Comparative chemical composition of 24-hour fermented sweet orange fruit (*Citrus sinensis*) peel meal and maize and effect on performance response of starting pullet chicks

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Abstract:

The study evaluated the effect of 24-hour fermentation of sweet orange fruit (Citrus sinensis) peel meal (24SOFPM) on its chemical composition and performance response to graded levels of peel meal in the diets of pullet chicks. Dry matter, crude protein and phosphorus level in 24SOFPM were close to that of maize. While limonene was higher in 24SOPFM, phytate was higher in maize than the 24SOPFM. One hundred and forty-four fourteen day-old Nera black pullet chicks were assigned to four experimental diets F_0, F_{10}, F_{20} and F_{30}. SOPFM substituted maize in F0, F10, F20 and F30 respectively at 0, 10, 20 and 30%. The feeding trial lasted the remaining 6 weeks of the chicks' phase. The study design was Completely Randomized Design. Daily feed intake was not significantly different ($p>0.05$). Average body weight gain was significantly different ($p<0.05$) and was depressed with no definite pattern in the SOPFM based diets. FCR was significantly different ($p<0.05$). Substitution of maize with SOFPM significantly ($p<0.05$) reduced feed cost/25kg, feed cost/bird and cost of production while decreasing efficiency of feed utilization for growth. Apparently, SOPFM might be a potential feedstuff which could substitute a proportion of maize in pullet chick's diet when fermented for 24 hours.

Keywords: chemical composition, performance, chick, sweet orange fruit peel meal

Introduction

Poultry species depend on cereal and legume crops as sources of energy and protein. These cereals and legume crops form the largest percentages of poultry feeds and constitute the highest cost items in compounded feeds especially when supplied from conventional feed sources (Anyachie and Madubuike, 2007). Moreover, these energy and protein ingredients are in short supply for livestock feed production due to stiff competition from man, industries, seasonal effect on availability and low production, thus, making them more expensive and consequently increasing feed cost, production cost and ultimately the price of livestock products. For the poultry industry to be sustained, incorporating agro-industrial by-products in poultry feeds is now being encouraged and explored. One agro-industrial by-product generated in large quantities in Nigeria is Sweet orange fruit (*Citrus sinensis*) peel. Nigeria is reported to produce 3,240,000 tonnes of fresh citrus fruit. This figure represents 3% of the world total citrus fruit production (FAO, 2004), and 86.61% of Africa's contribution. Sweet orange fruit peel is one of the two major by-products of sweet orange fruit processing, the other being pulp. It contains 60-65% of peel on dry matter basis (Ipinjolu, 2000). Oluremi *et al.* (2006) reported that sweet orange fruit peel is comparable in energy and protein with maize. Maize has a gross energy of 3390 Kcal/kg (Tuleun *et al*. 2005) while sweet orange peel has a gross energy of 3200-3300 Kcal/kg (Orayaga, 2010). Their protein content is 9.25% for maize (Tuleun *et al*. 2005) and 8-10% (Oluremi *et al*. 2007). Agu *et al.* (2010) observed that maize could be replaced by sun-dried orange rind (peel) in broiler starter diet at 20% for optimal performance and nutrient utilization. Gohl (1981) reported the presence of substances toxic to swine and poultry in dried citrus pulp that included seeds and that the high fibre content restricted its use in swine and poultry rations. Oluremi *et al.* (2007) had also reported the presence of phyto-nutrients such as oxalate, phytate, saponin, tannin, flavonoid and limonene in sun-dried sweet orange fruit peel. Jong-kyu *et al.* (1996) reported that dried citrus pulp at 10% in chicken diets reduced growth and feed intake and that 30% may be toxic. According to Jong-kyu *et al.* (1996), 2.5% level of citrus pulp in layers diet adversely affected yolk colour. They also reported that citrus peel that have been heated and dried could replace 5% of conventional diet for broiler chicks. In another experiment with layers result showed that intake did not change significantly, when 5% or 10% dried peel was added but egg production and feed intake declined at 15% inclusion level (Jong-kyu *et al.,* 1996). The workers concluded that citrus by-products can be utilized for not only ruminants but also monogastric animals and that information is required on what levels and types of citrus by-products are best for use. Due to the presence of anti-nutrients in a number of alternative feedstuffs, various methods of processing have been employed to improve the utilization of their nutrients. Some of these methods include fermentation (Adejinmi *et al.*, 2007; Ojokoh, 2007), ensiling (Obikaonu and Udedibie, 2007) retting, parboiling and sun-drying (Salami and Odunsi, 2003) among others.

