CHAPTER 25

DDGS in Horse, Rabbit and Dog Diets

Introduction

VERY LITTLE RESEARCH HAS BEEN CONDUCTED RELATED TO FEEDING DIETS CONTAINING DDGS to horses, rabbits and dogs. However, because of the increasing supply and availability of U.S. DDGS, as well as its high quality, relatively low cost and often the low risk of mycotoxins, it has tremendous potential to be used in greater quantities in horse, rabbit, and dog feeds. Unfortunately, there are no recent studies evaluating the effects of feeding reduced-oil DDGS to these animal species.

Horses

Researchers in Germany have estimated the digestible energy in distiller's co-products range from 11.5 to 14.2 MJ/kg (2,747 to 3,392 kcal/kg) of dry matter (DLG, 1995). The relatively high oil content in DDGS allows it to be an important energy source for performance horses (DLG, 1995; Orme et al., 1997). Four studies have been conducted to determine gross energy, dry matter, and nutrient digestibility of DDGS for horses and results are summarized in **Table 1**.

Leonard et al. (1975) conducted two studies to determine the gross energy (GE), dry matter (dry matter), and crude protein (CP) digestibility of DDGS in mature horses and reported no differences in GE and dry matter digestibility when DDGS was included up to 18 percent of the diet. However, responses were inconsistent for CP digestibility among the two experiments where CP digestibility decreased as DDGS inclusion rate increased in geldings, but increased as dietary DDGS level increased for mature horses. However, Pagan and Jackson (1991) fed pelleted diets containing 0, 5, 10 or 20 percent DDGS to horses, and reported much greater dry matter and CP digestibility than Leonard et al. (1975) and no meaningful effects of DDGS inclusion rate. Bonoma et al. (2008), fed weanling horses completely pelleted diets consisting of 50 percent alfalfa and 50 percent concentrate containing either corn and soybean meal or replacing 30 percent of the concentrate with DDGS. Their results showed a significant reduction in dry matter and CP digestibility when DDGS was fed. Furthermore, due to the high concentration of protein and relatively high protein digestibility in DDGS, Frape (1998) showed DDGS can be an effective partial replacement for soybean meal or dried skim milk powder in horse feeds. In general, perhaps with the exception of feeding DDGS to weanling horses, up to 20 percent DDGS can be used effectively in mature horse diets without negatively affecting dry matter and CP digestibility. These results suggest DDGS is a highly digestible energy source for horses.

Although horses can utilize the nutrients in DDGS quite well, palatability is one of the potential factors that could limit its use. Horses are very sensitive to dietary inclusion of novel feed ingredients. Therefore, Pagan and Jackson (1991) conducted a feed preference trial to determine if palatability is a concern. Horses were fed pelleted diets containing 0 percent, 5 percent, 10 percent or 20 percent DDGS in two tests over six consecutive days. Horses showed no differences in feed preference between diets containing 0 percent, 5 percent or 10 percent DDGS, and horses more frequently preferred the 20 percent DDGS diet compared with pellets containing lower levels of DDGS. These results suggest DDGS can be used effectively in pelleted horse feeds at levels up to 10 percent of the diet, without any negative effects on palatability, and increasing the DDGS dietary inclusion level to 20 percent may actually increase feed preference.

Hill (2002) evaluated eating behavior and feed intake responses of horses fed various proportions of wheat distiller's grains and concentrate at ratios of 1:0, 0.75:0.25, 0.50:0.50, and 0:1. When wheat distiller's grains were offered at a rate of 0.75 of dietary dry matter, and not soaked prior to feeding, there was a significant reduction in the rate of feed ingestion and the number of chews per kg of dry matter. If the concentrate was soaked before feeding, there was an increase in the number of feeding bouts when 0.25 of the concentrate dry matter was replaced with wheat distiller's grains. However, feed consumption was not affected until 0.5 of the concentrate dry matter was replaced with wheat distiller's grains. Based upon these results, Hill (2002) concluded that wheat distiller's grains can be used as a substitute for other energy and protein ingredients in horse rations, but the dietary inclusion rate depends on the method

Table 1. Summary of gross energy (GE), dry matter (dry matter), and crude protein (CP) digestibility of diets containing DDGS for horses

