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Effects of cassava peel mash on chemical composition, nutrient intake, and rumen environment parameters of West African dwarf rams supplemented with dried *Ficus thonningii* foliage

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Abstract: *The study evaluated effects of feeding cassava peel mash (CPM) supplemented with dried foliage of* Ficus thonningii *(DFF) on the performance of rams. Twenty rams were allotted to four dietary treatments (*ad libitum *CPM+2 per cent urea (control),* ad libitum *CPM supplemented with DFF at 0.6, 1.2 and 1.8 per cent of body weight respectively) for 90 days. From the results, crude protein content ranged from 1.99 per cent in CPM to 10.35 per cent in CPM+2 per cent urea. The total dry-matter intake ranged from 247.94 g.d^{-1} for rams fed with CPM+2 per cent urea to 377.00 g.d^{-1} for rams supplemented with DFF at 1.8 per cent BW. Higher (P < 0.05) rumen ammonia nitrogen was obtained in animals fed diets containing CPM+2 per cent urea. As the supplementation of DFF increased, total volatile fatty acids concentration as well as microbial contents increased (P < 0.05). In conclusion, supplementation of basal diet of cassava peel mash with dried* Ficus thonningii *foliage up to 1.8 per cent of body weight of rams is recommended for improved animal performance.*

Keywords: *Ficus thonningii* foliage, cassava peel mash, dry season, rumen microbes, West African dwarf rams

Poor nutrition, bad management practices, and diseases, as well as genotype of different animal species have been reported to be responsible for the poor productivity of small ruminants in many tropical countries (Peacock, 1996). Oni et al. (2010) reported that feeding systems based on poor quality tropical foliage due to seasonal effects and plant maturity, crop residues or agro-industrial by-products, which are deficient in protein content, might need additional protein for an efficient rumen ecosystem that will lead to improved nutrient intake and performance.

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However, forages in the form of grasses and legumes provide fairly good quality feed for ruminant animals, but the influence of season (dry), maturity of plants, and the reduction in area of land available for grazing due to urbanization and industrialization, negatively affects its productivity, quality, and availability (Sanon et al., 2007; Asadu et al., 2008). This eventually leads to reduced feed intake and digestibility by the ruminants, considerable weight loss, marked reduction in milk yield and other production and reproduction losses, and/or death (Tarawali et al., 1999). Several factors mentioned above also contributed to the reduced animal protein intake by humans especially in developing countries. In order to improve productivity, small ruminants should be fed with diets that will maintain a conducive environment for rumen microbes and the host animal. Obtaining diets that will meet nutrient requirements will necessitate the use of unconventional feedstuffs for livestock production, since feeding of concentrate diets to ruminants is not encouraged due to their high cost as well as their unavailability. Anele et al. (2008) advocated the use of indigenous multi-purpose tree (MPT) species which are rich in crude protein to improve animal nutrition during the critical period of the dry season when quality and quantity of forages is not sufficient. These plants have been reported by the Food and Agriculture Organization (FAO, 1997) to be more nutritious than most grasses and herbaceous legumes and conserve their nutrients into the dry season when feed resources are depleted; hence they are important in ruminant feeding systems. The MPT species produce high biomass of relatively good quality during the dry season. Most MPT species contain plant secondary metabolites which act as deterrents to insect, fungal, and bacterial attack. However, they were presented as anti-nutritional factors (ANFs) in animals which exert deleterious effects and disturb normal physiological functions when consumed in large quantities (Anele et al., 2008). *Ficus thonningii* is a less studied and less known fodder species in the scientific arena of animal nutrition. However, there are some studies which have identified it as an important fodder plant. For instance Smith (1992) rated *F. thonningii* as a fodder tree of high value in humid tropical Africa. Similarly, *F. thonningii* is appreciated for staying green and thus productive throughout most of the year and providing vitamins and minerals that are lacking in grassland pastures in the dry season (Tegbe et al., 2006).

