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Effect of dried sweet orange fruit *(Citrus sinensis)* pulp meal on rabbit carcass characteristics and organ weight

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Key words
Sweet orange pulp, rabbit, carcass characteristics, visceral organs

1 SUMMARY

A feeding trial was conducted with 36 mixed breed weanling rabbits consisting of 18 males and 18 females to evaluate the effect of dried sweet orange fruit *(Citrus sinensis)* pulp meal (SOPM) on carcass characteristics and organ weight. The experimental animals were randomly assigned to diets in which SOPM replaced dietary maize at 0, 5, 10, 15, 20 and 25% (w/w). There were six rabbits per dietary group with three males and three females fed diets in mash form *ad libitum* for 12 weeks. At the end of the 12th week, four rabbits (2 males and 2 females) per treatment whose weights were closest to the mean of the group were selected per treatment and starved for 18 hours to clear the guts. Live weights were recorded before stunning and sacrificing. Experimental diets had a significant effect (p<0.05) on the live weight, and singed weight, loin weight and hind limb weight expressed as % live weight of rabbit but did not significantly (p>0.05) affect bled weight, dressing percentage, percent weights of forelimb, rack/rib, visceral fat, abdominal fat, back fat and carcass length. Dietary treatments effect on the visceral organs (liver, kidney, lung, heart, pancreas, spleen and gall bladder) was not significant (p>0.05). Apart from oesophagus, tested diets had statistically similar (p>0.05) effects on gastro-intestinal tract weight, and the weights of its parts. Up to 25% maize replacement with SOPM did not affect the dressing percentage of rabbit carcass as well as the visceral organs which is an indication that SOPM may be a useful feed resource for rabbit feeding.

2 INTRODUCTION

The persistent increase in the cost of conventional ingredients such as maize used in compounding livestock feeds has necessitated intensive investigations into the use of agricultural and agro-based industrial by-products. Large quantities of agricultural by-products which are regarded non-conventional feed sources are produced in Nigeria (Hamzat *et al.*, 2005). The escalating cost of conventional feedstuffs has contributed to the low level of animal protein consumption in Nigeria (Dada *et al.*, 1998). Indeed, the animal protein consumption of 3.245g per head per day in Nigeria is far below the 35g per head per day recommended by the FAO (Abubakar *et al*, 2003). One of the ways of bridging the demand-supply gap is through rearing of rabbits.

Rabbit production for fast meat yield is however affected by inadequate and high cost of feed ingredients brought about mainly by the

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stiff competition between man and monogastric animals for grain and oil seeds (Agunbiade *et al.*, 2002). This has necessitated the search for and utilization of unconventional feedstuffs 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. A group of such wastes emanates from the citrus, a major fruit of sub-tropical region.

Sweet orange *(Citrus sinensis)* production in Nigeria is significant. According to FAO (2004) Nigeria produces 3% of fresh citrus in the world, and Africa produces 3,741, 000 tones of different varieties of citrus fruits of which Nigeria contributes 3, 240,000. Sweet orange fruit pulp is one of the by-products. In Nigeria it is mostly obtained after the exocarp is peeled off and the fruit juice removed. Orange fruit pulp is available throughout the year even though high production of the fruit is from October through March, and it is not being put into any productive use. Obioha (1992) reported that dried citrus pulp meal contains 5.2% crude protein, 3.4% fats, 15% crude fibre, 0.04% calcium, 0.03% phosphorus, 2700kcal/kg metabolisable energy, 1.40% lysine, and 0.14% methionine plus cystine. While it is obvious that citrus pulp meal is inferior to maize in its nutrient contents there is the possibility that it may be a useful feed ingredient for rabbit feeding because it is a monogastric herbivore. In a recent study it has been found that the sweet orange fruit pulp meal can replace dietary maize in rabbit ration at 25% level without suppressing their performance (Hon *et al.*, 2008). The objective of this study was to evaluate the effect of maize replacement with sweet orange fruit (*Citrus sinensis*) pulp meal on carcass weight and organs of rabbits.

