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Nutritive Value and Rumen Degradation of Stover of Two Sorghum Varieties in Camels

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Abstract

The new ruminant protein systems require information on feeds degradation characteristics. Currently in Sudan the information on rumen degradation of Sorghum Stover parts in camels is not available. Therefore, this study aimed to determine the rumen degradation and degradation characteristics of Stover of two Sorghum varieties namely; Wad Aakar and Feterita in order to improve camel's nutrition and production. The two Sorghum stover varieties Wad Aakar and Feterita stalks were divided into upper (U), middle (M) and lower (L) parts. The proximate analysis of the parts was determined. Three rumen fistulated camels were used to study the rumen degradation. The animals were fed *Medicago sativa* (Barseem) *ad libitum* and 2kg concentrate ration daily. Artificial fibre bags (18x14cm) were incubated in the rumen for different times and degradation characteristics were calculated. The effective degradability at different rates of outflow from the rumen of two Sorghum stover parts was calculated. Results showed that Sorghum stover varieties varied in proximate analysis and degradation characteristics of different parts. However, in the two Sorghum varieties the upper part had the highest CP and ash while the lower part had the highest CF, EE and OM. The least EE was shown in the middle part of the both Sorghum stover. In all plant parts, the highest potential degradability was observed in CP, while the least was shown in OM compared to other contents. The effective degradability varied in different parts of Sorghum Feterita and Wad Akar stovers and decreased with increasing rates of outflow from the rumen. It is concluded that camels have high fibres rumen degradation, therefore, we recommend the use of crop residues for camels feeding.

Keywords: Crop residues, Sorghum stover, rumen degradation, camels

المستخلص

تتطلب أنظمة البروتين الحديثة معلومات عن الخصائص التكسرية للاعلاف. حاليا في السودان المعلومات عن التكسر الكرشي لأجزاء تبن الذرة الرفيعة في الإبل غير متاح، لذلك كان الهدف من هذة الدراسة تحديد التكسر الكرشي والخصائص التكسرية لتبن نوعين من أصناف الذرة الرفيعة فترية و ودعكر لتحسين تغذية وانتاج الابل. تم تقسيم كل من صنفي تبن الذرة

الرفيعة فترِيتة و ودعكر الي اجزاء عليا، متوسطة وسفلى. وتم تحديد التحليل التقريبي للأجزاء . تم استخدام ثلاثة من الابل ثبتت بها نواسير بالكرش لدراسة التكسر في الكرش . تم تغذية الحيوانات على البرسيم حد الشبع و2 كيلوجرام عليقة مركزة يومياً. لحساب الخصائص التكسرية تم تحضين أكياس الياف صناعية (18×14سم) في الكرش لأوقات مختلفة. تم حساب التكسر الفعلي لأجزاء تبن الذرة الرفيعة عند معدلات مختلفة لسرعة المرور من الكرش. أظهرت النتائج ان صنفي تبن الذرة الرفيعة مختلفة في التحليل التقريبي والخصائص التكسرية للأجزاء المختلفة. لكن، في صنفي تبن الذرة الرفيعة اعطى الجزء العلوي اعلي نسبة للبروتين والمعادن بينما اعطى الجزء السفلي اعلي نسبة للألياف، الدهون و الماة العضوية. أقل نسبة دهون كانت في الجزء المتوسط لصنفي الذرة الرفيعة. في كل الاجزاء النباتية اعلى تكسر كرشي شوهد في البروتين بينما الاقل شوهد في المادة العضوية مقارنة مع المحتويات الاخرى. أختلف التكسر الفعلي في الأجزاء المختلفة لتبن الذرة الرفيعة ودعكر والفترِيتة وانخفض مع زيادة معدلات سرعة المرور من الكرش. خلصت الدراسة علي ان الابل لها تكسر كرشي عالي للالياف ولذلك نوصي باستخدام مخلفات المحاصيل الزراعية لتغذية الابل.

