Paper ISSN 0189-0514
Online ISSN 1427-4410
J. Anim. Prod. Res. (2021) 33(2):33-41

National Animal Production Research Institute
Ahmadu Bello University
P.M.B 1096, Shika-Zaria,
Kaduna State, Nigeria.
Email: japr@napri.gov.ng Url: journal.napri.gov.ng

GROWTH PERFORMANCE AND DIGESTIBILITY OF WEANER PIGS FED DIETS SUBSTITUTED WITH FRESH CABBAGE (*Brassica oleracea* var. capitata) WASTE

***Ilaboya, I. I., Imouokhome, J. I., Omastuli, M. O., Imonikhe, S. E. and Ogwum, J.**
Department of Animal Science and Animal Technology, Benson Idahosa University, Benin City, Edo State.
**Corresponding Author: iilaboya@biu.edu.ng. Tel: +2348058768730*

ABSTRACT

Twenty-seven mixed breeds of pigs were allotted to three dietary treatments in a completely randomized design, to assess growth performance and nutrient digestibility of weaner pigs fed diets substituted with fresh cabbage (*Brassica oleracea*) waste (CW). There were three replicates per treatment and 3 pigs per replicate. The control group (COG) was fed a ration containing 30% brewer dried grain and 70% concentrate. In contrast, the other two groups were fed the same diet but with 20 (CW-20) and 40 (CW-40) parts of the concentrate component substituted with cabbage waste on an equivalent basis. The experiment lasted for 8 weeks. The COG had the highest ($P<0.05$) final weight. Feed intake was not significantly different ($P>0.05$) among treatment means. Body weight change was not different ($P>0.05$) from the COG and the CW-20 group. Feed conversion ratio (FCR) increased ($P<0.05$) with increasing levels of CW with pigs in control having the least FCR. Cost of production was reduced for the substituted diets, but lowest in diet CW-40 (₦9,882). Crude protein and ash digestibility were highest ($P<0.05$) in pigs on the COG and CW-20 while crude fibre and fat digestibility were lowest in the COG and CW-40 respectively. It can be concluded, therefore, that 40% inclusion of cabbage waste can serve as an excellent supplemental feed resource for weaner pigs.

Keywords: *Brassica oleracea*, Digestibility, Weaner pigs, Economics, Performance.

INTRODUCTION

Cabbage waste is one of the several unwanted by-products generated by fruit producers and food industries in Nigeria that can be gotten rid of by using it as a feed source in pig production. The availability of high-quality feeds is a major constraint for improved livestock productivity under livestock production systems in Nigeria (Okai *et al.*, 2010). In combination with the unaffordable feed costs in this country, farmers are resorting to whatever resource is available to feed their animals. It is therefore important to find affordable alternative feed sources that can be fed to livestock to improve production. The search for alternative feed ingredients is an on-going struggle, aimed at using available local feed resources, crop residues and agro byproducts, to feed livestock as to ensure sufficient animal protein intake and food security for the Nigerian state.

Livestock rearing plays an important role in sustaining the livelihood of livestock farmers all over the world (FAO, 2011) with the swine sub-sector, like other livestock sectors, contributing immensely to animal protein availability in many countries of the world. Meanwhile, current recorded success in pig production in most developing countries like Nigeria is based on the importation of an almost complete package of technology, including parent and breeding stock, equipment, drugs and feed (Perez, 1997). Most of the feeds for pigs are composed mainly of cereal grains, and oil meals, which in principle, compete directly or indirectly with human food. In order to achieve sustainable livestock development, efficient use of available feed resources and expansion of the

feed resource base towards unconventional feedstuffs not competing with human food must be explored (FAO, 2013). One of such feed resources is fruit and vegetable wastes. The use of fruit and vegetable wastes as animal feed is an alternative of high interest because of its environmental and public benefits besides reducing the cost of animal production (Westerndorf, 2000). Roughly, one-third of the food produced in the world for human consumption every year, approximately 1.3 billion tons, get lost or wasted. Global quantity of food losses and waste per year is roughly 40-50% for fruits and vegetables (FAO, 2017). Cabbage (*Brassica oleracea*) waste like other vegetable wastes in most cases is being disposed of either by composting or dumping in landfills or rivers causing environmental pollution. Alternatives to such disposal methods could be recycled through feed resources for livestock. This approach can reduce the cost of feeding, giving higher profits to farmers and also contribute to sustainable intensification of the livestock industry (Wadhwa and Bakshi, 2013).

