ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 13, Issue, 01, pp. 61317-61321, January, 2023
https://doi.org/10.37118/ijdr.25918.01.2023

RESEARCH ARTICLE OPEN ACCESS

NUTRITIONAL VALUE OF FRUIT, STEM AND LEAF FOR KHAROB TREE (*PILIOSTIGMARETICULATUM)* AS RUMINANT FEED

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ARTICLE INFO

Article History:
Received 08th November, 2022
Received in revised form
26th November, 2022
Accepted 14th December, 2022
Published online 27th January, 2023

KeyWords:
Piliostigmareticulatum, Chemical composition, Anti nutritional factor, digestibility.

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ABSTRACT

This study aimed to determine the nutritive value of the leaf, fruit and stem of (*Piliostigmareticulatum)* which are mostly eaten by ruminants. The samples of this plant were collected randomly from SouthernKordofan during October 2018. Triplicate samples from each part were analysed. The chemical components being determined included DM, CF, CP, Ash, EE, NFE, ME, NDF, ADF, ADL, micro and macro mineral, digestibility of ruminant together with anti-nutritional factors namely: tannins, Phytic acid and Phenols. The mean percentages values of these parameters were analysed and compared by One Way ANOVA using SPSS programme. For proximate analysis, all parameters showed significance differences ($P \leq 0.05$) except ME which showed non-significant difference. The value of ME was found to be 9.93 for fruit, 9.46 for stem and 8.46 for leaf (MJ/Kg). For DM the highest percentage 93.69 in stem and the lowest 91.60 in leaf while 92.54 in fruit. For CP the highest percentage 30.93 in leaf and lowest 9.55 in stem while 12.72 in fruit. The highest CF 30.91 in fruit and the lowest 26.40 in leaf. However, ash content wasfound in this order 3.86, 7.76 and 8.79 for fruit, stem and leaf, respectively. For fat content the value was found to be as follows: 0.48, 1.45, and 1.96 in stem, leaf and fruit respectively. For NDF, ADF and ADL, they were (44.84, 37.89, and 22.57), (67.96, 58.03 and 50.50) and (57.40, 13.70 and 5.25) in fruit, stem and leaf respectively. For Digestibility and NFE they were (71.40, 40.82), (67.50, 48.63) and (52.00, 23.96) in fruit, stem and leaf respectively. For macro mineral Ca ranged between 1.0 in fruit and 1.25 in both stem and leaf. For micro minerals only Fe was detected showing 0.01 in fruit and 0.03 in leaf and none in stem. Anti-nutritional for tannins, Phytic acid and Phenol, showed less than 1.0 and they were (0.21, 0.31 and 0.23), (0.18, 0.21 and 0.18) and (0.19, 0.22 and 0.22) for fruit, stem and leaf respectively. Based on the obtained results, it can be concluded that fruit, stem and leaf of *P. reticulatum* were highly nutritious with leaf and fruit to be close in their nutritional value and to have lower anti-nutritional factors and so can be suggested to be used in animal feed.

Citation: ***Amasaib E. O, Babiker, M. E. M, Balgees A. Atta Elmnan and Babiker, E. M. 2023.*** "Nutritional value of fruit, stem and leaf for kharob tree (piliostigmareticulatum) as ruminant feed*", International Journal of Development Research*, 13, (01), 61317-61321.

INTRODUCTION

Tropical Africa is known to be rich in fodder trees and shrubs which constitute vital component in the livestock productivity in the arid and semi-arid zones which includes Sudan. Making use of their nutritive properties, different parts of the plant species from the genus *Piliostigma*are extensively exploited in Africa as food for human consumption as well as for drink. Moreover, plants of the genus including *P. reticulatum*, were traditionally used for treatment of wounds healing, ulcers, diabetes, general pain, inflammation and against infection. Sudan is considered as a leading Arab and African country in terms of livestock resources, which present all over its

