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Effect of Fermentation of Sweet Orange (*Citrus sinensis*) Fruit Peel on its Maize Replacement Value in Broiler Diet

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Abstract: A 70 day feeding trial was conducted with 120, 7day old Anak 2000 broiler chicks to study the effects of fermentation of sweet orange (*Citrus sinensis*) fruit peels on its replacement value as a dietary energy source. Sweet orange peels fermented for duration of 0, 24 and 48 h and thereafter dried and ground were used to each replace maize in the control diet at 30% level. The chicks were divided into four groups, each group replicated three times at the rate of ten chicks per replicate. A group each was assigned to one of the four isonitrogenous diets: CD (control), SP_0D $SP_{24}D$ and $SP_{48}D$, compounded. The performance, carcass quality and weights of the visceral organs were evaluated. Fermentation of sweet orange peels depressed the mean feed intake, body weight gain and live weight of broilers among the treatment groups highly significantly ($p<0.01$) the longer its duration. The performance of broilers in the orange peel based diets was inferior to the control. Fermentation of sweet orange peels caused significant disproportionate growth in % live weight of shoulder ($p<0.05$) and neck+back ($p<0.01$). Utilization of sweet orange peels significantly reduced ($p<0.05$) the % live weight of the abdominal fat thus improving the nutritive value of the meat. Kidney was the only visceral organ significantly affected ($p<0.05$) by the diets. The fermentation procedure in this study has proved inadequate to harness the nutritional potential of the sweet orange fruit peel.

Key words: Sweet orange fruit peel, fermentation, broiler chicks, performance, carcass quality

INTRODUCTION

Livestock plays an important role in Nigeria agriculture contributing 9.88% of the agricultural gross domestic product (CBN, 2003). The 2001 population of livestock in Nigeria has been estimated to be 118.59 m poultry, 45.26 m goats, 28.69 m sheep, 15.60 m cattle, 5.25m pigs and 1m horses, camels and donkeys (NPC, 2004). Despite this enormous resource, a wide gap exists between demand and supply. It has been reported, that the daily animal protein intake per caput in Nigeria is about 8g which is far below the required 35 g protein intake requirement of animal origin out of the 70 g daily recommended total protein intake (Obioha, 1992). One of the major reasons for the low level of animal protein intake in the tropics and in Nigeria in particular is because livestock production is not keeping pace with human population growth rate put at 3.2% (NPC, 2006). Another critical reason is the scarcity of conventional food stuff (energy and protein sources) for monogastric animal feeding and consequently the cost of livestock feed. In Nigeria, feed cost is estimated to be over 70% of the total cost of intensive livestock production. The search for alternative feed resources which are less competitive, not expensive and can be efficiently converted by farm animals to meat and other consumable animal products for the enhancement of animal production has therefore become of great interest.

The poultry industry is one fast means of providing the much needed animal protein to the teeming populace. It has been suggested that the expansion of the Nigeria poultry holds the greatest promise of bridging the animal protein gap in the country within the shortest possible time (Defwang, 1990). Some agro-industrial by-products like maize offal, cocoa husk meal, rice offal, brewer dried grain have been used in poultry diets to replace cereals (Uko *et al*., 1990; Sobamiwa and Akinwale, 1999; Udedibie and Emenalom, 1993). Broiler birds are probably the most universal and important of all poultry as producers of meat for human consumption. It has been reported that sweet orange (*Citrus sinensis*) peel meal obtained from ground sun dried peels can replace dietary maize in broiler

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chicken diet at 20% level without any adverse effect on performance (Agu, 2006). Feed processing helps to enhance the feeding quality of agro-industrial by-products by reducing the level of toxicants where present, improving their nutrient value, acceptability of feed and utilization by animals. This study therefore, investigated the effect of the fermentation of fresh sweet orange fruit peel on its maize replacement value in broiler chickens.

MATERIALS AND METHODS

The study was conducted in the Poultry experimental unit housed within the Livestock section of the Teaching and Research Farm University of Agriculture, Makurdi, Nigeria. A total of 120 healthy 7 day old Anak 2000 broiler chicks purchased from Obasanjo Farms were randomly divided into 4 dietary groups each containing thirty birds. Each group had three replicates and ten chicks per replicate. The dimension of each replicate pen was 164×83cm. The composition of the experimental diets is in Table 1. The test ingredient which was the only variable ingredient was the processed sweet orange (*Citrus sinensis*) fruit peel. Fresh sweet orange fruit peels were gathered from peeled orange sellers in the University town of Makurdi and divided into three portions. The first portion was Sun dried immediately (SP_0) while the 2nd portion was tied in synthetic sack for 24 h before Sun drying (SP_{24}). The third portion was similarly tied, but for 48 h before Sun drying (SP_{48}). Sun drying in each case took about 48 h by which time the peels became crispy. Each of the dried sweet orange peel portions was ground and analysed for its nutrient composition (Table 2). Each peel meal replaced maize as a dietary energy source at 30% level and added to the other ingredients to compound diets SP_0D, $SP_{24}D$ and $SP_{48}D$, respectively. The Control Diet (CD) did not contain sweet orange fruit peel meal. The experimental units were fed *ad libitum* and the birds had free access to cool drinking water daily for the feeding trial which lasted 70 days. Routine management procedures for broiler chickens in terms of sanitary measures, medication and vaccination programmes were adhered too. Feed and water wastages were avoided to guarantee the reliability of feed data from which other performance indices required for valid scientific inferences in this study will be derived and to ensure that the experimental pens were dry. The broilers

