THE EFFECT OF CORN DISTILLERS DRIED GRAINS WITH SOLUBLES INCLUSION RATE AND BIOCONVERSION ON THE NITROGEN, PHOSPHORUS AND ENERGY METABOLISM OF PIGLETS

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ABSTRACT

DDGS has some disadvantages (high fiber content, possible heat damage of amino acids) which may be able to be improved with a newly developed technique called bioconversion (a special fermentation technique). The purpose of this study was to determine the effect of DDGS and bioconverted DDGS on the N, P and energy digestibility and retention of piglets. Twenty-four weaned piglets weighing 8-10 kg were housed individually in a flat-deck cage. The diet of piglets in the control group did not contain DDGS, while other three diets contained DDGS or bioconverted DDGS in increasing amount: 5, 10 or 15%, respectively. The experimental diets had similar nutrient content. The results of this study indicated that corn DDGS and bioconverted DDGS had similar values for energy digestibility and retention. The average DE for the corn DDGS that was calculated in the present experiment was 14.42 MJ/kg of DM, and the average ME was 13.8 MJ/kg of DM. Adding increasing amounts of untreated DDGS to the diet tended to increase P digestibility and retention in the experiment. While the bioconversion improved both phosphorous digestibility and retention. Calcium digestibility and retention were similar for weaned piglets fed the DDGS diet compared to the bioconverted DDGS diets.

Our research confirms that even 15% corn DDGS can be included in diets of weaned piglets if highly digestible other components are used. The bioconversion does improve the feeding value of corn DDGS, but the actual inclusion in practical feeding will be depended on economical considerations.

KEYWORDS: piglet, digestibility, DDGS

INTRODUCTION

Distillers dried grains with solubles (DDGS) is the main co-product of ethanol production. In general, DDGS has high concentrations of nutrients such as protein, fat, vitamins, minerals, and fiber than parent grain. It reported that DDGS contains approximately 88.9% dry matter, 30.2% crude protein, 10.9% crude fat, 5.8% ash, 8.8% crude fiber, 16.2% ADF, and 42.1% NDF [18]. Production of ethanol has increased the availability of DDGS for use in livestock feeds. However, little emphasis has been placed on research documenting the energy, nitrogen (or amino acid), phosphorus and calcium digestibility of weaned piglets fed DDGS. Currently, some nutritionists recommend that DDGS should not be fed at concentrations greater that 20% (10% for pigs less than 12 kg) of the diet during the nursery period [14]; however, Stein and Shurson [24] suggested that acceptable growth performance can be achieved with inclusion of up to 30% DDGS. Spiehs et al. [19] found that increasing DDGS levels in the diet has tended to increase N intake. However, N retention, based on percentage, did not differ between treatments. Spiehs et al. [19] suggested that feed 10 to 20% DDGS should maintain N retention while tending to increase N excretion when fed to pigs. The indigestible form of P found in feed ingredients is phytic acid, which results in low levels of available phosphorus to be utilized by the animal. Xu et al. [31] recommended that feeding DDGS in swine diets increases percent P retention. However, Spiehs et al. [19] reported that fed 10 to 20% DDGS improved P retention and reduce P excretion. The relatively high digestibility of phosphorus in DDGS results in less inorganic phosphorus that is needed in diets containing DDGS [22].

Based on these information DDGS is valuable feed, but has some disadvantages (high fiber content, possible heat damage of amino acids) which may be able to be improved with a newly developed technique called bioconversion (a special fermentation technique). Therefore, the purpose of this study was to determine the effect of DDGS and bioconverted DDGS on the N, P and energy digestibility and retention of piglets.

MATERIALS AND METHODS

Experimental animals and housing

One week after weaning 24 hybrid piglets weighing 8-10 kg were selected for the trial. Piglets were housed individually in the flat-deck cage. The trial was carried out in change over design.

