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EFFECT OF REPLACEMENT OF MAIZE BY ANIMAL-FAT ON GROWTH AND FEED CONVERSION EFFICIENCY IN LARGE WHITE YORKSHIRE PIGS

N. Elanchezhian* and K. Ally[1]

Department of Animal Nutrition, Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry - 605 009 (India)
[1]Department of Animal Nutrition, College of Veterinary and Animal Sciences, Mannuthy, Trichur 680 651, Kerala (India)
*e-mail: *elanmozhi@gmail.com*

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ABSTRACT

An experiment was conducted to assess the effect of replacement of maize by animal-fat on the growth and feed conversion efficiency in Large White Yorkshire pigs. Thirty weaned piglets were randomly divided into three groups and allotted to the three dietary treatments [control ration (as per NRC, 1998), 50% maize of control ration replaced by animal-fat and 100% maize of control ration replaced by animal-fat] and maintained for 70 days. The daily feed intake and fortnightly body weight were recorded and average daily gain and feed conversion efficiency calculated. The average daily gain and feed conversion efficiency were found to be 813.0, 769.8, 678.4 g and 2.80, 2.88, 3.08, respectively, for the three respective treatment groups. There was no significant difference in the performance of pigs belonging to control ration group and the group fed with 50% maize of control ration replaced by animal-fat, but 50% replacement had higher average daily gain and feed conversion efficiency than the group fed with 100% maize of control ration replaced by animal-fat. The study revealed that the pigs fed diet having 50% maize replaced by animal-fat performed in a similar way to that of control fed group and was better than those pigs fed diet with 100% replacement of maize by animal-fat.

Keywords: Animal fat, feed conversion efficiency, growth, maize, pigs

INTRODUCTION

Maize forms the major source of energy in swine feed. India produces around 20 million tonnes of maize yr^{-1} which could meet only 60% of country's requirement (Best, 2012). The lower availability coupled with increasing price of maize, necessitates an alternative energy source for incorporation in swine feed. Animal fat is a byproduct of meat industry and can be included as a source of energy in swine ration. India produces 0.18 million tonnes of tallow and 0.02 million tonnes of lard $year^{-1}$ (FAO, 2016). The use of fat as an energy source for pigs has shown increased nutrient digestibility, improved growth rate, reduced dustiness of feeds and increased palatability (Beaulieu, 2009).

Gatlin *et al.* (2002) reported a linear increase in feed intake and feed efficiency when soybean oil replaced animal fat in pig feeds, but growth rate was unaffected. Beaulieu *et al.* (2009) conducted an experiment using tallow @ 0.5 and 4% in the feeds for pigs and reported a linear increase in growth rate with increasing energy concentration in diet. Realini *et al.* (2010) formulated swine diets with 10% each of tallow, sunflower oil or linseed oil and found no difference in the average daily gain and average daily feed intake among the treatment groups. Benz *et al.* (2011) used 5% of choice white grease or soybean oil in the diet of pigs and found greater average daily gain in soybean oil fed group.

However, no difference was observed in average feed intake or feed efficiency. Lee *et al.* (2011) reported no difference in average daily gain, average daily feed intake and feed conversion efficiency by feeding diets containing 3% tallow with other energy sources (15% corn germ, 5% glycerol or l5% palm kernel oil). Due to the varied results reported by several workers and also due to lack of studies on the effect of replacing maize by animal fat on growth and feed efficiency in pigs in India, the present studies were undertaken to assess the impact of replacing maize in ration by different levels of animal fat (containing mainly tallow, lard and little of poultry fat) on growth and feed efficiency in growing-finishing piglets.

MATERIALS AND METHODS

Thirty weaned Large White Yorkshire (LWY) female piglets of 116.65 ± 1.84 days age with average body weight of 24.02 ± 0.53 kg belonging to the Centre for Pig Production and Research, Mannuthy, COVAS, Thrissur, Kerala (India) were used as experimental animals. All the piglets were vaccinated against classical swine fever immediately after weaning and booster vaccine was given three months later. They were dewormed with albendazole suspension through feed before the start of experiment and repeated again before the booster vaccine. All piglets were randomly divided into three groups as uniformly as possible with respect to age and weight. Piglets of each group were allotted randomly into five pens with two piglets in each pen. All piglets were housed in the same shed and maintained under identical management conditions for 70 days. Clean drinking water was provided *ad libitum* in all the pens throughout the experimental period.

