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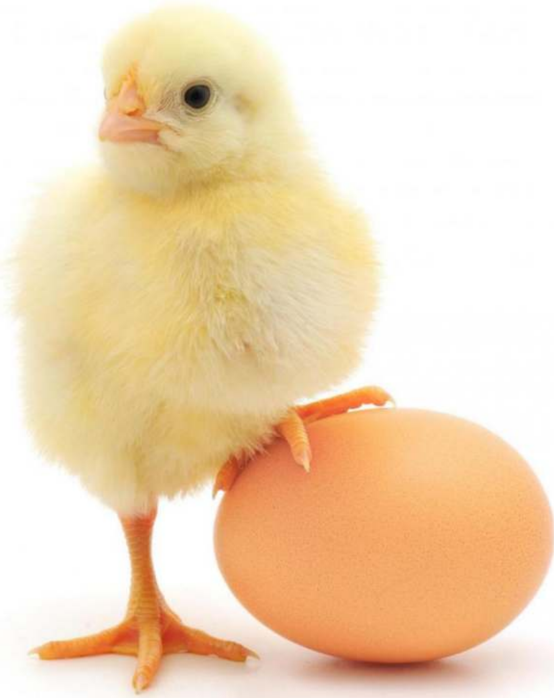

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The Nutritive Potentials of Sweet Orange (*Citrus sinensis*) Rind in Broiler Production

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Abstract: A feeding trial was conducted with one week old one hundred and fifty Anak broiler chickens to assess the nutritive potentials of sun dried sweet orange (*Citrus sinensis*) rind (SOR). They were randomly assigned to five dietary groups in which rind replaced maize at 0, 5, 10, 15, and 20% levels in both starter and finisher diets. Each group had thirty broilers and replicated thrice. The birds were fed *ad libitum* for a nine-week period during which performance indices and carcass cuts and organs were evaluated. Experimental diets had no significant effect ($p>0.05$) on feed intake, body weight gain, water consumption, water: feed ratio, feed conversion ratio and feed cost per broiler while final live weight was affected significantly ($p<0.05$). Increasing dietary SOR content beyond 15% reduced growth rate, which cumulatively caused a decrease in final live weight. Diets had significant effect only thigh+drumstick and the abdominal fat, and the dressing percentage values of broilers on the SOR diets were higher those on the control. The liver of chickens on the 20% SOR replacement treatment manifested hypoplasia. The study has shown that dried SOR can be used to replace dietary maize in the diet of broilers at 15% level.

Key words: Broiler, carcass, performance, sweet orange rind

Introduction

It has been noted that the shortage of feed during drought and their high costs are significant limiting factors to increasing the production of livestock in the developing countries. This shortage of food, especially the major cereals often prevent any significant development in production of poultry and pig as these stocks depend largely on a constant supply of cereal grains like maize, guinea corn and millet as a basic source of energy (Adegbola, 1976). Thus, this has led to increasing cost of finished feeds which often accounted for about 70 to 80% of the total cost required to raise poultry (Ademosun, 1982; Oruwari *et al.,* 1995) which contrasts with what is obtainable in the developed countries (Tackie and Flesncher, 1995). In other to reduce the cost of feeds and thus make poultry production profitable, there is a need to search for cheaper, non-competitive and readily available feed ingredients to replace the costly ones. The increasing mechanization of crop farming in developing economies has led to a rise in the tonnage of agro-allied by-products most of which lie waste. One of such wastes could emanate from the citrus, a major fruit of subtropical region (Rice and Rice, 1987). Citrus is botanically a large family whose dominant members include sweet orange (*Citrus sinensis*), tangerine orange (*Citrus reticulata*), grape fruit (*Citrus paradisi*). Sweet orange (*Citrus sinensis*) production in Nigeria is significant, with heavy direct consumption due primarily to few and small capacity processing industries to convert the fruit to juice, concentrate and canned fruit. Nigeria produces 3% of fresh citrus in the world, and Africa produces 3,741,000 tonnes of varieties of citrus fruits of which Nigeria contributes 3,240,000 (FAO, 2004). The rind (peels) obtained from the pericarp is available in large quantities during the citrus season thereby constituting environmental problems since it is not being put into any productive use. Information on the feeding potentials of this abundant agricultural waste to farm animals tends to emphasize more on its utilization as partial substitutes for cereals in concentrates ration for ruminants (Adegbola, 1976; Chapman *et al.*, 2000), the use of citrus pulp in dairy cow (Jeju Experimental Station, 1991). The objective of this study is to make a nutritional assessment of the feeding value of sun dried sweet orange (*Citrus sinensis*) rind and determine its potentials as a feed ingredient in broiler production.

