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Effect of cultivars of sweet potato (*Ipomoea batatas*) vine on *Insacco* rumen degradability and nutrient disappearance

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Abstract

In recent years, there has been considerable interest in the use of crop residues for feeding small ruminants in Nigeria. However, little is known about the nutritive value of such feedstuffs in the country. This poses a big challenge to ruminant animal production. Therefore, the evaluation of nutritive value of different cultivars of sweet potato vines in term of their degradation characteristics would provide useful information on the variability amongst cultivars. The objectives of the study was to determine in sacco rumen degradation and nutrient disappearance of sweet potato vines cultivars. Three treatments (Danchina and King J cultivars of potato and cowpea hay) were laid-out in a cross over design. Three different breeds of goats (West African Dwarf, Sahelian White and Sokoto Red Goat) were used to determine in sacco degradation. Exponential models of Orskov and Mc-Donald were used to estimate degradation kinetics. Data generated were subjected to analysis of variance. Significant (P<0.05) differences were observed on all degradation kinetics parameters. Results indicated that vines of King J cultivar have higher significant effect (p<0.05) on degradation kinetics parameter while cowpea hay had lower values. The result of the in sacco nutrient disappearances revealed that sweet potato vine cultivars have no significant effect (P>0.05) on dry matter disappearance (76.74 vs 80.41%) for Danchina and King J, respectively. However, the dry matter disappearance of cowpea (66.05%) was lower. Acid detergent fibre and neutral detergent fibre followed similar pattern with dry matter disappearance. Sweet potato vine cultivars have significant (P<0.05) effect on Crude Protein (CP) disappearance for Danchina and King J (80.08 and 90.14%) respectively. It is concluded that the sweet potato vine cultivars are more degradable than cowpea hay (control diet). It is therefore recommended that Sweet potato vines be used as ruminant feedstuff particularly during feed scarcity for improved performance and productivity.

Keywords: degradability, disappearance, danchina, king j, cowpea and vines

Effet des cultivars de vigne de patate douce (Ipomoea batatas) sur la dégradabilité in sacco du rumen et la disparition des nutriments

Résumé

Ces dernières années, l'utilisation des résidus de culture pour l'alimentation des petits ruminants au Nigeria a suscité un intérêt considérable. Cependant, on sait peu de choses sur la valeur nutritive de ces aliments dans le pays. Cela pose un grand défi à la production de ruminants. Par conséquent, l'évaluation de la valeur nutritive de différents cultivars de vignes de patates douces en termes de leurs caractéristiques de dégradation fournirait des informations utiles sur la variabilité entre les cultivars. L'objectif de l'étude était de déterminer in sacco la dégradation du rumen et la disparition des nutriments des cultivars de vignes de patates douces. Trois traitements (cultivars Danchina et King J de foin de pomme

de terre et de niébé) ont été disposés selon un schéma croisé. Trois races différentes de chèvres (naine d'Afrique de l'Ouest, blanche sahélienne et chèvre rouge de Sokoto) ont été utilisées pour déterminer la dégradation in sacco. Des modèles exponentiels d'Orskov et Mc-Donald ont été utilisés pour estimer la cinétique de dégradation. Les données générées ont été soumises à une analyse de variance. Des différences significatives (P<0,05) ont été observées sur tous les paramètres de cinétique de dégradation. Les résultats ont indiqué que les vignes du cultivar King J ont un effet significatif plus élevé (p<0,05) sur le paramètre de cinétique de dégradation tandis que le foin de niébé avait des valeurs plus faibles. Le résultat des disparitions de nutriments in sacco a révélé que les cultivars de vigne de patate douce n'avaient aucun effet significatif (P>0,05) sur la disparition de la matière sèche (76,74 contre 80,41%) pour Danchina et King J, respectivement. Cependant, la disparition de la matière sèche du niébé (66,05%) était plus faible. Les fibres détergentes acides et les fibres détergentes neutres ont suivi un schéma similaire avec disparition de la matière sèche. Les cultivars de vigne de patate douce ont un effet significatif (P <0,05) sur la disparition de la protéine crue (PC) pour Danchina et King J (80,08 et 90,14%) respectivement. Il est conclu que les cultivars de vigne de patate douce sont plus dégradables que le foin de niébé (régime témoin). Il est donc recommandé d'utiliser les vignes de patate douce comme aliment pour les ruminants, en particulier pendant la pénurie d'aliments pour améliorer les performances et la productivité.

