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Nutritional evaluation of non-conventional fattening diets fed to sheep under arid conditions of Egypt

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SUMMARY – The study aimed to evaluate nutrient utilization of four fattening diets based on silage of halophytic shrubs supplemented with concentrate feed mixture (CFM), barley grains (BG) and agricultural by-products [sunflower meal and ground date seeds (GDS)]. The halophytic silage contained a mixture of *Atriplex nummularia*, *Acacia saligna, Zygophyllum album, Halocnemum strobilaceum, Tamarix mannifera*, dried broiler litter and molasses. Metabolism trials were carried out on twelve fattened male sheep in four equal treatments. Animals in the control group (T1) were fed on berseem hay (as a basal diet) and supplemented with CFM whereas the silage was offered to animals in T2, T3 and T4 (as a basal diet) and supplemented with 3 energy sources: CFM, GDS and BG, respectively. Feed intake, digesibilities, nutritive values, water utilization, sodium and potassium balances and some rumen and blood metabolites were determined. Using the silage in T2, T3 and T4 instead of berseem hay (T1) as basal diets did not significantly affect the voluntary DMI, TDN and DCP intakes, digestibility of DM, CP, EE, NFE and OM, and nitrogen retention. Digestion coefficient of CF was affected ($P < 0.05$) by the type of fattening diets. The maximum digestibility coefficients of NDF, ADF and ADL were recorded for animals in T3. Intakes of TDN and DCP were comparable in T1, T2, T3 and T4, respectively. Water consumption was decreased by about 65% by using the silage supplemented with GDS and sunflower meal (T3) compared to the control diet (T1). Sodium intake was decreased about 37% when the fattening diet in T3 was used compared to the diet in T1. The maximum potassium retention was recorded for sheep in T4 and T3 and exceeded ($P > 0.05$) that of the control diet by 88% and 69%. Ruminal ammonia-N and total volatile fatty acids and enzymes of liver function concentrations were within the normal levels and were not affected by the type of fattening diets. The halophytic silage supplemented with ground date seeds could be highly recommended as a non-conventional fattening diet for sheep due to its nutrition and economic potentialities.

Key words: Halophytic shrubs, silage, nutritive value, nitrogen balance, sodium and potassium balances, sheep.

RESUME – *"Evaluation nutritionnelle des régimes alimentaires non conventionnels destinés à l'engraissement des ovins sous les conditions arides d'Egypte". L'objectif de cette étude est d'évaluer la valeur alimentaire de quatre régimes d'engraissement à base d'ensilage d'arbustes halophytes supplémentés avec du concentré (C), de l'orge (O) et des sous-produits agricoles [tourteau de tournesol, et noyaux de dattes broyés (NDB)]. L'ensilage est composé d'un mélange d'*Atriplex nummularia*,* Acacia saligna*,* Zygophyllum album*,* Halocnemum strobilaceum*,* Tamarix mannifera*, litière de volailles séchée et mélasse. Des essais de métabolisme ont été conduits sur 12 agneaux d'engraissement répartis en quatre groupes égaux. Un groupe témoin a reçu un régime (R1) à base de foin de bersim et complémenté avec le concentré C. L'ensilage à base d'arbustes a été distribué aux trois autres groupes et a été complémenté avec les trois sources d'énergie: C (R2), NDB (R3) et O (R4). L'ingestion des aliments, la digestibilité* in vivo *des régimes, la consommation d'eau, les bilans de sodium et de potassium et quelques métabolites du rumen et du sang ont été déterminés. Le remplacement du foin de bersim (R1) par l'ensilage d'arbustes (régimes R2, R3 et R4) comme aliments de base n'a pas d'effet significatif sur l'ingestion volontaire de la matière sèche, les nutriments totalement digestibles (NTD) et les matières azotées digestibles (MAD), la digestibilité de la matière sèche, des matières azotées totales, l'extrait éthéré, l'extrait éthéré non azoté, la matière organique et la rétention azotée. La digestibilité de la cellulose brute a varié avec le régime (P < 0,05). Les coefficients de digestibilité des parois totales (NDF), la lignocellulose (ADF) et la lignine (ADL) les plus élevés ont été obtenus avec le régime R3. Les quantités ingérées de NTD et MAD ont été similaires entre les quatre régimes. Par comparaison au régime témoin (R1), la consommation d'eau et l'ingestion de sodium ont diminué d'environ 65 et 37% respectivement, avec les ensilages additionnés de NDB et de tourteau de tournesol (R3). La quantité maximale de potassium retenue a été obtenue avec les régimes R4 et R3 et a dépassé de 88 et 69% celle enregistrée chez les animaux recevant le régime R1. Les concentrations d'azote ammoniacal et d'acides gras volatils dans le rumen ainsi que les enzymes du fonctionnement du foie sont dans les normes conventionnelles et n'ont pas été affectées par la composition du régime. Il ressort de ce travail, que l'utilisation d'ensilage à base d'arbustes halophytes complémenté avec les noyaux de dattes broyés pour l'engraissement des ovins est avantageuse.*

