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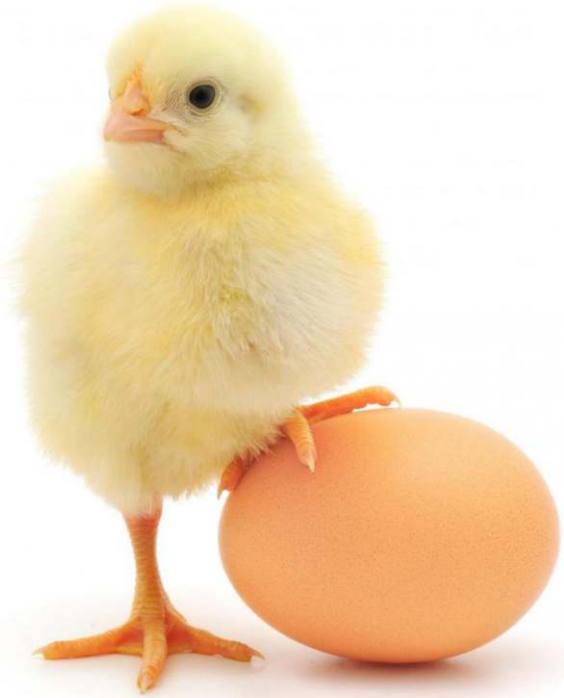

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Effect of Fermentation of Sweet Orange (*Citrus sinensis*) Fruit Peel on its Phytonutrients and the Performance of Broiler Starter

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Abstract: A 5-week feeding trial to determine the effect of fermentation of sweet orange (*Citrus sinensis*) fruit peel on its maize replacement value in broiler starter diet was conducted. Sweet orange fruit peels were collected from peeled orange sellers and divided into three portions. The first portion was not fermented (SP_0), while the second and third portions were fermented for 24hrs (SP_{24}) and 48hrs (SP_{48}), respectively. They were separately sun-dried, milled and samples screened and analyzed for phytonutrients. Four different diets namely the control (CD) and three test diets SP_0D, $SP_{24}D$ and $SP_{48}D$ in which SP_0, $SP_{24}D$ and SP_{48} replaced maize in the control diet (CD) at 30% level in that order were compounded. Seven-day old one hundred and twenty Anak 2000 broiler chicks were randomly assigned to these diet groups to evaluate their performance. There was a decrease in the concentration of each of oxalate, flavonoid, tannin, saponin and phytate detected in the peels as the duration of fermentation increased from 0 to 48hrs. Thirty percent replacement of maize by the fermented sweet orange fruit peel meal depressed body weight gain ($p<0.01$), feed intake ($p<0.05$) and live weight ($p<0.01$) of broiler starter. The fermentation technique used in this study did not improve the nutritive value of the sweet orange fruit peels to enhance its suitability as a feed resource in broiler starter production.

Key words: Sweet orange peel, phytonutrients, performance, broiler starter

INTRODUCTION

Domestic animals make important contribution to the global food security. They account for about 30% of the global value of food production and produce 34% of the protein and 16% of the energy consumed in human diets (FAO, 2002). In Nigeria, the high cost of animal protein has made the protein intake to fall below 10g per caput (FAO, 1996). Seasonal effect on the availability of energy and protein feed ingredients which are basic requirements in commercial feed preparation contributes to the high cost of animal protein. Since the livestock industry is a major contributor to the physical, mental and socio-economic development of any nation the need to search for, identify and develop alternative feed resources which are cheap and readily available is critical. This is with the view of replacing the more expensive ones (Bashar and Abubakar, 2001). Some agro-industrial by-products like maize offal, rice offal and brewer dried grain have been used to replace cereals (Joseph *et al.,* 2000). Whereas, numerous agro-industrial by-products are produced in most parts of the world including developing nations, their utilization is sometimes limited as a result of their poor understanding of their nutritional and economic values as well as proper use in livestock diets (Albrecht and Muck, 1991). Sweet orange (*Citrus sinensis*) processing wastes like citrus peels, citrus pulp are abundant in Nigeria for a greater part of the dry season when the fruits are harvested. There is a limited information on the antinutrients in citrus by-products and hence their utilization in the livestock industry. Recently, Oluremi *et al.* (2006) *repor*ted that sweet orange rind is comparable in energy and protein with maize and Agu (2006) reported that maize can be replaced by sun dried sweet orange rind in broiler starter diet at 20% for optimal performance and nutrient utilization. Several processing methods have been reported to improve the nutritive quality and utilization of some agro-allied by-products. These include fermentation (Ibrahim, 1981; Obioha and Anikwe, 1982; Adejinmi *et al.,* 2007) ensiling (Obikaonu and Udedibie, 2007).

The Objective of this study is to screen sun-dried fermented and unfermented sweet orange (*Citrus sinensis*) fruit peels to determine the phytonutrients they contain and evaluate the effect of utilization of these peels on the performance of broiler starter.