Experimental rations

The animals were fed with standard grower ration containing 18% crude protein (CP) and 3265 kcal ME kg^{-1} feed upto 50 kg body weight and finisher ration with 16% CP and 3265 kcal of ME kg^{-1} feed from 50 kg body weight as per NRC (2012). The three groups of piglets were randomly allotted to three dietary treatments *viz*., control ration as per NRC (1998), 50% maize in control ration replaced by animal-fat, and 100% maize in control ration replaced by animal-fat. Ingredient and chemical composition of pig grower and finisher ration used were as under:

Ingredients (%)	Grower rations[1]			Finisher rations[1]		
	Control ration	50% maize replaced in control ration	100% maize replaced in control ration	Control ration	50% maize replaced in control ration	100% maize replaced in control ration
Yellow maize	70	35	0	74	37	0
Wheat bran	1.5	31	59.8	3.6	34.7	64.9
Soybean meal	26.2	25.5	25.0	20.5	19.7	19.2
Animal fat	0	6.5	13.0	0	7.0	14.0
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Dicalcium phosphate	0.9	0.4	0.0	0.65	0.10	0.0
Calcite	0.85	1.1	1.7	0.75	1.0	1.4
Total	100	100	100	100	100	100
Nicomix AB_2D_3K[1] (g)	25	25	25	25	25	25
Nicomix BE[2] (g)	25	25	25	25	25	25
Zinc oxide[3] (g)	45	13	0	30	0	0
Oxylock antioxidant[4] (g)	10	10	10	10	10	10

[1]Nicomix A, B_2, D_3, K (Nicholas Piramal India Ltd, Mumbai) containing vitamin A - 82, 500 IU, vitamin B_2 - 50 mg, vitamin D_3 - 12,000 IU and vitamin K-10 mg g^{-1}.

[2]Nicomix BE (Nicholas Piramal India Ltd, Mumbai) containing vitamin B_1 - 4 mg, vitamin B_6 - 8 mg, vitamin B_{12} - 40 mg, niacin - 60 mg, calcium pantothenate - 40 mg and vitamin E - 40 mg g^{-1}.

[3]Zinc oxide (Nice Chemicals Pvt. Ltd., Kochi) containing 81.38% of Zn.; [4]Oxylock antioxidant (Vetline Ltd., Indore) contains Ethoxyquin, Butylated Hydroxy Toluene (BHT), Chelators and Surfactantant.

The ration used in this study had similar nutrients as per the recommendations of NRC (1998; 2012). The animal-fat was a mixture of mainly beef fat (tallow), pig fat (lard) and little of poultry fat, obtained from Rendering Plant of Meat Technology Unit, COVAS, Mannuthy, Thrissur, Kerala (India), freshly as and when the feed was prepared. The experiment was conducted as per completely randomized design with each treatment replicated five times. The pigs were weighed at the beginning of the experiment and later on at fortnight intervals. Daily feed intake was recorded. The feed conversion efficiency and average daily gain were calculated. Gross energy of feed and faeces were estimated using bomb calorimeter (plain jacket calorimeter, model: 1341, Parr Instruments Co., USA) to determine the energy utilization of pigs fed four experimental rations.

Feed intake, body weight and feed efficiency

Weighed quantities of feed were offered twice a day at 9.00 am and 3.00 pm. After adding feed in the manger little water was sprinkled over to moistening. The feed intake was measured daily after collecting the leftover feed, if any, and body weight of the individual animals were taken fortnightly in the morning hours before feeding. Then average daily gain and feed conversion efficiency was calculated. The data collected on various parameters were statistically analyzed as per Snedecor and Cochran (1994) and means compared by Duncan Multiple Range Test (DMRT) using Statistical Package for Social Studies (2008) software.

