EFFECT OF *MORINGAOLEIFERALAM* LEAVES SUPPLEMENTATION ON RUMEN FERMENTATION, DIGESTIBILITY, FREE RADICALS AND PRODUCTIVE PERFORMANCE OF GROWING LAMBS

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SUMMARY

The objective of this research was to study the antioxidant propertyof*Moringaoleifra* L leaves as feed supplement and its effect on nutrient intake, digestibility, nitrogen balance, and rumen fermentation and growth performance parameters of Rahmanisheep. Twenty one Rahmani lambs averaged (17±0.12 kg) body weight and 4 months old were divided into 3 groups, (7 animals each)in a completely randomized design experiment. Experimentalanimals were fed on concentrate feed mixture (CFM) and clover hay (CH) with different levels of *Moringaoleifera* leaves 0, (R1-control); 10gm/kg of the ration (R2) and 20g of the ration / Kg (R3), respectively in a feeding trial lasted for 90 days.Obtained results indicated thatR3 and R2groups fed rations supplemented with 20 and 10 gm*Moringa* leaves per kg of ration recorded the highest ($P<0.05$) EE digestibility compared with the R1, (control). R3 recoded higher ($P<0.05$) digestibility values of CP and NFE compared with R1 while differences were insignificantcompared with R2 as well as between R2 and R1.Insignificant differences ($P<0.05$) were observed among the three treatments in the digestibility of OM, CF and its fractions (NDF and ADF). R2 also recorded significantly ($P<0.05$) higher TDN values comparedwith R1, while between R3 and R1, differences were not significant. Both R3and R2 were significantly ($P<0.05$) higher in their nitrogen balance compared to R1.No significant differences were observed in pH values of rumen among three treatments at 0, 2 and 4 hours sampling time while at 6 hours R1 showed high ($P<0.05$) pH value compared with R2 and R3. R3 and R2recorded ($P<0.05$) higher values of NH_3N at all sampling times. The same trend was observed that R3 and R2 recorded ($P<0.05$) higher values of rumen TVFA, s compared with R1.No significant difference among R3 and R2 in the values of glutathione peroxidase in the serum of tested animalscompared with control, while, R3 and R2 recorded ($P<0.05$) higher values of serum Glutathione reductase compared with R1. Regarding to non- enzymatic anti-oxidants, R3 and R2 recoded ($P<0.05$) high concentration of Vit. C, Vit. E and zinc compared to R1.R3 and R2 recorded ($P< 0.05$) higher values of final body weight, weight gain and average daily weight gain and FCR compared with R1.It could be concluded that *Moringaoleifera* leaves are suitable feedsupplement at 10 or 20 g/kg of feed without any adverse effect on the performance of Rahmani lambs.

Keywords: *Anti-oxidants Digestibility, growth performance, Rahmani sheep, Moringa.*

INTRODUCTION

Performance ofruminants was reported to be low due to some factors such as feed shortage (quality or quantity) and health constraints (Tsedeke, 2007).Feed shortage is one of the obstacles' facing development of animal productionsector Therefore, many attempts have been made to the improve performance of animals using feed additives (Pluske, 2013).The World Health Organization (WHO) encourages using of medicinal herbs to reduce the use of drugs and chemicals as a Global trend to return to natural nutrients (Mohamed *et al*., 2003). Dietary antioxidants in medicinal herbs, such as vitamins and minerals play an important role in the performance of animals (El-Shahat and Abdel Monem, 2011) and improving digestion by enhancing the bile secretion and pancreatic enzyme activity (Platel*et al*.,2002) and hepatic metabolism (Ayotunde*et al*., 2011). Antioxidants are free radical scavengers; functioning to protect cells against oxidative damage which reduced risk of toxicity and minimum health hazards (Devegowda, 1996).Among herbal plants, Moringa*OleiferaLam*has been recorded higher demandfor its medicinal value as a good source of multi natural antioxidants such as ascorbic acid, flavonoids, phenolics and carotenoids (Anwar *et*

