Effects of Corn Cob-based Diets on the Levels of Nutritionally Related Blood Metabolites and Onset of Puberty in Mukota and Landrace×Mukota Gilts

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ABSTRACT : The objective of this study was to determine the levels of nutritionally related blood metabolites, age and body weight at puberty in gilts fed on corn cob-based diet in Mukota and Landrace×Mukota crossbred gilts. Ten gilts of each of Mukota and crossbred genotypes were fed two diets for 14 weeks in a 2×2 (breed×diet) factorial treatment arrangement. A corn-cob based diet, designed to contain 2,304 kcal ME/kg, and a standard pig grower diet, were used. The corn cob constituted 20 percent of the total ration. Fortnightly, bodyweights and feed conversion ratios (FCR) were recorded. Blood samples were collected to determine blood glucose, urea and creatinine levels. The average daily bodyweight gain (ADG) in the Mukota was lower ($p<0.05$) than in the crossbred gilts. Crossbred gilts fed on the corn cob-based diet had lower ($p<0.05$) urea values from eight weeks from the start of the experiment ($p<0.05$) compared to Mukota gilts fed the same diet. There were no differences in blood glucose and creatinine concentrations between diets and genotypes. The lack of differences in the nutritionally-related blood metabolites suggest that corn cobs could be incorporated at 20 percent inclusion without compromising blood metabolite concentrations and age at puberty of the Mukota and Landrace×Mukota gilts. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 10 : 1469-1474)***

Key Words : Mukota, Landrace×Mukota, Blood Metabolites, Puberty, Corn Cobs

INTRODUCTION

Over 70 percent of the total pig population in Zimbabwe is found in the smallholder farming areas (Central Statistical Office, 2000). The pigs found in the smallholder farming areas are adapted to low-input production systems and can survive and reproduce on low planes of nutrition (Holness, 1991). The improvement of rural pig production should thus depend on such genotypes if the smallholder farming systems are to be sustainable (Food and Agriculture Organisation, 2002). The Chinese Meishan pig (Van Wieren, 2000) and the Mukota (Zimbabwean indigenous pig) (Ndindana et al., 2002) are, perhaps, the only genotypes that have been found to have superior capacities to digest dietary fibre. Due to the influence of pig improvement organizations that promote the use of imported pigs, most smallholder farmers in Zimbabwe are increasingly using imported and crossbred pigs (Scherf, 1990; Mashatise, 2002). Crossbreds potentially combine the desirable characteristics of both the Mukota and imported genotypes (Chimonyo et al., 2001). Kanengoni et al. (2002) reported that Large White×Mukota crossbred pigs could digest and utilise fibrous diets that contain corn cobs to the same extent as local pigs. The utilization of fibrous diets has the advantage of reducing feed costs, largely by reducing the proportion of corn that is usually more expensive.

The monitoring of nutritionally related blood metabolites, such as glucose and urea, is one way of assessing nutritional status of animals. Although there are several reports on the ability of local pigs to use fibrous diets for growth (Ndindana et al., 2002; Kanengoni et al., 2004), there is no information on the influence of corn cob-based diets on the nutritionally related metabolite concentrations of the local and crossbred pigs. Nutritional status of gilts influences age at the onset of puberty, which is the first determinant of reproductive performance in a sow. The objective of this study was, therefore, to determine the effect of fibrous diets that are based on corn cobs on the levels of some nutritionally related blood metabolites in local Mukota and Landrace×Mukota crossbred gilts. The ages at which the gilts attained puberty were also compared.

MATERIALS AND METHODS

Study site

The experiment was conducted at the University of Zimbabwe, Harare, Zimbabwe. The area is approximately 1,200 m above sea level and at 17°47’S and 31°E. Mean diurnal temperature was 18°C throughout the trial. The area receives a mean annual rainfall of about 800 mm.

Animal selection and management

Ten gilts of each of the Mukota and crossbred genotypes, were randomly selected at the physiological age of proportionately about 0.1 of their mature body weights.

