14 Feeding Ethanol Coproducts to Swine

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14.1 INTRODUCTION

Utilization of ethanol coproducts to reduce diet costs has become important as more U.S.-grown corn is used in the fuel ethanol industry. While the majority of the distillers dried grains with solubles (DDGS) that is produced is used in diets fed to ruminants such as beef cattle (Chapter 12) and dairy cows (Chapter 13), DDGS has also been used in the feeding of swine for more than 50 years. However, new production technologies and new corn varieties have changed the gross composition of the grain, which now contains less protein and more fat than in the past. Please refer to Chapters 5 and 8 for details on ethanol production and DDGS composition. The changes in the composition of corn that have been observed during the past decades influence DDGS composition and may also change the response of pigs to diets containing DDGS. New production technologies in ethanol plants such as front-end fractionation or back-end separation have resulted in the production of a number of novel coproducts from the ethanol industry. Research to measure the nutritional value of these products has been conducted in recent years. Considerable new information about feeding ethanol coproducts to swine has, therefore, been generated during the last decade and currently much of this information is being implemented in the swine industry. The objective of this chapter is to summarize current knowledge about feeding ethanol coproducts to swine.

14.2 ETHANOL COPRODUCTS USED IN DIETS FED TO SWINE

Corn and sorghum are two grains that are most often used in the production of ethanol in the United States, with corn being predominant. Blends of sorghum and corn are sometimes also used (Urriola et al., 2009). In Europe and Canada, however, wheat and sometimes barley may be used in ethanol production. The composition of the DDGS obtained from ethanol production depends on the grain that was used and there are, therefore, differences among sources of DDGS depending on grain type. DDGS may also be produced as a result of beverage distillation, but the nutritional quality of DDGS originating from beverage distillation is not different from the quality of DDGS produced from ethanol distillation (Pahm et al., 2008a). Other factors that have been suggested to influence the composition and nutritional value of DDGS include the region in which the grain is produced (Fastinger and Mahan, 2006), but it has been demonstrated that in the United States, the variation in nutritional value of DDGS among regions is no greater than within regions (Pahm et al., 2008a; Stein et al., 2009).

While DDGS is the most common and best known coproduct from the ethanol industry, other coproducts are also produced. If the solubles are not added back to the fermented grain, a product called distillers dried grains (DDG) is produced. This product may have a greater nutritional value than DDGS, because addition of solubles to the fermented grain may increase the heat damage of the amino acids (AA) in the product (Pahm et al., 2008b).

When front-end grain fractionation is used before ethanol is produced, corn is usually degermed and dehulled and only the endosperm is used in ethanol production. This process results in production of either high-protein distillers dried grains (HP-DDG) or high-protein distillers dried grains with solubles (HP-DDGS). However, at this point, there is no commercial production of HP-DDGS, whereas there is a considerable production of HP-DDG (Widmer et al., 2007, 2008; Jacela et al., 2009; Kim et al., 2009).

The hulls that are removed from grain in the fractionation process are usually not used in swine feeding, but the corn germ that is extracted may be fed to pigs. Corn germ has a relatively high concentration of nonstarch polysaccharides with a total fat concentration of approximately 18% (Widmer et al., 2007).

If oil is extracted from the DDGS, a de-oiled DDGS that contains between 2% and 4% fat is produced (Jacela et al., 2007). Because of the low fat level in de-oiled DDGS, this product contains less energy than normal DDGS. Oil may also be removed by centrifugation, which is less efficient than removal by extraction, and a low-fat DDGS containing 7%–8% fat result from this process.

If fiber is removed from the DDGS, enhanced DDGS is obtained (Soares et al., 2008). This product contains approximately 10% less nonstarch polysaccharides than conventional DDGS and is expected to have a greater concentration of DE and ME than conventional DDGS.

14.3 CONCENTRATION AND DIGESTIBILITY OF NUTRIENTS IN ETHANOL COPRODUCTS

14.3.1 Carbohydrates

Production of ethanol or alcohol from grain is accomplished by fermentation of the starch fraction of the grain. All coproducts from the ethanol industry are, therefore, characterized by containing very little starch. The concentration of starch in DDGS produced from corn is approximately 7% (Stein and Shurson, 2009), whereas corn grain contains approximately 65% starch (Table 14.1).

