SHORT COMMUNICATION

The influence of distillers dried grains with solubles during gestation on sow productivity and milk composition

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Abstract

This study aimed to evaluate the effects of distillers dried grains with solubles (DDGS) during gestation on sow productivity, litter performance and milk composition. Thirty-six second- and third-parity (2.27 parity) sows (Yorkshire) were bred with semen from a pool of Landrace boars. The sows were randomly allotted to 1 of 3 groups and fed diets containing 0 (control), 12.5 or 25% DDGS during gestation. The sows were divided into 12 blocks of three animals. Piglets were cross-fostered, within dietary treatment groups 48 h after birth to standardise litter size to a range of 9 to 13 piglets. The 25% DDGS supplementation resulted in a greater (P=0.03) average daily feed intake (ADFI) during lactation compared with control sows. The weaning-to-oestrus interval was shorter in sows receiving 25% DDGS diets compared to the control (P=0.01). The number of piglets born was similar among treatments. The addition of 12.5 and 25% DDGS to the gestation diet increased the average daily gain (ADG) of the piglets during lactation (P=0.04). The results demonstrated that feeding 25% DDGS does not have negative effects on sow or litter performance and increases the sow ADFI and the piglet ADG during lactation.

Introduction

In recent years, the availability of distillers dried grains with solubles (DDGS) has increased its usage in swine diets. Previous works showed that feeding diets containing 40 to 80% DDGS to gestating sows had no effect on the farrowing rate, feed intake, sow weight gain, litter size at farrowing, or litter weights (Thong et al., 1978; Moneague and Cromwell, 1995). Feed Co-Products Handbook lists the maximum inclusion rate for DDGS as 50% in sow gestation diets (Weigel et al., 1997). The Pork Industry Handbook recommends slightly lower levels of DDGS usage, suggesting up to 40% in gestation diets (Harper and Forsyth, 1998). More recently, Wilson et al. (2003) confirmed that feeding gestating sows diets containing 50% DDGS had no negative impacts on sow performance and, during the second parity of this two-parity study, showed that the litter size at weaning was improved. Wang et al. (2013) reported that 40% DDGS included in late gestation and lactation diets was sufficient to replace all the dietary soybean meal without significantly affecting sow or litter performance or milk composition. The fibre content of the DDGS diet is approximately 3 times greater than the content in corn and soybean meal-based diets (National Research Council, 1998; Spiels et al., 2002) and may result in an improved litter size. In addition, fibre in gestation diets has been shown to increase the voluntary feed intake during lactation (Vestergaard and Danielsen, 1998; Courboulay and Gaudré, 2002; Guillemet et al., 2006; Quesnel et al., 2009). The objective of this research was to evaluate the influences of DDGS in gestation diets in amounts sufficient to replace half or all the dietary soybean meal on sow productivity and milk composition.

Materials and methods

This study was carried out in accordance with the Chinese guidelines (Science and Technology Ministry of China, 2006) for animal welfare and approved by the Northeast Agricultural University, Harbin, Cina.

Sows, treatments and management

Thirty-six second- and third-parity (2.27 parity) sows (Yorkshire) were bred with semen from a pool of Landrace boars. The sows were randomly allotted to 1 of 3 groups and fed diets containing 0 (control), 12.5 or 25% DDGS during gestation. The DDGS used for the experiment was obtained from plants (Jilin Alcohol Company Ltd., Jilin, China). The DDGS was analysed for crude protein (31.26%), crude fat (8.74%), crude fibre (7.13%) and phosphorus (0.79%) before the trial. Thirty-six gestating sows were used in a completely randomised block design. The sows were divided into 12 blocks of three animals. Experimental diets (Table 1) were formulated to meet or exceed the National Research Council nutrient requirements (National Research Council, 1998). On d 110 of gestation, the sows were moved to the farrowing house and placed in individual farrowing crates (1.5×2.1 m) equipped with a nipple waterer to provide water on an ad libitum basis. The crates were mounted over a solid concrete floor, and manure was removed manually each day. The farrowing room temperature was maintained at approximately 18 to 20°C. On the day of farrowing, sows were offered 2.0 kg of the same corn-soybean meal lactation diet (crude protein, 18.50%; metabolisable energy, 12.9 MJ/kg). Thereafter, this amount was increased by 1.0 kg daily until ad libitum consumption was achieved. Parturitions were watched but observers interfered as little as possible in the farrowing process. The piglets were cross-fostered, within dietary treatment groups 48 h after birth to standardise the litter size to range from 9 to 13 piglets. At d 7, piglets received an iron injection and males were castrated. At d 21 of lactation, litters were weaned and moved to nursery rooms set at 27°C, where they were provided free access to water and a standard post-weaning diet.

