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Evaluation of the Nutritive Potential of the Peels of Some Citrus Fruit Varieties as Feedingstuffs in Livestock Production

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Abstract: Four (4) varieties of citrus fruit namely *Citrus limonum* [lemon (Le), *Citrus qurantifolia* lime (Li)], *Citrus sinensis* washington (SO_w) and *Citrus sinensis* Ibadan (SO_i) were peeled separately, sun dried, milled using hammer mill machine and analyzed in the laboratory to determine yield, proximate composition and crude fibre fractions. The percent dry weight of the peels showed that the yield of sun dried peels which can be obtained per unit weight of fresh peels decreased in the order SO_i > SO_w > Le > Li. Highly significant variations ($p<0.01$) existed between the proximate constituents among the peel meal, and their dry matter of about 89% and crude protein of 9.30-10.96% are comparable to that of maize. Crude fibre and ash which were approximately 14% and 5% respectively are higher than 2.1% CF and 1.22% ash in maize. Acid detergent fibre was significantly different ($p<0.05$), while hemi-cellulose, cellulose, ADF and NDF were highly significantly different ($p<0.01$) among the peels. The ADF seems high in all the peels and growth trials are recommended with monogastric and ruminant animals to evaluate the replacement value of these citrus peel meals when incorporated into the diets of these farm animals.

Key words: Citrus peels, proximate composition, fibre fractions

Introduction

Contemporary animal feeding development in developing countries is partly geared towards searching for inexpensive readily available feed resources which can partially or wholly substitute the scarce and expensive concentrate feeds. This is because of the low level of animal production, scarcity of cereal grains and oil seed cake, and the very stiff competition existing between humans and the livestock industry for cereal grains which has greatly reduced the animal protein intake (Devendra, 1991). Feed cost is also widely recognized as representing the highest percent input making up the total cost of non-ruminant animal production thus Fetuga *et al.* (1975) reported that the profitable production of livestock depends on finding cheaper resources of protein and energy feeds not directly required as component of human dietaries. In Nigeria, tremendous availability of crop residues and agro-industrial by-products has been highlighted (Egbunike and Ikpi, 1988). One such by-product are the peels of citrus fruits. According to FAO (2004), 140 countries produce citrus fruits and Nigeria production is about 2%. Citrus fruits have been reported to be available throughout the year especially during the peak season of October to December which happens to be the bumper harvest period. Yearly world production of citrus fruits has been put at 106 million metric tons and orange fruits represent 65% (FAO, 2001). Sweet oranges are the most cultivated citrus plants mainly for its fruits and the juice which is used for preparation of squash or for flavouring (Yayock *et al.*, 1988). Lemon and lime are acid citrus fruits which differ from other citrus varieties in that they are typically consumed in association with other fruits. The objective of this study is to evaluate and compare the nutritive potentials of the sun-dried peels of lemon orange (*Citrus limonum*), lime orange (*Citrus qurantifolia*) and sweet orange (*Citrus sinensis*) varieties namely Washington and Ibadan as feed ingredients in livestock production.

Materials and Methods

Four different citrus fruits namely lemon (*Citrus limonum*), lime (*Citrus quarantifolia*), sweet orange (*Citrus sinensis*) both Washington and Ibadan varieties were purchased from a citrus market in Makurdi metropolis where the University of Agriculture, Makurdi is located. These fruits were peeled carefully by gently applying sharp razor blade on the epicarp i.e. the flavedo which contains chromoplast and oil sacs. Fresh weight of the peels from each of the four (4) citrus fruits was taken with Knettler Teledo balance and immediately sun dried until they were crispy. Corresponding dry weights of citrus fruits were taken. Thereafter, the peels were ground using a laboratory hammer milling machine with screening Sieve containing pores I mm in size to obtain Citrus Fruit Peel Meal (CFPM). Samples of each CFPM were analyzed at the Institute for Agricultural Research and Training (IAR and T) Ibadan for the proximate constituents and crude fibre fractions using standard methods (AOAC, 1995), and gross energy using the ballistic bomb calorimeter. All data obtained were analyzed with one way analysis of variance using the Minitab Statistical Software (1991).