الكلمات المفتاحية: مخلفات المحاصيل، تبن الذرة الرفيعة، التكسر الكرشي، الابل

Introduction

Dairy products and meat demand and prices increased substantially in the Sudan in the last decades due to the increased human population and urbanization and improved education, income, living standards and nutritional awareness. It is vital to produce cheap and high quality meat and dairy products by improving conventional animal species performance and exploiting neglected species. Camels are attractive for meat and milk production due to high population ranking 2nd to Somalia in world population (FAO,2009). They are efficient producers of high quality milk and meat in arid and semi- arid environments where it is difficult to rear other meat and milk producing animals (Farah *et al*., 1992). They have many valuable and distinguished products including milk, meat, hides and waber (Albert, 2002). In addition, they are used for riding, racing and packing. Nutrition is a main constraint for camel's production in the Sudan due to many factors. Rangeland generally deteriorated due to haphazard agricultural expansion and reduced area, successive droughts, over grazing and seasonal variations in feeds quantity and quality leading to serious shortages in the dry season affecting animal's performance and health (Ali,2003). Agricultural by-products and browses are exploited to fill the nutritional gap, especially in the dry season. Browses have high nutritive value and crop residues generally have low nutritive value. Feed gap was about 51% DM and rangeland contributed about 22% (AbuSuwar and Darag, 2002). Agricultural by-products are abundant in the Sudan and important in animal nutrition (AOAD, 2005). The main crop residues in the Sudan are Sorghum stover, Groundnut haulm, millet, sesame, wheat, cotton and sunflower straws. Total crop residues production in the Sudan was 15.344 thousand tons in 1993-1994 and available amounts were 5.904 thousand tones. Crop residues, especially Sorghum stover are abundant in the country, but have high fibres and low nutritive value, CP, digestibility, DMI and animal's performance (Hamed, 2007). Information on camel's nutrients requirements are scarce and information on cattle is used to calculate nutrients requirements. In addition, modern concepts of ruminant nutrition as the new protein systems (ARC,1982) are not applied in camel's nutrition. The new protein systems are based on microbial yield and feeds rumen degradation. Estimates of these two parameters are not available for camels in the Sudan to apply modern nutritional system in camel's nutrition. Consequently, this study was conducted to determine the rumen degradation and degradation characteristics of stover of two Sorghum varieties Wad Aakar and Feterita.

Material and methods

Study Site:

This study was conducted at the Central Veterinary Research Laboratory (CVRL), Animal Resources Research Corporation (ARRC), Ministry of Animal Resources, Fishers and Rangelands in Soba, Khartoum State, Sudan.

Experiment:

Animals:

Three Arabian fistulated camels, two females and one male at 5-8 years old and 291- 383kg live body weight were used in this study. They were injected with Ivomec **(**Ivermctine) against internal and external parasites.

Housing:

The animals were allocated at random to three individual pens shaded with corrugated iron sheets. The pens were 3.95 x 2.95 m in dimensions and were 3m high. Each pen has feeder and water trough.

Surgical preparation:

The animals were fasted of feed and water for 24 hrs before the operation. The animals were fitted with the rumen fistulae in November 2015 as described by Brown *et al.* (1968).

Anaesthesia:

Xylazine (2%) at 0.25 ml/100kg body weight was injected intramuscularly to sedate the animals. The animals were then anesthetized with Lidocaine (2%) for local infiltration and paravertebral nerve block.

Fistulation technique:

Cannulae:

The cannulae were 10.5 cm long tubes and were 4.5 cm in diameter. They were made from Teflon. They had a flang at one end to prevent it from coming outside the rumen. The other end of the cannulae was screwed to secure a cover. A screwed ring was used to fix each cannulae in the animals after fistulation. In addition, two hard plastic rings were used to secure the cannulae in position and one was intact with the skin.

