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Research Article

Effect of Diets Containing Treated and Untreated Sweet Orange (*Citrus sinensis*) Peels on the Performance and Nutrient Digestibility of West African Dwarf (WAD) Goats Fed Gamba Grass

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Abstract

Background and Objective: Feed shortage has been a major constraint to goat production in Nigeria particularly during the long dry season, thus supplementation to maintain animal weight during this period is required. Sweet orange peels are available all through the year and are reported to have calorie and protein values comparable with those of maize. Unprocessed sweet orange peels has been used in the diets of goats up to 50% level with no adverse effects. This study was, therefore, designed to evaluate the effects of diets containing treated and untreated sweet orange (*Citrus sinensis*) peels on the performance and nutrient digestibility of West African dwarf goats fed gamba grass. **Materials and Methods:** Nine male West African dwarf (WAD) goats aged 7-9 months with an average weight of 9.60 kg were used to evaluate the effect of diets containing treated and untreated sweet orange (*Citrus sinensis*) peels on the performance and nutrient digestibility of WAD goats fed gamba grass. Three diets, T_1, T_2 and T_3 were formulated to contain 0% sweet orange peel meal (SOPM), 60% unfermented sweet orange peel meal (UFSOPM) and 60% fermented sweet orange peel meal (FSOPM), respectively and used as concentrate diets. The goats were randomly assigned to the diets in a completely randomized design (n = 3). Each goat was fed 200 g/day of the respective diet as supplement to gamba grass for a period of 77 days. **Results:** Results showed that there were no significant differences ($p>0.05$) among the treatments in all the performance parameters measured. The mean daily feed intake were 312.40, 297.70 and 312.50 g while the mean daily weight gain were 23.00, 16.96 and 14.59 g for T_1, T_2 and T_3, respectively. The dry matter (DM), nutrient digestibility and nutrient intake values were also not significantly different ($p>0.05$) among the treatments. Dry matter and all the proximate constituents showed similar trend of slight decrease in digestibility from T_1-T_3. The nutrient intake also followed a similar trend as the DM and nutrient digestibility. **Conclusion:** Treated or untreated sweet orange peels can be used to replace 60% of maize offal in concentrate supplement diets of West African dwarf goats.

Key words: Treated sweet orange peels, untreated sweet orange peels, WAD goats, gamba grass, nutrient digestibility, nutrient intake

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Small ruminants appear to play a vital role in bridging the gap between requirements and supply of animal protein for human consumption. Goat meat in particular is healthy and nutritious and is exceptionally low in fat and calories compared with other meats[1]. In Nigeria, goats are generally kept in small herds on mixed farms, usually by women and children within rural households and provide their owners with a broad range of products and socio-economic service such as cash income, security, gifts and manure for their crops[2]. In spite of all these numerous advantages, feed shortage remains a major constraint to goat production in Nigeria. Moreover, in areas where fodder resources abound, seasonal fluctuations in nutritive value make sustainable gains unrealistic[3]. During the dry season, the available forages are very low in protein, energy and minerals, hence decrease in voluntary feed intake and digestibility[4]. The crude protein contents of principal forages such as gamba (*Andropogon gayanus*) and Guinea grasses (*Panicum maximum*) fall to as low as 2% for the most part of the dry season, alongside with reduced mineral and energy contents[5]. This leads to reduced feed intake and digestibility of dry matter as well as decreased animal productivity.

Crop residues and agro-industrial by-products that are used in supplementing principal forages during the long dry season are usually fibrous, low in digestibility and devoid of most essential nutrients which are required for increased rumen microbial fermentation and improved performance of the host animal[6]. Supplementation with concentrate supplements using cheap, viable and locally available feedstuffs is, therefore, necessary. Previous attempts on providing sustainable feed for ruminant production in Nigeria were focused on the use of crop residues and some agro-industrial by-products because of their relative abundance during the dry season[7]. In Nigeria, a number of agricultural by-products exist, this include: Corn cobs, groundnut shells, groundnut testa, yam peels, cassava peels, potato peels, citrus peels, citrus pulp, mango seed kernel etc.

