American Journal of Animal and Veterinary Sciences 9 (2): 110-115, 2014
ISSN: 1557-4555

doi:10.3844/ajavssp.2014.110.115 Published Online 9 (2) 2014 (http://www.thescipub.com/ajavs.toc)

EFFECT OF REPLACING CORN AND SOYBEAN MEAL WITH BREWERS RICE AND DRIED DISTILLERS BREWERS YEAST ON PERFORMANCE OF GROWING-FINISHING PIGS

[1]Ondieki Gekara, [1]Talesha Dokes and [2]Renita Marshall

[1]Department of Agriculture, University of Arkansas at Pine Bluff, AR, USA
[2]Agricultural Research and Extension Center, Southern University, Baton Rouge, LA, USA

Received 2014-01-07; Revised 2014-04-22; Accepted 2014-04-24

ABSTRACT

The objective of this study was to determine the effect of replacing corn and Soybean Meal (SBM) with Brewers Rice (BR) and Dried Distillers Brewers Yeast (DDBY), respectively, on ADG, G:F, Apparent Total Tract Digestibility (ATTD), fecal DM output and fecal loss of N and P of growing-finishing pigs. Sixty four Yorkshire x Duroc x Hampshire crosses (BW = 73±5.7 kg) were randomly assigned to corn/SBM (CSM), BR/SBM (RSM), corn/DDBY (CBY) or BR/DDBY (RBY) diets. Compared with pigs finished on corn based diets, pigs fed BR based diets gained faster (0.868 vs. 0.730 kg.pig^{-1}; $p<0.01$) and had better gain to feed ratio (0.30 vs. 0.25; $p<0.01$). Pigs finished on RBY diet had the least fecal DM output (0.245, 0.352, 0.575, 0.639 kg.pig^{-1}; $p<0.001$) and greatest ATTD (91.5, 87.8, 80.0, 77.9%; $p<0.001$) followed by RSM, CBY and CSM pigs, respectively. Pigs finished on RBY diet lost the least ($p<0.001$) amount of N (0.010, 0.013, 0.019, 0.021 kg.pig^{-1}) and P (0.010, 0.014, 0.016, 0.019 kg.pig^{-1}) in the feces followed by pigs finished on RSM, CBY and CSM, respectively. In conclusion, BR and DDBY can replace all corn and SBM in swine diets with no negative effects on performance of growing-finishing pigs.

Keywords: Corn, Brewers Rice, Soybean Meal, Dried Distillers Brewers Yeast, Growing-Finishing Pigs, Fecal Dm, Fecal N and P

1. INTRODUCTION

Swine diets are generally formulated on least cost basis and to obtain optimal nutrient use and minimize excretion of dietary nutrients. However, some nutrients are utilized less efficiently and are excreted in excess through the feces contributing to environmental pollution. Nitrogen and P are the most significant contributors to environmental pollution although other nutrients such as Ca, K, Cu and Zn are also of concern (Schutte *et al*., 1993). Dietary nutrients are excreted in excess because they are utilized less efficiently or nutrients supplied in the diet exceed the amounts needed by the animal (Lenis and Schutte, 1990; Kerr, 1995). Approximately 50 to 80% of N and 40 to 80% of P consumed is excreted, a substantial amount through the feces (Yano *et al*., 1999). Surplus N in manure leaches into ground and surface water, resulting in high nitrate levels in ground water and O_2 depletion by O_2-depleting plants growing in surface water (Aarnink and Verstegen, 2007).

Modifications of swine diets to replace feedstuffs used less efficiently or the more expensive feedstuffs continue to attract considerable research over the years. Other investigations have looked to include only nutrient amounts in diets to match animal needs; reports show a significant reduction in the excretion of nutrients such as N and P when dietary levels were restricted (Sutton *et al*., 1999; Cole *et al*., 2003; Aarnink and Verstegen, 2007). In addition, prices of

