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Nutrient quality and *in vitro* digestibility of dried cassava peel, mushroom degraded cassava peel and silage from guinea grass

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Target Audience: *Livestock farmers, Ruminant nutritionists, Researchers*

Abstract

There is a need to address the knowledge gap regarding the nutritional composition and digestibility of alternative feed resources in livestock nutrition to assess. This study was carried out to determine the nutritive quality and in vitro digestibility of dried cassava peel (DCP), mushroom degraded cassava peel (MDCP) and silage from guinea grass at different levels. Fresh Panicum maximum were harvested at 8 weeks after cutback chopped to 3-4 cm length, wilted for 24hours and ensiled for 4 months. Fresh cassava peels were sun-dried for 4 days. Some of the stored dried cassava peels were used as substrate to culture mushroom Pleurotus pulmonarius (oyster species) which was used in varying proportions in diets with dried cassava peels, grasses, silage and conventional feed. Samples from the diet composition were milled to determine chemical analyses and in vitro gas production techniques. The data collected were subjected to one-way analysis of variance (ANOVA) and the treatment means separated with Duncan Multiple Range Test. The result showed highest crude protein (CP) (17.42%) in diet containing 40% grass+50% DCP and 10% palm kernel cake (PKC) and least was observed in 100% DCP with the value of 4.90%. The highest methane gas at $P<0.05$ was observed in 100% DCP with 26.33ml and the lowest ($P<0.05$) was from 100% MDCP with 12.88ml. The diet having 40% Grass + 50% DCP + 10% PKC had the highest nutritional qualities. It was therefore concluded that mushroom degraded cassava peel can be used as protein supplement in ruminant feed..

Keywords: **crude protein, methane, mushroom, cassava peel**

Description of Problem

In most Sub-Saharan Africa (SSA), forage production is abundant and there may be more adequate quality during the rainy season but quality declines rapidly and becomes reduced during the dry season. The fibrous nature of forages limits their nutrient content, including protein, energy, minerals, and vitamins, essential for optimal rumen microbial fermentation and overall animal performance (15). Ruminants have the potential to turn feed that is low in quality into high protein content and make use of feeds from land not desirable for crops cultivation, however, the immediate use of these low quality crop residues is hindered by its low protein quality, minerals, vitamin, fibre and digestibility (12). The problem of dry season feed and feeding has been recognised as a limiting factor to a successful ruminant production enterprise in Nigeria due to poor nourishment of the animals during the dry season which eventually results to a drop in animal performance in terms of growth, work, maintenance, production and reproduction (9). Mushroom production has increased rapidly over the past few decades (10) and millions of tons of spent mushroom substrate (SMS) have become available for other uses (21). Spent mushroom substrate has been used as a feed resource for sheep, and beef cattle due to its contents of crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) as stated by (4). In addition, as SMS can be obtained cheaply from mushroom- processing plants, its utilization as a ruminant feed could be cost-effective. According to (4) who reported that one of the values of commercial cultivation of mushrooms, especially in a developing economy like Nigeria, is the availability of large quantities of several agro–industrial wastes which can serve as substrates for the cultivation of mushrooms. Cassava peels could serve as the substrates that enable the growth of these fungi and hence could also be improved into better quality for ruminant feed thereby increasing the digestibility with other agricultural wastes (1). The feed shortage in the dry season is further compounded by the low feed quality, which is insufficient to support reproduction performance and productivity (23). As a direct consequence, high losses in herd productivity have been reported (14). The aim of this study was therefore to evaluate the chemical composition, and *in vitro* digestibility of dried cassava peel, mushroom degraded cassava peel and silage from guinea grass.

