Potential of *Croton megalocarpus* Nut as an Alternative Protein Supplement for Feeding of Ruminants in the Tropics

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Key words: [Croton nut; Alternative protein; Nutritional value; *In sacco* degradation]

Abstract

[*Croton megalocarous* is a tree native to the arid and semi-arid rangelands of East Africa that produces nuts reported to contain high crude protein (CP). However, they are often neglected as a potential feed due to lack of information on how best to utilize them. This study was conducted to evaluate the chemical composition and *in sacco* dry matter (DM) degradability of four forms of croton namely whole nut (WN), peeled nut (PN), De-husked nut (DhN) and Defatted seed (DfS). DM of all forms was above 89%, ash content was highest in WN (5.9%) and least in PN (2.2%). Crude fibre content was high in WN (52.2%) and PN (57.8%) while the DhN and DfS had the highest CP (15.7%) and (19.8%) respectively. Ether extract content was highest in DhN (36.2%) and least in DfS (11.2%). *In sacco* DM degradability was highest after 48 hours of incubation in all forms with highest degradability recorded for DhN (60.5%) and the least for PN (34.5%). The rapidly soluble fraction (*a*), potentially degradable fraction (*a+b*), index value (*IV*) and effective degradability (*ED*) were significantly high in DhN compared to the other forms. High DM was an indication of good keeping quality implying that nuts could be harvested and stored for future feeding while ash content reflected on potential as a source of minerals for livestock. The CP and *IV* of all the croton forms was above the 7% and 33% minimum required for optimum rumen function and to support sufficient feed intake, respectively. Processing of croton nut by de-husking and oil extraction enhanced the CP, soluble and potentially degradable fractions of croton nut. Subsequently, the two forms could satisfy the minimum of 15% CP required for lactation and growth in addition to provision of readily fermentable nutrients to boost intake of low-quality forages.]

Introduction

Livestock production is a source of livelihood, wealth and nutrition thus an important economic activity by communities in the rangelands (Nabarro & Wannous 2014). However, increased frequency and length of the dry seasons decreases quantity of dry matter and quality of herbage in terms of carbohydrates and nitrogen concentration of livestock forages and feeds (Huho et al. 2012). This results to poor body conditions of animals and increased mortality which greatly affects productivity (Ojwang et al. 2010). Inadequate feeding is thus a major setback to the growth of livestock industry in the arid and semiarid lands (ASAL) and calls for identification and evaluation of alternative low cost non-human competitive feed resources which could be used for feeding livestock.

Various alternative, non-conventional feed resources for use in feeding livestock to enhance availability of feed and minimize competition from humans have been proposed (Makkar 2014). Croton (*Croton megalocarpus*) is a one such tree whose nuts have been reported to contain high content of crude protein and hence could be exploited for feeding livestock (Thijssen et al. 1996;Ndegwa et al. 2011). However, to utilize a resource as livestock feed, nutritional as well as feeding value need to be demonstrated which is lacking for Croton nut. Therefore, this study was aimed at evaluating the nutritional composition and *in sacco* DM degradability of the various processed forms of croton nut in order to provide insights on potential utilization as a protein supplement in ruminant diets.

Methods and Study Site

Site description

Samples of Croton nut were collected from Laikipia County found on the Northwest zone of Mount Kenya. The County is located on a high plateau with an altitude of between 1600m and 2300m above sea level with a total area of 9700km^2. The area experiences a bimodal rainfall pattern with long rains between March and June and short rains between October and December (MoALF 2017). The annual precipitation varies between 400 to 900mm and average temperature is between 16ºC and 26ºC. The area lies in semi-humid, semi-arid, arid to very arid agro ecological zones IV-VII, making the County to be considered as ASAL (MoALF 2017).

Croton nut collection and processing

Mature Croton nuts were collected from the ground; air dried under shade and ground using a hammer mill to pass through a 2mm sieve. The nuts were processed to give the four forms used in this analysis namely: Whole nuts (WN) – where no processing was done, Peeled nuts (PN) - where outer seed coat was removed, De-husked nut (DhN) - where husks were removed and Defatted seeds (DfS) - seeds whose oil had been extracted. The DfS form was obtained from a commercial plant that extracts bio-diesel from croton in Laikipia County.

