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Determination of Nutritional Values of Some Rangeland Plants Species Grazed by Camels, Through Chemical Method and Nylon Bags Technique in Gadarif and North Kordofan States, Sudan

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ABSTRACT:
This study has been carried to assess nutritional potential of some rangeland plants species (herbs, forbs, shrubs and trees) are grazed by camels in Gadarif and North Kordofan States, Sudan. The rangeland samples were chemically and biologically analyzed to evaluate their nutritional potential for camels through proximate analysis and *in situ* method. The study carried depended on randomized complete design with three fistulated camels in three replications and the data obtained were analyzed using descriptive statistics. The results obtained revealed that, the rangeland plants species varied in nutritional content and characteristics of degradation. The content of crude protein (CP) was highest in *Corchorus trilocularis* (Mulukhia) (12.0%), however, the *Grewia tenax* (Gudaim) showed least value (6.7%). *Boscia senegalensis* (Mukheit) showed highest CP potential degradability , while the least was shown in *Guiera senegalensis* (Gubeish). The results revealed that, the effective degradability differed in plants species and decreased with increasing rates of outflow from the rumen. It is concluded that camels have significant feeds rumen degradation, therefore, we recommended to the use of information obtained to adopt modern ruminants nutrition systems in camels nutrition for efficient feeding and production.

Keywords: Rangeland plants, rumen, degradation characteristics, camels

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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. Rangeland is very important in the world with about 50% of livestock population and it is also important for wildlife (Briske and Heitschmidt, 1991). It is important for domestic and wild animals nutrition in the Sudan (Mohamed,2004). Animal production relied mainly on rangeland (AOAD,1981). It provides about 75% of animal feeds in the country and the rest is provided by green forage and concentrates (Abdel Gadir, 1994). Currently, most of the world problems in livestock production are high production costs; low food efficiency due to insufficient food and lack of optimal use of available resources which are two important factors for proper management and maximum production. The use of rangeland plants can play an important role in reducing the cost of nutrients (Al-Masri, 2013; DiTomaso *et al* ., 2017). Information on camels 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 camels 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 camels nutrition. Consequently, this study was conducted to determine the rumen degradation and degradation characteristics of some Rangeland plants to improve camels' nutrition and production.

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Materials 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. Ascrewed 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

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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.

Samples origin and collection

The rangeland plants were brought from North Kordofan State in January 2016 including Sixteen samples were Grewia

tenax (Gudaim), Acacia mellifera (Kitir), Sesamum alatum (Semsemelgumal), Leptadenia pyrotechnica (Marakh), Balanites aegyptiaca (Hegleeg), Sida cardifolia (Njata), Geigeria alata (Gutgat), Cenchrus biflorus (Huskanit), Chrozophora brocciana (Argassi), Guiera senegalensis (Gubeish), Boscia senegalensis (Mukheit), Ocimum

basilicum (Rehan), Acacia seyal var seyal (Taleh),Acacia Senegal (Hashab), Ziziphus spina - Christi (Sidir) and Blepharis linarifolia (Seha). And five samples from Gedarif State were Cymbopogon nervatus (Nal), Sorghum arundinaceum (Adar), Sonchus cornutus (Molaita), Corchorus trilocularis (Mulukhia) and Ipomea cordofana (Tabar).

Identification of plants materials

The plants were identified and authenticated by a botanist at the Medicinal and Aromatic Plants Research Institute, Khartoum, Sudan. The voucher specimen has been deposited in the herbarium museum of the Institute. The voucher includes the vernacular name, description and distribution of the plants. After that the plant samples air

dried in the shade, grinded into fine powder and kept in plastic bags at room temperature ready for laboratory analysis to determine proximate analysis .

Degradation procedure

Plants 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) with an average pore size of 50 µm and weighing 2.5 - 3g were made from fibre manufactured according to Orskov *et al* . (1980). The empty bags were numbered, washed and oven dried at

filter cloth from a new military Parachute. They were

100 °c for 24 hrs. They were then individually weighed and

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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 plant 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 °c 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 **:**

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

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).

$$\mathbf{P = a + b\,(1 - e^{-ct})\ldots(i)}$$

Where :

P = Potential degradability

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 .

t = Incubation time

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 .

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

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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

Plants 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.

