RUMINAL FERMENTATION AND NUTRITIVE VALUE ASSESSMENT OF SELECTED ACACIA SPECIES IN VITRO

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Received on: 1/4/2009 *Accepted: 27/5/2009*

ABSTRACT

This study aimed to evaluate the nutritional value of the fresh shoots of 14 Acacia species (A. coriacea, A. cuthbertsonii, A. ineguilatera, A. iteaphylla, A. kempeana, A. ligulata, A. microbotrya, A. nilotica, A. oswaldii, A. pruinocarpa, A. saligna , A. sclerosperma, A. seyal and A. Victoria) that were imported to be cultivated in Saudi Arabia, and to determine the potentiality of these species as ruminant feed resources in comparison with alfalfa hay and wheat straw. Chemical analysis and in vitro gas production technique were used as the basis for this evaluation. The crude protein (CP) content among tested Acacia spp. ranged from 8.0 to 16.7% and it was comparable in A. iteaphylla with that of alfalfa hay, the values were 16.7 and 17.1% in A. iteaphyllal and alfalfa hay, respectively. Among the tested Acacia spp, A. ineguilatera had the highest condensed tannin (CT) values, which ranged from 10.4 to 77.0 mg/g dry matter (DM). Metabolizabole energy (ME, MJ/ kg DM) of the tested Acacia spp. ranged from 4.35 to 6.69 MJ/ kg DM, which could supply the animals with 53-84% of the ME as in alfalfa hay. The CT/CP ratio in Acacia spp. showed a negative correlation with either organic matter digestibility (OMD, %; $r = -0.72$, $P < 0.01$), potential gas production ($r = -0.71$, $P < 0.01$), ammonia production ($r = -0.86$, $P < 0.01$) or total volatile fatty acid concentrations ($r = -0.72$, $P < 0.01$). To ease the evaluation of the nutritive value of Acacia spp. the following equations could be applied,

OMD (%) = 36.5 + 0.02CP + 0.3 NDF – 0.75CT; ($r = 0.75$; $P < 0.001$);

ME (MJ/kg DM) = 5.8 + 0.14CP + 0.02NDF – 0.72CT; ($r = 0.79$; $P < 0.001$), [where NDF is neutral detergent fiber and CT was expressed as mg/g DM].

Key words: Acacia spp, in vitro gas production, nutritive value

1- INTRODUCTION

Browse legumes are commonly used to overcome the low nitrogen content of ruminant rations in tropical regions that is caused by the high cost of protein sources and their demand as human food (Humphreys, 1995). Leguminous trees and shrubs are widely used as fodder for livestock in the tropics and subtropics of the world, and only a few of the 900 *Acacia* genus are extensively cultivated for fodder (Felker and Bandurski, 1979). During the prolonged season of about 8 months in the year especially draught years, *Acacia* species serves as a source of needed nutrients to domestic herbivores. Browse legumes are a very heterogeneous group of plants, with crude protein (CP) ranging from 81 to 306 g/kg dry matter (DM), with variable rumen degradable and intestinally digestible fractions (Kaitho et al., 1998). Moreover, browse legume species have a substantial content of fermentable carbohydrates (Siaw et al., 1993; Krishnamoorthy et al., 1995; Fondevila et al., 2002) that yield volatile fatty acids as energy source for the animal.

The nutritive values of browse legumes depend on their nutrient composition and the presence of secondary compounds that may interact with the rumen microbial population, thereby limiting nutrient utilization (Makkar et al., 1995; Butter et al., 1999). The Fermentation pattern of forages can be estimated *in vitro* by gas production techniques (Menke and Steingass, 1988; Theodorou et al., 1994). Moreover, Menke and Steingass (1988) found a strong correlation between metabolizable energy (ME) value measured *in vivo* and those predicted from 24 h in *vitro* gas production and chemical composition of feeds.

The objectives of this study were: (1) to study the ruminal fermentation of tested *Acacia spp*; and (2) to assess the nutritive values of 14 *Acacia* species as potential new fodder resources for ruminants in comparison with alfalfa hay and wheat straw. Chemical composition, tannins content and degradation kinetics using gas production techniques, were carried out in order to evaluate its effectiveness in ruminants' ration and their value in designing feed management strategies.

