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Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

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Nutritional Evaluation of Sweet Orange (*Citrus sinensis*) Fruit Peel as a Feed Resource in Broiler Production

P.N. Agu[1], O.I.A. Oluremi[2] and C.D. Tuleun[2]
[1]Department of Animal Production, [2]Department of Animal Nutrition,
University of Agriculture, P.M.B. 2373, Makurdi, Benue State, Nigeria

Abstract: A study was conducted with broiler chicks to evaluate the nutritional potential of Sweet orange fruit (*Citrus sinensis*) peel as a feed resource. Sweet orange peels were sun dried, milled and used as a dietary substitute for maize. Six experimental diets coded as $M_{100}P_0$, $M_{90}P_{10}$, $M_{80}P_{20}$, $M_{70}P_{30}$, $M_{60}P_{40}$ and $M_{50}P_{50}$ were compounded such that Sweet Orange Peel Meal (SOPM) substituted maize at levels of 0, 10, 20, 30, 40 and 50%, respectively in broiler starter and finisher diets. One hundred and eighty (180) day-old Anak titan chicks were randomly divided into six groups and one of each was allotted to a diet of three replicates. The birds which were raised in deep litter pens for sixty-three days were fed *ad libitum* and had access to fresh cool drinking water daily. Performance data: feed intake, water consumption, body weight, Body Weight Gain (BWG), Feed Conversion Ratio (FCR) were collected during the feeding trial and carcass evaluation was done at the termination of the trial. In both starter and finisher phases, the diets had no effect ($p>0.05$) on feed intake, water consumption, body BWG and FCR but had significant effect ($p<0.01$) on the body weight of broilers as the level of the SOPM increased from 0-50%. There was a significant decrease in body weight at SOPM level higher than 20%. Experimental diets had highly significant effect ($p<0.001$) on dressing percent, drumstick and wing from 30% level of SOPM while other carcass cuts: thigh, breast, back, neck and shoulder were statistically the same ($p>0.05$) among the dietary groups. The diets had no effect ($p>0.05$) on kidney, liver, heart, spleen, gall bladder and lung but had significant effect ($p<0.01$) on proventriculus and gizzard as the SOPM level increased. The organs were normal and there were no observable adverse effects on the health of broilers. SOPM can be a dietary substitute for maize up to 20% level in the diet for broiler.

Key words: Orange peel, broiler, performance, carcass, organs

INTRODUCTION

In Nigeria, the state of nutrition of the populace is predominantly characterized by inadequate protein intake in both quantity and quality. This shortage has given rise to high prices of animal protein (Taiwo *et al*., 2005). The high costs of egg, meat and meat products are mainly due to high costs of raw materials for feed industry especially maize. The high cost of maize is attributed to its low production and high demand for human food, industrial use and animal feeds. Nutrition and feeds are critical in livestock development because abundant animal production hinges on availability of cheap and balanced feeds. Feed quality and quantity affect how many animals can be raised and how fast they can reach market weight There have been several attempts to reduce the cost of farm animal production by replacing some percentage of maize or all with agro-industrial by-products such as maize offal, wheat offal rice offal, cassava peel, brewers dried grain (Babatunde and Bamise, 1996; Ibiyo and Atteh, 2005). A number of residue materials like peels, rag, seed (Chapman *et al*., 2000) are produced when fresh citrus fruits are processed into juice, concentrate and canned fruit in developed countries or when they are peeled for direct human consumption as in the case of most developing countries like Nigeria. These by-products can be processed into wet and dried citrus pulp, citrus molasses, citrus meal and citrus seed meal.

Various studies aimed at determining the feeding value of these citrus by-products showed that they are excellent beef cattle feeds if used properly (Chapman *et al*., 2000). Some other studies showed that citrus by-products can also be utilized for monogastric animals (Oluremi *et al*., 2005; Oluremi *et al*., 2006). However, Jong-Kyu *et al*. (1996) said more information is needed on what levels and types of citrus by-products are best to use.

Poultry has been identified as a farm animal possessing a high level of biological economic efficiency in their production. Other advantages of poultry over most other farm animals' species are fecundity, maturity rate, generation interval and general acceptability of the animal product. This study was designed to evaluate the nutritive potentials of sun-dried sweet orange fruit (*Citrus sinensis*) peel as a feed resource in broiler chicken production.