Sow and litter performance

Within the first 12 h after birth (d 0), the numbers of total piglets, piglets born alive, and the piglets born dead were recorded, and piglets were identified by tattooing. Sows were weighed at insemination, d 110 of gestation, 24 h after farrowing (d 0), and d 21 of lacta-
tion. Backfat thickness was measured at the P2 position (left side of the 10th rib and 6 cm lateral to the spine) at weighing using a B-mode ultrasound (Renco Lean Meater Type 7; Renco, Minneapolis, MN, USA). The piglets were individually weighed at birth and d 21 of lactation. Throughout lactation, fresh feed was given at 0800 and 1600 h and feed refusals were weighed daily to calculate daily feed consumption.

Diet and milk analyses

The diets were analysed for crude protein, crude fat, Ca and P, and amino acids (Avelar et al., 2010). Milk samples were obtained from the sows on d 0 and d 21 of lactation. The piglets were separated from the dam after suckling. Thirty to fifty min later, the sow was injected with 10 IU of oxytocin in an ear vein and all functional glands were hand-milked. The total solids content as well as concentrations of fat, protein, and lactose were determined in the colostrum and milk according to the methods of the Association of Official Analytical Chemists (AOAC, 2000; methods 972.16, 33.2.31).

Statistical analysis

Data were analysed as a completely randomised design by using the GLM procedures (SAS Inst. Inc., Cary, NC, USA). The experimental unit was the sow. The statistical model included the effects of dietary treatments and parity as covariate. Multiple comparisons were used for the effects of dietary treatments by the Tukey-Kramer adjustment (Hayter, 1984) when there was a significant difference in the model. Statistically significant differences were assumed using P<0.05. There was no statistically significant effect (P>0.05) of parity for any of the response variables; thus, only the effects of dietary treatments are presented as main effects. The least squares means and SEM were presented.

Results and discussion

Sow body conditions

The effects of DDGS in the gestation diets on sow performance are presented in Table 2. No treatment effect was observed for body weight (BW) or backfat during gestation or lactation. Lactation backfat losses were similar among treatments. Supplementation with 25% DDGS during the gestation period resulted in greater (P=0.03) average daily feed intake (ADFI) in lactation compared with the control sows. Compared with control sows, the weaning-to-oestrus interval was shorter in sows receiving the 25% DDGS diet (P=0.01).

There were no differences in lactation BW and backfat changes both in the DDGS diets and control. In the same way, Monegue and Cromwell (1995) reported BW lost of 10 or 8 kg when diets contained 400 or 800 g DDGS/kg (the old type, lower in digestible and metabolisable energy, lower in digestible

Table 1. Composition of the experimental diets.

| Ingredient, %       | Control | 12.5% DDGS | 25% DDGS | SEM | P       |
|---------------------|---------|------------|----------|-----|---------|
| Corn                | 62.40   | 56.90      | 52.40    |     |         |
| Soybean meal        | 16.00   | 8.00       | 25.00    |     |         |
| Corn DDGS           |         |            |          |     |         |
| Wheat bran          | 18.00   | 19.00      | 19.00    |     |         |
| L-Lysine•HCl        | 0.12    | 0.12       | 0.24     |     |         |
| Limestone           | 1.00    | 1.12       | 1.20     |     |         |
| Dicalcium phosphate | 1.10    | 0.86       | 0.66     |     |         |
| Salt                | 0.50    | 0.50       | 0.50     |     |         |
| Vitamin and mineral premix° | 1.00 | 1.00 | 1.00 |     |         |

