt. Berseem (*Trifolium alexandrinum*) is the traditional Egyptian green fodder during winter season (from Nov. up end of May). About 1.400.000 feddan (feddan = 4200 m^2) are annually cultivated with berseem for ruminants feeding. Abundant amounts of nearly

41,000,000 tons of berseem forage are available during winter (Agriculture Economics and Statistics, 2014), while, green fodders are scarcely available during summer season. Limited level of irrigated water and occupation of agricultural lands with traditional summer food crops (rice, corn. etc.) are the two main constrains make sufficient amount of green fodders unavailable in reasonable cost during summer season. So, there is a badly need to find type of perennial fodder plant capable to grow particularly in the sandy soil of the newly reclaimed lands. One of the most interesting trees is moringa (*Moringa oleifera Lam.*), (syns. *Moringa pterygosperm*, family Moringaceae) is a multipurpose tropical tree and small to medium evergreen or deciduous tree that can reach up to 10-12 m. It is mainly used for food and has numerous industrial, medicinal and agricultural uses, including animal feeding. This traditional plant was rediscovered in the 1990s and its cultivation has since become increasingly popular in Asia and Africa, where it is among the most economically valuable crops. It has been dubbed the "miracle tree" or "tree of life" in popular media (Bosch, 2004; Radovich, 2009; Orwa *et al.*, 2009 and FAO, 2014). It is one of the most widely used species for fodder (Bakhashwain *et al*., 2010). It can grow in all types of soils and can tolerate dry seasons lasting up to 6 months (Mendieta-Araica *et al.*, 2013). It is a multipurpose tree; leaves and green fresh pods are used as vegetables by humans and are rich in carotene and ascorbic acid with a good profile of amino acids (Makkar and Becker, 1996). It is also used as livestock feed and its twigs are reported to be very palatable to ruminants and have appreciable crude protein levels (Sutherland *et al*., 1990; Sarwatt *et al*., 2002 and Kimoro, 2002). Intensive production of moringa as green fodder can harvested 8 times at year gave about 300 tons per acre when harvested every 40 days grows and at high 50 to 60 cm. The total dry matter (DM) yield from moringa is up to 24 tons ha^{-1} $year^{-1}$ (Reyes-Sánchez *et al.*, 2006a). Furthermore, *Moringa oleifera* is a non-leguminous multipurpose tree with a high crude protein in the leaves (251g/kg DM) and negligible content of tannis and other anti-nutritional compounds (Makkar and Becker, 1996 and Gidamis *et al.*, 2003). Moringa plant contains significant amounts of vitamins A, B, and C in the foliage with a good profile of amino acids (Ferreira *et al.*, 2008 and Mendieta-Araica *et al.*, 2011). As fresh forage, moringa has been included in the diets of many different animals. Positive effects on the feeding behavior in goats (Manh *et al.*, 2005) and on the growth rate in sheep (Ben Salem and Makkar, 2009); and had favorable production results with dairy cows (Reyes-Sánchez *et al.*, 2006b). Moringa leaves and green pods are used as vegetables by humans and offer well an alternative source of protein to ruminants. Moreover, its twigs are very palatable to ruminants and have appreciable crude protein levels (Kaijage *et al.*, 2003). Laboratory analysis (Asaolu, 2009) showed negligible amounts of tannins (1 to23 g/kg) in all fractions of the *Moringa oleifera* plant and high levels of sulphur-containing amino acids. There has been an increasing interest in the use of moringa as a protein source for livestock (Asaolu *et al.*, 2009 and 2010). During the last years, great attention has been given to moringa forage by many Egyptian animal nutritionists to overcome the difficulty of green fodder shortage particularly during summer season. So, this study was conducted to investigate the impact of feeding moringa fodder in partial or complete replacement of berseem forage in the feeding practices of Barki sheep.

MATERIALS AND METHODS

Feeds and tested rations:

The present study was carried out at Al- Noubaria Experimental Station affiliates Animal Production Research Institute, Agricultural Research Center, Giza, Egypt, in corporation with a private moringa farm located in Al-Noubaria province (about 180 km North Western Cairo City). Experimental fodders of 3rd cut berseem (*Trifolium alexandrinum*) and moringa (*Moringa oleifera Lam*.) were daily collected and brought to the animal station at 6.00 a.m. Five experimental rations based on changing the roughage type were fed on DM basis as: R_1) 60% concentrate feed mixture (CFM) + 40% fresh berseem, R_2) 60% CFM + 30% fresh berseem + 10% fresh moringa, R_3) 60% CFM + 20% fresh berseem + 20% fresh moringa, R_4) 60% CFM +10% fresh berseem + 30% fresh moringa and R_5) 60% CFM + 40% fresh moringa. Calculated feeding value of the CFM was 65% total digestible nutrients (TDN) and 14% crude protein (CP). Proximate chemical analyses of CFM were determined according to the standard methods of A.O.A.C. (2007). Table (1) illustrated the chemical composition of CFM (on DM basis).