Post-operative care:

To avoid the post-operative infection, the animals were injected with a broad spectrum antibiotic (Penivet Forte) intramuscularly for 7 days. The wounds were cleaned daily with Potassium Permanganate and Iodine. Pencillin powder was applied on wounds. The fistulated animals healed without problems and were ready for the experiment after 4 - 6 weeks from the surgery. The cannulae were cleaned regularly with a disinfectant.

Feeding:

Each animal was offered 2kg concentrate ration and *Medicago sativa* (Barseem) *ad lib.* in one meal in the morning at 8.0 am. The concentrate ration ingredients and calculated composition and energy are shown in Table1**.** In addition, the animals were offered minerals and vitamins blocks. Clean water was available all the time.

Feeds for rumen degradation:

Sorghum Stover Fractionation:

The two Sorghum stover vareities (Wad Aakar and Feterita) were divided into three fractions (parts) using a sharp cutter. The parts included the upper part (U), the middle part (M) and the lower part (L).

Degradation procedure:

Feeds degradability was conducted in the three fistulated camels using the nylon bags technique as described by Orskov *et al.* (1980).

Bags preparation:

Artificial fibre bags (18 x 14 cm) and weighing 2.5 - 3g were made from fibre filter cloth from a new military Parachute.

They were manufactured according to Orskov *et al.* (1980). The empty bags were numbered, washed and oven dried at 100 ºc for 24 hrs. They were then individually weighed and their weights were recorded. Plant samples were chopped to small pieces (2-3 cm) by a sharp cutter before weighing into the bags to behave similar to masticated particles. Five grams of each air dried feed sample were weighed into the bag, tied with a nylon string about 50 cm long and introduced into a 6 cm plastic tube above the fistula level to ease the bags movement in the rumen. About 4 - 6 bags were incubated at a time in the rumen of the fistulated camels. The bags were soaked in tap water before incubation in the rumen.

Bags incubation:

The bags were incubated for different periods including 6, 18, 24, 33, 48, 57, 72, 81 and 96 hrs. The bags were immediately removed at the end of each incubation period, washed under running tap water and dried in an oven at 100 ºc for 24 hrs. They were then removed and weighed. The residues in the bags in the three animals for every incubation period for each feed were mixed and stored for laboratory analysis.

Calculations:

Feeds DM losses (degradation) percentages were calculated from the following equation:

$$\frac{\text{Incubated sample dry weight} - \text{residue dry weight after incubation}}{\text{Incubated sample dry weight}} \times 100$$

Feeds degradation kinetics was described by curve - linear regression of DM, OM, CP and CF losses from the incubated bag with time (Orskov and McDonald, 1979).

P = a + b (1 - e $^{-ct}$**) . . . (i)**

Where:

P = Potential degradability

t = Incubation time

a = Axis intercept at time zero represents the soluble and completely degradable substrate rapidly washed out of the bag.

b = The difference between the intercept (a) and the asymptote and represents the insoluble but potentially degradable substrate degraded by the microorganism according to first order kinetics.

c = Rate constant of b function

a, b, c are constants fitted by an interactive least squares procedure.

Equation (i) provides curve constants that can be used for a specified diet to estimate the effective degradability.

Effective degradability = $a + \frac{bc}{c+k}$

Where:

a, b and c are constants as defined in equation (i)

k = Rumen small particle outflow rate.

Then a gragh was plotted by the fitted values of dry matter disappearance (%) against time of incubation in hrs to form a curve.

Laboratory analysis:

Feeds proximate analysis including dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE) and ash was determined according to the procedure described by AOAC (2000). Nitrogen free extract (NFE) was calculated by subtracting the sum of CP, CF, EE and ash from 100. The organic matter (OM) was calculated by subtracting ash from 100.

Statistical analysis:

Data were analyzed using descriptive statistics.

Table 1. The ingredients and calculated composition of the concentrate ration fed to the fistulated camels.