Materials and Methods

Fresh sweet orange rind was collected from peeled orange retailers at two locations: the Federal University of Agriculture, Makurdi and court 5, within Makurdi metropolis. The rind was sun dried until it became brittle and stored in synthetic bags tied at the open end to keep it in a dry state and was ground just before the experimental diets were compounded in the course of the trial. A sample of the milled sweet orange rind (SOR) was analyzed for its proximate constituents (A.O.A.C., 1990), gross energy using the Ballistic bomb calorimeter (Gallenkamp manufactured in the United Kingdom) and vitamin using the method of the American Association of Vitamin Chemists (1966). The results

Table 1: Nutrient composition of sweet orange (*Citrus Sinensis*) rind and maize (dry matter basis)

Nutrients	Feedstuffs	
	Sweet orange rind	Maize*
Dry matter (%)	89.65	90.48
Crude protein (%)	10.74	10.52
Crude fibre	7.86	2.20
Ether extract (%)	12.60	3.98
Ash (%)	11.90	1.72
Nitrogen free extract (%)	56.90	81.58
Metabolizable energy** (MJ/Kg)	16.66	17.66
Vitamin C (mg/100g)	3.88	-

*Source. Tuleun (2003). **Metabolizable energy = 53+38 (%CP+ 2.25 x% EE + 1.1x% NFE + 0.22CF) - modified formula of Carpenter and Clegg (1956).

obtained are in Table 1. Five isocaloric and isonitrogenous diets were compounded both at starter and finisher phases (Table 2). In these diets, rind was used to replace maize at 0, 5, 10, 15, and 20% levels in $M_{100}R_0$, $M_{95}R_5$, $M_{90}R_{10}$, $M_{85}R_{15}$, and $M_{80}R_{20}$ diets, respectively. One hundred and fifty day-old Anak broiler chicks were used in the study. The chicks were brooded together for one week on deep litter about 5cm thick. During this period they were fed a uniform diet formulated to contain 22.63% crude protein and 12.96MJ/kg metabolizable energy by using all the ingredients on Table 1 except the sweet orange rind. Thereafter the chicks were randomly distributed to five dietary groups of three replicates each and 10 chicks per replicate. Brooding continued for two more weeks. The actual feeding trial lasted nine weeks (five weeks for starter and four weeks for finisher). Vaccinations were given against Newcastle and infection bursal diseases, while coccidiostat and anti–stress were periodically administered as prophylactic measures through drinking water. All other management routines such as removal of litter, daily cleaning of drinkers, removal of stale feed were carried out during the study.

The birds were fed *ad libitum* and had access to drinking water throughout the trial. Feed intake was determined by difference between feed offered and leftover and likewise water consumption. The birds were weighed weekly, body weight gain (BWG) computed and feed conversion ratio obtained from the ratio of feed intake to BWG. Records of financial transactions were kept for cost benefit analysis. Eighteen hours to the termination of the feeding trial three broiler chickens per treatment were denied access to feed, weighed at the end of fasting and slaughtered for carcass evaluation. The slaughtered birds were held head down to ensure a thorough blood drain. The sacrificed birds were dressed by immersing in hot water (70°C) for about 20 seconds to defeather and thereafter plucked weights were taken before evisceration. Carcass cuts, visceral parts and abdominal fats were weighed and expressed as relative proportion (%) to corresponding live weights.

The data collected in the study was statistically analyzed using the analysis of variance procedure (Snedecor and Cochran, 1978) to determine significant effects. Means of significant ($p<0.05$) indices were separated using the least significant technique (Steel and Torrie, 1980).