Mots clés: Dégradabilité, disparition, Danchina, King j, niébé et vigne

Introduction

Scarcity of qualitative feeds is among the biggest challenges in ruminant production in the tropics, especially during the dry season. Efforts have been put to find a solution to the problem; among the options available is the use of crop residues (Odeyinka *et al.*, 2009). Among the crop residues with high potential of being used as feed for animal are sweet potato vines as its rich in protein, fiber and vitamins (Kebede and Tedesse, 2011). With its potential sweet potato vines can help in mitigating the feed shortages during the scarcity. Nigeria is the second largest producer of sweet potato in Africa after Uganda with over two million metric tonnes annually (FAO, 2016).Traditionally, majority of small-scale farmers in Africa and Asia produce sweet potato for tubers as source of energy or fodder and as source of protein and vitamins for human and livestock (Larbi *et al.,* 2007). Sweet potato vines can be safely fed to animals without any restrictions (Dahlanuddin, 2001). Potato vines could, therefore, serve as an important ruminant livestock feed resource in the developing countries. The value of sweet potato is attributed to its high yield, palatability and crude protein contents, as it contains about 15-30% crude protein in dry matter. These features make it a suitable feed supplement for animals receiving low quality forage in the dry season. However, cultivars have effect on the proximate composition of the vines (Baba *et al.* 2018). The feeding value of potato vines depends on the proportion of leaves to stem therein, the more the leaves content the higher the nutrition of the vines (An, 2004). The purpose of feedstuffs evaluation is to provide information regarding the capacity of individual feeds to meet the nutritional demand of an animal. Amongst many methods that have been used feed evaluation in the past, the *in sacco* method has been the most effective method to study rumen degradation (Orskov *et al.*, 1980). The technique is based on the assumption that disappearance of substrate from the bags represents actual substrate degradation by the rumen microbes and their enzymes. The *in situ* technique is also

suitable for kinetic studies and has been used widely to evaluate the rate and extent of degradation in the rumen (Ørskov, 1998). The aim of the study was to determine the effect of sweet potato vines cultivar on *in sacco* rumen degradation and nutrient disappearance.

Materials and methods

Experimental location

The study was conducted at Livestock Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture Bayero University, Kano.

Experimental animals and their management

Three different breed of male goats (West African Dwarf, Sahelian White and Sokoto Red Goat) weighed 20 Kg on average fitted with rumen cannula were fed with sweet potato vines (*Dan China, King J* and cowpea vines, with cowpea vines serving as control) supplemented with a concentrate in the ratio of 60:40 to fulfill their maintenance requirements for crude protein and energy (AFRC 1993). Water was offered *ad libitum* throughout the study period. The composition of concentrate is presented in Table 1. Diet was offered twice daily at 0800 and 1600 hours. The diet was offered in a 3×3 switch over experimental design. There was an adaptation period of 14 days at the commencement of each cycle. Apart from sweet potato vines all other feed ingredients were sourced from local market.

In sacco procedure

Dried samples of test materials were milled to pass 2 mm screen mesh. The samples consist of two cultivars of sweet potato vines (*Dan China and King J*) and cowpea vines. About 4g of sample in triplicate were weighed into nylon bag and incubated in the rumen of each goat for 8, 12, 18, 24, 32 and 48 h, in accordance to Ørskov *et al*. (1980). The bags were immersed in the rumen using a drawstring with a weight attached. All bags were placed in the rumen simultaneously, as well as removed simultaneously. After incubation time, the bags were removed from the rumen and thoroughly washed with a running tap water for 30 minutes to remove the feed debris and soluble. The bags were dried at 60^{o}C for 48h and weighted at room temperature. Disappearance for each feed at '0' time was obtained by washing the bags containing feed samples with the same running tap water for 30 minutes. The empty bags and bags containing residues following each incubation time were oven dried for 48 h at 60^{o}C and weighed at room temperature. The rumen incubated residues were finally analysed for chemical composition.