Chemical analysis

Ground samples of the various forms of croton were subjected to proximate analysis to determine DM, Ash, CF, EE and CP and expressed on dry matter basis according to AOAC (1990). Organic matter (OM) and Nitrogen free extracts NFE were computed from the various components of proximate analysis on dry matter basis.

***In sacco* degradation**

In sacco degradation analysis was carried out following the procedure of (Ørskov 2000). Nylon bags were incubated for 3, 9, 12, 24, 48, 72 and 96 hours in the rumen of the three fistulated steers.

The exponential equation of Ørskov & Mcdonald, (1979) was used to fit the data.

$$P = a + b(1 - e^{-ct}) \quad (1)$$

Where: ***P*** is the disappearance of dry matter DM (%) incubated in the rumen at time ***t***, ***a*** the rapidly soluble fraction, ***b*** is the insoluble but fermentable fraction, **c** is the rate of constant degradation per hour and ***e*** is 2.7182 (the base for natural logarithm)

Effective DM degradability (EDDM) to account for feed outflow from the rumen was calculated by applying the equation of McDonald, (1981) and index value (*IV*) using the equation by Ørskov & Shand, (1997)

$$ED = a + b(\frac{c}{c+kp}) \quad (2)$$

$$IV = a + 0.4b + 200c \quad (3)$$

Experimental design and Statistical analysis

Completely randomized design (CRD) was used. Where the various forms of croton nut constituted the treatments, which were replicated three times. The dependent variables were the components of proximate analysis and *in sacco* DM degradation. Analysis of variance was carried out on chemical composition components using STATA (2017). Significance between the means was tested using Tukeys' honest significance difference.

Results

Chemical composition

The chemical composition of the various forms of croton nuts are presented in Table 1. All the components significantly differed ($p<0.05$) between the various forms of croton with the exception of NFE. All forms had >89% DM while ash content was significantly high in WN (5.9%) and lowest in PN (2.2%). Crude fibre content was lower in DhN and DfS compared to WN and PN forms while EE was significantly low in DfS. CP content in DhN and DfS was higher and significantly different ($p<0.05$) from WN and PN. The NFE ranged between 14.2% and 17.4% ($p>0.05$).

Table 1: Chemical composition of the various forms of croton nut (DM %)

Forms of croton nut	Nutrient components of the feed resource[1]						
	DM	Ash	CF	EE	CP	OM	NFE
Whole Nut (WN)	89.2^{a}±	5.9^{a}±	52.2^{a}±	18.5^{a}±	8.9^{a}±	94.7^{a}±	14.3^{a}±
	0.13	0.20	0.82	0.99	0.41	0.18	0.54
Peeled Nut (PN)	96.2^{b}±	2.2^{b}±	57.8^{b}±	17.4^{a}±	8.0^{a}±	97.8^{b}±	14.2^{a}±
	0.13	0.01	0.78	0.25	0.15	0.01	0.73

Dehusked Nut (DhN)	91.7[c]±	2.3[b]±	33.6[c]±	36.2[b]±	15.7[b]±	97.7[b]±	11.9[a]±
	0.08	0.08	0.29	1.10	0.52	0.07	1.95
Defatted Seed (DfS)	91.9[c]±	3.8[c]±	47.6[a]±	11.3[c]±	19.8[c]±	96.5[c]±	17.4[a]±
	0.14	0.09	1.79	0.27	0.74	0.08	1.86

[a,b,c], Means with different superscripts letters along the columns are significantly different p<0.05. ±SE, standard error, [1]DM, dry matter; OM, Organic matter; CF, crude fibre; EE, ether extracts; CP, crude protein; NFE, nitrogen free extracts

***In sacco* DM degradation**

In sacco degradability results of the various forms of croton are presented in Table 2. The trend of all the degradation parameters was highest (p<0.05) in DhN and least in PN (DhN>DfS>WN>PN) except for the (***b***) fraction where the trend was the reverse (PN>WN>DfS>DhN).

