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Research Article

Cassava Pellets as a Partial Replacement for Maize in Lactating Goats' Rations

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Abstract

Research efforts have been directed at the use of non- conventional feed ingredients as a means of reducing cost of production. Cassava pellets are part of such ingredients. Thus this study aimed at evaluating cassava pellets as an alternative of maize in lactating goats' rations. Two experiments were carried out. The first experiment (digestion trial) was carried out on three mature Baladi goats' males to determine the nutritive value of cassava pellets. The experimental rations were designed as to replace clover hay (as a basic diet) by either 30% or 50% cassava pellets. The second experiment (feeding trial) was carried out on fifteen lactating Baladi goats to study the effects of replacing 50% and 75% of maize in the diet by cassava pellets on milk yield, milk composition, and some parameters of rumen fluid and blood plasma. The feeding trial extended from parturition until the end of week 18 of lactation. The first trial indicated that the digestibility of crude fiber was significantly decreased; however, the total digestible nutrients (TDN) were significantly increased by increasing cassava level in the diet. The nutritive value of cassava pellets in terms of TDN, digestible protein (DP), and metabolizable energy (ME) was 83.28%, 1.40%, and 10.86 MJ/kg DM, respectively. The second trial suggested that the daily fat corrected milk and the milk constituents were not significantly ($p \geq 0.05$) affected by feeding cassava pellets to lactating Baladi goats. Also, neither the fermentation parameters of rumen nor the nitrogen metabolites of blood plasma was negatively affected by both cassava pellets levels. It was concluded that the use of cassava pellets as a partial replacement for maize in lactating goats' rations would not adversely affect milk production.

Keywords: Cassava Pellets; Goats; Digestibility; Plasma; Milk

Introduction

In Egypt, due to the increasing cost and shortage of feedstuffs, research efforts have been directed at the use of cassava as non conventional feed ingredient.

Cassava (*Manihot esculenta Crantz*) is a shrubby plant cultivated in all soils. Its tuberous roots have a weight of 1 to 8 kg or more. Despite cassava leaves are rich in crude protein ≤ 20%, their high content of condensed tannins and hydrogen cyanide (HCN) is an important factor responsible for limiting the use of leaves as forage [1,2]. However, cyanide in cassava leaves could be reduced by 70% after two month of ensiling. It was found that sheep fed cassava foliage silage did not show any adverse effects on DM intake, body weight gain, as well as health condition [3,4].

At the harvest of cassava tubers, the HCN amount varies from harmless to lethal, i.e. from a few mg to 250mg/kg fresh root. Supplementation of fresh cassava pulp (FCP) in the diet of dairy cows at three levels: 0, 3.5, and 7.0 kg/h/d had no negative effects on milk production. HCN content of FCP was 72.20 ± 1.64 mg/kg DM [5]. However, the peeling of the outer skin, chipping, and the sun drying of the tubers detoxifies the HCN [1,6,7].

Cassava chips and pellets (dried irregular and cylindrical shape of slices, respectively) are the main root products used as energy ingredients in ruminant feeds. These products are rich in the non fiber carbohydrates (78.6%) that mainly are starch but very poor in the crude protein (≤ 2%). The rumen degradation coefficient of starch for cassava and wheat was 99.3% and 98.6%, respectively, [8-10]. Other cassava root products such as crushed dried whole roots [11], cassava bagasse (by product of cassava flour) [12], and dried waste of cassava starch extraction [13] have been evaluated as substitute of ground corn at different levels in diets for lactating cows. The results of milk yield, and milk contents showed that cassava root products diets could be used as a partial replacement of corn without any adverse effect on these items compared with the control diets. Thus, in this study, cassava pellets replaced different proportions of maize in diets for lactating Baladi goats.

Materials and Methods

The first experiment: Digestion trial

Three mature Baladi goats' males of about 28 ± 0.2 kg were used along three digestion trials of 21 days each (14 days preliminary period followed by 7 days' collection period). Three rations were designed as 100% clover hay (CH) (T 1), 70% CH+30% cassava pellets (T 2), and 50% CH + 50% cassava pellets (T 3). The cassava pellets were gifted from Thailand. The bucks received their maintenance requirements according to [14]. Faeces were quantitatively collected and feed residues, if any, were recorded for each animal. The chemical composition of feed ingredients and faeces, and HCN acid of cassava pellets were analyzed as described by [15]. The metabolizable energy (ME) of the diets was calculated as follows: ME= 0.15 digestible organic matter in dry matter% (DOMD%) [16]. Chemical composition of the experimental rations in the first experiment is shown in table 1. The comparison among means was done using Student T test according to [17].

