Research Article

Effect of Water Soaking of Sweet Orange (*Citrus sinensis*) Fruit Peels on Haematology, Carcass Yield and Internal Organs of Finisher Broiler Chickens

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Abstract | The experiment was conducted to determine the effect of water soaking of sweet orange (*Citrus sinensis*) fruit peels on haematology, carcass yield, internal organs and gastro-intestinal tract (GIT) of finisher broiler chickens. Four lots of sweet orange (*Citrus sinensis*) fruit peels were soaked in water for 0, 12, 24 and 36 hours, sun dried and milled to produce sweet orange fruit peel meal (SOFPM). Four SOFPM based diets namely D0, D12, D24, and D36 were compounded by replacing 20% of dietary maize in the control diet (DN) with the SOFPMs. One hundred and fifty (150) brooded Anak 2000 broiler chickens with an average initial weight of 1051.00 ± 0.92g were grouped into five, with each group replicated three times and a replicate contained 10 birds in completely randomized design and assigned to these diets in a feeding trial which lasted for 21 days. Results of analysis of variance on mean haematological indices, fasted body weights, carcass yield and internal organs were not significantly different (p>0.05) among the treatment groups. With the exception of large intestine length, which was significantly decreased (p<0.05) at D0, all other GIT morphometrical indices were not significantly different (p>0.05) among the treatment groups. It was concluded that 20% replacement of maize by SOFPM was safe for finishing broiler chickens.

Keywords | Haematology, Carcass, Citrus, Peel, Soaking

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INTRODUCTION

The use of agro-industrial by-products is a possible solution to the high cost of feed ingredients, which results to high cost of production, since some could be gotten relatively free of monetary cost (Orayaga et al., 2015a). Agro-industrial by-products such as mango fruit by-products (Guzmán et al., 2012; Orayaga et al., 2015b) and sweet orange fruit peels (Oluremi et al., 2007; Agu et al., 2010) have been identified as feed resources in animal production that can ameliorate the high cost of animal production, especially in mongastic animals.

Sweet orange (*Citrus sinensis*) fruits are produced on a large quantity in Nigeria. Over one hundred and forty (140) countries of the world produce citrus fruits and Brazil is at top the list (FAO, 2013). Nigeria also produces a large quantity of oranges even though it is not listed among ten top producers of the world (Kajo, 2012). Quantitatively, over 100 million metric tones of sweet orange fruits are produced worldwide annually (FAO, 2013). A large percentage of these citrus fruit are either fed to agro-processing industries for processing into various consumable products or consumed fresh locally. Whichever way the citrus fruits are handled, many by-products are generated which consist of 60-65% peel, 30-35% pulp (dry matter) and 0-10% seeds, resulting from processing of citrus fruits (Ipinjolu, 2000). The proximate compositions and energy value of the peels are indicators of its potential as a feed resource capable of replacing maize (Oluremi et al., 2007). The chemical composition of sweet orange peel is similar to that of maize in many respects: Whereas, maize has 8.9% crude protein (CP), 2.7% crude fibre (CF), 4.0% ether extract (EE), 1.3 ash% (Aduku, 2004) and 72% nitrogen free extract (NFE) (McDonald et al., 1995) while, the crude protein of sweet orange fruit peel meal on dry matter basis ranges from 9.30 to 10.96%, ether extract 2.35 to 2.90%, nitrogen free extract 65.30 to 67.95% and ash 5.07 to 5.56%. Orayaga et al. (2010) reported the proximate composition of the peels as 7.22% CP, 12.32% CF, 1.96% EE, 3.67% ash and 61.49% NFE and calculated metabolizable energy of 3167 $kcalkg^{-1}$.

Agro-industrial by-products are reported to have low nutritional value due to low nutrient content, high fibre, low palatability or presence of anti - nutritional factors (McDonald et al., 1995). However, appropriate treatment of nonconventional feedstuff can improve their utilization and thus better the health, productivity and profitability of farm animals (Tuleun et al., 2011).