Experimental diets

Seven treatments were formulated according to the Evonik [4] and NRC [16] recommendation (Table 1). The diet of piglets in the control group did not contain DDGS, while other three diets contained in increasing amount of DDGS (5, 10 and 15%) or bioconverted DDGS, respectively. Experimental diets had similar nutrient content. The composition and the calculated and measured nutrient content can be found in Table 1. TiO was included in the diet as an indigestible marker. Bioconversion was a one week solid-state fermentation process, which was carried out according to the method of Vig and Walia [27] using *Thermomyces lanuginosus*. The daily feed allowance was 2.8 times of the daily maintenance energy requirement (feed allowance, g = live weight$^{0.75}$ * 450 KJ/metabolic body weight / feed ME content, MJ/kg). The feed allowance was calculated at the beginning of each adaptation and collection period based on the live weight measurements. Animals were fed in two equal portions at 8:00 and 15:30. The feed was mixed with similar amount of water. Animals had free access to water from a nipple drinker. In case of feed refusal the leftover feed was removed and dried.

Collection of feces and urine

Feces collected several times daily from the pen and the tray underneath and were stored in a freezer at $-18C^o$. Only the non contaminated feces were collected. At the end of each collection period the collected samples were homogenized and 2 x 150g sample was prepared and stored at $-18C^o$. Every morning urine was collected in plastic buckets with 10 ml 50%- sulfuric acid The buckets were covered with a surgeon's cap with N-free cotton-wool (with the aim of filtrating out contamination). Collected urine was weighed once a day (after the morning feeding) and filtrated again through N-free cotton-wool. The pH of urine was checked with indicator paper. If the value did not fall between pH 1 to 2 additional 10 ml sulphuric acid was added and the pH checked again (after homogenization). Ten percent of filtrated and homogenized urine was removed and stored at -18°C until further processing.

Laboratory analyses

From the feedstuffs the dry matter, crude protein, crude fiber, crude fat, crude ash, Ca, P and amino acid content was determined. From the complete feeds the gross energy, dry matter, crude protein, crude fiber, crude fat, crude ash, Ca, P and Ti content was analyzed. From the fecal samples the gross energy, N, Ca, P and Ti content was determined. From urine samples the N, Ca and P content was determined.

Statistical analyses

Statistical analyses were carried out with SAS (SAS Institute Inc., Cary, NC, USA) using GLM procedure and Duncan range test to detect significant differences among treatments.

Table 1

Composition and nutrient content of experimental diets

Ingredients	Control	DDGS level 5%	DDGS level 10%	DDGS level 15%
Corn, flaked	25.84	22.71	19.58	16.44
Barley, flaked	25	25	25	25
Full-fat soybean	15	15	15	15
Soybean meal	13.63	11.39	9.14	6.9
Sweet whey powder	12	12	12	12
Pig intestine extract	2.5	2.5	2.5	2.5
Dry fat 99%	2.31	2.66	3	3.34
DDGS	0	5	10	15
Limestone	1.14	1.2	1.26	1.32
Monocalcium phosphate	0.85	0.76	0.67	0.58
L-Lys	0.35	0.4	0.44	0.49
DL-Met	0.17	0.16	0.16	0.16
L-Trp	0.04	0.04	0.05	0.06
L-Thr	0.04	0.05	0.07	0.08
Salt	0.13	0.13	0.13	0.13
Vit. Premix	0.5	0.5	0.5	0.5
TiO	0.5	0.5	0.5	0.5
Total	100	100	100	100
Calculated nutrient content, MJ/kg or %				
DEs	14.3	14.4	14.5	14.6
MEs	13.7	13.8	13.9	14.0
NEs	10.4	10.4	10.4	10.4
Crude protein	18	18	18	18
Crude fiber	4.2	4.4	4.6	4.8
Crude fat	6.9	7.5	8.0	8.6
Lys	1.33	1.34	1.35	1.35
dig Lys*	1.14	1.14	1.14	1.14
M+C	0.76	0.77	0.79	0.80
dig. M+C*	0.66	0.66	0.66	0.66
Thr	0.82	0.82	0.83	0.84
dig Thr*	0.68	0.68	0.68	0.68
Trp	0.25	0.25	0.25	0.25
dig Trp*	0.22	0.22	0.22	0.22
Ca	0.72	0.72	0.72	0.72
P	0.60	0.60	0.60	0.60
dig P	0.34	0.33	0.31	0.30
Na	0.15	0.15	0.15	0.15
dig. Lys/ NE	0.11	0.11	0.11	0.11
dig. M+C/dig. Lys	0.58	0.58	0.58	0.58
dig. Thr/dig. Lys	0.59	0.59	0.59	0.59
dig. Trp/dig. Lys	0.19	0.19	0.19	0.19
Ca/P	1.2	1.2	1.2	1.2