Digestibility and nitrogen balance trials:

Five digestibility and nitrogen balance trials were carried out using three Barki rams (47.5 ± 2kg, in average) for each ration consequently. Each trial lasted for four weeks; the first three weeks were as a preliminary period, followed by one week for feces and urine collection. Sheep were fed twice daily at 8.00 a.m. and 4.00 p.m. water was offered freely. Each animal was offered the tested diets according to

NRC (1994). Chemical composition of feeds, feces and urine were determined according to A.O.A.C. (2007) methods. Sub samples (20%) of feces and urine were taken once daily then stored at – 18 ºC until analyses. Fecal samples were dried at 60 ºC for 72 hrs. Feed and fecal samples were ground through 1 mm screen on a Wiley mill grinder and a sample of 50 gm/ (diet/sheep) was taken for analysis. The samples of feed and feces were analyzed for crude protein (CP), crude fiber (CF), ether extract (EE) and ash, while the urine samples were analyzed for nitrogen (N) content according to A.O.A.C. (2007). Cell wall constituents (NDF, ADF and ADL) were determined according to Van Soest *et al.* (1991). Hemicellulose and cellulose were calculated by differences. Total phenolic components (TPC) were assayed by Folin-Ciocalteu-reagent 2N (Sigma®–Aldrich, El-Safua Co., Alexandria, Egypt) based on known concentrations of tannic acid as the calibration curve (Sigma®–Aldrich) according to Makkar and Becker (1993). Condensed tannins (CT) were determined according to Makkar (2003). Saponins were extracted and isolated according to Ahmad *et al.* (1990). Mineral extracts of berseem and moringa were prepared and analyzed for Ca and Na after a wet digestion with a mixture of nitric, sulphuric and perchloric acids using an atomic absorption spectrophotometer (Unicam 919). Phosphorus was determined colorimetrically, using molydbovanadate reagent according to A.O.A.C. (2007).

Table (1): Chemical composition of the concentrate feed mixture (on DM basis).

Item	DM	OM	CP	CF	EE	NFE	Ash
CFM	89.81	93.27	13.64	6.96	2.53	70.14	6.73

The concentrate feed mixture (CFM) in cubes was formulated of: 35% ground yellow corn, 18% soybean meal, 28% wheat bran,10% barley grain, 5% cane molasses, 2% limestone, 1% sodium chloride and 1% minerals & vitamins mixture.

Rumen fermentation:

Rumen liquor samples were taken at 0, 1, 3 and 6 hrs after the morning meal from three fistulated female Barki ewes (weighed 43.00 ± 1.5 Kg BW) for each diet consequently. Collected rumen liquor was directly tested for pH using Orian 680 digital pH meter. Samples were strained through four layers of chesses cloth for each sampling time, while ammonia nitrogen (NH_3-N) was determined by using magnesium oxide (MgO) as described by the AL-Rabbat *et al.* (1971). Total volatile fatty acids (VFA's) concentration was estimated by using steam distillation methods (Warner, 1964); molar concentration of VFA's fraction was estimated by gas chromatography (Yang and Varga, 1989). Rumen volume was determined by colorimetric method of Cr-EDTA before, 3 and 6 hrs after feeding (El-Shazly *et al.*, 1976). The microbial nitrogen synthesized (gMN/d) in the rumen of sheep fed the experimental diets was calculated using the model equation justified by Chen *et al.* (1991) as follow: N supply (g/day) = «Pax70/ (0.83x0.116x1000) », where 70 is the N content (mg/mmol) of purines, (Pa mmol/day) is microbial purine absorbed by the animal. The supply of microbial N was calculated from Pa by assuming that: digestibility of microbial purines equals 0.83 and the purine-N: total microbial N ratio= 0.116.

Degradation kinetics:

Nylon bags technique (Mehrez and Ørskov, 1977) was used to determine degradability of DM and CP for roughages. Two polyester bags (7 X 15 cm) with pore size of 45 µm were used for each incubation time. Approximately 6 g of air-dried roughages (ground to 2 mm) were placed in each bag. All bags were incubated in the rumen of each sheep, then they were withdrawn after 3, 6, 12, 24, 48, 72 and 96h, rinsed in tap water until the water became clear, then they were squeezed gently. Microorganisms attached to the residual sample were eliminated by freezing at - 20°C (Kamel *et al*., 1995). Zero-time washing losses (a) were determined by washing 2 bags in running water for 15 min. The degradation kinetics of DM and CP were estimated (in each bag) by fitting the disappearance values to the equation $P = a + b (1- e^{-ct})$ as proposed by Ørskov and McDonald (1979), where P represents the disappearance after time "t". Least-squares estimated of soluble fractions are defined as the rapidly degraded fraction (a), slowly degraded fraction (b) and the rate of degradation (c). The effective degradability (ED) for tested rations were estimated from the equation of McDonald (1981), where ED = a + bc / (c + k), k is the out flow rate.

Feeding trials:

A feeding experiment was conducted for 75 days, using thirty male Barki sheep with an average live body weight 25.37±0.37 kg, and 7 months of age were randomly divided into five similar groups (6 male each). Experimental rations based on 60% CFM + 40% fresh berseem (R_1); 60% CFM + 30% berseem +

10% fresh moringa (R_2); 60% CFM+ 20% berseem+ 20% moringa (R_3); 60% CFM + 10% berseem + 30% moringa (R_4) and 60% CFM + 40% moringa (R_5). All rations were offered twice daily at 8.00 a.m. and 4.00 p.m. in two equal portions. Animals were housed in five shaded yards. Daily amounts of tested rations were calculated according to NRC (1994). Drinking water was available at all times.

Blood biochemical constituents:

Blood samples were collected at the end of the experimental period. Blood samples were withdrawn from the external jugular vein of each animal in heparinized tubes before feeding. Plasma was separated by centrifugation at 4000 rpm for 15 min.; various chemical parameters were calorimetrically determined using commercial kits, following the same steps as described by the manufacturers. Glucose concentration was determined according to Trinder (1969). Total protein (TP) was determined according to Armstrong and Carr (1964); albumin was determined according to Doumas *et al.* (1971) and globulin was calculated by subtracting albumin from total protein. Cholesterol was determined according to Roeschlau *et al.* (1974); kidney function was evaluated by measuring blood urea using the colorimetric method of Henry and Todd (1974). Creatinine was measured according to Faulkner and King (1976). Liver function was assessed by measuring the activities of aspartate aminotrasferase (AST) and alanine aminotransferase (ALT) according to Reitman and Frankel (1957).