The main objective of this study was to determine the nutritional potential of sun-dried 24-hour fermented sweet orange (*Citrus sinensis*) fruit peel meal (SOFPM) in the diet of pullet chicks by evaluating the effect of substitution of maize with sun-dried 24-hour fermented SOFPM on the performance and the economics of production of pullet chicks.

Materials and Methods

Experimental site

The study was conducted in the Poultry unit of the Teaching and Research Farm of Kogi State University, Anyigba, Nigeria. Anyigba is located on longitude 07° 30' N and latitude 07° 09' E (Kogi State Agricultural Development Project, 2010).

Procurement and preparation of test ingredient

Fresh sweet orange (*Citrus sinensis*) fruit peels of mixed varieties were collected from orange retailers into new empty synthetic grains bag. The content of the bag was compacted together in order to expel air, tied firmly, and thereafter left under a shade to ferment for 48 hours. The fermented peels were afterwards spread on concrete floor and allowed to sun-dry until they became crispy. The sun dried fermented peels were milled to obtain sweet orange fruit peel meal (SOFPM) which was used to substitute dietary maize in the control diet at 0, 10, 20 and 30%. Maize was procured from the open market in Anyigba and ground prior to use.

Chemical analyses

SOFPM, maize and experimental diets were analyzed for their proximate composition according to AOAC (1995). Nitrogen free extract (NFE) was determined by difference. The gross energy (GE) values of the samples were determined using the adiabatic oxygen Bomb calorimetric technique and converted to metabolizable energy (ME) as outlined by Pauzenga (1985). Calcium and phosphorus contents of fermented SOFPM and maize were determined using atomic spectrophotometry. Screening for phyto-nutrients and quantitative determination were done using the procedures of Allen's commercial organic analysis (1979) for

Table 1: Gross composition of experimental diets for pullet chicks fed fermented SOFPM (kg/100kg)

Ingredients	24 hour fermented SOFPM			
	F_0	F_{10}	F_{20}	F_{30}
Maize	44.00	39.60	35.20	30.80
SOFPM[1]	0	4.40	8.80	13.20
FFSBM[2]	39.00	39.00	39.00	39.00
BDG[3]	13.00	13.00	13.00	13.00
Bone ash	3.00	3.00	3.00	3.00
Methionine	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20
Common salt	0.30	0.30	0.30	0.30
Vitamin/mineral premix[4]	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00
Calculated nutrients				
Crude protein (%)	21.88	21.77	21.66	21.55
Crude fibre(%)	5.18	5.70	6.22	6.70
Ether extract (%)	8.87	9.01	9.16	9.30
Calcium (%)	1.18	1.18	1.18	1.18
Total phosphorus (%)	0.88	0.87	0.86	0.85
Energy (MJ/kgME)	12.11	12.05	11.98	11.91
Analyzed nutrients				
Dry matter (%)	90.36	90.41	90.30	90.23
Crude protein (%)	21.83	22.31	22.05	22.43
Crude fibre (%)	3.77	3.83	3.71	4.05
Ether extract (%)	4.23	4.27	4.17	4.13
Ash (%)	7.68	7.51	7.77	7.71
Nitrogen free extract (%)	52.86	52.50	52.60	51.92
Gross Energy (MJ/kg)	13.68	13.71	13.63	13.58
Energy (MJ/kgME)[5]	12.57	12.60	12.54	12.49

[1]SOFPM=Sweet orange fruit peel meal
[2]FFSBM=Full fat soybean meal, [3]BDG=Brewers' dried grain
[4]Animal care [(R)] supply /kg of feed
Vitamin A 1800IU, Vitamin D3 360IU, Vitamin E 3.6IU, Vitamin K 0.3mg, Vitamin B1 0.24mg, Vitamin B2 0.72mg, Vitamin B6 0.48mg, Vitamin B12 0.0024mg, Niacin 1.2mg, Pantothenic acid 1.2mg, Folic acid 0.12mg, Biotin 0.0096mg, Choline chloride 0.006mg, Iodine 0.000168g, Copper 0.00072g, Zinc 0.0072g, Cobalt 0.0288mg, Manganese 0.01152mg, Selenium 0.0288mg, Antioxidant 0.015mg.
kcal/kgME[5]= 37 x %CP + 81 x %EE + 35.5 x %NFE (Pauzenga, 1985)

flavonoids and limonene, Krihna and Ranjhan (1980) for tannin, Liener (1980) for oxalates, Maga (1983) for phytate and Brunner (1984) for saponin.