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Table 1. The Chemical and ingredient composition of the diets

	Composition (%)	
	Corn cob-based diet[1]	Pig-grower finisher®[2]
Ingredients (%)		
Corn	54.5	62.2
Soyabean meal	23.0	21.5
Corn cobs	20.0	-
Wheat bran	-	9.1
Carcass meal	-	5.3
Vegetable acid oil	-	0.2
Lysine	-	0.1
Methionine	-	0.1
Salt	-	0.2
Mineral/vitamin premix	0.3	0.3
Monocalcium phosphate	1.0	1.0
Limestone	1.2	-
Nutrient	Chemical composition (%)	
Dry matter	91.6	92.4
Organic matter	83.2	84.2
Crude protein	16.0	17.9
Neutral detergent fibre	28.7	13.5
Acid detergent fibre	15.3	8.6
Hemicellulose	23.1	4.8
Crude fibre	9.1	3.1
Ash	3.3	3.0
Metabolisable energy (kcal/kg)	2,304	2,688

[1] The experimental diet consisted of corn, soyabean meal, corn cobs, mineral/vitamin premix, monocalcium phosphate and limestone.
[2] The diet was bought from National Foods Ltd, Agribusiness Division, P.O. Box 269, Harare, Zimbabwe.

Initial bodyweights of the gilts were 15±1.1 and 22±1.1 kg for the Mukota and crossbreds, respectively. The pigs were obtained from Gwebi Agricultural College, Harare. The crosses were progeny of Landrace purebred sires and Mukota purebred dams. They were dipped against ectoparasites using acaricides every two weeks and were also given an anthelmintic (Valbazen) once a month. Five gilts were used per each treatment combination in a 2×2 (breed×diet) factorial treatment arrangement. The trial lasted 14 weeks. The pens used in the trial were raised 300 mm off the ground and the building was well aerated and lit. They were cleaned daily. Water was available *ad libitum*.

Diets

A corn cob-based diet and a standard grower-finisher diet were offered to the pigs in this study. Each pig was randomly allocated to each of the two diets. The pigs were allowed to adapt to the diets for 2 weeks and the 3rd week was for collection of samples. The feed was given as dry meal and the pig were offered food *ad libitum*. The chemical and ingredient composition of the diets is shown in Table 1. The soyabean meal contained 440 g CP/kg. The standard diet, the pig grower-finisher meal®, which was obtained from National Foods Ltd, Zimbabwe, contained vegetable oil blend, meat and bone meal, white corn, soyabean meal, wheat bran, salt, acidic lysine, methionine and mineral/vitamin premix. The chemical composition of the corn cobs was reported previously (Kanengoni et al., 2002).

Blood sampling

Blood samples were collected fortnightly for the determination of glucose and urea concentrations. Creatinine concentrations were determined at 0, 6, 10 and 14 weeks of the start of the experiment. Each pig was physically restrained and placed in dorsal recumbency. A 19-gauge needle was inserted into the caudal vena cava and blood was collected into 10 ml syringes. The blood samples were taken at 0700 h, before feeding the pigs. Blood for glucose analysis was put in sodium fluoride-coated tubes. Plain tubes were used for blood samples for urea and creatinine analyses. The blood that was put in plain tubes was left to coagulate for 10 minutes before centrifugation to separate the serum. Centrifugation of the samples was done at 1,500×g for 15 minutes at room temperature, within 2-3 h of sampling. Plasma or serum samples were then stored at -20°C pending analyses.

Determination of glucose, urea and creatinine concentrations

The levels of glucose, urea and creatinine were quantitatively determined using the ACE™® Clinical Chemistry kit (Schiapperella Biosystems, Amsterdam, The Netherlands).

Laboratory analyses

Dry matter (DM), organic matter (OM), CP and ash determinations were done according to the Association of Official Analytical Chemists (1994). The CP content of the diets was determined using the Kjeldahl procedure (AOAC, 1994). Acid detergent fibre (ADF) and neutral detergent fibre (NDF) in the feeds were determined using the procedure of Van Soest et al. (1991) on oven-dried samples. Hemicellulose content was determined as the difference between NDF and ADF contents.

Measurements

Average daily feed intake (ADFI) was estimated daily according to the method of Kanengoni et al. (2002). Body weights were taken fortnightly, prior to feeding, to estimate average daily gain (ADG). Feed conversion ratio (FCR) was calculated as the ratio of feed intake to bodyweight gain.