However, animal populations of the Sudan were estimated to consist of 52.08 million sheep, 43.44 million goat, 41.76 million cattle and 4.62 million camels (MARF, 2013). The majority of the animals are located is western Sudan (40%) followed by central Sudan (23%) (MARF, 2011). However, Sudan is characterized by multi-climatic regions ranging from desert in the North to high rainfall wood land in the south region. The natural pastures represent an important source of forage for the livestock, particularly those raised by nomadic and pastoral tribes in western and central Sudan (Abusuwar, 2007). On the other hand, the availability of the natural source is susceptible to fluctuation of rainfall, which its severe decline may lead to massive catastrophic loss in livestock and hence to a great loss for the animal owners and to the national economy as well. Because of this the animal production, should be planned and brought to reality so as to give rise to high livestock productivity and to settlements of pastoral tribes. In this context, fodder trees that are known to be grown in the Sudan should be investigated for biochemical ingredients. Of the fodder trees that were reported to be grown in Africa including Sudan is *P. reticulatum* which is listed in the inventory that based on the intensive reviews and reports made by Dicko (1980), Dicko and Sayers (1988), Keya *et al*., (1991). *P. reticulatum* belongs to the family Leguminoseae whose members are known to be containing several phenolic compounds in their different parts. *P. reticulatum* was reported to be rich in protein (Arnold *et al.*, 1985, Anhwange *et al.*, 2005), which it is similar in this content to Soya bean (Amonsou *et al.*, 2011) and peanuts (Ventachalam and Sathe 2005). These findings were reported in studies that may not reflect ecological and climatic conditions that prevailing in Sudan, which is also subject to intermittent rainfall and drought. For this reason, the present study was conducted with the aim to to evaluate the biochemical ingredient in leaves, stems and fruit and to compare of these ingredients in the three major parts of the tree.

MATERIAL AND METHODS

Plant Materials: The plant materials of species *P. reticulatum* were collected during the growing season (October 2018) from Tanna Area, Locality of Soudari, North Kordofan State-Sudan. Samples of fruits, stems and leaves of this plant were picked up manually by a volunteer villager. The samples were taken from top, middle and bottom of several plants of the same species. The plant species was identified and authenticated to be *P. reticulatum*at the herbarium of Department of Botany, Faculty of science – University of Khartoum. The plant samples were then air- dried separately, grounded and each part was kept in paper sac for further analysis.

Chemical analyses: Samples of fruits, stems and leaves of *P. reticulatum*were analyzed for their proximate components, DM, ash and CP according to AOAC (1990). NDF, ADF were determined according to Goering and Van Soest (1970) method. All the analysis was run in triplicate.For these analyses three samples for each.

Metabolizable energy of ruminant (MER) was determined according to the following formula by Ellis (1981):

$$ME=0.012\times CP+0.031\times EE+0.005\times CF+0.014\ Ash$$

In vitro digestibility: In vitro DM digestibility of samples was determined using methods of Tilly and Terry (1963). Rumen fluid was collected from local breed calves at the morning before feeding.

Minerals Contents

Macro Minerals: Potassium (K) and Sodium (Na) were determined by AOAC (2019) method using flame photometer. Calcium (Ca) and Magnesium (Mg) levels were carried out according to Chapman and Pratt (1982) by titration method. Phosphorus (P) level was carried out according to the method described by Champ and Pratt (1982) by atomic absorption spectrophotometer.

Microminerals: Iron (Fe), cupper (Cu) and cobalt (Co), were determined by atomic absorption according to the method described by Cookbook (1998).

Anti-nutritional factors

Phytic acid: The preparations to measure the phytic acid were conducted according to the standard curves described by FAO (1986). For the measurement a standard curve was made. Then the absorbance of the extracted sample was measured using spectrophotometer (JENWAY 6305, UV) at 480nm. Then the absorbance was used to determine phytic acid from the standard curve being made.

Phenols: Phenols were measured according to purssion blue spectrophotometric method FAO (1986) using the spectrophotometer (JENWAY 6305, UV). The absorbance was read at 720nm and the total polyphenols were calculated according to formula included in the procedure described for determination of phenol (FAO, 1986).

Tannin: Quantitative estimation of tannin was carried out using the modified vanillin-HCL method according to FAO (1986). For this estimation a standard curve was made and the absorbance was read at 500nm using spectrophotometer (JENWAY 6305, UV). The absorbance read was used to determine tannin from the standard curve and was expressed as a percent.

Statistical analysis: The data collected was subjected to analysis of variance (ANOVA) using statistical analysis system, followed by Duncan's multiple range test and differences were considered significant at $P\leq0.05$.