Item	T1	T2	T3	Cassava pellets
	100% hay	70% hay + 30% pellets	50% Hay + 50% Pellets	
CP	14.84	11.00	08.00	01.72
CF	28.74	20.20	15.00	01.50
EE	02.04	01.80	01.60	01.32
NFE	38.84	55.00	65.40	90.96
Ash	15.54	12.00	10.00	04.50
[1]HCN	-	-	-	25.00

Table 1: chemical composition of the rations used in the digestion trial (g/100g DM) ([1]HCN acid (mg/kg DM))

The second experiment: Feeding trial

Animals, dietary groups, sample collection, and chemical analysis

Fifteen homoparity Baladi does weighed on average 23 ± 0.2 kg were assigned randomly to three equal groups. All animals received diet consisting of 30% clover hay, 45% concentrate feed mixture (CFM) and 25% maize, on dry matter basis. The maize was partially replaced by cassava pellets as 0, 50, and 75%, in the first, second, and third group, respectively. The feed ingredients and composition of the formulated rations are represented in table 2. The goats were fed twice daily according to [14] requirements and water was available *ad libitum*. The experimental period extended from ten days before parturition (as an adaptation period) until 18 weeks of lactating period.

The goats were milked twice daily and individual milk yields were recorded biweekly. Representative samples of milk were taken from morning and afternoon milks once every two weeks. Milk was analyzed for total solids (TS), fat, protein, and ash by the methods of [18], lactose was estimated by the method of [19], solid not fat (SNF) was calculated by difference. At the end of feeding trial, only three goats of each group were used for rumen and blood samples.

Item	G1 0%	G 2 50%	G 3 75%	Maize	CFM
Ingredients% :					
Clover hay	30.00	30.00	30.00		
CFM	45.00	45.00	45.00		
Maize	25.00	12.50	06.25		
Cassava	00.00	12.50	18.75		
Cassava **:** maize	-	1:1	3:1		
Composition %:					
CP	13.03	12.00	11.50	08.20	14.50
EE	03.13	03.23	02.78	04.50	03.08
CF	18.09	16.76	16.09	12.10	14.31
NFE	56.64	58.89	60.35	69.00	60.56
Ash	09.11	09.12	09.28	06.20	07.55

Table 2: Feed ingredients and composition of the experimental rations used in the feeding trial.

Rumen samples were withdrawn by stomach tube before and at two, four, and six hours of morning feeding. Samples were strained through three layers of gauze and directed to the determination of pH value, total volatile fatty acids ($TVFA,_s$) [20], total nitrogen [15], and ammonia-nitrogen [21].

Blood samples were taken via the jugular vein in glass tubes containing EDTA before and at four hours of morning feeding. The plasma was separated by centrifugation and stored at -20°C until analysis for total protein, and non protein concentrations [15]. True protein was calculated by the difference.

Statistical analysis

Repeated measurements of rumen and blood were analyzed according to [17], using the following model: $Y_{ijk} = \mu + G_i + A_k (G_i) + S_j + G \times S_{ij} + E_{ijk}$. Where: Y is the effect of the observation, μ is the overall mean, G_i is the effect of group (i= 1,2, and 3), A_k (G_i) is the effect of animal k within group i, (error 1), S is the effect of sampling time (j= 0,2,4, and 6, for rumen, and = 0, and 4, for blood), G×S is the interaction between group and sampling time, E_{ikj} is the randomized error. Differences among means were tested using Tukey test [17]. Significance was declared at P ≤ 0.05.

Repeated measurements of milk yield and its constituents were reduced to pooled mean for each goat before statistical analysis. Pooled data were analyzed by ANOVA for a complete random design using the following model: $Y_i = \mu + G_i + e_i$. Where: Y is the effect of the pooled mean, μ is the overall mean, Gi is the group (i = 1, 2, and 3), e_i is the residual error. The degrees of freedom were partitioned as treatments=2, error=12. Differences among means were tested using Tukey test. Significance was declared at P ≤ 0.05 [17].

Results and Discussion

Chemical composition of cassava pellets

Data of table 1 illustrated that cassava pellets contained low levels of CP (1.72%) and CF (1.50%) but had high level of NFE (90.96%) on DM basis. The content of hydrocyanic acid (HCN) acid was 25 mg/kg DM.