Chemical analysis

Samples of potato vines, cowpea vines and concentrates straw were analyzed for proximate composition according to AOAC (2005). The Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) were analyzed according to Van Soest *et al.* (1991).

Degradation kinetics

The exponential model of Orskov and Mc Donald (1979) was used to estimate the rate and extent of dry matter, crude protein, crude fibre, acid detergent fibre and neutral detergent fibre degradation using the equation: $p = a + b\,(1 - e)^{-ct}$

Where, p = potential disappearance at time t
a = readily degradable fraction
b = the slowly degradable fraction
c = degradation rate constant of b
t = degradation time
e = Exponential

The model was fitted using the PROC NLIN procedures of the SAS 9.3 (SAS 2009)

The *In sacco* effective degradability (ED) of the DM, CP, CF, ADF and NDF was calculated using the following equation (Orskov and McDonald, 1979);

$$ED = a + bc/(k+c)\ X\ e^{-KL}$$

Where k is the estimated rate of the

outflow from the rumen and a, b, and c are the same parameters as described above, while L is the lag phase. The outflow rate of 0.05/h was the representative for medium feeding levels (AFRC, 1993).

Dry matter disappearance

Dry matter disappearance was estimated as described by Osuji *et al. (*1993):

$$DMD = \frac{(SWa - BW) \times DMa - (SWb - BW) \times DMb}{(SWa - BW) \times DMa}$$

Where: SWa= weight of original sample + nylon bag

BW = weight of empty nylon bag

SWb=weight of the sample + nylon bag after incubation

DMa = dry matter of feed sample

DMb = dry matter of residue sample

The measure of fraction of the DM, CP, ADF and NDF was expressed as the differences between the amount of the original samples and the remaining in the nylon bags after the incubation. Nutrients disappearance was calculated as the difference between the fractions of nutrients lost during the washing and the truly water soluble fraction (Woods *et al.,* 2003).

Statistical analysis

Data generated were subjected to a two-way analysis of variance using General Linear Models Procedure of SAS (Statistical Analysis System, Version 9.3, 2009). Least significance difference (LSD) was used for mean separation. Mean differences were considered significant at $P<0.05$.

Results and discussion

Table 1 shows the gross composition of the experimental diets. The dry matter contents ranges from (86.98%) in Cowpea having to (91.26%) in *King J* and (92.12%) in *Danchina*. The ash content varied, *King J* was found to have the highest ash content (9.23%), then *Cowpea* (8.33%) and finally *Danchina* (7.46%). The crude protein contents indicated that *King J* had the highest CP content (14.71%) followed by *Danchina* (13.74%) and then *Cowpea* (13.01%). The crude fibre content ranged from 18.00% for (*King J*), followed by 19.08% for (*Danchina*) and 20.40% for (*Cowpea)*. The variation in ether extract between the feed samples was not much *King J* had the lowest (3.95%), *Danchina* (4.26%) and *Cowpea* (4.38%). The nitrogen free extract values obtained were similar cross the treatments with *Danchina* having the highest (47.85%) then *King J* (45.37%) and *Cowpea* (40.86%). The acid detergent fibre value was higher in *Danchina* (27.53%) followed by *King J* (27.16%) and then *Cowpea* (25.95%). The composition of neutral detergent fibre indicated that, *Danchina* had the highest value (35.09%) while *Cowpea* had the lowest (33.06%). The experimental diets offered to the animals met the 16% required for CP as recommended by AFRC (1993). The chemical composition of the cowpea hay showed that crude protein (CP) contents of the diets (13.01%) was similar to diet (12.10% CP) reported by Mohatla*et al.* (2016) but lower than 23-27% reported by Ravhuhali *et al.* (2010) and Anele *et al.* (2011) respectively. The variation in the cowpea hay CP content between the present study and the subsequent one was due to differences in crop management and environmental characteristics (Singh *et al.* 2010). The neutral detergent fibre (NDF) value of the cowpea hay obtained in the present study (33.06) is close to 33.33% reported by *Mohatla et al.* (2016) less than 45% obtained by Ravhuhali *et al.* (2010). The acid detergent fibre (ADF) component (25.95%) obtained in the present study falls within that ensure optimum digestibility (Belyea and Ricketts, 1993) and thus would not have negative impact on the bio-