Browse plants alone cannot meet the nutrient requirement of animals that are kept in an intensive system of animal production. Provision of locally available feed resources, like agro-industrial by-products such as cassava processing wastes, could provide balanced diets for animals. Cassava peels and cassava roots offer tremendous potential as cheap alternative feedstuff to maize and are a potential source of starch/carbohydrates that can provide the energy for ruminants (Oduguwa et al., 2013a).

Cassava roots contain high levels of energy and minimal levels of crude protein and have been used as readily fermentable energy in ruminant rations (Oni et al., 2010). Nigeria produced over 37 million tonnes of cassava root annually out of the 271 million tonnes of total world production (FAO, 2011). As a result, large amounts of by-products are available after roots are harvested and processed into various products for industrial and domestic uses. Cassava peels, one of the by-products of cassava processing, are normally left to rot and become a source of environmental pollution due to improper disposal (Omilani et al., 2015).

Meanwhile, cassava peel has been shown to be beneficial in ruminant livestock production. Oduguwa et al. (2013b) reported that it is low in crude protein content (4.38–6.25 g kg^{-1} DM (dry matter)), but has a high fibre concentration similar to other agro-industrial by-products.

However, utilization of cassava in animal feed is limited by its short shelf life, low protein content, and presence of ANFs such as hydrocyanic acid (HCN) (Oduguwa et al., 2012). The reliability of cassava products and by-products will to a large extent depend on how well they can be processed and stored in safe consumable forms (Bokanga, 1995).

Processing of cassava peels by grating immediately after removal from the whole tuber, drainage of fluid from it by applying pressure on the bags that contain it, and then drying will provide a diet that is free of ANFs. This processed peel is high in quality because of moisture removal and it will keep for longer especially throughout the dry season so as to provide nutritious meal that will improve animal productivity during this period.

This study is therefore designed to determine the effects of feeding different levels of dried MPT species (*Ficus thonningii*) as supplement to dried cassava peel mash on growth performance of West African dwarf rams.

Materials and methods

Location and climate of study area

The field experiment was conducted at the Small Ruminant Experimental Unit, College of Animal Science and Livestock Production while the chemical analyses were carried out at the laboratory of the Department of Pasture and Range Management, both at the Federal University of Agriculture, Abeokuta (FUNAAB) Nigeria. The experimental site lies within the savanna agro-ecological zone of south-west Nigeria (latitude: 7°N, longitude 3.5°E, average annual rainfall: 1,037 mm). Abeokuta has a bimodal rainfall pattern that typically peaks in July and September with a break of 2–3 weeks in August. Temperatures are fairly uniform with daytime values of 28–30°C during the rainy season and 30–34°C during the dry season with the lowest night temperature of around 24°C during the Harmattan period between December and February. Relative humidity is high during the rainy season with values between 63 and 96 per cent compared with dry season values of 55–84 per cent. The temperature of the soil ranges from 24.5 to 31.0°C (Department of Water Resources and Agrometeorology, FUNAAB (2016)).

Sources of feed materials

Foliage of *Ficus thonningii* was harvested by pruning the branch of the trees from the Department of Pasture and Range Management multipurpose tree arboretum, FUNAAB. The harvested fresh foliage was wilted in the sun for 3–4 hours and dried under shade to avoid bleaching and loss of nutrients. It was then packed in sacks and stored.

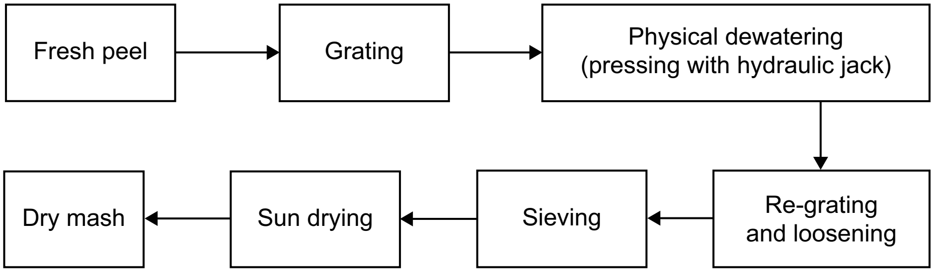

Figure 1 Steps in converting cassava peels into high-quality cassava peel
Source: Okike et al., 2015

The cassava peel mash (CPM) also referred to as 'high quality cassava peel coarse mash (HQCP)' was obtained from the Cassava Peel Processing Demonstration Factory of the International Livestock Research Institute (ILRI) within the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The process of cassava peel mash production is shown in Figure 1.