Experimental diets

Four diets were formulated for the experiment as shown in Table 1. SOFPM substituted maize at 0%, 10%, 20% and 30% in the experimental diets coded as F_0 (control), F_{10}, F_{20}, and F_{30}, respectively.

Experimental house, animals and management

The experiment was conducted in an open sided deep litter poultry house. The space between the foundation and the roof is made of wire mesh. The building was partitioned into individual units of about 1.8m x 1.2m dimension. One hundred and forty-four 14-day-old pullet chicks of Nera black strain were used for the feeding trial which lasted six weeks. Gumboro and lasota vaccines were administered via drinking water when the birds were twenty and twenty-eight days old, respectively. Feed and drinking water were provided *ad - libitum* and other standard routine management practices were followed.

Experimental Design

The birds were randomly allocated to the four experimental diets in a completely randomized design. Each diet group had 36 chicks which was replicated 3 times. Performance indices taken were average daily feed intake, average daily weight gain, feed conversion ratio and mortality. Birds in each treatment replicate were served feed and drinking water *ad- libitum.* Left over feed was collected and weighed weekly, and subtracted from the quantity offered to obtain weekly feed intake per replicate. The average daily feed intake (ADFI) was obtained by dividing the weekly feed consumed by 7 days and by the number of birds/replicate.

Birds were weighed at the beginning of the trial and weekly thereafter. Weight gain was computed by subtracting initial weight from final weight. Average daily weight gain (ADG) was determined by dividing weight gain by the number of birds and the number of days (42) the feeding trial lasted. Feed conversion ratio was computed by dividing the average daily feed consumed per bird with the average daily weight gain per bird.

Economic analysis

Economic analysis of using SOFPM as a feedstuff in raising pullet chicks was determined using market prices of the feed ingredients used and operation cost.

Statistical analysis

All data collected were statistically analyzed using the Analysis of Variance (ANOVA) outlined in the MINITAB statistical software (1991) for completely randomized design. Where significant effects of the experimental diets were obtained, means were separated using Fisher's least significant difference (LSD) as outlined by Steel and Torrie (1980).

Results and Discussion

Proximate, chemical composition and energy contents of maize and SOFPM

The proximate composition of 24-hour fermented SOFPM (Table 2) differed from 89.65% DM, 10.73% CP, 7.86% CF, 12.60% EE, 11.90% ash and 56.91% NFE reported by Agu *et al.* (2010) for sweet orange fruit peel. Ipinjolu (2000) observed 2.12% CP, 7.73% CF, 6.28% ash and 70.08% NFE. Oluremi *et al.* (2008) reported 85.9% DM, 7.44% CP, 12.9% CF, 2.29% EE, 3.85% ash, 73.5% NFE, 2440kcal/kgGE and 1529kcal/kgME for unfermented SOFPM. Oluremi *et al.* (2008) added that SOFPM fermented for 24 hours (24SOFPM) contained 87.6% DM, 8.29% CP, 13.9% CF, 2.50% EE, 4.35% ash, 71.00% NFE, 2530kcal/kg GE and

Table 2: Proximate and mineral composition of fermented sweet orange fruit (*Citrus sinensis*) peel meal and maize (dry matter basis)

Nutrient	24SOFPM[1]	Maize
Dry matter (%)	91.64	89.70
Crude protein (%)	7.33	9.73
Crude fibre (%)	13.92	2.03
Ether extract (%)	5.51	2.20
Ash (%)	6.88	2.35
Nitrogen free extract (%)	58.04	73.46
Gross Energy (MJ/kg)	12.05	14.18
Energy (MJ/kgME)[2]	11.52	13.02
Calcium (%)	0.06	0.10
Phosphorus (%)	0.14	0.16

[1]24SOFPM = 24 Hour-fermented Sweet orange fruit peel meal
[2]Energy= 37 x %CP + 81 x %EE + 35.5 x %NFE (Pauzenga, 1985)