availability of crude protein. The crude fibre (CF) composition of the diets (20.40%) was comparable to 23.30% reported by Pousga *et al.* (2019). Ether extract values obtained in the current study (4.38) is greater than the values (1.2 and

Table 1: Gross and proximate composition of the experimental diets (%)

Item	T1	T2	T3	Cowpea hay	Danchina	King J
Maize	03	24	09			
Wheat offal	30	14	22			
Cowpea husk	20	07	15			
Groundnut Cake	07	28	21			
Rice bran	12	10	10			
Rice Milling Waste	26	15	21			
Salt	02	02	02			
		Chemical Composition				
DM	91.24	90.97	90.00	86.98	92.12	91.26
CP	16.01	16.05	16.08	13.01	13.74	14.71
CF	22.47	21.17	20.73	20.40	19.08	18.00
EE	4.15	4.75	4.60	4.38	4.26	3.95
ASH	12.93	13.55	12.38	8.33	7.46	9.23
NFE	41.86	42.47	45.33	40.86	47.58	45.37
ADF	29.28	29.13	29.10	25.95	27.53	27.16
NDF	36.85	35.59	32.10	33.06	35.09	35.27

DM: Dry matter, CP: Crude protein, CF: Crude fiber, EE: Ether extract, NFE: Nitrogen Free Extract, ADF: Acid detergent fibre, NDF: Neutral detergent fiber, T1: Concentrate diets to the goats fed cowpea hay, T2: Concentrate diets to the goats fed danchina vine, T3:Concentrate diets to the goats fed king j vine.

Table 2 shows the effect of sweet potato vine cultivars on *in sacco* rumen degradability. There was significant ($p<0.05$) difference on DM degradation kinetics between the two potato vine cultivars and the cowpea hay. *Danchina* and *King J* sweet potato vines cultivars has significantly ($p<0.05$) higher degradation rate constant 'c' when compared with cowpea. No significant ($p>0.05$) difference was observed between the two potato vine cultivars and cowpea on DM potential degradability (PD) but cowpea had lower potential degradability. Moreover, *Danchina* and *King J* vines recorded higher DM *in sacco* effective degradability 'ED' and lag time than cowpea hay. Significant effect ($p<0.05$) was also observed between sweet potato vine cultivars and cowpea on CP degradation rate constant 'c' with the potato cultivars having higher value. Cowpea hay had higher potential degradability 'PD' compared to the potato vine cultivars. Potato vine cultivars have no effect ($p>0.05$) on the crude fiber degradation kinetics on the slowly degradable CF fraction “b”. No significant difference ($p>0.05$)was observed in the degradation rate constant fraction “c” and the effective degradability (ED) between the potato vine cultivars and the cowpea hay. Potato vine cultivars have no effect on the slowly degradable fraction “b”, degradation rate constant 'c”, potential degradability and effective degradability compared to *c*owpea hay. Sweet potato vine cultivars have significant effect on the dry matter fermentation. This contradicted