Table 2. Effect of distillers dried grains with solubles in the gestation diets on sow performance.

| Item                               | Control | 12.5% DDGS | 25% DDGS | SEM | P       |
|------------------------------------|---------|------------|----------|-----|---------|
| Number of sows                      | 12      | 12         | 12       |     |         |
| Average parity                      | 2.20    | 2.30       | 2.30     | 0.08| 0.86    |
| Gestation interval, d              | 114.20  | 114.70     | 115.30   | 0.27| 0.27    |
| Sow weight, kg                     |         |            |          |     |         |
| At insemination                    | 177.30  | 171.25     | 182.60   | 3.36| 0.40    |
| At d 110                           | 232.00  | 223.90     | 236.55   | 3.32| 0.30    |
| After farrowing                    | 211.50  | 205.30     | 216.20   | 3.65| 0.49    |
| Weaning                            | 209.00  | 203.50     | 215.80   | 3.42| 0.35    |
| Lactation weight loss              | 2.50    | 1.80       | 0.40     | 1.31| 0.81    |
| Backfat, mm                        |         |            |          |     |         |
| At insemination                    | 14.28   | 13.69      | 14.54    | 0.38| 0.67    |
| At d 110                           | 15.64   | 15.08      | 15.97    | 0.39| 0.66    |
| After farrowing                    | 15.86   | 15.27      | 16.18    | 0.34| 0.64    |
| Weaning                            | 14.60   | 14.23      | 15.46    | 0.38| 0.41    |
| Lactation backfat loss             | 1.26    | 1.04       | 0.72     | 0.20| 0.55    |
| Lactation ADFI, kg                 | 5.61ab  | 5.87ab     | 6.17ab   | 0.09| 0.03    |
| Weaning to oestrus, d              | 6.60ab  | 5.80ab     | 5.30ab   | 0.19| 0.01    |

Control, corn-soybean based diet; DDGS, distillers dried grains with solubles; CP, crude protein; ME, metabolisable energy; CF, crude fibre; NDF, neutral detergent fibre; Ca, calcium; P, phosphorus. °Provided the following per kilogram of diet: Cu as CuSO₄•SH₂O, 18.2 mg; Zn as ZnO, 120.6 mg; Se as Na₂SeO₃, 0.3 mg; Mn as MnSO₄•H₂O, 50.5 mg; Fe as FeSO₄•H₂O, 150.3 mg; I as KI, 0.4 mg; vitamin A, 11,050 U; vitamin D, 2310 U; vitamin E, 62.8 mg; vitamin K, 2.6 mg; riboflavin, 5.8 mg; panthenic acid, 20 mg; niacin, 25 mg; vitamin B₁₂, 325 µg; biotin, 0.5 mg; pyridoxine, 1.8 mg; thiamin, 350 µg; thiamin, 1.9 mg. †Values calculated following the Tables of Feed Composition and Nutritive Values in China (Xiong et al., 2008).
amino acids, and lower in available phosphorus than DDGS produced in modern), respectively, during lactation in sows. Hill et al. (2008) reported that sows fed soybean meal with 50 g beet pulp (BP)/kg or maize and soybean meal with 150 g DDGS/kg dietary lost 6.18 kg (BP) and 8.04 kg (DDGS), respectively, during the lactation period. In addition, all sows in both the control and DDGS treatment groups lost BW during lactation. However, Greiner et al. (2008) and Song et al. (2010) reported that sows fed increasing concentration of 100, 200 and 300 g DDGS/kg gained BW during lactation. Sows are restrictively fed during gestation to prevent excessive BW gain, and are allowed to consume feed on an ad libitum basis during lactation in contrast to cover nutrient requirements for milk production and to limit the mobilisation of sow body reserves (Dourmad et al., 1996). Sows fed the DDGS diets had increased ADFI compared to sows fed the control corn-soybean meal diets. The reason for the improved ADFI in the sows fed diets containing DDGS may be related to the increase in dietary fibre concentration resulting from the inclusion of DDGS in the gestation diets. Sows fed high level of fibre diet during gestation can improve the feed intake at lactation. Song et al. (2010) showed that sows fed 10, 20 or 30% DDGS tended to increase ADFI of sow at lactation. However, the lactation feed intake was not influenced by the inclusion of DDGS in the diets (Thong et al., 1978; Monegue and Cromwell, 1995; Wilson et al., 2003). More research needs to be conducted to verify if the increase in ADFI is a common consequence of including DDGS in diets fed to gestating sows. Wilson et al. (2003) demonstrated that sows fed the DDGS diets during the gestation period also had a shorter weaning-to-oestrus interval than sows fed no DDGS during gestation. In the experiment by Greiner et al. (2008) the weaning-to-oestrus interval was linearly reduced by the inclusion of DDGS in the lactation diet. 

