FEED INTAKE, GROWTH PERFORMANCE AND NUTRIENT DIGESTIBILITY IN GROWING RED SOKOTO BUCKS FED DIETS CONTAINING GRADED LEVELS OF DRIED SWEET ORANGE PEEL MEAL

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ABSTRACT

The study was carried out to evaluate the growth performance, nutrient digestibility and nitrogen intake of growing red sokoto bucks fed graded levels of dried sweet orange (Citrus sinensis) peel meal (DSOPM). Twelve animals aged between 5 – 7 months with average body weight of 9.17 kg were assigned to four dietary treatments T_1 (control), T_2, T_3 and T_4 containing 0%, 2.5%, 5.0% and 7.5% DSOPM, respectively in a completely randomized block design (CRBD) with three goats per treatment. Each animal was fed at 2.5% body weight and provided drinking water ad libitum for a period of 90 days. The results obtained revealed that DSOPM had significant ($p<0.05$) effect on total feed intake (TFI), average daily feed intake (ADFI), final body weight (FBW), total body weight (TBW) and average daily weight gain (ADWG). Diet containing 0% inclusion level was significantly ($p<0.05$) best in total feed intake (37.13 ± 2.10kg), total body weight (4.16 ± 0.44kg), average daily weight gain (0.05 ± 0.008kg) and feed conversion ration (8.93 ± 0.11) compared to other treatment diets. Diet with the highest inclusion level of DSOPM (7.5%) recorded the lowest TBW (1.66 ± 0.50kg), average daily weight gain (0.02 ± 0.009kg), total feed intake (27.52 ± 1.02kg) and average daily feed intake (0.31 ± 0.03kg). Dry matter (DM) digestibility significantly ($p<0.05$) declined across T_1, T_2, T_3 and T_4 (54.24 ± 3.09%, 48.63 ± 4.11%, 44.03 ± 4.01% and 37.78 ± 3.34%), respectively. Crude Protein (CP) digestibility was highest in T_3 (64.67 ± 4.11%) and lowest in T_4 (48.33 ± 3.98%). Crude Fibre (CF) digestibility was highest in T_3 (73.12 ± 12.05%) and lowest in T_4 (20.77 ± 11.40%). Digestibility of ether extract (91.75 ± 15.15%) was highest in diet T_2 and significantly ($p<0.05$) different from the other treatment diets. Nitrogen intake was highest in T_1 (3.34 ± 0.13%) and lowest in T_4 (2.83 ± 0.07%). It was concluded that diet T_1 (containing 0% level of DSOPM) supported better growth performance than T_2 (2.5%), T_3 (5.0%) and T_4 (7.5%) signifying that inclusion of DSOPM in goat diet significantly ($p<0.05$) reduced feed intake and improved nutrient digestibility.

Keywords: *Citrus sinensis* peels, Growth performance, Nutrient digestibility, Red sokoto goats

INTRODUCTION

Ruminant animals constitute a very important part of the livestock sub-sector of the Nigerian agricultural economy. The potential of small ruminant production in alleviating the low animal protein intake by man in developing nations such as in Nigeria has been reported (Fajemisin *et al*., 2010). Recently, more attention have been paid to small ruminant production in the tropics as their advantages are becoming more understood than ever before, particularly for their ability to produce meat, milk and skin, even in hostile environments (Konlan *et al*., 2012; Makun *et al.,* 2013; Okoruwa *et al*., 2013).

Goats are the most prolific of all domesticated ruminants under tropical and sub-tropical conditions (Webb and Mamabolo, 2004) and they play a significant role in livelihoods of the rural populace in most developing countries like South Africa. Apart from serving as a vital protein source, goats also provide income for meeting household needs (Peacock *et al*., 2005). Notwithstanding, the high cost of formulating livestock feed has been a major constraint militating against the increased production of valuable sources of animal protein (Okoruwa *et al*., 2013) in Nigeria. The shortage in feed supply due to high cost and seasonality, have caused ruminant livestock farmers to search for alternative feed resources that are inexpensive and readily available which are not directly required as component of human dietaries and can economically supplement the feed ingredients in rations without adverse effects on the rumen microbial fermentation and performance of the animals (Oluremi *et al.,* 2007a; Aka *et al*., 2011; Okoruwa *et al*., 2013).

In Nigeria, the availability of crop residues and agro-industrial by-products has been highlighted (Onyeonagu and Njoku, 2010). One such by-product is the peels of citrus fruits. Sweet orange (*Citrus sinensis*) peel is an alternative feed resource that is gaining more recognition among small ruminant producers. According to FAO (2004), 140 countries produce citrus fruits and Nigeria production is about 2%. Citrus fruits have been reported to be available throughout the year especially during the peak season of October to December which happens to be the bumper harvest period (Omodamiro and Umekwe, 2013). A good number of by products are derived from sweet orange fruits; these include citrus pulp, citrus molasses, citrus peel oil and citrus peels (Ezejiofor *et al*., 2011). Studies have shown that *Citrus sinensis* peel is a major source of pectins that is non-digestible carbohydrates that stimulate the growth of probiotic bacteria in the colon which prevent the growth of pathogenic bacteria. As a dietary supplement, sweet orange peel can enhance the immune system and decrease the risk of contamination of animal meat with pathogenic bacteria (Zohreh *et al.,* 2012).