2- MATERIALS AND METHODS

2.1- Study area and samples collection and processing

Browse tree leaves from fourteen species of Acacia being: *A. coriacea, A. cuthbertsonii, A. ineguilatera, A. iteaphylla, A. kempeana, A. ligulata, A. microbotrya, A. nilotica, A. oswaldii, A. pruinocarpa, A. saligna , A. sclerosperma, A. seyal* and *A. Victoria*, were collected from the Prince Sultan Research Center for Environment, Water and Desert, King Saud University (Al-Riyadh- Saudi Arabia). Al-Riyadh region (24°-38N'; 46°-43E') receives low

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annual rainfall, the wettest months are March and April, with average falls of 33.5 and 44.2 mm respectively. Minimum and maximum temperatures vary from 26 to 52 °C, respectively. Tested *Acacia spp* were cultivated at the similar time 2 years before sample collection in May 2006. Adequate quantities of fresh shoots (leaves and twigs) were harvested (about 1 kg) from at least 10 random different trees under each species, then pooled and dried at 50 °C in force draught oven for 48 h. Dried Acacia samples, alfalfa hay and wheat straw were ground with a 1 mm screen and stored until further analysis.

2.2- Chemical composition

Chemical composition of *Acacia* species, alfalfa hay and wheat straw was determined using the standard AOAC (1990) procedures to determine DM, organic matter (OM) and CP content. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined following the method of Van Soest et al. (1991), sodium sulphite was added.

2.2.1- Extraction and determination of condensed tannins

Approximately 0.1 g (1.0 mm sieve) was extracted three times with a mixture of 10 ml of acetone/ water (7:3, v/v) in water bath at 30 °C. The tubes (samples + solution) were centrifuged at 2000 xg for 15 min. After extraction the supernatant was transferred to a 10 ml volumetric flask and the lower layer was discarded. The combined aqueous fractions were made up to 10 ml with water, and stored for quantification of the condensed tannins (CT). The CT was determined using butanol/HCl assay (Porter et al., 1986), by adding 0.25 ml of the aqueous extract to 6 ml of *n*-butanol/HCl (95:5, v/v). Then it was vortexed and heated at 95 °C on a water bath for 1 h. The absorbance of the red anthocyanidin products (i.e. condensed tannins) was measured at 550 nm.

2.3- *In vitro* evaluation of roughage samples

Ruminal fluid used for the *in vitro* incubation of *Acacia spp.*, alfalfa hay and wheat straw was proportionally collected from 2 ruminally cannulated sheep before morning feed was offered. Sheep were fed alfalfa hay (CP = 17.1% of DM, NDF = 43.1% of DM, ADF = 25.1% of DM and ADL = 12% of DM) ad libitum. The *in vitro* incubation system (gas method) as described by Menke et al. (1979) was used to measure gas production of tested roughages. Buffered rumen liquor (2:1 v/v) was prepared as described by Menke and Steingass (1988). About 200 mg DM (1 mm) of the *Acacia* species, alfalfa hay and wheat straw were weighed into calibration syringes (60 ml). Syringes pistons were lubricated with vaseline to ease their sliding and to prevent escape of gas. The syringes were pre-warmed to 40 °C before the injection of 30 ml of rumen liquor-buffer mixture into each syringe, followed by incubation in a water bath (39± 0.1 °C). Three parallel syringes that contained rumen liquor-buffer mixture without substrate served as blanks. The syringes were gently shaken for 30 min after the start of incubation, then every hour during the first 10 h of incubation. Readings of gas values were recorded after 2, 4, 6, 12, 24, 48 and 72 h of incubation. Data for gas production were fitted to an exponential equation as proposed by Ørskov and McDonald (1979):

$GP = b\ (1\text{-}exp^{-ct})$,

where GP is gas production (ml) at time *t*, *b* is the gas potential production, and *c* is the rate of gas production (ml/h). Each sample was incubated in triplicates. At the end of the incubation, the supernatant of contents in each syringe was centrifuged at 3000 xg for 15 min and sampled, then stored at –20 °C pending analysis for *in vitro* volatile fatty acids (VFA). The VFA was determined by using gas chromatography (Shimadzu 2010A) equipped with a FID detector, and a fused silica capillary column of 30 m × 0.25 mm i.d.; 0.25 µm phase film (Stabiwaz-DA; Thames Restek UK, LTD). The split ratio in the injector port was 50:1 with a linear velocity of 10 mL/min of He. Oven temperature was programmed to increase from 100 °C to 200°C at 10 °C/min, injector and detector temperatures were 240 °C. Volatile fatty acids were identified by comparison of their retention times with standard of water soluble fatty acid mixes (Cat.# 47056, Supelco, Bellefonte, PA-USA). Indophenol method of Chaney and Marbach (1962) were used to assess NH_3-N concentration in supernatant of incubated Acacia samples.