Corresponding Author: O.I.A. Oluremi, Department of Animal Nutrition, University of Agriculture, P.M.B. 2373, Makurdi, Benue State, Nigeria

MATERIALS AND METHODS

Sweet orange fruit (*Citrus sinensis*) peel which was to be evaluated for its feed value was collected from sweet orange fruit retail sellers on the campus of the University of Agriculture, Makurdi where the study was conducted, at the Livestock Unit in the Teaching and Research Farm. Makurdi town is lowland located in latitude 6°-8°N and Longitude 6°-10°E. The area is warm with a minimum temperature range of 17.3-24.5°C and a maximum temperature range of 29.8-35.6°C (NAF, 2002). Annual rainfall is between 508-1016 mm (Benue State Government of Nigeria, 1982).

The peels were sun-dried for about 48 h on concrete floor until they were crispy, stored in synthetic bags and milled when the experimental diets were to be compounded. A sample of the peels was analyzed for its proximate constituents (Table 1) as recommended by AOAC (1995) at the Institute of Agricultural Research and Training (IAR and T), Ibadan. Six experimental diets designated as $M_{100}P_0$, $M_{80}P_{20}$, $M_{70}P_{30}$, $M_{60}P_{40}$ and $M_{50}P_{50}$ were compounded such that maize was substituted by sweet orange fruit peel meal at 0, 10, 20, 30, 40 and 50% levels respectively, both at the broiler starter and finisher phases. The gross compositions of the broiler starter diet formulated to supply approximately 23% CP and 3100 kcalME/kg and broiler finisher diet formulated to supply 21%CP and 3150 kcalME/kg are presented in Table 2.

One hundred and eighty (180) day-old Anak titan broiler chicks were randomly divided into six groups and a group assigned to one of the six broiler starter diets. Each dietary treatment with thirty broiler chicks was divided into three replicates at the rate of 10 chicks per replicate. The birds were raised in a deep litter house and fed *ad libitum* on broiler starter diet for 5 weeks and broiler finisher diet for 4 weeks. They had unrestricted assess to clean cool, drinking water. Vaccinations (Newcastle I/o at day-old, gumboro at 3 weeks, Newcastle (lasota) at 4 weeks were given as recommended by the National Veterinary Research Institute, Nigeria. Vitalyte a proven anti-stress was given a day prior to and after each vaccination and periodically. Antibiotics and coccidiostat were administered periodically through drinking water during the feeding trial. Data collected were performance indices: body weight, feed intake, water consumption, Feed Conversion Ratio (FCR), water: feed ratio and mortality. For carcass quality evaluation, three broiler chickens per treatment were fasted over night prior to slaughter at the termination of the feeding trial on the 63rd day. The fasted birds were weighed before slaughter and immediately after the slaughter, then dressed and weighed. The weights of the carcass cuts: drumstick, thigh, back, wing, shoulder, breast and neck and visceral organs: lungs, liver, spleen, heart, gall bladder, kidney, gizzard and proventriculus and were taken. Visceral and abdominal fats were also weighed. All weights were expressed as a percentage of fasted live weight of corresponding chicken.

Data collected were subjected to the Analysis of Variance (ANOVA) using the procedure of Steel and Torrie (1980) and where significant differences were observed, means of parameters were separated using the Least Significant Difference (LSD).

RESULTS AND DISCUSSION

The proximate composition of the sweet orange fruit (*Citrus sinensis*) peel meal (Table 1) showed that it has 10.73% Crude Protein (CP) which is comparable to 9.00%CP in maize. Sweet orange fruit meal has a Crude Fibre (CF) level of 7.86% as against 2.70% in maize and metabolizable energy (ME) content of 3988.70kcal/kg as against 3432.00 kca/kg in maize.