Oluremi et al. (2006) had earlier reported that the safe level for sun dried sweet orange peel meal is 15% replacement of maize for growth. Water soaking of sweet orange peel meal was reported to reduce anti-nutrients such as tannin, flavonoid, saponin and limonene and raised nutrient such as NFE (Orayaga et al., 2010). Growth performance of broiler starter chicks fed diets containing meals of sweet orange peel that were soaked in water, and incorporated in diets at 20% maize replacement were significantly better than those fed diets containing sun dried sweet orange peels which were not soaked in water (Orayaga et al., 2010). Digestibilities of nutrients namely NFE, EE and CF as well as total digestible nutrients were not significantly affected by water soaking of sweet orange peel meal. However, crude protein digestibility was slightly but significantly varied without pattern (Orayaga et al., 2015b).

It is established that the health, weight gain, carcass composition, internal organs and gastro-intestinal tract (GIT) morphometry are affected by the quality of diets animals are exposed to (Aduku, 2004), and the health status of an animal is reflected in the blood characteristics and thus, blood examination is a good way of screening the health status of an animal to investigate the effect of diet on it (Pflanzer, 1982).

This research therefore investigated the effect of sweet orange peels soaked in water, dried, milled and incorporated in broiler finisher diets as a replacement (20%) for maize on haematological profile, carcass yield, internal organ weights and gastro-intestinal morphometry of finisher broiler chickens.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Poultry house of the Livestock Unit, on the Teaching and Research Farm, University of Agriculture Makurdi, Benue State, Nigeria. Makurdi has a warm tropical temperature with a minimum temperature range of 24.20 $\pm$ 1.40°C and a maximum temperature range of 36.33 $\pm$ 3.70°C (TAC, 2009).

Diet Preparation

Sweet orange (*Citrus sinensis*) fruit peels were collected without monetary cost, from retailers' sell points, where the retailers peel the fruits for consumers and discard the peels, sun dried and divided into four lots. The first portion was not soaked in water (0 hours) whereas, the second, third and forth portions were soaked in water for 12 hours, 24 hours and 36 hours, respectively and thereafter sun dried for about 48 hours for the peels to attain less than 10% moisture. These separately treated sweet orange peels were individually milled to obtain sweet orange fruit peel meals coded $SOFPM_0$, $SOFPM_{12}$, $SOFPM_{24}$ and $SOFPM_{36}$, respectively. Each of the four sweet orange peel meals was used in replacing 20% maize in the control diet (DN) to obtain four test diets D0, D12, D24 and D36, respectively (Table 1). The experimental diets were subjected to proximate analysis using standard procedures (AOAC, 2000) to evaluate their proximate constituents and the result is presented in Table 1.

Experimental Birds and Design

One hundred and fifty brooded Anak 2000 strain broiler chicks with an average initial body weight of 1051.00 $\pm$ 0.92g were randomly grouped into five, which were also randomly assigned to the five diet groups namely DN, D0, D12, D24 and D36. Each dietary group had three replicates and each replicate contained 10 birds in a completely randomized design.

Management

Birds in each group were served the experimental diet and cool fresh drinking water without restriction for 21 days. Vitalite was added to water served the birds before and after weight measurements and when the house temperature was high as an anti-stress. Other management practices were strictly followed (Oluyemi and Roberts, 2000).