Pigs, which are one of the most prolific and fast-growing livestock are efficient in converting food waste to valuable animal products (Osaro, 1995). Recent research on fruit and vegetable waste utilization in livestock production showed that dried citrus pulp may be included up to 5, 20 and 15 per cent in diets of growing pigs, pregnant and lactating sows, respectively, without affecting reproductive and productive performance (O'Sullivan *et al.,* 2003). It can also be incorporated into the diets of rabbits at 20-30 percent levels (Hon *et al.,* 2009). Adebiyi *et al*. (2017) reported significant variations in weight and feed conversion of pigs fed rice waste-based diet, with maximal growth of weaned pigs observed at 37.5% rice waste inclusion.

Fresh tomato pomace can be used at 6 and 35 percent as supplementary feed in grower and finisher pigs, respectively, without adverse effect on their performance with decreased feed cost/kg gain (Sayed and Abdel-Azeem, 2009). Dried tomato pomace can also be fed up to 20% to growing rabbits without significantly affecting performance (Sayed and Abdel-Azeem, 2009) while it can be included up to 10-20% in chicken diets without adverse effect on egg production, body weight (Calislar and Uygur, 2010) and overall egg quality (Salajegheh *et al.,* 2012); however, higher levels may depress hen-day production (Jafari*et al.,* 2006). Dried mango peels up to 10% in the diet of finishing pigs had no deleterious effect on feed conversion ratio or performance and economized feeding cost (Rao *et al.,* 2003). This study, therefore, was carried out to investigate the growth performance and nutrient digestibility of weaner pigs fed diets substituted with fresh cabbage waste.

MATERIALS AND METHODS

The study was carried out at the piggery unit of the Faculty of Agriculture and Agricultural Technology Research Farms, Benson Idahosa University, Benin City, Edo State. The climate is tropical with an average annual temperature of 26.2 degrees Celsius and an average rainfall of 2075mm (Imuokhome and Omastuli, 2022). The area lies within the geographical coordinate of longitude $5^0$37'59.99" E and latitude $6^0$19'60.00" N of the Greenwich meridian, in the south-south geo-political zone of Nigeria (Imuokhome and Omastuli, 2022). The cabbage wastes were obtained from Santana fruit market in Benin, Edo state. The cabbage wastes were obtained daily, chopped, and incorporated fresh into daily feed rations.

Experimental animals, feeding and management

A total of 27 mixed breeds weaner pigs were obtained from the teaching and research farm at Benson Idahosa University. The animals were adapted for one week before the commencement of the experiment, which lasted for eight weeks. Experimental animals were randomly allotted to three dietary treatments with three replicates each and three animals per replicate. Pigs were

housed in properly disinfected pens and all routine management practices were strictly observed. The control group (COG) was fed a ration containing 30% cassava peel meal and 70% concentrate, while the other two groups were fed the same diet but with 20 (CW-20) and 40 (CW-40) parts of the concentrate component substituted with cabbage waste on an equivalence basis (Table 1).

Table 1: Gross composition of experimental diets

	Dietary groups#		
	Control	**CW-20**	**CW-40**
Ingredient composition (%)			
*Brewers Dried Grain (BDG)	30.00	30.00	30.00
Concentrate	70.00	50.00	30.00
Cabbage waste	0.00	20.00	40.00
Nutrient Composition (%)			
ME Kcal/Kg	2747.52	2537.55	2028.52
CP (g/kg)	17.55	17.93	18.98
Crude Fat	5.88	11.35	12.37
Crude Fibre	7.87	8.00	8.64
Ash	4.23	8.37	12.93

*Basal diet of Brewers Dried Grain and concentrate or the same containing 20 (CW-20) and 40 (CW-40) percent of cabbage waste replacing the concentrate

Concentrate composed of (kg/per 100 kg): Maize 25.83, soybean meal 10.20, wheat offal 18.53, groundnut cake 4.08, palm kernel cake 9.00, palm oil 0.30, limestone 1.25, salt 0.50 and premix 0.25.

#Calculated value

Data collection

Growth performance evaluation

The feed intake was obtained by subtracting the total leftover feed from the total quantity of feed offered weekly. Body weight gain was determined by subtracting the initial live weight from the final live weight. Feed conversion ratio (FCR) was obtained by dividing the total feed consumed by total weight gain for each pig.