On the basis of the high NFE, and low fiber contents (Table 1), cassava pellets could be considered as a concentrate feedstuff of high energy density. This consideration might be emphasized by the finding that the starch content (61.46%) represented 73.54% of the NFE in the cassava meal [22]. The lower content of HCN (25 mg/kg DM) in the used cassava pellets than that of cassava root meal (117 ppm) recorded by [23] could be attributed to that the drying process during chipping and pelletizing the cassava roots detoxifies a considerable level of HCN**.** Also**,** a higher level of HCN (79.0 ≤ HCN≤ 138.1 ppm) was recorded for the cassava pulp (81.6% moisture) used in the study of [24]. In this respect, it is notable to refer to the findings of [25] as follows: a) Feed could be used without cyanide poisoning at level HCN ≤ 600 ppm, b) Feed is potentially toxic and should be fed at restricted rate at 600 ≥ HCN ≤ 1800 ppm, and c) Feed is very toxic and should not be used at level HCN≥ 1800 ppm. The comparing of the HCN acid level reported here (25 mg/kg DM) by the lethal dose (2-2.3 mg/kg BW) suggested by [26] and by the findings of [25] indicated that the present level is considered very safe. The good health of the animals throughout the present trial emphasized this concept.

The first experiment: The digestion trial

It could be noticed that the apparent digestibility of OM ($P \leq 0.05$), NFE ($P \leq 0.01$), and EE ($P \leq 0.01$) were significantly increased with increasing cassava level in the diet being highest for the 50% level of cassava inclusion. However, cassava pellets significantly ($P \leq 0.01$) decreased the apparent digestibility coefficients of C.F. that were 64.6, 46.3, and 42.5% for the first, second, and third treatment, respectively (Table 3).

Item %	T1	T2	T3	²SE ±	Cassava ³pellets
DC :					
DM	68.10^{cb}	72.04^{ab}	76.54^{a}	02.5	82.84
OM	67.25^{c}	73.11^{b}	78.35^{a}	02.1	86.34
CP	73.29^{ab}	75.69^{a}	70.90^{cb}	02.7	74.50
CF	64.63^{A}	46.27^{B}	42.48^{BC}	04.6	00.00
EE	43.92^{C}	54.03^{B}	62.33^{A}	12.4	97.22
NFE	69.24^{C}	83.19^{AB}	87.85^{A}	01.6	87.55
NV:					
TDN	50.65^{c}	64.01^{ab}	70.49^{a}	08.6	83.28
DP	10.28^{A}	08.33^{B}	05.67^{C}	02.8	01.40
¹ME	08.52^{c}	09.65^{ab}	10.58^{a}	01.9	10.86

Table 3: Effect of replacing 0 (T1), 30 (T2), and 50% (T3) of clover hay by cassava pellets on digestion coefficients (DC)and nutritive values (NV)

(Notes, ($^{a, b, c}$), and ($^{A, B, C}$) Different superscripts in the same row differ significantly at (p<.05) and (p<.01), respectively,

¹ME=Metabolizable Energy (MJ/kg DM), ²SE, standard error of means (n=3), ³Calculated values)

Data in table 3 also showed that the nutritive values of the experimental diets expressed in terms of TDN, and ME were significantly ($P \leq 0.05$) increased with increasing cassava level in the diet being highest for the 50% level of cassava inclusion. However, cassava pellets significantly ($P \leq 0.01$) decreased the digestible protein (DP) that was 10.28, 8.33, and 5.67% for 0, 30, and 50% level of cassava, respectively. On the basis of the calculated digestibility coefficients reported for cassava pellets (Table 3), the nutritive values expressed in terms of TDN, DP, and ME could be estimated as 83.28%, 1.40%, and 10.86 MJ/kg DM, respectively (Table 3).

At the beginning, it should be mentioned that the indirect method that was applied in this study to determine the apparent digestibility coefficients (ADC_s) of cassava constituents depended on the assumption that the ADC_s of the clover hay constituents were stable and that was a reason of brining about of unpractical phenomena like the augmentation of the ADC above 100% or the diminution below zero (as observed in the unpublished arithmetical coefficients), so only the physiological coefficients are published here.