al., 2007; Makkar and Becker, 1996) and amino acids (Olugbemi*etal*., 2010).*MoringaOleiferaLam*is native to North India and fortunately, itis well distributed in many countries of tropics and subtropics (Anwar *et al*., 2007) widely distributed in the Philippines, Cambodia and Central, North and South America (Morton, 1991), Africa and South Asia (Fahey, 2005). It is used for food, medication and industrial purposes.*Moringaoleifera* extract wasreported to have antibacterial properties and conclusion was made to investigate it as a phototherapeutic agent to combat infectious agents (Patel, 2011). Most parts of the plant havebeen used in folk medicine in Africa and South Asia (Fahey, 2005). Sofidiya*et al*., (2006) and Ogbunugafor*et al*., (2011), reported that the medicinal effects of*Moringa*was ascribed to their possession of anti-oxidants, which are known to suppressformation of reactive oxygen species (ROS) and free radicals on the other hand plants generally contain chemical compounds such as saponins, tannins, oxalates,phytates, trypsin inhibitors and cyanogenic glycosides known as secondary metabolites,which are biologically active (Soetan and Oyewole, 2009). Plants are also known to possess high amounts of essential nutrients, vitamins, minerals and fattyacids and fiber (Gafar and Itodo, 2011). The plant was also claimed to boost immune systems (Jayavardhanan*et al*., 1994;Fuglier, 1999 andOlugbemi*et al*., 2010)).The leaves and green fresh pods are rich in carotene and ascorbic acid (vitamin C) with a good profileof amino acids (Makkar and Becker 1996 and Ogbunugafor*et al*., 2011).This study therefore aimed at evaluating the chemical and nutritional composition of*MoringaOleifera*, and to highlight its potential as feed supplement andmedicinal benefits as natural antioxidants in diets of sheep on intake, digestibility, growth performance, rumen parameters and blood ant oxidativestatus.

MATERIALS AND METHODS

This study was carried out into two stages: First stage, the digestibility trial, was conducted at the animalexperimental house of Animal Production Research Institute for a period of 28days, while second stage was for the growth trial which carried out at Mallawy Experimental Station, El-Meniagovernorate and lasted for 90 days. The two places are belonging to the Animal Production Research Institute.

Digestibility and rumen fermentation:

Animals and experimental design:

Three healthy Osimi rams (54 ± 2.3 kg) per treatment were housed individually inmetabolic cages at room temperature and used in three consecutive trials for nutrient feed intake and digestibility determination, while three Osimi rams (50 ± 3.6 kg) per treatment fitted with a permanent rumen fistula, were used as rumen fluid donors.Rams were fed on a basal diet formulated with different levels of *MoringaOleifera*leaves (0. 10 and 20 g/ Kg; respectively) to meet their maintenance requirements (NRC, 1985) composed of roughage: concentrate ratio 30:70, respectively with *ad lib*access to water. The period of this study was 28 days whereas; rams received the basal diet for three weeks as preliminary period and one week for sample collection.

Chemical analysis:

Feed ingredients, *Moringa* leaves powders, concentrate feed mixture CFM, clover hay CH and feces were analyzed for proximate analysis according to AOAC (1990)whereas, nitrogen free extract was calculated by difference. Fiber fractions (NDF and ADF) were analyzed according to (Van Soest., 1994).Nitrogen in urine was determined by micro-kjedahl methods. Nitrogen free extract was calculated by the difference of the sum of all the proximate composition from 100%. The chemical compositions of feed ingredients are presented in Table (1 and 2).

Rumen liquor:

Rumen liquor samples (100ml) were collected from each animal (tree rumen fistulaeted Ossimi rams per treatment) at 4 times, just before morning feeding, 0, 2, 4 and 6hours post-feeding.pHvalues were immediately recorded after collection using a hand pH meter (Orin-Res-EARH, model 30). Rumen liquor samples were filtered through 4 layers of cheesecloth followed by acidified with 0.1 N hydrochloric acid and concentrated orthophosphoric acid and stored by freezing for determination of NH_3-N concentration using MgO distillation method (Al- Rabbat *et al.,* 1971) and the concentration of TVFA, s were estimated

in rumen liquor by the steam distillation method as described by Warner (1964) using Mrkham micro distillation apparatus.