the findings of Fernandes *et al.* (2013) and Nasiru *et al.*(2016) who reported no significant effect of peanut forage hay and cattle manure vermicast on rice straw diets on degradation parameters. This could be due to the nature of the diets used. The dry matter slowly degradable fraction 'b' of sweet potato vine cultivars in the present study (90.67 and 104.77) was greater than 42.30 and 40.20 obtained by Phesatcha and Wanapat (2012) and Yacout *et al.* (2016) respectively. The range of dry matter degradation rate constant 'c' of the sweet potato vine cultivars obtained in this study (0.046 and 0.054) were in comparable to those reported by Kariuki *et al.* (2001) but lower than 0.071 reported by Phesatcha and Wanapat (2012). Differences in the rate of degradation "c" could be due to the amount of intracellular components and digestibility. It has been documented that 'c' fraction is a good predictor of intake (Chenost *et al.,* 2001). The effective degradability of the sweet potato vine obtained in the present study (41.10 and 43.67) were similar to (41.66 and 42.85) reported by Yacout *et al.* (2016) but lower than (84.90) those obtained by Phesatcha and Wanapat (2012). The low dry matter effective degradability contents of feed resources used in this study, despite high potential degradability values are likely as a result of low rate of degradation suggesting low intake and animal productivity. According to Turki and Atcham (2011), effective degradability of feed in the rumen depended on the length of retention of the feed in the rumen, which is also a function of the quantity and quality of the feed given to the animals. The variation in the ruminal CP degradation can be used in two ways, either to maximize substrate available for microbial and protein synthesis or to enhance the intestinal amino acid supply. The crude protein slowly degradable fraction 'b' of sweet potato vine cultivars in this study (73.20 and 76.60) was lower than 41.54 and 43.93 reported by Yacout *et al.* (2016). Differences in the effective degradability among forage crops can be explained by differences in the amount of fraction a, b and c. Therefore, forage crops that showed higher 'a' or lower 'b' fractions displayed higher effective degradability values and were less affected by outflow rate. Feedstuffs with higher effective degradability are those which are more degradable in the rumen of goats. Therefore the effective degradability of the present study was higher than those recorded by Yacout *et al.* (2016), and the differences in the effective degradability of the vines could be due to differences between varieties (USDA, 2004). The CF slowly degradable fraction 'b' of the present study was much higher than the CF slowly degradable fraction recorded by *Yacout et al.* (2016). The neutral detergent fibre 'b' value was higher than those reported by Phesatcha and Wanapat (2012). The rate of degradation 'c' of the present study was in agreement with the report of Nasiru *et al.* (2016) but lower than the report of Phesatcha and Wanapat (2012). Effective degradability was comparable with the report of Nasiru *et al.* (2016). The acid detergent fibre of slowly degraded fraction 'b' of the present study was not in agreement with Khorshidi *et al.* (2013).

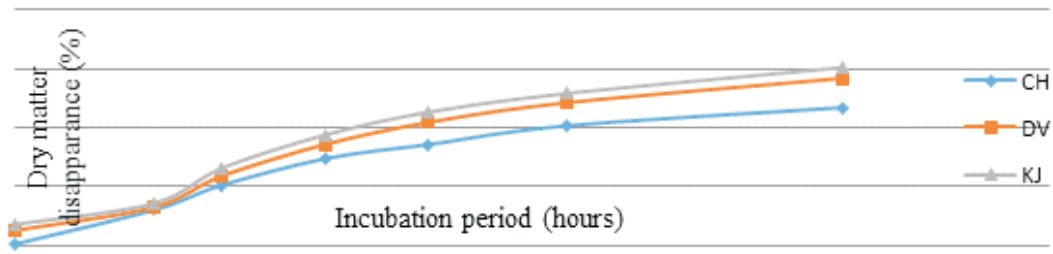
Table 2: Effect of sweet potato vine cultivars on DM, CP, CF, ADF and NDF *in sacco* rumen degradability