	(%)
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 and Discussion

Rangeland plants proximate analysis

Table.2 shows the proximate analysis of rangeland plants from Gedarif and North Kordofan States. The variations in range plants proximate analysis were reported by many workers in the Sudan (Braun *et al*., 1991 ; El Gazali *et al* ., 1997 ; Ibrahim, 2003 ; Sulieman, 2017 ; Elimam *et al* ., 2013a,b ; Ali, 2015). They were also reported abroad by Boulos (2002) and Andrews (1952). These variations were mainly genetic and were also influenced by environments and growth stages. This was also suggested by (Mohamed,2003). The highest CP in Mulukhia suggested it as an excelent range fodder and should be preserved to improve rangeland plants nutritive value. It should be conserved to supplement plants, especially in the dry season. However, Mulukhia had the highest CF and CP suggesting further studies to identify fibres types and their effects on the plant nutritive value and DMI. Huskanit high CP highlighted that it is an important rangeland grass and should be preserved and conserved to supplement animals in the dry season. Gudaim CP (6.7%) is

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about the margin of ruminants CP requirements (6.25%) to maintain normal rumen microflora and fermentation (Orskov,1982). The highest OM in Nal (97.2%) followed by Gubeish (96.6%) indicated low ash and animals may need elements supplementation in rangeland. The least OM in Taleh and Gutgat (89.9%) showed the high elements content. The high ash in Taleh was found by (Ahmed,1999). It is important to identify different elements in these plants for proper nutrition to avoid the excess of some elements and the adverse effects. In addition these plants could be exploited as elements source for animals to save the high elements imports cost. Semsemelgumal highest EE (5%) was genetic and was not suggested in high amounts for camels due to lack of gallbladder and may result in digestive disturbances. Nal least EE was associated with least ash and the highest OM among rangeland plants in this study. Gubeish highest NFE (76.1%) reflected high soluble carbohydrates and was associated with high OM, good CP and low ash and CF indicating good nutritive value and should be preserved in rangeland. Sidir high NFE (75.2%) and low CF with reasonable CP indicated good nutritive value. Mulukhia least NFE was associated with the highest CF and CP. Gutgat and Taleh had good nutritive value due to high NFE, low CF and reasoanable CP. However, they had the highest ash among plants. In this study Adar CP, EE and ash were lower and CF and NFE were higher compared to that found by Ibrahim *et al*.(2016) and Ibrahim (2003). Nal proximate analysis did not agree with that reported by (Elimam *et al* .,2013a). Huskanit CP and NFE were not in agreement with that reported by Le Houerou (1980). However, CF , EE and ash were lower. Seha EE was higher and CP and CF were lower than values obtained by Ali (2015). Tabar proximate analysis was not in line with what has been previously reported by Ibrahim *et al* .(2016). Rehan proximate analysis differed from that reported by Elbahi (2012). Molaita proximate analysis was not in line with that reported by Mohamed (2001). Gubeish and Argassi CP , CF and EE differed from that reported by Ali (2015). Crude protein and CF in Njata and Mukheit in this study were lower than those reported by Ali (2015) . Mulukhia proximate analysis did not agree with that reported by Elimam *et al*. (2013b) and Elbahi (2012). Sidir , kitir and Taleh proximate analysis differed from that recorded by many authors (Lamprey *et al* ., 1980 ; Elimam *et al* ., 2013b ; Elbahi, 2012 ;

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Babiker, 1998). Hegleeg CP, CF , and ash were lower than that stated by Elbahi (2012). Variations in plants

Degradation characteristics

Table 3. shows range plants degradation characteristics in the rumen of camels. Degradation characteristics varied greatly among range plants in DM, OM, CP and CF. The variations in degradation characteristics among rangeplants DM, OM, CP and CF were mainly genetic. Similar variations in degradation characteristics among rangeplants were found by many workers. It was found in rangeland plants in goats in Abu Haraz area (Elimam *et al*.,2013b). It was also found for browses in goats in the Gezira State (Elimam *et al* ., 2013b). In addition it was found for plant residues in goats in the Gezira State (Hamed, 2007).

Grasses

The variations among grasses in the soluble fraction (a) were mainly genetic and may be affected with proximate analysis, antinutritional factors and their interactions. Adar highest DM soluble fraction (a) and Huskanit least (a) were not expected. Adar had high NFE and CF, but not the highest and high tannins and alkaloids. Huskanit had the highest NFE and least CF, tannins and alkaloids. Nal highest CP soluble fraction and Huskanit least (a) were not expected. proxiamate analysis could be mainly genetic and were also due to growth stages and environment.