* SID digestibility is based on EvaPig 1.3.0.2

RESULTS AND DISCUSSION

Energy digestibility and retention

The results of this study indicated that corn DDGS and bioconverted DDGS had similar values for energy digestibility and retention. There were no significant differences between groups (Table 2). The average DE for the corn DDGS that was calculated in the present experiment was 14.42 MJ/kg of DM, and the average ME was 13.8 MJ/kg of DM. These values are similar to values of 14.43 and 12.71 MJ/ kg of DM in NRC [16], respectively. In some studies [19] it is observed that increasing amounts of DDGS in the diet increases gross energy intake. Pedersen et al. [16] reported that the GE values for the DDGS samples were on average 22.73 MJ/kg DM. Stein et al. [23] reported that in ten samples, DE ranged from 14.15 to 15.94 MJ/kg of DM. Spiehs et al. [20] also calculated values for DE and ME in DDGS to be approximately 16.69 and 15.69 MJ/kg DM.

Fastinger and Mahan [5] reported that the energy digestibility has been found to not differ among corn DDGS sources and ranged from 66.7 to 69.2%. However, energy digestibility of DDGS was higher when DDGS was fed in combination with cereal grain instead of cornstarch [11].

A trial conducted by the University of Illinois, USA, showed that adding both a new-generation phytase (Phyzyme® XP) together with a highly effective xylanase (Porzyme® 9300) to a corn-soy pig diet containing 20% corn DDGS significantly improved digestible energy by 5.6%. Xylanase cleaves the long chain of arabinoxylan into small fragments, and increased energy digestibility [13;15].

(40 vs. 90%) than of soluble dietary fiber [26]. Therefore, there were no differences in energy digestibility among the sources suggesting.

Nitrogen digestibility and retention

There were no significant differences between groups (Table 2). The dietary 5, 10 and 15% corn DDGS and bioconverted DDGS resulted in similar values to the control group when fed to weaned piglets. Thong et al. [25] reported that N retention decreased as the level of DDGS in the diet was increased from 0 to 17.7 and 44.2%. Stanogias et al. [21] found a tendency for increased N retention when high fiber diets containing soybean hulls and wheat bran were fed to growing pigs, but Holt et al. [8] showed that N retention for sows fed the corn-soybean meal control diet and the soybean hull diet were similar. Wilson et al. [29] reported that sows fed the 50% DDGS diet during the gestation period had higher N intake, fecal N excretion, and urinary N excretion than sows fed the control diet, and had a tendency for higher total N retention (g/d), but had no difference in N retention compared to sows fed the control diet.