Materials and methods

Experimental sites and sourcing of cassava peel

The study was conducted at the Department of Pasture and Range Management, College of Animal Science and Livestock Production (COLANIM), Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. Fresh *Panicum maximum* was cutback and later harvested at 8 weeks after cutback from established pasture, chopped to 3-4 cm length and allowed to wilt for 24hours. The wilted grasses were packed, compressed to expel air, properly stored and sealed in 120/litres plastic drums for 4 months and the drums were kept under the shed. After 4months, sub-samples were collected, oven dried at 40^0C and milled with hammer mill to obtain uniform mixture for chemical analysis. Fresh cassava peel was sun-dried for 4 days to the moisture content of 3-5%. The peels were packed in jute bags and stack away for 4 months in a well aerated room until required for analysis.

Some of the stored dried cassava peel was also used as substrate to culture mushroom *Pleurotus pulmonarius* (oyster species). The substrates were sprinkled with water mixed with $CaCO_3$ until they attained 65-70% moisture content. The substrate was spread for 12hours to drain and to allow fermentation. The substrates were puffed in nylon and sterilized in an autoclave at 121°C for 3hours. The sterilized substrates were allowed to cool at room temperature for another 12 to 24hours. After cooling the sterilized substrate, 60 grains of the spawn were introduced onto the substrate in each nylon. After two weeks, the mushroom was harvested, and the substrate was dried. The dried substrates were then milled to uniform mixture and kept for chemical analysis.

Table 1: Composition of experimental diets

Diet 1:	40% Silage + 25% CP + 25% MDCP + 10% PKC
Diet 2:	40% Silage + 50% CP + 10% PKC
Diet 3:	40% Silage + 50% MDCP + 10% PKC
Diet 4:	40% Grass + 25% CP + 25% MDCP + 10% PKC
Diet 5:	40% Grass + 50% CP + 10% PKC
Diet 6:	40% Grass + 50% MDCP + 10% PKC

Where CP = dried Cassava peel, SMS = MDCP = mushroom degraded cassava peel, PKC =Palm Kernel Cake.

Chemical analyses and *in vitro* gas production techniques

Analysis was carried out for proximate composition (3), fibre composition (19), *in vitro* gas production, organic matter digestibility (OMD) and metabolizable energy (12), Short Chain Fatty Acid (SCFA) (8) and Methane (18). Total gas volume (GV) was expressed as ml/200mg DM, CP and ash as g/kg DM, ME as MJ/kg DM and SCFA as µmol/g DM.

Statistical analysis

The data collected were subjected to one-way analysis of variance (ANOVA) and the treatment means separated with Duncan's Multiple Range Test using (17) package.

Results and Discussion

The proximate and fibre composition of whole silage, grass, mushroom degraded cassava peel (MDCP) and cassava peel is shown in Table 2. Crude protein was higher (10.10%) in 100% Grass while the lowest value (4.90%) was recorded in 100% dried cassava peel (DCP). However, the crude protein in MDCP (7.02%) was higher than 4.90% for DCP. The NDF of silage was 70.00% compared to 53.33% in 100% DCP. Also, the highest value of NDF was observed in whole grass (71.33%) while the lowest value of 52.67% observed in 100% MDCP. The ADF ranged from 24.67% in 100% DCP to 46.67% in silage.

There were significant differences ($P<0.05$) in the values of CP, EE, ash, ADF, ADL and cellulose while DM, NDF and Hemicellulose were not significantly different as presented in Table 3 for proximate and fibre composition of whole silage, un-ensiled grass, MDCP and DCP in varying composition. CP ranged from 9.05% in 40% Grass + 50% MDCP + 10% PKC to 7.87% in 40% Silage + 50% CP + 10% PKC. The highest value of EE was observed in 40% Grass + 50% MDCP + 10% PKC (12.33 %) while the lowest value is recorded in 40% Grass + 50% CP + 10% PKC (4.67%). The highest ASH values were observed in both 40% Silage + 50% MDCP + 10% PKC & 40% Grass + 50% MDCP + 10% PKC (11.67%) while the lowest is observed in both 40% Silage + 25% CP + 25% MDCP + 10% PKC & 40% Silage + 50% CP + 10% PKC (9.00%). Also, ADF values ranged from highest value of 45.33% in 40% Silage + 50% MDCP + 10% PKC to lowest value of 30.00 % in 40% Grass + 50% CP + 10% PKC. Highest value of ADL was observed in Diet 3 (14.67%) to lowest value of 10.00% in 40% Grass + 50% MDCP + 10% PKC.