Sweet orange peels in Nigeria can be easily collected at no cost from sweet orange fruit retailers who peel and sell sweet orange fruits to consumers for direct consumption. Oluremi *et al*. (2007b) reported that sweet orange peels contained 9.30 – 10.96% crude protein, 13.66 – 14.94% crude fibre, 2.33 – 2.90% ether extract, 65.30 – 67.95% nitrogen free extract and 5.07 – 5.56% ash. The composition of citrus peel is similar to that of citrus pulp, except that citrus peel has a higher content of citrus essential oils (CEO). The CEO in citrus peel have antimicrobial and antioxidant properties so citrus peel could act as a preservative, which would be beneficial for long term storage of feed (Nam *et al*., 2009). Sweet orange peels contain tannin, saponin, oxalate, flavonoid and limonene, although the amounts present, is in such quantities that may not be deleterious to the health of animals. Processing such as sun-drying and fermentation of the sweet orange peels further reduce even the small quantities of these anti-nutrients that are present (Oluremi *et al*., 2007b).

The peels are available through out the year and are usually noticed on streets and along major roads in Nigeria, because government and orange retailers have no strategic disposal programme, thus, becoming an environmental problem (Oluremi *et al*., 2006). Rather than discarding the orange peels, suggested that they can be sun-dried and then milled in grinding machine to fine particle to obtain the orange peel meal which can be a potential feed ingredient for ruminants (Silva *et al*., 1997; Oluremi *et al*., 2007a; Oyewole *et al.,* 2013). Sweet orange fruit rind (peel) meal has been reported to have both calorie and protein comparable with maize (Oluremi *et al*., 2006). The peel contains citrus essential oil and the oil is composed of 91 – 94% d-limonene and 2.0-2.1% ϐ-myrcene as a minor constituent. Polymetholated flavones are also a class of compound found in citrus peel and produce no negative side effects in the animals fed polymetholated flavones containing diets (Silva *et al*., 1997). Ruminants feeding systems based on locally available by-product feedstuffs are often a practical alternative because the rumen microbial ecosystem can utilize by-product feedstuffs which often contain high levels of structural fibre to meet their nutrient requirements for maintenance, growth, reproduction and milk production (Bampidis and Robinson, 2006). Feeding citrus peels to small ruminants could be a practice that would diminish dependence on grains and contribute to reducing the environmental problems linked to their elimination (Abdel Gawad *et al*., 2013).

The general objectives of this study was to evaluate the nutritional potential of sun-dried 48 hours sweet orange (*Citrus sinensis*) peel meal in the diets of growing bucks. While the specific objectives were to evaluate the growth performance and nutrient digestibility of growing red sokoto bucks fed diets containing graded levels of dried sweet orange peel meal (DSOPM).

MATERIALS AND METHODS

Location of the Study: The study was conducted at the Teaching and Research Farm, of the Department of Animal Science, Ahmadu Bello University, Samaru, Zaria, Nigeria. The area is geographically situated between Latitude 11^0 12'N and Longitude 7^0 37'E at an altitude of 670 metres above sea level. Vegetationally, it is located in the Northern Guinea Savanna zone of Ngeria. Detailed description of Samaru climate had been documented (Malau-Aduli and Abubakar, 1992).

Experimental Design: The experimental design used was Completely Randomized Block Design (CRBD) comprising of four treatments (blocks) replicated thrice with each replicate having three animals.

Experimental Deits: Groundnut and cowpea haulms were sourced from the harvested haulms produced for practical purposes by students of the Faculty of Agriculture, Ahmadu Bello University, Zaria. Fresh sweet orange (*Citrus sinensis*) peels of mixed varieties were collected from orange fruit retailers from different locations around Zaria metropolis in Kaduna State of Nigeria. They were sun-dried on concrete floors for 48 hours, when it became crispy; it was milled to obtain sweet orange peel meal and stored in synthetic bags before incorporation in the diets (Oyewole *et al*., 2012; Oyewole *et al*., 2013; Oloche *et al*., 2015). Four diets were formulated containing maize offal, rice bran, cotton seed cake, groundnut haulms, cowpea haulms, bone meal and common salt (Table 1). Dried sweet orange peel meal (DSOPM) substituted maize offal at 0%, 2.5%, 5.0% and 7.5% inclusion levels in the experimental diets. Twelve bucks were randomly assigned to the four dietary treatments (0%, 2.5%, 5.0% and 7.5%) comprising of three animals per treatment.

