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Potential of tannin ferrous plants to improve efficiency of sheep production in dry areas

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ABSTRACT

This research was performed to study the effect of feeding ammoniated wheat straw and its mixture with *Cassava* or/and *Acacia Saligna* on methane emission and growth performance of Barki lambs under semi-arid condition. The study conducted at Animal Production Research Station, Borg El Arab, belonging to Animal Production Research Institute, Agricultural Research Center, Egypt. A total number of twenty five Barki lambs were randomly allocated into six groups. These animals often depend on low quality crop residues and limited feed supplement. Egyptian desert consider a source of tannin-ferrous plants (TFP) along the year. These plants had lot of nutritive problems need to solve before depending on them as a fodder. In vitro experiments conducted to evaluate the effect of several mixtures of TFP with urea treated wheat straw (TWS) on dry matter degradation, ammonia-N and methane production. Six treatments were examined(G1) CFM+ *Acacia Saligna* (A): TW Sat (50:50), (G2) CFM+ Prosopis Juliflora (P): TWS at (50:50), (G3) CFM+ *Cassava* (C): TWS at (50:50), (G4) CFM+ A: P: TWS at (25: 25: 50), (G5) CFM+ A: C: TWS at (25: 25: 50) and (G6) CFM+ P: C: TWS at (25: 25: 50), respectively. Samples of each forage type collected after 0, 3, 6, 12 and 24 h of incubation for determination of cumulative gas production. In addition, thirty growing male Barki lambs, aged average 3 months were used to study the effect of the tested rations on growth performance. The results showed that the condensed tannin (CT) content ranged from 20 (A: C: TWS –G5) to 30 g/kg DM (Acacia saligna). Methane production per unit of fermented DM was inversely related to protein solubility. G1showed a lower ($P<0.01$) ruminal NH_3-N concentration which associated with the decrease ($P<0.01$) in rumen protein degradability. After 24 h of in vitro incubation, CH_4 production was17, 18, 17, 15, 13 and 14 ml, for all groups, respectively. Daily body gains were significantly affected by tested rations. The highest values recorded with G 5. Consequently, consumption of combination of TFP containing various classes of secondary components with resource of NPN leads to reduce CH_4 emission from ruminants and improve lamb growth performance.

***Keywords:* Acacia saligna – Cassava – Economic efficiency- Growing Sheep**

INTRODUCTION

Feed resources deficiency considers one of the basic constraints to improve animal production in arid and semi-arid regions of Egypt. Improving nutritional status of livestock graze in desert (sheep, camels and goats), particularly during the prolonged dry seasons, could increase the average annual animal production by approximately 27%. Attention directed towards the necessity of utilizing the marginal resources, i.e. saline soils and underground water for producing unconventional animal feeds. The native natural rangelands constitute the principal feed resources in the Egyptian deserts. They are widely distributed throughout several regions of Egypt due to presence of numerous salines along the Mediterranean and Red Seas shores and inlands). Halophytes represent a major part of the natural range, particularly perennials and shrubby ones. The less and unpalatable plant species represent approximately 70% of the total coverage. Several attempts made towards utilization of such low value or unpalatable halophytic plants through proper processing methods to improve their palatability and nutritional utilization. Under semi-arid area condition, small ruminant fed on trees and shrubs such as Cassava and Acacia to solve the attendant problems of low productivity (El Shaer

2010 and Eissa et al., 2015a). However, such trees and shrubs foliage are generally rich in anti-nutritional factors, particularly tannins (Makkar, 2003). Feeding a mixture of these fodder shrubs could minimize or overcome the problems of palatability and toxic effects (Lowry, 1990; Yusran and Teleni, 2000; Anbarasu et al., 2001; Patra et al., 2002; El Shaer 2010; Eissa et al., 2015a, b and Eissa et al., 2016).

Research on mitigating methane (CH4) emission from ruminants has received a great attention especially during the last decade. It globally estimated that, ruminants produce 80 million tons of CH4 annually, which accounts for 28% of anthropogenic emissions (Beauchemin et al., 2008). Tannins represent an important class of plant secondary metabolites that produced by the plants in their intermediary metabolism. The objective of this study aimed to evaluate the possible effects of feeding ammoniated wheat straw and its mixture with *Cassava* or/and *Acacia Saligna* on methane emission and growth performance of Barki lambs under semi-arid condition.

