Performance and nutrient utilization of rabbits fed diets based on crop residues fermented with *Rhizopus oligosporus*

Adedire¹, A.O., Oduguwa², O.O., Edema³, M.O., Onifade⁴ O.S. and Onwuka² C.F.I.

¹Department of Nutrition and Dietetics,
Wesley University of Science and Technology
Ondo, Ondo State.

²Department of Animal Nutrition, Federal University of Agriculture,
Abeokuta Ogun State. ³Department of Food Science and Technology, Animal Nutrition,
Federal University of Technology, Akure, Ondo State.

⁴Department of Pasture and Range Management, Federal University of Agriculture,
Abeokuta Ogun State

Abstract

This study was conducted to evaluate the performance and nutrient utilization of rabbits fed diets containing corn cob and cowpea husk incubated with *Rhizopus oligosporus*. A total of twenty four rabbits were assigned to four groups, each divided into three groups of two rabbits per replicate. Four experimental diets containing fermented and unfermented crop residues were formulated. The fermented crop residues were incubated with *Rhizopus oligosporus* and were allowed to ferment for 48 hours. The proximate composition as well as the fibre fractions of the fermented and unfermented crop residues was determined. The experiment was arranged in a 2x2 factorial design and was analysed using analysis of variance. The result indicated that average growth rate of rabbits fed fermented cowpea husk were higher numerically than those fed the other diets. The average weekly feed intake was significantly ($p < 0.05$) affected by the weight gain. Feed efficiency and protein efficiency ratios were not significantly ($p > 0.05$) affected by fibre sources while fermentation did not impose any significant impact on these parameters. *Rhizopus* fermentation improved the performance and utilization of crude fibre, phosphorus, ADF and NDF by rabbits fed corn cob and cowpea husk. It was concluded that corn cob and cowpea husk possessed the potential as fibre sources in rabbit ration.

Keywords: corn cob, cowpea husk, fermentation, rabbit, *Rhizopus oligosporus*

Introduction

In recent times, rabbit keeping has gained ground among Nigerian households and researchers as an alternative source of animal protein and as experimental animals (Akanno and Ibe, 2006). Rabbits are herbivores with post gastric digestion. They have enlarged ceaca which harbour microbes. This anatomical and physiological adaptation confers on rabbits an added ability to utilize fibrous materials over other monogastrics like poultry (Oduguwa *et al.*, 1999).

Attempts to improve the nutritive value of waste agricultural residues by biological means have produced varied results (Belewu, 2001). Some of such approaches, of potential benefit, are treating by-products (which are majorly cellulose) with enzymes and ensiling (especially for high

moisture products) among others. These treatments will break the lignin content of the crop residues and thereby degrade the fibre fractions for easier utilization by animals. Fermentation technology has been developed in which for example, a considerable amount of unicellular biomass could be multiplied by using it to ferment the by-products containing cellulose which are not directly utilized by humans.

In Nigeria, large quantities of agro-industrial by-products are produced and many of them have potentials as non-conventional feed stuffs (Adeniji and Ehimere, 2003). At present, corn cobs are thrown away or used as fuel while cowpea husk are fed to ruminants in small quantities by peasant farmers. Therefore, large quantities are burnt to reduce refuse dump. Though corn cob and cowpea husk are

seasonal, they are widely available in their seasons. These crop residues though cellulosic, sometimes also include starchy and/or sugary components. They will therefore be a good substrate for a filamentous fungus like *Rhizopus oligosporus* which is a fungus that degrades solid substrate with the aid of its *hyphae* in addition to its enzymes. Hence, this study was aimed at assessing the performance of weaner rabbits fed fermented and unfermented corn cob (CC) and cowpea husk (CH).

Materials and Methods

The study was carried out at the rabbitary unit of the Teaching and Research Farm, University of Agriculture, Abeokuta. Pure culture of *R. oligosporus* (10^7 conc. of spores/ml) was used to ferment the crop residues (test ingredients) and these were allowed to ferment anaerobically for 48 hours. The fermented sundried crop

residues were then analysed before incorporation into the diets. Table 1 shows the composition of the experimental diets.

Twenty four weaner rabbits of both sexes having initial average weight of between 597.19g and 583.33g were used. They were allocated on weight equalization basis into four groups. Each treatment was replicated thrice with two rabbits per replicate. There were four dietary treatments. The first two contained untreated crop residues i.e. CC and CH while the last two contained crop residues that have been treated with *R. oligosporus*. The crop residues used were incorporated to supply 12.5% crude fibre (CF) in the respective diets.