Experimental Animals: The experimental animals were locally sourced from Anchau market in Ikara Local Government Area of Kaduna State. Thirty-six weaned red sokoto bucks aged between 5 – 7 months with average weight of 9.17kg were used. The animals were vaccinated against pestes des petits ruminants (PPR), using PPR vaccine and dewormed using albendazole suspension (Sambezole) administered orally at about 1ml/10kg body weight. Ecto-parasites were checked using Ivermectin (Ivomec) at 2ml/10kg body weight. Two weeks to the arrival of the animals to the experimental site, 12 pens were thoroughly washed and cleaned using disinfectant (Izal) and allowed to dry. On arrival, the animals were weighed and randomly distributed into four treatment groups of three animals per replicate, in a Completely Randomized Block Design (CRBD). The animals were housed in an open-sided, well-ventilated pens which was bedded with wood shavings to serve both as litter materials and beddings and equipped with feed and water troughs. Animals were given a weighed amount of the experimental diet containing varying levels of DSOPM (0%, 2.5%, 5.0% and 7.5%) between 0:700 and 09:00 hour daily. They were allowed 3 hours to feed on the concentrate afterwhich the groundnut and cowpea haulms were served *ad libitum*. Clean fresh drinking water was served to the animals daily *ad libitum*.

Table 1: Perceentage dietary ingredients and proximate compositions of varied levels of dried sweet orange peel meal in experimental diets fed to growing red Sokoto goats

Feed Ingredients	DSOPM	Experimental Diets			
		0% DSOPM	2.5% DSOPM	5.0% DSOPM	7.5% DSOPM
Maize Offal	-	42.50	40.00	37.50	35.00
Rice Bran	-	9.00	9.00	9.00	9.00
Cotton Seed Cake	-	14.00	14.00	14.00	14.00
Groundnut Haulms	-	15.00	15.00	15.00	15.00
Cowpea Haulms	-	15.00	15.00	15.00	15.00
DSOPM	-	0.00	2.50	5.00	7.50
Bone Meal	-	3.00	3.00	3.00	3.00
Common Salt	-	1.50	1.50	1.50	1.50
Total	-	100.00	100.00	100.00	100.00
Analyzed nutrients (%)					
Dry Matter	89.60	93.48	93.42	92.25	93.64
Crude Protein	7.00	16.38	15.00	13.19	14.13
Crude Fibre	13.50	16.13	15.13	17.03	16.00
Ether Extract	2.40	9.41	10.14	10.39	10.68
Nitrogen Free Extract	65.38	64.36	53.48	70.31	65.30
Ash	6.90	15.33	17.65	10.44	18.58

Key: *DSOPM = dried sweet orange peel meal*

The feeding trial lasted for 90 days after an acclimatization period of seven (7) days.

Performance Indices: The goats were weighed at the beginning of the experiment and subsequently on a weekly basis to evaluate average weight changes. Data on feed intake and body weight gain were determined. Feed intake was obtained by subtracting left-over feeds from the quantity offered each week to obtain weekly feed intake per replicate. The goats were weighed at the beginning, fortnightly and at the end of the study. Weight gain was computed by subtracting initial weight from final weight. Average daily weight gain (ADWG) was determined by dividing weight gain by the number of goats and the number of days of the feeding trial.

Digestibility and Nitrogen Balance: At the end of the growth study, all the animals were weighed and transferred to individual metabolic crates fitted with facilities for separate collection of voided faeces and urine. Experimental diets fed were the same as those used in the growth study. An adjustment period of 7 days was allowed before the faecal and urine samples were measured for subsequent 7 days. Faeces voided daily was collected separately from animals in each treatment and were pooled, thoroughly mixed and sub-samples taken. Feed intake was measured by finding the difference between the amount of feed offered and the amount leftover. Nitrogen loss from urine due to bacterial infestation and growth were prevented by introducing the urine into a well-labelled urine collection bottle containing 5ml 0.1M tetraoxosulphate (vi) acid (H_2SO_4) and stored in a refrigerator for laboratory subsequent analysis. Feed and faecal samples were oven dried at 65^0 C to constant weight, milled and stored in air tight containers, until required for nutrient analysis. Apparent digestibility of the diets was calculated as the difference between nutrient intake and nutient in faeces, expressed as a percentage of the nutrient intake using the formula: Apparent Nutrient Digestibility = Nutrient intake – Nutrients in faeces / Nutrient intake x 100 (Marshal, 2001; Aduku, 2004; Okoruwa *et al.* 2012; Bello and Tsado, 2013).