Experimental animals, management, and feeding

Twenty (20) West African dwarf (WAD) rams aged 10–12 months with mean body weight of 14.5 ± 0.5 kg were used for the experiment. The rams were adapted to the experimental area for 21 days, were dewormed and administered medications to improve their immune system. During adaptation all rams were fed CPM supplemented with cowpea haulms with fresh water offered *ad libitum*. After adaptation, the rams were housed intensively in well-ventilated individual pens (2 m^2 floor spaces) in an open-side type of house with corrugated aluminium roofing sheets and wooden slatted floor. The rams were allowed 14 days' adjustment period in the experimental pen during which they were fed experimental diets in order to get them adapted to the feeds prior to the commencement of the actual experiment.

The experimental rams were divided into four groups of five rams per treatment, balanced for body weight and allotted to the experimental diets in a completely randomized design. A basal diet of CPM was offered with fresh water *ad libitum* daily to each ram while the supplementary diet of dried foliage of *Ficus thonningii* (DFF) was offered at 0.6, 1.2, and 1.8 per cent body weight, respectively, in separate containers from that of CPM. The diet for rams in the control group (CPM-urea) was obtained by enriching CPM with urea at 2 per cent (to satisfy the minimum protein requirement for optimum rumen microbial functions). The urea was dissolved in water and the solution sprinkled over the proportionate weight CPM and mixed thoroughly before feeding. During the 90-day experimental period, quantities of feeds offered and refused were measured daily to compute feed intake on a DM basis. At the end of the feeding trial, three rams per treatment were transferred into metabolic cages for a digestibility trial over a 7-day period (4 days for adaptation and 3 days for feed and faecal samples collection). Ruminal fluid samples were collected at the start of the experiment and six hours post feeding on the last day of the experiment using oesophageal suction tube for the determination of rumen pH, ammonia nitrogen, and volatile fatty acids as well as for microbial determination.

Chemical analyses

The sub-samples of CPM and DFF faeces were oven dried at 65°C until constant weight was obtained and ground to pass through 1 mm sieve using laboratory hammer mill (Model DFZH-Bühler, Uzwil, Switzerland) and analysed for proximate composition (dry matter (DM), crude protein (CP), ether extract, ash and organic matter contents (100-ash)) according to the method of the Association of Official Analytical Chemists (AOAC, 2010). Fibre fractions analysis (acid detergent fibre (ADF), neutral detergent fibre (NDF), and acid detergent lignin (ADL)) were determined as described by Van Soest et al. (1991). Anti-nutritional factors such as tannin was determined according to the procedures of Jaffe (2003) for CPM and DFF while hydrocyanic acid (HCN) content was determined by the alkaline titration method (AOAC, 2010). The metabolizable energy was calculated using the formula: ME (MJ/kgDM) = 13.5 – 0.15 × ADF per cent + 0.14 × CP per cent – 0.15 × Ash per cent according to Ministry of Agriculture, Fisheries and Food (MAFF, 1984).

The pH and temperature of the rumen fluid were measured immediately after collection with the use of a pH meter (Hanna instruments, pH 211, microprocessor pH meter, K012818, Portugal). Thereafter 30 ml of rumen fluid was taken and filtered through four layers of cheese cloth for analyses of rumen ammonia nitrogen (AOAC, 2010) and volatile fatty acids (Samuel et al., 1997).

For microbial determination, a sub-portion of the rumen fluid was fixed with 10 per cent formalin solution in a sterilized 0.9 per cent saline solution for the enumeration of total bacteria, protozoa, and fungal counts according to the method of Baker and Breach (1986).