Nal had moderate CP and high tannins and alkaloids. Huskanit had the highest CP and least tannins and alkaloids reported by Elsaid *et al* . (2021) who found that tannins content was (7.29%) and alkaloids content was (1.884%) in Nal while in Huskanit tannins content was (0.11%) and alkaloids content was (0.60%) . Adar had the least (a) with low CP and high tannins and alkaloids. Tannins content was (7.51%) in Adar while alkaloids content was (1.530%) (Elsaid *et al* ., 2021). Nal highest CF soluble fraction and Huskanit least (a) were not expected. Nal had high CF, tannins and alkaloids and low NFE. Huskanit had the least CF, tannins and alkaloids and the highest NFE. Nal high OM soluble fraction was associated with the highest OM, but it had the highest CF and high tannins and alkaloids. Huskanit least OM soluble fraction was associated with high OM, NFE and low tannins and alkaloids. Nal highest CP and CF soluble fractions and Huskanit least DM, CP, CF, and OM soluble fractions were difficults to explain. This suggested interactions among plants proximate analysis, tannins and alkaloids and rumen microbes and fermentation. Further precise studies are

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required to understand these interactions. Huskanit highest DM part degraded with time (b) was mainly due to high CP, NFE and least CF, tannins and alkaloids. Adar least (b) value was due to low CP, moderate NFE and CF and high tannins and alkaloids. Adar highest CP part degraded with time was associated with the least CP among grasses, moderate NFE and CF and high tannins and alkaloids. Huskanit least (b) was associated with the highest CP and NFE and least CF, tannins and alkaloids. These antinutritional factors, even at these two low levels, may suppressed CP degradation. Huskanit highest CF part degraded with time was associated with the least CF, tannins and alkaloids and the highest CP and NFE. Nal least (b) in CF was associated with the least NFE, high CF, tannins and alkaloids and moderate CP. Huskanit highest (b) in OM was associated with the highest CP and NFE and least CF, tannins and alkaloids. Adar least (b) in OM was mainly due to low CP and high CF, tannins and alkaloids. Nal highest DM potential degradability (P) was associated with high CP, CF, tannins and alkaloids and least NFE. Adar least (P) in DM was associated with low CP, NFE and high tannins and alkaloids. This suggested that antinutritional factors suppressed (P) value. Adar highest (P) value in CP was associated with low CP and high NFE, tannins and alkaloids. Huskanit low (P) value in CP was associated with high CP and NFE and least CF, tannins and alkaloids .This suggested that (P) was suppressed by antinutritional factors. Nal highest (P) in CF and OM was associated with high OM, CF, tannins and alkaloids. Adar least (P) in CF was associated with high CF, NFE, tannins and alkaloids. This indicated that antinutritional factors suppressed (P). The variations among grasses in degradation rate (c) were mainly genetic and may be affected with many factors. Nal highest DM and CF degradation rate associated with high CP, CF, tannins and alkaloids. Huskanit least (c) value was associated with high CP, NFE and least CF, tannins and alkaloids. Adar highest (c) value in CP and OM was associated with low CP and high CF, NFE, tannins and alkaloids.

Forbs

Tabar highest DM soluble fraction was mainly due to low CF and high NFE but, it had high alkaloids. Molaita least value was associated with relatively low CP among forbs and high alkaloids that may had depressed degradation. However, it had high NFE. Alkaloids content was (1.564%) in Tabar while it was (1.626%) in Molaita recorded by Elsaid