Corresponding Authors: Ondieki Gekara, Department of Agriculture, University of Arkansas at Pine Bluff, AR, USA

traditional feedstuffs in swine diets, corn and Soy Bean Meal (SBM), continue to rise owing to their alternative uses as renewable energy sources. Alternative but effective energy and protein feedstuffs need to be investigated for their optimal utilization by pigs. Brewers Rice (BR), a by-product of rice processing and Dried Distillers Brewers Yeast (DDBY), a by-product of beer manufacturing, can be suitable and cheaper alternatives to corn and SBM, respectively. Although BR has a lower energy density compared to corn, its starch is more readily available because of a lower amylose to amylopectin ratio (Goddard *et al*., 1984) and lower Non-Starch Polysaccharides (NSP) and resistant starch (RS; Berry, 1986). These biochemical differences make BR more digestible than corn because rice contains about 20% amylose compared to more than 25% for corn (Rooney and Pflugfelder, 1986; Bjorck *et al*., 1994). Literature is lacking on the effect of replacing corn and SBM with BR and DDBY, respectively, on pig performance, fecal DM output and fecal loss of N and P by growing-finishing pigs. We hypothesized that replacing corn and SBM with BR and DDBY, respectively, will increase nutrient utilization (G:F and ATTD) and reduce fecal DM output ,and loss of N and P with out any negative effects on pig productivity. The objectives of this research were to determine the effect of; (1) replacing corn and SBM with BR and DDBY, respectively, on fecal DM output and loss of N and P in growing-finishing pigs and (2) replacing corn and SBM with BR and DDBY, respectively, on ADG, G:F and ATTD of growing-finishing pigs.

2. MATERIALS AND METHODS

The experiment used growing-finishing managed to meet the recommendations of the University of Arkansas at Pine Bluff (UAPB) Institutional Animal Care and Use Committee.

2.1. Animals, Housing and Experimental Design

Animals used in this experiment were a mixture of barrows and gilts of approximately ¾ Yorkshire×⅛ Duroc×⅛ Hampshire breeding. The animals weighed 73±5.7 kg^{-1} on day 0. Sixteen animals were born and raised on the UAPB Farm while forty eight animals of similar breeding were sourced from a nearby private farm. Experimental animals were housed in semi-open concrete floor pens measuring 2.13×6.26 m of which 2.13×2.13 m portion is open section and a similar area is under roof. All animals were grouped by weight and randomly assigned to four experimental diets. The design of this experiment was a randomized complete block with each pen consisting of four pigs considered the experimental unit. There were four diet treatments in this experiment, replicated four times, for a total of sixteen pens. This study was conducted between November 2, 2012 and November 30, 2012 and lasted 28 days.

2.2. Diets

Experimental diets were mixed at the UAPB Farmusing ingredients sourced locally. The treatment diets were: (1) Corn/Soybean Meal (CSM; control); (2) Brewers Rice/Soybean Meal (RSM); (3) Brewers Rice/dried distillers Brewers Yeast (RBY); and (4) Corn/dried distillers Brewers Yeast (CBY). All diets were formulated to contain 14% CP; dietary Ca and P met the National Research Council (NRC, 2012) recommendations for pigs in this class. Feed was weighed and fed manually to the animals daily at 0900 h. Daily feed amounts offered were based on the daily nutrient requirements for growing-finishing pigs following NRC (2012) recommendations. Animals were fed at 3.7% of BW on a DM basis. Feed intake at this level was calculated to supply adequate nutrients to support maintenance and attain more efficient ADG. The feed amounts were adjusted midway through the experimental period, to match changing animal needs due to increased growth. Drinking water was provided at all times via wall mounted nipple drinkers.

2.3. Variables Measured

Variables determined included: ADG, G:F, ATTD, fecal DM output and fecal loss of N and P and feed and fecal N and P. To determine ADG, animals were weighed on days 0, 14 and 28. The ATTD of DM, N and P was the calculated percent difference between intake DM, N and P and fecal DM, N and P. The fecal loss of N and P was calculated from average fecal output excreted during the five days of the sampling period. Fecal DM output was determined by multiplying the average total feces collected by the DM percent of each fecal sample.

Feed and fecal samples were dried and ground to pass through a 2 mm screen using the Wiley mill (Thomas Scientific, Swedesboro, NJ). Ground samples from five sampling days were composited into one sample each. Composite fecal and feed samples were analyzed for DM, N, P, Neutral Detergent Fiber (NDF) Acid Detergent Fiber (ADF) and ash.

Samples for P analysis were digested in nitric acid (HNO_3) on a hot block heated to more than 60°C for up to 1½ h with appearance of reddish smoke signaling that initial digestion was complete. Hydrogen peroxide (H_2O_2) was added at this point and further digestion allowed to continue until about 5 mL of sample was left in the tube. The digested solution was diluted to bring the volume to 25 mL. The diluted sample was run through the Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) analyzer for final determination of P concentration.