Proximate analysis and nutrient digestibility evaluation

The proximate composition of feed samples was determined using AOAC (1990) methods of analysis. Three animals were randomly allotted from each treatment into metabolic cages for 5 days for a digestion trial. The first 2 days were for cage adaptation and the faecal collection was done during the next 3 days. Faeces were collected from individual animals and thereafter weighed to determine the fresh weight. Faecal samples were oven-dried at 65^{o}C until constant weight and pulverized for further analysis. Faecal samples were analyzed for crude protein, fibre, ether extract and ash (AOAC, 1990).

Feed cost analysis

The market cost of feedstuff during the study was used to calculate the total cost of feed, cost

of feed per kg, cost per kg live weight and the economy of feed conversion.

Statistical analysis

All data were subjected to analysis of variance (ANOVA) using SAS (2012). Significant means were separated using Duncan's Multiple Range Test in the SAS package.

RESULTS

Proximate analysis of experimental diets

The results of the proximate composition of the experimental diets are shown in Table 2. The results obtained show that the dry matter in the diets ranged from 46.90-62.30% while crude protein, crude fibre, ether extract, ash, and nitrogen free extracts ranged from 18.53-18.98%; 5.20-8.30%; 5.03-7.47%; 16.30- 20.90 and 10.30-16.54% respectively. The diet substituted with cabbage waste; CW-20 had the highest crude protein value (37.10) while COG had the lowest crude protein value (36.70). The dry matter was higher (62.30) in COG and lowest in CW-20 (46.90). The crude fibre was highest in CW-20 (8.30) and least in CW-40 (5.20).

Table 2: Proximate composition of the experimental diet

	Dietary Group		
Proximate composition	**COG**	**CW-20**	**CW-40**
Moisture, %	36.70	37.10	36.80
Crude protein, %	18.53	18.73	18.98
Crude fibre, %	5.80	8.30	5.20
Ether extract, %	5.03	7.47	6.48
Ash, %	16.30	18.30	20.90
Nitrogen Free Extract	16.54	10.30	11.64
Dry matter, %	62.30	46.90	47.20

Basal diet of brewers dried grain (control) or the same containing 20(CW-20) and 40(CW-40) percent of cabbage waste replacing maize, soyabean, wheat offal, groundnut cake, and palm kernel cake

[abc] Means along the same row with different superscripts are significantly different

CW-fresh cabbage waste

Growth performance

Results on the performance of weaner pigs fed diets supplemented with varying levels of cabbage waste in Table 3. The values showed a significant ($P<0.05$) variation among treatments except for their initial weights. Pigs on the control treatment (COG) had the highest ($P<0.05$) final body weight (30.40 kg), followed by pigs fed CW-20 (28.18 kg). Low body weight was observed for pigs on CW-40 (21.14 kg). There was no significant difference in the feed intake of weaner pigs fed the different treatment diets. Feed conversion ratio (FCR) increased ($P<0.05$) with an increasing level of CW with pigs in the control treatment having the least FCR (3.08) while those on CW-40 had the highest (6.16).

Table 3: Growth performance of weaner pig fed diets supplemented with fresh cabbage waste

Parameters	Dietary groups			SEM
	COG	CW-20	CW-40	
Initial BW (kg)	13.00	13.00	12.00	0.36
Final BW (kg)	30.40[a]	28.18[b]	21.14[c]	0.52
Net BW change (kg)	17.40[a]	15.18[a]	9.14[b]	1.33
Feed Intake (kg)	6.20	5.41	5.23	0.36
Feed conversion ratio	3.08[a]	3.55[a]	6.16[b]	0.71

[abc] Means along the same row with different superscripts are significantly different. CW-fresh cabbage waste

Basal diet of brewers dried grain (control) or the same containing 20(CW-20) and 40(CW-40) percent of cabbage waste replacing maize, soyabean, wheat offal, groundnut cake, and palm kernel cake

Cost analysis

Feed cost per kg was highest (₦ 2794.97) for the control diet (Table 4) and reduced with increasing levels of cabbage waste. Similar trends were also observed for feed cost per weight gain of pigs. The cost of feeding was calculated by multiplying feed intake by the cost of feed. However, feed cost per weight gain was calculated by multiplying feed cost per body weight gain (kg).