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et al . (2021). Gutgat high CP soluble fraction was mainly due to high NFE although it had high tannins and moderate alkaloids stated by Elsaid *et al* . (2021) who found that tannins and alkaloids content was (11.27%) and (1.0%) respectively. Rehan least value was associated with high CP, NFE and low CF but, it had high tannins and alkaloids and may depressed degradation . Tannins and alkaloids content was (7.03%) and (2.0%) respectively stated by Elsaid *et al* . (2021). Semsemelgumal highest CF soluble fraction was associated with low CF and alkaloids (0.6%) and high NFE and tannins (9.24%) (Elsaid *et al* ., 2021). Molaita least value was associated with relatively high CF and low CP among forbs but, it had high NFE and high alkaloids that may had depressed degradation. Tabar high OM soluble fraction was mainly due to low CF and high NFE. However, it had high alkaloids. Gutgat least value was associated with high NFE and tannins and may depressed degradation. Semsemelgumal least DM value of (b) was associated with low CF and high NFE and tannins. The latter may suppressed degradation. Rehan least value was associated with high CP, NFE and low CF. However, the high tannins and alkaloids may reduced degradation. Molaita had the highest CP value of (b) although it had high CP, CF and NFE among forbs but, it had high alkaloids that may reduced degradation. Gutgat least value was associated with relatively low CP and high NFE. It also had high tannins that may reduced degradation. Gutgat highest CF value of (b) was associated with low CF and high NFE. It had high tannins which were expected to depress degradation. Rehan least value was associated with low CF and high CP, NFE, tannins and alkaloids. The high antinutritional factors may decreased degradation. Semsemelgumal highest OM value of (b) was associated with high NFE and low CF. However, the high tannins were expected to reduce degradation. Seha least value was associated with high NFE, low CF and moderate CP among forbs but, it had high tannins and alkaloids (Elsaid *et al* ., 2021) who found that tannins content was (9.75%) and alkaloids content was (1.6%) that may suppressed degradation. Tabar highest DM value of (P) was mainly due to low CF and high NFE. The high alkaloids had no adverse effects on degradation. Rehan least value was associated with high CP, NFE and low CF. However, high tannins and alkaloids may reduced degradation. Seha highest CP value of (P) was associated with

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moderate CP, high NFE, and low CF among forbs. However, the high tannins and alkaloids were expected to suppress degradation. Rehan least value was associated with high CP, NFE and low CF but, the high tannins and alkaloids may reduced degradation. Semsemelgumal highest CF value of (P) was mainly due to low CF and high NFE. However, the high tannins were expected to reduce degradation. Rehan least value was associated with low CF and high CP and NFE but, high tannins and alkaloids may reduced degradation . Tabar highest OM value of (P) was mainly due to low CF and high NFE but, the high alkaloids had no adverse effects on degradation. Rehan least value was associated with high CP and NFE and low CF but, high tannins and alkaloids reduced degradation. Seha highest DM degradation rate was associated with high NFE, moderate CP and low CF among forbs but, high tannins and alkaloids were expected to suppress degradation rate. Semsemelgumal least value was not expected as it had low CF and high NFE but, high tannins may reduced degradation rate. Tabar highest CP degradation rate was associated with high NFE and low CF. It seems that the high alkaloids had no adverse effects on degradation rate. Semsemelgumal least value was not expected as it had high NFE and low CF. The high tannins may reduced degradation rate. Rehan highest CF degradation rate was associated with high CP and NFE and low CF. However, high tannins and alkaloids did not affect degradation rate. Seha least value was associated with low CF, high NFE and moderate CP among forbs. High tannins and alkaloids suppressed degradation rate. Seha highest OM degradation rate was associated with high NFE, moderate CP and low CF among forbs. High tannin and alkaloids did not suppress degradation rate. Tabar least value was associated with high NFE and low CF. High alkaloids reduced degradation rate.

Shrubs and Trees

Mukheit highest DM soluble fraction was associated with high OM and NFE, low CF and moderate CP. It was also associated with high tannins and alkaloids which were expected to reduce the soluble fraction stated by (Elsaid *et al* ., 2021) who recorded that (15.20%) tannins and (1.4%) alkaloids . Mulukhia and Taleh least values were associated with high CF and moderate CP. Mulukhia had low tannins and high alkaloids stated by Elsaid *et al* . (2021) who found that tannins and alkaloids content was (0.87%) and (1.974%) respectively and the latter may depressed (a) value. Taleh had high