2.4. Sampling Procedures

Animals were weighed at the start (day 0), day 14 and end of the experiment (day 28). Sub-samples of each feed were placed in a bag and stored in a freezer at-20°C, until further lab analysis. Total feces were collected within each pen during the last five days of the experiment. The feces were collected at the same time, in numerical order starting with the same penevery collection day. All feces were gathered and placed in pre-weighed buckets. Once the weight was determined, the feces were mixed within the bucket and a sub-sample prepared for lab analysis. The fecal sub-samples were stored in a freezer at-20°C, awaiting further lab analysis. During the sampling period the pens were not allowed to be washed down to ensure that all the feces excreted by the pigs during the sampling period were collected.

2.5. Statistical Analysis

Data was analyzed as a randomized complete block design, with pen comprising of four pigs as the experimental unit and block based on initial pig BW. All data were subjected to Analysis Of Variance (ANOVA) generated using the GLM procedures of SAS (SAS Inst. Inc., Cary, NC). The error term of pen within diet was used to test the effect of treatments on response variables determined. Treatment differences were considered significant at $p<0.05$. Least significance difference was used to separate means when a significant F-value for treatment means ($p<0.05$) was observed in the ANOVA.

3. RESULTS

Compared to pigs finished on corn based diets, pigs finished on brewers rice based diets gained faster ($p<0.01$); the protein source had no negative effect on pig ADG (**Table 2**). Fecal loss of dietary N was reduced ($p<0.001$) the most for pigs finished on RBY diet and reduced the least for CSM and CBY pigs, RSM pigs were intermediate (**Table 3**). Response to dietary P was somewhat different; pigs finished on RBY diet had the least ($p<0.001$) loss of dietary P followed by RSM, CSM and CBY in that order. Consequently, digestibility of dietary N and P was greater ($p<0.001$) for BR based diet compared with corn based diets.

4. DISCUSSION

Possible reasons why pigs fed BR based diets had a significant reduction in fecal DM output was probably due to lower NDF and ADF (fiber) levels (**Table 1**) compared to corn based diets. Fiber has a negative correlation with digestibility and this inverse relationship probably explains why corn with higher fiber content was less digested compared with BR. Greater ATTD for BR based diets meant that less feces was excreted compared to corn based diets. These findings compare favorably with our previous work (Gekara *et al*., 2013) and those of Yano *et al*. (1999), although the latter group used chickens in their studies.

Greater ATTD for RBY pigs followed by RSM, CSM and CBY, in that order, may have been due to differences in the concentration of NSP, mainly the cell wall carbohydrates, RS to amylase digestion and other complexes (Englyst *et al*., 1992; Gallant *et al*., 1992; Brown, 1996). Brewers rice based diets probably had a lower amylose (Goddard *et al*., 1984), NSP and RS (Berry, 1986) concentration making BR more digestible than corn based diets. Regular rice contains about 20% amylose compared to more than 25% for corn (Bjorck *et al*., 1994; Rooney and Pflugfelder, 1986).

The significant reduction in the fecal loss of N and P may have been due to differences in ATTD and dietary NDF and ADF. Brewers rice based diets had a greater N and P digestibility and lower levels of NDF and ADF compared with corn based diets. Fiber (mainly ADF) and digestibility are negatively correlated, thus, the significantly lower ADF levels in RBY and RSM diets compared with CSM and CBY diets probably explains the corresponding differences in animal response. Furthermore, a probable more favorable N to P ratio (Bjorck *et al*., 1994; French, 1973) in BR based diets compared with corn based diets may have resulted in greater digestibility and lower excretion of N and P in the feces. Additional research should determine the extent of N and P bound to NSP and how this affects availability of N and P in corn and BR relative to utilization in swine.

Table 1. Composition of experimental diets

Item	Experimental Diet[1] RBY	CBY	CSM	RSM
Brewers rice (%)	-	76.80	-	77.74
Corn, dented yellow (%)	78.20	-	77.15	-
Soybean meal (%)	10.00	13.60	-	-
Alfalfa pellets (%)	8.15	5.60	8.00	4.46
Dried distillers brewers yeast (%)	-	-	11.15	14.55
Dicalcium phosphate (%)	2.45	2.15	1.75	1.50
Limestone (%)	0.75	1.80	1.10	1.30
Salt (%)	0.20	0.20	0.20	0.20
Mineral/vitamin premix[2] (%)	0.25	0.25	0.25	0.25
Nutrient composition				
ME, kcal/kg	30.18	27.30	30.74	28.54
CP (%)	14.03	14.03	14.03	14.03
P (%)	0.79	0.75	0.84	0.74
Ca (%)	0.99	0.90	1.00	0.94
Lys (%)	0.56	0.76	0.62	0.42
Analyzed composition				
N (%)	1.86	2.33	2.15	2.27
P (%)	0.60	0.86	0.73	0.74
NDF (%)	10.50	2.73	10.15	2.34
ADF (%)	4.94	2.85	4.22	2.83
Ash (%)	5.63	5.70	5.88	4.81