2.4- Estimation of nutritive values

The organic matter digestibility (OMD) and metabolizable energy (ME) were calculated according to the following equations (Menke and Steingass 1988):

OMD (%) = 14.88 +0.889 GP +0.45 CP + 0.0651 XA

ME (MJ/kg DM) = 2.2+ 0.136 GP+ 0.057CP, where

GP= accumulated gas production after 24 h incubation (ml/ 200mg DM)

CP= crude protein (% of DM)

XA= ash content (% of DM)

2.5- Statistical analysis

Data were subjected to analysis of variance (ANOVA) using the SAS/Statview Institute, Inc. (1999). Significant differences between individual means were identified using least significant difference (LSD) multiple range test.

3- RESULTS

Chemical composition

The CP content among the tested *Acacia spp.* ranged from 8.0 to 16.7 % and was comparable in *A. iteaphylla* with that of alfalfa hay, the values were 16.7 and 17.1% in *A. iteaphyllal* and alfalfa hay,

respectively. Meanwhile, wheat straw had the lowest CP content among the tested feedstuffs. Fiber fractions (NDF, ADF and ADL) were higher in wheat straw than those of other tested feedstuff. The values of NDF, ADF and ADL for *Acacia spp.* ranged from 33.6 to 56.0%, 20.9 to 45.0% and 4.2 to 15.0%, respectively. Alfalfa hay had intermediate values for the fiber fractions (Table 1). Condensed tannin (CT) content varied among the tested *Acacia spp* ranging from 10.4 to 77.0 mg/g DM, and *A. ineguilatera* had the highest CT value.

Feedstuff degradation kinetics

Degradation kinetics of *Acacia spp*, alfalfa hay and wheat straw are presented in Table 2. Potential gas production (*b*, ml/ 200mg DM) among *Acacia spp* ranged from 15.4 to 39.5 ml/200 mg DM. Meanwhile, the extent of degradation for alfalfa hay had no significant differences ($P > 0.05$) compared to *A. kempeana, A. nilotica* and *A. seyal*, the values were 38.3, 39.1, 36.9 and 39.5 ml/200 mg DM, respectively. Wheat straw had an intermediate value of *b* fraction compared to those of tested *Acacia* species (Table 2). The constant degradation rate (*c*, ml/h) was the highest for *A. pruinocara* (0.112) and the lowest in *A. cuthbertsonii* (0.021). The *c* values for alfalfa hay and *A. pruinocara* were not significantly ($P > 0.05$) different.

Assessment of the nutritive value

Calculated ME (MJ/ kg DM) for the tested species of *Acacia*, alfalfa hay and wheat straw are shown in Table 2. Alfalfa hay had the highest ME. The organic matter digestibility (OMD) was the highest in alfalfa hay and it ranged from 25.4 to 39.7% for the tested *Acacia spp*. The values for alfalfa hay and wheat straw were 46.46 and 35.41 %, respectively (Table 2).

***In vitro* ruminal fermentation parameters**

Ammonia concentration (NH_3-N; µg/ml) in rumen medium varied among the tested roughage, *A. nilotica* had the highest concentration which did not differ significantly from that of alfalfa hay incubated in rumen liquor (Table 3). Concentration of total VFA for *Acacia spp.* ranged from 22.9 to 45.6 m*M* in *A. inegullatera* and *A. seyal*, respectively. As for the conventional roughage, total VFA values were 43.2 and 38.1 *m*M for alfalfa hay and wheat straw respectively. The lowest molar proportion of acetate was found in *A. inegullatera* (0.583) and the highest values were found for *A. seyal* (0.683), and alfalfa hay (0.676). Molar proportion of *n*-butyrate was significantly lower ($P < 0.05$) in alfalfa hay than *A. inegullatera*. The *n*-valerate proportion of VFA was significantly higher ($P < 0.05$) for alfalfa hay compared to other tested roughages. The highest values of molar proportion of *iso*-valerate were detected in *A. saligna* and alfalfa hay. The ratio between acetate to propionate for *Acacia spp.* ranged from 2.6 to 4.1 for *A. inegullatera* and *A. seyal*, respectively, this ratio was 4.3 for alfalfa hay and wheat straw for 3.6.

Correlations between chemical compositions, parameters of *in vitro* gas production and ruminal fermentation parameters

The correlations between chemical composition, parameters of *in vitro* gas production and ruminal fermentation parameters for *Acacia spp.* are presented in Table 4. The *b* fraction positively correlated ($P < 0.01$) with CP content of *Acacia spp.* Meanwhile, fiber fractions had negative correlations with gas production, NH_3-N concentration and total VFA (TVFA). Molar proportion of acetate was positively ($P < 0.01$) correlated with gas production. Total branched short chain fatty acids (TBSCFA) were negatively ($P > 0.05$) influenced by CT content of *Acacia spp.* Moreover, CT content had a significantly negative correlation with the ratio of acetate: propionate (Table 4).