Mots-clés : *Arbustes halophytes, ensilage, valeur alimentaire, bilan azoté, bilan sodium, bilan potassium, mouton.*

Introduction

Animal feed shortage is the main constraint to the development of animal production in Egypt. Animal production practices in the Egyptian deserts are mainly based on natural vegetation as animal feeds. The rangelands of Sinai are an open shrub vegetation, most likely salt and/or drought tolerant plant species (Gihad and El Shaer, 1994). They are characterized by less palatable and unpalatable species that are dominated and widely distributed. It is of interest to overcome such constraints to provide available good quality feed resources. Therefore, this study aimed to evaluate the utilization of ensiled unpalatable halophytes mixed with some agro-industrial by-products.

Materials and methods

A silage was made from a mixture of succulent parts of three chopped unpalatable natural shrubs (10% *Tamarix mannifera*, 10% *Zygophyllun album* and 10% *Halocnemum strobilaceum*); two less palatable cultivated shrubs (12% *Atriplex nummularia* and 18% *Acacia saligna*); then mixed with 30% broiler litter (BL) and 10% molasses according to their dry matter (DM) percentage. The physical traits (colour, smell and texture) and fermentative traits [pH, NH3-N and total volatile fatty acids (TVFAs)] of silage were tested frequently before feeding. Energy contents of concentrate feed mixture (CFM), ground date seeds (GDS), barley grains (BG), sunflower meal (SFM), berseem hay and the halophytic silage contained 60.5, 72.0, 77.4, 35.0, 40.9 and 46.1% total digestible nutrients (TDN), respectively whereas crude protein (CP) contents were 14.4, 7.60, 11.5, 27.5, 12.8, and 11.9%, respectively.

Twelve Barki male sheep in equally four treatments (3 animals/treatment) were used in digestibility trials. Animals were housed in metabolism cages for two months, the first 7 weeks were adaptation period followed by one week as a collection period. Animals in the control group (T1) were fed on 40% berseem hay (as a basal diet) and supplemented with 60% CFM, whereas the silage (40%) was offered in T2, T3 and T4 (as a basal diet) and supplemented with 3 energy sources according to the requirements recommended by Kearl (1982): 60% CFM, 40% GDS and 40% BG, respectively. Sunflower meal (20%) was added to diets of treatments T3 and T4 to adjust their content of CP.

Intakes of fattening diets for each animal in the four treatments were recorded and sampled for chemical analyses. Drinking water was available for one hour daily and measured. Urine excretion was measured and faeces excretion was weighed. Samples from faeces and urine were taken for proximate analyses. At the end of collection period, blood and rumen samples were taken at 6 hours post feeding.

Proximate analyses of diets, faeces and ruminal ammonia-nitrogen were determined (AOAC, 1990). Total nitrogen in urine and faeces was determined by the micro Kjeldahl method. Fibre constituents [neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL)] were determined (Goering and van Soest, 1970). Sodium and potassium contents were determined by the standard flame photometry. The pH values of silage were tested whereas TVFAs were determined by the procedure of Warner (1964). Blood samples were tested for liver function: aspartate aminotransferase (GOT) and alanine aminotransferase (GPT), using colorimetric method end point (Schmidt and Schmidt, 1963). Blood urea-nitrogen (BUN) levels were determined (Coulomb and Larreau, 1963) and creatinine levels were also determined (Jaffe, 1986). Data were statistically analysed as a completely random design according to SAS (1990). Duncan multiple range test was also used.

Results and discussion

Chemical composition of feed ingredients and fermentative traits of the silage

The fermentative traits of silage showed that the ensiled materials showed good aroma with yellowish colour and the texture was soft. The pH values were acidic (3.95) with optimum values of ammonia-nitrogen (0.35% of DM) and TVFAs (7 meq/100 ml). Therefore, based on the measured physical and fermentative traits of ensiled materials, it seemed that good quality silage was obtained and available to be fed to growing fattened sheep. Data in Table 1 indicated that the CP content of silage was quite comparable to that of berseem hay (11.9 vs 12.8) but dry matter and crude fibre (CF) contents were less than that of berseem hay (81.2 and 75.6%, respectively).