***Feedlot performance**:*

Twenty one Rahmani lambs averaged 17±0.12kg body weight and 4 months old were divided into 3 groups of 7 animals each according to live weight for 90 days trial. Animals were weighed individually firstly and biweekly until the end of the experimental period. The growing lambs were fed (in groups) CFM and CH with different levels of *Moringa oleifera* leaves (0. 10 and 20 g/ Kg of ration, respectively) twice a dayat 8 AM and 4PM and the remaining amounts from the previous day were measured.Water was offered freely all the day round. The CFM was adjusted biweekly according to the body weight changes. Daily feed intake, daily body weight gain were recorded and feed efficiency (g feed/g gain) were calculated accordingly. Lambs were weighted biweekly before morning feeding after 17 hours fasting period.Experimental rations were offered as 70 % CFM and 30% roughage) were offered at 3% of live body weight (LBW).The concentrates feed mixture (CFM) composed of yellow corn grain (55 %), wheat bran (20%), soybean meal (10%), cottonseed meal (12.50%), sodium chloride (1%), limestone (1.3%) and avitamins-minerals mixture (0.2%).

Blood collection and analyses:

The blood samples were taken at the end of termination of the experiment from the jugular vein in dry clean glasses tubes. Each blood samples were divided into two portions; the first portions were poured in tubes without anticoagulant for determination of serum total antioxidant capacity (TAC) and non-enzymatic antioxidants (Vitamin C, Vitamin E, Zinc (Zn) Selenium (Se)by using commercial kits. The second portions were poured in tubes containing 20 IU heparin as anticoagulant and then centrifuged for 15 minutes at 4000 rpm to obtain plasma were used for determination of glutathione peroxidase (GSH-Px) and glutathione reductase (GR-ase) according to Pagelia and Valentine (1967).

***Statistical analysis**:*

Analysis of variance (one-way, ANOVA) was performed to compare between different groups .Statistical analysis was carried out using SAS (2003) and Duncan's multiple range Test (Duncan, 1955) was used to separate the means when the main effect was significant.). The following model was used:

$Yij = \mu + Ti + eij$

Where: Yij = Individual observation, μ = overall mean, Ti = effect of treatment, eij = random error

RESULTS AND DISCUSSION

Chemical composition:

The proximate composition of Moringa leaves and experimental feed ingredients and the formulated rations are shown in Tables (1 and 2). Asshownin Table (1), the crude protein (CP) content of *Moringa* is 24.44 and it exceeds by far the minimum protein requirements for ruminants recommended by ARC (1985).Very close results to that recorded in this research were reported by Makkar and Becker (1996) and Manh *et al*. (2005) whom obtained CP values of 25.1 and 26.4 % respectively while Odee (1998) reported a CP content of 29% for *M. Oleifera*. Variability in the nutrient content of browses has been attributed to within species differences, plant parts, season, harvesting regime, location, soil type and age (Norton 1994).Other studieshave reported variable protein contents ranging between16, 22.42, 23.27, 27.4 and 40% (Moyo *et al* , 2011; Gidamis *et al*., 2003;Sarwatt *et al.,* 2004; Nouala *et al*., 2006; Reyes-Sanchez *et al*., 2006; Oduro *et al*., 2008 and Sanchez-Machado *et al*.,2009).This level of crude protein content is of particular nutritional significance as it may meet animal's protein and energy requirements and boost the immune system against diseases (Kyriazakis and Houdijk, 2006; Brisibe *et al.,* 2009 and Moyo *et al* , 2011). *Moringa* was reported to have high quality protein whichis easily digested and that is influenced by the quality of its amino acids (Foidl *et al.*, 2001). Ogbeand John, (2011) reported that *Moringa* leave proximate analysis revealed the presence of high crude protein(17.01% ±0.1) and carbohydrate (63.11% ±0.09). The leaves also contained appreciableamounts of crude fiber (7.09% ±0.11), ash (7.93% ± 0.12), crude fat (2.11% ±0.11) and fattyacid (1.69% ±0.09). The total ash content showed it contained minerals,

Ca (1.91% ±0.08), K(0.97% ±0.01), Na (192.95±4.4), Fe (107.48±8.2), Mn (81.65±2.31), Zn (60.06±0.3) and P(30.15±0.5) parts per million (ppm). Magnesium (0.38% ±0.01) and copper (6.10±0.19) werethe least.As shown in Table (1) leaves of *Moringa* have high amounts of ascorbic acid, tocopherol vitamins, zinc and selenium minerals similar as reported by (Gafar and Itodo, 2011; Makkar and Becker, 1996).