Haematological Evaluation

During the carcass evaluation, birds were bled by severing the neck vein and 5mL blood samples were collected into sample tubes containing about 2mg of ethylene diamine tetra acetoacetic acid (EDTA, Mahavir chemical industries) each. Blood was allowed to run under gravity into EDTA (Mahavir chemical industries) tubes after the severing of the neck vein and was taken immediately to the veterinary laboratory for analysis. Blood parameters analyzed were red blood cell count (RBC), haemoglobin concentration (Hb), mean corpuscular volume (MCV), mean

Table 1: Gross composition of experimental diets for finisher Broiler

Ingredient (%)	**Experimental Diets**				
	DN	**D0**	**D12**	**D24**	**D36**
Maize	54.01	43.21	43.21	43.21	43.21
SOPM[1]	0	10.80	10.80	10.80	10.80
Maize Offal	9.00	9.00	9.00	9.00	9.00
Groundnut cake	22.94	22.94	22.94	22.94	22.94
Brewers dried grain	6.50	6.50	6.50	6.50	6.50
Blood meal	3.00	3.00	3.00	3.00	3.00
Bone ash	3.00	3.00	3.00	3.00	3.00
Oyster shell	0.50	0.50	0.50	0.50	0.50
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.30	0.30	0.30	0.30	0.30
Common salt	0.25	0.25	0.25	0.25	0.25
Vitamin / mineral premix[2]	0.25	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated nutrients					
ME (kcal/kg)	2990.65	2985.63	2988.51	2975.91	2975.61
Crude protein (%)	20.00	19.97	19.97	19.95	19.95
Crude fibre (%)	4.77	5.31	5.31	5.33	5.34
Crude fat (%)	4.36	4.10	4.10	3.99	3.99
Calcium (%)	1.35	1.36	1.36	1.35	1.35
Determined Nutrients					
Crude protein (%DM)	22.38	22.51	20.48	21.73	22.42
Crude fibre (%DM)	5.45	5.60	5.61	5.73	6.04
Crude fat (%DM)	4.06	4.04	4.09	4.15	4.04
Ash (%DM)	10.70	10.66	10.63	10.22	11.77
NFE (%DM)	57.32	57.19	57.19	58.16	55.73

[1]**SOFPM**= sweet orange fruit peel meal; **ME**= metabolisable energy; **DN**= control diet; **D0**= diet containing the meal of sweet orange peel not soaked in water; **D12**= diet containing the meal of sweet orange peel soaked in water for 12 hours; **D24**= diet containing the meal of sweet orange peel soaked in water for 24 hours; **D36**= diet containing the meal of sweet orange peel soaked in water for 36 hours; [2]Mineral-vitamin premix (Bio-mix brand) contained the following per kg of diet: Vitamin A 15 000 IU, Vitamin D3 300 IU, Vitamin E 30 IU, Vitamin K 2.5 mg, Vitamin B1.2 2 mg, Thiamine (B1) 2 mg, Riboflavin (B2) 6 mg, Pyridoxine (B6) 4mg, Niacin 40 mg, Pantothenic acid 10 mg, Folic acid 1 mg, Biotin 0.08mg, Choline chloride 0.50g, Antioxidant 0.125g, Manganese 0.096g, Zinc 0.06g, Iron 0.024g, Copper 0.006g, Iodine 0.0014 g, Selenium 0.24mg, Cobalt 0.24 mg; **DM**= dry matter; **CP**= crude protein; **NFE**= nitrogen free extract

corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and packed cell volume (PCV) using standard procedures (Jain, 1993).

Carcass Evaluation

At the end of the feeding trial, a day to carcass evaluation, the birds were fasted of feed for 18 hours as recommended (Aduku and Olukosi, 2000) and final weights of all the birds were taken using a sensitive weighing scale (Mettler Toledo). Average weights per replicate were calculated. Three birds whose mean weight was similar to the mean of the treatment group were carefully selected, bled, plucked, washed, eviscerated and separated into carcass cuts, internal organs, gastro-intestinal tract and offals, using the method described by the Canadian Meat Inspection Agency (2012).

Data analysis

All data generated was subjected to analysis of variance using Minitab (2004) and where significant differences occurred, the means were separated using Duncan Multiple Range Test (Duncan, 1955). Relative weights and lengths in percentage were transformed using arcsine transformations as outlined by Little and Hills (1977) before analysis of variance was carried out.