Chemical Analysis: Ten percent representative of each feed offered and refused was sampled every day and combined for the entire collection period on each replicate basis using air tight containers. Sub-sampling was performed on the aggregated feed materials for both offered and refused and kept in the refrigerator for analysis. Samples of feeds and faeces were weighed and oven dried at 105°C for 48 hours to constant weight. Both feed and faecal samples were ground using a hammer mill to pass through a sieve of 1 mm diameter and were analyzed for dry matter (DM), crude protein (CP) was calculated as N x 6.25, crude fibre (CF) and ether extract (EE). Nitrogen free extract (NFE) was determined by difference while ash content was determined by combusting samples at 550^{o} C overnight according to procedure described by AOAC (2001). The nitrogen content of the urine was determined by the Kjeldahl method according to AOAC (2001) procedure.

Statistical Analysis: All data generated were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedures of Statistical Analysis System version 9.0 (SAS, 2002). Significant differences at $p<0.05$ among means were separated using Duncan Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSIONS

The dietary composition of the experimental diets fed to the growing red sokoto bucks indicated diferences nutrients arising for substitution of maize meal with dried sweet orange peel meal (DSOPM) (Table 1). The effect of DSOPM on growth performance of the goats indicated that the initial body weights of animals were not significantly different ($p>0.05$), indicating that similar weight of animals were used at the commencement of the study. Final body weights of growing goats were significantly ($p<0.05$) influenced by the dietary treatments, with animals on 0% inclusion having higher mean body weight (13.33 ± 0.25kg), while the lowest mean body weight (10.83 ± 0.10kg) was recorded for goats receiving 7.5% DSOPM inclusion (Table 2). The observed highest mean final body weight and mean total body weight gain values for goats fed diet having 0% DSOPM inclusion could be as a result of the ability of the goats to properly utilize nutrients in the diets without DSOPM than in diets with DSOPM. The result of this study on weight gain is in agreement with the report of Nkoku and Evbuomwan (2014) that efficient utilization of nutrients in diets that supply adequate energy and protein is required for optimum growth performance of ruminants. Mean body weights (MBW) of the animals were 4.16 ± 0.44, 2.83 ± 0.63, 2.66 ± 0.36 and 1.66 ± 0.50kg for 0%, 2.5%, 5.0% and 7.5% inclusions of DSOPM, respectively. Animals on 0% DSOPM had significantly ($p<0.05$) higher body weights followed by 2.5%, 5.0% and 7.5% DSOPM inclusions. This result is in agreement with the result of Oyewole *et al.* (2012) who reported that substituting maize with sweet orange fruit peel meal significantly ($p<0.05$) reduced live weight of growing pullets. However, the MTBW values obtained in this study, were comparable to the range of values (2.73 – 3.51kg) and (2.07 – 5.32kg) reported by Okoruwa *et al.* (2013) for West African Dwarf (WAD) sheep and Okoruwa *et al.* (2015) for WAD male sheep respectively. Feed intake followed a similar pattern of variation as observed in MTBW, with their values ranging from 27.52kg (at 7.5% inclusion) to 37.13kg (at 0% inclusion). However, the highest total feed intake value obtained at 0% inclusion level might be as a result of palatability of the diet, nature of diet preparation and the nutrient content of the diet which make the goats to consume more to meet up with their energy and protein requirement (Okoruwa *et al.,* 2015). The highest average daily weight gain (0.05kg) and average daily feed intake (0.41kg) values recorded for animals at 0% inclusion level were consistent with the reports of Ososanya *et al*. (2013) and Okoruwa *et al*. (2015). Furthermore, Ososanya (2010) and Okoruwa and Adewumi, (2010) reported that feed intake is an important factor in the utilization of feed by livestock and is also a critical determinant of energy and protein as well as performance in small ruminant. There was no significant ($p>0.05$) difference in the average daily weight gain (ADWG) between animals on 2.5% (0.03 ± 0.005kg) and 5.0% (0.03 ± 0.003kg) but 0% (0.05 ± 0.008kg) was significantly ($p<0.05$) higher than goats on 2.5% and 5.0% inclusion levels. Feed conversion ratio (FCR) that is measured by feed intake per unit weight gain was significantly ($p<0.05$) higher in goats at

Table 2: Performance response of growing red Sokoto goats fed varied levels of dried sweet orange peel meal in the diets

Parameters	Experimental Diets			
	0% DSOPM	2.5% DSOPM	5.0% DSOPM	7.5% DSOPM
Initial body weight (kg)	9.17±0.71	9.17±0.18	9.17±0.10	9.17±0.09
Final body weight (kg)	13.33±0.25^{a}	12.00±0.21^{ab}	11.83±0.08^{ab}	10.83±0.10^{b}
Total body weight (kg)	4.16±0.44^{a}	2.83±0.63^{b}	2.66±0.36^{b}	1.66±0.50^{c}
ADWG (kg/day)	0.05±0.008^{a}	0.03±0.005^{ab}	0.03±0.003^{ab}	0.02±0.009^{b}
Total feed intake (kg)	37.13±2.01^{a}	32.65±3.20^{a}	30.65±2.03^{bc}	27.52±1.02^{c}
ADFI (kg)	0.41±0.01	0.36±0.01	0.34±0.05	0.31±0.03
Feed conversion ratio	8.93±0.11^{c}	11.54±1.91^{b}	11.52±0.81^{b}	16.57±0.10^{a}