Oestrus detection was done twice per day for 30 min, at 0700 h, before the morning feeding and at 1500 h. Puberty and subsequent oestruses were determined based on the swelling and reddening of the vulva and by the standing

Table 2. Effects of corn cob-based diets on growth performance in Mukota and Landrace×Mukota gilts

Trait	Treatment[1]	LSmean	SE	Significance		
				Genotype	Diet	Breed×diet
ADFI (kg/day)	CCO	1.82				
	CCN	1.62	0.134	NS[2]	NS	NS
	MCO	1.60				
	MCN	1.55				
ADG (kg/day)	CCO	0.53[a]				
	CCN	0.61[a]	0.053	***	NS	NS
	MCO	0.27[b]				
	MCN	0.35[b]				
FCR	CCO	3.51[a]				
	CCN	3.17[a]	0.341	***	NS	NS
	MCO	4.46[b]				
	MCN	4.43[b]				

[1] CCO: crossbred gilts fed on corn cob-based diet; CCN: crossbred gilts fed on conventional diet; MCO: Mukota gilts fed on corn cobs; MCN: Mukota gilts fed on the conventional diet; ADFI: average daily feed intake; ADG: average daily gain; FCR: feed conversion ratio.
[2] NS = Not significant ($p>0.05$); *** $p<0.001$.
[a, b, c] For each parameter, values with different superscripts within a row are different.

Table 3. Effects of corn cob-based diets on plasma glucose concentrations in Mukota and Landrace×Mukota gilts

Week	LSmean glucose concentration (mmol/L)			
	Treatment [1]			
	CCO	MCN	CCN	MCO
0	4.34	4.46	5.06	4.84
2	4.44	4.88	5.36	4.80
4	4.74	4.24	4.88	4.26
6	4.32	4.74	4.30	4.34
8	4.95	4.08	5.00	4.80
10	4.54	4.32	4.33	4.76
12	4.92	4.21	5.02	4.78
14	4.90	4.44	4.87	4.76
SE	0.483	0.461	0.480	0.462
N	5	5	5	5

[1] CCO: crossbred gilts fed on corn cob-based diet; CCN: crossbred gilts fed on conventional diet; MCO: Mukota gilts fed on corn cobs; MCN: Mukota gilts fed on the conventional diet.

reaction (reflex) of the gilts when pressure was exerted on their backs. Age and body weight at the first observed oestrus was recorded.

Statistical analyses

The effects of diet and genotype on ADG, ADFI and FCR, age and body weight at puberty were analysed using the generalised linear models procedure of SAS (1996). The initial body weight was used as a covariate. The model was:

$$Y_{ijk} = \mu+D_i+G_j+(D\times G)_{ij}+b_1X+\varepsilon_{ijk}$$

where:
Y_{ijkl} = response variable (ADFI, ADG, FCR);
μ = overall mean common to all observations;
X_l = covariate, initial weight of the i^{th} animal with b_1 as the linear regression coefficient of initial weight;
D_i = fixed effect of diet;
G_j = fixed effect of genotype;
$(D\times G)_{ij}$ = interaction of diet *i* with genotype *j*; and
ε_{ijk} = random residual error.

The influence of genotype and diet on glucose, urea and creatinine concentrations were determined using the repeated measures analysis of variance (PROC MIXED) of SAS (1996), as described by Littel et al. (1998). The model was:

$$Y_{ijkl} = \mu+D_i+G_j+W_k+(D\times G)_{ij}+(D\times W)_{ik} +(G\times W)_{jk}+ (D\times G\times W)_{ijk}+p(D\times G)_{ijl}+b_1X+\varepsilon_{ijkl}$$

where:
Y_{ijkl} = response variable (glucose, urea, creatinine);
μ = population mean;
X_l = covariate, initial weight of the l^{th} animal with b_1 as the linear regression coefficient of initial weight;
D_i = fixed effect of diet (i = 1, 2);
G_j = fixed effect of genotype (j = 1, 2);
W_k = fixed effect of time (week);
$(D\times G)_{ij}$ = interaction of diet *i* with genotype *j*;
$(D\times W)_{ik}$= diet×week interaction;
$(G\times W)_{jk}$= genotype×week interaction;
$p(D\times B)_{ijk}$ = random effect of pig within diet and genotype;
$(D\times G\times W)_{ijk}$ = diet×genotype×week interaction;
ε_{ijkl} = random residual error.

RESULTS

Effect of genotype and diet on ADG, ADFI and FCR

The influence of the diets on ADFI, ADG and FCR of Mukota and crossbred gilts are shown in Table 2. The ADFI was similar between the two diets. Crossbred gilts grew faster ($p<0.05$) than the Mukota gilts fed on both the corn

Table 4. Effects of corn cob-based diets on serum creatinine concentrations in Mukota and Landrace×Mukota gilts

Week	LSmean creatinine concentration (μmol/L)			
	Treatment[1]			
	CCO	CCN	MCO	MCN
0	111.95±9.537	112.76±9.721	108.75±9.567	108.54±9.684
6	118.55±9.537	113.16±9.721	105.75±9.567	116.94±9.684
10	112.55±9.537	111.16±9.721	100.75±9.567	110.94±9.684
14	97.45±11.537	117.90±11.521	149.21±11.667	130.22±9.684

[1] CCO: crossbred gilts fed on corn cob-based diet; CCN: crossbred gilts fed on conventional diet.
MCO: Mukota gilts fed on corn cobs; MCN: Mukota gilts fed on the conventional diet.