Table 1: Percent dry weight content of fresh citrus fruit peels

Citrus Varieties	Dry Weight (%)
So_w	31.57^{ab}
So_i	37.43^{a}
Le	23.67^{b}
Li	23.45^{b}
SEM	2.6**

SO_w = *Citrus sinensis* (washington variety), SO_i = *Citrus sinensis*, (Ibadan variety), Le = *Citrus limonum,* Li = *Citrus quarantifolia,* SEM = Standard error of mean (p<0.01), ^{a,b}Means with different superscripts on the same row are significantly different (p<0.01)

Table 2: Proximate constituents and gross energy of dried citrus fruit peel meal (% DM)

	Citrus Fruit Peel Meals				
Nutrients	SO_w	SO_i	Le	Li	SEM
Dry matter	89.71^{b}	89.57^{c}	89.35^{a}	89.93^{a}	0.01^{**}
Crude protein	10.96^{a}	10.49^{b}	9.30^{d}	9.72^{c}	0.14^{**}
Crude fibre	13.66^{d}	14.81^{b}	14.94^{a}	14.37^{c}	0.02^{**}
Ether extract	2.35^{d}	2.54^{c}	2.77^{b}	2.90^{a}	0.03^{**}
Ash	5.46^{b}	5.56^{a}	5.18^{c}	5.07^{d}	0.77^{**}
Nitrogen free extract	67.57	65.30	67.83	67.95	1.07^{NS}
Gross energy (Kcal/Kg)	2980^{b}	2990^{a}	2970^{c}	2960^{d}	3.00^{**}

SO_w = *Citrus sinensis* (washington variety), SO_i = *Citrus sinensis* (Ibadan variety), Le = *Citrus limonum*, Li= *Citrus quarantifolia*, SEM = Standard error of mean (p<0.01 ^{a,b,c,d}Means with different superscripts on the same row are significantly different (p<0.01), ^{NS} = Standard error of mean not significantly different (p>0.05)

Results and Discussion

The percent dry weight of fresh citrus fruit peels is presented in Table 1. Dry weights differed highly significantly (p<0.01). While the dry weight of the sweet orange varieties (SO_w and SO_i) did not differ (p>0.05), So_i had significantly higher (p<0.01) dry weight content than that of Le and Li in that order. This result shows that SO_i will yield a higher tonnage of dried citrus peel from its epicarp than the output from SO_W followed by Le. The least output will be given by Li. If other nutritive properties of the peels favour their utilization in the formulation of practical livestock diets, it thus appear that sweet orange varieties will be citrus fruits of choice among the four citrus fruits in producing this by-product. Sun drying of citrus peels was neither difficult nor time consuming. With a temperature range of 24-27^{0}C, the peels of SO_w, SO_i and Li became crispy within 48 hrs while for Le, an additional 24 hrs was required. This is unlike citrus pulp another citrus by-product which is difficult to dry because it has a slimy consistency and it is very hydrophilic due to the presence of pectin.

The proximate nutrients and gross energy of the citrus fruit peel meals expressed in dry matter is in Table 2. The proximate composition of maize and some other unconventional dietary energy feedstuffs adapted for purposes of comparison is in Table 3. Highly significant differences (p<0.01) were observed between the Dry Matter (DM), Crude Protein (CP), Crude Fibre (CF), ether extract and ash contents of the citrus peel meals with the exception of Nitrogen Free Extract (NFE). The gross energy of CFPM was also highly significantly different (p<0.01). Gross energy of 2990 Kcal/Kg for SO_i and 2980 Kcal/Kg for SO_W were statistically higher than 2970 Kcal/Kg and 2960 Kcal/Kg for Le and Li, respectively. Sweet orange citrus varieties under investigation i.e. SO_w and SO_i have higher CP content of 10.96% and 10.94%, respectively than Le and Li. Nonetheless, the CP in all the citrus fruit peel meals compare with CP in maize which has been variously reported (Tuleun *et al.*, 2005 and Sykes, 1970), and in Sorghum (Smith *et al.*, 1970). In addition to maize, sorghum among other cereals has been investigated as a dietary energy source in poultry, swine and rabbit diets (Sykes, 1970). The highly significant difference (p<0.01) in the ash content of the citrus fruit peel meal decreased in the order SO_i>SO_w>Le>Li showing that the two *Citrus sinensis* varieties were higher in their ash content. The ash content of the CFPM which was approximately 5% was higher than 1.22% for maize (Tuleun *et al.*, 2005), 1.90% for sorghum (Smith *et al.*, 1970) and 4.57% for cassava root meal (Udedibe *et al.*, 2004) but similar to 5.35% for maize processing waste (Okah, 2004). This shows that compared with maize and sorghum, the peel meal of SO_W, SO_i, Le and Li may be less deficient in minerals. It has been reported that usually, grains and vegetable protein ingredients are relatively poor in mineral contents compared with those of animal protein foodstuff (Banerjee, 1976). The CF in the citrus fruit peel meals ranged from 13.6-14.9% DM. This is appreciably high compared with 2.1% and 2.3% for maize (Sykes, 1970; Tuleun *et al.*, 2005). The dietary implication of a high CF as in these CFPM is that, it may limit its maize replacement value in the diets of monogastric animals, most especially poultry and swine because of the low dietary fibre utilization efficiency of these livestock species. The NFE from the citrus fruit peel meal which is the portion of carbohydrates in the peels readily digestible was within a range of 65.50-67.95%. These values are lower than 82.85% for maize and 70.11% for maize processing waste (Okah, 2004), 82.30% for sorghum (Smith *et al.*, 1970) and 87.64% for cassava root meal (Udedibe *et al.*, 2004). Hence, using any of the