Key: *^{abc}Means in the same row having different superscripts are significantly different (p<0.05), ADWG = Average daily weight gain; ADFI = Average daily feed intake; DSOPM = Dried sweet orange peel meal*

Table 3: Apparent nutrient digestibility (%DM) of growing red Sokoto goats fed varied levels of dried sweet orange peel meal in the diets

Parameters (%)	Experimental Diets			
	0% DSOPM	2.5% DSOPM	5.0% DSOPM	7.5% DSOPM
Dry Matter	54.24±3.09^{a}	48.63±4.11^{a}	44.034.01^{ab}	37.78±3.34^{b}
Crude Protein	53.53±4.08^{b}	62.94±4.00^{a}	64.67±4.11^{a}	48.33±3.98^{c}
Crude Fibre	43.45±13.08^{b}	34.26±11.04^{b}	73.12±12.05^{a}	20.77±11.40^{bc}
Ether Extract	69.49±22.10^{ab}	91.75±15.15^{a}	70.61±9.00^{ab}	45.02±4.95^{b}
Nitrogen Free Extract	74.18±1.26	78.79±1.00	73.73±1.11	75.32±1.29
Ash	37.92±5.40^{b}	89.09±7.10^{a}	32.91±4.00^{c}	40.27±4.40^{b}

Key: *^{abc}Means in the same row having different superscripts are significantly different (p<0.05), DSOPM = Dried sweet orange peel meal*

Table 4: Nitrogen utilization (g/day) of growing red Sokoto goats fed varied levels of dried sweet orange peel meal in the diets

Parameters	Experimental Diets			
	0% DSOPM	2.5% DSOPM	5.0% DSOPM	7.5% DSOPM
Nitrogen intake	3.34±0.13^{a}	3.12±0.12^{a}	2.98±0.06^{b}	2.83±0.07^{b}
Faecal Nitrogen	1.97±0.11^{a}	1.80±0.09^{a}	1.60±0.07^{ab}	1.51±0.02^{b}
Urinary Nitrogen	0.62±0.01	0.62±0.01	0.62±0.01	0.61±0.01
Digested Nitrogen	0.98±0.37^{a}	0.75±0.31^{ab}	0.63±0.19^{b}	0.61±0.21^{b}
Nitrogen retention	29.34±2.01^{a}	24.04±0.20^{b}	21.14±0.11^{c}	21.55±0.08^{d}

Key: *^{abc}Means in the same row having different superscripts are significantly different (p<0.05), DSOPM = Dried sweet orange peel meal*

7.5% inclusion level (16.57 ± 0.10) and lowest in those on 0% (8.93 ± 0.11). This implies that, the efficiency at which goats converted feeds for their body weight gain in diet at 0% inclusion level is lowest, indicating a better feed conversion ratio of the feed. Moreover, the positive response between average daily weight gain and better feed conversion ratio obtained at 0% inclusion level could be probably used to further attest the superiority of goats on the control diet (0%) in terms of nutrient utilization for body weight gain over others.

The apparent nutrient digestibility (% DM) of growing goats fed experimental diets indicated significant difference (p<0.05) in the dry matter digestibility with diet at 0% (54.24%) being the highest and diet at 7.5% (37.78%) the lowest (Table 3). Nutrient digestibility in animals is the classical and direct method for estimating feed digestion by ruminants; hence studies on digestibility of ruminant feeds are very important as they allow for the estimation of nutrients actually available for ruminant nutrition (Okoruwa *et al.*, 2012).

This difference could probably explain nutrient accumulation rate in the diets. This was contrary from those reported by Oloche *et al*. (2013) and Okoruwa *et al*. (2013) who reported that there was no significant (p>0.05) difference between treatment groups. Dry matter range values of 37.78 – 54.24% were lower as compared with range values of 93.29 – 94.01% reported by Oloche *et al*. (2013) for WAD goats fed diets containing graded levels of sweet orange peel meal.