Table 1: Composition of the experimental diets (%)

	Starter diets				Finisher diets			
Ingredients	CD	SP_0D	$SP_{24}D$	$SP_{48}D$	CD	SP_0D	$SP_{24}D$	$SP_{48}D$
Maize	44.43	31.10	31.10	31.10	51.61	36.13	36.13	36.13
FFSM	42.62	42.62	42.62	42.62	35.44	35.44	35.44	35.44
SOFPM	0	13.33	13.33	13.33	0	15.48	15.48	15.48
BDG	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50
Blood meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Bone meal	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Common salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix*	0.20	0.20	0.20	0.20	0.25	0.25	0.25	0.25
Methionine	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
Total	100	100	100	100	100	100	100	100
Calculated nutrients (%DM):								
Crude protein	23.50	23.32	23.44	23.67	21.41	21.19	21.32	21.59
Crude fibre	3.99	5.47	5.61	5.71	3.95	5.53	5.69	5.80
Ether extract	9.94	9.71	9.74	9.79	8.93	8.67	8.63	8.78
ME (kcal kg^{-1})	3241.00	2987.40	2994.90	3025.00	3235.40	2940.90	2949.60	2984.60
Calcium[1]	1.41	1.41	1.41	1.41	1.40	1.40	1.40	1.40
Phosphorus[2]	0.88	0.87	0.87	0.87	0.85	0.85	0.85	0.85

FFSM = Full Fat Soybean, SOFPM = Sweet Orange Fruit Peel Meal, BDG = Brewer Dried Grain, *Vitamin/mineral premix, [1, 2]Values did not include the contribution from SOFPM

Table 2: Nutrient composition of fermented sweet orange fruit peels (%DM)

Nutrients	SP_0	SP_{24}	SP_{48}
Dry Matter (DM)	85.91	87.57	89.23
Crude Protein (CP)	7.44	8.29	10.04
Crude Fibre (CF)	12.87	13.91	14.63
Ether Extract (EE)	2.29	2.50	2.95
Ash	3.85	4.35	4.47
Nitrogen Free Extract (NFE)	73.54	70.95	67.86
Gross energy (kcal kg^{-1})	2440.00	2530.00	2890.00
[1]Metabolisable energy (kcal kg^{-1})	1529.30	1585.40	1811.50

[1]Metabolisable energy = 0.860+0.629(G.E-0.78CF) by Cambell (1986)

were weighed weekly to determine the growth rate in each diet group. The corresponding feed intake for each experimental unit was also recorded. The Feed Conversion Ratio (FCR) was obtained from the ratio of feed intake: body weight gain. At the end of the trial (70th day), three broiler chickens were randomly selected from each dietary group for carcass evaluation. Prior to slaughter, the birds were starved of feed for about 18 h and individual Live Weight (LW) taken. Then the head was severed from the rest of the body from the neck. Slaughtered birds were immersed in hot water (about 80°C) for about 10s, immediately defethered, eviscerated and cut into carcass parts. The weights of the carcass cuts and internal organs were taken using the Mettler B12001 electronic balance. All weights were expressed as percentage of Live Weight (LW). Dressing percentage was calculated using the formula recommended by Fielding (1991). The nutrients in the test ingredients i.e. SP_0, SP_{24} and SP_{48} were determined using the standard methods (AOAC, 1995).

All the performance, carcass quality and visceral organs data obtained in the trial were statistically analysed using one-way Analysis of Variance procedure outlined in Minitab Statistical Software (1991). The means of parameters which were significantly different were separated by applying the Least Significant Difference (LSD) procedure (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The nutrient composition of the sweet orange fruit peel meals in Table 2 shows that their Crude Protein (CP), Crude Fibre (CF), Ether Extract (EE), ash and Gross Energy (GE) contents expressed on percent of Dry Matter (DM) increased from the 0 h to 48 h fermentation duration, whereas the Nitrogen Free Extract (NFE) decreased. The CP in the peels fermented for 0 and 24 h were lower than 9.25% CP in maize (Tuleun *et al*., 2005), while 10.04% CP for the peels fermented for 48 h was higher. The CF in the peels which was in the range of 12.87-14.63% DM was comparatively higher than 2.20% CF reported for maize (Tuleun *et al*., 2005). The CF obtained in this study agrees with CF content of 13.66-14.99% DM in the peels of some citrus fruit varieties (Olureni *et al*., 2007). This high peel CF may reduce its feeding value compared to dietary maize in non-ruminant nutrition.