		Parameters				
Nutrients		**A**	**b**	**c**	**PD**	**ED**
DM	Cowpea hay	-2.10[a]	78.43[c]	0.034[c]	80.53	35.60[b]
	Danchina	-3.93[b]	90.67[b]	0.046[b]	86.74	41.10[a]
	King J	-15.73[c]	104.77[a]	0.054[a]	89.04	43.67[a]
	S.E	0.86	1.32	0.00	1.06	0.29
CP	Cowpea hay	40.07[a]	60.00[b]	0.028[b]	100	38.70[b]
	Danchina	8.77[b]	73.20[a]	0.053[a]	81.97	46.90[a]
	King J	10.37[b]	76.60[a]	0.051[a]	86.97	49.80[a]
	S.E	1.66	1.47	0.00	1.10	0.26
CF	Cowpea hay	7.07[b]	70.27	0.040	77.34[b]	39.17
	Danchina	16.07[a]	66.13	0.039	82.20[a]	45.17
	King J	0.60[c]	58.47	0.038	59.07[c]	27.30
	S.E	0.35	1.53	0.00	1.70	0.17
ADF	Cowpea hay	3.37	74.60	0.045	77.97	39.43
	Danchina	3.93	68.93	0.046	72.86	37.97
	King J	5.87	68.37	0.041	74.24	36.90
	S.E	0.86	1.02	0.002	1.36	0.11
NDF	Cowpea hay	3.40	76.23[a]	0.048[b]	78.33[a]	36.17
	Danchina	-0.30	59.07[b]	0.053[a]	58.77[b]	31.10
	King J	2.10	57.37[b]	0.035[c]	60.77[b]	31.23
	S.E	2.38	1.46	1.09	1.09	0.19

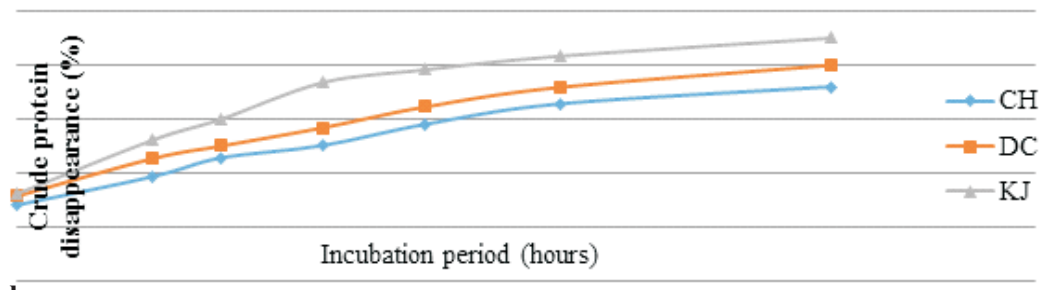
Values within a column and within DM, CP, CF, ADF and NDF differ ($P < 0.05$) significantly. a: quickly soluble fraction; b: slowly degradable fraction; c: degradation rate constant (fraction/hour); PD: potential degradability; ED: effective degradability (%); LT: lag time; SE: standard error, DM: dry matter, CP: crude protein, CF: crude fiber, ADF: acid detergent fibre, NDF: neutral detergent fibre.

Nutrients disappearance of sweet potato vines revealed the possible degradation of nutrients incubated *in sacc*o after certain period of time. Sweet potato vines cultivars have no effect ($p>0.05$) on DM disappearance (76.74 vs 80.41 %) for *Danchina* and *King J* respectively. However, *in sacco* DM disappearance of cowpea (66.05%) was lower ($p<0.05$) when compared with the two potato cultivars. The disappearance of *in sacco* CP did not follow the same pattern with the *in sacco* rumen DM disappearance (Figure 1a). There was significant effect ($p<0.05$) between *in sacco* rumen CP disappearance for sweet potato vines (80.08 and 90.14%) for *Danchina* and *King J* respectively) and Cowpea hay (72.10%). Sweet potato vines had increased ($p<0.05$) CP *in sacco* rumen disappearance than Cowpea hay. Figure 1c revealed the disappearance pattern of acid detergent fiber (ADF). Sweet potato vine cultivars have no effect ($p>0.05$) on *in sacco* rumen ADF disappearance. Moreover, there is no significant difference ($p>0.05$) on *in sacco* rumen ADF disappearance between the cowpea hay and the two sweet potato vine cultivars (68.50, 65.39 and 64.38 for cowpea, *Danchina* and *King J* respectively). The disappearance of *In sacco* rumen NDF disappearance follows similar pattern with *In sacco* ADF disappearance (Figure 1d) Based on the findings, sweet potato vine cultivars had