MATERIALS AND METHODS

The study was conducted in the University of Agriculture Makurdi at the Teaching and Research Farm between the months of November and December which falls within the dry season when the town experiences daily

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Table 1: Qualitative evaluation of phytonutrients in dried fermented sweet orange (*Citrus sinensis*) fruit peel meals

	Sweet orange fruit peel meals		
Phytonutrients	SP_0	SP_{24}	SP_{48}
Oxalate	++	+	-
Flavonoid	++	-	-
Tannin	++	+	-
Saponin	++	+	+
Phytate	++	+	-

++ = Present in moderate amounts. + = Present in trace amounts. - = Absent

Table 2: Quantitative determination of phytonutrients in and the proximate composition of dried ensiled sweet orange (*Citrus sinensis*) fruit peel meals (%)

	Sweet orange fruit peel meals			
	SP_0	SP_{24}	SP_{48}	SD
Phytonutrients				
Oxalate	0.024	0.015	0	0.012
Flavonoid	0.036	0	0	0.021
Tannin	0.018	0.012	0	0.009
Saponin	0.057	0.033	0.023	0.017
Phytate	0.019	0.013	0	0.010
Proximate composition (%DM)				
Dry matter	85.91	87.57	89.23	
Crude protein	7.44	8.29	10.00	
Crude fibre	12.87	13.91	14.63	
Ether extract	2.29	2.50	2.95	
Ash	3.85	4.35	4.47	
Nitrogen free extract	73.54	70.95	67.86	
Gross energy (kcal/kg)	2440.00	2530.00	2890.00	
Metabolizable energy (kcal/kg)	1529.30	1585.40	1811.50	

SD = Standard deviation

high temperatures. The maximum temperature range in Makurdi is 29.8°C to 35.6°C (TAC, 2002). Sweet orange (*Citrus sinensis*) fruit peel (the test ingredient) was collected fresh from orange sellers within Makurdi. The collected peels were divided into three portions for processing. One portion was thinly spread out on a concrete platform and sun dried immediately (SP_0). The second and third portions were put in separate synthetic sacs and tied up for 24 and 48hrs, respectively. Thereafter, they were sun dried like SP_0 to obtain SP_{24} and SP_{48}, in that order. Each portion of sun dried peels was milled and samples were screened in the laboratory for phytonutrients (Table 1). The quantitative amounts of these chemical compounds (Table 2) were determined with the methods recommended by Harborne (1973), Sofowora (1993) Trease and Evans (1989). The proximate composition of the processed peels (Table 3) was done using the methods recommended by AOAC (1995). Four experimental diets were compounded namely the control diet (CD) and three other diets in which dietary maize in the control diet was replaced at 30% level by each of SP_0, SP_{24} and SP_{48} to obtain diets SP_0D, $SP_{24}D$ and $SP_{48}D$, respectively (Table 4). One hundred and twenty 7-day old Anak 2000

Table 3: The gross and nutrient composition of broiler starter experimental diets

	Experimental Diets			
Nutrients	CD	SP_0D	$SP_{24}D$	$SP_{48}D$
Maize	44.43	31.10	31.10	31.10
Full-fat soybean meal	42.62	42.62	42.62	42.62
Sweet orange peel meal	0	13.33	13.33	13.33
Brewer dried grain	6.50	6.50	6.50	6.50
Blood meal	2.00	2.00	2.00	2.00
Bone meal	3.50	3.50	3.50	3.50
Common salt	0.30	0.30	0.30	0.30
Vitamin/mineral premix	0.20	0.20	0.20	0.20
Methionine	0.30	0.30	0.30	0.30
Lysine	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00
Calculated nutrients:				
Crude protein	23.50	23.32	23.44	23.67
Crude fibre	3.99	5.47	5.61	5.71
Ether extract	9.94	9.71	9.74	9.79
[1]Energy (kcal/kg ME)	3241.00	2987.40	2994.90	3025.00
Ca[2]	1.41	1.41	1.41	1.41
P[3]	0.88	0.87	0.87	0.87

[1]Metabolizable energy = 0.860 + 0.629 (G.E - 0.78CF) by Cambell (1986). [2,3]Values did not include the contributions from sweet orange fruit peel meals.

broiler starter chicks were randomly assigned to the four diets at the rate of 30 chicks per diet. Each diet group was replicated three times with a total of 10 chicks per replicate. The birds were on the diets for 35 days and fed *ad libitum*. Daily drinking water supply was not restricted. The feeding troughs and the drinkers were cleaned daily in the morning hours before fresh supplies of feed and drinking water. Vitalyte was administered as an anti-stress and coccidiostat was given at alternate weeks against coccidiosis. Infectious bursal disease (gumboro) and Newcastle (lasota) vaccines obtained from the National Veterinary Research Institute, Vom in Nigeria were given to the broiler chicks through drinking water at the rate of 0.005ml/chick. Performance indices determined were feed intake, body weight, body weight gain (BWG), feed conversion ratio (FCR) and rate of mortality. The feeding trial was a Complete Randomized Design. The data collected was statistically analyzed using the Analysis of Variance (ANOVA) technique outlined in the Minitab Statistical Software (1991). Where significant effects of the experimental diets were obtained, means were separated by the Least Significant Difference (LSD) procedure outlined by Steel and Torrie (1980).