3 MATERIALS AND METHODS

The ingredient (sweet orange fruit pulp) was obtained from peeled orange retailers on the campus of Akperan Orshi College of Agriculture, Yandev, Nigeria, where the study was conducted. It was rinsed with water to remove sand, which gets attached to the pulp when it is discarded after the fruit juice has been sucked and immediately sun-dried until it became brittle. Sun-dried pulp was stored in livestock feed bags that were tied at the open end to keep it in a dry state until use. The pulpwas milled using a 2-mm screen hammer mill to obtain sweet orange fruit pulp meal (SOPM). The meal was incorporated into the experimental diets replacing maize at 0, 5, 10, 15, 20 and 25% to give diets coded $SOPM_0$, $SOPM_5$, $SOPM_{10}$, $SOPM_{15}$, $SOPM_{20}$ and $SOPM_{25}$. The proximate compositions and gross energy of the diets were determined using standard methods (A.O.A.C, 1995).

Thirty-six weanling rabbits (18 males and 18 females) of mixed breeds and between 5 to 6 weeks old obtained from some local breeders were used as the experimental animals. The rabbits were allowed a one-week adjustment period before the feeding trial commenced during which they were treated with ivermectin subcutaneously at dosage of 0.1ml per rabbit against ecto and endo–parasites. In addition, embazin forte was orally administered at the rate of 0.6g/l of drinking water as prophylactic treatment against coccidiosis while oxytrox L.A. was administered subcutaneously at the dosage of 0.2ml per rabbit against bacterial infections. At the end of the adjustment period, the experimental rabbits were weighted individually and divided into 6 groups of similar live weight. Each group consisting of 6 rabbits (3 males and 3 females) was randomly assigned to one of the six dietary treatments. Each experimental group was replicated six times with a rabbit each as a replicate in a complete randomized design (CRD). The rabbits were singly kept in a 40cm x 40cm x 40cm wire cage housed in a zinc roofed fenced building with open sides for purposes of good ventilation. Experimental diets in mash form along with cool fresh drinking water were served *ad libitum* throughout the feeding trial which lasted for 84 days. At the end of the 12th weeks, four rabbits (2 males and 2 females) per treatment group whose weights were closest to the mean of the group were selected, and starved for 18 hours to clear the guts. Live weights were recorded before stunning and slaughter by cutting transversely across the trachea, oesophagus, large carotid arteries and jugular veins. Sacrificed rabbits were allowed to bleed to death under gravity and thereafter singedand eviscerated. Carcass cuts and visceral organs were weighed and expressed as percentage of the live weight. Dressing percentage was calculated using the formula of Fielding (1991):

$$\text{Dressing \%} = \frac{\text{Dressed carcass weight}}{\text{Live weight}} \times 100$$

The weight of oesophagus, stomach, small intestine, caecum and colon were expressed as percentages of the gastro-intestinal tract (GIT) weight. The carcass was cut into the following retail parts: forelimb, rack/ribs, loin, hind limb and their weights expressed as percentages of the live weights. All weights were taken with the Mettler Electro balance P 163, CH 8606. The linear measurements of the oesophagus, stomach, small intestine, caecum and colon were taken with a metre rule and expressed as percentages of the GIT length. The carcass length was measured and this represents the length from the atlas to the Os ischii (Blasco *et al.*, 1993).

Data obtained were subjected to one-way Analysis of Variance (ANOVA) using the Minitab Statistical Software (1991). Where significant differences were observed, means were compared by Duncan's Multiple Range Test as outlined by Akindele (1996).

4 RESULTS AND DISCUSSION

The proximate nutrients and the calorific value of dried sweet orange fruit (*Citrus sinensis*) pulp meal used in this study was determined to be as previously reported by Hon *et al.* (2008). Dried pulp meal has on dry matter basis 7.71% crude protein, 9.86% crude fibre, 5.18% ash, 75.31% nitrogen free extract, and a metabolisable energy content of 3756.14kcal/kg which is higher than the metabolisable energy content of maize at 3432.00kcal/kg (Aduku, 1993). The crude protein of SOPM is however inferior to 9.00% crude protein of maize. Sweet orange fruit pulp meal seems to be a potential energy feedstuff resource for farm animals. The proximate compositions and energy contents of the experimental diets are shown in Table 1.

TABLE 1: The proximate nutrients of the experimental diets (%dry matter) in which maize in rabbit diet was supplemented with Sweet orange pulp meal (SOPM) at between 0 – 25%.

