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Evaluation of millet residue meal based diets as feed for the domestic rabbit (*Oryctolagus cuniculus*)

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Abstract

This research evaluated the nutritive value of millet residue meal with fish meal, soybean meal or fish-soybean meal combination (1:2) as protein source. The treatments were labelled according to protein source as fish meal diet, soybean meal diet and fish-soybean meal diet. Thirty nulliparous mixed-breed rabbits of an initial mean (±SD) body weight of 1852.6±122.7 g were used in a completely randomised design with 10 rabbits per treatment. The rabbits were allowed four weeks to adjust to the experimental diets before breeding was initiated. The feed intake during gestation and the reproductive data of the rabbits were assessed over two reproductive cycles. Does on the fish meal diet had poorer ($P<0.05$) DMI, daily growth rate and FCR than those on the soybean meal diet during the pre-breeding period. Does on the fish meal diet delivered less ($P<0.05$) number of kits at birth and weaned less kits compared to those on the soybean meal diet. Those on the soybean meal diet were heaviest ($P<0.05$) at mating and at kindling. They out-performed does on the fish meal diet in most of the parameters measured. Parity did not affect reproductive performance, but growth rate of the does had a positive linear relationship with DMI ($r= 0.77$; $P<0.01$) and a negative linear relationship with FCR ($r= -0.83$; $P<0.01$) during the pre-breeding period. It was concluded that millet residue meal may be a better feed source for rabbit does if soybean meal rather than fish meal or fish-soybean meal combination (1:2) is used to improve the protein content.

Keywords: Apparent Digestibility, Domestic Rabbit, Litter Size, Mortality, Reproductive Characteristics, Weaning Weight

Introduction

The potential to use rabbits to improve protein intake and create wealth in resource-poor communities is great (Lukefahr et al., 2000). Rabbit meat is high in protein and low in fat, cholesterol, sodium and energy (Shaeffer et al., 2008). The market for rabbit meat is expanding because the meat is now considered a delicacy and health food by many (Dalle Zotte, 2002). The Government of Ghana has promoted rabbit production since 1972 with the establishment of a farm with a rabbit population of 7,000 (Mamattah, 1978). Unfortunately, like is happening in many developing countries, there are no commercial feeds available to support large scale rabbit production in Ghana. Dry season feeding of the stock has, therefore, remained a nagging problem for those who keep the animals in reasonable commercial quantities. Agro-industrial by-products have been considered useful supplements for rabbits, especially in the dry season.

Millet residue meal is a by-product which could be used as animal feed in Ghana (Okai et al., 2005). It is obtained by sun-drying the residue left when a mixture of millet dough or flour and water is sieved during the preparation of millet porridges and millet beer. Large quantities of the product could be gathered in population centres in Ghana since millet porridges are popular meals in Ghana. However, the product's 14% crude protein content (Okai et al., 2005) is lower than the 17-21% (Shockey, 1998; Salma et al., 2004; Kim Dong et al., 2008) required by the rabbit for higher productivity. This experiment, therefore, sought to evaluate the nutritive value of the millet residue meal when fish meal, soybean meal or fish-soybean meal combination (1:2) is used as a protein source to improve the protein content of the diet to make it more suitable for rabbit feeding.

Materials and Methods

The experiment was conducted at the Cattle Research Station of the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. Kumasi is in a semi-deciduous forest ecological zone. Annual precipitation averages 1300 mm. The mean temperature is 26°C while relative humidity averages 93% at 06.00 h and 58% at 15.00 h.

Millet residue meal is obtained by sun-drying the solid mass left when a mixture of millet dough or flour and water is strained during the preparation of millet porridges and millet beer. Samples for the experiment were bought from a commercial millet porridge producer in Kumasi. The millet residue meal was used to formulate three diets which contained fish meal, soybean meal or fish-soybean meal combination (1:2) as protein source (Table 1). The source of protein was used to label the diets as fish meal diet, soybean meal diet and fish-soybean meal diet.

Thirty nulliparous mixed-breed rabbits were used in a completely randomized design, which took the body weights of the rabbits into consideration. The mean (±SD) body weight of the rabbits at the start of the experiment was 1852.6±122.7 g. Each dietary treatment had 10 replications and a rabbit was considered a replicate.