The increasing of the OM digestibility, TDN, and ME with increasing the cassava pellets (Table 3) may be due to the reduction of ash content as the level of cassava pellets increased (Table 1).The decreasing of the CF digestibility and the increasing of the NFE digestibility with increasing the cassava pellets may be explained on the basis that cassava pellets contained high level of non structural carbohydrates (NFE) (90.96%) and low level of structural carbohydrates (C.F) (1.5%) (Table 1), therefore, bacteria attack the simpler carbohydrates by preference. Moreover, the undigested cellulose of hay surrounding the fat may serve as a barrier against digestive action, so, with increasing cassava proportion, the EE digestibility was increased as shown in table 3. The present results agree with those of [24,27].

The present nutritive values of cassava pellets expressed as TDN (83.28%) and ME (10.86 MJ/kg DM) are in line with those reported by [24] who found that the TDN, and ME contents of cassava pulp fed to beef cattle (*Bos indicus*) were 74.4%, and 11.3 MJ/kg DM, respectively. However, the nutritive value of cassava pellets namely TDN (83.28%) (Table 3) is higher than that of sweet tubers fed to the Egyptian sheep being 27.8% [28]. It might be related to DM content that was 91.09 and 29.45% for cassava pellets and sweet potato tubers, respectively.

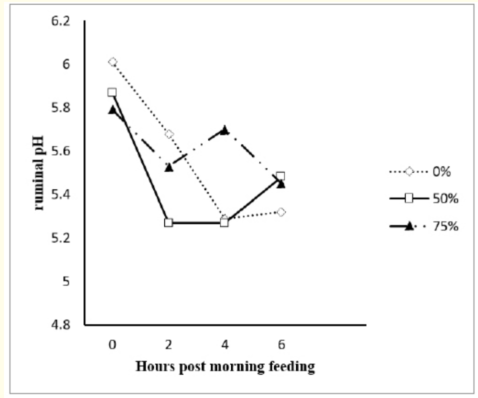

Figure 1a: Effect of replacing 0, 50, and 75% of maize by cassava pellets on ruminal pH.

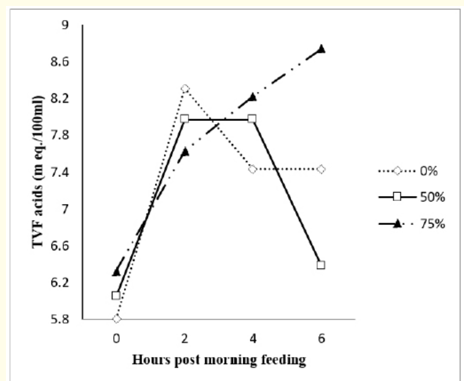

Figure 1b: Effect of replacing 0, 50, and 75% of maize by cassava pellets on ruminal TVFA,s.

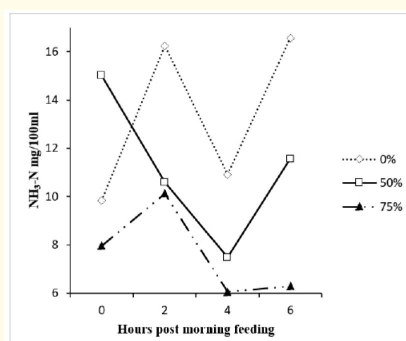

Figure 1c: Effect of replacing 0, 50, and 75% of maize by cassava pellets on ruminal NH3 – N.

The second experiment: The feeding trial

Effect of cassava pellets on some parameters of rumen fluid

Data in figure 1 showed that as the level of cassava pellets increased, the values of ruminal pH, total $VFA_{,S}$, NH_3-N, and total protein N (Figure 1: a, b, c, and d, respectively) were decreased. Only the significant ($P \leq 0.05$) decreasing effect was recorded for the cassava pellets on the ruminal NH_3-N concentration that was 13.40, 11.16, and 7.61mg/100 ml for replacing 0, 50, and 75% of maize with cassava pellets, respectively. It is notable to point out that the pH value was around 5.5 for all the experimental rations. Moreover, data in figure (1: a, b, c, and d) indicated that concentrations of ruminal pH, TVFA,s, NH_3-N, and total protein nitrogen (total N) were fluctuated by time of sampling. Data concerned with statistical analysis of ruminal fluid parameters (Table 5) showed that effect of sampling time was high significant on pH, and significant on $TVFA_{,s}$, however, neither NH_3-N nor total N was affected by sampling time. It should be noticed that no clear interaction effects were noticed between sampling times and groups regarding pH, total N, TVFA, s and NH_{3-} N (Table 5).