Digestibility coefficients and nutritive values:

Data of digestibility trial in Table (3) showed thatR3 and R2 groups fed rations supplemented with 20 and 10gm *Moringa* leaves per kg of ration recorded the highest (P<0.05)EE digestibility compared with the R1, (the control group). R3 recoded higher (P<0.05) digestibility values of CP and NFE compared with R1 while insignificant (P<0.05) between R3 and R2 and also between R2 and R1.This is probably because *Moringa* fodder consists of more degradable components especially crude protein (Fadiyimu *et al*., 2010). No significant difference was recorded among R3 R2 and R1 thedigestibility values of OM, CF and its fractions (NDF and ADF). Regarding to Nutritive values of tested rations, R3 recorded significantly (P<0.05) higher TDN values compared to control while between R3 andR2 and between R2 and R1 differences were not significant. Both R3 and R2 were significantly (P<0.05) higher in their nitrogen balance compared with control. As shown in Table (3) DCPvalues of R3, R2 and R1were statistically insignificant. As shown in Table (3), level of *Moringa* supplementation was significant (P<0.05) for NFE digestibility suggesting that increasing level of *Moringa* supplementation will probably enhance the utilization of the soluble carbohydrate components of the dietary organic matter.

Table (3) depicts the nitrogen (N) balance when *Moringa*leaves were fed to experimental sheep. N intake increased from control treatment to R3 3, hence it has significant (P<0.05) direct relationship with dietary level of *Moringa.* This is probably due to increased CP intake with increasing level of *Moringa* inclusion in the experimental diets as reported above. According to Brooker *et al.*, (1995), when feed is high in soluble plant protein, N metabolism occur mainly in the rumen rather than in the lower digestive tracts leading to the production of large quantities of ammonia N in excess of the requirements of rumen microorganisms. The ammonia N not utilized by the bacteria is converted to urea by the animal and excreted in urine. This means that more rumen ammonia would be produced with the *Moringa*-supplemented diets which would have increased as N intake increases from treatments 2 to 3. This perhaps explains why values of total N output were recorded as the level of *Moringa*supplementation increased in this study. Fadiyimu *et al*., (2010) reported that *M. oleifera* had significantly higher crude protein intake, higher dry matter and nutrient digestibility's, higher nitrogen retention and better hematological profile in the supplemented than non-supplemented animals.

Rumen liquor parameters:

As given in Table (4), no significant differences (P<0.05) were observed in pH values of rumen among three treatments at 0, 2 and 4 hours sampling time while at 6 hours control group (R1) showed higher (P<0.05) of pH value compared with R2 and R3 supplemented with*Moringa* leaves. The means of pH values of sheep in the three tested groups were within the normal range as mentioned by Hungate (1996) being 5.5 to 6.86 as shown in Table (4). Variations in pH values obtained in the present study could be explained that rumen pH values were varied according to the nature of diet, after feeding time and quantities of organic acids in the ingesta mentioned before by Phillipson (1970). Recorded values of NH_3N concentration as given in Table (4) indicated that the minimum NH_3N value was recorded at zero time and gradually increased to the maximum at 4 hours post feeding and tended to decrease again at 6hours post feeding. Groups of R3 and R2 supplemented with *Moringa* leaves recorded significantly (P<0.05) higher values of NH_3N in all times. The significant increase in NH_3N values in *Moringa*R3 and R2 than control could be attributed to the high content of soluble protein in *Moringa* leaves (Brooker*el al.*, 1995).Ammonia-N concentration was found in this current study to be within the normal range described by Church (1976), being 10 to 45 mg/100 ml depending on composition of the ration, time of sampling and method of analysis used. Also, Mehrez (1992) indicated that the optimal NH_3-N concentration for maximum rate of fermentation in the rumen was affected by the dietary type and level of fermented energy in the rumen. The same trend was observed that R3 and R2 supplemented with *Moringa* recorded (P<0.05) higher values of rumen TVFA,s compared with control. Recorded values of TVFA,s concentration as given in Table (4) indicated that the minimum value was recorded at zero time and gradually increased to the maximum at 4 hours post feeding and tended to decrease again at 6hours post feeding. The highest value of TVFA's concentration was at 4 hours post feeding, which was reflected on pH values at the same time.