Crude protein digestibility range from 48.33 in 7.5% to 64.67% in 5.0% inclusion levels respectively. The higher significant (p<0.05) difference observed in 5.0% compared to 0%, 2.5% and 7.5% could be as a result of the presence of tannin and saponin in the test diets which reduced protein degradation in the rumen so that appreciable quantity was available post-ruminally for digestion. This is in agreement with earlier report of Nkoku and Evbuomwan (2014) that the presence of tannin and saponin lowers the solubility of proteins entering the abomasum and small intestine for digestion. It has been reported that sweet orange peel meal contains saponin and tannins (Oyewole 2011). Crude fibre digestibility was significantly highest at 5.0% inclusion level (73.12 ± 12.05%) and low at 0% (43.45 ± 13.08%) followed by 2.5% (34.26 11.04%) before 7.5% (20.77 ± 11.40%) which was the lowest. The low crude fibre digestibility observed was probably because the rumen micro-organisms were not able to effectively digest the nature of fibre in the diets. While the highest CF digestibility at 5.0% inclusion level (73.12 ± 12.05%) might be due to changes in the rate of ingesta from the rumen. This observation was different from range values of 79.5 – 82.11% and 69.43 – 80.23% reported by Oloche *et al*. (2013) and Okoruwa *et al*. (2013) for WAD goats and sheep, respectively. They observed that the high digestibility of CF is a reflection of longer retention of feeds in the digestive system. Ether extract digestibility showed significant (p<0.05) difference between 2.5% (91.75 ± 15.15%) and 5.0% (70.61 ± 9.00%) before 0% (69.49 ± 22.10%). 7.5% inclusion level (45.02 ± 4.95%) was significantly (p<0.05) lower than 0%, 2.5% and 5.0%.

The highest ether extract digestibility value recorded in animals on 2.5% and 5.0% inclusion levels confirmed the reports of Okoruwa *et al*. (2013) that the diets were more effective in improving the utilization of ether extract. Nitrogen free extract digestibility values were 78.79 ± 1.00, 75.32 ± 1.29, 74.18 ± 1.26 and 73.73 ± 1.11% for 2.5%, 7.5%, 0% and 5.0% inclusion levels respectively, with no significant (p>0.05) differences between treatment groups. The observed range values were higher than 50.81% – 57.93% reported by Oloche *et al*. (2013) for WAD goats fed graded levels of sweet orange peel meal and was also higher than 64.89% – 68.37% reported by Okoruwa *et al*. (2013) for WAD sheep fed graded levels of orange and pineapple pulps. More so, the high NFE digestibility reported in this study implies that substantial amounts of fermentable carbohydrates were digested. Suggesting better proportion of energy for improving rumen fermentation that provides appropriate balance of nutrient to the animals for absorption. This agreed with the reports of Okoruwa and Njidda (2012) that nutrient digestibility among other factors will depend on differential level of a ration and vary level of nutrient composition in the diet taken by animal.

The nitrogen metabolism result indicated significant (p<0.05) variations in digested nitrogen (g/day) across the dietary treatments (Table 4). The control diet 0% (0.98 ± 0.37 g/day) had the highest digested nitrogen followed by 2.5% (0.75 ± 0.31 g/day), while 5.0% and 7.5% inclusion levels were not significantly (p>0.05) different. The goats on 0% inclusion digested significantly (p<0.05) higher values of nitrogen per day than those on 2.5%, 5.0% and 7.5%. This may be as a result of higher nitrogen intake by animals on 0%. The nitrogen retention (NR) in 0% and 2.5% inclusion levels were 29.34 ± 2.01 and 24.04 ± 0.20 g/day respectively which were significantly (p<0.05) higher than those in 5.0% and 7.5% (21.14 ± 0.11 and 21.55 ± 0.08g/day), respectively. This result is similar to the report of Aye and Adegun (2010) that the N-retention for diets with high protein levels tend to be higher (p<0.05) compared to low protein level diets.

The treatment effects on nitrogen balance were not significantly (p>0.05) different. Nitrogen balance values for goats on 0%, 2.5%, 5.0% and 7.5% were 0.98 ± 0.37, 0.75 ± 0.31, 0.63 ± 0.19 and 0.61 ± 0.21 g/day respectively. This is contrary to 1.12 – 5.35 g/day reported by Aye and Adegun (2010) for WAD sheep fed gliricidia based multinutrient block supplements suggesting that N-intake significantly (p<0.05) influenced N-balance.

Conclusion: It was concluded that goats fed the control diet (0%) performed better than other treatment diets signifying that incorporation of dried sweet orange peel meal in goat diet significantly (p<0.05) reduced feed intake while at the same time improved the digestibility of crude protein and crude fibre at 5.0% level of inclusion. Dried sweet orange peel meal could be used as feed for growing goats without any detrimental effect.

REFERENCES

ABDEL GAWAD, A. M., MAHMOUD, A. E. M. and SLIBI, Y. H. A. (2013). Response of growing bulls fed ration containing different levels of *Citrus* pulp. *World Applied Sciences Journal*, 28(10): 1475 – 1480.

ADUKU, A. O. (2004). *Animal Nutrition in the Tropics.* Davon Computer and Business Bureau, Zaria, Nigeria.