MATERIAL & METHODS

This study conducted in Animal Production Research Station, Borg El Arab, belonging to Animal Production Research Institute, Agricultural Research Center, Egypt.

Animals and Management

Thirty growing Barki male lambs aged about 3 months and weighed 12.16±0.11kg were divided randomly into six groups, 5 lambs each, and were housed separately in shaded pens. The animals were weighed at the beginning then biweekly. The feeding experiment lasted 18 weeks. Barki lambs fed for 3 weeks as a transitional period on the experimental rations before the start of the experimental work.

Experimental treatments:

The tree fodder *Cassava*, Prosopis Juliflora and *Acacia Saligna* (leaves & twigs) were harvested along the sub-roads from the North Western Coast of Egypt on the Mediterranean Sea, west of Alexandria city, latitudes 21°and 31° North and longitudes 25° and 35° East. Samples from each species (up to 200 g) were dried at 55°C for 48 h and grounded to pass a 1-mm screen for subsequent chemical and in vitro analyses. Similarly, samples of wheat straw treated by injecting ammonia in Borg El Arab Livestock Research Station. Feed samples were analyzed for dry matter (DM) and total ash using the method of A.O.A.C (1995). The cell wall constituents (CWC) and acid detergent fiber (ADF) were analyzed by methods described by Van Soest (1965).

Four complete rations were prepared with the roughage component containing one or two of tree fodders and one crop residue combinations. The roughage to concentrate ratio maintained at 60:40 level to meet the nutrient requirement (NRC, 1985) for growing sheep. The level of the ingredients in the concentrate portion was adjusted to maintain iso-protein -iso-caloric experimental rations. The chemical analysis and cell wall constituents of CFM and different types of roughages are presented in Table (1).

The gas was determined with a portable GASMET DX4030 gear using the CO_2 Technique, which measure the CO_2 content and then calculate the ratio CH_4/CO_2 (Patra *et al*. 2006). Condensed tannins were determined by the butanol-HCl-iron method (Patra *et al*. 2006).

Blood samples:

Blood samples were collected from the jugular vein once before feeding (3 animals of each group) at the end of growth period. Blood samples were centrifuged at 4000 rpm for 20 min. Part of the separated serum was directed to enzymes activity determination, while the other part was stored frozen at -20 ºC till biochemical analysis. Commercial kits were used for all colorimetric biochemical determination.

Table (1): Chemical composition and of feed ingredients.

Item	DM	Chemical composition						Fiber Fraction		
		OM	CP	CF	EE	NFE	Ash	NDF	ADF	ADL
Prosopis Juliflora	**70.39**	**93.30**	**17.52**	**30.70**	**2.72**	**42.36**	**6.70**	**57.41**	**42.69**	**39.23**
Acacia Saligne	**52.45**	**91.66**	**15.66**	**31.59**	**1.47**	**42.94**	**8.34**	**60.86**	**54.57**	**48.96**
Cassava	**44.39**	**88.26**	**22.94**	**28.05**	**2.92**	**34.35**	**11.74**	**35.49**	**26.29**	**19.47**
Treated Wheat Straw	**98.00**	**89.00**	**9.86**	**48.23**	**3.90**	**27.07**	**11.00**	**35.42**	**30.22**	**27.33**
CFM*	**91.20**	**93.90**	**15.70**	**14.23**	**3.13**	**60.84**	**6.10**	**43.00**	**17.30**	**5.80**

* Concentrate feed mixture (CFM) consisted of yellow corn , undecortecated cotton seed , wheat barn, 3.5% molasses, 2.5% limestone, 1% common salt and 0.5% minerals mixture The level of the ingredients in the concentrate portion was adjusted to maintain iso-protein - iso-caloric experimental rations.

Lambs received diets in groups. Tested rations met the nutrient requirement (NRC, 1985) for growing sheep as follow:

(G1) CFM+ *Acacia Saligna* (A): TWS at (50:50).
(G2) CFM+ Prosopis Juliflora (P): TWS at (50:50).
(G3) CFM+ *Cassava* (C): TWS at (50:50).
(G4) CFM+ A: P: TWS at (25: 25: 50)
(G5) CFM+ A: C: TWS at (25: 25: 50)
(G6) CFM+ P: C: TWS at (25: 25: 50

Economic efficiency:

Economic efficiency was calculated, as total output/total input according to the local prices (where one ton CFM = 2800 L.E.; *Cassava* = 500 L.E.; *Acacia Saligna* = 500 L.E.; Treated wheat straw = 710 L.E.; Kg live body weight of lambs = 35 L.E.