Ingredients	(%)
Sorghum grains (Feterita)	47
Groundnut cake	10
Wheat bran	40
Minerals / Mixed	02
Salt	01
CP	18.9
ME (MJ/Kg DM)	12.6

Results

Feeds proximate analysis:

Table 2. shows the proximate analysis of different parts of Sorghum stover varieties. The proximate analysis varied among Sorghum varieties and parts. Feterita stover upper part had the highest CP and ash. Nitrogen free extract, CF and OM were highest in the lower part. The lower part had the highest EE and the middle part had the least EE. Wad Akar stover upper part had the highest CP and ash. The middle part had the highest NFE and least CP and EE. The lower part had the highest CF, EE and OM. In the two Sorghum varieties the upper part had the highest CP and ash and the lower part had the highest CF, EE and OM. The middle part had the least EE.

Degradation characteristics:

Table 3. shows the degradation characteristics of different parts of Sorghum Feterita and Wad Akar stovers in the rumen of camels. In Feterita DM the soluble fraction was highest in the middle part and least in the lower part while (b) and (P) were highest in the lower part and least in the upper part. The degradation rate was highest in the upper part and least in the lower part. In CP the soluble fraction was highest in the upper part and least in the middle part. The value of (b) was highest in the lower part and least in the upper part. The value of (P) was highest in the upper part and least in the middle part. The degradation rate was highest in the upper part and least in the middle part. In CF the soluble fraction was highest in the middle part and least in the upper part while the values of (b) and (P) were highest in the lower part and least in the upper part. The degradation rate was highest in the middle part and least in the upper part. In OM the soluble fraction was highest in the middle part and least in the lower part while the values of (b) and (P) were highest in the lower part and least in the upper part.

The degradation rate was highest in the upper part and least in the lower part. In wad Akar DM the soluble fraction was highest in the lower part and least in the upper part. The value of (b) was highest in the upper part and least in the lower part. The value of (P) was highest in the lower part and least in the middle part. The degradation rate was highest in the upper part and least in the lower part. In CP the soluble fraction was highest in the middle part and least in the upper part. The value of (b) was highest in the upper part and least in the middle part. The value of (P) was highest in the upper part and least in the lower part. The degradation rate was highest in the lower part and was similar in the upper and middle part. In CF the soluble fraction was highest in the lower part and was similar in the upper and middle part. The value of (b) was highest in the upper part and least in the middle part. The value of (P) was highest in the lower part and least in the middle part. The degradation rate was highest in the lower part and least in the middle part. In OM the soluble fraction was highest in the lower part and least in the upper part. The value of (b) was highest in the upper part and least in the lower part. The value of (P) was highest in the lower part and least in the middle part. The degradation rate was highest in the upper part and least in the lower part. Crude protein potential degradability was the highest and that OM was the least in all parts of the two Sorghum varieties. In DM the soluble fraction was similar in the upper part of the two Sorghum varieties. It was higher in the lower part in wad Akar and in the middle part in Feterita.

Effective degradability:

Table 4. shows the effective degradability of different parts of Sorghum Feterita and Wad Akar stovers at different rates of outflow from the rumen in camels.

Table 2. The proximate analysis (%DM) of different parts of Sorghum Feterita and Wad Akar stovers.

Plants/ Fractions	DM	CP	CF	EE	Ash	NFE	OM
Feterita:Upper	95.0	6.9	44.0	1.9	13.5	33.7	86.5
Middle	93.0	6.7	46.0	1.5	8.0	37.8	92.0
Lower	94.0	6.6	47.0	2.4	6.0	38.0	94.0
Wad Akar:Upper	94.0	6.5	44.5	2.0	13.3	33.7	86.7
Middle	95.0	6.1	47.0	1.7	7.0	38.2	93.0
Lower	95.0	6.4	48.5	2.3	5.7	37.1	94.3

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Table 3. The degradation characteristics of different parts of Sorghum Feterita and Wad Akar stovers in the rumen of camels.