Antioxidant activity:

Determination of enzymatic and non –enzymatic antioxidant in the serum of tested animal of the three treatments is shown in Table (5). Analyses of variance showed no significant difference among R3, R2 and R1 in the values of glutathione peroxidase in the serum of tested animals, while, R3 and R2 recorded (P<0.05) higher values of serum Glutathione reductase compared with control. Regarding to non-enzymatic anti-oxidants as shown in Table (5), R3 and R2 recoded (P<0.05) high concentration values of Vit. C, Vit. E, zinc and selenium compared with control. The same trend of significance was observed with values of the overall total antioxidant capacity. Yang *et al.* (2006) reported that with the survey of120 edible plant species, *Moringa oleifera* were found among the most promisingspecies according to their high antioxidant activity, high contents of micronutrients and phyto-chemicals, processing properties, ease of growing and palatability. Yang *et al*. (2006) also reported that concentrations of four natural antioxidants (total phenolics and anti-oxidant vitamins A, C and E) were measured in four species of *Moringa*and found the content ranges on a dryweight basis were 74−210 μmol/g for phenolics, 70−100 μmol/g for ascorbate (Vit C), 1.1−2.8 μmol/g for β-carotene and 0.7 − 1.1 μmol/g for α-tocopherol (Vit E). Antioxidant content of *Moringas* are high even compared to vegetables and fruitsknown for high antioxidant contents such as strawberries high in phenolics (330 mg gallic acid (GA)/100g fw, or ~190 μmol GA/g dw); hot pepper high in ascorbate (200mg/100g fw, or ~110 μmol/g dw), carrot high in β-carotene (10 mg/100g fw, or ~1.8μmol/g dw) and soybean which is high in α-tocopherol (0.85 mg/100g fw, or ~1.8μmol/g dw). *Moring* isan excellent source of a wide spectrum of dietaryantioxidants. Moyo *et al.* (2011) reported that dried *Moringa* leaves had high levels of zinc (31.03 mg/kg) while, Barminas *et al.* (1998) reported 25.5 mg/kg indried*Moringa* leaves. Zinc is essential for the synthesisof DNA, RNA, insulin and function and/or structure of several enzymes (Brisibe *et al*., 2009). Zinc is alsorequired for cellreproduction and growth especiallysperm cells. In addition, Zn is known for its anti-viral, anti-bacterial, anti-fungal and anti-cancer properties (Brisibe *et al*., 2009). Beta-carotene is the most potent precursor to vitamin A. *Moringa* is reported to be rich in vitamin C whichincreases iron absorption in the animal's body (Anwar *et al*., 2007). Beta-carotene rich *Moringa*leaves can thus be animportant source of vitamin A, can be used for releasingthe bound iron status and thus, help in reducing anemia as well as prevalence of Vitamin A deficiency. Vitamin E with selenium contains antioxidant that workco-dependently in the body to help destroy free radicals(Rock *et al.*, 2001). The interaction of selenium andimmune function focuses around the seleno-protein, glutathione peroxidase. Gluthione peroxidase inactivatesoxygen radicals such as hydrogen peroxide and preventsthem causing cellular damage.

Growth performance:

As illustrated in Table (6), groups R3 and R2 fed rations supplemented with *Moringa* leaves at levels 20 and 10 gm/ kg of the tested rations recorded (P< 0.05) higher values of final body weight, weight gain and average daily weight gain compared with control. Regarding to feed intake, no significant difference were found among three treatments in DM, TDN intake while groups in R3 and R2 had (P>0.05) higher CP intake compared with control. *Moringa* is reported to have high quality protein whichis easily digested and that is influenced by the quality of its amino acids (Foidl *et al*., 2001). Groups fed R3 and R2 achieved (P< 0.05) higher FCR compared with control. This positive achievement in FCR by R3and R2 could be attributed to the significant effect of incorporation of dried *Moringa* leaves in rations fed to animals of those groups on their rumen activities, nutrients digestibility and growth performance. Mahmoud (2013) reported that rations contained *Moringa oleifera* stems achieved higher feed efficiency than control rations with highly significant different and concluded that *Moringa oleifera* stems are suitable for feeding sheep and can be used to replace a part of clover hay or concentrate feed mixture without any adverse effect on the performance of Rahmani lambs. Worku (2016) reported that *Moringa* leaves totally replacing cottonseed cake in growing lambs fed on low-quality hay increased hay intake, diet DM digestibility and daily weight gain. Sultana *et al*. (2015) found that Bengal goat fed diet (75% Moringa foliage and 25% CFM) recoded (P<0.05) the highest daily live weight gain compared with control.