Table 1. Chemical composition (% DM basis) of feed ingredients†

Criteria	Basal diets		Feed supplements			SFM
	S	BH	GDS	BG	CFM	
DM	48.0	87.0	90.0	90.0	90.0	87.0
CP	11.9	12.8	7.60	11.5	14.4	27.5
CF	17.2	30.2	9.70	6.20	11.2	29.1
Ash	22.1	13.4	2.50	3.30	10.3	6.50
Na	2.13	2.20	0.14	0.21	1.25	0.36
K	1.86	1.30	0.35	0.47	1.10	1.40
NDF	47.3	55.8	73.7	68.4	48.0	51.3
ADF	31.5	38.5	48.3	9.00	16.0	29.2
ADL	15.0	7.40	12.7	2.00	6.00	9.70

†S: silage; BH: berseem hay; GDS: ground date seeds; BG: barley grain; CFM: concentrate feed mixture; SFM: sunflower meal.

The silage showed higher energy value compared to berseem hay (46.1 vs 40.9% TDN) due to the inclusion of molasses and broiler litter in the ensiled materials. Ash content of silage was higher than that of berseem hay due to that silage was made from halophytic shrubs, which were rich in ash content (El Shaer *et al*., 1991). Owing to its richness in CP and energy content, silage is considered as a good quality. CFM contained the highest CP, CF and ash than that of GDS and BG, respectively. Meanwhile, energy content of GDS and BG was comparable. Sodium content of silage was similar to that of berseem hay but potassium level of the same silage exceeded by 43% that of berseem hay. The silage had lower values of NDF, ADF than that of the hay but ADL content was approximately 103% higher than that of berseem hay. It may be due to that silage was made from halophytic woody and lignified shrubs (El Shaer *et al*., 1990). GDS and BG showed comparable values of NDF whereas CFM exhibited the lowest value (48.8%).

Intakes, digestibilities, nutritive value and water consumption

Intakes of basal diets, supplements and the total rations did not differ significantly ($P > 0.05$) among treatments (Table 2). Sheep in T1, T2 and T3 consumed comparable amount of basal diets, which averaged 12.7 g/kg body weight (BW), whereas the maximum intake was reached in T4 and exceeded by 32.5% the intake of berseem hay in the control diet (T1). This increase of intake in T4 may be attributed to mutual associative effect between silage and barley grains in addition to higher CP percentage of diet in T4. The results are in harmony with the findings of El Shaer *et al*. (1991) who reported that feeding sheep and goats on silage of *Halocnemum strobilaceum* and broiler litter led to higher intake than that of berseem hay. On the other hand, utilisation of barley grains as feed supplement in sheep diet resulted in an increase in feed intake.

The maximum total intakes of basal diets and feed supplements (37.7 g/kg BW) was recorded in T4, which contained the silage and barley grains plus sunflower meal. It could be concluded that diet in T4 was more palatable based on its higher DM intake (DMI). DM and CP digestibilties (Table 2) did not vary significantly but CF, NDF, ADF and ADL varied significantly ($P < 0.05$) among treatments. NDF and ADF digestion were improved as a result of inclusion of GDS or BG plus SFM in T3 and T4 compared to those fed the control diet (T1). Ensiling salty shrubs with broiler litter and supplemented by GDS or BG (T3 and T4) improved the digestibilities of fibre components for fattened sheep. Similar findings were obtained by El Shaer *et al*. (1990, 1991).

The intakes of TDN and digestible crude protein (DCP) did not vary significantly among treatments

(Table 2). The total TDN from diets in T1, T3 and T4 were comparable and were higher (about 16%) than that recorded for fattened sheep in T2. Since animals in T2 consumed the lowest amount of TDN due to their lower TDN percent of the total diet (50%). Total DCP of fattening diets was the greatest in T4 which exceeded by 22.9% that of the control diet (T1). The results indicated that fattened sheep on unconventional feeds appeared to consume and utilize the DCP and TDN similarly to those fed conventional feed (berseem hay and CFM in T1). El Shaer *et al.* (1991) and Abdou (1998) found similar results on salt marsh plant silages.