Table 4: Cost analysis of weaner pigs fed diets substituted with fresh cabbage waste

Parameters	Dietary groups			SEM
	COG	CW-20	CW-40	
Feed Intake (kg)	6.20	5.41	5.23	0.36
Cost of feed/kg	2794.97	2483.5	1889.67	-
Cost of feeding/kg	17328.83	13435.74	9882.95	-
Body weight gain (kg)	17.40[a]	15.18[a]	9.14[b]	1.33
Feed cost/weight gain	160.63	163.60	206.75	-

[abc] Means along the same row with different superscripts are significantly different. CW-fresh cabbage waste

Basal diet of brewers dried grain (control) or the same containing 20(CW-20) and 40(CW-40) percent of cabbage waste replacing maize, soyabean, wheat offal, groundnut cake, and palm kernel cake

Nutrient digestibility

The CW-40 groups had a significantly high ($P<0.05$) CP (84.97%) and ash (67.10%) digestibility (Table 5) but the COG (56.18%, 41.59%) and CW-20 (62.03%, 42.94%) group were not significantly different. Treatment CW-20 had the highest ($P<0.05$) crude fibre digestibility value (56.47%) while there was no observable difference in the COG (22.54%)

and treatment CW-40 (27.81%). Ether extract digestibility was highest (P<0.05) in the COG (62.35%) and treatment CW-20 (61.78%) while CW-40 group had the lowest (27.81%).

Table 5: Digestibility of weaner pig fed diets substituted with fresh cabbage waste

Parameters	Dietary groups			SEM
	Control	CW-20	CW-40	
Crude protein, %	56.18[a]	62.03[a]	84.97[b]	4.48
Crude fibre, %	22.54[a]	56.47[b]	27.81[a]	5.46
Crude fat, %	62.35[a]	61.78[a]	37.69[b]	4.36
Ash, %	41.59[a]	42.94[a]	67.10[b]	4.17

[abc] Means along the same row with different superscripts are significantly different. CW-fresh cabbage waste

Basal diet of brewers dried grain (control) or the same containing 20(CW-20) and 40(CW-40) percent of cabbage waste replacing maize, soyabean, wheat offal, groundnut cake and palm kernel cake,

DISCUSSION

Feed intake of pigs on the three treatments showed that pigs fed BDG-cabbage waste had no observable difference but pigs on the COG had the highest (6.20 kg) intake. Higher inclusion of CW-40 did not have any negative influence on feed consumption in weaner pigs. Replacement of up to 40% BDG feed with CW in the diets resulted in increased bulk and crude fibre content of the cabbage waste-based diets, hence lowered energy content is expected. This could still be responsible for the reduction in the feed intake (5.23kg) of the pigs fed the CW-40 diet. This agrees with the report of Adebiyi *et al*. (2017) that higher inclusion of rice waste reduced feed intake and consequently weight change in weaner pigs. Reports of a study by Ogunsipe *et al*. (2017) also showed reduced feed intake and weight gain in grower pigs fed increasing levels of cocoa bean shell meal in replacement of maize. However, the findings of this study negate that of Kwak and Kang (2006) who observed a higher feed intake due to relatively low energy levels in food waste mixture. The result showed a significant difference in the FCR values which increased with higher inclusion of cabbage waste in the diet and was lowest in the COG which contained no cabbage waste which did not differ significantly from the CW-20. This means that the COG and CW-20 had a better utilization of feed compared to CW-40. The reduced utilization can also be attributed to the increased dietary content and lower concentration of energy as the cabbage waste increased (Raj *et al.,* 2006).

It is interesting to consider the prices of feed in the various treatments, even though FCR was higher for pigs fed the CW-supplemented diets, the cost of production was reduced (₦9,882). This shows that it is economical to use cabbage waste in pig diets, but at levels that do not have a negative effect on growth performance. This agrees with the works of Adebiyi *et al.* (2017) who reported reduced costs on the performance of growing/weaner pigs fed palm oil sludge and rice waste. However, Esteban *et al.* (2007) recorded increased cost (by 20%) with the inclusion of fruit-vegetable and fish waste as alternative feedstuff in pig diets; the cost incurred was due to the processing and conservation.