The following equations (Menke and Steingass, 1988) were predicted to estimate the OMD and ME of tested *Acacia spp.* using their chemical composition:

$OMD = 36.5 + 0.02CP + 0.3NDF - 0.75CT$;

($r = 0.756$; $P < 0.001$) ..... equation 1,

$ME = 5.8 + 0.14CP + 0.02NDF - 0.72CT$;

($r = 0.798$; $P < 0.001$) ..... equation 2;

where OMD, ME, CP, NDF and CT are organic matter digestibility (%), metabolizabole energy (MJ/kg DM), crude protein (% of DM), neutral detergent fiber content (% of DM) and condensed tannins (mg/g DM), respectively.

DISCUSSION

In the current study, variations in chemical composition among the tested *Acacia* species may be partly due to genotypic factors which control accumulation of forage nutrients. Accumulation of nutrients in plants is a property of species and varies among species and genera (Minson, 1990; Rubanza *et al.*, 2005). Chemical composition of *A. nilotica* and *A. senegal* in the current study were different from those reported by Rubanza *et al.* (2005), who found that CP, NDF, ADF and ADL concentrations were 17.6, 22.2, 13.4 and 5.5; 14.5, 25.0, 14.8 and 6.4 for *A. nilotica and A. senegal*, respectively. Differences in CP contents within species could be attributed to stage of growth, proportion of leaves in tested samples and the season. Topps (1997) noted a high CP content in young leaves of *A. senegal* compared with mature leaves (31.9 *vs* 21.9% of DM). Moreover, shoots had lower CP content than leaves at any stage of growth. Aganga *et al.* (1998) found different values of CP content in *A. nilotica* among the seasons (wet *vs* dry), and the tested part of the plant (leaves *vs* pods).

Differences of NDF, ADF and ADL contents could similarly be due to species genotypic differences in factors that control fiber accumulation in the plant and stage of growth. Minson (1990) reported that the

fiber contents increase with the advance of foliage maturity as a result of lignification. In the current study, the higher fiber fractions in *A. saligna* and *A. seyal* than those reported by Ben Salem *et al.* (2005) and Rubanza *et al.* (2005) might be attributed to the portions of either leaves or stems in tested samples. The succulent parts were used in the current study compared with the leaves in the previous reports.

The minimal CP content of dry material for maintenance of sheep had been indicated by Milford and Haydock (1965) to be 7.2 %; however, it was suggested to be at least 8.9 % CP in plant material (NRC, 1985). The CP values of tested acacia in the present study were mostly well above the recommended levels at previous reports, suggesting that they maintain CP requirement of sheep. On the other hand, the CP of wheat straw (3.9%) was lower than the level which would sustain sheep if used as the only sources of feed. The *A. cuthbertsonii, A. ingeruilatera, A. iteaphylla, A. ligulata, A. microbotrya and A. oswaldii* were found to have sufficient CP content than those recommended by previous reports (Haydock 1965; NRC, 1985), but the OMD and ME were found to be lower ($P < 0.05$) than wheat straw (Table 2). In the current study, the extent of gas production and OMD were positively correlated ($P < 0.01$) with CP content; however the utilization of CP by rumen microorganisms might be limited by tannins' presence in the incubation medium, forming hydrogen bonds between the phenolic sub-units of the polymer and carbonyl group of the protein peptides resulting in a tannin-protein complex which may protect protein from ruminal digestion (Barry and Manley, 1984). The effect of CT from *L. corniculatus* on 11 strains of rumen bacteria was studied by Min *et al.* (2005) who noted that CT reduced rate of proteolysis and inhibited growth of proteolytic rumen microorganism, and these negative effects were correlated to the level of CT. The negative correlation ($r = -0.14$, $P > 0.05$) between the TBSCFA content and CT in the current study could be due to reduction of protein degradability as a result of the inhibiting effect of CT on microbial activities. Demjanec et al. (1995) found that the molar proportion of branched-chain fatty acids (valerate, *iso*-butyrate and *iso*-valerate) were higher when sheep were fed unheated soybean meal and decreased in linear fashion with roasting time of soybean meal. These changes in proportion of TBSCFA were anticipated because branched-chain VFA are produced by microbial deamination of branched chain amino acids. Significant increases in *in vitro* VFA and branched chain fatty acid production were also observed when polyethylene glycol was added for binding of tannins in the *in vitro* fermentation of tanniferous trees like *Calliandra calothyrsus, Leucaena diversifolia, L. pallida* (McSweeney et al., 1999) and *A. angustissima* (Hoffmann et al., 2000).