1585kcal/kg ME. The observed CP (9.73%) for maize (Table 2) is higher than 8.90% reported by Aduku (1993) and 9.25% (Tuleun *et al.*, 2005). Age of maize at harvesting, variety, storage conditions and duration in storage before purchase may have resulted in these differences. Crude protein value of 9.73% for maize in this study is also higher than 7.33% CP of the SOFPM used. This may indicate that the protein quality of maize is superior to SOFPM. Amount of protein, balanced amino acid profile and absence of phyto-nutrients are some of the factors that enhance protein quality. The EE (2.20%) observed for maize is lower than 4.00% (Aduku, 1993) and 5.51% for SOFPM. The observed CF (2.03%) for maize is lower than 2.70% in literature (Aduku 1993) and 13.92% for SOFPM. This will make maize more digestible by pullet chicks, and less bulky. Ash contents of 6.88% and 2.35% were obtained for SOFPM and maize, respectively. This may mean that SOFPM contained more total minerals than maize and may be less palatable than the latter. NFE for maize (73.46%) is higher than 58.04% for SOFPM suggesting that maize possesses more utilizable soluble sugars than SOFPM. SOFPM and maize have similar phosphorus levels but calcium content of maize is higher than that of SOFPM. Methods of processing and handling coupled with the variety of the maize may have resulted in these differences.

Phyto-nutrients in maize and SOFPM

Phyto-nutrients determination in the samples showed that limonene level in maize is lower than in SOFPM (Table 3). 24 hour fermented SOFPM contained 1.26% limonene, 0.09% flavonoid, 1.28% saponin, 1.34% oxalate, 0.08% tannin and 0.97% phytate. Fermentation of SOFPM for 24 hours did not completely eliminate the determined phyto-nutrients. The level of each phyto-nutrient present in the SOFPM used is higher than those reported by Oluremi *et al.* (2010). This difference may be due to varietal difference, processing and handling methods, and the stage of maturity at which the sweet orange fruits from which the peels used were harvested (Agu *et al.,* 2010). The observed phytate content of maize is higher than the value observed for SOFPM. The concentrations of these phyto-nutrients in fermented SOFPM are however lower than

Table 3: Quantitative composition of phyto-nutrients (%) in fermented sweet orange fruit (*Citrus sinensis*) peel meal and maize (dry matter basis)

Phyto-nutrient	24SOFPM[1]	Maize
Limonene	1.26	0.78
Flavonoid	0.09	-
Saponin	1.28	-
Oxalate	1.34	-
Tannin	0.08	-
Phytate	0.97	2.00

24SOFPM[1] = 24 Hour-fermented Sweet orange fruit peel meal

levels reported in literature to have adverse effects on farm animals. For tannin a range of 1 to 20% has been reported (Price and Butler, 1980) and for saponin 3% (Kumar, 1991).

Effect of 24-hour fermented SOFPM on performance of pullet chicks

The performance of pullet chicks is shown in Table 4. Feed intake of pullet chicks was not significantly affected ($p>0.05$) by the experimental diets. Feed intake varied between 41.65g to 43.87g/bird. This is perhaps an indication that the diets were well accepted and palatable to the chicks. Feed intake was however lower than a mean of 47.42g to 53.58g observed with 4 to 8 week old black Harco pullet chicks. Final body weight was significantly depressed ($p<0.05$). Birds on the control had higher final weight than those on SOFPM based diets. Decrease in live-weight of 3.7%, 13.3% and 8% relative to the control was recorded for F_{10}, F_{20}, and F_{30}, respectively. This agrees with the observations of Agu *et al.* (2010) and Oluremi *et al.* (2010) that broilers on control diets (maize-based) were heavier than those on orange peel based diets. Daily body weight gain (BWG) significantly declined ($p<0.05$) from 13.08g in the control group to 10.83g in the SOFPM based diet group. The trend observed for weight gain despite similarity in feed intake suggests better nutrient utilization by chicks on the maize based diet group compared with SOFPM based diets. The presence of phytate, flavonoid, limonene, oxalate, saponin and tannin in the SOFPM though in concentrations reported safe for the birds (Oluremi *et al.,* 2007) may have lowered nutrient utilization by pullet chicks in the SOFPM diet groups. Feed conversion ratio (FCR) of pullet chicks was

Table 4: Effect of 24-hour fermented sweet orange fruit (*Citrus sinensis*) peel meal on performance of pullet chicks

Performance indices	Experimental diets				SEM
	F_0	F_{10}	F_{20}	F_{30}	
Initial weight (g)	139.44	140.00	135.55	137.22	2.14
Final weight (g)	680.57^a	655.60^a	590.25^b	626.43^{ab}	11.61
Feed intake (g)	43.87	42.68	41.65	43.04	0.99^{ns}
Daily weight gain (g)	13.08^a	12.28^{ab}	10.83^b	11.65^b	0.28
FCR	3.36^a	3.48^{ab}	3.85^c	3.69^b	0.06
Mortality (%)	0	0	0	0	-

Means on the same row with different superscripts are significantly different ($p < 0.05$)
SEM = Standard error of mean

significantly different (p<0.05). No mortality was recorded in the study. Therefore, the concentrations of phyto-nutrients in SOFPM may not be adverse to the survival of pullet chicks.