All the experimental protocols were approved by the Nigerian Institute of Animal Science (NIAS).

Table 2: Effect of sweet orange (*Citrus sinensis*) fruit peel meal on haematological profile of broiler finisher chicken

Haematological indices	Experimental Diets					
	DN	D0	D12	D24	D36	SEM	LS
RBC (10^6/mL)	3.76	2.18	1.92	2.15	1.78	0.65	NS
Hb (g/dL)	11.43	10.00	10.33	10.90	11.57	0.47	NS
PCV (%)	34.33	30.00	31.00	32.67	34.33	0.86	NS
MCV (fl)	123.03	146.62	162.79	157.56	195.3	28.00	NS
MCH (pg)	40.92	48.88	53.80	52.56	66.10	9.24	NS
MCHC (g/dL)	33.30	33.33	33.33	33.36	33.69	0.16	NS

SEM= Standard error of mean; **LS**= level of significance; **NS** = Not significant (p>0.05); **DN**= control diet; **D0**= diet containing the meal of sweet orange peel not soaked in water; **D12**= diet containing the meal of sweet orange peel soaked in water for 12 hours; **D24**= diet containing the meal of sweet orange peel soaked in water for 24 hours; **D36**= diet containing the meal of sweet orange peel soaked in water for 36 hours; **RBC** = red blood cell count; **Hb** = haemoglobin concentration; **PCV** = packed cell volume; **MCV** = Mean corpuscular volume; **MCH** = Mean corpuscular haemoglobin; **MCHC** = Mean corpuscular haemoglobin concentration

Table 3: Effect of sweet orange (*Citrus sinensis*) fruit peel meal on weight and carcass yield of broiler finisher chickens

Carcass parameter	Experimental Diets						
	DN	D0	D12	D24	D36	SEM	LS
Fasted live weight (g)	1866.70	1750.00	1883.30	1883.30	1650.00	67.08	NS
Bled weight (%FW)	97.31	95.10	96.29	95.58	94.87	1.29	NS
Plucked weight (%FW)	92.89	89.80	88.52	88.03	89.19	1.22	NS
Dressed weight (%FW)	74.95	72.21	71.28	71.86	71.78	0.87	NS
Breast (%FW)	22.37	20.45	22.16	22.54	22.17	0.59	NS
Thigh (%FW)	13.15	12.58	11.55	11.64	12.06	0.36	NS
Drumstick (%FW)	10.27	10.81	9.92	10.24	10.01	0.45	NS
Back (%FW)	10.69	9.99	9.59	9.12	9.26	0.34	NS
Wing (%FW)	8.14	7.81	8.02	7.94	8.41	0.22	NS

SEM= Standard error of mean; **LS**= level of significance; **NS** = Not significant (p>0.05); **DN**= control diet; **D0**= diet containing the meal of sweet orange peel not soaked in water; **D12**= diet containing the meal of sweet orange peel soaked in water for 12 hours; **D24**= diet containing the meal of sweet orange peel soaked in water for 24 hours; **D36**= diet containing the meal of sweet orange peel soaked in water for 36 hours

RESULTS AND DISCUSSION

Haematological Variables

The results of haematological variables are presented in Table 2. The broiler finisher chickens in the SOFPM based diet groups had haematology variables satisfactorily comparable to the haematology variables of chickens in the maize based diet group. These values obtained were within normal limits of 3 x 10^6mm^{-3} to 5x10^6mm^{-3} for RBC, 9 to 13g/dl for Hb and 30 to 40% for PCV (Jain, 1993) and agree with the report of Nowaczewski and Kontecka (2012). The MCV, MCH and MCHC were similar to the control group. The red blood cell size, shape and colour were not negatively affected by diets containing SOFPM. Thus the use of SOFPM as a replacement for maize at 20% did not have any adverse effect on the levels of these blood parameters. The production of these health indicators in the bone marrow (red blood cells) seemed normal. Nutritional deficiencies resulting in abnormal development of red blood cells affect the size and shape of the erythrocyte released into the blood system because erythropoiesis is dependent on adequate supply of iron and protein; and on copper, cobalt and vitamins such as pyridoxine, folic acid, riboflavin, and cyanocobalamin for normal red cells and haemoglobin production (Pflanzer, 1982). The normocitic and normochromic appearance of the blood of these birds fed diets containing SOPM as reflected by the MCV and MCH values revealed that SOFPM did not negatively interfere with absorbability of nutrients required for blood formation and function by broiler birds neither did it present poisonous treats to broiler chickens.