The proximate composition of the diets as well as the fibre fractions were determined by the methods of AOAC (1990) while mineral (Ca and P) were determined by the methods of Grueling (1996). At the end of

Table 1: Gross composition of the experiment diets diets (%)

	UNFERMENTED		FERMENTED	
	CC	CH	CC	CH
Maize	35.00	35.00	35.00	35.00
SBM	12.00	12.00	12.00	12.00
GNC	12.00	10.00	10.00	10.00
Fibre source	33.42	35.67	35.70	37.87
Wheat offal	2.98	2.73	2.70	0.53
Lysine	0.50	0.50	0.50	0.50
Methionine	0.50	0.50	0.50	0.50
Bone meal	2.00	2.00	2.00	2.00
Oyster shell	1.00	1.00	1.00	1.00
Premix	0.30	0.30	0.30	0.30
Salt	0.30	0.30	0.30	0.30
	100	100	100	100
Calculated analysis				
Energy ME (Kcal/g)	2.48	2.46	2.47	2.45
Crude protein (%)	15.48	17.84	15.14	18.83
Crude fibre (%)	14.99	15.24	14.88	14.66
Determined analysis				
Energy ME (Kcal/g)	2.68	2.28	2.48	2.46
Crude protein (%)	15.24	17.94	15.78	17.90
Crude fibre(%)	14.79	14.90	14.67	14.56

NOTE : CC – Corn cob; CH – Cowpea husk

Table 2: The proximate composition of fermented and unfermented crop residues

	UNFERMENTED		FERMENTED	
	CC	CH	CC	CH
Dry matter (%)	95.79	95.06	96.40	95.50
Crude protein (%)	2.47	12.06	7.02	14.45
Ether extract (%)	0.60	0.69	0.96	1.20
Crude fibre (%)	37.40	35.04	35.01	33.01
Ash (%)	2.80	7.02	4.78	10.20
NFE (%)	52.52	40.26	51.63	37.64
NDF	29.35	29.58	32.48	33.82
ADF	36.38	34.85	35.94	32.40

NOTE : CC – Corn cob; CH – Cowpea husk

the 8th week of the experiment, three rabbits randomly selected from each treatment (one per replicate) were retained for the digestibility study. A known amount of feed was given to each group and the faeces voided from each group were weighed. The faeces were collected for a period of seven days and were oven dried at 70°C for 48 hours. The dried samples were subjected to chemical analysis and the result of the chemical analysis of the feeds and faeces were used in calculating the digestibility of each nutrient by the rabbits.

Data collected includes feed intake, initial, weekly and final weights. These were used to compute weight gained, feed and protein efficiency ratios. Weight of faeces voided were also recorded to determine the nutrient digested by the experimental rabbits. These data were analyzed using Analysis of Variance (ANOVA) test (SAS, 1999) and the means were separated using Duncan multiple range test (Steel and Torrie, 1980) at 0.05% of probability.

Results

The proximate composition of fermented and unfermented crop residues (corn cob and cowpea husk) is shown in table 2. The results showed that fermented cowpea husk had the highest crude protein which was 14.45% while unfermented corn cob had the lowest level of crude protein (2.47%).

The unfermented corn cob had the highest crude fibre which was 37.40% while fermented cowpea husk had the lowest crude fibre (33.01%). Ash content of the test ingredients followed the same trend as crude protein. As observed, the crude protein, ether extract and ash contents were increased with fermentation while the crude fibre content was reduced.

Table 3 shows the effect of fibre source and fermentation (incubation with *Rhizopus oligosporus*) on performance characteristics of rabbits. Rabbits fed cowpea husk had higher final live weight (1095.73g) which was significantly ($p < 0.05$) higher than the weight of rabbits fed corn cob. Rabbits fed fermented crop

Table 3: Effect of fibre source and fermentation on the performance of experimental rabbits

	FIBRE SOURCE			FERMENTATION		
	CC	CH	SEM	FM	UF	SEM
Initial wt (g)	792.75	826.82	20.53	583.33	579.17	21.60
Final wt (g)	1015.31	1095.73	11.79	1063.35a	1002.22b	42.16
Av. Wkly wt gain (g)	35.84	40.99	4.49	40.79	37.39	5.30
Av. Wkly feed intake (g)	167.98b	170.43a	0.59	170.02	168.61	0.47
Feed eff. ratio	0.21	0.24	0.02	0.24	0.22	0.03
Protein eff. ratio	1.34	1.30	0.21	1.09	1.01	0.20

^{a b} Means on the same column having different superscripts were significantly different ($p < 0.05$).