more than 50% dry matter disappearance at 48 hours of incubation. This indicated that all the cultivars could be used as feed for livestock due to the forage quality that meet the requirements for feeding livestock as observed by Larbi *et al.,* (2007). The *in sacco* nutrients disappearance indicated that the disappearance features of *Cowpea, Danchina* and *King J* vines differed slightly among themselves. This is similar to the report of Chumpawadee *et al.* (2005). Results of dry matter disappearance observed values are in accordance with the values reported by Chumpawadee *et al.* (2005) but higher than those reported by Fadel *et al.* (2007). The CP disappearance values obtained were comparable to those obtained by Chumpawadee *et al.* (2005). Greater CP disappearance was reported by Bayourthe *et al.* (2000) for Pea (*Pisum sativum*) flour. Lower CP disappearance value was obtained by Danesh *et al.* (2005). The result for the CP disappearance of sweet potato vines in this study showed that nutrient disappearance was comparatively higher. The CP nutrients of *King J* and *Danchina* vines disappeared faster in the rumen than that of the Cowpea. This could be due to greater proteolytic activities of the ruminal microflora there by evoking a higher disappearance Antwi *et al.* (2014). The Acid detergent fibre and neutral detergent fibre disappearance obtained in this study were comparable to the values reported by Pawelek *et al.* (2008). The disappearance parameters measured in this study are of paramount importance as they influence rumen fill and hence feed intake (Van Soest, 1987).



a



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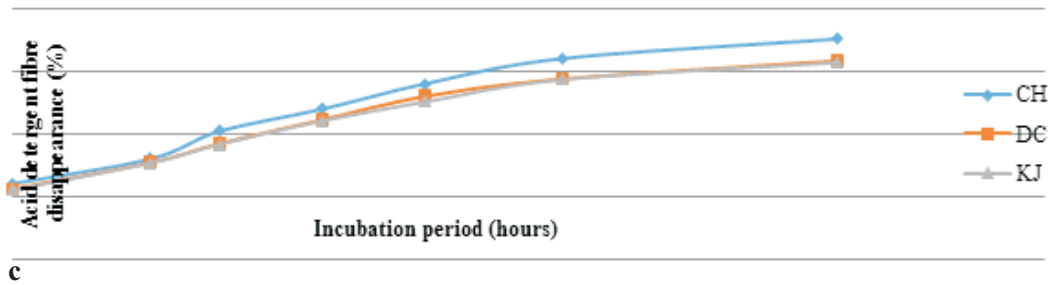

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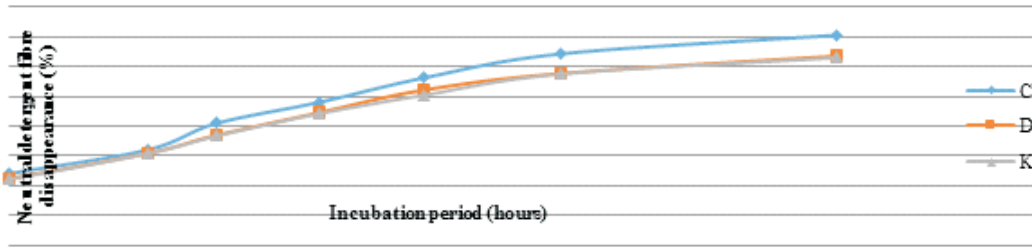

d

Figure 1: Pattern of disappearance of a) dry matter b) crude protein c) acid detergent fibre d) neutral detergent fibre from CH: cowpea hay, DC: danchina sweet potato vine cultivar, KJ: king j sweet potato vine cultivar during rumen incubation for various times in goat

Conclusion

The study showed that *King J.* and *Danchina* sweet potato vine cultivars can be fed to animals as a replacement of cowpea hay as they were proven to be nutritionally good in term of rumen degradation characteristics and nutrients disappearance. More research should be conducted further with a view to ascertaining the nutritive value of sweet potato vines.

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