Reproductive and piglet performance

Sow reproductive and piglet performance are shown in Table 3. No treatments effects were observed on the total born litter weight, the total numbers of piglets, the average piglet birth BW and piglets born alive, the average born alive litter weight, average birth weights of all live born piglets, the number of piglets per litter and the litter weights at weaning. However, the addition of 12.5 and 25% DDGS to the gestation diet increased the average daily gain (ADG) of the piglets during lactation (P=0.04).

Similarly to our work, Thong et al. (1978) and Monegue et al. (1995) reported that feeding diets containing 40 to 80% DDGS to gestating sows had no effects on the litter size or weights at farrowing. Wilson et al. (2003) reported that sows fed DDGS as 50% of the diet during gestation, demonstrated no effects on the number of pigs weaned or litter weight. However, the results of the latter experiment indicated that, when sows were fed DDGS during 2 parities, the litter size was improved in the second parity (Wilson et al., 2003). Though the reason for the improved litter size in sows fed diets containing DDGS is not known, it may be related to the increase in dietary fibre concentration resulting from the inclusion of DDGS in the diets (Guillemet et al., 2006; Quesnel et al., 2009). It has been demonstrated that sows fed gestation diets containing increased concentrations of dietary fibre, compared with a corn-soybean meal control diet, often have increased litter sizes (Guillemet et al., 2006; Quesnel et al., 2009). The performances response to dietary fibre are not consistent, depending on fibre source and duration of sows receiving a fibrous diet. Holt et al. (2006) reported that feeding a diet with soybean hulls resulted in fewer pigs born, whereas sows receiving a diet with ground wheat straw gained more and produced heavier piglets (Veum et al., 2009). This increased ADG may be due to the greater daily intake of the same lactation diet by sows fed the gestation diets containing 12.5 and 25% DDGS.

Table 3. Effect of distillers dried grains with solubles in the gestation diets on sow reproductive and litter performance.

