Animal and Veterinary Sciences
2018; 6(1): 1-5
http://www.sciencepublishinggroup.com/j/avs
doi: 10.11648/j.avs.20180601.11
ISSN: 2328-5842 (Print); ISSN: 2328-5850 (Online)

Evaluation of Rumen Filtrate for Fermentation of Sweet Orange (*Citrus sinensis*) Peel in Rabbit Feed

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To cite this article:

Oluwabiyi Ikeolu Atanda Oluremi, Ejeh Emmanuel Ajih, Winifred Anthony. Evaluation of Rumen Filtrate for Fermentation of Sweet Orange (*Citrus sinensis*) Peel in Rabbit Feed. *Animal and Veterinary Sciences*. Vol. 6, No. 1, 2018, pp. 1-5. doi: 10.11648/j.avs.20180601.11

Received: September 4, 2017; **Accepted**: October 8, 2017; **Published**: January 17, 2018

Abstract: Feeding accounts for about 70% of the total cost of non-ruminant animal production in Nigeria. A ninety-one day feeding trial was conducted using thirty (30), 6-7 week old mixed breed weaner rabbits at the Federal University of Agriculture Makurdi, Nigeria from October 10, 2015 to January 9, 2016. The objective was to determine the potential of filtrate from rumen content mixed with water, to improve the nutritive value of Sweet orange (*Citrus sinensis*) peel by fermentation in rabbit production. The filtrate was obtained from the rumen content of cattle and drinking water mixed in equal ratio of 1:1. The filtrate was added to 5kg each of freshly collected sweet orange peel in ratio 1:5 (T1), 2:5 (T2), 3:5 (T3), 4:5 (T4) and 5:5 (T5). Each was mixed thoroughly, put in polythene bags and sealed on top, left under shade of tree to ferment for 24hrs, and thereafter sun-dried. Each of these was milled and used to replace maize in a practical rabbit diet (D) at 30% level. Five rabbits each, individually housed in a rabbit hutch and each serving as a replicate were randomly assigned to and fed diets D, T1, T2, T3, T4 and T5. The experimental diets had significant effect ($p<0.05$) on the final live body weight and daily body weight gain with rabbits in treatment T5 having superior weights of 1928.00 g and 15.85 g, respectively. The diets had no significant effect ($p>0.05$) on percent live weight of liver, kidney, lung, heart and spleen and, on the coefficient of digestibility of dry matter, crude protein, crude fibre, ether extract, nitrogen free extract and total digestible nutrient. Of the carcass yield indicators; dressing weight, fore limb, hind limb and loin, the experimental diets significantly affected ($p<0.05$) only the loin, with the rabbits in T5 having a comparatively higher weight. The result obtained showed that, rumen filtrate obtained from a mixture of the rumen content of cattle and water at ratio 1:1, when mixed with sweet orange peel atratio 5:5 can be used to ferment sweet orange peel to improve its nutritive value for maize replacement at 30% in rabbit feed.

Keywords: Rumen, Filtrate, Fermentation, Orange Peel, Rabbit

1. Introduction

The demand for food due to increasing population is a major challenge to the livestock and poultry industry in several developing countries including Nigeria, because of the often scarce and unpredictable supply of the major feed ingredients especially the energy (maize, guinea corn) and protein (soybean, groundnut, fishmeal) sources. This situation is inimical to adequate supply of farm animal products like meat, milk, egg which are essential for body growth and development, and maintenance of physiological processes. Animal protein shortage in the diet of the average Nigerian is shown in the consumption of 3.24g per caput which is far below 35g daily requirement recommended by FAO [1]. Thus, the need to search for, identify and develop alternative feed resources which are cheap and readily available [2], to reduce the cost of production for sustainable development of farm animals so as to mitigate the low per capita animal protein intake. Feeding accounts for about 70% of the total cost of animal production especially the non-ruminant. The nutritional status of most Nigerians is characterized by inadequate protein intake both in quality and quantity [3]. There is serious global concern about poor handling of agricultural and domestic wastes. Studies on the utilisation of agro-allied by-product in animal feed have

increased to reduce the high cost of production. It has been reported [4] that sweet orange rind can be used as replacement feedstuff for maize in the ration of grower rabbit at a level of 15%. Sweet orange (C*itrus sinensis*) fruit peel, is one of such wastes. It is abundant in Nigeria and with no cost attached, high in energy [2], and not being harnessed for any productive use. Rabbit is a small herbivorous non-ruminant animal. It produces high quality white meat and can effectively utilize very cheap cellulose rich feed resources. Rumen content is an important animal by-product in the abattoir industry in Nigeria [5, 6] and can be converted into a beneficial use by taking advantage of its microbial population rather than its present status as an agricultural waste. Studies applying simple cost effective techniques to improve its feed value in the nutrition of rabbit by using rumen content an organic microbial waste found in abattoirs are on-going to produce a bio-friendly alternative energy feedstuff. Its utilisation in the formulation of rabbit (*Oryctolaguscuniculus*) diet as a replacement for maize, a highly competitive conventional energy source will be of practical importance. The objective of this study was to determine the potential of bovine rumen filtrate to improve the nutritive value of sweet orange peel in rabbit feed.