NOTE: CC – Corn cob; CH – Cowpea husk; AV – average; Wkly – weekly; FM – Fermented; UF – Unfermented; SEM – Standard error of means; wt -weight

residue had a higher final live weight of 1063.33g, compared to those fed unfermented products (1002.22g). The feed intake by the experimental rabbits was not significantly different ($p > 0.05$) among the rabbits on the two fibre sources. Rabbits on cowpea consumed more (170.43g) than rabbits of corn cob (167.98g). The average weekly weight gain followed the same trend as feed intake but not significant ($p > 0.05$) among rabbits on fermented and unfermented products. Feed efficiency ratio of cowpea husk was better than that of corn cob though, it was not significantly ($p > 0.05$) different. On the other hand, rabbits on corn cob utilized the crude protein of the feed better than those on cowpea husk but not significantly different ($p > 0.05$). The feed and protein efficiency ratios were better with fermentation but not

significantly ($p > 0.05$) different from the unfermented products.

The effect of interaction of fibre source with fermentation is presented on Table 4. Fermented cowpea husk recorded significantly ($p < 0.05$) highest final weight (1162.50g) while unfermented cowpea husk recorded the lowest which was significantly ($p < 0.05$) different from others except unfermented cowpea husk. In addition, the rabbits on fermented cowpea husk were able to utilize the feed and the protein content better than on other crop residues. Rabbits on unfermented cowpea husk had the highest feed intake (171.00g) but not significantly ($p > 0.05$) different from rabbits on other crop residue.

Table 5 shows the effect of the fibre source and fermentation on nutrients digestibility by the experimental rabbits. The values

Table 4: The effects of interaction of fibre source with fermentation on performance of experimental rabbits

	FERMENTED		UNFERMENTED		SEM
	CC	CH	CC	CH	
Initial wt (g)	583.33	583.33	575.00	583.33	21.66
Final wt (g)	1083.33 ^b	1162.52 ^a	984.00 ^c	961.67 ^c	42.16
Av.wkly. wt gain (g)	38.55	43.48	37.35	37.42	5.30
Av.wkly.feed intake (g)	170.29	169.70	164.38	171.00	0.47
Feed efficiency ratio	0.22	0.26	0.22	0.22	0.03
Protein efficiency ratio	1.43	1.43	1.22	1.21	0.30

^{abc} Means on the same row having different superscripts are significantly different ($p < 0.05$).

NOTE : CH – Cowpea husk; CC – Corn cob; wt – weight; AV – average; Wkly – weekly; SEM – Standard error of means

Table 5: The effect of fibre source and fermentation on nutrient digestibility by experimental rabbits

DIGESTIBILITY (%)	FIBRE SOURCE		SEM	FERMENTATION		SEM
	CC	CH		FM	UF	
Dry matter	69.00	68.86	0.26	67.81	67.01	1.22
Protein	87.98 ^a	81.62 ^b	0.55	70.53	71.48	1.59
Crude fibre	59.25	60.48	0.59	54.22	54.98	1.42
NDF	38.20 ^b	52.54 ^a	0.43	47.00	37.24	1.90
ADF	21.84	22.59	0.23	22.64	20.14	1.62
Ether extract	63.08	63.66	0.14	60.11	60.03	1.40
Total ash	53.44	58.01	1.31	52.56	51.00	1.98
Calcium	60.88	64.88	2.91	56.19	60.87	3.00
Phosphorus	55.35 ^b	57.87 ^a	0.77	51.28	51.92	0.17

^{ab}Means on the same row having different superscripts are significantly different ($p < 0.05$). NOTE: UF – Unfermented; FM – Fermented; CH – Cowpea husk; SEM – Standard error of means.

obtained revealed that rabbits on corn cob were able to digest a significantly ($p < 0.05$) higher percentage of protein (87.98%) than those of on cowpea husk. Crude fibre, acid detergent fibre (ADF) and total ash digestibility by rabbits on cowpea husk (60.48%, 22.59% and 58.01% respectively) were higher but not significantly ($p > 0.05$) different from those on corn cob.