Table 2

Effect of bioconversion and DDGS dietary inclusion rate on the N, Ca, P and energy digestibility and retention in weaned piglets

Treatment	Control		DDGS			Bioconverted DDGS	
DDGS	0%	5%	10%	15%	5%	10%	15%
N dig.	79.1	81.2	79.1	78.9	80.6	80.5	82.5
Ca dig.	60.8	63.0	61.5	64.2	61.4	62.1	67.2
P dig.	42.7^{a}	51.0^{ab}	49.2^{ab}	51.6^{ab}	44.5^{a}	50.5^{ab}	59.0^{b}
E dig.	76.5	79.1	76.6	75.8	76.7	76.9	79.4
N ret.	66.3	69.1	67.1	67.0	67.4	67.4	69.4
Ca ret.	57.9	59.5	57.8	61.3	57.9	58.2	65.1
P ret.	41.9^{a}	50.1^{ab}	49.4^{ab}	50.3^{ab}	42.8^{a}	49.5^{ab}	57.5^{b}
E ret.	75.9	78.6	76.1	75.4	76.2	76.4	78.9

^{a,b} Means in rows having a common superscript do not differ significantly (P>0,05).

In the present study, corn DDGS contained less starch (4 vs. 7%) and more fiber (mostly insoluble) than mean values [17,24]. The apparent total tract digestibility (ATTD) of insoluble dietary fiber in corn DDGS is lower

However, this indicates that the inclusion of DDGS in diets but formulated to have similar nutrient content do not affect N retention and digestibility in weaned piglets.

Phosphorus digestibility and retention

Adding increasing amounts of untreated DDGS to the diet tended to increase P digestibility and retention in the experiment. While in the case of the bioconverted DDGS groups the bioconversion (adding specialized enzymes) improved both phosphorous digestibility and retention. In the case of the 15% bioconverted DDGS group the values significantly exceeded those found in the control group (Table 2).

In some studies, digestibility of P decreased due to the source, fermentation, processing or drying procedures of the dry grind method [3,28]. Phosphorus digestibility can also be influenced by the Ca:P ratio. The higher the concentration of Ca as compared to P improves the digestibility of P [31]. The amount of DDGS in the diet can also affect the digestibility of P. Xu et al. [31] observed improvements in bioavailability of P in pigs fed DDGS. This improvement also reflected an improvement in digestibility of P. Stein [22] estimated the P digestibility to be between 35% to 50% in corn DDGS. Spiehs et al. [19] reported that feeding 10 - 20 % DDGS improved P retention and reduced P excretion. The relatively high digestibility of P in DDGS results in less inorganic phosphorus that is needed in diets containing DDGS [22]. Pigs fed phytase-supplemented diets excreted 30% less P confirming that supplemental phytase improves P digestion and decrease P excretion [9]. However, supplementation of xylanase alone did not improve P digestibility of DDGS [32], but the combination of xylanase and phytase improved the apparent total tract digestibility (ATTD) of P and Ca of wheat based diet fed to growing pig [12,30]. Efficiency of P digestibility was better when both xylanase and phytase were added [15]. Combination of enzymes is more effective over single enzyme supplementation to improve nutrient digestibility. The effects of supplemental enzymes on nutrient digestibility depend on concentration of enzymes in diet [1].

Calcium digestibility and retention

Calcium digestibility and retention were similar for weaned piglets fed the DDGS diet compared with the bioconverted DDGS diets (Table 2). The results of this study indicate that Ca digestibility and retention were not negatively affected by feeding DDGS. Very little is known about Ca availability in feedstuffs [16].

In some studies, the improvement in calcium digestibility that was observed as phytase was added to the diets [2,7,10] and is likely a result of increased release of calcium during the breakdown of calcium phytate complexes in the gut. The negative effects of phytate on calcium digestibility may be a result of direct binding of calcium to phytate [18], but phytate may also compromise Na dependent active transport systems [6]; which may result in reduced calcium digestibility. However, when exogenous phytase is added to the diet and some of the phytates are hydrolyzed, these negative effects are reduced and calcium absorption is improved.

CONCLUSIONS

Our research confirms that even 15% corn DDGS can be included in the diets of weaned piglets if highly digestible other components are used. The bioconversion does improve the feeding value of corn DDGS, but the actual inclusion in practical feeding will be depended on economical considerations.

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