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NFE, low CF and moderate CP. It also had high tannins and alkaloids which may depressed (a) value reported by Elsaid *et al* . (2021) who recorded that (12.41%) tannins and (2.2%) alkaloids . Hegleeg highest CP, CF and OM soluble fraction was associated with high NFE, low CF and moderate CP. It had high tannins and alkaloids (Elsaid *et al* ., 2021) who recorded that (12.39%) tannins and (1.6%) alkaloids which were expected to reduce (a) value. Taleh least value was associated with high NFE, low CF and moderate CP . However, the high tannins and alkaloids which may depressed (a) value. Taleh highest DM and CP values of (b) was associated with high NFE, low CF and moderate CP. The high tannins and alkaloids had no adverse effects on (b) value. Gubeish least value was associated with low CF, high OM and NFE and moderate CP. However, it had low tannins and alkaloids. Tannins and alkaloids content was (4.68%) and (0.8%) respectively stated by Elsaid *et al* . (2021). Sidir highest CF value of (b) was associated with high NFE, low CF and moderate CP. It is interesting that high tannins and alkaloids had no adverse effect on (b) value. Tannins and alkaloids content was (9.89%) and (1.4%) respectively stated by Elsaid *et al* . (2021). Argassi least value was associated with high NFE, low CF and moderate CP. However, it had high alkaloids and low tannins suggesting that the former had adverse effects on (b) value. Tannins and alkaloids content was (0.41%) and (1.934%) respectively stated by Elsaid *et al* . (2021). Gudaim highest OM value of (b) was associated with high NFE, low CF and CP. It had moderate tannins and low alkaloids which had no adverse effects on (b) value. Tannins and alkaloids content was (6.66%) and (0.8%) respectively reported by Elsaid *et al* . (2021). Mulukhia least value was associated with high CF and moderate CP. Tannins were not likely to depress (b) value to low tannins. However, high alkaloids may depressed (b) value. Taleh highest DM value of (P) was associated with high NFE, low CF and moderate CP . However, the high tannins and alkaloids had no effects on (P) value. Mulukhia least value was associated with high CF and moderate CP. High alkaloids may depressed (P) value, but tannins were not likely to exert effects due to low value. Mukheit highest CP value of (P) was associated with high OM and NFE, low CF and moderate CP. However, high tannins and alkaloids had no adverse effects on (P) value. Gubeish least value was associated with low CF, high OM and NFE and moderate CP. Low tannins and alkaloids had effects on

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(P) value. Sidir highest CF value of (P) was associated with low CF, high NFE and moderate CP. However, high tannins and alkaloids had no adverse effect on (P) value. Argassi least value was associated with high NFE, low CF and moderate CP. High alkaloids had adverse effects on (P) value, but tannins were not expected to have adverse effects on (P) value. Hegleeg highest OM value of (P) was associated with high NFE, low CF and moderate CP. However, the high tannins and alkaloids had no adverse effects on (P) value. Mulukhia least value was associated with high CF and moderate CP. High alkaloids depressed (P) value. Low tannins had no effects on (P) value. Hegleeg highest DM degradation rate was associated with high NFE, low CF and moderate CP. High tannins and alkaloids exerted no adverse effects on (c) value. Njata least value was associated with high NFE, low CF and moderate CP. However, it had low tannins and alkaloids and it was difficult to explain the results. Tannins and alkaloids content was (1.07%) and (0.6%) respectively recorded by Elsaid *et al* . (2021). Hegleeg highest CP degradation rate was associated with high NFE, low CF and moderate CP. High tannins and alkaloids had no adverse effects on (c) value. Marakh least value was associated with high NFE, low CF and moderate CP. Tannins and alkaloids were low to exert adverse effects. Tannins and alkaloids content was (0.27%) and (0.8%) respectively recorded by Elsaid *et al* . (2021). Gubeish highest CF degradation rate was associated with low CF, high OM and NFE and moderate CP. In addition to low tannins and alkaloids had no effects on (c) value. Hashab least value was associated with high NFE, low CF and moderate CP. The degradation rate was likely to be depressed by the antinutritional factors. Tannins and alkaloids content was (7.35%) and (2.4%) respectively recorded by Elsaid *et al* . (2021). Gubeish highest OM degradation rate was associated with high OM and NFE, low CF and moderate CP. Low tannins and alkaloids had no effects on (c) value. Gudaim least value was associated with high NFE, low CF and CP. Moderate tannins may reduced (c) value, but the low alkaloids had no adverse effects on (c) value.