Statistical analyses:

Collected data were statistically analyzed using the method of least squares analysis of variance using General Linear Models (GLM) procedure (SAS, 2000). The model used was as follow: $Yij = \mu + Ti + eij$ Where: Yij = an observation taken on the jth individual, μ=overall mean, Ti = a fixed effect of the ith treatment (i=1 to 5), eij = A random error assumed to be normally distributed with mean = 0 and variance = σ2. Significant differences among means were separated using LSD test according to Duncan (1955).

RESULTS AND DISCUSSION

Chemical composition, cell wall constituents, minerals content and anti-nutritional factors of experimental forages:

Data of chemical composition, cell wall constituents, and macro elements content of berseem (*Trifolium alexandrinum*) and *Moringa oleifera* green forages are shown in Table (2). Moisture content of moringa was lower than berseem (72.07 vs. 83.53%). Dry matter composition showed that moringa forage contained higher crude protein (CP) equals one and half time have that of berseem (18.33 vs. 11.97%), which is within the range of 15.6 to 26.4% reported by other workers (Malik *et al.*, 1967; Gupta *et al.*, 1989; Becker, 1995; Makkar and Becker, 1996 and 1997, Reyes Sánchez *et al.*, 2006a; Ogbe and John, 2011 and Khalel *et al.*, 2014). Crude fiber (CF) and nitrogen free extract (NFE) were lower in moringa than berseem. Both forages had high ash content being, 8.83% for berseem and 8.87% for moringa. Residual soil particles attached plants during harvesting might be the reason of high ash content. All cell wall constituents were slightly lower in moringa than berseem except hemicellulose. It is important to realize that the chemical composition of moringa can vary considerably mainly depending on the amount of smaller branches, twigs included along with the leaves in the leaf meal and may be due to the differences in the locality of its growth and the stage of maturity prior harvesting. This was shown by Fujihara *et al.* (2005) who analyzed different fractions of *Moringa oleifera* (leaves, seed cake, and soft twigs). The leaves and seed cake had a CP content of approximately 25 to 30 % while leaves with soft twigs had a CP content of 19.5 %.

The CP content of soft twigs alone was yet somewhat lower but this fraction can be used for animals with lower nutrient requirements (Khalel *et al.*, 2014). Macro elements content were remarkably higher in moringa than berseem except that for sodium which was two times higher in berseem than moringa. These results were to a great extent in agreement with those optioned by Moyo *et al.* (2011) in their comprehensive study on moringa dry leaves cultivated under South Africa eco-system. Calcium had the highest value of (3.69%) but sodium had the lowest value (0.21%). Total polyphenols, condensed tannins and saponins were higher in moringa than berseem forage. Polyphenols in this study (2.53%) were lower than 4.3% previously reported by Foidl *et al.* (2001) for moringa leaves. It's worth noting, that at this present concentration simple phenols do not produce any adverse effects when consumed by animals. Meanwhile, these polyphenols have been reported to have multiple beneficial effects that include antioxidant activity, anti-inflammatory action, inhibition of platelets aggregation, antimicrobial and antitumor activities (Thurber and Fahey, 2009). Condensed tannins were 1.78% for moringa vs. 0.43% for

berseem. Comparable value of condensed tannins being 1.4% was recorded by Foidl *et al.* (2001), for fresh moringa foliage while much higher value (3.12%) was recorded for moringa dry leaves by Moyo *et al*. (2011). However, drying was reported to reduce condensed tannins by 15 to 30% relative to fresh plant (Vitti *et al.,* 2005). Saponins were 1.72% for moringa vs. 0.83% for berseem. Comparable value of saponins being 1.60 and 1.75% was recorded by Ogbe and John (2011) and Ojiako (2014), for *Moringa oleifera* leaves. Saponins are glycosides, which include steroid saponins and triterpenoid saponins (Dei *et al*., 2007). These compounds have been observed to kill protozoans, to impair the protein digestion and the uptake of vitamins and minerals in the gut and to act as hypoglycemic agent. Thus, these compounds affect animals in both positive and negative ways (Das *et al.*, 2012).

Table (2): Chemical composition, cell wall constituents, minerals content and anti-nutritional factors of berseem and moringa forages.

Item	Berseem clover	*Moringa oleifera*
Chemical composition, %:		
Moisture	83.53	72.07
DM	16.47	27.93
OM	91.17	91.13
CP	11.97	18.33
CF	26.15	21.46
EE	1.52	2.15
NFE	51.53	49.19
Ash	8.83	8.87
Cell wall constituents, %:		
NDF	48.74	46.62
ADF	36.33	33.82
ADL	11.83	10.11
Hemicellulose	12.41	12.80
Cellulose	24.50	23.71
Macro elements, %:		
Ca	1.47	3.69
P	0.24	0.33
Na	0.49	0.21
Anti-nutritional factors, %:		
Total polyphenols	1.28	2.53
Condensed tannins	0.43	1.78
Saponins	0.83	1.72

Nutrients digestibility and dietary nitrogen utilization:

Apparent nutrients digestion coefficients of experimental rations are given in Table (3). It's obviously that, R_5 (40% moringa) and R_4 (10% berseem + 30% moringa) had the highest ($P<0.05$) digestibility values for all nutrients followed by those of R_3 (20% berseem + 20% moringa), while the lowest values were recorded with R_1 containing 40% berseem. The positive effect of moringa on nutrients digestibility could be regarded to its high content of slow degradable protein or essential amino acids needed to enhance rumen microbial activity. Similar assumption was reported by Poppi and McLennan (1995) that feeding moringa forage improved nitrogen supply and corrected N deficiency of low quality diets. Moreover, Reyes-Sánchez *et al.* (2006b) reported that feeding moringa forage had limited effect on rumen fill due to its low NDF content in which feed intake and nutrients digestibility could be improved. As a result of the higher nutrients digestibility associated moringa containing rations, nutritive values expressed as TDN was ($P<0.05$) higher for R_5 and R_4 than R_1 being respectively, 66.79 and 64.91 vs. 59.78 for TDN%, while DCP was ($P<0.05$) higher for all moringa rations (R_2, R_3, R_4 and R_5) than R_1 being respectively, 8.56, 9.06, 9.48 and 9.92 vs. 8.08 for DCP%. The present results are in good agreement with those reported by Newton *et al.* (2010), Mendieta-Araica *et al.* (2013) and Nouman *et al.* (2013). They also reported that moringa forage is rich in most nutrients as its addition to low quality diets is useful to increase their dry matter intake and nutrients digestibility. Results of nitrogen utilization as well showed remarkable ($P< 0.05$) increase of N-absorbed and N-retained relative to increase N-intake for moringa containing rations. Values of N-intake were 21.76, 22.82, 23.89, 24.94 and 26.01 and N-retained were 5.15, 5.58, 6.77, 7.64 and 8.03 for R_1, R_2, R_3, R_4 and R_5, respectively. The results indicated that

feeding moringa forage in partial or complete substitution of berseem fodder could improve dietary N-utilization with all moringa rations. These results confirmed the previous findings of Mendieta-Aracia *et al.* (2013) and Nouman *et al.* (2013) that moringa leaves had good quality protein, rich of essential amino acids which can enhance dietary N utilization and improve animal productivity.

Table (3): Dry matter intake (g/h/d), nutrients digestibility, nutritive value and nitrogen utilization of the experimental rations fed to male Barki sheep (means ± SE).

Item	Experimental rations				
	R_1	R_2	R_3	R_4	R_5
Dry matter intake (g/h/d):					
Concentrate	628.67	628.67	628.67	628.67	628.67
Berseem	419.99	314.57	209.99	104.58	-
Moringa	-	104.74	209.47	314.21	418.95
TFI*	419.99	419.31	419.46	418.79	418.95
Total DMI	1048.66	1047.98	1048.13	1047.46	1047.62
Digestibility coefficients (%):					
DM	60.12±0.32^{d}	61.24±0.41^{cd}	64.95±0.45^{c}	66.01±0.17^{b}	67.20±0.26^{a}
OM	62.92±0.42^{c}	63.29±0.38^{c}	65.89±0.35^{b}	68.02±0.44^{ab}	69.95±0.31^{a}
CP	62.28±0.47^{b}	62.94±0.36^{b}	63.58±0.24^{a}	63.71±0.13^{a}	63.91±0.12^{a}
CF	55.82±0.17^{d}	55.83±0.14^{d}	57.82±0.08^{c}	58.45±0.25^{b}	60.18±0.26^{a}
EE	61.17±0.15^{d}	64.59±0.13^{c}	63.73±0.27^{c}	70.64±0.14^{b}	72.28±0.29^{a}
NFE	64.93±0.34^{d}	65.02±0.14^{d}	68.26±0.09^{c}	71.01±0.23^{b}	73.40±0.18^{a}
Nutritive value (%):					
TDN	59.78±0.58^{d}	60.27±0.49^{d}	62.69±0.13^{c}	64.91±0.28^{b}	66.79±0.24^{a}
DCP	8.08±0.16^{d}	8.56±0.11^{c}	9.06±0.19^{c}	9.48±0.14^{b}	9.92±0.21^{a}
Nitrogen utilization (g/h/d):					
N-intake (g/d)	21.76±0.25^{b}	22.82±0.22^{b}	23.89±0.28^{ab}	24.94±0.34^{a}	26.01±0.25^{a}
N-absorbed (g/d)	13.55±0.25^{d}	14.36±0.22^{c}	15.19±0.19^{b}	15.89±0.16^{b}	16.62±0.21^{a}
N-retained (g/d)	5.15±0.09^{e}	5.58±0.11^{d}	6.77±0.13^{c}	7.64±0.15^{b}	8.03±0.20 ^{a}
N- retained e as % of N-intake	23.67±0.35^{d}	24.45±0.22^{c}	28.34±0.27^{b}	30.63±0.21^{a}	30.87±0.47^{a}
N- retained as % of N-absorbed	38.01±0.55^{c}	38.86±0.76^{c}	44.57±0.33^{b}	48.08±0.39^{a}	48.32±0.41^{a}

a, b, c, d and e: means in the same row with different superscripts are significantly (P<0.05) different.
**TFI = Total fodder intake [berseem (Trifolium alexandrinum) +Moringa oleifera].*
R_1 = 60 % CFM + 40 % berseem (Trifolium alexandrinum).
R_2 = 60 % CFM + 30 % berseem (Trifolium alexandrinum) + 10 % Moringa oleifera.
R_3 = 60 % CFM + 20 % berseem (Trifolium alexandrinum) + 20 % Moringa oleifera.
R_4 = 60 % CFM + 10 % berseem (Trifolium alexandrinum) + 30 % Moringa oleifera.
R_5 = 60 % CFM + 40 % Moringa oleifera.