Economics of production of pullet chicks fed 24-hour fermented SOFPM

The effect of feeding SOFPM on the economics of production of pullet chicks is shown in Table 5. Substitution of maize with SOFPM reduced feed cost/25kg significantly (p<0.05) as the level of SOFPM increased. Consequently, it was more expensive compounding the control diet which cost N2155 per 25kg than the diets containing SOFPM. Among the SOFPM based diets the least cost per 25kg bag was N2032.72 for the diet containing highest SOFPM. This is because the sweet orange fruit peels were not bought, although cost of transportation and handling were attached to SOFPM. In spite of this, SOFPM based diets were cheaper. The cost of feed consumed per bird reduced from N168.06 to N153.77 and was not affected significantly (p>0.05). Feed cost/kg gain tended to increase significantly (p<0.05) from N306.04 to N338.21 as dietary SOFPM content increased. Maize substitution with SOFPM though resulted in lower feed cost per bird seemed to cause an increase in the cost of unit weight gain in pullet chicks most probably because of the disparity in feed value between maize and SOFPM thus giving chicks in the maize group an advantage.

Conclusion

SOFPM was inferior to maize in proximate nutrients (CP, CF, EE, Ash, NFE, ME, Ca and P) and phyto-nutrients (limonene, flavonoid, saponin, oxalate and tannin) comparatively. The performance of pullet chicks on the SOFPM diets was lower than chicks on the maize based diet. No mortality was recorded in the course of the trial thus SOFPM can be considered safe for pullet chicks. However, for optimal performance, its level of maize substitution should not exceed 10%.

References

Adejinmi, O. O., Hamzat, R. A. and Fapohunda, J. B. 2007. Performance and nutrient digestibility of rabbits fed fermented and unfermented Cocoa pod husk. *Nigerian Journal of Animal*

Table 5: Economics of feeding 24-hour fermented sweet orange fruit (*Citrus sinensis*) peel meal to pullet chicks

Economic indices	Experimental diets				SEM
	F_0	F_{10}	F_{20}	F_{30}	
Feed cost (₦/25kg)	2155.00^a	2113.00^b	2072.58^c	2032.75^d	0.07
Cost saving (₦/25kg)	-	42.00	82.25	122.25	-
Feed cost/kg gain (₦/chick)	306.04^b	311.53^{ab}	338.21^a	318.89^{ab}	5.61
Feed cost/bird (₦)	168.06	160.48	153.77	156.01	3.67^{ns}
Cost of day old chick (₦)	200.00	200.00	200.00	200.00	-
[1]Operating cost (₦/chick)	94.66	94.66	94.66	94.66	-
Cost of production (₦/bird)	462.72	455.14	448.43	450.67	3.67^{ns}
Cost saving (₦/chick)	-	7.58	14.29	12.05	-

Means on the same row with different superscripts are significantly different (p < 0.05)
^{ns} = Not significant (p > 0.05)
SEM = Standard error of mean
[1]Operating cost computed from cost of energy, vaccination, medication and other consumables

Production 34 (1):63– 68.

Aduku, A. O. 1993. Tropical Feedstuff Analysis Table. Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria.

Agu, P. N., Oluremi, O. I. A. and Tuleun, C. D. 2010. Nutritional evaluation of sweet orange (*Citrus sinensis*) fruit peel as a feed resource in broiler production. *International Journal of Poultry Science 9(7):684–688.*

Allen's commercial organic analysis 1979. A treatise on mode of assaying and proximate analytical examination of various organic chemicals and products. Ed: Leffmann, F., Davis, W.A., Samuel, S. and Sadtler, S. B. 4th edition. P. Blackston's Sons and Co. Pub. Walnut Street, Philadelphia. Vol 1X, Pp. 156-189.

Anyaehie, A. A. and Madubuike, F. N. 2007. Effect of enzyme supplementation of high-fibre soybean-based diets on serum biochemistry and internal egg quality of laying hens. Proceedings of the 32nd Annual Conference of the Nigerian Society for Animal Production (NSAP), University of Calabar, March 18th -21st, 2007. pp.4-6.

AOAC 1995. Official Methods of Analysis (16th ed). Association of Official Analytical Chemists, Washington DC.

Brunner, J. H. 1984. Direct spectrophotometer determination of spaonin. *Anal. Chem*. 34. 1314-1326.