Results and Discussion

The nutrient composition of SOR and maize in Table 1 shows that both feedstuffs are similar in terms of their dry matter (DM), crude protein (CP) and metabolizable energy (ME) contents but the sweet orange rind has higher levels of CF, EE and ash and lower levels of NFE compared with maize. A fibre level of 7.86% in SOR is not beyond the limit of what chickens can accommodate in their ration (SON, 1989). Its fat content may be advantageous not only as a dietary energy source but also in binding the powdery constituents of mash feed. Nigerian feeds are usually too dusty for lack of dietary fat. The reduction of dustiness in absence of pelleting may increase feed intake and thereby improve performance. In monogastric nutrition, CP and ME have particularly been established as critical nutrients required for optimal performance (NRC, 1994; Olomu and Offiong, 1980; Baghel and Pradhan, 1989). Thus, the nutrient composition of SOR appears to be such that it may be able to perform the dietary functions of maize in broiler nutrition.

The performance response of broiler to dietary maize replacement with SOR is presented in Table 3. There was no significant effect ($p>0.05$) of diets on water consumption, feed intake, BWG, FCR, water:feed ratio between the treatment groups. The broilers on the SOR based diets had higher water consumption than broilers on the control diet and furthermore water consumption increased as the dietary content of SOR increased up to 15%. The water:feed ratio also gradually increased from 2.89 to 3.26 as the level of maize replaced rose from 5% to 20%. These observations can be attributed to the oil present in the oil sac of orange rind that has been reported to be acidic and bitter (Adegbola, 1976). The consumption of more water per unit weight of feed intake by the chickens appears to be a metabolic response to neutralize the effect of the bitter taste of oil in the rind. The study has shown the potential of SOR in broiler diet up to 15% maize replacement to stimulate the birds to eat more compared with control diet. Mean fed intake at 20% SOR replacement was least (80.85 g/day) despite the fact that all the diets had same energy to protein ratio. Sweet orange rind has been reported to be unpalatable because of the bitter taste of its oil (Adegbola, 1976). The drop in feed intake at 20% SOR replacement could be an indication that at this level of replacement, the diet becomes less palatable to broilers. D-limonene an appetite depressing factor, reported to be present in citrus rind (Jong-Kyu *et al.*, 1996) may have caused the depressed feed intake. The

Table 2: Experimental broiler starter and finisher diets with sweet orange rind replacing maize at 0, 5, 10, 15 and 20% levels

Feed Ingredients (%)	Starter Diets					Finisher Diets				
	$M_{100}R_0$	$M_{95}R_5$	$M_{90}R_{10}$	$M_{85}R_{15}$	$M_{80}R_{20}$	$M_{100}R_0$	$M_{95}R_5$	$M_{90}R_{10}$	$M_{85}R_{15}$	$M_{80}R_{20}$
Maize	45.70	43.41	41.13	38.84	36.56	52.83	50.19	47.55	44.91	42.26
Full fat soybean	41.35	41.35	41.35	41.35	41.35	34.22	34.22	34.22	34.22	34.22
Orange rind	0	2.29	4.57	6.86	9.14	0	2.64	5.28	7.92	10.57
Blood meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
BDG[1]	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
Oyster shell	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Premix [2]	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
DL-methionine	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
L- lysine	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
Calculated Nutrients										
Energy (MJME/kg)	12.96	12.96	12.97	12.98	12.99	13.00	13.00	13.10	13.02	13.03
Crude protein (%)	22.63	22.65	22.65	22.66	22.68	20.65	20.67	20.69	20.70	20.72
Calorie: Protein ratio	137:1	137:1	137:1	137:1	137:1	150:1	150:1	150:1	150:1	150:1
Crude fibre (%)	4.70	4.80	4.90	4.99	5.09	4.44	4.55	4.65	4.77	4.89

[1]Brewer-dried grain. [2]Vitamin/mineral premix: Each 1kg contains Vit. A 6,000.000 IU, Vit D_3 1.2,000,000 IU, Vit. E 12,000IU, Vit. K_2, 200mg thiamine 800mg, Riboflavin 2,400mg, Pantothenic acid 4,000mg, Pyridoxine 2,000mg, Niacin 16,000mg, Vit. B_{12} 8mg, Folic acid 250mg, Biotin 32ng, Choline Chloride 200g, Antioxidant 50g, Mn 38.4g, Zn 24g, Fe 9.6g, Cu 2.4g, Se 96mg, Co 96g.