RESULTS

Proximate analysis: Table (1) shows the dry matter (DM), Fat, crude protein (CP), crude fibre (CF), ash, nitrogen free extract (NFE), and metabolic energy (ME) content of the three parts of the tree.In The results of DM, Fat, CP, CF, ash and NFE, were significantly different ($P<0.01$). The CP was significantly high ($P\leq0.01$) in leaves, but there was no significant difference between stem and fruit, which was slightly differed from each other. On the other hand, samples of the three parts of the plant did not differ significantly in their metabolic energy ($P>0.05$). For DM, it was higher in stem followed by fruit and then of the leaves. The CF percentage was higher in fruits, followed by stem and then the leaves. Fat was higher in fruit, followed by leaves and was highly reduced in stem.

Cell wall content: The results of the different fiber fraction types namely: Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL) in fruit, stem and leaves of*P. reticulatum*were presented in Table (2). The percentage of NDF was found to be in this order: 67.96±0.46, 57.40±0.09 and 44.84±0.26 for stem, leaves and fruits, respectively. While, For ADF, it was in this order 58.03±0.53, 37.89±0.18 and 13.70±0.02 for stem fruits and leaves, respectively. However the same order was shown for ADL and it was 50.50±0.2, 22.52±0.1 and 5.28±0.2 in the same parts, respectively. The percentage of both ADF and ADL were highly lowered in the leaves of *P. reticulatum.*

Table 1. Proximate analysis of fruit, stem and leave of *P. reticulatum*

Traits	Treat Groups			Sig
	Fruits	Stems	Leaves	
DM	92.54±0.01b	93.69±0.05a	91.60±0.28c	**
Fat	1.96±0.00a	0.48±0.00c	1.45±0.00b	**
CP	12.72±0.12b	9.55±0.45b	30.97±1.22a	**
CF	30.91±0.14a	27.25±0.20b	26.40±0.19c	**
Ash	3.86±0.01c	7.76±0.07b	8.7950±0.02a	**
NFE	40.82±0.02b	48.63±0.78a	23.96±1.16c	**
ME	9.93 ± 0.55^a	9.46 ± 0.04^a	8.96 ± 0.08^a	NS

Means of the same superscripts in the same raw are statistically significantlyat ($P\leq0.05$)
(**) indication of high significantly.
(NS) indication of no significantly.

Table 2. Percentages of values of NDF, ADF and ADL in fruits stem and leaf of *P. reticulatum.*

Traits	Plant Part			Sig.
	Fruits	Stems	Leaves	
NDF	44.84 ± 0.26^c	67.96 ± 0.46^a	57.40 ± 0.09^b	**
ADF	37.89 ± 0.18^b	58.03 ± 0.53^a	13.70 ± 0.02^c	**
ADL	2.52 ± 0.11^b	5.50 ± 0.20^a	5.28 ± 0.02^c	**

Percentages of the same row bearing different lower superscript are significantly different, ($P\leq0.001$) is highly significant.
(**) indication of high significantly.

In Vitro-digestibility of ruminant: The in vitro of digestibility of protein in fruit, stem and leaves of *P. reticulatum*, are shown in Figure (1). The digestibility was significantly low (P≤0.05), while leaves contain more CP, less Cf and ADL. The digestibility of fruit, stem and leaves were as followers: 71.50±1.5, 67.50±1.50 and 52.00±0.001, respectively.

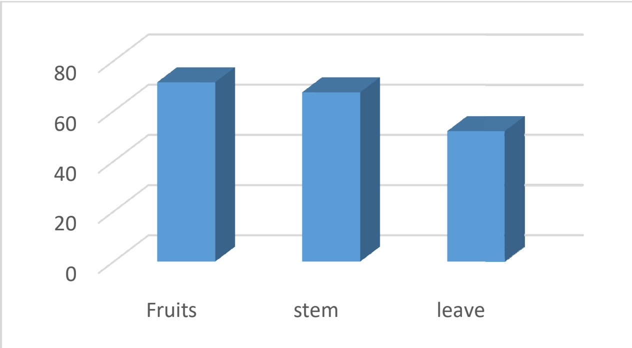

Figure 1. Percentage Digestibility of fruit, stem and leaf of *P. reticulatum*

Macro and Micro minerals content: The results showed the percentages of macro and micro minerals are shown in Table (3). The results of Na, K, were significantly different in fruits, stems and leaves while no significant difference for Ca. Mg was only significantly higher (P≤0.05) in leaves, but did not differ significantly in fruit and stem. Also P was significantly low (P≤0.05) in stem but was higher in fruit and leaves and slightly different from each other. The results showing the percentage of micro minerals namely: Fe, Co and Cu in fruit, stem and leaves in Table 4 The results showed that only Fe was detected in fruits and leaves and its values were significantly different (P≤0.05); and it was higher (0.03) in leaves than that in the fruit (0.01).