The rabbits were housed in individual cages measuring 60 × 60 × 45 cm. The cages, including the floors, were made of wire mesh and were kept in dwarf-walled barns. Each cage had its own water and feed troughs, which were cleaned daily during the experiment.

Equilibration of the experimental rabbits lasted for 4 wks, during which time the experimental diets were fed to physiologically adjust the rabbits to the diets before breeding. Five clinically healthy bucks were used for breeding in the experiment. Each buck served two females from each treatment group. Re-breeding after kindling started 7 d postpartum and weaning of kits was done at 28 d of age. Pregnancy was tested by abdominal palpation 10 d post mating. The rabbits that refused mating or failed to become pregnant were immediately given the chance to re-mate.

The experimental rabbits were offered 300 g (258-264 g DM) of the appropriate diets per animal per day. Feed refused was weighed every morning to determine feed intake by difference. Water was supplied free choice. The rabbits were weighed at mating. Does and their kits were also weighed within 24 h of kindling. Dry matter intake during gestation and reproductive data were recorded over two reproductive cycles.

Four experimental rabbits from each treatment group were used for the apparent digestibility trial. Three weeks into the equilibration period, feed intake and total faeces voided were recorded for 7 d to determine apparent digestibility of dry matter, crude protein, neutral detergent fibre and acid detergent fibre. Total faecal collection was achieved by tying mosquito wire netting under the floor of each cage to retain the faeces. Daily faecal outputs for individual animals were weighed and stored separately at 4°C in a refrigerator. The faeces from individual animals were bulked and thoroughly mixed at the end of 7 d and samples were taken for laboratory analyses.

The proximate contents of the millet residue meal and experimental diets as well as the dry matter and crude protein of the faecal samples were determined by the AOAC methods (AOAC, 1997). The neutral detergent fibre and acid detergent fibre contents of the millet residue meal, experimental diets and faecal samples were determined following the procedures of Van Soest et al (1991). The metabolisable energy (ME) in the diets was estimated by the method of Pauzenga (1985).

Statistical analysis

Data were analysed by analysis of variance (ANOVA) and where appropriate the Duncan's multiple range test was used to compare significant treatment mean differences. Treatment was used as the fixed factor for analysis but where data were available for both first and second parities, treatment, parity and treatment x parity were used in the model for analysis. Data for pre-weaning kit mortality were square-root transformed before ANOVA. The Pearson correlation method was used to correlate DMI and FCR with growth rate during the pre-breeding period. The SPSS computer statistical package (SPSS, 2006) was used for the analyses.

Results

The chemical contents of the millet residue meal and the experimental diets are presented in Table 2. All the diets had similar crude protein and carbohydrate contents, but energy was slightly higher in the fish meal diet while acid detergent fibre was slightly lower in the soybean meal diet. Table 3 gives the apparent digestibility of dry matter, crude protein, neutral detergent fibre and acid detergent fibre of the experimental diets. Apparent digestibility of acid detergent fibre was higher ($P<0.05$) for the soybean meal diet than for the fish meal and fish-soybean meal diets. Table 4 presents the treatment effect on dry matter intake and the reproductive performance of the rabbits offered the experimental diets. Does on the fish meal diet ate less ($P<0.05$) than those on the soybean meal diet during the pre-breeding period. The pre-breeding daily growth rate was also lower ($P<0.05$) in does on the fish meal and fish-soybean meal diets than those on the soybean meal diet. The pre-breeding growth rate was correlated with DMI ($r= 0.77$; $P<0.01$) and FCR ($r= -0.83$; $P<0.01$) and the does on the fish meal and fish-soybean meal diets were less efficient in feed utilization than those on the soybean meal diet. The does on the soybean meal diet were heavier ($P<0.05$) at mating and at kindling compared to those on fish meal and fish-soybean meal diets. Litter size and weight at birth and litter size and weight at weaning followed the same trend, with does on soybean meal diet obtaining higher ($P<0.05$) values than those on fish meal diet. However, kit weight at weaning and pre-weaning daily growth rate were lower ($P<0.05$) in the soybean meal diet group than in the fish meal and fish-soybean meal diet groups.