The impeding effect of CT on nitrogen degradation would lead to decrease protein breakdown and ammonia releases. This finding is confirmed by the negative correlation found in the current study between NH_3-N concentration and either CT level ($r = -0.83$; $P < 0.01$) or CT/CP ratio ($r = -0.86$; $P < 0.01$). The NH_3-N concentrations in incubation medium for the tested roughage were 6.4 to 14.3 mg/dL, 6.7 mg/dL and 13.3 mg/dL for *Acacia spp.*, wheat straw and alfalfa hay respectively, which were within the average cited by Satter and Slyter (1974) for optimum microbial protein synthesis and activities. However, the OMD for *Acacia spp.* was lower than alfalfa hay and wheat straw. The proposed reduction in OMD of *Acacia spp.* in the current study was associated with other factors rather than ammonia concentration in incubation medium. McSweeney et al. (2001) and Evitayani et al. (2004) found that the CT not bound to protein can inhibit fermentation of structural carbohydrates in the rumen by forming indigestible complex with cell wall carbohydrates. It can also form complex with microbial enzymes, rendering them inactive (Gambel et al., 1996). Tannins were frequently observed to reduce structural carbohydrate degradation by reducing the number of cellulolytic microbes in rumen fluid (Singleton, 1981), inhibiting cellulase (Makkar, 1993), preventing adhesion of microbes on the feed particles (Leinmüller and Menke, 1990). Therefore, the negative correlation between CT content and the *in vitro* gas production ($r = -0.73$; $P < 0.01$) and VFA concentration ($r = -0.75$; $P < 0.01$) could be attributed to the impeding effect of CT on the activities of rumen microorganisms in degradation of acacia nutrients, as VFA is a by-product arising mainly from microbial fermentation of carbohydrates. Tannins could reduce fibre digestion by complexing with lignocelluloses and preventing microbial digestion and/or by directly inhibiting cellulolytic microorganisms. Subsequently, the production of acetate as end-product for fibre digestion would be decreased. These findings were supported by the negative correlation ($r = -0.66$, $P < 0.05$) found in the current study between acetate concentration and CT content in the tested acacia, and hence decreased the ratio of acetate: propionate in a negative manner with CT content in *Acacia spp.*

Negative impacts of CT in the reduction of OMD of *Acacia spp* are consistent with the *in vitro* (Getachew et al., 2000; Getachew et al., 2008) and *in sacco* (Hervás et al., 2003) studies. Moreover, Khazaal et al. (1993) reported that microbial gas production and *in vivo* DM disappearance decreased with increased concentration of extractable polyphenolics in browse species. Similarly, Chiquette et al. (1988) demonstrated lower gas production from high tannin than low tannin containing variety of *Louts corniculatus*. Results of our study are in agreement

with the extensively reported suppressive effects of CT on rumen degradation, and on the interference of these compounds with microbial attachment to feeds and degradation.

It may be difficult to attribute the reduction of either ME or OMD solely to the content of CT. In the present study gas production and OMD were negatively correlated with fiber fractions (i.e. NDF, ADF and ADL), but this correlation was not-significant with NDF and ADF; and was highly significant ($r = -0.40$; $P < 0.01$) with ADL (Table 4). Numerous evidences (Van Soest, 1982; McDonald et al., 1995 and Buxton, 1996) indicated that high cell wall constituents also set a limit to potential feed intake by physical fill effect as well as by reducing the digestibility of feeds. Nherera et al. (1998) reported that the effect of polyphenolics on gas production to be complex and varies across browse species, which led them to suggest that the fiber fraction of browse species may be more important than tannins in limiting fermentation *in vitro*. Factors affecting the nutritive values found in the current study were summarized in equations 1 and 2 to ease the assessment of *Acacia spp.* by using their chemical composition (i.e. CP, NDF and CT).

CONCLUSIONS

Based on the chemical composition, all tested *Acacia spp.* were found to have higher CP content than wheat straw. The CP content in *A. iteaphylla* was comparable to that of alfalfa hay (16.7 *vs* 17.1% DM). High content of CT in *Acacia spp.* was found to have a negative effect on its nutritive value (i.e. ME and OMD) estimated from gas production. The ME of the tested *Acacia spp.* ranged from 4.35 to 6.69 MJ/ kg DM, which could supply the animals with 53-84% of ME as in alfalfa hay. To ease the evaluation of nutritive value of *Acacia spp.* as ME and OMD the equations 1 and 2 could be applied.