CONCLUSION

This study revealed that *Moringaoleifera* had high crude protein and lower crude fiber contents and its inclusion in the diets of sheep as supplement resulted in significantly higher crude protein intake, higher dry matter and nutrient digestibility's, higher nitrogen retention and better health and growth performance in the supplemented than non-supplemented animals at 10 or 20 g/kg of rations.

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تأثير إضافة اوراق المورنجا على وظائف الكرش، الهضم و الشوارد الحرة والاداءالانتاجى للحملان النامية

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قسم بحوث استخدام المخلفات -معهد بحوث الانتاج الحيوانى مركز البحوث الزراعية – الدقى-الجيزة- مصر.

يهدف هذا البحث الى دراسة اثر المواد المضادة للاكسدة فى اوراق المورنجا كاضافة علفية وتاثرها على الماكول من المركبات الغذائية، معاملات الهضم ، ميزان النيتروجين، تخمرات الكرش واداء النمو فى الاغنام الرحمانى. تم استخدام عدد ٢١ حمل رحمانى بمتوسط وزن ١٧ ± ٠.١٢ كجم وعمر ٤ اشهر وزعت عشوائيا على ثلاث مجموعات بكل مجموعة ٧ حملان. تم تغذيت حيوانات التجربة على عليقة مكونة من خليط من العلف المركز ودريس البرسيم وتم اضافة اوراق المورنجا الجافة للعليقة بنسب (٠ ، ١٠ و ٢٠ جم/ كجم من العليقة) وتم تغذية الثلاث معاملات لمدة ٩٠ يوم كفترة تجريب. أظهرت النتائج المتحصل عليها ان المجموعة الثالثة والثانيةالمدعمة علائقها بالمورنجا (١٠ و ٢٠جم/كجم عليقة) نتائج معنوية فى معاملات هضم االدهن بالمقارنة بالمجموعة الضابطة عند درجة معنوية ($P<0.05$) وحققت المجموعة الثالثة فروقا معنوية فى معاملات هضم البروتين والمركب الخالى من الازوت بالمقارنةبالمجموعةالضابطةولم تكن الفروق معنوية بين المجموعة الثالثة والمجموعة الثانية وبين المجموعة الثانية والمجموعة الضابطة لنفس القياسات. اما معاملات هضم المادة لمادة العضوية والالياف ومكوناتها كانت الفروق بينها غير معنوية للثلاث مجموعاتو حققت المجموعات المضاف اليها المورنجا فروقا معنوية فى قيم المركبات الكلية المهضومة وميزان الازوت بالمقارنة بالمجموعة الضابطة. كانت الفروق غير معنوية بين المجموعات الثلاث فى قيم pH عند ٠ و٢ و٤ ساعات من اخذ العينة بينما كانت الفروق معنوية عند ٦ ساعات للمجموعة الضابطة بالمقارنة بالمجموعتينالمدعمتين بالمورنجا. حققت المجموعة الثالثة والثانية المدعمة بالمورنجا فروقا معنوية فى قيم الامونيا ومجموع الاحماض الدهنية الطيارة بالكرش بالمقارنة بالمجموعة الضابطة. حققت المعاملة الثالثة والثانية فروقا معنوية فى قيم الانزيمات المضادة للاكسدة والانزيمات غير الموكسدة بالمقارنة بالمجموعة الضابطة. حققت المجموعتينالمدعمة بالمورنجا فروقا معنوية فى قيم الزيادة الكلية واليومية فى الوزن وكذلك معاملالتحويل الغذائى بالمقارنة بالمجموعة الضابطة. يخلص من هذا البحث ان اوراق المورنجا يمكن استخدامها كاضافة فى اعلاف الاغنام بمعدل ١٠ او ٢٠ جرام لكل كيلو جرام من العليقة دون اى اثار سلبيةعلى اداءالنمو.

Table (1): Nutrient contents of Moringa leaves

Item	%
Nutrients analyzed of Moringa leaves (% DW)	
DM	23.10
OM	91.79
CP	24.44
CF	3.43
EE	2.51
NFE	61.41
Ash	8.21
Non-enzymatic antioxidants in Moringaoleifera leaves	
Ascorbic acid(mg/g)	5.82
Tocopherol (µg/g)	5.91
Zinc (Zn) *(mg/Kg)*	1.82
Selenium (Se) *(mg/Kg)*	0.11

Table (2): Chemical composition of feed ingredients and the formulated rations % (on DM basis)

Item	Clover hay	Concentrate feed mixture	Control ration
OM	89.41	88.06	88.46
CP	12.33	14.96	14.18
CF	26.29	12.11	16.37
EE	1.91	5.38	4.34
NFE	48.88	55.61	53.57
Ash	10.59	11.94	11.54
NDF	51.96	36.27	40.98
ADF	35.33	22.1	26.09

Table (3): Digestibility, nutritive values and nitrogen balance ofexperimental rations.