RESULTS AND DISCUSSION

Feed intake

Data on weekly average feed intake of pigs given the three experimental rations control ration, 50% maize replaced with fat and 100% maize replaced with fat are presented in Table 1. The total feed intake recorded were 159.28, 154.98 and 145.98 kg, respectively, and statistically control ration and 50% maize replaced with fat had similar feed intake but higher than that of 100% maize replaced with fat treatment. There was no difference in the feed intake between treatments in first three weeks, whereas from fourth to tenth week except for week eighth, there was no difference in the feed intake of pigs among control ration and 50% maize replaced with fat but was higher ($p<0.05$) than that of

Table 1: Chemical composition of grower and finisher rations on dry matter basis

Constituents (%)	Grower ration[1]			Finisher ration[1]		
	Control ration	50% maize replaced in control ration	100% maize replaced in control ration	Control ration	50% maize replaced in control ration	100% maize replaced in control ration
Dry matter	89.20 ± 0.12	90.56 ± 0.11	91.41 ± 0.13	89.11 ± 0.12	90.41 ± 0.17	91.50 ± 0.18
Crude protein	18.25 ± 0.11	18.18 ± 0.17	18.03 ± 0.13	16.39 ± 0.10	16.28 ± 0.06	16.06 ± 0.18
Ether extract	3.10 ± 0.05	8.53 ± 0.09	13.69 ± 0.10	3.28 ± 0.06	9.04 ± 0.11	14.11 ± 0.07
Crude fibre	3.72 ± 0.11	6.58 ± 0.13	9.42 ± 0.10	3.73 ± 0.07	6.54 ± 0.10	9.40 ± 0.03
Total ash	5.64 ± 0.17	9.50 ± 0.20	12.40 ± 0.18	5.54 ± 0.15	9.54 ± 0.12	12.47 ± 0.14
Nitrogen free extract	69.29 ± 0.16	57.21 ± 0.21	46.46 ± 0.21	71.06 ± 0.20	58.60 ± 0.30	47.96 ± 0.05
Acid insoluble ash	1.10 ± 0.02	4.51 ± 0.09	6.63 ± 0.12	1.04 ± 0.06	4.29 ± 0.13	6.52 ± 0.16
Gross energy (kcal kg^{-1})	4132.20 ± 22.9	4134.9 ± 14.1	4212.89 ± 9.2	4165.2 ± 22.2	4203.1 ± 17.0	4448.3 ± 36.7
Calcium	0.59 ± 0.01	0.62 ± 0.006	0.78 ± 0.01	0.62 ± 0.02	0.65 ± 0.01	0.77 ± 0.02
Phosphorus	0.58 ± 0.01	0.71 ± 0.01	0.85 ± 0.01	0.55 ± 0.02	0.72 ± 0.02	0.83 ± 0.01
Magnesium	0.14 ± 0.006	0.24 ± 0.009	0.40 ± 0.007	0.13 ± 0.008	0.25 ± 0.01	0.37 ± 0.02
Manganese (ppm)	16.78 ± 0.38	39.14 ± 1.76	69.99 ± 1.18	16.59 ± 0.45	38.76 ± 0.96	69.85 ± 1.31
Copper (ppm)	6.35 ± 0.08	9.34 ± 0.06	12.62 ± 0.19	6.15 ± 0.15	9.17 ± 0.08	12.39 ± 0.15
Zinc (ppm)	71.52 ± 1.29	67.19 ± 2.23	88.52 ± 1.15	71.39 ± 1.36	64.95 ± 1.47	88.50 ± 1.62

[1]Mean of four values with SE

100% maize replaced with fat treatment. in eighth week, there was no difference between 50% maize replaced with fat and 100% maize replaced with fat, but had lower ($p<0.05$) feed intake than control ration treatment. From the results on weekly feed intake it could be seen that replacement of maize at 100% level by animal fat lowered the feed intake, but there was no significant difference between control and 50%maize replacement group except in eighth week. This is in agreement with Bhar *et al.* (2000) who observed similar feed intake in crossbred pigs fed diet with 0 and 50% replacement of maize by wheat bran. Discuss the results with studies where maize was replaced by fat not with wheat bran.

Body weight and average weight gain

The data on body weight and weight gain of pigs are presented in Table 2. The average initial and final body weight of piglets belonging to three groups were 23.94, 23.96 and 24.01 kg and 80.85, 77.85 and 71.50 kg, respectively. The statistical analysis of the data revealed no significant difference in the average body weight among treatments during the first two fortnights, however, during the third to fifth fortnight the average body weight 100% maize replaced with fat group was significantly lower ($p>0.05$) in comparison to control ration and 50% maize replaced with fat groups. In present study, the pigs maintained on 100% maize replaced with fat treatment recorded significantly lower growth rate compared to control ration and 50% maize replaced with fat groups. This may be due to the higher level of wheat bran (64.9%) in 100% maize replaced with fat ration which resulted in high crude fibre (9.40%) and acid insoluble ash (6.52%) content in the ration. This is in agreement with Kyriajakis and Eman (1995) who observed a significant decrease in growth rate in growing purebred pigs fed on a high level (60%) of wheat bran containing diet Sikka (2007) found that replacement of maize and rice bran with paddy grain in growing and finishing pigs led to significant decrease in the growth rate due to higher crude fibre content.