Statistical analysis

Data collected were subjected to one-way analysis of variance in a completely randomized design (SAS, 2009). Significant means were separated using Duncan multiple range test (Duncan, 1955).

Results and discussion

Table 1 shows the chemical composition of the feed ingredients that consisted of dried *Ficus thonningii* foliage (DFF), cassava peel mash (CPM), and CPM-urea. The CP content ranged from 1.99 per cent in CPM to 10.35 per cent in CPM-urea. The mean NDF content was 26.61 per cent ranging from 19.53 per cent in CPM-urea to 37.80 per cent in DFF. The hydrocyanic acid content ranged from 1.02 per cent in CPM-urea to 1.32 per cent in CPM. The total polyphenols (as tannic acid equivalent) varied ($P < 0.05$) from 4.00 per cent in CPM- urea to 5.6 per cent in DFF. The high dry matter content of the feed ingredients is good for the rumen function of ruminant animals

Table 1 Chemical composition (% DM) of dried foliage *Ficus thonningii*, cassava peel mash and cassava peel mash +2% urea

Parameters (%)	*Dried F. thonningii foliage*	*Cassava peel mash*	*CPM-urea*
Dry matter	90.00	90.00	87.53
Crude protein	10.12	1.99	10.35
Ether extract	12.60	0.67	4.35
Ash	12.38	2.70	3.72
Organic matter	87.62	97.30	96.28
Neutral detergent fibre	37.80	22.50	19.53
Acid detergent fibre	20.40	14.40	13.09
Acid detergent lignin	6.00	7.80	6.51
Cellulose	14.40	6.60	6.58
Hemicellulose	17.40	8.10	6.44
Tannin (mg/100 g)	5.60	4.80	4.00
Hydrocyanide (mg kg^{-1})	–	1.32	1.02
Metabolizable energy (MJ kg^{-1} DM)	9.99	11.21	12.43

as they act as substrate for fermentative functions of the microbes. The CP contents of the ingredients were high and adequate for meeting the protein requirements of 9.60–15.00 per cent for ruminant animals (Crowder and Chedda, 1977: 127–9) except in CPM (1.99 per cent), which necessitates its fortification with a protein source such as browse leguminous tree, which are rich sources of protein and some minerals. The CP content of DFF in this study, was lower than the 14.7 per cent reported by Bamikole et al. (2004) but higher than the report of Roothaert (2000). The CP value however falls within the range of 10–37 per cent reported for browse plants in Nigeria (Mecha and Adegbola, 1980). Agro-ecological conditions and seasons when the browse was harvested could have been responsible for the differences recorded in the CP contents. Oduguwa et al. (2013a) reported a higher value of CP content (4.61 per cent DM) for untreated cassava peels. The variation in CP composition of the CPM may be attributed to differences in processing undertaken, species differences or the age of harvesting. However, the CP content was higher in CPM-urea. The NDF, ADF, and ADL reported for DFF varied slightly with the values of 36.5, 25.5, and 4.7 per cent DM, respectively, reported by Oni et al. (2008) for *Enterolobium cyclocarpum* foliage. The lower NDF content (22.50 per cent) in CPM in this study compared with 53.8 per cent reported by Oduguwa et al. (2013b) could be due to the process of grating employed for the production of CPM which could have been responsible for breaking the fibre linkages. The NDF contents of all the feed ingredients were however lower than 600–650 g kg^{-1} DM above which intake of tropical feeds by ruminants would be limited (Van Soest et al., 1991).