2. Materials and Methods

2.1. Experimental Site

The study was conducted at the Teaching and Research Farm, Federal University of Agriculture Makurdi, Nigeria between October 2015 and January 2016.

2.2. Test Ingredient, Collection, Processing and Experimental Diets

The test ingredient was sweet orange (*Citrus sinensis*) peel (SOP) shown in Figure 1. The SOP was collected fresh from orange sellers within Makurdi metropolis a night before processing and treated with bovine rumen content filtrate. Fresh rumen content was collected from 4 randomly selected slaughtered cattle at the Wurukum abattoir in Makurdi and mixed to obtain a mass to which potable water was added in ratio 1:1. This mixture was stirred with a wooden stirrer and sieved to collect rumen filtrate (RF)shown in Figure 2 which was added to 5 kg each of sweet orange peel in ratio 1:5 (T1), 2:5 (T2), 3:5 (T3), 4:5 (T4) and 5:5 (T5). Each was mixed thoroughly manually, packed into polythene bags, tied at the open end, leftunder shade of tree to ferment for 24h, and thereafter sun-dried within 48h to less than 10% moisture. Figure 3. Each of (T1), (T2), (T3), (T4) and (T5) was milled and used to replace 30% maize in apractical rabbit diet (D) to obtain 5 sweet orange peel based diets: T1, T2, T3, T4 and T5 (Table 1). Thirty (30) healthy mixed breed grower rabbits were used for the feeding trial.

Figure 1. *Fresh Sweet Orange Peels.*

Figure 2. *Rumen Filtrate.*

Figure 3. *Sundried Sweet Orange Peels.*

2.3. Experimental Animal, Management and Design

They were housed singly in 40 x 60 x 40cm^3 cages and randomly allotted to the six dietary treatments D, T1, T2, T3, T4 and T5 with a total of five rabbits per treatment each of which served as a replicate. The experimental design was a completely randomized design. Known quantities of feed and drinking water were served. Feed and water intake were determined by difference. Feed conversion ratio (FCR), body weight gain (BWG), water: feed ratio, protein intake, protein efficiency ratio were calculated. The feeding trial lasted ninety-one days.

2.4. Digestibility Trial

Digestibility trial was carried out using 3 rabbits replicate

per treatment in the last week of the feeding trial. They were served weighed feed and measured drinking water daily. Faecal droppings per rabbit were collected daily, weighed, oven dried at 105°C to constant weight, put in a desiccator and re-weighed.

2.5. Carcass Yield Evaluation

Carcass evaluation was done on the last day of the trial with same rabbits used for digestibility. The diets were withdrawn 18h prior to slaughter. Rabbits were weighed, stunned by hitting the base of the neck, slaughtered and bled. The bled rabbits were weighed, eviscerated and weighed, singed and weighed. The internal organs were detached and rabbit carcass cut into head, neck, forelimb, hind limb, rack/ribs and loin, and separately weighed. The weights were expressed as percentage of live weight (% LW).

2.6. Analysis

2.6.1. Chemical Analysis

Feed and faecal samples were analysed for their proximate constituents [7]. Metabolisable energy was calculated using the procedure of Pauzenga [8].

2.6.2. Statistical Analysis

Data generated were subjected to analysis of variance using Minitab [9]. Means of data significantly different ($p<0.05$) were separated by least significant difference.

3. Results

The proximate analysis of the bovine rumen filtrate treated and fermented sweet orange peel showed that it contained 7.76-8.54% crude protein (CP), 12.17-13.24% crude fibre (CF), 2.91-3.29% ether extract (EE), 9.84-10.95% ash and 64.27-67.32% nitrogen free extract (NFE), and 2756.01-2826.49kcalME/kg [10]. The effect of the experimental diets on growth showed significant variation ($p>0.05$) in the final live weight and body weight gain of rabbits (Table 2). The diets however had no significant effect ($p>0.05$) on feed intake, feed conversion ratio, water intake, water:feed ratio, protein intake and protein efficiency ratio (PER) of the rabbits. The effect of the experimental diets on the carcass yield and nutrient digestibility of rabbits is presented in Table 3. The diets had significant effect ($p<0.05$) only on the% live weight of loin while, the fore-limb, hind-limb and rack/rib did not differ significantly ($p>0.05$) among the treatment groups. It was observed that the dressed weight of the rabbit was also not significantly different ($p>0.05$) and varied from 50.54% to 55.24%. The experimental diets had no effect ($p>0.05$) on any of the visceral organs: liver, kidney, lung, heart and spleen. Similarly, the coefficient of digestibility of the nutrients: crude protein, crude fibre, ether extract and nitrogen free extract and dry matter and total digestible nutrients did not differ significantly ($p>0.05$).