Rumen fermentation:

Rumen fermentation activity of animals fed experimental rations is given in Table (4). Rumen liquor pH values and NH_3-N concentration were lower (P<0.05) with increasing moringa in rations (R_3, R_4 and R_5) than R_1 and R_2, while total VFA's concentration was remarkably higher for R_3, R_4 and R_5 than R_1 and R_2. In similar trend, microbial nitrogen yield was greater with the moringa rations (R_5) than that of R_1 (40% berseem containing ration). Molar proportion % of propionic acid and butyric acid were insignificantly lower with increasing moringa in experimental rations. Acetic acid, acetic: propionic ratio and rumen volume (L) were higher (P<0.05) with increasing moringa in rations. These results are matching with the results of degradation kinetics (Table 5) that moringa had higher DM effective degradability but lower soluble and degradable CP than berseem forage. Moreover, the obvious high microbial protein synthesis and dietary nitrogen utilization may indicated that moringa containing rations improved the synchrony between dietary energy and protein which was resulted in lower ruminal ammonia-N and higher VFA's than berseem. The present results confirmed the previous results of Hoffmann *et al.* (2003) who stated that, the low ruminal NH_3-N associated with moringa supplementation is attributed to its low protein degradability. Soliva *et al.* (2005) concluded that moringa leaves are not suggested as a source of rumen protected protein. They proposed that it promotes rumen microbial protein synthesis due to its substantial contents of readily fermentable N and energy. They concluded that it still

has to be shown whether or not this protein is arriving at the duodenum of the ruminant and in how far these feeds are competitive to the more common protein sources in highly productive growing or milk producing ruminants. However, Alexander *et al.* (2008) found that NH_3-N concentration was decreased when a medium of white clover hay was incubated with moringa leaves extract. Some other studies mentioned that, the relatively high contents of tannins and saponins which are naturely occurring in moringa leaves could affect ruminal proteolytic activity resulted in lower ruminal ammonia-N (Oliveira *et al.*, 1999; Sliwinski *et al.*, 2002 and Soliva *et al*., 2005). The later assumption may not hold true since VFA's concentration and microbial yield in the present study were higher with moringa rations, however, moringa contained higher tannins and polyphenols than berseem (see Table 2). The rate of out flow observed in this study with R_5 could be considered as suitable rate of out flow for efficient microbial nitrogen synthesis.

Table (4): Overall mean of rumen parameters of sheep fed the experimental rations (means ± SE).

Item	Experimental rations				
	R_1	R_2	R_3	R_4	R_5
pH	6.44 ±0.04^{a}	6.42 ±0.05^{a}	6.36 ±0.02^{ab}	6.31 ±0.07^{b}	6.28 ± 0.05^{b}
NH_3-N concentration(mg/100ml)	15.11 ±0.09^{a}	15.09 ±0.06^{a}	13.81 ±0.17^{b}	13.76 ±0.11^{b}	12.22 ±0.19^{c}
VFA´s concentration (meq/100 ml)	11.28 ±0.32^{b}	11.32 ±0.14^{b}	14.60 ±0.24^{ab}	14.67 ±0.27^{ab}	15.68 ±0.18^{a}
Molar proportion %					
Acetic acid, %	57.86 ±0.42^{b}	57.94 ±0.62^{b}	60.43 ±0.17^{ab}	62.89 ±0.76^{a}	63.04 ±0.33^{a}
Propionic acid, %	25.91 ±0.52	25.65 ±0.68	25.44 ±0.610	25.07 ±0.78	25.02 ±0.71
Butyric acid, %	10.89 ±0.16	9.24 ±0.22	9.01 ±0.17	8.91 ±0.21	8.84 ±0.12
Acetic : propionic ratio	2.23 ± 0.03^{b}	2.26 ±0.05^{b}	2.38 ±0.09^{ab}	2.51 ±0.06^{a}	2.52 ±0.01^{a}
Rumen volume (L)	3.05 ±0.08^{d}	3.24 ±0.03^{c}	3.36 ±0.12^{b}	3.44 ±0.17^{b}	3.68 ±0.09^{a}
Rate of out flow (% hr)	6.20 ±0.10^{a}	6.14 ±0.09^{a}	6.06 ±0.11^{b}	5.93 ±0.06^{b}	5.64 ±0.11^{c}
Microbial nitrogen yield (g/d)	12.67 ±0.05^{d}	12.77 ±0.11^{d}	13.30 ±0.10^{c}	13.70 ±0.07^{b}	14.09 ±0.09^{a}

a, b, c and d: means in the same row with different superscripts are significantly (P<0.05) different.
R_1 = 60 % CFM + 40 % berseem (Trifolium alexandrinum).
R_2 = 60 % CFM + 30 % berseem (Trifolium alexandrinum) + 10 % Moringa oleifera.
R_3 = 60 % CFM + 20 % berseem (Trifolium alexandrinum) + 20 % Moringa oleifera.
R_4 = 60 % CFM + 10 % berseem (Trifolium alexandrinum) + 30 % Moringa oleifera.
R_5 = 60 % CFM + 40 % Moringa oleifera.