Item	Experimental rations			±SE
	R_1	R_2	R3	
Intake				
DM intake(g/day)	1068.57	1079.76	1103.52	
Digestibility coefficients %				
OM	70.39	71.62	73.12	1.02
CP	70.8^{3b}	72.65^{ab}	73.82^{a}	0.54
CF	50.65	51.46	53.16	0.71
EE	80.89^{b}	82.84^{a}	83.08^{a}	0.31
NFE	75.74^{b}	76.61^{ab}	77.15^{a}	0.32
NDF	65.76	66.16	66.49	2.03
ADF	58.75	59.18	59.86	0.79
Nutritive value %				
TDN	66.66^{b}	67.85^{ab}	69.19^{a}	0.65
DCP	10.04	10.30	10.47	0.41
Nitrogen Utilization (g/day)				
N I	24.24	24.51	25.04	0.33
N O	22.53	22.59	22.98	0.54
N B	1.71^{b}	1.92^{a}	2.06^{a}	0.05

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

Table (4): Rumen parameters of sheep fed the experimental rations.

Item	Experimental rations			SE±
	R_1	R_2	R3	
pH				
Sampling time (hr):				
0	6.87	6.78	6.75	0.12
2	6.25	6.21	6.17	0.12
4	5.98	5.93	5.84	0.05
6	6.57^{a}	6.41^{b}	6.36^{b}	0.03
NH3-N (mg/100 ml				
Sampling time (hr):				
0	12.19^{b}	12.53^{b}	13.53^{a}	0.13
2	14.56^{c}	16.80^{b}	18.54^{a}	0.08
4	18.51^{b}	18.97^{b}	21.32^{a}	0.17
6	15.17^{b}	15.51^{b}	16.76^{a}	0.22
TVFA,s (meq/100 ml				
Sampling time (hr):				
0	6.76^{b}	7.98^{a}	8.03^{a}	0.11
2	8.15^{b}	8.56^{ab}	8.69^{a}	0.12
4	10.38^{c}	10.87^{b}	11.51^{a}	0.13
6	8.11^{c}	8.34^{b}	8.56^{a}	0.06

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

Table (5): Effect of experimental rations on serum anti-oxidant status of tested lambs.

Item	Experimental rations			±SE
	R_1	R_2	R_3	
Enzymatic Antioxidants				
Glutathione peroxidase (U/ml)	23.64	24.17	23.97	0.24
Glutathione reductase (U/L)	38.26^{b}	38.97^{a}	39.05^{a}	0.13
Non- enzymatic Antioxidants				
Vitamin C, µmol L	20.79^{c}	21.25^{b}	21.98^{a}	0.06
Vitamin E , µmol L	3.85^{b}	4.06^{ab}	4.35^{a}	0.09
Zinc (Zn) µg/dl	52.14^{c}	61.76^{b}	69.34^{a}	0.39
Selenium (Se) (µg/l)	121.15^{c}	137.11^{b}	142.29^{a}	0.25
The overall total antioxidant capacity (mmol/L)	0.84^{b}	0.98^{a}	1.05^{a}	0.03

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

Table (6): Effect of experimental rations on growth performance of growing lambs.

Item	Experimental rations			±SE
	R1	R_2	R_3	
Body Change				
Initial body weight (IBW) , Kg	17.12	16.86	17.38	0.38
Final body weight (IBW) , Kg	25.86^{c}	26.68^{b}	27.91^{a}	0.27
Weight gain, (Kg)	8.74^{b}	9.82^{a}	10.53^{a}	0.27
Daily weight gain , (g)	97.16^{c}	109.09^{b}	117.05^{a}	1.14
Feed Intake				
Dry matter intake (DMI), (Kg)	0.86	0.87	0.91	0.04
TDN, (Kg)	0.57	0.59	0.63	0.01
CP, (g)	86.38^{c}	89.63^{b}	95.26^{a}	0.34
Feed conversion ratio (FCR) (g/g)	8.85^{b}	7.98^{a}	7.77^{a}	0.18

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