Statistical analysis:

Data were statistically analyzed using One-Way Layout with Means Comparisons Procedure (SAS,2003).

RESULTS AND DISCUSSION

Chemical composition:

The chemical composition of different forages combinations are presented in Table 2. It observed that CP content was noticeably higher with **G2** (16.80%) than **G1** (15.36%) or **G5** (15.70%). While the content of EE was lower(3.04%) in **G1** compared with the other forages (mixture with treated wheat straw).Moreover, the highest value of CF and NFE (38.43 and 29.22 %) were recorded with **G1**&**G5**, respectively and the lowest values (37.23% and 26.64%) were detected with **G6**&**G4,** respectively. The differences in DM and OM were of fewer values. The chemical composition obtained in the present study is nearly similar to that obtained by Cloete *et al.* (1983), for the effect of feeding ammoniated wheat straw to sheep, by Ben Salem *et al.*, (2005), Fulkerson *et al.*, (2008) and Shaker *et al.*, (2014) on some salt tolerant fodder shrubs mixtures, and Eissa *et al.* (2015$_{a, b}$) for *Cassava* or *Acacia Saligna* with ammoniated wheat straw fed to growing Barki lambs. The ADF values were increased slightly due to treatment of wheat straw. While the CWC and hemicellulose decreased due to ammoniation. Data is in agreement with results obtained by Horton (1981). Kiangi & Kategile (1981) also reported a decrease in CWC of maize stover ammoniated by urea. ADF, CWC and hemicellulose, to a lesser extent, seemed to decrease slightly due to the inclusion of fish meal to the experimental diets. On the other hand, ADF, CWC and hemicellulose decreased when TWS mixed with *Acacia* and/or *Cassava*. Similar results had been obtained by Eissa *et al.* (2015 and 2016) on Barki sheep fed forage tree legumes mixed with ammoniated wheat straw.

Table (2): Chemical composition and cell wall constituents (% on DM basis) of different forages combinations

Item	A:TWS G1	P:TWS G2	C:TWS G3	A:P:TWS G4	A:C:TWS G5	P:C:TWS G6
DM	80.28	89.50	89.00	87.00	81.50	85.20
Chemical composition,% on DM basis:						
OM	85.93	89.81	89.00	82.98	87.23	83.90
CP	15.36	15.12	16.80	14.70	15.70	15.70
CF	38.20	38.43	38.23	38.10	38.80	37.23
EE	3.58	3.04	3.90	3.54	4.22	4.13
NFE	28.79	29.22	28.07	26.64	28.81	27.84
Ash	14.07	14.19	13.00	17.02	12.47	15.10
Fiber fraction:						
CWC	43.12	42.32	40.42	44.26	41.23	43.00
ADF	19.00	24.00	25.22	30.00	28.00	17.30
Hemi-cellulose**	24.12	18.32	15.20	14.26	13.23	25.70

** Hemi-cellulose = CWC-ADF

Correlations among cell wall content (CWC), condensed tannin (CT) of tested forages and methane production

Data of methane production and condensed tannin (CT) are presented in Table (3). Results showed that methane production tended to increase with the increase of condensed tannin and the decrease of fiber components. The high gas production (GP) indicates greater fermentation to support rapid rumen microbial growth (Gemeda and Hassen, 2015). In current study, the main factors affecting GP and IVOMD of browsing were CWC and tannin contents. The differences among groups could be due to the difference in chemical structure of cell walls (Tiemann *et al.,* 2008) and the molecular weight of tannins (Patra and Saxena, 2011).As the digestibility of a ration decreases, the percentage of energy converted to methane increases to a point as high as 9%(National Institute of Water and Atmosphere NIWA, 2005)**.**So, in the present study **G5** was the most fermentable ration that could be associated with the low ADF. On the other hand, the mixture **G4** had the least fermentable ration which could due to the negative influence of CT irrespective of CWC composition. In case a feed ration is highly digestible, it would be expected that 6% of the energy would be converted to methane. In agreement with current finding, studies done on different tropical browses showed negative effects of plant phenolic compounds on their fermentation and digestion (Guglielmelli *et al.,* 2011; Jayanegara *et al.,* 2011 and Sebata *et al.,* 2011). The positive effect of ferrous plants is that tannins decreases about 40%-50% of methane production in precedent combinations.