Table 5. Effects of corn cob-based diets on serum urea concentrations in Mukota and Landrace×Mukota gilts

Week	LSmean urea concentration (mmol/L)			
	Treatment[1]			
	CCO	MCN	CCN	MCO
0	2.98	4.32	3.02	3.82
2	3.84	5.84	4.88	4.66
4	3.58	3.97	3.68	3.09
6	4.42	3.24	5.14	4.10
8	2.73	3.77	4.24	4.51
10	2.78	4.70	4.12	4.53
12	2.76	4.87	3.98	4.56
14	2.74	5.56	3.99	4.58
SE	0.544	0.691	0.543	0.692
N	5	5	5	5

[1] CCO: crossbred gilts fed on corn cob-based diet; CCN: crossbred gilts fed on conventional diet; MCO: Mukota gilts fed on corn cobs; MCN: Mukota gilts fed on the conventional diet.

cob-based and the conventional diets. Within genotypes, no difference was detected in ADG between the diets. Feed conversion ratio was higher ($p<0.05$) in Mukota than in crossbred pigs across diets.

Effects of genotype and diet on levels of glucose, urea and creatinine

The levels of plasma glucose and serum creatinine in the treatment groups are shown in Table 3 and 4, respectively. There were no effects of genotype and diet on blood glucose and creatinine concentrations. The influence of genotype and diet on serum urea concentration is shown in Table 5. There was a significant ($p<0.05$) interaction between genotype, diet and time on serum urea concentration. The four treatment groups had the same urea levels ($p<0.05$) at the start of the trial. From week 8 up to the end of the trial, Mukota gilts on both the standard and the cob-meal diet had higher ($p<0.05$) urea levels than the crossbreds. No differences were detected within the Mukota gilts on both diets. Within the crossbred gilts, however, those that were on the corn cob-based diet had lower ($p<0.05$) urea values than those on the standard diet.

Effect of breed and diet on age and body weight at puberty

As shown in Table 6, there were no differences between

Table 6. Effects of corn cob-based diets on reproductive performance (mean age and body weight at puberty) in Mukota and Landrace×Mukota gilts

Trait	Treatment[1]				SE
	CCO	CCN	MCO	MCN	
Age at puberty (days)	164.3	179.1	155.3	162.2	11.42
Body weight at puberty (kg)	49.5[a]	53[a]	21.7[b]	20.5[b]	4.73

[1] CCO: crossbred gilts fed on corn cob-based diet; CCN: crossbred gilts fed on conventional diet; MCO: Mukota gilts fed on corn cobs; MCN: Mukota gilts fed on the conventional diet.
* $p<0.05$.
[a, b] Values with different superscript letters within a row were different ($p<0.05$).

genotypes and diets on the age of attainment of puberty among the four treatment combinations. However, the body weights at puberty were higher ($p<0.05$) in the crossbreds than the Mukota. The Mukota and crossbred gilts were 18 and 29 percent of their respective average mature weights at the exhibition of first oestrus.

DISCUSSION

The similar ADFI between diets and genotypes suggests that the corn cob-based diet was palatable to the gilts. This shows that, unless prevented by bulk, or perhaps palatability, a pig tends to eat until its energy requirement is fulfilled, since energy is the first limiting nutrient in pigs (Coffey et al., 1982). Chigaru et al. (1981) also made similar observations for Mukota gilts between 25 to 32 weeks of age on low planes of nutrition. The higher ADG in the crossbred than Mukota gilts indicates genotype differences in growth rate. The crossbred pigs are likely to have benefited from breed complementarity and, probably, heterosis form the crossbreeding programme. Landrace pigs exhibit growth rates of about 750 g per day (Ly, 2000). The observation that, within the crossbred gilts, there were no differences between those that were on the standard and the corn-cob based diets, suggest that the crossbred pigs are able to digest, absorb and utilize nutrients, especially fibre, to the same extent as the Mukota pigs. Large White ×Mukota pigs have also been reported to digest dietary fibre to the same extent as the Mukota (Chimonyo et al., 2001; Kanengoni et al., 2002). Ly et al. (1998) also reported similar findings in the crosses between Landrace and the Cuban Creole pigs. Crosses between the Landrace and local Indian pigs have also been reported to utilize high levels of fibre from rice bran (Soren et al., 2003; 2004).