Degradation kinetics:

Estimates of ruminal degradation contents (a, b and c) fitted with rates of DM and CP disappearance of tested roughages are presented in Table (5). The results illustrated that washing loss soluble degradable fraction% "a", potentially degradable fraction% "b", rate of degradation "c" and effective degradability "ED" of DM were lower (P<0.05) for berseem than moringa, meanwhile mixing berseem with moringa was associated with improving all degradable fractions than for berseem alone. The high degradable fractions of moringa DM could be regarded to its high contents of soluble ash and readily fermentable carbohydrates. Ndemanisho *et al.* (2007) reported that moringa leaves had higher values of ruminal DM degradation kinetics than leucaena. In the contrast, berseem had the highest CP (P<0.05) degradation fractions of a and b and effective degradability "ED" either alone or in mixture in comparison to moringa. Highest (P<0.05) ruminal undegradable protein (RUP) was recorded with R_5, while R_1 and R_2 were recorded lowest values. Makkar and Becker (1996) reported that about 95% of moringa crude protein was found to be available either in the rumen or in the post rumen. The protein potentially digestible in the intestine (PDI) was 47% of the total crude protein of moringa. The PDI is available to the animal for

production purposes. They added that PDI values obtained for moringa leaves were much higher than those for various conventional protein supplements like seed meal. High crude protein contents and high PDI values of moringa leaves could suggest that these leaves are good source of protein supplement for high producing animals. Kleinschmit *et al.* (2007) cited that proteins that resist degradation in the rumen and pass to the lower tract for digestion" bypass" is necessary for maximizing production of ruminants and high producing dairy animals. They concluded that values of potential and effective degradability and rates of degradation of both DM and CP were affected by diet formulation and levels of fibrous carbohydrates rather than animal species.

Average daily gain, feed intake, feed conversion and economic efficiency:

Average daily gain, feed intake, feed conversion and economic efficiency are given in Table (6). Daily DM intake was nearly comparable among groups. Feed conversion was improved ($P<0.05$) with all moringa rations in comparison with R_1 (40% berseem). Aregheore (2002) found that feeding *M. oleifera* at 20 or 50% of the total daily forage intake to goats was resulted in better dietary protein utilization and feed conversion. Economic return and economic efficiency were higher with moringa than berseem. In this context, Adegun and Aye (2013) reported that the cost of produced milk was reduced when *M. oleifera* leaf meal replaced cotton seed meal in the rations of dairy cows, which in turn increase profits.

Table (5): Degradation kinetics of DM and CP of experimental forages (means ± SE).

Item	Experimental rations				
	R_1	R_2	R_3	R_4	R_5
	DM				
a	28.11±0.17^{c}	28.65±0.52^{bc}	30.03±0.35^{b}	31.98±0.49^{a}	32.16±0.34^{a}
b	37.14±0.86^{c}	38.41±0.57^{c}	42.58±0.52^{b}	42.99±0.57^{b}	44.29±0.38^{a}
c	0.051±0.001^{d}	0.053±0.002^{c}	0.058±0.002^{b}	0.058±0.002^{c}	0.062±0.002^{a}
ED	51.49±0.17^{d}	53.18±0.22^{c}	58.09±0.30^{b}	60.31±0.37^{ab}	62.01±0.21^{a}
	CP				
a	23.47±0.20^{a}	23.36±0.23^{a}	21.12±0.19^{b}	20.07±0.18^{c}	20.00±0.14^{c}
b	57.92±0.42^{a}	57.79±0.28^{a}	51.60±0.33^{b}	50.79±0.32^{b}	45.32±0.21^{c}
c	0.074±0.002^{a}	0.073±0.002^{a}	0.067±0.002^{b}	0.067±0.001^{b}	0.063±0.001^{c}
ED	64.68±0.12^{a}	64.32±0.17^{a}	56.76±0.11^{b}	55.15±0.32^{b}	50.70±0.22^{c}
RUP	35.32±0.44^{c}	35.68±0.34^{c}	43.24±0.39^{b}	44.85±0.30^{b}	49.30±0.21^{a}

a, b, c and d: means in the same row with different superscripts are significantly ($P<0.05$) different.
a= soluble degradable fraction (%). b= potentially degradable fraction (%).
c= rate of degradability (% h-1). ED= effective degradability (%).
RUP = 100 - ED (Ørskov and McDonald, 1979).
R_1 = 60 % CFM + 40 % berseem (Trifolium alexandrinum).
R_2 = 60 % CFM + 30 % berseem (Trifolium alexandrinum) + 10 % Moringa oleifera.
R_3 = 60 % CFM + 20 % berseem (Trifolium alexandrinum) + 20 % Moringa oleifera.
R_4 = 60 % CFM + 10 % berseem (Trifolium alexandrinum) + 30 % Moringa oleifera.
R_5 = 60 % CFM + 40 % Moringa oleifera.

Blood parameters:

Table (7) illustrated that blood glucose was increased ($P<0.05$) with increasing moringa in rations compared with the control one. However, high blood glucose level with moringa feeding might support the assumption that, moringa forage could help in bypassing some soluble carbohydrates to be absorbed as glucose which helps in increasing the metabolizable energy intake. Annison *et al.* (2002) found a linear relationship between glucose entry rate and metabolizable energy intake. Total protein, albumin and globulin were higher ($P<0.05$) for male Barki sheep fed moringa rations (R_3, R_4 and R_5) than those fed berseem ration (R_1), while no significant differ between R_1 and R_2. Moreover, blood cholesterol was decreased ($P<0.05$) with moringa rations, however the effect was more pronounced with 40% moringa ration. Urea was decreased with increasing moringa level in rations compared with R_1 (40% berseem), while insignificantly differ ($P>0.05$) among rations of creatinine, aspartate (AST) and alanine (ALT) transaminases were concern. In other words, feeding moringa up to 40% of the whole daily ration did not badly affects liver or kidney functions. On the other hand, the significantly lower cholesterol level associated with feeding moringa may be related to the higher phytonutrients content of moringa than other common forages. Astuti *et al.* (2011) reported that saponins content in moringa had good effect on animal health as expressed in low serum cholesterol and normal essential fatty acids concentration. The

Table (6): Average daily gain, feed intake, feed conversion (means ± SE) and economic efficiency of male Barki sheep fed the experimental rations.