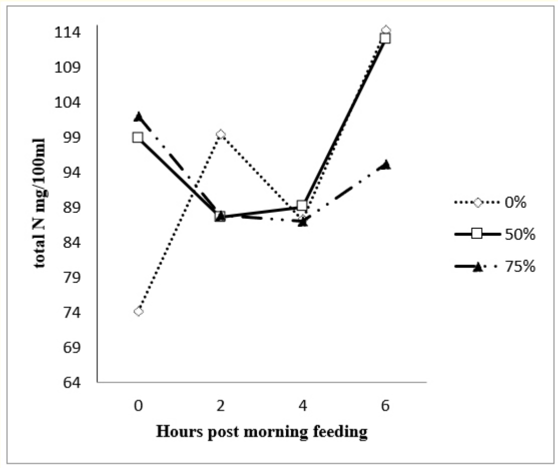

Figure 1d: Effect of replacing 0, 50, and 75% of maize by cassava pellets on ruminal total N.

Item	G1 0%	G2 50%	G3 75%	[1]SE ±
Total protein:				
0 h	6.86	7,01	7.35	
4 h	6.35	6.81	7.25	
mean	**6.61**	**6.91**	**7.30**	.36
Non protein :				
0 h	0.26	0.39	0.24	
4 h	0.23	0.18	0.16	
mean	**0.25**	**0.24**	**0.20**	.026
True protein:				
0 h	6.60	6.70	7.11	
4 h	6.13	6.63	7.09	
Mean	**6.37**	**6.67**	**7.01**	.369

Table 4: Effect of replacing 0, 50, and 75% of maize by cassava pellets on blood plasma proteins (g/100ml)

(Note, 1SE, standard error of means (n=6))

S.O.V	**df**	**MS**	**Of**	**Rumen**		**Tab.** [1]$F_{\alpha.05}$
		pH	**TVFA**	**NH_3N**	**Total N**	
Total	35					
G	2	.013	.709	78.4*	119	$F^{2,6}$
A(G)	6	.023	2.21	12.0	283	
S	3	.691**	8.93*	29.3	707	$F^{3,18}$
S×G	6	.031	2.27	21.8	132	$F^{6,18}$
E.2	18	.032	2.52	36.9	686	
S.O.V	**df**	**MS**	**of**	**Plasma**	**protein**	**Tab.** $F_{\alpha.05}$
		Total	**Non**	**True**		
Total	17					
G	2	.777	.004	.816		$F^{2,6}$
A(G)	6	.319	.010	.287		
S	1	.497**	.027**	.140**		$F^{1,6}$
S×G	2	.074*	.002	.095**		$F^{2,6}$
E.2	6	.011	.001	.001		

Table 5: Statistical analysis of rumen and blood parameters

(* = significant, ** =high significant, and [1]$F^{2,6}$ (5.14), $F^{3,18}$(3.16), $F^{6,18}$(3.66), $F^{1,6}$ (5.99))

The non significant decrease of ruminal total N may be related to reduction of N intake as the level of cassava pellets was increased. The significant decrease in the ruminal NH_{3-} N concentration resulting from cassava pellets inclusion could suggest that N utilization was improved (Figure 1: c). This suggestion could be explained on the basis of the finding stated that diets rich in readily fermentable carbohydrates and containing moderate or large amounts of concentrates depressed NH_{3-} N in the rumen [29.30]. The similarity shown in figure (1: b) for the TVFA's concentration may be due to similarity in the ratio of concentrate to roughage (C:R) (70:30) for all the experimental groups (Table 2). Also, the relatively lower of pH value reported here (around 5.5) than normal values (around neutral) may be related to the high proportion of C to R intake [31].

All parameters of rumen fluid reported here are in line with those observed by [32] for dairy cows fed readily fermentable carbohydrates. In a study reported by [33], ten goats were assigned in a replicated 5×5 Latin square design. All goats received the same ratio of R to C (36:64). Ground corn of the concentrate was replaced by cassava chips at 0, 25, 50, 75, and 100% for treatments 1,2,3,4, and 5, respectively. Values of rumen parameters expressed as pH, NH3-N and volatile fatty acids were 6.61, 6,53, 6.57, 6.55, 6.59; 16.18, 18.82.14.72, 14.72, 14.26 mg/dl; and 75.5, 78.1, 75.0, 79.2 and 76.3 mmol/L for levels 0, 25,50, 75 and 100%, respectively. Only, differences among the 0, 50, and 75% replacement of corn by cassava chips were not significant.