4. Discussion

Dry matter content was above 90% and all the nutrients were seemingly high. The implication of high dry matter is that it will enhance long shelf-life of sweet orange peel if stored in a cool dry place, in addition to having a relatively higher proportion of nutrients. Crude protein, crude fibre and ash present increased as the quantity of the rumen filtrate added to sweet orange peel increased while, the NFE and ME decreased. The increased CP was likely due to the higher concentration of bacteria as more filtrate was added, thereby causing higher bacterial cell multiplication and bacterial cell protein. This high concentration of bacteria in the sweet orange peel media may have resulted in a level of fermentation in which more digestible carbohydrate was utilized for energetic process causing increased CF, reduced NFE and ME contents. Hence, (T5) had highest CP (8.54%) and CF (13.24%), and least NFE (64.27%) and ME (2,758.01kcal/kg). While the high CF may reduce its feeding value compared to dietary maize in non-ruminant nutrition [11], its NFE values showed that it contained high content of digestible carbohydrate. Thus, sweet orange peel can be utilized as energy feed ingredient in rabbit diet.

In both growth indices, rabbits fed diets containing (T5) had comparatively higher live weight of 1928.00g and 15.85g BWG. The trend of variation of the BWG was the same as that of the live weight. This BWG was higher than 10.76-13.05g reported by [1] when rabbits were fed sweet orange pulp meal as alternative energy source. The rabbits in T5 had a better growth performance than rabbits fed the maize-based (Figure 4).

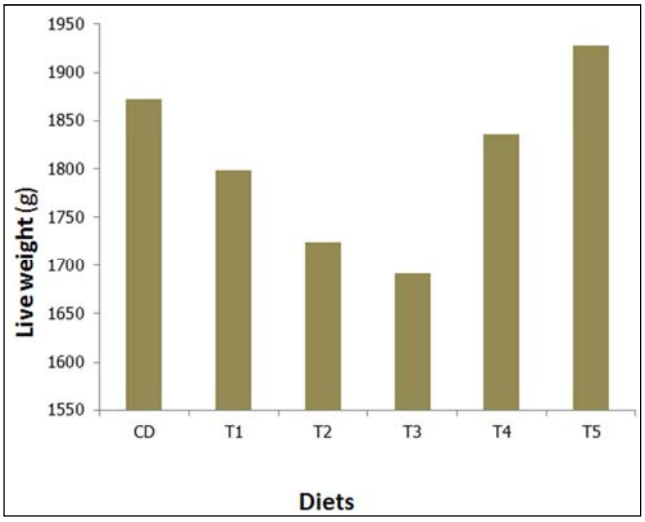

Figure 4. *Final Live Weight of Experimental Rabbits.*

The observation that only the % live weight of the loin differed significantly among the prime carcass cuts may not be attributable to the dietary effect but to precision in cutting the prime parts. The non-significant percent dressed weight showed that the filtrate fermented sweet orange peel did not have any adverse effect on the meat yield of the rabbits. This is of practical significance since the primary product needed

is meat. These organs which appeared normal in shape and size help to determine the health of farm animals in general. The normal appearance of these organs and the apparent good state of health of the experimental rabbits showed that these bovine rumen filtrate treated sweet orange peel were not detrimental to the rabbits. The total digestible nutrient values were also high and ranged from 73.38 to 80.22%. This has revealed that fermented sweet orange peel is energy concentrate feed material.

5. Conclusion

The proximate constituents of bovine rumen filtrate treated and fermented sweet orange peel (especially crude fibre) were inferior to maize. Rabbits fed diet T5 which contained sweet orange peel treated in ratio 5 litre rumen filtrate: 5 kg sweet orange peel had a comparative growth performance advantage (final live body weight and body weight gain) over rabbits fed convectional maize-based diets. Rumen filtrate obtained from a mixture of the rumen content of cattle and water at ratio 1:1 when mixed with sweet orange peel at ratio 5:5 can be used to ferment sweet orange peel to improve its feed value for maize replacement at 30% in rabbit diet. Further studies are necessary to elucidate other processing methods that would enhance the feeding value of the sweet orange peel by reducing its crude fibre content.