Table 3: Chemical composition of maize and some unconventional dietary energy feedstuffs

	Feedstuffs			
	Maize[1]	MPW[2]	Sorghum[3]	CRM[4]
Dry matter	90.48	90.15	88.20	92.71
Crude protein	9.25	15.50	9.70	2.37
Crude fibre	2.20	7.99	3.10	3.15
Ether extract	3.98	1.05	3.00	2.27
Ash	1.72	5.35	1.90	4.57
Nitrogen free extract	82.85	70.11	82.30	87.64

MPW = Maize processing waste, CBS = Cocoa bean shell, MSKM = Mango seed kernel meal, CRM = Cassava root meal, [1]Tuleun *et al.* (2005), [2]Okah (2004), [3]Smith *et al.* (1977), [4]Udedibe *et al.* (2004)

Table 4: Crude Fibre Fractions in Citrus Peel Meal (%) Fractions

	Citrus Fruit Peel Meal				
	SO_w	SO_i	Le	Li	SEM
Hemi-cellulose	21.62[a]	21.10[c]	21.30[b]	21.21b[c]	0.05**
Cellulose	34.07[b]	35.29[a]	33.38	33.50[c]	0.27**
ADL	5.64[ab]	6.10[a]	5.46	5.29[b]	0.26*
ADF	39.71[b]	41.39[a]	38.84	38.79[c]	0.03**
NDF	61.33[b]	62.50[a]	60.21[c]	60.00[a]	0.08**

SO_w = *Citrus sinensis* (washington variety), SO_i = *Citrus sinensis* (Ibadan variety), Le = *Citrus limonum,* Li= *Citrus quarantifolia,* SEM = Standard error of mean, [a,b,c,d]Means with different superscripts on the same row are significantly different ($p<0.05$; $p<0.01$)

peel meals of these citrus fruits in diet formulation may require calorie boosting to improve the nutritional value of the diet. The ether extracts obtained from the citrus fruit peel meals varied from 2.35-2.90% DM and was lower than 3.98% for maize (Tuleun *et al.*, 2005), 4.22% for cooked wild cocoyam (Onuh, 2005), 3.00% for yellow sorghum (Smith *et al.*, 1977). This may be nutritionally advantageous since it is not desirable for animal feed to contain too much fat which may have some effect like mould development and rancidity with adverse effects on the health of the animal. The low crude fat in the peel meals may cause the metabolizable energy of the citrus peel meal to be lower thus making them inferior to maize. The DM of the peels (89.35-89.93%) were observed to be lower than 90.48% and 92.10% reported for maize and wheat offal, respectively (Shoremi and Adama, 2001), but similar to 89.70% for maize offal (Adesehinwa *et al.*, 2001). Thus, the DM range in this study is within reported values of feedstuffs which have high replacement value for maize. The high DM content of the citrus peels may also favour long duration storage. Fractions of crude fibre from the citrus fruit peel meals presented in Table 4 revealed in varying significant amounts the presence of hemi-cellulose, cellulose, Acid Detergent Fibre (ADF), Neutral Detergent Fibre (NDF) and Acid Detergent Lignin (ADL). Fibre as a nutrient is harder to digest than NFE and determines dietary nutritive value because of its influence on the proportion of chemically available nutrients which can be utilized by livestock. According to McDonald *et al.* (1973), the CF portion of a diet has the highest influence on its digestibility and both the quantity and quality are important as determining factors. While the sweet orange varieties (SO_w and SO_i) specifically have higher ADL, ADF and NDF values than Le and Li, in nutritive terms, these fibre constituents are generally high in all the citrus peel meals. This portrays the peels of the different citrus fruit varieties evaluated as materials of low digestibility.