experimental diets had significant effect (P<0.05) on final live body weight of the broilers. In line with the dietary intake pattern in this study, diets containing 5, 10 and 15% SOR produced heavier chickens 2223g, 2206g, and 2153g, respectively than those in the control group 2123g. The statistical relationship between them at these replacement levels was not significant (p>0.05). The 20% group yielded broilers with the smallest and significantly lower (p<0.05) mean live body weight of 1723g. Body weight has been reported to increase in proportion to feed intake (Bogart and Taylor, 1983). The final live body weight sequence that is being associated with the feed intake level seems to be a reflection of the suitability of the diets for broilers. With the exception of birds on the 20% SOR replacement, the mean final live body weights of the broilers in the other groups were higher than a range of 1820g to 2120g reported by Udedibe *et al.* (2004) who fed some unconventional feeds to broilers. Growth rate of 32.14g/day recorded for broilers in the control group was similar to 33.55g, 33.28g, and 32.47g for broiler on diets containing 5, 10 and 15% SOR respectively, whereas at 20% SOR, a decline in growth rate was recorded. The experimental diets had no significant effect (p>0.05) on FCR. Feed conversion to meat was least efficient in the 20% SOR diet as the chickens in this group required more feed per unit weight gain. Another obvious implication is that it will take a longer time for chickens receiving this diet to reach a live body weight numerically comparable with broilers on the other diets. It therefore seems that at 20% of maize replacement with sun dried SOR, the latter may begin to impair the ability of broilers to utilise dietary nutrients for normal growth. There was a reduction in feed cost with increase in the quantity of maize replaced because SOR has no purchasing cost attached to it. It was collected free from peeled orange retailers who were relieved of the difficulties they experience in its daily disposal. Considering the food intake regimes, birds on the 5% SOR diet had the highest feed cost of $0.39/kg. There was however, no significant difference (p>0.05) in the cost of feed required to raise a broiler chicken to market weight. There was a drop in the cost of feed as the SOR content increased, which means that raising broilers on the 20% SOR diet was cheapest ($1.82). However, this level of replacement cannot be recommended in favour of 15% SOR diet that was next to it in order of cost effectiveness because of the very apparent mean body weight difference between the chickens in the two dietary groups. The mortality records showed that the survival rates of the birds receiving the SOR diet were as high as the control group. Mortality occurred only between weeks 8 and 9 and post-mortem examinations suspected bacteria infection thus eliminating dietary complications. This might be a good indicator of the suitability of SOR as a dietary energy feeds stuff in broiler diets.

The data generated from carcass evaluation is presented in Table 4 the diets had significant effects (p<0.05) only on thigh+drumstick and the abdominal fat deposit of broilers. The relative weights of thigh+drumstick significantly increased (p<0.05) in the broilers receiving the SOR based diets up to 15% SOR replacement and thereafter decreased. Generally, the values obtained for carcass cuts of birds on the SOR diets were higher than for the control. The abdominal fat content of 0.28% to 0.65% live weight showed a significant increasing effect (p<0.05) from 0% to 20% SOR replacement. The abdominal fat level in this study

Table 3: Effect of sweet orange rind as replacement for maize in broiler diet on performance and economics of production

Performance Indices	Experimental Diets					
	$M_{100}R_0$	$M_{95}R_5$	$M_{90}R_{10}$	$M_{85}R_{15}$	$M_{80}R_{20}$	SEM
Initial body weight (g/bird)	108.33	109.67	110.00	107.67	109.17	3.73^{NS}
Mean feed intake (g/day)	86.63	89.86	86.68	87.52	80.85	11.92^{NS}
Mean water consumption (ml/day)	229.10	234.81	235.47	241.92	238.30	23.03^{NS}
Water: feed ratio	2.97	2.89	3.04	3.07	3.26	0.26^{NS}
Final body weight (g/bird)	2123.33^{ab}	2223.33^{a}	2206.67^{ab}	2153.33^{ab}	1723.33^{b}	139.98*
Mean body weight gain (g/day)	32.14	33.55	33.28	32.47	25.62	12.36^{NS}
Feed conversion ratio	2.70	2.68	2.60	2.70	3.16	1.49^{NS}
Survivability (%)	96.67	100.00	93.33	90.00	93.33	
Cost of experimental diet (N/kg)	51.73	51.43	50.50	49.54	47.96	
Mean feed intake cost per broiler (N)	282.52	291.15	279.34	272.95	242.27	9.54^{NS}