High digestibility values obtained for most of the nutrients suggest that the diets were highly

degraded in the guts of the animals. The crude protein digestibility was highest in CW-40 (84.97%); this could be a result of the palatability of the fresh cabbage for pigs (Adebiyi *et al*., 2017). This suggests that protein digestibility increased with increasing levels of cabbage waste. This result is in line with the findings of Westendorf. (2000) that CP digestibility by pigs fed food waste was comparable to those fed with corn/soybean meal diets. It also conforms to the work of Adesehinwa *et al.* (2011) who observed an increase in CP digestibility of growing pigs fed increasing levels of cassava peel meal but negates the findings of Okolo *et al*. (2012).

Crude fiber digestibility values varied from 22.54 to 56.47%. Pigs in CW-20 (56.47%) were seen to have had higher crude fibre digestibility while the COG (22.54%) and CW-40 (27.81) groups had the lowest digestibility. This shows poor utilization of the crude fibre from CW even as its inclusion level increased in the diets, and this could be attributed to reduced fermentation of the fibre in the gut of the pigs. It has been reported that utilization of crude fibre by non-ruminants varies considerably according to the fibre source, degree of lignification, level of inclusion, and the extent of processing (Freira *et al.,* 2000; Galassi *et al.,* 2004; Wang *et al.,* 2004).

Pigs in the CW-40 group with the highest waste inclusion were seen to have had the least fat digestibility probably because of the high inclusion of CW. Finally, the apparent digestibility of the crude ash contained in the diets was significantly affected by the fresh cabbage waste inclusion (CW-40). The replacement levels brought about slight numerical variations in the crude ash digestibility by the animals; the levels were sufficient and above resulting in variation to reports by Adsos *et al*. (2015). These variations could be attributed to the differences in the experimental diets.

CONCLUSION

Cabbage waste which is a good source of nutrients can be fed fresh and supplemented with other diets in weaner pigs without affecting their performance, cost analysis and nutrient digestibility. It led to effective and efficient utilization of the waste which could be used to reduce the production cost, thereby, increasing profits and also helping in waste management and reduction of environmental pollution. It can be concluded, therefore, that 40% inclusion of cabbage waste can serve as an excellent supplemental feed resource for weaner pigs.

ACKNOWLEDGMENT

The authors wish to thank Paul Ogbeifun of Benson Idahosa University and Temitope Lawal of the University of Ibadan for some of the laboratory analysis.

REFERENCES

Adebiyi, O. A., Dare, A. M. and Bankole, T. O. (2017). Effect of food waste on the performance and haematological profile of weaned pigs. *Journal of Animal Production Research, 29: 128-135.*

Adesehinwa, A.O.K., Obi, O.O., Makanjuola, B. A., Oluwole O.O. and Adeshina M. A. (2011). Growing pigs fed cassava peel based diet supplemented with or without Farmazyme 3000: Effect on growth, carcass and blood parameters. *African Journal of Biotechnology, 10: 2791-2796.*

Adsos, A. P., Inkyung, P., Peter, F., Elke, V. and Sung, W. K. (2015). Effect of dietary supplementation of xylanase on apparent ileal digestibility of nutrients, viscosity of digesta, and intestinal morphology of growing pigs fed corn and soybean meal based diet. *Animal Nutrition, 1: 19-23.*

AOAC. (1990). Official Methods of Analysis, 15th ed. Association of Official Analytical Chemists, Arlington, VA.

Calislar, S. and Uygur, G. (2010). Effects of dry tomato pulp on egg yolk pigmentation and some egg yield characteristics of laying hens. *Journal of Animal Veterinary Advances, 9: 96-98.*

Esteban, M. B., García, A. J., Ramos, P. and Márquez, M. C. (2007). Evaluation of fruit–vegetable and fish wastes as alternative feedstuffs in pig diets. *Waste Management, 27: 193-200.*

FAO. (2011). World Livestock 2011 – Livestock in Food Security. Food and Agricultural Organization of the United Nations, Rome, Italy.

FAO. (2013). Food Wastage Footprint: Impacts on Natural Resources. Food and Agricultural Organization of the United Nations, Rome, Italy.

FAO. (2017). Save Food. Global Initiative on food loss and waste reduction. Key facts on food loss and waste you should know. Food and Agricultural Organization of the United Nations, Rome, Italy.