Effective degradability

Tables 4 to 6 show the effective degradability of the plant samples at different rates of outflow from the rumen in camels. The effective degradability varied in the plants and decreased with increasing rates of

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outflow from the rumen. The decreased effective degradability with increased rates of outflow from the rumen were reported by many authors (Orskov, 1982 ; Elimam, 1983). The plant samples varied in response to rates of outflow due to genetic factors, proximate analysis, antinutritional factors and their interactions. This was reported by many scientists (Orskov, 1982 ; Elimam, 1983). There were variations in plants ranking order at different rates of outflow from the rumen reflecting the variations in degradation characteristics.

Conclusions

It was concluded that camels generally high rumen degradation and recommended to use available information to adopt modern ruminants nutrition systems in camels nutrition for efficient feeding and production. Moreover, antinutritional factors should be considered in grazing camels due to adverse effects on plants nutritive value. Further studies are required to evaluate rangeland plants and proximate analysis, antinutritional factors, degradation characteristics and outflow rates from the rumen to apply modern concepts of ruminants nutrition in camels.

Acknowledgement

I would like to express my thanks to Dr. Salwa Mohamed Elbashir, professor Asma Hamed, Dr. Idriss Ahmed Yagoup and Dr. Nuha Hamed Talib for their assistance and supporting. Sincere thanks to professor Mohamed Elamin Elimam for his assistance and advices.

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Table 2. The proximate analysis (%DM) of rangeland plants from Gedarif and North Kordofan States, Sudan.

Vern Name	Botanical Name	*DM*	*CP*	*CF*	*EE*	*Ash*	*NFE*	*OM*
Argassi	Chrozophora brochianna	*98.0*	*07.3*	*13.6*	*3.3*	*03.9*	*71.9*	*96.1*
Marakh	Leptadenia pyrotechnica	*98.5*	*08.3*	*11.8*	*3.3*	*04.9*	*71.7*	*95.1*
Kitir	Acacia mellifera	*98.0*	*10.2*	*13.2*	*2.9*	*05.9*	*67.8*	*94.1*
Seha	Blepharis linarifolia	*98.5*	*08.6*	*12.7*	*4.1*	*06.4*	*68.2*	*93.6*
Hashab	Acacia Senegal	*97.5*	*08.7*	*14.9*	*3.1*	*07.8*	*65.5*	*92.2*
Gudaim	Grewia tenax	*98.5*	*06.7*	*10.3*	*3.0*	*06.4*	*73.6*	*93.6*
Huskanit	Cenchrus biflorus	*99.0*	*11.6*	*10.6*	*2.4*	*07.4*	*68.0*	*92.6*
Hegleeg	Balanites aegyptiaca	*98.0*	*09.6*	*15.8*	*2.9*	*08.3*	*63.4*	*91.7*
Njata	Sida cardifolia	*97.0*	*08.1*	*15.2*	*3.0*	*06.8*	*66.9*	*93.2*
Gubeish	Guiera senegalensis	*98.5*	*09.3*	*08.4*	*2.8*	*03.4*	*76.1*	*96.6*
Semsemelgumal	Sesamum alatum	*99.0*	*07.1*	*12.3*	*5.0*	*04.0*	*71.6*	*96.0*
Mukheit	Boscia senegalensis	*97.0*	*08.5*	*13.3*	*3.5*	*06.3*	*68.4*	*93.7*
Taleh	Acacia seyal var seyal	*96.0*	*08.2*	*11.9*	*3.0*	*10.1*	*66.8*	*89.9*
Sidir	Ziziphus spina - Christi	*98.0*	*07.3*	*06.9*	*4.2*	*06.4*	*75.2*	*93.6*
Rehan	Ocimum basilicum	*98.0*	*11.2*	*16.5*	*2.5*	*09.8*	*60.0*	*90.2*
Gutgat	Geigeria alata	*96.5*	*07.3*	*13.5*	*3.8*	*10.1*	*65.3*	*89.9*
Molaita	Sonchus cornutus	*93.0*	*09.3*	*22.3*	*2.0*	*05.6*	*60.8*	*94.4*
Nal	Cymbopogon nervatus	*94.0*	*10.7*	*39.0*	*1.8*	*02.8*	*45.7*	*97.2*
Adar	Sorghum arundinaceum	*94.0*	*07.2*	*26.3*	*3.1*	*09.1*	*54.3*	*90.9*
Tabar	Ipomea cordofana	*94.0*	*08.5*	*14.1*	*3.1*	*05.6*	*68.7*	*94.4*
Mulukhia	Corchorus trilocularis	*94.0*	*12.0*	*45.5*	*1.9*	*08.2*	*32.4*	*91.8*

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Table 3 . The degradation characteristics of rangeland plants in the rumen of camels.