^{a,b,} means in the same row with different superscripts are significantly different (P<0.05) . ^{NS}Not significantly (P>0.05).
SEM = Standard error of mean

Table 4: Effect of maize replacement with sweet orange rind on the carcass quality and visceral parts of Broiler chickens

Carcass quality	Experimental Diets					
	$M_{100}R_0$	$M_{95}R_5$	$M_{90}R_{10}$	$M_{85}R_{15}$	$M_{80}R_{20}$	SEM
Carcass cuts						
Live BW (g)	2139.66	2355.00	2256.66	2159.00	1983.66	251.15^{NS}
Plucked weight (g)	1926.50	2116.23	2023.67	1969.77	1767.00	223.34^{NS}
Dressed weight (g)	1646.53	1813.40	1751.70	1696.30	1557.83	194.17^{NS}
Dressing percentage	76.98	77.13	77.78	78.39	78.46	1.91^{NS}
Relative weight of cuts[1]						
Breast weight	23.41	22.95	22.03	21.52	22.17	1.82^{NS}
Thigh+drumstick	20.92^{c}	21.28^{bc}	22.54^{ab}	23.74^{a}	22.45^{ab}	0.66*
Loin+neck weight	9.45	9.38	9.44	8.79	9.86	0.54^{NS}
Wing weight	8.49	8.14	8.67	8.34	8.43	0.35^{NS}
Back weight						
Visceral part[2]	7.87	8.49	8.15	7.90	8.16	0.64^{NS}
Liver	1.81	1.85	1.82	1.85	1.57	0.17^{NS}
Kidney	0.64	0.48	0.56	0.58	0.59	0.08^{NS}
Lung	0.58	0.50	0.45	0.48	0.53	0.14^{NS}
Spleen	0.13	0.09	0.09	0.15	0.16	0.06^{NS}
Gizzard	3.02	2.99	2.97	2.83	3.24	0.48^{NS}
Bile	0.27	0.18	0.41	0.26	0.28	0.07^{NS}
Heart	0.43	0.41	0.44	0.47	0.41	0.06^{NS}
Abdominal fat	0.28^{b}	0.47^{ab}	0.56^{ab}	0.58^{ab}	0.65^{a}	0.09
Intestinal tract	5.77	5.75	5.06	4.42	5.22	0.63^{NS}

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05). ^{NS}Not significantly different (P>0.05)
SEM= Standard error of mean. 1, 2 = values are expressed as percentages of live weight.

is similar to 0.38-0.65% reported by Sogunle *et al.* (2005). The increase in dietary fat of the experimental diets as their SOR content increased could be due to the oil sacs present in the rind. The range in this study is much lower than 2% estimated that abdominal fat of broiler finisher could be (Anonymous, 1983). This seems an economic advantage, as abdominal fat constitutes part of the live weight of broilers and affect price. While, other carcass traits did not show a definite order, it was observed that the dressing percent of broilers on all the treatments were higher than 75%, and 68.5% (Adeniji, 2005) but comparable with 79.76% (Idowu and Eruvbetine, 2005). This result becomes important since dressing percent is the absolute value of saleable meat. The effect of diet on the visceral organs was not significant (p>0.05). It was observed that the liver of the chickens on 20% SOR replacement manifested hypoplasia. It is possible that metabolic processes to neutralize the bitter taste of SOR by the liver requires the release of fluid from the liver cells thereby causing reduced liver size.

Conclusion: The results of this study have shown that up to 15% dietary maize in broiler diet can be replaced with sun dried SOR without reducing the performance of broilers. As a high energy and protein source like maize, its inclusion in livestock feed would help to reduce the cost of maize, a major feedstuff in animal feed formulation. It is therefore suggested that its practical abundance should be exploited as a significant leap to reduce the high demand on maize, its accompanying high cost and its direct effect on the cost of finished table meat product. Other processing methods can also be applied to SOR in order to further reduce its bitter taste, which this study has revealed restricted feed intake by broilers.

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