Plants	D M				CP				CF				OM			
Feterita /Fractions	**a**	**b**	**P**	**c**	**a**	**b**	**P**	**c**	**a**	**b**	**P**	**c**	**a**	**b**	**P**	**c**
Upper	16	38.0	54.0	0.0346	30	64.0	94.0	0.0309	08	49.2	57.2	0.0289	15	33.9	48.9	0.0358
Middle	19	42.3	61.3	0.0331	20	66.7	86.7	0.0287	16	51.2	67.2	0.0351	18	41.6	59.6	0.0306
Lower	14	60.3	74.3	0.0241	21	68.0	89.0	0.0300	12	59.0	71.0	0.0290	14	59.5	73.5	0.0212
Wad Akar /Fractions	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Upper	16	38.9	54.9	0.0325	20	70.3	90.3	0.0287	13	52.0	65.0	0.0256	15	35.2	50.2	0.0280
Middle	18	34.2	52.2	0.0279	36	45.9	81.9	0.0287	13	43.6	56.6	0.0228	17	33.1	50.1	0.0274
Lower	28	29.8	57.8	0.0256	30	51.0	81.0	0.0305	20	46.0	66.0	0.0266	28	27.7	55.7	0.0218

a = soluble fraction (%), b = portion degraded with time (%)
p = potential degradability (%) , c = rate constant of b function.

Table 4. The effective degradability of different parts of Sorghum Feterita and Wad Akar stovers at different rates of outflow from the rumen in camels.

Feterita /Fractions	K	DM	CP	CF	OM
Upper	0.01	45.5	78.4	44.6	41.5
	0.04	33.6	57.9	28.6	31.0
	0.07	28.6	49.6	22.4	26.5
	0.10	25.8	45.1	19.0	23.9
Middle	0.01	51.5	69.5	55.8	49.4
	0.04	38.2	47.9	39.3	36.0
	0.07	32.6	39.4	33.0	30.7
	0.10	29.5	34.9	29.3	27.7
Lower	0.01	56.6	72.0	55.9	54.4
	0.04	36.7	50.1	36.8	34.6
	0.07	29.4	41.4	29.3	27.8
	0.10	25.7	36.7	25.3	24.4
Wad Akar /Fractions	-	-	-	-	-
Upper	0.01	45.7	72.1	50.4	40.9
	0.04	33.4	49.4	33.3	29.5
	0.07	28.3	40.4	26.9	25.1
	0.10	25.5	35.7	23.6	22.7
Middle	0.01	43.2	70.0	43.3	41.2
	0.04	32.1	55.2	28.8	30.5
	0.07	27.7	49.3	23.7	26.3
	0.10	25.5	46.2	21.1	24.1
Lower	0.01	49.4	68.4	53.4	46.9
	0.04	39.6	52.1	38.4	37.8
	0.07	35.9	45.5	32.7	34.6
	0.10	34.1	41.9	29.7	32.9

K = Rumen outflow rate/hr.

Effective degradability = $a + \frac{bc}{c+k}$

Discussion

Feeds proximate analysis:

The variations in proximate analysis among Sorghum varieties and parts were mainly genetic. Similar results were found by Hamed (2007). Feterita stover higher CP and lower CF in all parts compared to wad Akar was mainly genetic and may be affected by the environment. This showed that Feterita had better nutritive value compared to Wad Akar. The decreased CP from the upper to the lower parts suggested that it will be better to treat different parts using different levels of the upgrading materials. Similar suggestions were also made by Hamed (2007). However, NFE increased from the upper to the lower part in Feterita and generally increased from the upper to the lower part in wad Akar. In addition, EE generally increased from the upper to the lower part and was higher in Wad Akar. The low CP and EE in the three parts of Sorghum Feterita and Sorghum Wad Akar stovers in this study is a common feature of stovers . Similar findings were reported by Hamed (2007). Crude fibre in different parts of Sorghum Feterita and Wad Akar stovers was higher than that obtained by Hamed (2007). However, ash and NFE were lower and ash in the upper part was higher. The variations among workers could be due to varieties and environment.