Feed conversion efficiency

The data on the fortnightly feed conversion efficiency and their cumulative values of pigs under three treatment groups are presented in Table 4. The overall feed conversion efficiency recorded was 2.80, 2.88 and 3.08, respectively. There was no significant difference between control ration and 50% maize replaced with fat for feed conversion efficiency during any fortnight and cumulative period, but had better result than that of 100% maize replaced with fat treatment. the result observed in 100%

Table 2: Average feed intake (kg) and weight gain (kg) of LWY pigs maintained on the three experimental rations (mean of 5 observations)

Weeks	Feed intake[1]			Weight gain[1]		
	Control ration	50% maize replaced in control ration	100% maize replaced in control ration	Control ration	50% maize replaced in control ration	100% maize replaced in control ration
0	-	-	-	23.94 ± 1.30	23.96 ± 1.55	24.01 ± 1.19
1	9.83 ± 0.51	9.59 ± 0.24	9.25 ± 0.07	-	-	-
2	10.92 ± 0.77	10.30 ± 0.30	10.06 ± 0.06	34.19 ± 1.71	34.09 ± 1.74	32.95 ± 1.07
3	12.58 ± 0.68	12.60 ± 0.39	12.22 ± 0.17	-	-	-
4	13.98 ± 0.84^{b}	13.29 ± 0.53^{b}	11.36 ± 0.31^{a}	44.54 ± 2.04	43.62 ± 2.15	40.92 ± 1.39
5	17.14 ± 0.81^{b}	16.70 ± 0.66^{b}	15.58 ± 0.42^{a}	-	-	-
6	17.52 ± 0.75^{b}	17.38 ± 0.66^{b}	15.65 ± 0.71^{a}	56.87 ± 2.35^{b}	55.15 ± 2.48^{b}	50.87 ± 1.76^{a}
7	18.22 ± 0.69^{b}	17.74 ± 0.39^{b}	16.81 ± 0.67^{a}	-	-	-
8	19.18 ± 0.75^{b}	16.72 ± 0.36^{b}	17.43 ± 0.51^{a}	68.00 ± 2.31^{b}	65.05 ± 2.44^{b}	60.26 ± 1.72^{a}
9	18.86 ± 0.57^{b}	19.05 ± 0.66^{b}	17.73 ± 0.28^{a}	-	-	-
10	21.05 ± 0.53^{b}	21.61 ± 0.49^{b}	19.89 ± 0.32^{a}	80.85 ± 2.76^{b}	77.85 ± 2.35^{b}	71.50 ± 2.00^{a}
Total	159.28 ± 6.54^{b}	154.98 ± 4.42^{b}	145.98 ± 3.30^{a}	-	-	-

a, b - Means of different superscripts within the same row differ significantly; Significant ($P<0.05$)

Table 3: Average body weight gain (kg) and feed conversion efficiency of LWY pigs maintained on the three experimental rations

Fortnight	Weight gain[1]			Feed conversion efficiency[1]		
	Control ration	50% maize replaced in control ration	100% maize replaced in control ration	Control ration	50% maize replaced in control ration	100% maize replaced in control ration
1	10.25 ± 0.50^{b}	10.13 ± 0.27^{b}	8.94 ± 0.25^{a}	2.03 ± 0.12^{a}	1.97 ± 0.06^{a}	2.17 ± 0.06^{b}
2	10.35 ± 0.63^{b}	9.53 ± 0.46^{b}	7.97 ± 0.34^{a}	2.58 ± 0.13^{a}	2.73 ± 0.07^{a}	2.97 ± 0.08^{b}
3	12.33 ± 0.39^{b}	11.53 ± 0.49^{b}	9.95 ± 0.51^{a}	2.82 ± 0.11^{a}	2.97 ± 0.12^{a}	3.15 ± 0.08^{b}
4	11.13 ± 0.39^{b}	9.90 ± 0.27^{b}	9.39 ± 0.26^{a}	3.38 ± 0.18^{a}	3.49 ± 0.11^{a}	3.66 ± 0.16^{b}
5	12.85 ± 0.73^{b}	12.80 ± 0.41^{b}	11.24 ± 0.45^{a}	3.13 ± 0.13^{a}	3.19 ± 0.16^{a}	3.36 ± 0.10^{b}

[1]Mean of 5 observations

a, b - Means of different superscripts within the same row differ significantly; Significant ($P<0.05$)

maize replaced with fat treatment may be due to the higher level of crude fibre (9.4% and acid insoluble ash (6.52%) content in the ration.