Table 1. *Composition of the Experimental Diets.*

	Experimental Diets					
Ingredients	**D**	**T1**	**T2**	**T3**	**T4**	**T5**
Maize	27.00	18.90	18.90	18.90	18.90	18.90
Full fat soybean	15.00	15.00	15.00	15.00	15.00	15.00
Sweet orange peel	0	8.10	8.10	8.10	8.10	8.10
Brewers dried grain	25.00	25.00	25.00	25.00	25.00	25.00
Rice offal	30.00	30.00	30.00	30.00	30.00	30.00
Bone ash	2.50	2.50	2.50	2.50	2.50	2.50
Vitamin/mineral premix	0.25	0.25	0.25	0.25	0.25	0.25
Table salt	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100

Table 2. *Effect of Experimental Diets on the Performance of Grower Rabbits.*

Parameters	**Experimental diets**						**SEM**
	D	**T1**	**T2**	**T3**	**T4**	**T5**	
Initial weight (g)	489.00	478.00	488.00	485.00	486.00	485.00	30.51^{ns}
Final weight (g)	1872.20^{ab}	1798.60^{bc}	1724.00^{cd}	1691.00^{d}	1835.60^{ab}	1928.00^{a}	49.04^{*}
Body weight gain (g)	15.20^{ab}	14.62^{bc}	13.57^{cd}	13.26^{d}	14.83^{a}	15.85^{a}	0.54^{*}
Feed intake (g)	71.83	70.42	68.07	70.63	72.66	77.32	2.23^{ns}
Feed conversion ratio	4.73	4.80	5.29	5.36	4.94	4.88	0.26^{ns}
Water intake(ml)	365.91	312.80	282.52	353.44	349.14	391.67	48.35^{ns}
Water:feed ratio	5.10	4.44	4.16	5.00	4.75	5.02	0.64^{ns}
Protein intake (g)	14.36	13.86	12.98	13.77	15.02	14.94	0.50^{ns}
PER	0.94	0.96	0.98	1.04	1.02	0.94	0.05^{ns}
Mortality%	0	0	0	0	0	0	0

*$p<0.05$); $^{ns}(p>0.05)$; PER = protein efficiency ratio; SEM = Standard error of mean.

Table 3. *Effect of Experimental Diets on the Carcass Yield and Coefficient of Digestibility of Growing Rabbits.*

Parameters	**Experimental diets**						**SEM**
	D	**T1**	**T2**	**T3**	**T4**	**T5**	
Live weight (kg)	1.87^{ab}	1.78^{bc}	$1.^{82bc}$	1.71^{c}	$.92^{ab}$	2.00^{a}	0.05^{*}
Carcass yield (%LW)							
Dressed weight	55.24	50.54	51.47	51.52	53.00	52.74	0.96^{ns}
Fore-limb	10.78	9.53	9.47	10.03	10.56	10.02	0.34^{ns}
Hind limb	22.05	20.72	22.02	20.68	21.53	21.09	0.63^{ns}
Rack/rib	10.78	9.57	9.40	8.24	8.88	8.81	0.76^{ns}
Loin	11.63^{b}	10.71^{c}	10.58^{bc}	12.27^{a}	2.04^{ab}	12.83^{a}	0.50*
Liver	2.36	2.34	2.30	2.30	2.33	2.18	0.11^{ns}
Kidney	0.52	0.58	0.55	0.54	0.45	0.47	0.04^{ns}
Lung	0.45	0.64	0.49	0.38	0.40	0.35	0.06^{ns}
Heart	0.29	0.24	0.29	0.28	0.26	0.23	0.03^{ns}
Spleen	0.02	0.02	0.02	0.02	0.04	0.02	0^{ns}
Gall bladder	0.04	0.03	0.05	0.04	0.05	0.03	0^{ns}
Nutrient Digestibility (%)							
Dry matter	69.49	75.41	72.38	77.61	72.47	71.99	2.96^{ns}
Crude protein	78.63	84.64	79.74	84.32	79.38	79.74	2.36^{ns}
Crude fibre	60.48	70.20	68.57	74.72	63.99	70.75	3.42^{ns}
Ether extract	91.93	94.51	93.43	94.79	93.73	92.92	1.06^{ns}
Nitrogen free extract	69.15	72.11	67.48	75.54	73.54	68.19	3.31^{ns}
Total digestible nutrient	73.38	77.86	74.18	80.22	77.02	75.53	2.49^{ns}

$^{*}(p<0.05)$; $^{ns}(p>0.05)$; %LW= percentage live weight, SEM = Standard error of mean.

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