Table 2. Intake, digestibility, nutritive values and water consumption†

Criteria	T1	T2	T3	T4	SE	F test
Live BW (kg)	46.3	43.7	40.3	46	1.58	
Intake (g DM/kg BW)						
Basal diet	12.6	12.4	13.1	16.7	1.00	ns
Supplement	22.4	21.8	21.5	20.9	0.47	ns
Total diet	35.0	34.2	34.6	37.7	1.14	ns
Digestibility coefficient (%)						
DM	58.9	53.5	54.1	55.8	1.04	ns
CP	61.1	60.6	55.5	64.2	1.41	ns
CF	38.58^{ab}	27.9^{b}	48.9^{a}	38.6^{ab}	2.77	**
NDF	50.7^{ab}	48.0^{b}	$56,9^{a}$	56.6^{a}	1.42	*
ADF	42.2^{ab}	35.3^{c}	48.0^{a}	36.9^{bc}	1.69	**
ADL	6.27^{b}	13.3^{a}	14.2^{a}	12.6^{a}	1.03	*
Total digestible nutrients (g/kg BW)	19.7	17.2	19.5	20.1	0.66	ns
Digestible crude protein (g/kg BW)	2.97	2.81	2.63	3.65	0.16	ns
Free water intake (ml/kg BW)	145.7^{a}	128.2^{ab}	69.6^{c}	102.3^{bc}	9.93	*
Free water intake (ml/g DMI)	4.18^{a}	3.73^{a}	1.96^{c}	2.70^{b}	0.28	***
Total water intake (ml/kg BW)	161.93^{a}	155.5^{a}	98.1^{b}	135.2^{ab}	9.49	*

†T1: berseem hay + concentrate feed mixture (CFM); T2: silage + CFM; T3: silage + ground date seeds (GDS); T4: silage + barley grains (BG).
^{a,b,c}Value with different letters on the same row significantly varied at 5%.
*P < 0.05; **P < 0.01; ***P < 0.001; ns: not significant.

Free and total water intake varied significantly among treatments (Table 2). Sheep in T3 consumed the lowest amount of free water (69.6 ml/kg BW), whereas those fed the control diet (T1) showed the highest free water consumption (145.7 ml/kg BW). It appears that animals in T3 were able to digest crude fibre and fibre constituents more than their mates in other groups due to the lowest free water consumption. It could be concluded from such findings that replacement of berseem hay with silage supplemented with GDS or BG reduced water consumption which is considered as the limiting factor in the desert (Abou El Nasr, 1985). Summation of free water, feed moisture and oxidation water intake, resembling the total water intake, followed the same trend of free water intake. The maximum intakes of water (161.9 ml/kg BW) was recorded in (T1) while the lowest one was attained in T3.

Nitrogen, sodium and potassium utilisation

Nitrogen intake excretion and retention did not differ significantly due to treatment effect (Table 3). The fattened sheep in T4 ate more nitrogen than other sheep in T1, T2 and T3 by 17.2, 22.7 and 19.2%, respectively. The higher nitrogen intake (2356 mg N/kg $W^{0.75}$) in T4 may be attributed monthly to two factors: (i) higher DMI (as shown in Table 2); and (ii) higher CP content in the whole diet (T4). It seems that all growing sheep were in positive nitrogen balance and animal tended to retain various levels of nitrogen.

It appeared that sheep fed the conventional (T1) or non-conventional diets (T2, T3 and T4) tended to utilize the nitrogen similarly. It could be concluded that replacing berseem hay (T1) with silage (T2) led to an improvement in nitrogen balance since the two diets of T1 and T2 were similar in supplements but varied in basal diets. Utilisation of barley grains in T4 instead of date seeds (T3) led to an increase in nitrogen balance by about 61%. The results are in harmony with many investigators (Abou El Nasr, 1985; Khamis 1988; Allam *et al.*, 1997). It was found that total sodium intake from feeds and drinking water and sodium excretion differed significantly due to treatments effect (Table 3). Total sodium consumed by sheep in T1 was the highest (1909 mg Na/kg $W^{0.75}$) due mainly to high sodium percentage in their diet content. A high positive correlation (r = 0.91) between sodium of feeds and free water intake was found. Therefore, when sodium of feed intake increased (as shown in T1) the free water intake was also increased. Apparent sodium retention did not differ significantly among treatments. The highest value of sodium retention was recorded in T3, whereas the minimum value was recorded in T1. It could be concluded that replacing berseem hay and CFM in T1 with silage and GDS mixed with SFM enhanced Na retention in T3. The obtained results agree with the findings of many authors (Meyer and Weir, 1954; Ahmed, 1995). Potassium intake and excretion did not differ significantly among treatments but potassium retention varied significantly. The greatest potassium intake, excretion and retention were recorded for animals in T4 whereas the minimum value of potassium intake was attained for those in T1. Although sheep in T1 and T3 consumed comparable amounts of potassium being 1319 and 1321 mg/kg $W^{0.75}$, they retained potassium in their bodies much better than that of T1. It was noticed that replacing conventions diets (T1) with non-conventional diets in T3 and T4 enhanced potassium and sodium retention for sheep (Ahmed, 1995).