Table 2. *In sacco* degradability characteristics for various forms of croton nut

Form of croton nut	Dry matter degradability parameters (%)[e]							
	24 h	48h	*a*	*b*	*a+b*	c	*IV*	*ED*
Whole Nut (WN)	38.7[a]±	43.7[a]±	30.8[a]±	12.5[a]±	43.4[a]±	0.04[a]±	44.6[a]±	31.75[a]±
	1.79	1.62	0.40	0.32	0.08	0.00	0.57	0.40
Peeled Nut (PN)	32.7[a]±	34.5[b]±	27.2[a]±	12.9[a]±	40.2[a]±	0.03[a]±	39.5[a]±	28.07[a]±
	0.15	1.27	0.97	4.06	5.04	0.02	2.77	0.82
Dehusked Nut (DhN)	60.7[b]±	60.5[c]±	52.1[b]±	8.6[a]±	60.7[b]±	0.16[a]±	88.3[a]±	53.05[b]±
	4.8	0.82	0.33	0.63	0.29	0.10	5.69	0.36
Defatted Seed (DfS)	48.3[ab]±	50.3[a]±	36.1[a]±	12.2[a]±	48.4[ab]±	0.08[a]±	58.2[a]±	37.11[a]±
	3.95	0.90	3.15	3.56	0.41	0.04	4.71	3.11

[a,b,c], Means with different superscripts letters along the columns are significantly different p<0.05. **(**±SE) standard error, h is hour - dry matter degradability after 24 and 48h; *a* is rapidly soluble fraction, *b* is insoluble but fermentable fraction, and *c* is the rate constant of degradation; *IV*, index value; *ED* effective digestibility

Discussion

The DM content in all forms was above 86% which is the recommended level for storage of feeds as it impends growth of fungi and consequently reduces aflatoxin contamination. It therefore means that the nuts could be collected and stored for later use during periods of feed scarcity in ASAL. High ash content (2-2-5.9%) and EE (11.2-36.2%) may be indicative of potential of Croton nut as a good source of minerals, energy as well as supply fat soluble vitamins for ruminant animals. Whereas, the CP level in all forms was above the recommended (8%) required for maintenance in grazing ruminant animals (NRC 2001). Processing by removal of the husk (hard woody pericarp) and fat reduced the fibre fractions and enhanced the CP profiles of croton nut. The CP level in DhN and DfS were within the recommended range of 11.9% to 16.6% for increased milk production for lactating animals (NRC 2001). The CP observed in this study for DfS compared favourably with 18% reported by Thijssen et al. (1996) in seeds and could be used to supply protein to ruminant animals which is often a limiting nutrient during prolonged dry season in ASAL areas.

The level of DM degradation of a feedstuff provides information on palatability and consequently the level of intake (Akhirany et al. 2013). *In sacco* degradability characteristics of the various croton forms were within the wide range of degradability for most tropical browse forages species utilized as livestock feed (Osuga et al. 2006). High rapidly degradable fraction in both DhN and DfS could be attributed to higher nutrient composition in these forms from the relatively high levels of CP and NFE which provide are sources of nutrients for rumen microbes hence increases their population and ability to act on fibre in the feed (Olivares-Palma et al. 2013). High fibre content reduces degradability of the feed as observed in PN which had high fibre content and low DM degradability. The index value for all forms of croton were above the minimum acceptable level (33) as recommended by Ørskov & Ryle, (1990), which indicates the minimum amount of feed that an

animal can consume sufficiently to meet its maintenance needs. Processing had a profound effect on the degradability of croton with the later forms (DhN and DfS) being more degradable compared to the fore forms (WN and PN). High Effective degradability recorded in DhN and DfS implies that nutrients are more readily available for utilisation by ruminants (Olivares-Palma et al. 2013). In conclusion, processing of the nut by removal of the peel, husks, and oil improves nutrient availability and degradation of croton nut. Dehusked and defatted croton seeds have potential for inclusion in ruminant rations in ASAL to avert the effects of protein deficiency occasioned by drought hence improving productivity

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