Table 3. Percentage of macro and micro minerals in fruits, stem and leaf of P. reticulatum

Minerals	Plant samples			Sig
	Fruits	Stem	Leaf	
Ca	1.00±0.00^a	1.25±0.25^a	1.25±0.25^a	NS
Mg	0.45±0.15^b	0.45±0.15^b	1.20±0.00^a	NS
Na	0.26±0.00^a	0.14±0.00^c	0.19±0.00^b	**
K	0.50±0.00^b	0.35±0.00^c	0.55±0.00^a	**
P	0.14±0.00^a	0.10±0.00^c	0.13±0.00^a	*
Fe	0.01±0.00^b	0.00±0.00^c	0.03±0.00^a	*
Co	0.00±0.00^a	0.00±0.00^a	0.00±0.00^a	NS
Cu	0.00±0.00^a	0.00±0.00^a	0.00±0.00^a	NS

Percentages of the same row with different lower superscripts were significantly different (P < 0.05)
(**) indication of high significantly.
(*) indication of significantly.

Anti -nutritional factor: The result of anti-nutritional factor namely: Phytic Acid, Tannin and Phenol was illustrated in Table (4). The result showed that phytic acid of different part of *P. reticulatum* were not significantly different (P>0.05) while for the phenol and tanninthere were significant difference (P≤0.05).

Table 4. Percentage of Anti-nutrition: Phytic, Tannin and Phenol in fruits, stem and leaf of *P. reticulatum*

Traits	Treat Group			Sig
	Fruit	Stem	Leave	
Phytic	0.21±0.00^a	0.18±0.01^a	0.19±0.01^a	NS
Tannin	0.31±0.00^a	0.21±0.00^b	0.22±0.00^b	*
Phenol	0.23±0.00^a	0.18±0.00^b	0.22±0.01^b	*

Percentages of the same row with different lower superscripts were significantly different (P ≤ 0.05). (*) indication of significantly.
(NS) indication of no significantly.

DISCUSSION

The plant *Piliostigma* tree is used as many other legumes for multiple purposes, of which is being used naturally as a fodder tree in tropical Africa including Sudan and many other countries around the world (Osti *et al*., 2006; Lau *et al.,* 2005). In the present study, random samples from the stem, fruit and leaves of the species *P. reticulatum*, which are consumed indiscriminately as fodder by grazing ruminants, were investigated individually for their chemical composition to assess their nutritional status. However, a study of this kind may give insight on the way it can be used for, whether as a fodder tree for pastoral ruminants or as a feed supplement for those raised in the farmsystem. The chemical composition of the three samples of *P. reticulatum* showed almost significant differences in all constituents being measured except for the Metabolizable energy where the three samples of the plant revealed similar results between 8.79% for the leaf and 9.46 for the stem. However, these nearly similar values of Metabolizable energy is morelikely brought about because the net energy generated by NFE (carbohydrates) and EE (fat) in each samplewas nearly equal to that produced by the same parameters in the other sample. The results of ME in this study were similar to the results obtained by (Verma*et al*, 2012) who stated that Metabolizable energy of buds and flowers of *B. variegata*were found to be 9.2 and 9.4 MJ/kg respectively.

Despite of close percentage values of DM in the three samples, yet they were significantly different (P≤0.05), which implies that the leaf had relatively appreciable moisture content as it had a lower DM compared to those of fruit and the stem. The results of DM of the leaf in this study were comparable to found in another *Piliostigma* species (*B. purpurea)* studied in India (Sharma, 2012). This variation between these *Piliostigma*species might be due to nature of the leaf whether had been investigated fresh or dried, its stage of maturity, the type of soil and the climatic conditions. However, such conditions were assumed to be the cause of such variation (Chibinga and Nambenye, 2016, Underwood *et al*., 1981). Regarding the ash content of fruit of this study, it was almost half (3.86%) the values of those of the stem (7.76) and the leaf (8.74%) which implies that it could contain a lower minerals content compared to contents of the two remaining samples; the fruits and the leaf might rather have a higher content of organic components such as protein, fibres, fat and carbohydrates. Such interpretation of ash content in relationship to other proximate components was reported by Omoregie and Oluyemsi (2010). The obtained result of Ash content is higher than that reported by (Sharma 2012). In this context, the variation in macro minerals content in the fruit, stem and leaf of *P. reticulatum*was slight and the leaf showed higher mineral values for Ca, Mg, and K, and this probably could explain it's a higher ash content compared to that of fruit and the stem. In contrast to this, the results of micro minerals revealed similarity with findings of other studies conducted elsewhere (Ajani *et al.,* 2016) and only iron was detected in the present study while other trace elements such as Co and Cu, were not detected. Higher results of Ca, Na, Mg were reported by (Ighodaro *et al.,* 2012, Haroun *et al 2019*), while lower values of the mineral content were noted by (Sharma, 2012).