Table 1: Proximate composition of sweet orange fruit (*Citrus sinensis*) Peel Meal (SOPM) and Maize (%DM)

Nutrient	SOPM[1]	Maize[2]
Dry matter	89.65	86.00
Crude protein	10.73	9.00
Crude fibre	7.86	2.70
Ether extract	12.60	4.00
Ash	11.90	1.30
Nitrogen free extract	56.91	83.00
Metabolizable energy (Kcal/kg)	3988.70	3432.00

[1]Laboratory analysis, [2]Aduku (1993)

The performance of broiler chickens showing water intake, feed intake, body weight, Body Weight Gain (BWG), Feed Conversion Ratio (FCR) and mortality in the starter and finisher phases is presented in Table 3. In the broiler starter, there were no significant differences ($p>0.05$) in the mean daily water consumption, feed intake, BWG and FCR among the dietary treatments as the level of maize substituted with SOPM increased. The experimental diets however had a highly significant effect ($p<0.001$) on the mean final body weights of the broiler chickens at the end of the starter phase. The mean final body weights of the dietary groups decreased with increased levels of SOPM in the diets. It was observed that at 10% and 20% levels of maize substitution, there was statistical similarity ($p>0.05$) in the mean final body weights of chickens in these groups, 1.52 kg and 1.42 kg, respectively with the chickens in the control group (1.54 kg). In spite that dietary requirements for growth were not compromised in any of the dietary treatments, it was observed that for diets which had maize substitution higher than 20% the daily feed intake per bird decreased and hence the chickens receiving these diets did not have enough dietary nutrients and thus depressed growth. It has been reported that weight and feed intake were negatively affected as the level of citrus in poultry diet increased (Yang and Chung, 1985). The effects of the experimental diets on mean water consumption, feed intake, BWG and FCR in the finisher phase were not significant

Table 2: Gross composition of the experimental diets for broiler starter and finisher (kg)

	Broiler starter						Broiler finisher					
Ingredients	$M_{100}P_0$	$M_{90}P_{10}$	$M_{80}P_{20}$	$M_{70}P_{30}$	$M_{60}P_{40}$	$M_{50}P_{50}$	$M_{100}P_0$	$M_{90}P_{10}$	$M_{80}P_{20}$	$M_{70}P_{30}$	$M_{60}P_{40}$	$M_{50}P_{50}$
Maize	44.46	40.01	35.57	31.12	26.68	22.23	51.61	46.45	41.29	36.13	30.97	25.81
Full fat soybean meal	42.59	42.59	42.59	42.59	42.59	42.59	35.44	35.44	35.44	35.44	35.44	35.44
Sweet orange peel meal	0	4.45	8.89	13.34	17.78	22.23	0	4.45	8.89	13.34	17.78	22.23
Blood meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Brewer's dried grain	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50
Bone meal	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Oyster shell	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mineral/vitamin premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Common salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutrients												
ME (kcal/kg)	3154.84	3158.92	3163.00	3167.08	3171.15	3171.15	3212.15	3216.88	3221.61	3226.15	3231.08	3235.83
Crude protein (%)	23.00	23.03	23.06	23.08	23.11	23.14	20.97	21.03	21.06	21.09	21.13	21.15
Crude fibre (%)	4.89	5.08	5.28	5.47	5.66	5.86	4.89	5.08	5.28	5.47	5.66	5.86
Crude fat (%)	3.76	4.08	4.40	4.78	5.06	5.38	3.97	4.17	4.55	4.93	5.30	5.68

*0.25 kg of premix will supply the following: Vitamin A 1500 IU, Vitamin D 300 IU, Vitamin E 3.00, Vitamin K 0.25 g, Thiamine 0.2 mg, Riboflavin 0.6 mg, Pantothenic acid 1.00 mg, Pyridoxine 0.4999 mg, Niacin 4.00 mg, Vitamin B12 0.002 mg, Folic acid 0.10 mg, Biotin 0.008 mg, Choline chloride 0.05 g, Antioxidant 0.012 g, Manganese 0.0096 g, Zinc 0.0060 g, Copper 0.0006g, Iodine 0.006 g, Iodine 0.00014 g, Selenium 0.024, Cobalt 0.004 mg