Higher tannin content in animal diets has been reported to affect the nutritive value of ruminant feeds by reducing voluntary feed intake and digestibility

Table 2 Nutrient intake of West African dwarf rams fed cassava peel mash (CPM) supplemented with dried *Ficus thonningii* foliage (DFF) at different levels (g/day)

Parameters (g/day)	*Ad libitum CPM-urea*	*Ad libitum CPM + DFF at 0.6% BW*	*Ad libitum CPM + DFF at 1.2% BW*	*Ad libitum CPM + DFF at 1.8% BW*	*SEM*
Dry matter intake	247.94^{b}	316.99^{ab}	316.69^{ab}	377.00^{a}	31.18
Crude protein intake	25.66^{a}	11.04^{b}	13.70^{ab}	18.66^{ab}	2.12
Ether extract intake	10.79^{b}	9.04^{b}	12.95^{ab}	18.88^{a}	1.23
Ash intake	15.44^{b}	14.18^{ab}	17.34^{ab}	23.45^{a}	1.89
Neutral detergent fibre intake	48.42^{b}	80.21^{a}	85.16^{a}	105.81^{a}	7.27
Acid detergent fibre intake	32.45^{b}	49.13^{ab}	51.05^{ab}	62.52^{a}	4.57

Note: ^{a,b} Mean values along the same rows with different superscripts are significantly ($P < 0.05$) different.

(Barry and McNabb, 1999). The tannin contents of all feed ingredients in this study were lower than 6.0 per cent DM reported by Reed (1995) above which feed intake and digestibility by ruminants will be lowered and activity of rumen microbes will be reduced.

The hydrocyanic acid (HCN) content in this study was lower than 81.3 mg kg^{-1} reported by Oduguwa et al. (2013b). The processing of cassava peel before it was turned to mash would have resulted in the reduction in HCN contents of the ingredients (Wanapat et al., 2000). The concentration of HCN in the ingredients in this study was below the recommended 50 mg kg^{-1} DM safe level (Oni et al., 2010).

Nutrient intake of West African dwarf rams fed cassava peel mash supplemented with dried *Ficus thonningii* foliage at different levels is shown in Table 2. The total dry matter intake of experimental rams ranged from 247.94 g.d^{-1} for rams fed with CPM-urea to 377.00 g.d^{-1} for rams supplemented with DFF in 1.8 per cent BW. A higher value ($P < 0.05$) of 25.66 g.d^{-1} was recorded in rams fed with CPM-urea while there was an increasing CP intake as the level of DFF that was used in supplementing animals fed CPM increased. Rams that were supplemented with DFF at 1.8 per cent BW had significantly ($P < 0.05$) higher NDF intake above other rams on different diets.

The higher DM intake recorded in sheep fed CPM and supplemented with DFF could be attributed to the increased palatability of the feed. Maximum intake obtained was above the recommended voluntary feed intake of 68 g/kg $W^{0.75}$ (Kearl, 1982) for goat breeds commonly found in developing countries. The low DM intake recorded in the control may be attributed to low palatability of urea in comparison with DFF.

Protein intake is a major determinant of ruminant performance due to increased availability of fermentable nitrogen and other nutrients required by rumen bacteria, as well as the greater opportunities for some of the protein to escape rumen fermentation (Oni et al., 2010). Higher NDF intake in rams fed DFF supplementation at 1.8 per cent BW shows that the diets are a good source of carbohydrates to ruminant animals as NDF represent the soluble fraction of the fibre component of foliage. The higher fibre

Table 3 Volatile fatty acid, pH and ammonia concentrations of West African dwarf rams fed cassava peel mash (CPM) supplemented with dried *Ficus thonningii* foliage (DFF) at different levels

Parameters		*Ad libitum CPM-urea*	*Ad libitum CPM + DFF at 0.6% BW*	*Ad libitum CPM + DFF at 1.2% BW*	*Ad libitum CPM + DFF at 1.8% BW*	*SEM*
pH	Before	6.72^{c}	6.66^{c}	6.83^{b}	7.00^{a}	0.01
	After	6.16^{b}	6.32^{b}	7.01^{a}	7.07^{a}	0.04
Temperature (°C)	Before	28.38^{c}	29.11^{b}	30.56^{a}	28.78^{bc}	0.09
	After	26.44^{b}	26.39^{b}	27.06^{a}	26.75^{ab}	0.07
NH_3-N (%)	Before	25.52^{a}	23.81^{ab}	21.26^{b}	24.92^{a}.	0.76
	After	40.82	29.62	28.07	31.47	2.00
Total VFA (%)	Before	0.65^{b}	0.94^{a}	0.96^{a}	0.99^{a}	0.01
	After	0.47^{bc}	1.20^{ab}	1.24^{c}	1.38^{a}	0.02