Table 4 shows the effect of cassava peel and mushroom degraded cassava peel on gas production of silage. The gas production of silage, cassava peel and mushroom degraded cassava peel were significantly ($p<0.05$) different except for the gas production at 6, 24, 36, 48, and 60 hours. The gas production at 3hrs for 40% Silage + 25% CP + 25% MDCP + 10% PKC & 40% Grass + 50% MDCP + 10% PKC had the highest value (3.25ml/200mgDM) with the least value (0.25ml/200mgDM) from 40% Silage + 50% MDCP + 10% PKC. At 9hrs, the highest gas volume produced was 14.00ml/200mgDM and the least value was 4.25ml/200mgDM, which were produced from 40% Grass + 50% CP + 10% PKC and 40% Silage + 50% MDCP + 10% PKC respectively. At 72 hours, the gas production was 59.00ml/200mgDM for 40% Grass + 50% CP + 10% PKC and the least ($p<0.05$) value of 17.50ml/200mgDM for 40% Silage + 50% CP + 10% PKC.

There were significant ($P<0.05$) differences on the post incubation parameters of silage, cassava peel and mushroom degraded cassava peel except the fractional rate of gas production (c), the lag time, and the Metabolizable energy which were not significantly ($p>0.05$) different as presented in Table 5. The highest value of 0.82μmol for short chain fatty acid (SCFA) composition was recorded in 40% Grass + 50% CP + 10% PKC while the least value was 0.22μmol produced from 40% Silage + 50% MDCP + 10% PKC. For Organic matter digestibility (OMD), however, it is observed that the highest value of 51.90% was obtained from Diet 4, while the least value was 35.79% produced in 40% Silage + 50% MDCP + 10% PKC. The highest methane gas (CH_4) (25.00ml) was produced in 40% Silage + 25% CP + 25% MDCP + 10% PKC with the least value of 11.25ml in 40% Silage + 50% MDCP + 10% PKC. The volume of gas production in time had the highest value of 43.00 (ml/200mgDM) in 40% Grass + 50% MDCP + 10% PKC, while the least value of 4.86(ml/200mgDM) was produced from 40% Silage + 50% CP + 10% PKC.

Table 2: Proximate and fibre composition (%) of whole silage, unensiled grass, mushroom degraded cassava peel (MDCP) and dried cassava peel

DIETS	DM%	CP%	EE%	ASH%	NDF%	ADF%	ADL%	HEM%	CELL%
100%S	83.67[a]	9.80[a]	3.67	9.33[a]	70.00[a]	46.67[a]	8.00[bc]	23.33[a]	38.67[a]
100%G	79.00[ab]	10.10[a]	1.67	11.67[a]	71.33[a]	39.33[b]	6.00[c]	32.00[a]	33.33[ab]
100%MDCP	77.00[b]	7.02[b]	2.33	11.33[a]	52.67[b]	44.60[ab]	14.00[a]	8.67[b]	30.00[b]
100%DCP	82.67[a]	4.90[b]	1.67	6.00[c]	53.33[b]	24.67[c]	10.00[b]	28.67[a]	14.67[c]
SEM	1.05	1.63	0.41	0.71	3.21	2.67	1.02	3.26	2.81

[a, b, c]:Means in same column with different superscripts are significantly ($p<0.05$) different.