Table 1. Chemical composition of different *Acacia* spp, alfalfa hay and wheat straw.

	OM[1]	CP	NDF	ADF	ADL	CT[2]
	(% of dry matter)					mg/ g DM
A. coriacea	83.3	12.2	55.8	33.6	10.5	11.7
A. cuthbertsonii	84.2	9.6	44.0	37.0	11.9	65.1
A. ineguilatera	82.0	8.0	56.0	45.0	15.0	77.0
A. iteaphylla	83.6	16.7	51.2	40.4	12.5	40.1
A. kempeana	81.5	12.2	53.5	40.3	10.5	31.1
A. ligulata	84.8	8.4	39.5	27.5	14.1	62.1
A. microbotrya	84.4	13.1	43.0	34.8	8.4	57.8
A. nilotica	88.0	13.8	42.6	35.4	6.0	15.7
A. oswaldii	89.1	11.3	36.7	22.6	8.3	55.4
A. pruinocarpa	82.1	10.9	47.3	33.4	15.6	25.0
A. saligna	89.7	12.6	33.6	20.9	9.5	40.1
A. sclerosperma	87.7	14.4	43.0	32.1	9.4	33.7
A. seyal	90.7	14.4	34.7	27.0	4.2	10.4
A. victoria	88.4	12.4	44.6	31.3	7.3	19.3
Alfalfa hay	88.0	17.1	43.1	25.1	12.0	ND[3]
Wheat straw	84.1	3.9	75.3	46.2	15.8	ND

[1]OM, organic matter; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; ADL, acid detergent lignin.
[2]Condensed tannins expressed as mg anthocyanidin equivalent per g DM.
[3]ND = not detected

Table 2. Gas production constants (ml/200 mg DM) and predicted metabolizable energy (ME, MJ/kg DM) and organic matter digestibility (OMD, %) of different *Acacia spp.*, in comparison with alfalfa hay and wheat straw.

	Gas production constants			
	b^1 (ml/200 mg DM)	c^1 (ml/h)	ME	OMD
A. coriacea	24.17^{cd}	0.064^{bc}	5.54^{d}	32.21^{d}
A. cuthbertsonii	20.58^{de}	0.021^{e}	4.35^{f}	25.36^{f}
A. ineguilatera	15.38^{f}	0.057^{c}	4.26^{f}	25.36^{f}
A. iteaphylla	26.56^{cd}	0.038^{d}	5.32^{de}	29.07^{e}
A. kempeana	39.07^{a}	0.053^{cd}	6.69^{b}	39.72^{b}
A. ligulata	18.21^{ef}	0.064^{bc}	4.61^{ef}	27.57^{ef}
A. microbotrya	18.10^{ef}	0.075^{b}	5.03^{e}	28.48^{e}
A. nilotica	36.93^{a}	0.052^{cd}	6.42^{bc}	37.30^{bc}
A. oswaldii	19.20^{e}	0.065^{bc}	4.96^{e}	28.72^{e}
A. pruinocara	23.37^{d}	0.112^{a}	5.80^{cd}	34.35^{cd}
A. saligna	26.72^{cd}	0.050^{cd}	5.47^{de}	31.59^{de}
A. sclerosperma	27.31^{c}	0.061^{bc}	5.98^{cd}	34.25^{cd}
A. seyal	39.46^{a}	0.038^{d}	6.11^{c}	35.08^{cd}
A. victoria	25.24^{cd}	0.065^{bc}	5.59^{d}	32.42^{d}
Alfalfa hay	38.33^{a}	0.112^{a}	8.08^{a}	46.46^{a}
Wheat straw	32.43^{b}	0.048^{cd}	5.56^{d}	35.41^{c}
S.E.M.	1.132	0.004	0.137	0.877

[1]The potential gas production *(b)* and rate of gas production *(c)* are constants predicted by the exponential model proposed by Ørskov and McDonald (1979).

[a-f] Means in the same column with different superscript letters are significantly different ($P < 0.05$).

S.E.M., standard error of the mean.

Table 3. Ammonia concentration (NH_3-N, µg/ml), total volatile fatty acids (VFAs, m*M*) and molar proportion of constitute VFAs and acetate to propionate ratio of *Acacia* spp., and alfalfa hay and wheat straw incubated with rumen fluid *in vitro*.