The performance of broiler chickens in the feeding trial is in Table 3. It was observed that the replacement of maize with sweet orange fruit peel meal in the diet affected the Live Weight (LW), Body Weight Gain (BWG) and feed intake significantly. The mean final live weight of broilers in the Control Group (CG) was 2022g and it was significantly higher ($p<0.05$) than 1397, 1239 and 1110 g for chickens in SP_0, $SP_{24}D$ and $SP_{48}D$, respectively. There was no significant difference ($p>0.05$) in the live weights

Table 3: The growth performance of Broilers on experimental diets

	Experimental diets				
Performance indices	CD	SP_0D	$SP_{24}D$	$SP_{48}D$	SEM
Initial body weight (g bird^{-1})	72.17	73.67	74.00	72.00	5.53^{NS}
Final body weight (g bird^{-1})	2022.33^{a}	1397.67^{b}	1239.67^{b}	1110.67^{b}	156.00**
Feed intake (g bird^{-1})	98.02^{a}	68.50^{b}	63.10^{b}	63.77^{b}	4.84**
Body weight gain (g/day/bird)	27.86^{a}	18.92^{b}	16.65^{b}	14.84^{b}	2.21**
Feed conversion ratio	3.35	3.47	3.69	3.77	0.21^{NS}
Mortality	1/30	0/30	0/30	0/30	

SEM = Standard Error of Mean, ^{NS}Not significantly different ($p>0.05$), ^{a,b}Means in the same row with different superscripts are highly significantly different ($p<0.01$)

Table 4: The Carcass data of broilers on experimental diets

	Experimental diets				
Carcass indices	CD	SP_0D	$SP_{24}D$	$SP_{48}D$	SEM
Pre-slaughter weight (g bird^{-1})	1713.30	1323.30	1156.70	1173.30	235.45^{NS}
Plucked weight (%LW)	44.79	94.59	94.63	95.14	1.54^{NS}
Eviscerated weight (%LW)	81.04	78.79	75.97	77.42	2.03^{NS}
Dressing percentage	77.42	75.38	71.62	73.68	2.22^{NS}
Thigh (%LW)	10.68	11.05	10.19	10.60	0.59^{NS}
Drumstick (%LW)	11.73	11.87	10.82	10.58	0.55^{NS}
Breast (%LW)	18.15	17.46	16.34	16.23	1.22^{NS}
Wing (%LW)	4.67	4.73	4.75	5.02	0.12^{NS}
Shoulder (%LW)	4.67	5.89	6.10	6.13	0.96*
Neck+back (%LW)	17.90	15.62	15.03	15.55	0.44**
Abdominal fat (%LW)	1.19	0.40	0.37	0.39	0.25*

%LW = Percent Live Weight, SEM = Standard Error of Mean, ^{NS}Not significantly different ($p>0.05$), ^{a,b}Means in the same row with different superscripts are significantly different ($p<0.01$)

Table 5: The weight of visceral organs of Broilers fed experimental diets (%LW)

	Experimental diets				
Visceral organs	CD	SP_0D	$SP_{24}D$	$SP_{48}D$	SEM
Gizzard	2.90	2.35	2.99	2.82	0.33^{NS}
Proventriculus	0.44	0.54	0.54	0.49	0.05^{NS}
Liver	1.86	2.25	2.25	2.27	0.19^{NS}
Heart	0.44	0.46	0.39	0.52	0.05^{NS}
Gall bladder	0.16	0.15	0.19	0.24	0.07^{NS}
Kidney	0.69^{b}	0.95^{a}	1.00^{a}	0.94^{a}	0.09^{*}
Spleen	0.15	0.12	0.14	0.16	0.02^{NS}
Lung	0.80	0.63	0.68	0.88	0.10^{NS}