Freira, J. P. B., Guerreiro, A. J. G., Cunha, L. F. and Aumaitre, A. (2000). Effect of dietary fibre source on total tract digestibility, caecum volatile fatty acids and digestive transit time in the weaned piglet. *Animal Feed Science and Technology, 87: 71-83.*

Galassi, G., Colombini, S., Malagutti, L., Crovetto, G.M. and Rapetti, L. (2010). Effects of high fibreand low protein diets on performance, digestibility, nitrogen excretion and ammonia emission in the heavy pig. *Animal Feed Science and Technology, 161: 140-148.*

Hon, F. M., Oluremi, O. I. A. and Anugwa, F. O. I. (2009). The effect of dried sweet orange (Citrus sinensis) fruit pulp meal on the growth performance of rabbits. *Pakistan Journal of Nutrition, 8:1150-1155.*

Imouokhome, J. I. and Omastuli, M. O. (2022). Principle component analysis of egg quality traits of indigenous chicken genotypes in Edo State. *BIU Journal of Basic and Applied Sciences 7: (1): 33-42.*

Jafari, M., Pirmohammadi, R. and Bampidis, V. (2006). The use of dried tomato pulp in diets of laying hens. *International Journal of Poultry Science, 5: 618-622.*

Kwak, W. and Kang, J. (2006). Effect of feeding food waste-broiler litter and bakery by-product mixture to pigs. *Bioresearch Technology, 97: 243-249.*

O'Sullivan, T. C., Lynch, P. B., Morrissey, P. A. and O'Grady, J. F. (2003). Evaluation of citrus pulp in diets for sows and growing pigs. *Irish Journal of Agriculture and Food Research, 42: 243-253.*

Ogunsipe, M. H., Ibidapo, I., Oloruntola, O. D. and Agbede, J. O. (2017). Growth performance of pigs on dietary cocoa bean shell meal. *Livestock Research for Rural Development, 29: 18.*

Okai, D. B., Boateng M., Amoah, K. O., Saah, E. and Ills, E. E. (2009). Effect of dried sweet orange pulp on growth performance and carcass characteristics of rats. Proceeding of the 16th biennial conference of the Ghana Society of Animal Production, KNUST, Kumasi.

Okolo, F. A., Ocheja, J. O., Lalabe, B. C. and Ejiga, P. A. (2012). Digestibility, performance and bioeconomics of growing West African Dwarf goats fed diets containing graded levels of cashew nut shell. *International Journal of Agriculture and Rural Development, 15: 1000-1007.*

Osaro, O. M. (1995). Enhancing production performance of small holder pig farmers. In: Pig Production Workshop Training Manual. National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Zaria, Nigeria, Pp. 100-130.

Pérez, R. (1997). Feeding pigs in the tropics. FAO Animal Production and Health Paper – 132. Food and Agricultural Organization of the United Nations, Rome.

Raj, S., Skiba, G., Weremko, D. and Fandrejewski, H. (2006). Digestibility of energy and nutrients in pigs previously fed a high-fibre diet. *Journal of Animal and Feed Sciences, 15: 591-598*

Rao, D. S., Ravi, A. and Yedukondalu, R. (2003). Inclusion of dried mango (Mangifera indica) peels in finisher rations of pigs on their performance. *Indian Journal of Animal Nutrition, 20: 120-123.*

Salajegheh, M. H., Ghazi, S., Mahdavi, R. and Mozafari, O. (2012). Effects of different levels of dried tomato pomace on performance, egg quality and serum metabolites of laying hens. *African Journal of Biotechnology, 11: 15373-15379.*

SAS. (2012). Statistical Analytical Software Users' Guide.Version 9.2.SAS Institute Inc. Cary.

Sayed, A. N. and Abdel-Azeem, A. M. (2009). Evaluation of dried tomato pomace as feedstuff in the diets of growing rabbit. *International Journal for Agro Veterinary and Medical Sciences, 3: 13-18.*

Wadhwa, M. and Bakshi, M.P.S. (2013). Utilization of Fruit and Vegetable Waste as Feed and as Substrate for Generation of Other Value Added Products. RAP publication, 2013/04.Animal Production and Health Commission for Asia and the Pacific, Bangkok, Thailand. Food and Agricultural Organization of the United Nations, Rome.

Wang, J. F., Zhu, Y.H., Li, D. F., Jorgensen, H. and Jensen, B. B. (2004). The influence of different fiber and starch types on nutrient balance and energy metabolism in growing pigs. *Asian-Australasian Journal of Animal Sciences, 17: 263-270*

Westendorf, M. L. (2000). Food Wastes to Animal Feed. Iowa State University Press, Ames, IA, Pp. 3-16, 69-90.