RESULTS AND DISCUSSION

The laboratory analysis to screen for phytochemicals in SP_0, SP_{24} and SP_{48} revealed the presence of oxalate, flavonoid, tannin, saponin and phytate in all or some of the peels (Table 1). The unfermented sweet orange peels (SP_0) contain all these phytonutrients. This observation has been reported in literature (Oluremi *et al*., 2007). The peels fermented for 24hrs (SP_{24}) contain all these compounds with the exception of flavonoid

Table 4: Performance of broiler starter fed diets containing dried fermented sweet orange (*Citrus sinensis*) fruit peel meal

	Experimental Diets				
Performance indices	CD	SP_0D	$SP_{24}D$	$SP_{48}D$	SEM
Initial live weight (g/bird)	72.17	73.76	74.00	72.00	2.53^{NS}
Final live weight (g/bird)	831.67^a	550.67^b	558.67^b	491.00^b	59.34**
Body weight gain (g/bird/day)	21.70^a	13.63^b	13.85^b	11.97^b	1.64**
Feed intake (g/bird/day)	56.16^a	37.72^b	38.78^b	34.02^b	5.53*
FCR (g feed:g body weight gain)	2.57	2.79	2.82	2.88	0.23^{NS}

SEM = Standard error of mean. ^{NS}Not significantly different (p>0.05). *Means with different in the same row are significantly different (p<0.05). ** Means with different in the same row are highly significantly different (p<0.01).

whereas SP_{48} contains only saponin. Quantitatively, fermented sweet orange peels caused a reduction in the concentration of the phytonutrients identified thus making the sweet orange peels fermented for 48hrs to have lower levels of these chemical compounds (Table 2). Apart from decrease in the levels of oxalate (0.024% to 0%), flavonoid (0.036% to 0%), tannin (0.018% to 0%), saponin (0.057% to 0.023%) and phytate (0.019% to 0%) in SP_0, SP_{24} and SP_{48} as the duration of fermentation increased, their concentrations were small and below the levels already reported in literature to have adverse effects on farm animals. For tannin a wide range of 1-20% has been reported (Price and Butler, 1980) and for saponin a level of 3% (Kumar, 1991). Phytate and oxalate concentrations in the sweet orange peels which varied from 0% to 0.019% and 0% to 0.024%, in that order were insignificant compared with 146-353mg% of phytate in maize and 0.275% in beet roots Concon (1988).

The effect of feeding diets containing fermented sweet orange (*Citrus sinensis*) fruit peel meal to broiler starter on their performance is in Table 4. The mean feed intake differed statistically among the treatment groups at 5% level of probability. The starter chicks in the control group had a significantly (p<0.05) higher feed intake of 56g/day than chicks in the sweet orange peel based diets. The chicks on diet $SP_{48}D$ which contained the meal of sweet orange peels fermented for 48hrs had the least mean feed intake (34g/day). The apparent decrease in feed intake as the fermentation time increased may probably be that fermented peels rendered the compounded diets unpalatable. Consequently, appetite for these diets dropped. It is difficult to link the observed decline in feed consumption to the presence of any of oxalate, flavonoid, saponin, tannin and phytate. This is because the concentrations of these phytonutrients in the orange peels are safe for broiler starter. The experimental diets had a highly significant effect (p<0.01) on the body weight gain of the starter birds. The trend of BWG is similar to that of feed intake. It seems that the depressed feed consumption in the orange peel based diets impaired the growth rate of the starter birds thereby making the control group to record a faster growth rate of 21.70g/day as against 13.63g/day, 13.85g/day and 11.97g/day for SP_0D, $SP_{24}D$ and $SP_{48}D$, respectively. This can be as a result of the inability of the experimental chicks to obtain adequate nutrients needed from the feed consumed to make their growth rate at least comparable with the control. The experimental diets had a highly significant effect (p<0.01) on the final live body weight of broiler starter. The cumulative effect of BWG in each of the diet groups over 35 days the feeding trial lasted is reflected in the final mean live weight. The birds in the control group were significantly heavier (p<0.01) with a mean body weight of 831.67g compared with 550.67g, 558.67g and 491.00g which were statistically similar for SP_0D, $SP_{24}D$ and $SP_{48}D$, in that order. The effect of the diet on the feed conversion ratio (FCR) was not significant (p>0.05). There was no record of loss of any bird in any of the diet groups throughout the feeding trial.

Conclusion: Fermenting sweet orange (*Citrus sinensis*) fruit peel as processed in this study yielded a feeding stuff inferior in nutritive quality to maize as a dietary energy source. The quantitative presence of some Phytonutrients in the sweet orange peels could not have been the cause of depressed performance of the broiler starter chicks on the sweet orange peel meal based diets in this study because of their low concentrations. The high crude fibre levels in the fermented peels may be a critical factor to be implicated in the poor growth performance in the broiler starter chicks. Further studies are recommended to elucidate appropriate processing treatments to apply to sweet orange peels to improve its nutritive value in order to enhance its suitability as a feed resource in broiler production.

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