It is notable to report that replacement of corn meal by dehydrated ground cassava roots at levels 0,25,50,75, and 100% in diets fed to lactating cows had no significant effect on the microbial protein synthesis reflecting that both corn and cassava had similar potential use by rumen microorganisms [11]. Moreover, the present pattern of fermentation parameters across sampling times is in line with that observed by [32, 34].

Effect of cassava pellets on some parameters of blood plasma

Inspection data of table 4 indicated that no significant differences (P ≥ 0.05) were recorded for all studied blood plasma parameters (total protein, non protein, and true protein) among the lactating goats fed on rations containing cassava pellets as 0, 12.5, and 18.75% of the total feed ingredients (Table 2). Statistical analysis illustrated that sampling time had high significant effects on all parameters of blood plasma, also, indicated that interaction effect between sampling times and groups was a remarkable significant, non significant, and a high significant for total, non, and true proteins of blood plasma, respectively (Table 5).

The non significant differences in the blood parameters among the three groups (Table 4) confirm that cassava pellets can replace up to 75% of the maize of lactating goats' rations without any adverse effect on blood N metabolites. The means of these parameters are in the normal range reported by [35] for healthy goats. The present result of plasma total proteins is in line with that reported by [36] who studied the effect of replacing 100% of yellow corn by cassava pellets on the performance of lactating buffaloes. They did not find a significant difference between corn and cassava groups in serum total proteins that were7.68, and 8.24g/100ml, respectively. Moreover, [33] found that blood urea nitrogen was not significantly affected by inclusion cassava chips at 0, 25, 50, 75, and 100% as a replacement for corn in goats' diet.

Effect of cassava pellets on milk yield and composition

The effect of replacing 0, 50, and 75% of maize by cassava pellets in the lactating Baladi goats' rations on milk production is shown in table 6. Data showed that both levels of cassava pellets insignificantly decreased milk production with about the same rate. Obviously, the decrease in the daily milk yield (622.46, 522.40, and 514.0 g/h/d) as cassava level increased was parallel to the corresponding gradual decrease in the dietary protein level being 13.03, 12.00, and 11.5% for 0, 50, 75% replacement of maize with cassava pellets, respectively, (Table 2). Both levels of cassava pellets had no significant effect on the milk constituents.

Item	G1 0%	G2 50%	G3 75%	[1]SE ±
Milk yield: (g/h/d)	622.46	522.40	514.00	2.19
4% FCM: (g/h/d)	635.53	505.11	521.90	2.69
Composition %:				
Total solids	13.63	13.28	13.74	0.23
Fat	04.17	03.78	04.55	0.22
Protein	03.79	03.54	03.64	0.14
Lactose	04.88	04.95	04.73	0.37
Ash	00.79	00.79	00.81	0.02

Table 6: Effect of replacing 0, 50, and 75% of maize by cassava pellets on the milk yield and milk composition

(Note, [1]SE=standard error of means (n=45))

Regarding milk composition, the different levels of cassava pellets did not significantly affect milk constituents (Table 6). The present results are in line with those reported by [37] who found that yields of actual milk and 4% fat corrected milk (FCM), and composition of milk components were not affected by incorporating tapioca pellets at 0, 6, or 12% of the diet fed to lactating Holstein cows. Moreover, [38] used cassava chips at 9.9 and 19.7% of total DMI for lactating cows and found that 3.5% FCM were 14.05, and 13.83 kg/h/d, respectively. Furthermore, the present findings agree with that reported for dairy cows diets containing dried waste of cassava starch extraction at levels 0, 33, and 66% as a partial replacement of ground corn [13].

However, the present results disagree with those of [39] who reported that feeds containing cassava chips might gave slightly higher milk for a similar intake of diet. They found that milk yield was 21.14 and 22.27 kg/day and milk fat was 4.13 and 4.04% for lactating cows fed nil and 400g cassava chips per kg compound feed, respectively. Also, the present results are not in line with findings of Lima., *et al*. (2015) who suggested that inclusion of cassava bagasse up to 15% of total dry matter intake linearly increased milk production in dairy cows. Generally, the variable observations among the present study, and the others could be due to the cassava processing, replacement level, animal type, and the concentrate level.

Conclusion

It may be concluded that 50 or even 75% of maize could be replaced by cassava pellets in the goats' rations without any adverse effects on their milk production, rumen fermentation, or blood N metabolites.

Conflict of Interest

The authors confirm that this article content has no conflict of interest.

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