Nutrients	**Experimental diets**					
	$SOPM_0$	**$SOPM_5$**	**$SOPM_{10}$**	**$SOPM_{15}$**	**$SOPM_{20}$**	**$SOPM_{25}$**
Dry Matter (%)	89.64	89.22	89.30	89.38	90.14	90.70
Crude protein (%)	17.85	17.93	17.92	17.90	17.75	17.64
Crude fibre (%)	10.90	11.38	11.79	12.20	12.54	12.90
Ether extract (%)	4.92	2.48	2.68	2.71	4.13	4.20
Ash (%)	7.63	4.97	5.33	5.50	7.12	7.59
Nitrogen free extract (%)	58.70	63.24	62.28	61.69	58.46	57.67
Gross energy (kcal/kg)	3822.67	3763.33	3703.30	3688.38	3625.48	3603.28
[1]Digestible energy (kcal/kg)	2734.00	2693.00	2714.00	2719.00	2613.00	2726.00

[1]Digestible Energy= (37×%CP) + (81.8×%EE) + (35.5×%NFE), Pauzenga (1985). $SOPM_0$ = Diet containing 0% sweet orange pulp meal; $SOPM_5$ = Diet containing 5% sweet orange pulp meal; $SOPM_{10}$ = Diet containing 10% sweet orange pulp meal; $SOPM_{15}$ = Diet containing 15% sweet orange pulp meal; $SOPM_{20}$ = Diet containing 20% sweet orange pulp meal; $SOPM_{25}$ = Diet containing 25% sweet orange pulp meal

The replacement of maize with SOPM as an energy source in rabbits diet did not have any significant effects ($p>0.05$) on bled weight, and the percent weights of forelimb, rack/rib, visceral fat, back fat and abdominal fat, dressing percentage, and carcass length among the dietary treatments (Table 2). However, the experimental diets had significant effects ($p<0.05$) on live weight at slaughter, and singed weight, loin weight, and hind limb weight. The live weight of rabbits slaughtered ranged from 1575 to 1813g and rabbits in dietary group $SOPM_{10}$ were significantly heavier than the mean live weights of each of the other dietary groups, which were statistically comparable. There was an apparent decrease in growth rate of rabbits once the 10% maize replacement with SOPM was exceeded. The dressing values of 60.7 to 65.2% in this trial were lower than 75.81 to 79.04% reported when orange peel was used as a dietary substitute for maize in growing rabbit diet (Oluremi *et al.*, 2005). The differences may be due to breeds of rabbits used and probably also differences in the proximate constituents of the test ingredient, which in turn affected the dietary composition. From the means of

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the dressing percentage obtained, it can be deduced that, irrespective of maize, or SOPM as dietary energy source for rabbits up to 25% level replacements, the available rabbit's meat for human consumption is practically the same in quantity.

Table 2: Effect of sweet orange (C*itrus sinensis)* pulp meal in the diet of rabbits on carcass characteristics.

Carcass indices	**Experimental diets**						**SEM**
	$SOPM_0$	$SOPM_0$	$SOPM_0$	$SOPM_0$	$SOPM_0$	$SOPM_0$	
No of Rabbits slaughtered	4	4	4	4	4	4	
Live weight (LW) g	1650^{b}	1637^{b}	1813^{a}	1688^{b}	1621^{b}	1575^{b}	36.80^{*}
Bled weight (%LW)	93.20	93.90	93.90	94.10	94.60	95.30	0.89^{ns}
Singed weight (%LW)	72.80^{a}	71.40^{a}	65.50^{b}	70.40^{a}	73.00^{a}	71.10^{a}	1.15^{*}
Dressing percentage	64.03	62.70	60.70	62.20	65.20	62.40	1.42^{ns}
Forelimb weight (%LW)	16.40	13.70	13.80	12.60	15.10	14.80	0.96^{ns}
Racks/Ribs weight (%LW)	8.32	6.89	7.65	7.42	7.76	6.40	0.61^{ns}
Loin weight (%LW)	15.86^{a}	12.22^{b}	11.72^{b}	13.23^{b}	13.09^{b}	10.64^{b}	0.80^{*}
Hindlimb weight (%LW)	25.80^{a}	21.10^{b}	20.30^{b}	19.60^{b}	18.90^{b}	18.30^{b}	0.96^{*}
Visceral fat weight (%LW)	0.78	0.46	0.20	0.51	0.40	0.40	0.10^{ns}
Abdominal fat weight (%LW)	0.72	0.49	0.77	0.29	0.21	0.34	0.13^{ns}
Back fat weight (%LW)	1.27	0.92	1.45	1.65	0.94	0.63	0.27^{ns}
Carcass length (cm)	35.20	33.20	33.90	33.70	34.00	34.40	0.89^{ns}