Blood parameters:

Table 4 shows some blood parameters measured at the end of growth period. The obtained results revealed that blood parameters of Barki sheep fed mixture of shrubs with ammoniated wheat straw had slight insignificant differences.

Table (3): Methane production and condensed tannin (CT) of feed ingredients.

Item	A:TWS G1	P:TWS G2	C:TWS G3	A:P:TWS G4	A:C:TWS G5	P:C:TWS G6
Methane production ml/200 mg DM:						
	17	**18**	**17**	**15**	**13**	**4**
CT, **g/kg DM**						
	30	**26**	**28**	**23**	**20**	**25**
Fiber fraction:						
CWC	**43.12**	**42.32**	**40.42**	**44.26**	**35.23**	**40.00**
ADF	**19.00**	**24.00**	**20.22**	**20.00**	**17.00**	**17.30**

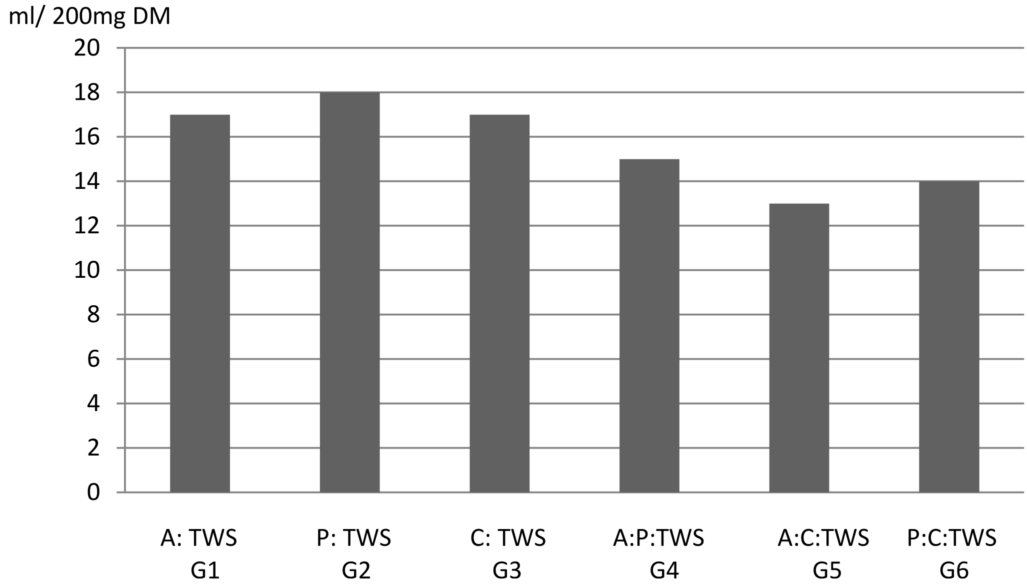

Fig (1): Methane production from experimental rations

The lowest concentrations of total proteins (TP), albumin (AL), globulin (GL) and albumin/ globulin ratio (A/g ratio) were detected with **G6**. These findings are in accordance with those reported by Eissa *et al.* (2016). This reduction of TP in animals fed salt shrubs (G3) might be owing to the high content of tannins in these plants. In agreement, Muller et al. (1989) and Reed et al. (1990) reported that high content of tannins in acacia probably decreases the digestibility of crude protein. Coles (1986) found that poor absorption of dietary constituents from the intestinal tract leads to hypoproteinemia. Mahmoud (2001) reported that the decrease in concentration of globulin in sheep might be due to the presence of a high level of tannins, which form complexes with diet. Thus, **G5** was higher than **G6** in total proteins (TP), albumin (AL), globulin (GL) and albumin/ globulin ratio (A/g ratio).This increase might be owing to ammoniation of wheat straw. The same trend was found in blood urea-N concentration (mg/dl).Generally, this can attributed to the high protein content in the mixture of shrubs and to the additional nitrogen in the urea treated wheat straw, which is utilized efficiently by rumen microflora (Shaker *et al.* 2014). Concentrations of enzymes aspartate amino transferase (AST) and alanine amino transferase (ALT) that conventionally used for diagnosing hepatic damage. Both AST and ALT concentrations were higher with salt tolerant shrubs mixture groups but the differences were significant for ALT concentration only. Generally, the obtained results indicate that blood components measured show slight differences due to source of shrubs, where all levels were within the normal ranges reported by Kaneko (1989) for healthy goats and in line with findings of Shaker *et al.* (2014) who used salt tolerant shrubs mixture in small ruminant rations.