The comparison of reproductive performance according to parity of the rabbit does is presented in Table 5. Does were heavier ($P<0.05$) at second parity mating than at the first, but parity did not affect any of the other reproductive parameters measured in this research. The treatment × parity interactions showed significant difference only in kit weaning weight and pre-weaning daily growth rate. The mean (±SE) weaning weight recorded for kits in the fish meal diet group was 426.38±21.23 g in parity 1 and 395.45±21.23 g in parity 2. The corresponding values were 323.76±21.23 and 377.45±21.23 g, and 428.93±21.23 and 458.13±21.23 g for kits in the soybean meal and fish-soybean meal diet groups. The mean (±SE) pre-weaning daily growth rate in parities 1 and 2 were 12.91±0.69 and 12.05±0.69 g, 9.05±0.69 and 11.38±0.69 g, and 13.04±0.69 and 10.68±0.69 g for kits in the fish meal, soybean meal and fish-soybean meal diet groups, respectively.

Discussion

The protein and energy contents of the present diets are high enough to ensure good performance of rabbit does. The relatively low fibre content of the soybean meal diet may explain its apparent higher nutrients digestibility. High fibre levels are known to increase the rate of digesta passage through the gastro-intestinal tract, which reduces nutrients digestibility (Wen-Shyg Chiou et al., 1998). The high apparent nutrient digestibility values obtained in all the treatments may probably be because caecotrophy was not prevented in this study. The actual digestibility values when caecotrophy is not allowed may, therefore, be lower.

The higher DMI and better FCR in the soybean meal diet group may account for their higher daily growth rate during the pre-breeding period. The similar DMI during gestation in the treatment groups shows that the low ($P<0.05$) DMI calculated for the fish meal diet group during the pre-breeding period was overcome after a long adjustment period. The imported fish meal used in this research did not have a pleasant odour, which at higher inclusion level (14%) may not have been masked adequately enough by the other ingredients, leading to an initial low DMI. The higher DMI, higher daily growth rate and lower FCR calculated for the does on the soybean meal diet during the pre-breeding period may explain their heavier weights at mating and at kindling. The better feed utilization efficiency obtained by the soybean meal diet group suggests that the quality of the imported fish meal used in this research was poor and that rabbits may need a good quality fish meal to make better use of it. Good quality fish meal is expected to provide a better amino acid balance than soybean meal, but this does not appear to be the case in the present research. Pike et al. (1990) reported that the feeding value of fish meal is affected by the conditions and temperatures at which the fish is processed. According to them fresh fish processed at temperatures below 90^{o}C elicited higher protein digestibility and growth rates in the salmon and mink. In any case, it has also been reported in sheep that digestibility of solar dried sardines (74%) and soybean meal (76%) were similar, but nitrogen in the dried sardine diet was not as efficiently utilized as nitrogen in the soybean meal diet (Early et al., 2001). Contrary to expectation, both nutrient digestibility and FCR were better in does fed the soybean meal diet than those fed the fish meal containing diets in this research. The poor performance of the fish meal diet group and the middle position occupied by the fish-soybean meal diet group in many of the parameters measured in this research suggest that the rabbit may not be able to efficiently use high levels of fish meal in the diet. A further investigation is, therefore, warranted to illuminate the use of fish meal and soybean meal in the diets of the domestic rabbit. The bigger ($P<0.05$) litter sizes at birth and weaning for the soybean meal diet group may be assigned to their probable better nutrition as indicated by their superior performance during the pre-breeding period. The bigger litter sizes in the soybean meal diet group may account for the significantly bigger litter weights attained in the group at birth and at weaning. The present mean (±SE) litter size at birth of 4.62±0.23 compares favourably with the 4.5 kits/birth reported in Nigeria (Ehiobu et al., 1997). It is, however, at the lower end of the range of 3.2-6.7 kits/birth reported earlier by others (Nguyen Quang Suc, 1996; Ojewola et al., 2006; Iheukwumere, 2008). The soybean meal diet produced the highest litter weight at birth, due to the relatively bigger litter size at birth recorded for that treatment group. The present mean (±SE) litter weight at birth of 267.27±10.14 g is slightly better than the 248 g obtained in a previous work although the mean of 226.75 g for the does on the fish meal diet is at the lower end of the range of 223-291 g obtained in the earlier study (Ojewola et al., 2006). The present litter weights at birth are poorer than the range of 315-400 g reported in Vietnam by Kim Dong et al. (2008), probably because of the smaller litter size at birth recorded in this research. The present mean (±SE) kit weight at birth of 61.25±1.98 g is better than the range