The higher efficiency of feed utilization for bodyweight gain in the crossbred gilts than in the Mukota gilts is likely to have been due to heterosis. Kirkwood and Aherne (1985) reported that the inclusion of supplementary dietary fibre reduced the rate and/or amount of apparent absorption of nutrients. The values observed for FCR, however, were similar to those recorded in Mukota (Ndindana et al., 2002) and Large White×Mukota F_1 crosses (Chimonyo et al., 2001; Kanengoni et al., 2004). Nevertheless, it is evident that the crossbred pigs grew and converted feed more efficiently than Mukota pigs.

The concentrations of glucose were within the expected range (Mistrukan and Rawnsley, 1977) for both genotypes and dietary treatments. Glucose levels, in general, indicate the efficiency of utilization of ME in a given diet (Fanimo, 1991). The similarity in glucose levels in the pigs on the standard diet and those on the corn cob-based diet suggest that the pigs had similar retention capacities of energy. These observations also indicate that 20 percent inclusion of corn cobs in diets for Mukota and crossbred pigs does not alter the availability of dietary energy to the pigs. The capacity of the crossbred pigs to extract energy-yielding nutrients from fibrous diets is crucial for improving pig productivity for less poor smallholder farmers through crossbreeding.

Urea and creatinine levels indicate the adequacy of protein in terms of quality and quantity in the diet for the animals. The creatinine values for both genotypes were within the expected range for healthy pigs (Jain, 1993), suggesting that the urea that was detected in the blood was most likely coming from elevated dietary protein rather than from impaired kidney function. Proteins with biologically unbalanced amino acids also produce abnormal creatinine values. High levels of urea assist in showing whether there is protein malnutrition, alterations in the dietary intake of protein or pattern of protein utilization, and possibly the extent of muscle wastage (Eggum, 1970). The observed higher urea levels in Mukota than crossbred gilts could suggest that Mukota pigs could require less dietary nitrogen than crossbred pigs. Chulu et al. (2002) also made similar suggestions when comparing haematological and clinical parameters in Mukota and Large White genotypes. Such observations also suggest that the recommended standard pig diets are inappropriate for Mukota pigs. It is likely that the dietary protein levels that are recommended are higher than the requirements for the slow-growing Mukota pigs. More research, therefore, needs to be done to determine their optimum dietary protein requirements, so as to reduce feed costs. Locally available feeding materials with low to medium protein levels are likely to supply adequate amounts of protein to the Mukota pigs. The low urea concentrations in the crossbred pigs that were fed on corn cobs as compared on the standard diet further indicate the need to low protein requirements for slow-growing pigs. The crossbreds, which were growing faster than the Mukota, were probably using most of the dietary protein for growth, hence the low urea values.

The age at puberty of the Mukota gilts observed in this study was higher than previously reported (90 to 120 days) (Holness, 1991). The delay in the exhibition of puberty could have been due to the failure to expose the gilts to a mature boar, a scenario reported to delay puberty by 2 to 5 weeks (Dyck, 1988). The attainment of puberty at lower body weights in Mukota than the crossbred gilts, may suggest the existence of different threshold body weights at puberty for the two genotypes that could be related to the mature body weights. The relatively early attainment of puberty in the Mukota pigs indicates that they have a short generation interval. This suggests that more gain could be attained through selection. The lack of differences in the diets on the age and body weight at the attainment of puberty suggests that both Mukota and crossbred gilts are able to utilize corn cobs without compromising their reproductive performance. It is, however, not clear whether the fibrous diets influence ovulation rates and litter size.

CONCLUSION

The inclusion of corn cobs at 20 percent in the diets of growing gilts did not affect ADFI, ADG and FCR in gilts. The corn cob-based diet did not influence the levels of glucose and creatinine. Urea concentration in crossbred gilts fed a corn cob diet from week 8, however, were low. The findings from this study indicate that corn cob diets, at 20 percent inclusion rate, can be used in diets for Mukota and crossbred pigs. The protein level for the pigs, from 145 days, however, needs to be increased and the appropriate level determined. Inclusion of corn cobs in both the Mukota and crossbred pigs did not influence age and bodyweight at puberty.

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