Table (4): Effect of feeding experimental rations for Barki lambs on some blood serum parameters

Item	A:TWS G1	P:TWS G2	C:TWS G3	A:P:TWS G4	A:C:TWS G5	P:C:TWS G6
Total protein, g/dl	7.06±0.46[ab]	7.10±0.25[ab]	7.45±0.25[ab]	6.82±0.51[ab]	8.11±0.50[a]	6.55±0.51[ab]
Albumin(A), g/dl	3.87±0.23[ab]	3.63±0.29[b]	3.90±0.29[b]	3.70±0.23[b]	4.61±0.38[a]	3.94±0.23[b]
Globulin(G), g/dl	3.19±0.24	3.46±0.10	3.86±0.10	3.12±0.29	3.50±0.14	3.45±0.29
A/G	1.22±0.04[ab]	1.05±0.10[b]	1.45±0.10[b]	1.20±0.07[ab]	1.31±0.07[a]	1.55±0.07[ab]
Urea-N, mg/dl	22.13±0.65[ab]	23.19±0.52[a]	24.10±0.52[a]	21.50±0.43[b]	22.62±0.39[ab]	23.50±0.43[b]
Creatinine mg/dl	1.24±0.18[b]	1.81±0.12[a]	1.92±0.12[a]	1.21±0.10[b]	1.23±0.11[b]	1.72±0.10[b]
AST, u/l	30.44±0.59	30.10±0.48	31.15±0.48	30.18±0.52	31.05±0.58	30.48±0.52
ALT, u/l	17.96±0.32[a]	16.11±0.45[b]	17.20±0.45[b]	17.94±0.40[a]	17.98±0.29[a]	16.90±0.40[a]

in the same row with different superscripts differ significantly at $P<0.05$.

Growth performance and economic efficiency:

Growth performance and feed efficiency of Barki lambs fed experimental rations are represented in Table 5. Results showed wide range of dietary concentrations of the condensed tannin (CT) ranged from 20 to 30 g/kg DM (Table 3) which reflected on the improved daily weight gain of lambs on temperate fresh forages. The obtained results revealed significant differences ($P<0.05$) among groups fed different rations in final body weight, total body gain and daily body gain. The highest values recorded with G5 (33.46 kg, 21.38 kg, and 170g, respectively) while the lowest values were detected with G1 (28.70kg, 16.38kg and 130 g, respectively). Moreover, the differences were not significant between G1, G3 G4and G6. This improvement could be attributed to the increase in dry matter intake (DMI, g/h/d) in G5 compared with other groups (878 *vs.*834 G1, 818 G2, 832 G3, 840 G4 and 834 G6). There is an inverse relationship between high CT level in forages (more than 50 g CT/kg DM) and palatability, voluntary intake, digestibility and N retention in ruminants. With respect to ruminant nutrition, specific levels of tannins consider of beneficial effect including better utilization of dietary protein, faster body weight or wool growth, higher milk yield, increased fertility and improved animal welfare and health through the prevention of bloat and reduced worm burdens (Mueller-Harvey, 2006). Aganga and Tshwenyane (2003) reported that the average daily gain was slightly higher with significant increase in feed intake and feed conversion ratio for Tswana goats fed forage legumes tree as supplement.

This effect was ascribed to increase levels of post-rumen available proteins (Barry and McNabb, 1999; Barry *et al.*, 2001; Ben Salem *et al.*, 2003, Gemeda and Hassen, 2015 and Eissa *et al*, 2005$_{a,b}$). Economic efficiency results in Table (5), indicate that feed cost/kg gain tended to decrease with **G5** (A: C: TWS), compared with other groups. Thus, the highest value of economic efficiency was detected with **G5** (3.91%). In this respect, Eissa *et al.* (2015$_{a,b}$ and 2016) found that economic efficiency was greatly improved with substitution of legumes trees with ammoniated wheat straw in sheep rations.

Table (5): Growth performance and feed efficiency of Barki lambs fed experimental rations.