| Item                              | Treatments                                      | SEM   | P    |
|-----------------------------------|-------------------------------------------------|-------|------|
| Total piglets born                | Control, 12.5% DDGS, 25% DDGS                  |       |      |
| Total born litter weight, kg      | 12.10                                           | 11.90 | 11.80| 0.34| 0.94|
| Average piglet birth BW, kg       | 1.40                                            | 1.44  | 1.41 | 0.03| 0.89|
| Piglets born alive                | 10.90                                           | 10.70 | 10.40| 0.38| 0.88|
| Born alive litter weight, kg      | 15.84                                           | 16.05 | 15.18| 0.64| 0.85|
| Born alive piglet BW, kg          | 1.45                                            | 1.48  | 1.47 | 0.03| 0.94|
| Piglets per litter at weaning     | 9.40                                            | 9.10  | 9.60 | 0.32| 0.82|
| Litter weaned weight, kg          | 53.38                                           | 56.49 | 59.74| 2.00| 0.45|
| Average piglet BW at weaning, kg  | 5.69                                            | 6.28  | 6.28 | 0.12| 0.07|
| Litter gain weight, kg            | 37.54                                           | 40.44 | 44.56| 1.80| 0.29|
| ADG, kg/d                        | 0.20<sup>a</sup>                                | 0.23<sup>b</sup> | 0.23<sup>b</sup> | 0.01| 0.04|
| Piglet survival to weaning, %     | 92.77                                           | 85.96 | 93.27| 0.04| 0.73|

Control, corn-soybean based diet; DDGS, distillers dried grains with solubles; BW, body weight; ADG, average daily gain. *Treatments with different superscripts within the same row are different (P<0.05).

Table 4. Effect of distillers dried grains with solubles in the gestation diets on the composition of sow colostrum and milk.

| Item                              | Treatments                                      | SEM   | P    |
|-----------------------------------|-------------------------------------------------|-------|------|
| Total solids, %                   | Control, 12.5% DDGS, 25% DDGS                  |       |      |
| Farrowing d 0                     | 23.53                                           | 22.46 | 23.76| 0.38| 0.35|
| Weaning d 21                      | 16.85                                           | 15.99 | 17.22| 0.33| 0.32|
| Protein, %                        | Control, 12.5% DDGS, 25% DDGS                  |       |      |
| Farrowing d 0                     | 12.25                                           | 12.53 | 13.06| 0.25| 0.44|
| Weaning d 21                      | 6.72                                            | 6.51  | 6.10 | 0.34| 0.77|
| Fat, %                            | Control, 12.5% DDGS, 25% DDGS                  |       |      |
| Farrowing d 0                     | 3.54                                            | 4.03  | 4.40 | 0.15| 0.06|
| Weaning d 21                      | 5.45                                            | 5.75  | 5.90 | 0.15| 0.52|
| Lactose, %                        | Control, 12.5% DDGS, 25% DDGS                  |       |      |
| Farrowing d 0                     | 3.86                                            | 4.00  | 3.82 | 0.09| 0.82|
| Weaning d 21                      | 4.94                                            | 5.20  | 5.26 | 0.15| 0.68|

Control, corn-soybean based diet; DDGS, distillers dried grains with solubles.
among the sows fed the DDGS diets compared with the controls. Sows fed the DDGS diets during gestation tended to increase the fat concentration of the colostrum compared with the controls.

The compositions of colostrum and milk are very important to the growth and development of the piglet, both during lactation and after weaning (Devillers et al., 2007; Cabrera et al., 2010; Kim and Wu, 2009). In our study, no differences were observed in the total solids, protein, fat or lactose among the sows fed the DDGS diets compared with the controls. Wang et al. (2013) reported that 20 or 40% DDGS included during late gestation and lactation diets did not significantly affect the milk composition at d 0 or 21. This observation agrees with the findings of Song et al. (2010), who concluded that feeding diets containing 0, 10, 20 or 30% DDGS to lactating sows had no effect on milk composition at d 0 or 19. However, sows fed the DDGS diets during gestation tended to increase the fat concentration of the colostrum compared with the controls. The reason may be that the DDGS contains 10 to 15% lipids (Rausch and Belyea, 2006).

Conclusions

This result suggests that including 12.5 or 25% DDGS in the gestation diets in amounts sufficient to replace half or all the dietary soybean meal does not negatively affect sow or litter performance, and the 12.5 and 25% DDGS diet could increase the sow ADFI and piglet ADG during lactation. No effects were observed on the total solids, protein, fat or lactose content in milk among the sows fed the DDGS diets compared with the controls.

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