Daily gain and feed conversion efficiency of growing pigs

To reach body weight of 50 kg, control ration and 50% maize replaced with fat treatment took 4 weeks, whereas 100% maize replaced with fat treatment took 5 weeks period. Average daily gain and feed conversion efficiency of growing pigs maintained on the three experimental grower rations control ration, 50% maize replaced with fat and 100% maize replaced with fat are presented in Table 3. The average weight gain of these pigs during growing stage was 27.10, 25.49 and 26.86 kg, respectively. There was no significant difference in the average weight gain among the three treatments. The average daily gain in the three groups was 774.29, 728.29 and 639.52 g, respectively. There was no difference in the average daily gain between control ration and 50% maize replaced with fat treatments. The pigs on these treatments had higher ($P<0.05$) daily gain than that of 100% maize replaced with fat treatment. Pigs under 100% maize replaced with fat group took longer period (42 days) to reach 50 kg body weight than other groups (35 days). The total feed intake of grower ration was 64.45, 62.48 and 73.82 kg and the feed conversion efficiency was 2.37, 2.45 and 2.75, respectively for three treatments. The treatment control ration and 50% maize replaced with fat recorded similar values but had significantly lesser feed intake and better feed conversion efficiency than that of 100% maize replaced with fat treatment.

The result indicates that the average daily gain in growing pigs were not affected by 50% maize replaced by animal fat. The lower performance values recorded in 100% maize replaced with fat groups may be because of higher level of wheat bran.

Daily gain and feed conversion efficiency of finisher pigs

The pigs were maintained till the 100% maize replaced with fat group reaches 70 kg body weight. The average weight gain of these pigs during finisher stage was 29.81, 28.40 and 20.63 kg and average daily gain was 851.71, 811.43 and 736.78 g, respectively for three treatments.

Statistical analysis revealed no difference in weight gain and average daily gain between control ration and 50% maize replaced with fat, however these treatments had higher ($p<0.05$) values than 100% maize replaced with fat treatment. The feed intake and feed conversion efficiency in the three groups was 94.83, 92.50, 72.16 and 3.18, 3.26 and 3.50, respectively. The treatment control ration and 50% maize replaced with fat recorded similar values but had significantly better feed conversion efficiency than that of 100% maize replaced with fat treatment.

Overall daily gain and feed conversion efficiency of experimental pigs

The average final weight and weight gain of these pigs for overall period were 80.85, 77.85 and 71.50 kg and 56.91, 53.89 and 47.49 kg, respectively. The overall average daily gain was 813.00, 769.86 and 678.43 g, respectively, for three treatments. There was no difference in final body weight, weight gain and average daily gain between control ration and 50% maize replaced with fat, but had higher

values than that of 100% maize replaced with fat treatment group. The total feed intake and overall feed conversion efficiency for three treatment groups were159.28, 154.98, 145.98 and 2.80, 2.88, 3.08, respectively. There was no significant difference for these parameters between control ration and 50% maize replaced with fat, but had better feed conversion efficiency than that of 100% maize replaced with fat treatment.

In present study 100% maize replaced with fat treatment recorded significantly lower average daily gain and feed efficiency as compared to the other groups. This may be due to high crude fibre (9.4%) and acid insoluble ash (6.52%) contents in the ration which might have affected the digestion and utilization of nutrients. This is in agreement with Kyriazakis and Emmans (1995) who reported decreased weight gain and feed conversion efficiency in growing purebred pigs fed on a high level (> 60%) of wheat bran in their diet. Growth rate and feed efficiency of pigs were depressed as fiber level in the diet increased (Cline and Richert, 2000; Grieshop, 2000).

Conclusion: This study revealed that the pigs fed with diet having 50% maize replaced by animal fat performed in a similar way to that of control fed group and was better than those fed with diet having 100% replacement of maize by animal fat.

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