Sweet orange peels are reported to have calorie and protein values comparable with those of maize[8]. It is reported to contain some quantities of tannin, saponin, oxalate, phytate, limonene and flavonoid[7]. However, processing methods such as sun-drying and fermentation of the sweet orange peels reduces even the small quantities of these anti-nutrients that are present in the orange peels to minimal levels[9]. Sweet orange peels are usually available all through the year[8] and it has been used in the diets of goats without processing up to 50% level without adverse effects. This study was, therefore, designed to evaluate the effects of diets containing treated and untreated sweet orange (*Citrus sinensis*) peels on the performance and nutrient digestibility of West African dwarf goats fed gamba grass.

MATERIALS AND METHODS

The experiment was conducted at the Sheep and Goat Unit of the Teaching and Research Farm, University of Agriculture, Makurdi. Sweet orange peels were collected from sweet orange retailers who peel and sell oranges for direct consumption. The collected peels were divided into two, one part was immediately sun-dried while the other was fermented by soaking in water for 24 h, drained and sun-dried on concrete floors. The treated and untreated dried peels were then separately crushed into meals using a cereal grinding engine and stored in synthetic bags for use. Three diets were formulated and compounded, diet 1, 2 and 3 to contain 0% SOPM, 60% UFSOPM and 60% FSOPM, respectively. The research procedure and protocol was approved by Animal Research Ethics Committee of University of Agriculture, Makurdi (UAM/AREC 2017/010).

A total of nine male grower WAD goats weighing between 9.25-9.63 kg were purchased from medium scale farmers within Makurdi metropolis. The animals were vaccinated at source against Peste des petits ruminants (PPR) using the PPR vaccine and de-wormed using albendazole. A week to the arrival of the goats, the pens were thoroughly washed and disinfected using izal solution and allowed to dry. The feeding and drinking troughs were also properly washed and sun-dried. Wood shaving was spread on the concrete floor to act as litter material and bedding. On arrival to the farm the animals were weighed and randomly distributed into three treatment groups (n = 3) and each animal was a replicate in a Completely Randomized Design (CRD). The animals were individually housed in separate compartments. Subsequently, each animal was fed with 200 g of the concentrate supplement at about 08:00 h daily, while the grass was given at 10:00 and 14:00 h, respectively. Daily, the grass was weighed and tied with a rope to the roof of each compartment such that the grass dangled down within the reach of each goat. This was to enhance intake of the grass and to minimize wastage of the grass through trampling.

Fresh portable water was made available for each animal daily. The animals were allowed a period of about 2 weeks to get used to feed and environment before data collection commenced. The goats were weighed weekly during the course of the experiment to estimate the changes in weight in the animals. In addition, feed intake was calculated as the

difference between the amounts of feed that was fed and left over for each day. Seven days to the end of experiment, the animals were transferred into metabolism cages with nylon nets well fitted beneath each cage for easy collection of the faecal samples. Faecal samples were collected daily, weighed and dried to constant weight. After the seven days, the dried samples were bulked by replicates, thoroughly mixed and proximate constituents of the sub-samples assayed. Similarly, the grass and feed samples were also tested for proximate constituents using standard method[10]. Data collected from the study was subjected to the one-way analysis of variance at $\alpha = 0.05$ using the Minitab statistical software[11].

RESULTS AND DISCUSSION

The result for the proximate composition of the experimental diets is presented in Table 1. The dry matter values of the diets ranged from 88.05-88.14% with no significant difference ($p>0.05$) among the diets. Hence, it could be said that treatment does not have negative impact on the shelf life of the diets. The crude protein (CP) values were between 13.16-14.21% and values increased from T_1 (13.60%) to T_3 (14.21%). Control treatment 1 (0% SOPM) was the lowest, followed by T_2 (60% UFSOPM), while T_3 with 60% FSOPM was the highest. Fermentation appears to improve crude protein level. Orayaga[9] observed that water soaking increased CP content of SOPM, which agrees with results obtained from this study. The observed CP values of the diets were higher than 11.00-13.00%, a CP value required to provide adequate protein needed for maintenance and moderate growth of goats[12]. Ether extract values were between 3.38-3.46% and adequate, because excess fat in animal diets enhances growth of mold and rancidity with adverse effect on the health of the animals. Nitrogen free extract values were 67.82, 66.52 and 64.78% for T_1, T_2 and T_3, respectively. Observed values indicate that the experimental diets contained appreciable amount of fermentable carbohydrate for adequate energy supply.