SEM = Standard Error of Mean, ^{NS}Not significantly different ($p>0.05$), ^{a,b}Means with different superscript in the same row are significantly different ($p<0.05$)

of broilers among the treatment receiving the sweet orange peel meal based diets. This implies that the processing of sweet orange peel by fermentation applied in this study has not improved the nutrients quality of the peel to make it a suitable replacement for maize as an energy source in raising broilers. The longer the time for fermentation of the fresh sweet orange fruit peels, the lighter the broiler chickens became. Diet treatment effect on BWG which is a measure of the growth rate of broilers was highly significant ($p<0.01$). The birds in the control group had the highest daily BWG of 27.86 g broiler^{-1} whereas for the orange fruit peel diets, BWG were significantly lower. The growth rates of the experimental chickens were depressed in the diets containing the sweet orange peel meals. This shows that long duration of fermentation of the fresh orange peels resulted in a more adverse effect on BWG. In other words as the length of fermentation of the peels increased from 0 h to 48 h, daily BWG decreased, from 18.92 bird^{-1} to 14.84 g bird^{-1}. This daily BWG range was found to be lower than an average of 25.7g to 33.5g (Oluremi *et al*., 2006) and 38.11g to 58.37g (Agu, 2006) when unfermented sweet orange peel meal substituted maize in the diet of broilers. The effect of the experimental diets on the mean feed intake of broiler chickens was highly significant ($p<0.01$). The control group had an average daily intake of 98.02g and it was significantly higher than the intake regime of 63.10-68.50g in the sweet orange fruit peel meal based diets. Sweet orange fruit peel contains oil which is acidic and confers on it a sharp taste which may have been responsible for the depression in the quantity of feed consumed by broilers in the SP_0D, $SP_{24}D$ and $SP_{48}D$ test groups. The experimental diets did not have any significant effect ($p>0.05$) on Feed Conversion Ratio (FCR) of broilers. A progressive decline in FCR as the duration of peel fermentation increased was observed. This is an indication that long fermentation period of the sweet orange peels impairs nutrient utilization in broilers. In the feeding trial, only one chicken from the control treatment died. This mortality rate is lower than 1% which is below a mortality rate of less than 4% regarded as normal for broiler (AERLS, 1987).

Broiler carcass data and the result of the statistical analysis are in Table 4. The effects of the diets on pre-slaughter Live Weight (LW), dressing percentage, plucked weight, eviscerated weight and the following carcass cuts: Thigh, drumstick, breast and wing weights expressed as percent LW were not significantly different ($p>0.05$) among the treatment means. This shows that the substitution of maize with sweet orange fruit peel in broiler chicken diet did not have any negative effect on these carcass cuts compared with the control in terms of proportionate growth in relation to live eight. The experimental diets however, had significant effects on shoulder cut ($p<0.05$), neck+back cut ($p<0.01$) and abdominal fat ($p<0.05$) expressed as %LW. As the time lag of peels fermentation increased the shoulder cut showed a significant increase ($p<0.05$) while the neck+back cut significantly decreased ($p<0.01$). The abdominal fat was observed to be significantly reduced in the sweet orange peel meal based diets. There is the possibility that sweet orange peel possesses some intrinsic factor(s) which do not promote the deposition of fat in the body. In a recent study (Oluremi *et al*., 2007), the presence of saponin in sweet orange peel has been reported and this compound has been observed to have hypocholestremic action (Oakenfu and Sudhu, 1983). It is known that high carcass fat reduces the economic value of animal meat. It thus appear that if adequate processing techniques to enhance the nutritive value of sweet orange fruit peel can be evolved to enable it promote fast broiler growth rate, then it can be a viable dietary energy substitute for maize in feeding with a view to reducing the cholesterol content of meat.

The result obtained showing the effect of the experimental diets on visceral organs of broiler chicken is in Table 5. The % live weight of kidney of the experimental chickens for SP_0D (0.95%), $SP_{24}D$ (1.00%) and $SP_{48}D$ (0.94%), were significantly higher ($p<0.05$) than 0.69% for CD the control diet. It is hoped that further studies will investigate the cause of this significant kidney weight in view of the critical role this organ plays. The % live weight of proventriculus, gizzard, liver, gall bladder, heart, lung and spleen of broilers on the sweet orange fruit peel

diets were statistically comparable ($p>0.05$) with the corresponding visceral organ weights in the control diet. This result shows that sweet orange fruit peel at 30% level of maize replacement investigated did not have adverse effect on most of the internal organs. This citrus by-product may therefore, not threaten the health of broiler chickens.

CONCLUSION

The performance data has evidently showed that fermentation of sweet orange (*Citrus sinensis*) peels depressed broiler performance. However, it did not result in disproportionate growth of most of the carcass cults nor did it jeopardize the health of the birds. The only mortality recorded was the loss of one chicken in the control group. With the exception of the kidney weight, substituting dietary maize with sweet orange peel meal did not produce any significant effect ($p>0.05$) as visceral organ weights. Visceral organs are critical for good health status of broiler chickens just like any other farm animals. While the nutrient composition of sweet orange fruit peel seems to highlight its potential to serve as an alternative feed stuff to maize, it's apparent that the fermentation technique employed in the present study is not adequate to transform it into a form that will enhance its usefulness. Further studies are required to discover appropriate processing methods to harness its nutritional potential.

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