Plants	D M				CP				CF				OM			
	a	b	P	c	a	b	P	c	a	b	P	c	a	b	P	c
Grasses:Nal	7	30	37	0.0273	12	66	78	0.0207	40	44	84	0.0230	10	26	36	0.0212
Adar	11	18	29	0.0246	7	84	91	0.0267	5	54	59	0.0216	7	15	22	0.0238
Huskanit	3.5	33	36.5	0.0200	7	65.5	72.5	0.0241	4	63	67	0.0200	3	29.7	32.7	0.0236
Forbs:Molaita	13	36	49	0.0304	15	76	91	0.0321	8	66	74	0.0221	13	32	45	0.0298
Tabar	20	47	67	0.0274	16	72	88	0.0324	12	67	79	0.0270	17	48	65	0.0235
Gutgat	14	35	49	0.0305	25	61	86	0.0292	10	69	79	0.0248	12	32	44	0.0260
Seha	15	39	54	0.0342	20	74	94	0.0307	14	62	76	0.0193	13	31	44	0.0317
Rehan	10	34	44	0.0316	12	70	82	0.0269	9	61	70	0.0307	7	33	40	0.0306
Semsemelgumal	17	48	65	0.0241	21	68.7	89.7	0.0259	15	65	80	0.0230	16	48.6	64.6	0.0257
Sh&Tr: Mukheit	35	28	63	0.0357	36	61	97	0.0301	23	64	87	0.0308	33	29	62	0.0214
Gudaim	24	44	68	0.0269	20	73	93	0.0268	15	69	84	0.0257	20	40	60	0.0145
Marakh	15	32	47	0.0239	16	72	88	0.0227	6	63	69	0.0258	13	32	45	0.0204

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

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Table 3. (continue)

Plants	D M				CP				CF				OM			
	a	**b**	**P**	**c**	**a**	**b**	**P**	**c**	**a**	**b**	**P**	**c**	**a**	**b**	**P**	**c**
Njata	20	36	56	0.0237	25	61	86	0.0267	11	59	70	0.0299	18	35	53	0.0250
Argassi	10	29.8	39.8	0.0365	18	64.4	82.4	0.0290	5	35	40	0.0336	9	30.9	39.9	0.0251
Gubeish	8	20.7	28.7	0.0376	11	44	55	0.0345	8	60	68	0.0339	7	19.4	26.4	0.0375
Mulukhia	5	21.9	26.9	0.0374	10	54	64	0.0313	5	46.9	51.9	0.0308	5	17.8	22.8	0.0336
Sidir	15	53	68	0.0239	17	73	90	0.0316	20	72	92	0.0224	10	55	65	0.0246
Kitir	22	37.9	59.9	0.0313	24	64	88	0.0326	20	66	86	0.0278	19	38.8	57.8	0.0311
Taleh	5	67	72	0.0286	10	85	95	0.0265	3	62	65	0.0320	4	56	60	0.0339
Hashab	20	41	61	0.0268	32	58	90	0.0245	25	62	87	0.0200	23	31	54	0.0309
Hegleeg	30	40	70	0.0407	38	54	92	0.0380	35	54	89	0.0248	35	34	69	0.0305

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

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Table 4. The effective degradability of grasses at different rates of outflow from the rumen in camels.

Grasses	K	DM	CP	CF	OM
Nal	0.01	28.9	56.5	70.7	27.7
	0.04	19.2	34.5	56.0	19.0
	0.07	15.4	27.0	50.9	16.0
	0.10	13.4	23.3	48.2	14.5
Adar	0.01	23.8	68.1	41.9	17.6
	0.04	17.9	40.6	23.9	12.6
	0.07	15.7	30.2	17.7	10.8
	0.10	14.6	24.7	14.6	09.9
Huskanit	0.01	25.5	53.3	46.0	23.9
	0.04	14.5	31.6	25.0	14.0
	0.07	10.8	23.8	18.0	10.5
	0.10	09.0	19.7	14.5	08.7

K = Rumen outflow rate/hr.

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

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Table 5. The effective degradability of forbs at different rates of outflow from the rumen in camels.