Table 1: Composition of three millet residue meal based diets fed to female rabbits

Ingredient	Level of inclusion (g/100 g dry mass)		
	Fish meal diet	Soybean meal diet	Fish-soybean meal diet
Millet residue meal	83	74	76
Fish meal	14	0	7
Soybean meal	0	23	14
Dicalcium phosphate	2	2	2
Vitamin/mineral premix	0.5	0.5	0.5
Common salt	0.5	0.5	0.5

Table 2: Chemical composition of millet residue meal and three millet residue meal based diets fed to female rabbits

Feed fraction	Mean (g/100 g dry mass)			
	Millet residue Meal	Fish meal diet	Soybean meal diet	Fish-soybean meal diet
Dry matter, g/100 g wet mass	90.6	86.6	85.9	88.0
Crude protein	15.2	20.3	20.4	20.1
Crude fibre	8.6	5.4	7.2	6.2
Ether extract	3.3	3.5	3.0	3.6
Ash	2.1	4.8	9.0	10.1
Nitrogen free extract	70.8	66.0	60.4	60.0
Neutral detergent fibre	53.1	44.2	31.9	33.1
Acid detergent fibre	12.0	11.0	8.1	10.0
*ME (MJ/kg)	13.9	14.0	13.0	13.1

*Estimated according to Pauzenga (1985): ME (kcal/kg) = (35 x percent crude protein) + (81.8 x percent ether extract) + (35.5 x percent nitrogen free extract)

Table 3: Apparent digestibility of some feed fractions by female rabbits fed three millet residue meal based diets

Feed fraction	Mean (±SD, g/100 g dry mass)		
	Fish meal diet (n= 4)	Soybean meal diet (n= 4)	Fish-soybean meal diet (n= 4)
Dry matter	70.8±7.64	82.7±6.0	77.2±13.11
Crude protein	82.5±6.76	90.7±4.59	85.7±4.44
Neutral detergent fibre	70.6±7.26	69.2±7.19	74.4±10.27
Acid detergent fibre	39.0±2.94[a]	60.9±7.07[b]	31.4±6.18[a]

[ab]Means on the same row with different superscripts are significantly different (P<0.05)

of 44.4-53.9 g obtained by Kim Dong et al. (2008) and the 52.3 g reported by Ojewola et al. (2006). The mean (±SE) litter size at weaning (3.37±0.18) in this research is comparable to the 3.2 and 3.3 reported by Ehiobu et al. (1997) and Ojewola et al. (2006), respectively, but is lower than the 5.3-7.7 reported in Vietnam (Kim Dong et al., 2008). The current litter weights at weaning are lower than the 1464-3135 g earlier reported (Ojewola et al., 2008; Kim Dong et al., 2008; Akpo et al., 2008), probably because of the smaller litter size at weaning and the lower pre-weaning growth rate recorded in this research.

Kits in larger litters at weaning tended to have lower pre-weaning growth rate and lower weight at weaning. This may be the result of keener competition among the kits for milk, which may have caused the weaker kits to suffer under-nutrition and thereby grow slowly. The pre-weaning mortality in this research does not appear to follow any obvious pattern. The present pre-weaning mortality is better than the 27.9% obtained by Ehiobu et al. (1997) who also found no apparent reason for the wide range of 0-100% mortality observed in the treatment groups. The current overall mean (±SE) pre-weaning mortality of 25.64±2.83% is, however, higher than the 15% reported by Akpo et al. (2008) and the 16.7% and 20.8% reported by Kpodékon et al. (2008) in Benin. The present results indicate that even though the rabbit does could be mated 2 wks postpartum, pregnancy occurred at about the 5th week postpartum. This indicates that fertility will be low in these rabbits when re-mating intervals are short (Nicodemus et al., 2002). An improved feeding management system may, therefore, be required to change the situation. The current results confirm that 5-6 breeding cycles a year are possible in Ghana under the current conditions (Karikari and Asare, 2009).