$^{a,\,b}$Means in the same row with different superscripts are significantly different ($p<0.05$).
^{ns}Not significant ($p>0.05$). SEM = Standard error of mean; $SOPM_0$ = Diet containing 0% sweet orange pulp meal; $SOPM_5$ = Diet containing 5% sweet orange pulp meal; $SOPM_{10}$ = Diet containing 10% sweet orange pulp meal; $SOPM_{15}$ = Diet containing 15% sweet orange pulp meal; $SOPM_{20}$ = Diet containing 20% sweet orange pulp meal; $SOPM_{25}$ = Diet containing 25% sweet orange pulp meal.

Singed weight of the rabbits on diet $SOPM_{10}$ (65.50% LW) was least and significantly different ($p<0.05$) from singed weights of 70.4 to 73.0 % LW of other diets which were similar ($p>0.05$). This observation, which is the opposite of the live weight of rabbits, is an indication that rabbits in $SOPM_{10}$ may possibly have more fur on their skin than those on other diets. The lower carcass weights of the primal parts in the SOPM based diets which compared to the control showed a reduction in meat and carcass yields as maize was replaced by SOPM in the experimental diets. The carcass lengths of the rabbits in his study were statistically similar ($p>0.05$) irrespective of the type of diet. Thus, it can be said that there was similarity in the skeletal development of the rabbits as they grew to maturity as reported by Sandford (1999). The visceral, abdominal, and back fat weights were not adversely affected by dietary treatments. The low fat weights recorded in this study may be due to the fact that the rabbits did not consume excess energy, which could have been converted into fat and stored around the belly and some major organs in the body.

The effect of dried SOPM in the diet of rabbits on visceral organ weights and gastrointestinal tract parts is presented in Table 3. There were no statistically significant differences ($p>0.05$) in the mean weights expressed as percentage of liver, paired kidney, lungs, heart, pancreas, spleen and gall bladder among the SOPM-based treatment groups and the control group. None of the visceral organs in the experimental rabbits appeared to have been damaged by replacing maize with SOPM at up to 25% level and no single experimental rabbit manifested any signs of distress throughout the feeding trial. Since these organs help to determine the heath status of farm animals replacement of maize with SOPM in the diet of growing rabbit at levels of up to 25% did not prove detrimental to their health. Apart from the oesophagus, the weight of the complete GIT and the weights of the following emptied components: stomach, small intestine, caecum and colon expressed as percentage of the actual GIT weights were statistically the same ($p>0.05$) among the treatments.

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Table 3: Effect of sweet orange (C*itrus sinensis)* pulp meal in the diets of rabbits on visceral organ weights gastro-intestinal tract and its parts.

Carcass indices	Experimental diets						SEM
	$SOPM_0$	$SOPM_5$	$SOPM_{10}$	$SOPM_{15}$	$SOPM_{20}$	$SOPM_{25}$	
No. of Rabbits slaughtered	4	4	4	4	4	4	
Liver weight (%LW)	2.10	2.06	2.22	2.62	2.49	2.42	0.16^{ns}
Paired kidney weight (%LW)	0.51	0.61	0.52	0.51	0.46	0.48	0.04^{ns}
Lungs weight (%LW)	0.56	0.71	0.50	0.61	0.69	0.55	0.06^{ns}
Heart weight (%LW)	0.26	0.25	0.19	0.24	0.24	0.20	0.02^{ns}
Pancreas weight (%LW)	0.87	0.72	0.81	0.96	0.61	0.54	0.18^{ns}
Spleen weight (%LW)	0.04	0.04	0.03	0.04	0.05	0.03	0.004^{ns}
Gall bladder weight (%LW)	0.03	0.03	0.04	0.02	0.04	0.03	0.01^{ns}
Gastro-intestinal tract (GIT) weight (g)	261.65	284.75	326.50	305.25	342.00	318.75	8.06^{ns}
Oesophagus weight (%GIT)	0.49^{ab}	0.58^{a}	0.52^{a}	0.40^{b}	0.50^{a}	0.56^{a}	0.03^{*}
Empty stomach weight (%GIT)	6.04	5.85	5.47	5.77	4.66	4.75	0.42^{ns}
Empty small intestine weight (%GIT)	11.11	11.77	11.76	10.51	9.83	8.75	1.16^{ns}
Empty caecum weight (%GIT)	9.44	8.40	7.45	7.04	8.35	6.93	0.86^{ns}
Empty colon weight (%GIT)	9.43	8.40	8.74	9.13	7.77	9.62	0.65^{ns}