[1]Treatments: CSM = Corn/Soybean Meal; RSM = brewers Rice/Soybean Meal; CBY = Corn/dried distillers Brewers Yeast; RBY = brewers Rice/dried distillers Brewers Yeast

[2]Mineral/vitamin premix provided per kilogram: Iron, 180 ppm; Zinc, 180 ppm; Manganese, 37 ppm; Copper, 75 ppm; Iodine, 2.5 ppm; Selenium, 1.5 ppm; Vitamin A, 15,000 IU; Vitamin D3, 2,500 IU; Vitamin E, 60 IU; Vitamin B12, 62 µg; Menadione, 2.5 mg^{-1}; Riboflriboflavin, 13.7 mg; D-pantothenic Acid, 102.5 mg^{-1}

Table 2. Average daily gain, fecal output, apparent total tract digestibility and feed efficiency ofgrowing-finishing pigs

Item	Treatment[1] CSM[1]	RSM	CBY	RBY	SEM	P value
BW at start (kg)	70.259	71.989	73.722	74.006	5.710	>0.100
BW at end (kg)	90.795	97.045	94.034	97.557	5.204	<0.010
DM intake (kg)	2.889	2.886	2.870	2.899	0.000	
ADG (kg)	0.734^{b}	0.895^{a}	0.725^{b}	0.841^{a}	0.041	<0.010
FO[2] (kg)	0.639^{a}	0.352^{c}	0.575^{b}	0.245^{d}	0.093	<0.001
ATTD (%)	77.896^{d}	87.794^{b}	79.956^{c}	91.518^{a}	3.217	<0.001
G:F(kg/kg)	0.254^{b}	0.310^{a}	0.253^{b}	0.290^{a}	0.014	<0.010

[1]Treatments: CSM = Corn/Soybean Meal; RSM = brewers Rice/Soybean Meal; CBY = Corn/dried distillers Brewers Yeast; RBY = brewers Rice/dried distillers Brewers Yeast

[2]FO = Fecal Output (dry matter)

[3]ATTD = Apparent Total Tract Digestibility

Table 3. Intake and digestibility of N and P in growing-finishing pigs

Item	Treatment[1] CSM[1]	RSM	CBY	RBY	SEM	P value
Intake N (kg)	0.054^{d}	0.067^{a}	0.062^{c}	0.066^{b}	0.003	<0.001
Intake P (kg)	0.017^{d}	0.025^{a}	0.021^{b}	0.018^{c}	0.001	<0.001
Fecal N (kg)	0.021^{a}	0.013^{b}	0.019^{a}	0.010^{c}	0.003	<0.001
Fecal P (kg)	0.016^{b}	0.014^{c}	0.019^{a}	0.010^{d}	0.002	<0.001
Digest N (%)	60.442^{d}	79.943^{b}	69.420^{c}	84.443^{a}	5.388	<0.001
Digest P (%)	8.971^{b}	45.167^{a}	11.630^{b}	43.678^{a}	9.870	<0.001

[1]Treatments: CSM = Corn/Soybean Meal; RSM = brewers Rice/Soybean Meal; CBY = Corn/dried distillers Brewers Yeast; RBY = brewers Rice/dried distillers Brewer's Yeast a-d; Means within a row with different superscripts differ (p<0.05)

A better gain to feed ratio for pigs fed BR based diets compared with corn can be attributed to greater ADG since feed intake was the same across diets. Although intake of N and P was greater for pigs fed BR based diets, pigs fed corn based diets excreted more N and P in the feces. Diet modification BR and replaced corn and SBM, respectively, may have resulted in greater N and P digestibility and reduced excretion in the feces.

3.1. Implications

Results of this study further confirm that diet modification to include highly digestible plant based feedstuffs remains a viable option that can reduce excessive excretion of feed nutrients, notably N and P. Furthermore, significant reduction in fecal N and P is a boon and adds value to efforts aimed at reducing environmental pollution caused by manure generated through intensive swine and poultry operations.