FAO 2004. FAOSTAT data 2005. Food and Agricultural Organization of the United Nations, Rome, Italy. February 2005.

Gohl, B. 1981. Tropical Feeds: Feed information, summaries and nutritive value. FAO Animal Production and Health series. No. 12, Rome, Italy. Food and Agricultural Organization. pp.10-16.

Ipinjolu, J.K. 2000. Performance of juvenile orange koi carp (*Cyprinu carpioleanneanus*) fed diets supplemented with sweet orange peel meal: Body composition, nutrition, utilization and skin pigmentation. *Sokoto Journal of Veterinary Science,2000:228-229.*

Jong-kyu, Ha, Kim, S. W. and Kim W. Y. 1996. Use of Agro-Industrial By-products as animal feeds in Korea. Animal Science and Technology College of Agriculture and Life Sciences. Seoul National University, Suweon. pp. 441-744.

Kogi State Agricultural Developmemt Project 2010. Land use and soil classification of sampling and experimental soils.

Krihna, G. and Ranjhan, S.K. 1980. Laboratory manual for nutrition research. Vikas publishing house PVT. Ltd. New Delhi, India. 134p.

Kumar, R. 1991. Antinutritional factors: The potential risks of toxicity and methods of alleviating them. Proceedings of F.A.O. Expert consultation held at the Malaysian Agricultural Research and Development, Kuala Lumpur, Malaysia, October 14-19 1991.

Liener, I. E. 1980. Toxic constituents of plant foodstuffs, 2nd Ed. Academic press, New York.

Maga, J. A. 1983. Phytate, its chemistry, occurrence and method of analysis. Oxford press, U.K.

MINITAB Statistical Software 1991. V.14.2 MINITAB Inc. P.A.; USA.

Obikaonu, H. O. and Udedibie, A. B. I. 2007. Comparative evaluation of ensiled cassava peel meal end sundried cassava peel meal as substitute for maize on the performance of starter and finished broiler. Proceedings of the 32nd Annual Conference of the Nigerian Society for Animal Production (NSAP), University of Calabar, March 18th-21st, 2007. Pp. 307-312.

Oluremi, O. I. A., Ojighen, V. O. and Ejembi, E. H. 2006. The nutritive potentials of sweet orange (*Citrus sinensis*) rind in broiler production. *International Journal of Poultry Science 5(7):613-617.*

Oluremi, O. I. A., Ngi, J. and Andrew, I. A. 2007. Phytonutrients in citrus peel meal and nutritional implication for livestock production. *Livestock Research for Rural Development* Vol.9 Article 89. *http//www.cipav.org.co.//lrrd/19/7olur19089.htm.*

Oluremi, O. I. A., Mou, P. and Adenkola, A. Y. 2008. Effect of sweet orange (*Citrus sinensis*) fruit peel on its maize replacement value in broiler diet. *Livestock Research for Rural Development* 20(2)2008. *http//www.lrrd.org/lrrd20/2/olur20020.htm.*

Oluremi, O. I. A., Okafor, F. N., Adenkola, A. Y. and Orayaga, K. T. 2010. Effect of fermentation of sweet orange (*Citrus sinensis*) fruit peel on its phytonutrients and the performance of broiler starter. *International Journal of Poultry Science* 9(6):546-549.

Orayaga, K. T. 2010. Effect of duration of water soaking of sweet orange (*Citrus sinensis*) fruit peel on its nutritional composition and maize replacement value in broiler diets. M.Sc. Thesis submitted to the Department of Animal Nutrition, University of Agriculture, Makurdi. 140p.

Pauzenga, U. 1985. Feeding Parent stock. *Journal of Zootecnica International, December, 1985, pp. 22-24.*

Price, M. L. and Butter, L. G. 1980. Tannin and Nutrition. Purdue University. Agricultural Experimental Station No.272.West Lafayette; IN.

Salami, R. I. and Odunsi, A. A. 2003. Evaluation of processed cassava peel meal as substitutes for maize in the diets of layers. *International Journal of Poultry Science 2 (2):112-116.*

Steel, R. G. D. and Torrie, J. H. 1980. *Principles and procedures of statistics*. McGraw-Hill Book Co. Inc. New York.

Tuleun, C. D., Njike, M. C., Ikurior, S. A. and Ehiobu, N. G. 2005. Laying performance and egg quality of hens fed cassava root meal/brewers yeast slurry based diets. *Production Animal Technology. 1:148-152.*

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