Phosphorus digestibility by rabbits on cowpea husk (57.87%) was significantly ($p < 0.05$) higher than those on corn cob. Calcium digestibility was not significantly ($p > 0.05$) different among the rabbits on the two fibre sources. Neutral detergent fibre digestibility (NDF) by rabbits on cowpea husk was significantly ($p < 0.05$) higher than those on corn cob while ether extract digestibility by rabbits on the two fibre sources were not significantly ($p > 0.05$) different from each other.

Nutrient digestibility by experimental rabbits were not significant ($p > 0.05$) among the treatments (fermented and unfermented). Fermentation did not improve protein, crude fibre and calcium digestibility but slightly enhanced digestibility of neutral detergent fibre, acid detergent fibre and total ash. The values obtained revealed that phosphorus and ether extract digestibility was not affected by fermentation.

The effect of fibre source and fermentation interaction on nutrient digestibility is shown on Table 6. Rabbit on unfermented corn cob digested a higher percentage of crude protein (88.01%) which was significantly ($p < 0.05$) higher than those of fermented and unfermented cowpea husk but not significantly different from fermented corn cob (87.94%).

Rabbit on fermented corn cob (62.88%) were able to digest crude fibre significant

Table 6: The effect of fibre source and fermentation interaction on nutrient digestibility by experimental rabbits

DIGESTIBILITY (%)	FERMENTED		UNFERMENTED		SEM
	CC	CH	CC	CH	
Dry matter	63.63	68.91	69.37	68.81	0.92
Protein	87.94 ^a	80.40 ^b	88.01	82.85 ^b	1.16
Crude fibre	62.88 ^a	60.35 ^{ab}	55.61 ^b	60.62 ^{ab}	1.59
NDF	40.69 ^c	59.35 ^a	35.71 ^d	45.73 ^b	1.42
ADF	27.54 ^b	31.63 ^a	16.13 ^c	13.54 ^d	1.00
Ether extract	64.02 ^a	64.15 ^a	62.14 ^b	63.16 ^a	1.04
Total ash	55.12	58.05	51.75	57.98	2.55
Calcium	61.97	64.90	59.80	64.86	4.97
Phosphorus	55.99 ^b	57.99 ^a	54.71 ^c	57.76 ^a	0.20

^{abcd} Means on the same row having different superscripts are significantly different ($p < 0.05$). NOTE :

CC – Corn cob; CH – Cowpea husk; SEM – Standard error of means

($p < 0.05$) higher than those on unfermented corn cob but not significantly ($p > 0.05$) higher than those fermented and unfermented cowpea husk. Calcium and phosphorus digestibility followed the same trend. Rabbits on fermented cowpea husk recorded the highest percentage of digestibility (64.90% and 51.99% respectively) which was significantly ($p < 0.05$) higher than fermented and unfermented corn cob in phosphorus digestibility but not significantly ($p > 0.05$) higher than unfermented cowpea husk. Total ash and ether extract digestibility also followed the same trend. Rabbits on fermented cowpea husk recorded highest digestibility in ash and ether extract (58.05% and 64.15% respectively) which was significantly ($p < 0.05$) higher in ether extract but not significantly higher ($p > 0.05$)

in total ash digestibility. Rabbits on fermented cowpea husk digested acid detergent fibre and neutral detergent fibre significantly ($p < 0.05$) better than rabbits on other crop residues. Rabbits on unfermented cowpea husk least digested acid detergent fibre (11.96%) and unfermented corn cob had the lowest digestibility for neutral detergent fibre.

Discussion

The observed final live weight was poor generally. This could be as a result of lower feed intake and this may be due to coarseness of the texture of the crop residues. The feed intake obtained was much lower than what Doma *et al.* (1999) obtained when they incorporated up to 40% of cowpea husk and 20% of corn cob into diets of weaning New Zealand rabbits. The

average weekly feed intake also had a great influence on average weekly weight gained by the experimental rabbits. The results of feed and protein efficiency ratios obtained revealed that the little intake of CH by the experimental rabbits was better utilized than CC.

The trend of dry matter digestibility was proportional to the level of fibre in the diet especially with the degree of lignification (Gidinne *et al.*, 1998), that is, the higher the fibre content, the better the dry matter digestibility. This observation is in agreement with the report of Aboushour and Baraket (1986) that dry matter intake and digestibility increased as dietary fibre increased. The result obtained revealed that protein digestibility did not improve with fermentation but the interactive effect of fibre source and fermentation increased it greatly. This may be due to inclusion of *R. oligosporus* which is a single cell protein (Soccol, 1994) and so also the breaking down of insoluble fibre which can be fermented further in the caeca of the experimental rabbits to get more protein and vitamins through ceacotrophy (Oduguwa *et al.*, 1999).