Table 3: Effect of experimental diets on the performance of broiler chickens

	Broiler starter dietary treatments						
Performance indices	$M_{100}P_0$	$M_{90}P_{10}$	$M_{80}P_{20}$	$M_{70}P_{30}$	$M_{60}P_{40}$	$M_{50}P_{50}$	SEM
Daily water intake (ml/bird)	174.24	192.40	197.27	162.47	179.01	163.63	98.05^{ns}
Daily feed intake (g/bird)	65.98	67.56	67.25	57.74	57.42	52.68	38.73^{ns}
Initial live weight (g/bird)	108.00	112.33	118.67	107.00	106.67	111.67	2.95^{ns}
Daily BWG (g/bird)	41.02	40.12	37.10	29.64	27.47	23.78	12.69^{ns}
Final body weight (g/bird)	1.54^{a}	1.52^{ab}	1.42^{abc}	1.14^{bcd}	1.11^{d}	0.94^{d}	0.88***
FCR	1.85	1.94	2.11	2.25	2.39	2.62	0.62^{ns}
Mortality	0/30	0/30	0/30	0/30	0/30	0/30	
	Broiler finisher dietary treatments						
Performance indices	$M_{100}P_0$	$M_{90}P_{10}$	$M_{80}P_{20}$	$M_{70}P_{30}$	$M_{60}P_{40}$	$M_{50}P_{50}$	SEM
Daily water intake (ml/bird)	460.08	498.47	484.75	485.36	493.65	408.73	37.73^{ns}
Daily feed intake (g/bird)	160.22	159.27	160.85	150.11	147.35	135.98	14.75^{ns}
Initial live weight (g/bird)	52.32	47.32	45.57	38.10	34.77	31.14	10.06^{ns}
Daily BWG (g/bird)	41.02	40.12	37.10	29.64	27.47	23.78	12.69^{ns}
Final body weight (g/bird)	3.33^{a}	3.01^{ab}	2.99^{abc}	2.41^{bcd}	2.23^{d}	2.01^{d}	0.19***
FCR	2.83	3.19	2.95	3.31	3.37	3.59	0.50^{ns}
Mortality	2/30	1/30	0/30	0/30	0/30	0/30	

[a,b,c,d]Figures with different superscripts in the same row are highly significantly different ($p<0.001$).
[ns]Not significantly different ($p>0.05$), SEM = Standard Error Mean

($p>0.05$) as in the starter phase. However the comparatively higher values of these performance indices may be a response to the relatively higher metabolic activities in broiler chickens at the finisher phase due to the faster growth which normally characterizes this physiological phase of growth. According to MacDonald *et al*. (1998), the more feed an animal consumes each day, the greater will be the opportunity for increasing its daily production. Consequently, the mean BWG of the broiler finisher (31.14-52.32 g) were also higher than of the broiler starter (23.78-41.02 g). The experimental diets caused a significant variation ($p<0.01$) in the mean final body weights of broiler finisher among the treatment groups. Significant reduction in their body weights was observed at SOPM inclusion higher than 20%. It has been reported that there is a reduction in energy intake with increased in fibre intake which reduces both growth and energy utilization (Close, 1993). Due to the higher fibre content of SOPM relative to maize, the fibre level in the experimental diets increased from 4.48-5.61% as the dietary SOPM content increased. It was observed that mean final body weights in the diet groups which varied from 2.01-3.3 kg were evidently higher than the recommended live weight of 1.6-1.8 kg for broiler finishers (Kekeocha, 1984). Thus, dietary incorporation of SOPM at up to 50% maize replacement did not depress broiler growth below the acceptable range of 1.6-1.8 kg live weight. This demonstrates the potential of SOPM as a feed ingredient in the diet of broiler chickens. The result of the carcass and visceral organs evaluation is presented in Table 4. The effect of the dietary

Table 4: Effect of dietary treatments on carcass, carcass cuts and internal organs of broiler chickens