Item	Experimental rations				
	R_1	R_2	R_3	R_4	R_5
Initial BW (kg/h)	25.75 ±1.50	25.55 ±1.75	25.00 ±1.66	25.10 ±1.42	25.60 ±1.55
Final BW (kg/h)	34.65 ±1.33^{c}	34.81 ±1.17^{c}	35.47 ±1.29^{b}	36.25 ±0.97^{ab}	38.89 ±1.44^{a}
Total gain (Kg/h)	8.90 ±0.26^{d}	9.26 ± 0.18^{d}	10.47 ±0.30^{c}	11.15 ± 0.15^{b}	13.29 ± 0.19^{a}
Average daily gain (g/h)	118.67 ±1.63^{d}	123.45 ±4.33^{d}	139.64 ±1.88^{c}	148.66 ±0.41^{b}	177.20 ±1.59^{a}
Feed intake(g/h/d):					
DMI	1025.50 ±19.7	1030.20 ±24.6	1055.30 ±15.6	1065.60 ±23.1	1070.50 ±22.5
TDNI	613.04 ±15.07^{c}	620.90 ±16.88^{c}	661.57 ±12.43^{b}	691.68 ±21.05^{a}	714.99 ±9.18^{a}
Feed conversion:					
Kg DMI/ Kg gain	8.64 ±0.15^{a}	8.35 ±0.21^{a}	7.56 ±0.09^{b}	7.17 ±0.22^{b}	6.04 ±0.13^{c}
Kg TDNI/ Kg gain	5.17 ±0.05^{a}	5.03 ±0.6^{ab}	4.74 ±0.11^{b}	4.65 ±0.8^{b}	4.03 ±0.05^{c}
Economic efficiency:					
Average daily feed cost (L.E)	2.07	2.01	2.00	1.95	1.89
Price of daily gain(L.E)	3.92	4.07	4.61	4.91	5.85
Economical return (L.E /h/d)	1.85	2.06	2.61	2.96	3.96
Economic efficiency (%)	1.89	2.02	2.31	2.52	3.10
Relative economic efficiency	100	107	122	133	164

a, b, c and d: means in the same row with different superscripts are significantly (P<0.05) different.

Calculation based on the following price in Egyptian pound (L.E.) per ton at 2014: Berseem clover = 240 L.E/ton. Moringa forage = 230 L.E. / ton, CFM = 2150 L.E. / ton. The price of one kg of live body weight was 33 L.E.

$$\text{Economic efficiency (\%)} = \frac{\text{Price of daily gain (L.E)}}{\text{Average daily feed cost (L.E)}}$$

R_1 = 60 % CFM + 40 % berseem (Trifolium alexandrinum).
R_2 = 60 % CFM + 30 % berseem (Trifolium alexandrinum) + 10 % Moringa oleifera.
R_3 = 60 % CFM + 20 % berseem (Trifolium alexandrinum) + 20 % Moringa oleifera.
R_4 = 60 % CFM + 10 % berseem (Trifolium alexandrinum) + 30 % Moringa oleifera.
R_5 = 60 % CFM + 40 % Moringa oleifera.

Table (7): Blood biochemical constituents of male Barki sheep fed the experimental rations (means ± SE).

Item	Experimental rations				
	R_1	R_2	R_3	R_4	R_5
Glucose, mg/dl	56.65±0.74^{b}	57.54±0.55^{b}	62.87±0.63^{ab}	65.32±0.88^{a}	66.64±0.53^{a}
Cholesterol, mg/dl	94.39±0.59^{a}	92.31±0.89^{a}	81.53±0.28^{b}	83.49±0.63^{b}	76.62±0.53^{c}
Total protein, g/dl	6.68±0.33^{b}	6.85±0.21^{b}	7.18±0.28^{ab}	7.42±0.11^{a}	7.85±0.52^{a}
Albumin, g/dl	3.11±0.10^{b}	3.19±0.09^{b}	3.49±0.12^{a}	3.63±0.07^{a}	3.77±0.09^{a}
Globulin, g/dl	3.57±0.09^{c}	3.66±0.10^{c}	3.69±0.19^{b}	3.79±0.13^{b}	4.08±0.19^{a}
Urea, mg/dl	21.73±0.53^{a}	21.18±0.31^{ab}	20.22±0.29^{b}	20.54±0.33^{b}	20.18±0.42^{b}
Creatinine, mg/dl	0.95±0.08	0.93±0.05	0.90±0.10	0.88±0.06	0.86±0.09
AST, U/L	33.83±0.22	32.44±0.49	32.23±0.63	31.77±0.39	31.14±0.52
ALT, U/L	20.18±0.68	20.06±0.74	19.96±0.55	19.83±0.79	19.39±0.61

a, b and c: means in the same row with different superscripts are significantly (P<0.05) different.

R_1 = 60 % CFM + 40 % berseem (Trifolium alexandrinum).
R_2 = 60 % CFM + 30 % berseem (Trifolium alexandrinum) + 10 % Moringa oleifera.
R_3 = 60 % CFM + 20 % berseem (Trifolium alexandrinum) + 20 % Moringa oleifera.
R_4 = 60 % CFM + 10 % berseem (Trifolium alexandrinum) + 30 % Moringa oleifera.
R_5 = 60 % CFM + 40 % Moringa oleifera.

lower blood urea level associated with feeding moringa forage was expected from the higher dietary N utilization of rations containing moringa than that contained berseem (Table 3). Hoffmann *et al.* (2003) assumed that, the high utilization of moringa nitrogen could be regarded to its cationic protein and rumen microbes interaction that allow their availability in the small intestine in an intact form.