Carcass yield

The result of carcass yield is presented on Table 3. Final weight, bled and plucked percentages were not significantly affected (p>0.05) by the dietary treatments. Mean final weight in this report were within broiler chicken table weight range of 1600g to 2000g, reported by Oluyemi and Robert (2000). The dressing percent of 71.28 to 74.95% agrees with the report of Aduku and Olukosi (2000) for

Table 4: Effect of sweet orange (*Citrus sinensis*) fruit peel meal on internal organs of finisher broiler chickens

Internal organ	Experimental Diets						
	DN	D0	D12	D24	D36	SEM	LS
Heart (%FW)	0.48	0.41	0.37	0.43	0.41	0.30	NS
Liver (%FW)	1.68	1.90	1.68	1.75	1.81	0.18	NS
Empty gizzard (%FW)	1.65	1.76	1.76	1.97	1.81	0.40	NS
Lungs (%FW)	0.60	0.60	0.45	0.55	0.63	0.26	NS
Spleen (%FW	0.08	0.09	0.08	0.09	0.12	0.19	NS
Pancreas (%FW)	0.23	0.19	0.21	0.18	0.18	0.31	NS
Proventriculus (%FW)	0.34	0.39	0.35	0.36	0.42	0.14	NS
Kidney (%FW)	0.63	0.50	0.63	0.67	0.68	0.18	NS
Gall bladder (%FW)	0.09	0.14	0.16	0.13	0.11	0.16	NS

SEM= Standard error of mean; **LS**= level of significance; **NS** = Not significant (p>0.05); **DN**= control diet; **D0**= diet containing the meal of sweet orange peel not soaked in water; **D12**= diet containing the meal of sweet orange peel soaked in water for 12 hours; **D24**= diet containing the meal of sweet orange peel soaked in water for 24 hours; **D36**= diet containing the meal of sweet orange peel soaked in water for 36 hours

Table 5: Effect of sweet orange (*Citrus sinensis*) fruit peel meal on gastro-intestinal tract (GIT) of finisher broiler chickens

GIT parameter	Experimental Diets						
	DN	D0	D12	D24	D36	SEM	LS
GIT length (cm)	265.00	264.33	263.00	254.83	245.00	10.91	NS
Small intestine (%GIT)	70.18	72.54	68.68	68.14	71.88	0.74	NS
Large intestine (%GIT)	4.65^{a}	3.60^{b}	5.76^{a}	5.70^{a}	6.40^{a}	0.75	S
Caeca (%GIT)	13.63	13.76	12.89	15.12	11.93	0.81	NS

SEM= Standard error of mean; **LS**= level of significance; **NS** = Not significant (p>0.05); **S**= significantly different (P<0.05); **DN**= control diet; **D0**= diet containing the meal of sweet orange peel not soaked in water; **D12**= diet containing the meal of sweet orange peel soaked in water for 12 hours; **D24**= diet containing the meal of sweet orange peel soaked in water for 24 hours; **D36**= diet containing the meal of sweet orange peel soaked in water for 36 hours