The result for the performance of WAD goats fed the experimental diets is presented in Table 2. The mean weight gains were 23.00, 16.96 and 14.59 g/day for

Table 1: Gross and proximate composition of the experimental diets

	Experimental diets			
Feed ingredients (%)	T_1 (0% SOPM)	T_2 (60% UFSOPM)	T_3 (60% FSOPM)	Gamba grass
Rice offal	20.00	20.00	20.00	–
Maize offal	57.26	22.90	22.90	–
SOPM	0.00	34.36	34.36	–
Soybean meal (full fat)	19.74	19.74	19.74	–
Bone meal	2.00	2.00	2.00	–
Salt	1.00	1.00	1.00	–
Total (kg)	100	100	100	–
Determined values (%)				
Dry matter	88.11	88.14	88.05	22.34
Crude protein	13.62	13.93	14.21	9.92
Nitrogen free extracts	67.82	66.52	64.78	44.97
Ether extract	3.38	3.42	3.46	3.46
Crude fibre	9.96	10.67	11.78	31.61
Ash	5.22	5.46	5.77	9.97

T_1: 0% SOPM (sweet orange peel meal), T_2: 60% UFSOPM (unfermented sweet orange peel meal), T_3: 60% FSOPM (fermented sweet orange peel meal)

Table 2: Performance of West African dwarf goats fed the experimental diets

	Experimental diets			
Parameters	T_1 (0% SOPM)	T_2 (60% UFSOPM)	T_3 (60% FSOPM)	SEM
Initial weight (kg)	9.83	9.25	9.72	1.35^{ns}
Final weight (kg)	11.17	10.20	10.53	1.38^{ns}
Total weight gain	1.33	0.95	0.82	0.52^{ns}
Mean daily weight gain (g/day)	23.00	16.96	14.59	9.26^{ns}
Total forage feed intake (kg)	10.79	10.25	10.68	1.02^{ns}
Total concentrate feed intake (kg)	6.71	6.42	6.82	0.77^{ns}
Total feed intake (kg)	17.49	16.67	17.50	1.51^{ns}
Mean daily feed intake	312.40	297.70	312.50	26.91^{ns}
Feed conversion ratio	13.57	17.55	21.42	25.99^{ns}

T_1: 0% SOPM (Sweet orange peel meal), T_2: 60% UFSOPM (unfermented sweet orange peel meal), T_3: 60% FSOPM (fermented sweet orange peel meal), SEM: Standard error of the mean

Table 3: Apparent nutrient digestibility of goats fed the experimental diets

	Experimental diets			
Parameters (%)	T_1 (0% SOPM)	T2 (60% UFSOPM)	T3 (60% FSOPM)	SEM
Dry matter	75.10	74.75	72.27	0.95^{ns}
Crude protein	78.23	75.53	73.61	1.75^{ns}
Ether extract	89.45	89.51	88.45	0.85^{ns}
Crude fibre	76.85	77.70	74.19	1.03^{ns}
Ash	79.46	79.80	79.45	0.83^{ns}
Nitrogen free extracts	72.60	71.63	69.03	1.14^{ns}
Organic matter	91.79	91.40	91.50	0.15^{ns}

T_1: 0% SOPM (sweet orange peel meal), T_2: 60% UFSOPM (unfermented sweet orange peel meal), T_3: 60% FSOPM (fermented sweet orange peel meal), SEM: Standard error of the mean

Table 4: Dry matter and nutrient intake of experimental goats (g/day)

	Experimental diets			
Parameters	T_1 (0% SOPM)	T_2 (60% UFSOPM)	T_3 (60% FSOPM)	SEM
Dry matter	273.35	240.64	228.20	18.36^{ns}
Crude protein	36.35	28.29	27.87	2.75^{ns}
Ether extract	11.17	9.22	9.66	0.73^{ns}
Crude fibre	60.68	56.77	51.71	5.01^{ns}
Ash	22.53	20.66	19.41	1.65^{ns}
Nitrogen free extracts	146.90	118.96	125.20	9.33^{ns}
Organic matter	251.50	219.70	208.80	16.57^{ns}