4. CONCLUSION

Brewers rice and dried distillers brewers yeast can replace all corn and soybean meal, respectively, in diets for growing-finishing pigs and reduce fecal DM output and fecal loss of N and P with no negative effects on animal growth and productivity. In this study, brewers rice/dried distillers brewers yeast based diets may have provided animals with highly digestible nutrients and less manure, contributing to reduced environmental pollution. However, the superior performance of brewers rice and dried distillers brewers yeast over corn and soybean meal, respectively, may need further investigation to determine the effect of diet on carcass quality and other characteristics including eating attributes.

5. REFRENCES

Aarnink, A.J.A. and M.W.A. Verstegen, 2007. Nutrition, key factor to reduce environmental load from pig production. Livestock Sci., 109: 194-203. DOI: 10.1016/j.livsci.2007.01.112

Berry, C.S., 1986. Resistant starch: Formation and measurement of starch that survives exhaustive digestion with amylolytic enzymes during the determination of dietary fibre. J. Cereal Sci., 4: 301-314. DOI: 10.1016/S0733-5210(86)80034-0

Bjorck, I., Y. Granfeldt, H. Liljberg, T. Tovar and N.G. Asp. 1994. Food properties affecting the digestion and absorption of carbohydrates. Am J. Clin. Nut. 59: 699S-705S.

Brown, I., 1996. Complex carbohydrates and resistant starch. Nut. Rev., 54: S115-S119. DOI: 10.1111/j.1753-4887.1996.tb03830.x

Cole, N.A., L.W. Greene, F.T. McCollum, T. Montgomery and K. McBride, 2003. Influence of oscillating dietary crude protein concentration on performance, acid-base balance and nitrogen excretion of steers. J. Anim. Sci., 81: 2660-2668. PMID: 14601868

Englyst, H.N., S.M. Kingman and J.H. Cummings, 1992. Classification and measurement of nutritionally important starch fractions. Eur. J. Clin. Nut., 46: 533-550. PMID: 1330528

French, D., 1973. Chemical and physical properties of starch. J. Anim. Sci., 37:1048-1061.

Gallant, D.J., B. Bouchet, A. Buleon and S. Perez, 1992. Physical characteristics of starch granules and susceptibility to enzymatic degradation. Eur. J. Clin. Nut., 46: S3-16. PMID: 1330527

Gekara, O., T. Dokes and R. Marshall, 2013. Diet modification to reduce fecal excretion of nitrogen and phosphorus in growing-finishing pigs. Am. J. Anim. Vet. Sci., 8: 197-202. DOI: 10.3844/ajavsp.2013.197.202

Goddard, M., G. Young and R. Marcus, 1984. The effect of amylose content on insulin and glucose responses to ingested rice. Am. J. Clin. Nut., 39: 388-392. PMID: 6364775

Kerr, B.J., 1995. Nutritional Strategies for Waste Reduction Management. In: Nitrogen, Longenecker, J.B. and I.W. Spears (Eds.), New Horizons in Animal Nutrition and Health. The Institution of Nutrition of the University of North Carolina, Chapel Hill, NC, USA, pp: 47-68.

Lenis, N.P. and J.B. Schutte, 1990. Amino Acid Supply of Piglets and Grow-Finish Pigs in Relation to Nitrogen Excretion. In: Manure Issues: Nutritional Solution for Pigs and Poultry, Jongblood, A.W. and J. Coppoolse (Eds.), Service Agricultural Research, Wageningen, The Netherland, pp: 79-89.

NRC, 2012. Nutrient Requirements of Swine. 11th Edn., Nation, Acad. Press. Washington, D.C.

Rooney, L.W. and R.L. Pflugfelder, 1986. Factors affecting starch digestibility with special emphasis on sorghum and corn. J. Anim. Sci., 63:1607-1623. PMID: 3539904

Schutte, J.B., J. de Jong and J.M. van Kempen, 1993. Dietary protein in relation to requirement and pollution in pigs during the body weight range of 20-40 kg.

Sutton, A.L., K.B. Kephart, M.W. Verstegen, T.T. Canh and P.J. Hobbs, 1999. Potential for reduction of odorous compounds in swine manure through diet modification. J. Anim. Sci., 77: 430-439. PMID: 10100673

Yano, F., T. Nakajima and M. Matsuda, 1999. Reduction of nitrogen and phosphorus from livestock waste: A major priority for intensive animal production. Asian-Aust. J. Anim. Sci. 24: 651-656.