CONCLUSION

From the results of this study, it's fair to conclude that introducing *Moringa oleifera* green forage in partial or complete replacement of berseem (*Trifolium alexandrinum*) fodder is highly recommended to improve growth performance, health status and economic revenue of male Barki sheep. However, there is a need for more studies concerning with energy and protein utilization of fresh or dry moringa leaves in the feeding practices of sheep.

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أثر الإحلال الكلي أو الجزئي للبرسيم من المورينجا على الأداء الإنتاجى للأغنام.

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أجريت هذة الدراسة لمعرفة مدي تأثير الإستبدال الجزئي او الكلى للبرسيم بالمورينجا ومدي تأثيرها علي معاملات الهضم ومعدل إختفاء المادة الجافه والبروتين للمورينجا مقارنه بالبرسيم و الاستفادة من النيتروجين ونشاط تخمرات الكرش والأداء الإنتاجي وخصائص الدم للأغنام البرقي. تم أجراء تجارب الهضم لمخاليط العلائق المختبرة باستخدام كباش برقى (ثلاثة لكل عليقة) بينما أستخدمت ثلاثة نعاج مزودة بفستيولات الكرش لقياس نشاط الكرش و لتقدير معدل التحلل للمادة الجافة والبروتين فى الكرش. وأستخدم ثلاثون ذكر من أغنام البرقي بمتوسط وزن 25.37±0.37كجم عند 7 شهور من العمر قسمت عشوائيا إلي خمس مجموعات متشابهه (6 ذكر /مجموعه) فى تجارب التغذيه والنمو والتى غذيت لمدة 75 يوم مع تسجيل الأوزان وأخذ عينات الدم في نهايه مدة التغذية.

و كانت العلائق المستخدمه كما يلى :

1. عليقه المحطه (مجموعة ضابطه) تحتوي علي60٪ من العلف المركز+40 ٪ برسيم طازج.
2. عليقه تحتوي علي60٪ من العلف المركز +30٪ برسيم طازج + 10٪ مورينجا طازجة.
3. عليقه تحتوي علي60٪ من العلف المركز +20٪ برسيم طازج + 20٪ مورينجا طازجة.
4. عليقه تحتوي علي60٪ من العلف المركز +10٪ برسيم طازج + 30٪ مورينجا طازجة.
5. عليقه تحتوي علي60٪ من العلف المركز +40٪ مورينجا طازجة.

و تم حساب متطلبات التغذية علي أساس NRC (1994) .

أشارت النتائج إلي إرتفاع معاملات الهضم للعلائق المحتوية علي المورينجا حيث سجلت العليقه الرابعة (10٪ برسيم طازج + 30٪ مورينجا طازجة) و الخامسة (40٪ مورينجا) أعلي قيم هضمية تبعها العليقه الثالثة (20٪ برسيم طازج + 20٪ مورينجا طازجة) بينما سجلت العليقه الأولي (40٪ برسيم طازج) أقل القيم. فى حين سجلت قيم المواد المهضومة الكلية اعلي القيم للعلائق الرابعة والخامسة مقارنه بالعليقه الأولي (المقارنة) في حين سجلت قيم البروتين المهضوم اعلي القيم لكل العلائق المحتويه على المورينجا مقارنة بالعليقه الأولي (40٪ برسيم طازج). كما أظهرت النتائج الزيادة الملحوظة في النيتروجين المحتجز والممتص والراجع إلي النيتروجين المأكول والمهضوم مع العلائق المحتوية علي المورينجا مقارنة بالعليقة المحتوية علي البرسيم فقط كذلك تحسن معدل الإستفادة من النيتروجين. سجلت درجة حموضه سائل الكرش والامونيا أقل القيم بصورة معنوية مع زيادة المورينجا في العلائق (الثالثة والرابعة والخامسة) مقارنة بالأولي والثانية بينما إرتفع نسبه الأحماض الدهنية الطيارة مع زيادة المورينجا في العلائق (الثالثة والرابعة والخامسة) مقارنة بالأولي والثانية. كذلك زاد البروتين الميكروبي مع زيادة المورينجا فى العليقه الخامسة مقارنة بالأولي. بينما قل حمض البروبيونيك والبيوتيرك بصورة غير معنوية مع زيادة المورينجا في العلائق التجريبية. كذلك زاد نسبة حمض الخليك ونسبه حمض الخليك الي البروبيونيك وحجم سائل الكرش, كما لوحظ إرتفاع معدل التكسير للمادة الجافة والبروتين غيرالقابل للتحلل فى الكرش بشكل ملحوظ مع زيادة مستوي المورينجا حتي 40٪ مقارنة بالعليقه الكنترول (الضابطه). وكما إرتفع العائد الإقتصادي والكفاءة الإقتصادية بزيادة المورينجا مقارنة بالبرسيم. وزادت نسبه تركيز السكر والبروتين الكلي والألبيومين والجلوبيولين في الدم لذكور الأغنام المغذاة علي العلائق المحتوية علي المورينجا مقارنة بالعليقه الاولي (40٪ برسيم طازج) بينما إنخفض تركيزات الكوليستيرول واليوريا فى الدم معنويا حيث كان التأثير أكثر وضوحا مع نسبة 40٪ مورينجا.

ويمكن القول ان التغذية علي المورينجا حتى نسبة 40٪ ليس له اي تاثير ضار علي وظائف الكبد أو الكلي. وخلصت هذه الدراسة إلي إرتفاع درجة الإستساغة والقيمة الغذائية للمورينجا لذلك ينصح بالإستبدال الجزئي أوالكلي حتى40٪ للمورينجا محل البرسيم في علائق تغذية الأغنام لما لذلك تأثير على تحسن الأداء والإستفاده الأقتصاديه.