LW = Live weight, GIT = Gastro-intestinal tract. ^{a,b}Means in the same row with different superscripts are significantly different ($p<0.05$). ^{ns}Not significant ($p>0.05$). SEM=Standard error of mean.
$SOPM_0$ = Diet containing 0% sweet orange pulp meal ; $SOPM_5$ = Diet containing 5% sweet orange pulp meal; $SOPM_{10}$ = Diet containing 10% sweet orange pulp meal; $SOPM_{15}$ = Diet containing 15% sweet orange pulp meal; $SOPM_{20}$ = Diet containing 20% sweet orange pulp meal; $SOPM_{25}$ = Diet containing 25% sweet orange pulp meal.

The relative weight of the oesophagus, though significantly different ($p<0.05$) among the dietary treatments, did not follow a particular sequence. The result showed that irrespective of increasing levels of SOPM in the dietary treatments, the experimental diets supported non-discriminatory growth and development of the gastro-intestinal tract and its parts. The average length of the gastrointestinal tract of the rabbits in the groups varied ($p>0.05$) from 490.00cm to 509.00cm (Table 4). The morphometric measurements of each of esophagus, stomach, small intestine, caecum, and colon did not vary significantly ($p>0.05$) and hence were comparable among all the treatment groups. The values of each of the morphometric parameters in the control groups were observed in between the values for rabbits fed the SOPM-based diets.

The result of this study has shown that, at up to 25% dietary maize replacement with sun dried SOPM, rabbit meat available for human consumption was comparable to that of the control group. Furthermore, neither the GIT nor any of its parts, and the visceral organs were affected by this supplementation. Thus, 25% of maize can be replaced with sun dried SOPM in growing rabbit diet without any adverse effect on the animals.

The utilization of SOPM as a substitute for maize in compounding rabbit diet will reduce the cost of feed because at the moment no market value is placed on the pulp which is a major by-product of citrus fruit processing at individual and agro-industry industry levels. It is expected that as interest grows in the potential of this feed resource, it will become an important ingredient in feed formulation by feed millers.

Table 4: Effect of sweet orange (C*itrus sinensis)* pulp in the diet of rabbits on morphometric measurements of the gastro-intestinal tract.

Carcass indices	Experimental diets						SEM
	$SOPM_0$	$SOPM_5$	$SOPM_{10}$	$SOPM_{15}$	$SOPM_{20}$	$SOPM_{25}$	
No of Rabbits slaughtered	4	4	4	4	4	4	
Gastro-intestinal tract (GIT) length (cm)	509.00	490.00	499.00	488.00	501.00	500.00	15.48^{ns}
Oesophagus length (%GIT)	2.86	2.46	2.70	2.94	2.74	2.56	0.18^{ns}
Stomach (%GIT)	2.02	1.94	1.95	2.26	2.04	2.15	0.12^{ns}
Small intestine length (%GIT)	59.09	60.12	59.62	58.78	58.52	59.22	0.93^{ns}
Caecum length (%GIT)	8.60	8.83	8.27	9.05	9.99	9.16	0.62^{ns}
Colon length (%GIT)	27.42	26.68	27.45	27.07	26.70	26.93	0.74^{ns}

GIT = Gastro-intestinal tract

^{ns}Not significant (p>0.05). SEM=Standard error of mean. $SOPM_0$ = Diet containing 0% sweet orange pulp meal; $SOPM_5$ = Diet containing 5% sweet orange pulp meal; $SOPM_{10}$ = Diet containing 10% sweet orange pulp meal; $SOPM_{15}$ = Diet containing 15% sweet orange pulp meal; $SOPM_{20}$ = Diet containing 20% sweet orange pulp meal; $SOPM_{25}$ = Diet containing 25% sweet orange pulp meal.

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