Notes: $^{a,b,c.}$ Mean values along the same rows with different superscripts are significantly different ($P < 0.05$).
NH_3-N: ammonia nitrogen, VFA: volatile fatty acids.

intakes recorded in this study were a result of the dried materials that constituted the diets; this provided adequate coarse insoluble fibre for normal rumen function which is associated with adequate rumination and cellulose digestion.

Table 3 shows the volatile fatty acid, pH, and ammonia concentrations of West African dwarf rams fed cassava peel mash (CPM) supplemented with dried *Ficus thonningii* foliage (DFF) at different levels. There were differences ($P < 0.05$) in the pH of the rumen of rams at the end of the experiment between the diets, ranging from 6.16 in rams fed CPM-urea to 7.07 in rams fed CPM supplemented with DFF at 1.8 per cent. There was a significant difference in the ammonia nitrogen contents of rams that were fed with CPM based diets. As the supplementation of DFF increased in the diet of the animals, the total volatile fatty acids concentration also increased ($P < 0.05$). The ruminal pH of the various diets in this study were higher than 5.6, which is considered to be the threshold for rumen acidosis in beef cattle fed high concentrate diets (Yusuf et al., 2013). The rumen ammonia nitrogen (NH_3-N) concentration at the end of the experiment fell within the 5–20 mg NH_3/100 ml reported by Kempton et al. (1977) for optimum rumen ammonia concentration. Values obtained for rumen NH_3-N showed that higher protein intake by rams fed CPM-urea resulted in increased microbial fermentation of protein within the rumen. Lower rumen NH_3-N with DFF supplementation will make more protein available for post-ruminal absorption in the intestine.

Higher production of total volatile fatty acid (VFA) was obtained with an increase in the level of DFF supplementation. This result is a consequence of increased carbohydrate fermentation by rumen microbes since more fibre was consumed by rams supplemented with DFF. However, lower VFA content in the rumen of rams fed CPM- urea compared with other diets could be due to low fibre intake. Additionally, the animals fed urea had increased amounts of rumen NH_3-N, which is a product of urea fermentation. This high amount of rumen NH_3-N also had a resultant effect on

VFA levels because the degradation of urea and metabolism of the ammonia requires a considerable and commensurate amount of energy in the form of VFA (Oba and Allen, 2003). According to Preston and Leng (1987: 117–8), additional protein and energy are required by animals to maintain an efficient rumen ecosystem that will stimulate nutrient intake and improve animal performance. This reveals the complementary action between the CPM and DFF for ruminant productivity.

The effects of cassava peel mash (CPM) supplemented with dried *Ficus thonningii* foliage (DFF) at different levels on microbial contents of West African dwarf rams are presented in Table 4. The highest ($P < 0.05$) value for total anaerobic bacteria (TAB) was in rams fed CPM supplemented with DFF at 1.2 per cent with a value of 2.35×10^6 cfu/ml while the lowest ($P < 0.05$) TAB was obtained from the rumen of rams fed CPM-urea with a value of 1.60×10^6 cfu/ml. Rams fed CPM supplemented with DFF at 1.2 per cent had the highest value of 1.75×10^6 cfu/ml for amylolytic bacteria, which was significantly higher than other treatments. There were differences ($P < 0.05$) in the total protozoan counts (TPC) of the rams at the end of the experiment, which ranged from 0.20 ($\times 10^6$ cfu/ml) in rams fed CPM supplemented with DFF at 0.6 per cent to 1.35 ($\times 10^6$ cfu/ml) in rams fed CPM supplemented with DFF at 1.2 per cent.