Conclusion: Quantitative and qualitative assessments of the peels of *Citrus sinensis* (Washington and Ibadan varieties), *Citrus limonum* (Lemon) and *Citrus qurantifolia* (Lime) to evaluate their potential in livestock feeding showed that peels obtained from the citrus sinensis varieties i.e. SO_w and SO_i will yield a higher tonnage of sun dried peels from the epicarp. Except for the Le peels which required an additional 24 hrs for drying, the process is completed within 48 hrs with a temperature range of 24°C to 27°C for SO_w, SO_i and Li. The proximate nutrient contents of the citrus fruit peel meal revealed some differences and highlighted the similarity existing among them and between some energy giving feedstuffs like maize sorghum, maize processing waste suggesting that in practical terms, the peel meal of each of these citrus varieties can be used to replace dietary maize at some levels. Whereas, the characterization of CF from the peels into hemi-cellulose, cellulose, NDF, ADF and ADL showed that these fibre constituents seem high, implying that citrus peel meals are feeding materials of low digestibility, growth trials with monogastric and ruminant farm animals are recommended in order to determine the replacement value of the citrus fruit peel meals.

References

Adesehinwa, A.O., B.K. Ogunmodede and I.I. Dafwang, 2001. Replacement Value of maize offal for maize in the diet of weaner pigs containing chicken offal meal. Nig. J. Anim. Prod., 28: 158-161.

A.O.A.C., 1995. Official Methods of Analysis. 16th Ed. Washington DC.

Banerjee, G.C., 1976. Poultry. 1st Ed. Oxford and IBH Publishing Co. PVT Ltd, Bidhan Chandra Krishi Viswaxidyalnya Mahanpur, Huringhah, India.

Devendra, C., 1991. Feed Resources in Goat Husbandry and Breeding in the Tropics. Paper presented in an International Seminar organised by German Foundation for International Development (DSF) at Institute of Advanced Studies. University of Malaysia, Kwala Lumpur., pp: 121-135.

Egbunike, G.N. and A.E. Ikpi, 1988. Utilization of research results on Forage and Agricultural by-products materials as Animal fed Resources in Africa. In: Azowela, B.H, said, A.N., Wenen-Agenelia and J.A. Katogile, (Eds). Proc. OANESA/ARNAB Workshop Malawi. December 5-9, pp: 447-488.

F.A.O., 2001. Anuario de production. http.www. F.A.O. Org.

F.A.O., 2004. Commodity Review and Outlook. Source: UNCTAA from F.A.O. data.

Fetuga, B.L., G.M. Babatunde, O.A. Olusanya and V.A. Oyenuga, 1975. The composition nutrient, digestibility and energy value of maize cobs, yam peels and plantain peels for 3 groups of Pig. Nig. J. Anim. Prod., 2: 95-103.

McDonald, P., R.A. Edward and C.A. Morgan, 1973. Anim. Nutr., 3rd Ed. Longman, pp: 232-235.

Minitab, 1991. Minitab Statistical Software. Rehearse 8.21. Minitab Inc. State College, P.A.

Okah, U., 2004. Effect of Dietary Replacement of maize with maize processing wastes on the performance of Broiler Starter. In: Ogunji, J.O., I.I. Osakwe, V.W. Ewa, S.O. Alaku, S.O. Otuma and B.O. Nweze. Proc. 9th Annual Conf. of Anim. Sci. Assoc. Nig. Abakaliki, Nigeria. Sept. 13th-16th, pp: 2-4.

Onuh, S.O., 2005. Evaluation of the performance of finishing Broilers fed different agro-industrial by-products. In: Onah, D.N., A.O. Ani, S.O.C. Ugwu, R.C. Ezeokonkwo, J.I. Ihedioha and K.F. Chah. Proc. of the 30th Ann. Conf. of NSAP, Nsukka, Nigeria. Mar. 20th-24th, 30: 169-171.

Shoremi, O.I.A. and I.S. Adama, 2001. Utilization of wheat offals by weaner pigs in a warm environment. Ind. J. Anim. Sci., 71: 83-85.

Smith, W.C., M. Almond, G.Savage and T.I.J. Lawrence, 1970. A Nutritional evaluation of sorghum in pig diets. A study commissioned by the U.S. feed Grains Council., pp: 1-15.

Sykes, A.H., 1970. Grain sorghum in poultry nutrition. A Technical Publication of the U.S. Feed Grain Council, London, England., pp: 5-16.

Tuleun, C.D., M.C., Njike, S.A. Ikurior and N.G. Ehiobu, 2005. Laying performance and Egg quality of hens fed Cassava root meal/brewers yeast slurry based diets. Prod. Anim. Tech., 1: 146-152.

Udedibe, A.B.I., B.C. Anyaegbu, G.C. Onyechekwu and O.C. Egbuokporo, 2004. Effect of Feeding different levels of fermented and unfermented cassava tuber meals on the performance of broilers. Nig. J. Anim. Prod., 31: 211-217.

Yayock, J.Y., G. Lombin and J.O. Owonubi, 1988. Crop Science and Production in warm climates. Macmillian Int. Agri. Series. Macmillian Publishers Ltd. London., pp: 307.