Item	A:TWS G1	P:TWS G2	C:TWS G3	A:P:TWS G4	A:C:TWS G5	P:C:TWS G6
No. of lambs	5	5	5	5	5	5
Feeding period, weeks	18	18	18	18	18	18
Initial weight, (kg)	12.28±0.11	12.32±0.29	12.02±0.06	12.32±0.29	12.08±0.46	12.02±0.06
Final weight, (kg)	31.66±0.48^{b}	28.70±0.46^{c}	31.42±0.53^{b}	32.23±0.46^{c}	33.46±0.48^{a}	31.99±0.53^{b}
Total gain, (kg)	19.38±0.42^{b}	16.38±0.32^{c}	19.40±0.53^{b}	19.90±0.32 ^{b}	21.38±0.13^{a}	19.97±0.53^{b}
Daily body gain, (g)	154±0.003^{b}	130±0.003^{c}	154±0.004^{b}	158±0.003^{b}	170±0.001^{a}	156±0.004^{b}
Daily feed intake:						
Roughage, (R)	350	358	365	375	390	366
CFM, (C)	484	460	467	465	488	468
Total DMI (g/h/d)	834	818	832	840	878	834
DMI as %BW	2.6	2.4	2.5	2.7	3	2.6
R/C	40:60	44:56	44:56	44:56	44:56	44:56
CP intake	129	116	128	129	129	128
Feed conversion						
Kg CP/Kg gain	0.155	0.143	0.150	0.154	0.160	0.153
Economic efficiency						
Coast of consumed, L.E.	1.48	1.47	1.45	1.46	1.52	1.50
Price of kg gain, L.E.	5.39	5.13	5.39	5.54	5.95	5.13
Feed cost/kg gain, L.E.	9.63	9.43	9.44	9.48	8.96	12.43
Efficiency, %	3.63	2.82	3.71	3.80	3.91	3.82

a-d: Means in the same row with different superscripts differ significantly at P<0.05.

In vitro digestibility data using sheep rumen fluid (Table 6) indicated that pH values ranged from 6.27 to 7.2 for all studied groups. Rumen ammonia nitrogen (NH-N) and total volatile fatty acids (TVFA's) significantly increased in A: C: TWS **G5** and the lowest values were determined in the in A: TWS **G1**. These results may attributed to the low content of tannin in A: C: TWS **G5**. Narjisse et al. (1995) reported that rumen ammonia was depressed (P < 0.05) by tannin infusion in sheep. Kumar and Vaithiyanthan (2003) reported that tannins bind to proteins, cell walls and cell soluble content and adversely affect rumen microbial and intestinal enzyme activity and consequently reduce ruminal VFA's (2003). Muller, et al., (1989) found that reduction of ruminal NH-N and total VFA concentration by saponins was due partly to defaunation. Cheeke (1999) found that saponins have pronounced antiprotozoal activity.

Thus reduction in ruminal protozoa numbers observed when saponins fed (Klita, et al., 1996) or within in vitro ruminal fermentation system (Wang, et al., 1998). It caused by reaction of saponins with cholesterol in the protozoal cell membrane, causing break down of the membrane, cell lysis and death.

Table (6): Growth fermentation of of Barki sheep fed experimental rations.

Fermentation parameters	A:TWS G1	P:TWS G2	C:TWS G3	A:P:TWS G4	A:C:TWS G5	P:C:TWS G6
pH	6.50^{b}	7.3^{b}	6.46^{b}	6.27^{c}	7.12^{a}	6.30^{c}
NHN mg/100 ml	4.60^{c}	5.10^{b}	5.80^{a}	5.90^{a}	6.10^{a}	6.00^{a}
TVFA's mg/100 m	5.70^{c}	6.10^{b}	6.99^{ab}	7.34^{a}	7.80^{a}	7.70^{a}

a-b: Means in the same row with different superscripts differ significantly at P<0.05.

Conclusion

It could be concluded that using mixture of salt tolerant plants Acacia saligna and /or Casava with ammoniated wheat straw in small ruminants' diet can maintain better growth performance with no hazard effects on blood parameters with decrease in methane production of Barki lambs. It's pointed to the potential of using previous shrubs mixtures or treated wheat straw with concentrate feed mixture to enhance livestock feed supply and ensure acceptable level of production under North Western Coast conditions in Egypt. The results have wealth of information on the complementary nutritional role of these three shrub species and the benefit of shrubs mixed diets for ruminants, mainly sheep and goats.

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