The inclusion of DFF as supplement in the diets of experimental rams fed CPM showed an increase in the population of rumen microorganisms especially the bacterial population which is responsible for the greater proportion of fermentative breakdown of plant components in the rumen. Van Soest (1994) reported that an increased rumen microbial population will in turn induce higher fermentation rates,

Table 4 Microbial contents of West African dwarf rams fed cassava peel mash (CPM) supplemented with dried *Ficus thonningii* foliage (DFF) at different levels

Parameters		*Ad libitum CPM- urea*	*Ad libitum CPM + DFF at 0.6% BW*	*Ad libitum CPM + DFF at 1.2% BW*	*Ad libitum CPM + DFF at 1.8% BW*	*SEM*
Total anaerobic bacteria ($\times 10^6$ cfu/ml)	Before	2.55^{a}	0.65^{b}	1.55^{ab}	1.95^{ab}	0.278
	After	1.60^{c}	1.80^{bc}	2.35^{a}	2.10^{b}	0.10
Amylolytic ($\times 10^6$ cfu/ml)	Before	1.35^{a}	0.40^{b}	0.20^{b}	0.25^{b}	0.162
	After	1.10^{b}	0.90^{b}	1.75^{a}	1.50^{ab}	0.13
Proteolytic ($\times 10^6$ cfu/ml)	Before	0.50^{a}	0.40^{ab}	0.25^{b}	0.25^{b}	0.043
	After	1.30	1.20	1.30	1.25	0.08
Cellulolytic ($\times 10^6$ cfu/ml)	Before	0.25^{ab}	0.25^{ab}	0.20^{b}	0.35^{a}	0.023
	After	1.00	0.70	0.95	0.80	0.06
Total protozoan count ($\times 10^6$ cfu/ml)	Before	0.15^{bc}	0.30^{b}	0.10^{c}	0.50^{a}	0.051
	After	0.40^{ab}	0.20^{b}	1.35^{a}	1.00^{ab}	0.19
Total fungi count ($\times 10^6$ cfu/ml)	Before	0.00	0.00	0.00	0.05	0.008
	After	0.40	0.30	0.25	0.25	0.04

Notes: ^{abc} mean values in the same row with different superscripts are significantly (< 0.05) different
SEM = Standard error of mean

therefore improving digestibility. Further, Latham et al. (1971) advocated feeding a diet that will supply a ready form of fermentable carbohydrates which will result in higher numbers of bacteria in the rumen. Feeding of cassava peel mash to rams in this study ensured a continuous supply of energy source while supplementation with DFF at different levels provided essential nutrients to the microbes.

Singh et al. (2011) reported slightly higher values of total bacteria count (2.69×10^8 cfu/ml to 2.93×10^8 cfu/ml) in goats that were fed *Ficus infectoria*. A higher content of bacteria that was reported by these authors could be because of supplementing the goats' diet with concentrate while in the present study, cassava peel mash was fed as a basal diet.

The activity of protozoa in the rumen have been found to influence the volume of the rumen bacteria, retention time of the digesta, concentration and proportion of volatile fatty acids, levels of other acidic metabolites and ammonia, environmental pH, and numbers and type of rumen bacteria present. Changes in any of these parameters will influence ruminal function with resultant beneficial or detrimental consequences for the host. The values of protozoan count in this study were in the same range of 0.98×10^6 cfu/ml to 1.05×10^6 cfu/ml reported by Singh et al. (2011) for feeding of *Ficus infectoria* to goats.

Conclusion and recommendation

In conclusion, processing of browse plants as hay before feeding to ruminants will be an effective way to reduce the concentration of the ANFs they contained. Supplementation of basal cassava peel meal with dried *Ficus thonningii* foliage up to 1.8 per cent of body weight of rams resulted in improved animal performance. Addition of urea to cassava peel meal resulted in lower rumen volatile fatty acids, which shows in higher energy utilization. Further study can include feeding urea-treated cassava peel meal with supplementation of browse species. Livestock owners should take advantage of large quantities of waste cassava peel produced during the harvest, process it to increase its shelf life, and feed it to animals with a protein source supplement so as to improve their performance and production during the dry season when feeds are scarce.

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