	NH_3-N (µg/ml)	Total VFA (m*M*)	VFA molar proportion						
			Acetate	Propionate	*n*-Butyrate	*iso*-Butyrate	*n*-Valerate	*iso*-Valereate	Acetate: propionate
A. coriacea	113^{c}	31.6^{d}	0.623^{cde}	0.197^{bcd}	0.112^{abc}	0.023^{ab}	0.030^{b}	0.015^{ab}	3.17^{def}
A. cuthbertsonii	79^{de}	26.2^{e}	0.603^{ef}	0.213^{ab}	0.118^{ab}	0.021^{abc}	0.029^{b}	0.016^{ab}	2.83^{fg}
A. ineguilatera	64^{e}	22.9^{f}	0.583^{f}	0.229^{a}	0.125^{a}	0.018^{abc}	0.030^{b}	0.016^{ab}	2.55^{g}
A. iteaphylla	107^{c}	30.6^{d}	0.628^{cde}	0.193^{bcde}	0.112^{abcd}	0.023^{a}	0.030^{b}	0.017^{ab}	3.25^{def}
A. kempeana	118^{bc}	43.3^{ab}	0.677^{a}	0.169^{fg}	0.096^{cde}	0.017^{abc}	0.029^{b}	0.014^{ab}	4.03^{abc}
A. ligulata	64^{e}	23.0^{ef}	0.616^{cde}	0.211^{ab}	0.190^{abcde}	0.019^{abc}	0.029^{b}	0.017^{ab}	2.92^{fg}
A. microbotrya	85^{d}	24.3^{ef}	0.607^{ef}	0.215^{ab}	0.108^{abcde}	0.021^{abc}	0.032^{b}	0.016^{ab}	2.83^{fg}
A. nilotica	143^{a}	40.9^{bc}	0.669^{ab}	0.173^{efg}	0.098^{cde}	0.018^{abc}	0.029^{b}	0.014^{ab}	3.87^{abc}
A. oswaldii	79^{de}	25.3^{ef}	0.616^{cde}	0.207^{abc}	0.110^{abcd}	0.021^{abc}	0.030^{b}	0.017^{ab}	2.98^{efg}
A. pruinocarpa	106^{c}	30.4^{d}	0.611^{def}	0.209^{ab}	0.112^{abcd}	0.021^{abc}	0.030^{b}	0.016^{ab}	2.92^{fg}
A. saligna	116^{bc}	33.4^{d}	0.6447^{bc}	0.178^{defg}	0.103^{bcde}	0.022^{abc}	0.031^{b}	0.020^{a}	3.61^{bcd}
A. sclerosperma	114^{c}	32.7^{d}	0.638^{cd}	0.184^{cdef}	0.106^{bcde}	0.023^{a}	0.031^{b}	0.018^{ab}	3.48^{cde}
A. seyal	108^{c}	45.6^{a}	0.683^{a}	0.165^{fg}	0.0940^{de}	0.017^{abc}	0.028^{b}	0.013^{b}	4.13^{ab}
A. victoria	110^{c}	31.5^{d}	0.629^{cde}	0.198^{bcd}	0.107^{abcde}	0.023^{ab}	0.031^{b}	0.016^{ab}	3.20^{def}
Alfalfa hay	133^{ab}	43.2^{ab}	0.676^{a}	0.157^{e}	0.091^{cde}	0.017^{abc}	0.040^{a}	0.020^{a}	4.29^{a}
Wheat straw	67^{de}	38.1^{c}	0.643^{bcd}	0.177^{defg}	0.114^{abc}	0.019^{abc}	0.030^{b}	0.015^{ab}	3.64^{bcd}
S.E.M	2.6	0.44	0.005	0.004	0.003	0.0008	0.001	0.001	0.001

[a-g] Means in the same column with different superscript letters are significantly different ($P < 0.05$).
S.E.M., standard error of the mean.

Table 4. Correlation coefficients of *in vitro* gas production, organic matter digestibility (OMD), chemical composition, ammonia concentrations (NH_3-N) and volatile fatty acids of *Acacia* spp.