AKA, L. O., UGOHUKWU, N. C., AHMED, A. and PILAU, N. N. (2011). The effect of ruminal incubation of bioactive yeast (*Saccharomyces cerevisiae*) on potential rumen degradability of *Panicum maximum* and *Centrosema pubescens* in West African dwarf sheep. *Sokoto Journal of Veterinary Sciences*, 9(1): 28 – 35.

AOAC (2001). *Official Methods of Analysis.* 18th Editon, Association of Official and Analytical Chemists, Washington DC, USA.

AYE, P. A. and ADEGUN, M. K. (2010). Digestibility and growth in West African dwarf sheep fed *Gliricidia*-based multinutrient block supplements. *Agriculture and Biology Journal of North America*, 1(6): 1133 – 1139.

BAMPIDIS, V. A. and ROBINSON, P. H. (2006). *Citrus* by-products as ruminant feeds: A review. *Animal Feed Science Technology*, 128: 175 – 217.

BELLO, A. A. and TSADO, D. N. (2013). Feed intake and nutrient digestibility of growing Yankasa rams fed sorghum stover supplement with graded levels of dried poultry droppings based diets. *Asian Journal of Animal Science*, 7(2): 56 – 63.

DUNCAN, D. B. (1955). New multiple ranges and multiple f tests. *Biometrics*, 11(1): 1 – 42.

EZEJIOFOR, T. I. N., EKE, N. V., OKECHUKWU, R. I., NWOGUIKPE, R. N. and DURU, C. M. (2011). Waste to wealth: Industrial raw materials potential of peels of Nigerian sweet orange (*Citrus sinensis*). *African Journal of Biotechnology*, 10(33): 6257 – 6264.

FAO (2004). *Commodity Review and Outlook*. Source: UNCTAA from Food and Agricultural Organisation Data.

FAJEMISIN, A. N., FADIYIMU, A. A. and ALOKAN, J. A. (2010). Nitrogen retention and haematological indices of West African dwarf rams fed sun dried and fermented rumen digesta and cage hen dropping diets. Pages 604 – 607. *In: Proceedings of the 35th Conference of Nigerian Society for Animal Production (NSAP)*, 14th – 17th March, University of Ibadan, Nigeria.

KONLAN, S. P., KARIKARI, P. K. and ANSAH, T. (2012). Productive and blood indices of dwarf rams fed a mixture of rice straw and groundnut haulms alone on supplemented with concentrates containing different levels of shea nut cake. *Pakistan Journal of Nutrition*, 11(6): 566 – 571.

MAKUN, H. J., OTARU, S. M. and DUNG, D. D. (2013). Effect of management practices on milk yield and live weight changes of indigenous breeds of goats supplemented with groundnut haulms and concentrate in sub humid zone of

Nigeria. *Sokoto Journal of Veterinary Sciences*, 11(1): 45 – 50.

MALAU-ADULI, A. E. O. and ABUBAKAR, B. Y. (1992). Estimation of 305 – day yield from milk yield in Bunaji and Friesian x Bunaji Crosses. *Nigeria Journal of Animal Production*, 19(182): 141.

MARSHAL, H. J. (2001). Animal feeding and nutrition. 9th Edition, Kendall Hunt Publishing Company, Nigeria.

NAM, I. S., GARNSWORTHY, P. C. and AHN, J. H. (2009). Effects of freeze-dried citrus peel on feed preservation, aflatoxin contamination and in vitro ruminal fermentation. *Asian-Australia Journal of Animal Science*, 22(5): 674 – 680.

NJOKU, V. I. and EVBUOMWAN, B. O. (2014). Utilization of essential oil and pectin extracted from Nigerian orange peels. *Greener Journal of Chemical Science and Technology*, 1(1): 1 – 5.

OKORUWA, M. I., OBIKU, A. and AGBONLAHOR, I. (2013). Rumen indices and performance response of West African dwarf (WAD) sheep as influenced by orange with pineapple pulps. *International Journal of AgriScience*, 3(11): 862 – 870.

OKORUWA, M. I., IGENE, F. U. and ISIKA, M. A. (2012). Replacement value of cassava peels with rice husk for guinea grass in the diet of West African dwarf sheep. *Journal of Agricultural Science*, 4(7): 254 – 261.

OKORUWA, M. I. AND NJIDDA, A. (2012). Rumen characteristics and nitrogen utilization of West African dwarf sheep as influenced by guinea grass and dried pineapple pulps. *Pakistan Journal of Nutrition*, 11(6): 580 – 583.

OKORUWA, M. I. and ADEWUMI, M. K. (2010). Effect of replacing *Panicum maximum* with dried pineapple pulp on nutrient digestibility and nitrogen balance of West African dwarf sheep. *Nigerian Journal of Animal Science,* 12: 103 – 109.

OKORUWA, M. I., EHEBHA, E. T. E. and OMORAGBON, E. (2015). Replacement value of avocado seeds with orange peels meal for guinea grass on growth performance and nutrient digestibility of growing sheep. *International Journal of Research in Agriculture and Forestry*, 2(7): 35 – 40.