Degradation characteristics:

The highest (a) value in Feterita stover middle part DM was associated with high CF and low CP and NFE. The least value in the lower part was associated with high CF and low CP and NFE. The two fractions had high CF and low CP and NFE and the lower value in the lower part may be mainly to higher lignification in the lower part indicating variations in fibres types among the two fraction. The highest (b) and (p) in the lower part were associated with the least (a) and the least values in the upper part were associated with high CF and low CP and NFE. The highest (c) value in the upper part was associated with high CF and low CP and NFE and the least value in the lower part was associated with high CF and low CP and NFE.

The highest (a) value in CP in the upper part was associated with low CP and NFE and high CF and the latter may be less lignified. The least (a) in the middle part was mainly due to high CF and low CP and NFE. The highest (b) in the lower part and least in the upper one although they had high CF and low CP and NFE was not expected as the lower part was expected to be more lignified. The highest (P) and (c) in the upper part and least in the middle one although they had similar CP, CF and NFE suggested increased lignification from the upper to the lower part. The highest (a) value in CF in the middle part and least in the upper one and the highest (b) and (P) in the lower part and least in the upper one were not expected due to increased plants lignification from the upper to the lower part. The highest (c) value in the middle part and least in the upper one was not expected due to increased lignification from the upper to the lower part. The highest (a) value in OM in the middle part and least in the lower one were mainly due to increased lignification from the upper to the lower one. The highest (b) and (P) in the lower part and least in the upper part were not expected due to increased lignification from the upper to the lower part. The highest (c) value in the upper part and least in the lower part were associated with increased lignification from the upper to the lower part. In wad Akar the highest DM soluble fraction in the lower part and least in the upper part was not expected as lignification increased from the upper to the lower one. The highest (b) and (c) in the upper part and least in the lower part were mainly due to increased lignification from the upper to the lower one. The highest (P) in the lower part and least in the middle part were not expected as lignification increased from the upper to the lower part. The highest (a) in CP in the middle part and least in the upper part were not expected as lignification increased from the upper to the lower part. The highest (b) in the upper part and least in the middle part and the highest (P) in the upper part and least in the lower part were mainly due to increased lignification from the upper to the lower part. The highest (c) in the lower part and similar values in the upper and middle part showed the highly complicated relationship among degradation characteristics and fibres types in stover fractions. The highest (a) in CF in the lower part and similar values in the upper and middle part reflected the highly complicated relationship among degradation characteristics and fibres types in stover fractions. The highest (b) in the upper part and least in the middle part was mainly due to increased lignification from the upper to the lower one. The highest (P) in the lower part and least in the middle one and the highest (c) in the lower part and least in the middle one suggested the highly complicated relationship among degradation characteristics and fibres types in stover fractions. The highest (a) in OM in the lower part and least in upper one, highest (b) in the upper part and least in the lower one and highest (P) in the lower part and least in the middle part showed the highly complicated relationship among degradation characteristics and fibres types in stover fractions. The highest (c) in the upper part and least in the lower part was mainly due to increased lignification from the upper to the lower part. Crude protein potential degradability was the highest and that OM was the least in all parts of the two Sorghum varieties.

Effective degradability:

The decreased effective degradability of parts of the two Sorghum varieties with increased rates of outflow from the rumen were reported by many authors (Orskov, 1982; Elimam, 1983). The two Sorghum stover parts varied in response to rates of outflow due to genetic factors and proximate analysis and the variations in plants ranking order at different rates of outflow from the rumen reflecting the variations in degradation characteristics.

Conclusion

Camels generally high fibres rumen degradation recommended upgrading crop residues and supplementation for optimum feeding. In addition to use crop residues for grazing camels in droughts due to high rumen degradation. Moreover, Further studies are required on camel's rumen degradation to adopt modern ruminant's nutrition systems in camel's nutrition for efficient feeding and production.

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