Dietary fiber is the sum of carbohydrates and lignin that are resistant to digestion by mammalian enzymes in the small intestine, but that may be partially or completely fermented in the hindgut (AACC, 2001; IOM, 2006). Methods to measure dietary fiber include the crude fiber analysis (Mertens, 2003), the ADF and NDF procedures (Van Soest, 1963), and the total dietary fiber (TDF) procedure, which may separate dietary fiber into insoluble (IDF) and soluble dietary fiber (SDF; Prosky et al., 1984). An alternative to analyzing samples for dietary fiber is to calculate the concentration of organic residue (OR) in a feed ingredient by subtracting CP, ash, moisture, ether extract, sugar, and starch from 100 (de Lange, 2008).

TABLE 14.1
Chemical Composition of Corn, Sorghum, and Wheat, and Ethanol Coproducts Produced from Corn, Sorghum, and Wheat and Fed to Swine (As-Fed Basis)

	Grain or Coproduct										
Item	Corn	Sorghum	Wheat	Corn DDGS	Sorghum DDGS	Wheat DDGS	Corn DDG	Corn HP-DDG	De-oiled Corn DDGS	Enhanced Corn DDGS	Corn Germ
N	4	1	1	34	3	4	1	1	1	2	1
Gross energy (kcal/kg)	3891	3848	3830	4776	4334	4817	—	4989	—	4742	4919
Crude protein (%)	8.0	9.8	12.44	27.5	31.0	38.2	28.8	41.1	31.2	29.1	14.0
Calcium (%)	0.01	0.01	0.04	0.03	—	0.15	—	0.01	0.05	0.27	0.03
Phosphorus (%)	0.22	0.24	0.38	0.61	0.64	1.04	—	0.37	0.76	0.86	1.09
Crude fat (%)	3.3	—	2.0	10.2	7.7	3.6	—	3.7	4.0	10.8	17.6
Crude fiber (%)	—	—	2.4	6.6	9.8	7.6	—	—	—	—	—
Starch (%)	—	—	—	7.3	—	—	3.83	11.2	—	—	23.6
Neutral detergent fiber (%)	7.3	7.3	14.2	37.6	40.7	32.4	37.3	16.4	34.6	29.7	20.4
Acid detergent fiber (%)	2.4	3.8	2.9	11.1	22.8	17.0	18.2	8.7	16.1	8.7	5.6
Total dietary fiber (%)	—	—	—	31.8	32.2	—	43.0	—	—	25.2	—
Ash	0.9	—	—	3.8	3.6	4.8	—	3.2	4.64	—	3.3
Indispensable amino acids (%)											
Arginine	0.39	0.32	0.57	1.16	1.10	1.53	1.15	1.54	1.31	1.34	1.08
Histidine	0.23	0.23	0.29	0.72	0.71	0.92	0.68	1.14	0.82	0.75	0.41
Isoleucine	0.28	0.37	0.43	1.01	1.36	1.35	1.08	1.75	1.21	1.04	0.45
Leucine	0.95	1.25	0.83	3.17	4.17	2.66	3.69	5.89	3.64	3.26	1.06
Lysine	0.24	0.20	0.36	0.78	0.68	0.65	0.81	1.23	0.87	0.93	0.79
Methionine	0.21	0.18	0.21	0.55	0.53	0.53	0.56	0.83	0.58	0.58	0.25
Phenylalanine	0.38	0.47	0.53	1.34	1.68	1.92	1.52	2.29	1.69	1.38	0.57
Threonine	0.26	0.29	0.33	1.06	1.07	1.21	1.10	1.52	1.10	1.03	0.51
Tryptophan	0.09	0.07	0.16	0.21	0.35	0.40	0.22	0.21	0.19	0.19	0.12
Valine	0.38	0.48	0.55	1.35	1.65	1.70	1.39	2.11	1.54	1.40	0.71
Dispensable amino acids (%)											
Alanine	0.58	0.86	0.44	1.94	2.90	1.48	2.16	3.17	2.13	1.99	0.91
Aspartic acid	0.55	0.60	0.62	1.83	2.17	1.92	1.86	2.54	1.84	1.80	1.05

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