	CP	NDF	ADF	ADL	*b*	OMD	NH_3-N	TVFA	Ace.	Prop.	TBSCFA	Acc/Pro	CT	CT/CP
CP	1.00	-0.12	-0.06	-0.50**	0.50**	0.39**	0.60**	0.48**	0.47**	-0.53**	0.15	0.49**	-0.49**	-0.72**
NDF		1.00	0.86**	0.51**	-0.12	-0.01	0.01	-0.10	-0.27*	0.25	-0.05	-0.25	0.04	0.10
ADF			1.00	0.40**	-0.03	-0.05	-0.02	-0.05	-0.22	0.23	-0.24	-0.20	0.13	0.17
ADL				1.00	-0.57**	-0.40**	-0.48**	-0.57**	-0.63**	0.61**	0.18	-0.63**	0.50**	0.56**
b					1.00	0.82**	0.78**	0.98**	0.93**	-0.89**	-0.49**	0.92**	-0.73**	-0.71**
OMD						1.00	0.79**	0.83**	0.76**	-0.70**	-0.35*	0.73**	-0.76**	-0.72**
NH_3-N							1.00	0.79**	0.72**	-0.77**	-0.02	0.73**	-0.83**	-0.86**
TVFA								1.00	0.92**	-0.89**	-0.45**	0.92**	-0.75**	-0.72**
Ace.									1.00	-0.96**	-0.35*	0.99**	-0.66**	-0.66**
Prop.										1.00	0.16	-0.99**	0.67**	0.69**
TBSCFA											1.00	-0.28*	-0.14	-0.02
Ace/Pro												1.00	-0.66**	-0.66**
CT													1.00	0.93**
CT/CP														1.00

CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; ADL, acid detergent lignin; *b*, potential *in vitro* gas production; OMD, organic matter digestibility; NH_3-N, *in vitro* ammonia concentration; TVFA, *in vitro* concentration of total volatile fatty acids; Ace, acetate; Pro, propionate; TBSCFA, total branched short chain fatty acids; Ace/Pro, acetate:propionate ratio; CT, condensed tannins; CT/CP, condensed tannins: crude protein ratio.

* $P < 0.05$.

** $P < 0.01$.

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الملخص العربى

تخمرات الكرش وتقدير القيمة الغذائية لبعض أنواع الأكاسيا معملياً باستخدام طريقة إنتاج الغاز

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بريده ٥١٤٥٢- ص.ب ٦٦٢٢

المملكة العربية السعودية

هذه الدراسة تهدف إلي تقدير القيمة الغذائية لعدد ١٤ نوع من نبات الأكاسيا " *A. coriacea, A. cuthbertsonii, A. ineguilatera, A. iteaphylla, A. kempeana, A. ligulata, A. microbotrya, A. nilotica, A. oswaldii, A. pruinocarpa, A. saligna , A. sclerosperma, A. seyal* and *A. Victoria*" والتي تم إستيرادها بهدف الإستزراع في المملكة العربية السعودية وكذلك تقييم مدي جودة هذه النباتات كمصدر غذائي للحيوانات المجترة مقارنة بدريس البرسيم وتبن القمح. التحليل الكيميائي وكمية الغاز المنتج تم إستخدامهم كأساس لهذا التقييم.

محتوي البروتين الخام في أنواع الأكاسيا موضوع الدراسة تراوح مابين ٨-١٦,٧٪ من المادة الجافة وكان محتوي النوع *A. iteaphylla* من البروتين الخام مقارب لمحتوي دريس البرسيم وكانت النسبة هي ١٦,٧ و ١٧,١ علي التوالي. كمية التانينات المكثفة في أنواع الأكاسيا تراوحت مابين ١٠,٤ إلي ٧٧ مليجرام/جرام مادة جافة وكان أعلي تركيز لها في النوع *A. ineguilatera*. الطاقة الميتابوليزمية لأنواع الأكاسيا كانت تتراوح مابين ٤,٣٥ إلي ٦,٦٩ ميجا جول/كجم ماده جافة وهذه القيم تمثل ٥٣ الي ٨٤٪ من الطاقة الميتابوليزمية المقدرة في دريس البرسيم. النسبة بين التانينات ومحتوي البروتين الخام كان لها تأثير سلبي علي كل من معامل هضم المادة العضوية ($r = - 0.72, P < 0.001$) & كمية الغاز المنتج ($r = - 0.71, P < 0.001$) & إنتاج الأمونيا ($r = - 0.66, P < 0.001$) & تركيز الأحماض الدهنية الكلية ($r = - 0.72, P < 0.001$).

لسهوله تقدير القيمة الغذائية لأنواع الأكاسيا يمكن إستخدام المعادلات التالية:

معامل هضم المادة العضوية (%) = ٣٦,٥ + ٠,٠٢ البروتين الخام + ٠,٣ الألياف المقاومة للمحاليل المتعادلة - ٠,٧٥ التانينات المكثفة & ($r = - 0.72, P < 0.001$).

الطاقة الميتابوليزمية (ميجا جول/كجم مادة جافة) = ٥,٨ + ٠,١٤ البروتين الخام + ٠,٠٢ الألياف المقاومة للمحاليل المتعادلة - ٠,٧٢ التانينات المكثفة ($r = - 0.79, P < 0.001$).

بحيث إن التانينات المكثفة مقدرة كمليجرام / جرام مادة جافة.