	Dietary treatments						
Indices	$M_{100}P_0$	$M_{90}P_{10}$	$M_{80}P_{20}$	$M_{70}P_{30}$	$M_{60}P_{40}$	$M_{50}P_{50}$	SEM
Carcass							
Live weight (g/bird)	2580.00^{a}	2450.00^{ab}	2580.00^{ab}	2350.00^{b}	1850.00^{c}	1830.00^{c}	100.83***
Slaughter weight (g/bird)	2545.55^{a}	2373.80^{ab}	2517.21^{ab}	2257.10^{b}	1758.45^{c}	1773.73^{c}	109.14***
Plucked weight (g/bird)	2325.00^{a}	2225.00^{ab}	2300.00^{ab}	2150.00^{ab}	1650.00^{ab}	1675.00^{b}	110.87***
Dressed weight (g/bird)	1799.85^{a}	1636.15^{a}	1786.76^{ab}	1555.45^{ab}	1168.25^{c}	1229.15^{c}	82.43***
Dressing percentage	69.76^{a}	66.78^{ab}	69.27^{ab}	66.19^{c}	63.12^{c}	67.18^{bc}	1.51*
Carcass cuts[1]							
Drumstick	9.59^{b}	9.58^{b}	9.19^{b}	11.08^{a}	10.11^{ab}	10.92^{a}	0.52*
Thigh	11.09	10.70	10.88	10.81	10.76	11.09	0.33**
Neck	8.38	9.41	7.81	7.96	8.14	7.69	0.46^{ns}
Breast	22.43	22.52	22.84	19.11	17.81	22.45	3.04^{ns}
Back	8.63	8.62	8.41	7.34	7.07	7.33	0.87^{ns}
Wings	3.53^{c}	3.62^{c}	3.85^{abc}	4.17^{a}	4.06^{ab}	3.78^{bc}	0.14*
Shoulder	3.53	3.44	3.64	3.84	3.94	3.58	0.24^{ns}
Internal organs[1]							
Proventriculus	0.31^{c}	0.34^{c}	0.34^{c}	0.39^{bc}	0.45^{ab}	0.50^{a}	0.04*
Gizzard	1.79^{c}	1.85^{bc}	1.74^{c}	2.61^{a}	2.65^{a}	2.55^{ab}	0.30*
Kidney	0.63	0.84	0.73	0.70	0.89	0.87	0.14^{ns}
Gall bladder	0.10	0.07	0.14	0.18	0.19	0.18	0.04^{ns}
Spleen	1.25	0.21	0.19	0.10	0.76	0.09	0.25^{ns}
Heart	0.39	0.50	0.49	0.52	0.48	0.48	0.08^{ns}
Lungs	0.45	0.60	0.48	0.49	0.53	0.51	0.04^{ns}
Pancreas	0.24	0.19	0.25	0.26	0.31	0.26	0.04^{ns}
Liver	1.75	1.82	1.88	1.79	2.07	2.01	0.24^{ns}

[1]All carcass cuts and internal organs were expressed as % of live weight.

[a,b,c]Figures with different superscripts in the same row were highly significant ($p<0.001$) and significant ($p<0.05$) different

[ns]Not significantly different ($p>0.05$). SEM = Standard Error of Mean

treatment was highly significant on dressed weight ($p<0.001$) and significant on dressing percent, drumstick, wings, proventriculus and gizzard ($p<0.05$) expressed as percent live weight. In diets where 0, 10, 20 and 30% maize had been substituted with SOPM statistically similar ($p>0.05$) effect was noticed in the mean dressed weight of broiler finisher. The mean dressing percent values obtained in birds fed on diets in which 0, 10 and 20% maize had been substituted were not significantly different ($p>0.05$). Mean dressed weight and dressing percent at the higher levels of maize substitution were lower ($p<0.05$) than at 0, 10 and 20% levels. The utilization of SOPM as a substitute feed ingredient for maize did not suppress the physiological development of these prime carcass cuts (thigh, breast, back, neck and shoulder) of broiler finisher to make them statistically inferior to the carcass cuts from the broiler finisher on the control diet. The significant variations ($p<0.05$) obtained in drumstick and wing which are also important carcass cuts did not follow a particular order consequently, it repeatability or otherwise in other studies will help to infer dietary effect or not.

The effects of substituting maize with SOPM resulted in significant increase ($p<0.05$) in the percent of live weight of proventriculus and gizzard as the level of sweet orange peel meal in the diets increased from 0 to 50%. Digestive enzymes which require aqueous medium start their activities in the proventriculus being the organ which most closely resembles the mammalian stomach. In addition, the more fibrous a feed is the more water it absorbs. Gizzard is an organ involved in digestion in the avian species and thus there may have been some enlargements to cope with more fibrous sweet orange peel meal (7.86%CF) which replaced maize (2.70%CF). The percent of live weight of the other organs were statistically similar ($p>0.05$) among the dietary groups and the gross examination of these organs showed that they were normal. Furthermore, there were no observable negative effects on the health of the birds.

Conclusion: In this study, the performance of the broiler starter and finisher, the carcass evaluation and visceral organ examination of broiler finisher fed diets in which maize was substituted at 0, 10, 20, 30, 40 and 50% with sweet orange peel meal have revealed that SOPM is a potential feed resource in broiler raising. The feeding trial showed that it can be included up to 20% in their diets without adverse effects. However, where fast growth is not the priority SOPM can substitute maize up to 50% level because broiler finishers in this dietary group were able to attain a mean live weight of above 2.0 kg at 9 weeks.

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