a satisfactory broiler dressing percent of 71 to 75% and was superior to 66.37 to 70.19% reported by Tuleun et al. (2011) when broiler chickens were fed diets containing mucuna seed meal. Dressing percentage is affected by weight of birds, plane of nutrition, pre-slaughter activities and dressing method (Aduku and Olukosi, 2000). Since other factors that affect dressing percentage were kept constant except the diet composition, it could be suggested that the diets were similar in nutritive value. None of the carcass cuts evaluated was significantly affected (p>0.05) by the diet treatments. The birds had similar proportions for all the parts between the treatment groups. Disproportionate growth, which favours the growth of some parts at the expense of other parts, could be caused by diet (Hubbard, 2006) and a situation where there was no significant difference means that the diets were similar in value with respect to supporting carcass yield.

Internal Organs

Internal organs relative weights were not significantly affected (Table 4) among the dietary treatments groups. Internal organs such as gall bladder and the liver would vary in size (enlargement) if diets contain poisonous substances. No significant differences imply that the SOFPM did not introduce poison in the diets and the anti-nutritional levels were tolerable to the birds. Oluremi et al. (2007) had reported the presence of anti-nutritional factors in sweet orange peels but Agu et al. (2010) observed a similarity in growth performance of finisher broiler chickens when even 20% of maize was replaced by SOPM in their diets. This did not however shade light on effect of SOMP on internal organs, but similarity among treatment groups suggests that 20% SOPM in diets of broiler chickens was a safe level. Non-significant difference among treatment groups for empty gizzard and proventriculus suggests that though fibre contents of SOFPM based diets seemed to be a little higher, it did not affect these organs, which would have enlarged if extra load of grinding was put on them. Abnormal blood circulation occasioned by dietary factors would cause variation in the size of the heart (Frandson, 1986). Non-significant difference among the treatment groups for heart (percent live weight) indicated a normal blood circulation among all the dietary groups. The pancreas is the site for production of many of the digestive enzymes.

There was no significant difference in percent pancreas weight among the treatments groups and digestion especially in the small intestine was not apparently obstructed in any form as a result of the replacement of maize with SOFPM.

Gastro-intestinal Tract (GIT) Morphometry

Gastro-intestinal tract morphometry results are presented in Table 5. GIT lengths in this study which ranged from 245cm to 265cm were higher than the GIT lengths of 197.5cm to 213.5cm reported by Oluremi et al. (2010) when 30% maize was replaced with SOPM in the diets of broiler chicken. The cause of the differences is not clearly understood since the breed used by Oluremi et al. (2010) and that used in this study were the same. There was no significant difference in the relative small intestine length and caeca length. The large intestine was significantly affected ($p<0.05$), and tended to increase with increase in the duration of soaking. The large intestine is the site for water reabsorption and temporary storage site for faecal materials (McDonald et al., 1995). SOFPM based diets are implicated for higher water consumption by broiler chickens (Orayaga et al., 2015b). It then means there was high water consumption and as the task of water reabsorption increased, the large intestine developed more to effectively absorb water. It is also possible that though the fibre level of the diets containing sweet orange peels exceeded the 5% recommended level (Nigerian Industrial Standard, 1989) by fractions as calculated and barely above one for the analysed crude fibre levels, it might have induced high faecal production which had to be accommodated by the large intestine temporary, thereby causing it to enlarge.

CONCLUSION

It was concluded that 20% maize replacement by sweet orange fruit peel meal was safe for the broilers as indicated by haematological parameters, carcass yield, internal organs and GIT morphometry of finisher broiler chickens. Moreover, soaking the sweet orange fruit peels in water before using it to compound diets at this level of maize replacement was not necessary.

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AUTHORS' CONTRIBUTION

Kanan Tyohemba Orayaga carried out the greater part of the research and wrote the article. Oluwabiyi Ikeolu Atanda Oluremi supervised the entire research and write up. Adeshina Yahaya Adenkola gave professional health assistance during the research and also assisted in collecting blood and running haematological analysis.

CONFLICT OF INTEREST

No conflict of interest

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