Of the three samples investigated, the leaf seemed to contain high nutritive value as reflected in having 30.97% (CP) and 1.48 (fat) and the latter was almost three times that of the stem (0.48%) and slightly less than that of the fruit (1.96%). In addition to that, it contained 26.40% (CF) compared to30.91% and 27.25% for the fruit and the stem, respectively. On the other hand, its lowered content of NFE (23.96%) compared to that of fruit (40.8%) and stem (48.00%)might explain its high content of CP as well as CF. This could also be confirmed by having a lower ADL percentage (5.25%) compared to those in fruit (22.52%) and stem (50.50%). Similar to the leaf, the fruit of this plant, exhibited nearly the same nutritive value reflected in percentage values of fat (1.96%), DM (92.54%), CF (30.91%), as well as having comparable macro minerals. In contrast to the leaf, the fruit showed a higher ADF, NDFand NFE and this implies that it has

However, these two components together with the low percentage of fat content (0.48%), probably would place the stem next to leaf and fruit in the assessment of their nutritive values.The same trend was reported by (Verma *et al* 2012) who concluded that, the buds of B. *variegate is* superiorto follower in term of its nutritive value. Regarding *in-vitro* digestibility it has been considered as the second step in feed evaluation (Mahumoud *et al.,* 2017). On the other hand, CP, CF content and DM degradability values are used as indicator to use them as feed supplements for ruminants (Andualem *et al.,* 2016). In the present study, it was evident that the overall digestibility of fruit of *P. reticulatum* was higher when compared to those of the leaf and stem. This high digestibility is more likely to be due to the presence of a relatively low ADL and slightly increased ADF and NDF where these two components were reported to produce negative influence on the digestibility of the diet (Doma *et al.*, 1995; Goodchild, 1994; Baumualin *et al.,* 1980).

However, the high digestibility of the fruit could further indicatesits usefulness as a feed for ruminants despite the current results which revealed that it contained slightly low CP content (12.72%) when compared to that of the leaf (30.97%) as well as having CF of 30.91% compared to 27% and 26% for the stem and the leaf, respectively. Moreover, the high digestibility of fruit may strengthen its potential use as feed for ruminants whether being used alone as a feed or in concentrate feed containing different nutrients. This potential use could be strengthened even further because of its estimated high content of fat, slightly less ash percentage and the moderate percentage of NFE (40.84%) compared to those in the other two samples. However, although digestibility could be indicative to the nutritive value of the sample, but digestibility alone may give a poor assessment, because there is often no relationship between digestibility and feed intake, particularly, nutritive value of fodder trees and shrubs. In this context, digestibility values of 52%, 67% and 71.5 for leaf, stem and the fruit in this study, was in agreement with level previously reported for the legumes and browse species (Buxton 1996; Bediye *et al.,* 1996). However, this relatively high digestibility shown by the three samples of the present study might be influenced by presence of relatively low percentages of the anti-nutritional factors namely; tannins, phytic acid and phenols. These secondary metabolites did not reach the level that can inhibit digestibility or influence it negatively and they were each, less than 0.5%. The adverse effect of tannins on nutrient digestibility was confirmed experimentally on digestibility of DM, CP and NFE in rabbits fed with graded levels of *Acacia albida* pods (Igwebuike*et al*., 2008). In this context, Jansman (1993) reported that tannins depresses nutrient digestibility by forming indigestible complexes with nutrients and inhibiting the activities of digestive enzymes. However, it had been reported that the tannin having more than 2% could contribute to poor digestibility of the leaves (Atta Elmnan*et al*., 2013; Atta Elmnan and Sharaf 2020; Khanal and Subba 2001; Subba 1998; Wood *et al.,* 1994).

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