Where S= Silage, G= Un-ensiled grass, DCP = dried cassava peel, MDCP = mushroom degraded cassava peel

Table 3: Proximate and fibre composition of whole silage, un-ensiled grass, mushroom degraded cassava peel and dried cassava peel in varying composition (%)

DIETS	DM	CP	EE	ASH	NDF	ADF	ADL	HEM	CELL
40% Silage + 25% CP + 25% MDCP + 10% PKC	83.33	8.40[a]	2.00[c]	9.00[b]	64.67	36.00[b]	7.33[b]	28.67[ab]	28.67[a]
40% Silage + 50% CP + 10% PKC	86.33	7.87[a]	9.33[a]	9.00[b]	58.67	32.00[c]	13.33[a]	26.67[ab]	18.67[b]
40% Silage + 50% MDCP + 10% PKC	84.67	8.93[b]	5.33[b]	11.67[a]	60.67	45.33[a]	14.67[a]	15.33[b]	30.67[a]
40% Grass + 25% CP + 25% MDCP + 10% PKC	80.00	8.52	9.69[a]	9.67[b]	66.00	39.33[b]	12.67[ab]	26.67	26.67[a]
40% Grass + 50% CP + 10% PKC	84.33	7.99	4.67[b]	10.67[b]	57.33	30.00[b]	12.67[ab]	27.33	17.33[b]
40% Grass + 50% MDCP + 10% PKC	84.00	9.05	12.33[a]	11.67[b]	67.33	40.00[a]	10.00[a]	27.33	30.00[a]
SEM	1.31	0.91	1.00	1.02	2.87	1.41	0.64	2.71	1.71

[a, b, c]: Means in same column with different superscripts are significantly ($p<0.05$) different.

Where S= Silage, G= un-ensiled grass, DCP = dried cassava peel, MDCP = mushroom degraded cassava peel

Table 4: Effect of cassava peel and mushroom degraded cassava peel on gas production of silage

	Time (hrs)								
DIETS	**3**	**6**	**9**	**12**	**24**	**36**	**48**	**60**	**72**
40% Silage + 25% CP + 25% MDCP + 10% PKC	3.25[a]	6.50	9.50[ab]	12.00[ab]	19.75	26.50	30.50	32.50	33.50[ab]
40% Silage + 50% CP + 10% PKC	2.50[a]	6.25	8.75[ab]	11.75[ab]	18.00	22.00	23.75	24.50	17.50[b]
40% Silage + 50% MDCP + 10% PKC	0.25[b]	3.00	4.25[b]	5.75[b]	11.75	17.00	20.00	22.00	22.50[b]
40% Grass + 25% CP + 25% MDCP + 10% PKC	2.50	5.25	9.75[ab]	13.00[b]	25.75[b]	34.50[ab]	40.50[ab]	43.75[ab]	45.50[ab]
40% Grass + 50% CP + 10% PKC	4.00	7.50	14.00[a]	19.25[a]	36.75[a]	47.00[a]	53.00[a]	57.50[a]	59.00[a]
40% Grass + 50% MDCP + 10% PKC	3.25	5.75	8.50[b]	10.75[b]	19.25[b]	26.50[b]	31.00[bc]	34.75[bc]	36.00[bc]
SEM	0.38	0.56	0.93	1.26	2.55	3.24	3.64	3.96	4.07

[a, b, c]:Means in same column with different superscripts are significantly ($p<0.05$) different.

Where S= Silage, G= un-ensiled grass, DCP = dried cassava peel, MDCP = mushroom degraded cassava peel

Table 5: Effect of silage, cassava peel and mushroom degraded cassava peel on post incubation parameters

DIETS	B	C	Lag	SCFA	ME	OMD	CH_4	DMD
40% Silage + 25% CP + 25% MDCP + 10% PKC	14.36[bc]	0.39	1.20	0.41[a]	4.96	44.57[ab]	25.00[a]	24.67[a]
40% Silage + 50% CP + 10% PKC	4.86[bc]	0.49	1.58	0.37[a]	4.75	43.51[ab]	11.67[c]	18.25[b]
40% Silage + 50% MDCP + 10% PKC	33.81[a]	0.02	2.63	0.22[a]	3.84	35.79[b]	11.25[c]	17.67[b]
40% Grass + 25% CP + 25% MDCP + 10% PKC	23.31[b]	0.51[ab]	1.52	0.56[b]	5.82[b]	51.90[ab]	19.67	14.63[b]
40% Grass + 50% CP + 10% PKC	15.55[b]	0.82[a]	1.09	0.82[a]	7.26[a]	59.93[a]	20.13	19.67[a]
40% Grass + 50% MDCP + 10% PKC	43.00[a]	0.03[c]	2.05	0.40[b]	4.93[b]	45.62[b]	15.67	15.25[b]
SEM	3.74	0.09	0.17	0.06	0.34	2.01	0.78	0.74

[a, b, c]: Means in same column with different superscripts are significantly ($p<0.05$) different.