Table 4: Dry matter intake (DMI) and reproductive characteristics of rabbit does fed three millet residue meal based diets for two reproductive cycles

Variable	Mean			Standard error
	Fish meal diet (N=20)	Soybean meal diet (N=20)	Fish-soybean meal diet (N=20)	
Doe initial body weight, g	1890.00	1862.80	1805.00	38.43
Doe pre-breeding DMI, g/d	61.45[a]	72.45[b]	66.00[ab]	3.01
Doe pre-breeding growth rate, g/d	9.73[a]	15.22[b]	11.26[a]	0.85
Doe pre-breeding FCR*	6.38[b]	4.79[a]	6.21[b]	0.30
Doe DMI during gestation, g/d	96.19	101.05	98.05	3.37
Doe weight at mating, g	2263.00[a]	2660.00[b]	2366.00[a]	62.97
Doe weight at kindling, g	2290.00[a]	2700.00[b]	2450.00[a]	59.98
Litter size at birth, kits/birth	3.95[a]	5.35[b]	4.55[ab]	0.39
Litter weight at birth, g	226.75[a]	301.55[b]	273.5[ab]	17.57
Kit weight at birth, g	62.07	60.20	61.48	3.43
Litter size at weaning (d 28), kits/doe	2.70[a]	4.15[b]	3.25[ab]	0.32
Litter weight at weaning (d 28), g	1074.00[a]	1436.00[b]	1214[ab]	101.81
Kit weight at weaning (d 28), g	411.42[b]	350.60[a]	393.53[b]	15.01
Pre-weaning (28 d) growth rate, g/d	12.4[b]	10.37[a]	11.86[b]	0.49
Pre-weaning (28 d) mortality, %	30.67	20.51	25.74	4.91
Kindling to postpartum mating, d	12.50	13.20	11.35	1.44
Kindling interval, d	66.25	64.00	60.00	4.63

[ab]Means on the same row with different superscripts are significantly different ($P<0.05$); *Feed conversion ratio

Table 5: Reproductive characteristics at first and second parities of rabbit does fed three millet residue meal based diets

Variable	Mean		Standard error
	Parity 1 (N=30)	Parity 2 (N=30)	
Doe DMI during gestation, g/d	94.83	102.03	2.75
Doe weight at mating, g	2351.00[a]	2508.00[b]	51.41
Doe weight at kindling, g	2414.00	2546	48.97
Litter size at birth, kits/birth	4.53	4.70	0.32
Litter weight at birth, g	265.57	268.97	14.35
Kit weight at birth, g	63.46	59.04	2.80
Litter size at weaning (d 28), kits/doe	3.33	3.40	0.26
Litter weight at weaning (d 28), g	1228.00	1255.00	83.13
Kit weight at weaning (d 28), g	393.02	377.34	12.27
Pre-weaning (28 d) growth rate, g/d	11.77	11.37	0.40
Pre-weaning (28 d) mortality, %	24.50	26.77	4.01
Kindling to postpartum mating, d	13.17	11.53	1.17

[ab]Means on the same row with different superscripts are significantly different ($P<0.05$)

Performance of the does was similar for both first and second parities in this research. Akpo et al. (2008), however, reported that litter size at birth and litter weight at weaning were significantly lower in the first parity than in the second parity.

Conclusion

Both DMI and FCR proved to be important factors in accounting for the growth rate disparities in the rabbit does in this research. The poor performance of the rabbit does on the fish meal diet (14% inclusion level) suggests that higher inclusion level of fish meal alone may not guarantee good performance. Despite the small animal numbers used in the present research, the results show that does on the soybean meal diet performed better than their counterparts on the fish meal and fish-soybean meal diets in several of the traits considered. It is, therefore, concluded that rabbit does may perform better on millet residue meal with soybean meal than with fish meal or fish-soybean meal combination (1:2) as protein source.

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