T_1: 0% SOPM (sweet orange peel meal), T_2: 60% FSOPM (unfermented sweet orange peel meal), T_3: 60% FSOPM (fermented sweet orange peel meal), SEM: Standard error of the mean

treatments T_1, T_2 and T_3, respectively and there was no significant difference ($p>0.05$) among the treatments. Therefore, treatments containing UFSOPM and FSOPM supported weight gain. Observed values were similar with 12.20-24.70 g/day for WAD goats[13,14]. The mean daily feed intake was 312.40, 297.70 and 312.50 g/day for T_1, T_2 and T_3 and these were similar ($p>0.05$) among treatments. This imply that treatments containing UFSOPM and FSOPM were acceptable to the goats and that any of the treatments could be used as a concentrate supplement for goats. Observed values were similar with 291.55-313.42 g/day for WAD goats fed cassava-peel leaf meal based diet[15].

The result of the apparent nutrient digestibility of the experimental diets containing sweet orange peel meal is presented in Table 3. Results from this study show that the nutrient digestibility values of dry matter, crude protein, crude fibre, ether extract and nitrogen free extract were not significantly different ($p>0.05$) among the treatments. Dry matter (DM) digestibility ranged from 72.27-75.10% and were higher than 55.50-72.50% for West African dwarf buck fed cassava leaf-maize offal based diets[16]. The crude protein (CP) digestibility was between 73.61-78.23% and showed similarity in trend with DM digestibility. There was no significant difference ($p>0.05$) among the treatments, therefore, incorporating fermented or unfermented SOPM in the diets of goats did not prevent appreciable amounts of CP from reaching the abomasum for digestibility. Furthermore, fermentation of the test ingredient was not of any advantage to the animals. Values of CP digestibility were within 71.80-86.74% for WAD goats fed *Panicum maximum* and supplemented with different protein sources[16]. Crude fibre digestibility values ranged from 74.19-77.70% and treatments containing UFSOPM and FSOPM were similar to the control. Observed values were comparable with 69.00-80.01% for WAD goats[17]. This implies that the diets UFSOPM and FSOPM do not negatively affect crude fibre digestibility. The nitrogen free extract (NFE) digestibility ranged from 69.03-72.60% and are considerably higher than the 42.87-43.77% WAD goats fed cassava peel-cassava leaf meal[15]. This implies that the experimental diets contained adequate fermentable carbohydrates and highly digestible crude fibre fractions.

The result for the nutrient intake of the experimental animals is presented in Table 4. The CP intake had no significant difference ($p>0.05$) among the treatments. Observed values range from 27.87-36.35 g/day and was higher than 17.72-28.36 g/day for rams fed urea-treated rice straw with supplements[17]. The higher CP values indicate that the experimental diets provided adequate protein needed for healthy growth, cell repairs and normal functioning of the goats. The values of NFE intake range from 118.96-146.90 g/day and there was no significant difference ($p>0.05$) among the treatments. This implying that all the treatments had appreciable uptake of energy from the diets fed.

The result of the feed trial which was limited to a period of 77 days discovers the possibility of replacement of maize offal with up to 60% of UFSOPM and FSOPM without deleterious effects on WAD goats fed gamba grass. This study will help the researcher to uncover the effect of diets containing treated and untreated sweet orange peels on performance, digestibility and intake of nutrients of WAD goats which many researchers have not explored. Since, in Nigeria, the agricultural by-product citrus peels, among others exist in abundance and cheap, it is recommended that up to 60% UFSOPM and FSOPM could be used as replacement for maize offal to reduce the cost of ruminant production to optimize the profit.

CONCLUSION

The result of this study showed that replacement of maize offal with unfermented or fermented sweet orange peel meal up to 60% did not have adverse effect on the performance, digestibility and intake of nutrients, therefore, any of the experimental diets could be used as concentrate supplements for goats to enhance production and minimize cost.

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