OLOCHE, J., AYOADE, J. A. and OLUREMI, O. I. A. (2013). Effect of replacement of sweet orange (*Citrus sinensis*) peel meal with maize offal on apparent digestibility and nutrient intake of West African dwarf (WAD) goats. *Journal of Agriculture and Veterinary Science*, 5(3): 1 – 4.

OLOCHE, J., OLUREMI, O. I. A. and PAUL, J. A. (2015). Performance response and blood profile of West African dwarf goats fed shea butter (*Vitellaria paradoxa*) leaves supplemented with diets containing different levels of sweet orange (*Citrus sinensis*) peels. *American Journal of Experimental Agriculture*, 6(6): 410 – 415.

OLUREMI, O. I. A., ANDREW, I. A. and NGI, J. (2007a). Evaluation of the nutritional potential of the peels of some citrus fruits varieties of feeding stuff in livestock production. *Parkistan Journal of Nutrition*, 6(6): 653 – 656.

OLUREMI, O. I. A., NGI, A. J. and ANDREW, A. I. (2007b). Phyto-nutrients in citrus fruit peel meal and nutritional implication for livestock production. *Livestock Research for Rural Development,* 19(7): 1 – 5.

OLUREMI, O. I. A., OJIGHEN, V. O. and EJEMBI, E. H. (2006). The nutritive potential of sweet orange (*Citrus sinensis*) in broiler production. *International Poultry Science,* 5(7): 613 – 617.

OMODAMIRO O. D. and UMEKWE J. C. (2013). Evaluation of anti-inflammatory, antibacterial and antioxidant properties of ethanolic extracts of *Citrus sinensis* peel and leaves. *Journal of Chemical and Pharmaceutical Research*, 5(5): 56 – 66.

ONYEONAGU, C. C. and NJOKU, O. L. (2010). Crop residues and agro-industrial by-products used in traditional sheep and goat production in rural communities of Markudi LGA. *Journal of Tropical*

Agriculture, Food, Environment and Extension, 9(3): 161 – 169.

OSOSANYA, T. O. (2010). Effect of varying levels of broiler litter on growth performance and nutrient digestibility of West African Dwarf lambs. *Nigerian Journal of Animal Science,* 12: 123 – 128.

OSOSANYA, T. O., ALABI, B. and SORUNKE, O. (2013). Performance and digestibility of corncob and cowpea husk diets by West African dwarf sheep. *Pakistan Journal of Nutrition*, 12(1): 85 – 88.

OYEWOLE, B. O. (2011). *Nutritional Potential of Fermented Sweet Orange (Citrus sinensis) Fruit Peel Meal in the Diets of Pullet Chicks, Grower and Layers*. Ph.D Thesis, Department of Animal Nutrition, University of Agriculture, Makurdi, Nigeria.

OYEWOLE, B. O., OLUREMI, O. I. A., ARIBIDO, S. O. and AYOADE, J. A. (2012). Effect of naturally fermented sweet orange (*Citrus sinensis*) fruit peel meal on performance and economics of production of growing pullets. *International Journal of Agriculture and Rural Development*, 15(2): 1029 –1032.

OYEWOLE1 B. O., OLUREMI, O. I. A., ARIBIDO, S. O. and AYOADE, J. A. (2013). Productive and haematological performance of growing pullets fed fermented sweet orange (*Citrus sinensis*) fruit peel meal based diets. *International Journal of Agriculture and Biosciences*, 2(2): 68 – 71.

PEACOCK, C., DEVENDRA, C., AHUYA, C., ROETS, M., HOSSAIN, M. and OSAFO, E. (2005). Goats. Pages 361 – 385. *In:* OWEN, E., KITALYI, A., JAYASURIYA, N. and SMITH, T. (Eds.), *Livestock and Wealth Creation: Improving the Husbandry of Animals Kept by Resource-Poor People in Developing Countries.* Nottingham University Press, United Kingdom.

SAS (2002). *Statistical Analysis System, Computer Software, SAS/STAT User's Guide Version 9.* Statistical Analysis Systems Institute, Cary, North Carolina 27513, USA.

SILVA, A. G., WANDERLEY, R. C., PEDROSO, A. F. and ASHBELL, A. (1997). Rumen digestion kinetics of citrus peel. *Animal Feed Science Technology*, 68: 247 – 257.

WEBB, E. C. and MAMABOLO, M. J. (2004). Production and reproduction characteristics of South African indigenous goats in communal farming system. *South Africa Journal of Animal Science*, 34: 236 – 239.

ZOHREH, P., ALI, A., ALAW, Q. and ALIREZA, S. (2012). Does different levels of dried *Citrus sinensis* peel affect on broilers gastrointestinal microbial population? *Annals of Biological Research*, 3(9): 4474 – 4479.