Table 3. Nitrogen, sodium and potassium utilisation (mg/kg $W^{0.75}$)†

	T1	T2	T3	T4	SE	F test
Nitrogen intake	2016	1895	1915	2356	78.4	ns
Total nitrogen excretion	1660	1493	1729	2042	84.1	ns
Nitrogen retention	356	402	186	314	34.3	ns
Sodium intake	1909	1774	1271	1501	90.4	*
Sodium excretion	1840	1681	1156	1404	92.5	**
Sodium retention	69	93	115	97	7.9	ns
Potassium intake	1319	1423	1321	1512	53	ns
Potassium excretion	1246	1366	1198	1375	51.8	ns
Potassium retention	73	57	123	137	10.7	***

†T1: berseem hay + concentrate feed mixture (CFM); T2: silage + CFM; T3: silage + ground date seeds (GDS); T4: silage + barley grains (BG).
*P < 0.05; **P < 0.01; ***P < 0.001; ns: not significant.

Some rumen and blood metabolites

All rumen and blood metabolites indicators did not vary significantly among treatments (Table 4). The maximum NH3-N level (26.2 mg/100 ml) was recorded in T4 due to high nitrogen content of the whole diet (2.35%) whereas NH3-N levels in T1, T2 and T3 were comparable and concentrations were within the normal levels (Abdou, 1998; Eid, 1998).

The fattening diets, which were iso-energetic, exhibited similar levels of ruminal TVFAs. BUN levels were in coincidence with the ruminal NH3-N concentrations and were within the normal levels in all treatments. The maximum BUN level (7.4 mg/100 ml) was attained in T4 which showed higher ammonia-nitrogen level. Creatinine levels ranged from 0.97 mg/100 ml (T1) to 1.37 mg/100 ml (T2) and were within the normal levels of sheep. Results indicated that all animals were in a good nutritional status. Data are in coincidence with the findings of Blanch and Setchell (1960) and Eid (1998).

Data on the concentrations of GOT and GPT, as liver function indicators (Table 4), were below the critical levels and within the normal levels as reported by Rakha (1985), Allam *et al.* (1997) and Abdou

(1998). Blood sodium and potassium concentrations were within the normal levels, which are in agreement with the findings of Ahmed (1995) and Eid (1998) on sheep. There were no adverse effect on kidney and liver function, this indicated that animals were in a good health as result of inclusion of halophytes supplemented by ground date seeds or barley grains in sheep fattening diets.

Table 4. Some rumen and blood metabolites concentrations of sheep fed the fattening diets†

Criteria††	T1	T2	T3	T4	SE	F test
RNH3-N (mg/100 ml)	24.2	25.5	24.5	26.2	0.46	ns
TVFAs (mg/100 ml)	5.58	5.60	5.71	5.94	0.09	ns
BUN (mg/100 ml)	5.80	6.80	5.30	7.40	0.40	ns
Creatinine (mg/100 ml)	0.97	1.37	1.33	1.10	0.09	ns
GOT (U/L)	7.33	8.00	7.33	5.33	0.89	ns
GPT (U/L)	3.33	2.67	4.00	3.33	0.33	ns
Sodium (mg/100 ml)	321	338	330	332	0.39	ns
Potassium (mg/100 ml)	21.0	18.7	20.3	21.0	0.39	ns

†T1: berseem hay + concentrate feed mixture (CFM); T2: silage + CFM; T3: silage + ground date seeds (GDS); T4: silage + barley grains (BG).
††RNH3-N: ruminal ammonia-nitrogen; TVFAs: ruminal total volatile fatty acids; BUN: blood urea nitrogen.
ns: not significant.

In conclusion, based on the prices of 1998 (when 1 US$ = 3.45 L€) feeding the silage could reduce the feed costs by 35% since one tonne of DM of silage and berseem hay were 297 and 457 L€, respectively. The feed costs of the total diets in T1, T2, T3 and T4 were 540, 484, 331 and 646 L€/tonne DM of diet, respectively. The production costs (feed costs × total DMI/total gain) were 4.46, 4.55, 3.55 and 5.35 L€/kg of live weight in T1, T2, T3 and T4 in respective order. Feeding the non-conventional diets, particularly in T3, could reduce the production cost by about 33% in comparison with the conventional fattening diets in T1. Therefore, the study strongly recommended the utilisation of the halophytic silage as a basal diet, supplemented with agro-industrial by products, GDS in particular, as fattened sheep diets under the arid conditions.

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