Forbs	K	DM	CP	CF	OM
Molaita	0.01	40.0	72.9	53.4	36.9
	0.04	28.5	48.8	31.5	26.7
	0.07	23.9	38.9	23.8	22.6
	0.10	21.4	33.5	19.9	20.3
Tabar	0.01	54.4	71.0	60.9	50.7
	0.04	39.1	48.2	39.0	34.8
	0.07	33.2	38.8	30.6	29.0
	0.10	30.1	33.6	26.2	26.1
Gutgat	0.01	40.4	70.4	59.2	35.1
	0.04	29.1	50.7	36.4	24.6
	0.07	24.6	42.9	28.0	20.7
	0.10	22.2	38.8	23.7	18.6
Seha	0.01	45.2	75.8	54.8	36.6
	0.04	32.9	52.1	34.2	26.7
	0.07	27.8	42.6	27.4	22.7
	0.10	24.9	37.4	24.0	20.5
Rehan	0.01	17.6	63.0	55.0	31.9
	0.04	14.4	40.1	35.5	21.3
	0.07	13.1	31.4	27.6	17.0
	0.10	12.4	26.8	23.3	14.7
Semsemelguml	0.01	50.9	70.6	60.3	50.9
	0.04	35.0	48.0	38.7	35.0
	0.07	29.3	39.6	31.0	29.0
	0.10	26.3	35.1	27.2	25.9

K = Rumen outflow rate/hr.

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

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Table 6. The effective degradability of shrubs and trees at different rates of outflow from the rumen in camels.

Sh&Tr	K	DM	CP	CF	OM
Mukheit	0.01	56.9	81.8	71.3	52.8
	0.04	48.2	62.2	50.8	43.1
	0.07	44.5	54.3	42.6	39.8
	0.10	42.4	50.1	38.0	38.1
Gudaim	0.01	56.0	73.2	64.7	43.7
	0.04	41.7	49.3	41.9	30.6
	0.07	36.2	40.2	33.5	26.9
	0.10	33.3	35.4	29.1	25.0
Marakh	0.01	37.6	65.9	51.4	34.4
	0.04	26.9	42.0	30.7	23.8
	0.07	23.1	33.6	22.9	20.2
	0.10	21.2	29.3	18.9	18.4
Njata	0.01	45.3	69.4	55.2	43.0
	0.04	33.3	49.4	36.2	31.5
	0.07	29.1	41.8	28.7	27.2
	0.10	26.9	37.9	24.6	25.0
Argassi	0.01	33.4	65.9	31.9	31.1
	0.04	24.2	45.0	20.9	20.9
	0.07	20.2	36.9	16.4	17.2
	0.10	17.9	32.5	13.8	15.2
Gubeish	0.01	24.4	45.1	54.3	22.3
	0.04	18.0	31.4	35.5	16.4
	0.07	15.2	25.5	27.6	13.8
	0.10	13.7	22.3	23.2	12.3
Mulukhia	0.01	22.3	50.9	40.4	18.7
	0.04	15.6	33.7	25.4	13.1
	0.07	12.6	26.7	19.3	10.8

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	0.10	10.9	22.9	16.0	09.5

Table 6 . (continue)

Sidir	0.01	52.4	72.5	69.8	49.1
	0.04	34.8	49.2	45.8	30.9
	0.07	28.5	39.7	37.5	24.3
	0.10	25.2	34.5	33.2	20.9
Kitir	0.01	50.7	72.9	68.5	48.4
	0.04	38.6	52.7	47.0	35.9
	0.07	33.7	44.3	38.8	30.9
	0.10	31.0	39.7	34.4	28.2
Taleh	0.01	54.6	71.7	50.2	47.2
	0.04	32.9	43.9	30.6	29.7
	0.07	24.4	33.3	22.5	22.3
	0.10	19.9	27.8	18.0	18.2
Hashab	0.01	49.9	73.2	66.3	46.4
	0.04	36.4	54.0	45.7	36.5
	0.07	31.4	47.0	38.8	32.5
	0.10	28.7	43.4	35.3	30.3
Hegleeg	0.01	62.1	80.8	73.5	60.6
	0.04	50.2	64.3	55.7	49.7
	0.07	44.7	57.0	49.1	45.3
	0.10	41.6	52.9	45.7	42.9

K = Rumen outflow rate/hr.

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