Fermentation did not have any significant ($p > 0.05$) effect on the nutrient digestibility by the experimental rabbits. This observation suggests that the treatment (fermentation) did not exert any stimulating effect that could have enhanced better digestibility. On the other hand, the interaction of fibre source and fermentation significantly enhanced nutrients digestibility by the experimental rabbits. This may be due to the fact that degree of fibre utilization depends in the nature of the fibre (Jokthan *et al.*, 2006) and the nature of the fibre used had been improved by *R. oligosporus* fermentation. Neutral detergent fibre (NDF) digestibility was higher in CH, both fermented and

unfermented when compared with CC. The low level lignocelluloses fibre (cell wall content) in CH (Oosting *et al.*, 1993) may be the explanation for this observation. The experimental rabbits were able to digest higher percentage of NDF than ADF in all the dietary treatments. This observation suggests that fermented products contain a more soluble fibre fraction (hemicelluloses and cellulose) than unfermented products.

Conclusion

From this study it has been shown that CC and CH possess potential as fibre sources in rabbit's rations. Though fermentation is one of the processing methods in reducing the level of lignocelluloses fibre in crop residues, *Rhizopus* fermentation only slightly improved the quality of crop residues used (corn cob and cowpea husk).

References

- A.O.A.C. 1990. The official methods of Analysis. Association of Official Analytical chemists. 12th edition, Washington, D.C.
- Abou-shour, A.M. and Baraket, M.A. 1986. Effect of dietary fibre levels on digestibility performance and caecal microbial activity in growing rabbits. *World Rev. Anim. Prod.* 22:52-54.
- Adeniji, A.A. and Ehiemere, S. 2003. Effect of replacing maize with sorghum offal in the diets of weaner rabbits. *J. Agric. Res and Dev.* 2:1-6.
- Akano, E.C. and Ibe, S.R. 2006. Prediction of body weight of the domestic rabbit at Different stages of growth using linear body measurement. *Nig. J. Anim. Prod.* 33(1):3-8
- Belewu, M.A. 2001. Effect of fungus (*Volvariella volvacea*) treated cotton waste as a replacement for cotton seed cake and meal by West African dwarf goat. *Trop. J. Anim. Sci.* 1:137-142.
- G.E. Jokthan, J.P. Alawa, I.A. Adeyinka

- and A.M. Adamu. 2006. The effect of fibre sources on the performance of young rabbits. *Nig. J. Anim. Prod.* 33(2): 192-196.
- Oosting, O.J., Viets T.C. and Bruchem, J.V. 1993. Ammonia treated wheat straw: Efficiency of microbial protein synthesis, rumen microbial protein, pool size and turn over and small intestinal protein digestion in sheep. *Netherlands J. Agric. Sci.* 41:35-151.
- D o m a , U . D . a n d Adegbola, T.A. Bamgbose, A.M. and Umeh, P.A. 1999. Utilization of cowpea shell and maize cobs in diets for rabbits. *Trop. J. Anim. Sci.* 2:27-32.
- Gidenne, T. Carabano, R. Garcia, J. and de Bias, C., 1998. Fibre digestion in Nutrition of Rabbits (Eds. C. de Bias and J. Wiseman) pp 69-88.
- Grueling, H.T. 1996. The chemical analysis of plant tissue. mimeo, No. 662, Agronomy Department, Cornell University, Ithaca, New York, U.S.A.
- Oduguwa, O.O. Sobamiwa, O.O. Sanni, D and Akintunde, A.Y. 1999. Effect of Ureatreatment on the utilization of cocoa-pod husk in rabbit's diet. *Trop. J. Anim. Sci.* 1:23-28.
- SAS. 1999. SAS User's Guide. Statistical Analysis Institute Inc. Cary. North Carolina.
- Soccol C. 1994. Breeding and growth of *Rhizopus spp.* in raw cassava by solid state fermentation. *Appli. Microbiology and Biotech.* 41:330-336.
- Steel, R.G.D. and Torrie, J.H. 1980. Principle and procedure of statistic. 2nd edition. McGraw Hill Book Company. New York.

Received: 16/04/2006

Accepted: 02/08/2011