Where S= Silage, G= Un-ensiled grass, DCP = dried cassava peel, MDCP = mushroom degraded cassava peel

Analysis of mushroom degraded cassava peel revealed that there was an increase in the dietary CP compared to that of dried cassava peel. The little increase in the protein level of SMS is in agreement with the report by (11) that *Pleurotus pulmonarius* has the potential to convert cheap ligno-cellulosic into valuable protein at a low cost, this result is supported by (9) who reported the enrichment of cassava peels and pulp with protein when fermented with different fungi types. Low crude protein level of 4.90% in 100%DCP sample was increased to 7.87% in diet with 50% MDCP inclusion in silage-based diet and 9.50% at 50% inclusion of MDCP too in the diet composition with grass. Proteins are also necessary in animals' diets, since they are classified as nutritionally essential amino acid and must be included in diets for non-ruminants to maintain physiological functions of the whole body (5, 20). Through the process of digestion, animals break down ingested protein into free amino acids that are then used in metabolism (5). Thus, the enrichment of the *Pleurotus* inoculated peels with protein and inclusion of this with other feed ingredients through the process of digestion would help animals to break down ingested protein into free amino acids that are then used in metabolism (20).

The fibre content of the MDCP was higher than the fibre content reported for DCP. However, lower fibre level was observed in diet containing 50% DCP. The protein content of cassava peels, and leaves has been reported to be approximately at 3.6%, 5.5% and 21% respectively (9). It was also observed that inclusion of MDCP with other diets reduced the fibre content which helps in degradation since the cellulose, hemicellulose and lignin content of cassava peels which might not be available to livestock depending on the strength of the fibre content in the different fermenting substrates (6).

There was increase in the ash content of MDCP than DCP only, this could be attributed to the enrichment of minerals by the mycelia of the mushroom grown on the peel. The volume of gas of silage produced increases as it approaches the end of the incubation time because, in the gas production test method, the microbial population is still constant at all hours of incubation, and there is no entry or exit route for microorganisms. Similar results were reported by (13), where mushroom spawning of red grape pomace linearly increased the rate of in vitro gas production. High gas production and methane of whole samples obtained in this study are in agreement with finding of (16) that in most cases, feedstuffs that show high capacity for gas production are also observed to be synonymous for high methane production. Therefore, owing to higher methane production in MDCP substrate, part of the energy is wasted, hence other processing methods could be adopted to reduce the availability of hydrogen and production of methane. The effect of microbial enzymes on feedstuff depends on the nature of the feed and its availability to microorganisms. Mushroom cultivation increases the sample surface, improving the microorganisms' access; therefore, rumen fermentation increases and gas and methane production increases. The high gas produced may be as a result of the nature and level of fibre, presence of secondary metabolites in the composition of the diet (7) and potential of the rumen liquor for incubation.

The study shows that grass combined with Cassava peel have the highest Organic matter digestibility value and highest gas production. Organic matter digestibility has been shown to have high correlation with gas volume (14) as it implies that the microbes in the rumen and animal have high nutrient uptake. The fractional rate of gas production also indicates a better nutrient availability for rumen micro-organisms.

Conclusion and Application

1. The crude protein content of cassava peel increased after it has been used as substrate to cultivate mushroom which shows that the mushroom degraded cassava peel can be used as protein supplement in ruminant feed.
2. The inclusion of bio-processed agro waste in minimal proportion can be used to reduce the cost of livestock feeds and can be improved through bio-processing of agricultural wastes into animal feeds.

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