Age	DDGS %	GE digestibility %	Dry matter digestibility %	CP digestibility %	Reference
Mature geldings (400 kg)	0	43.8	44.1	60.0	Leonard et al. (1975)
	5	40.7	40.1	56.8	
	10	41.8	41.4	54.7	
Mature horses (460 kg)	0	44.7	43.0	35.6	Leonard et al. (1975)
	9.1	43.2	42.1	44.7	
	18.2	38.9	41.5	49.9	
Weanlings (276 kg)	0	-	67.2	64.1	Bonoma et al. (2008)
	15	-	51.1	51,5	
Horses of varying ages	0	-	58.9	69.8	Pagen and Jackson (1991)
	5	-	57.7	68.3	
	10	-	57.7	67.6	
	20	-	58.7	67.0	

of feed presentation to the horse. Soaking of the concentrate before feeding reduced the level of the distiller's co-product that could be incorporated into the ration to meet the desired amount of dry matter intake.

Only one study has been published to determine the effects of feeding DDGS diets on horse growth performance (Bonoma et al., 2008) fed weanling horses pelleted diets consisting of 50 percent alfalfa and 50 percent concentrate containing either corn and soybean meal or 30 percent of the concentrate replaced with DDGS. Growth rate and feed conversion were not different between the two dietary treatments. However, feeding the DDGS diet resulted in reduced dry matter, protein, acid detergent fiber and neutral detergent fiber digestibility compared to feeding the corn-soybean meal concentrate. Therefore, for weanling horses, less than 30 percent of the concentrate or less than 15 percent of the total diet should be replaced with DDGS when alfalfa is used as the forage source and comprising 50 percent of the total diet. If a forage source that is lower in quality than alfalfa is used, it may be advisable to use less DDGS as a partial substitute for corn and soybean meal in concentrates fed to weanling horses.

Rabbits

Very little research has been conducted to evaluate the feeding value of DDGS for rabbits. One study was conducted in Spain where researchers compared the nutrient digestibility of wheat bran, corn gluten feed and DDGS in New Zealand White x Californian crossbred rabbits (Villamide et al., 1989). The basal diet contained a low amount of

energy (2200 kcal/kg dry matter) and a high energy to protein ratio (25 kcal DE/g digestible protein). Although the fiber content of the diets was similar, energy and acid detergent fiber digestibility was highest for rabbits fed the DDGS diet (74.0 percent and 58.3 percent, respectively) compared to rabbits fed diets containing wheat bran (59.4 percent and 9.6 percent, respectively) and corn gluten feed (65.0 percent and 27.7 percent, respectively). Furthermore, rabbits fed the DDGS diet had the highest level of protein digestibility (70.1 percent) compared to rabbits fed the wheat bran (66.6 percent) and corn gluten feed (61.4 percent) diets. These results suggest DDGS is a suitable ingredient for rabbit diets and it provides more digestible energy, ADF and protein than wheat bran and corn gluten feed.

Villamide and Fraga (1998) developed equations to predict digestible crude protein from chemical composition of feed ingredients categorized as dry forages (n = 26), cereals

and cereal by-products (including DDGS; n = 29), protein concentrates (n = 18), and by-products (n = 22). Crude protein content was the best predictor of digestible protein in cereals and cereal by-products flowed by ADF content resulting in a digestible crude protein equation of y = -10.856 + 0.628 × percent crude protein + 0.224 × percentADF.

Recently, Alagón et al. (2016) determined and compared the nutritional value of DDGS derived from barley, corn, and wheat from bioethanol plants in Spain (and a corn DDGS sample from Brazil) for growing rabbits (**Table 2**). Barley DDGS had lower dry matter and ether extract (crude fat) digestibility than corn and wheat DDGS, and had lower gross energy digestibility corn DDGS (Spain) and wheat DDGS. As a result, digestible energy values were similar among corn and wheat DDGS sources but greater than for barley DDGS. Furthermore, digestible protein was less in barley DDGS compared with Brazilian corn DDGS and wheat DDGS. It is unknown how U.S. corn DDGS would compare to the sources evaluated in this study, but these results indicated that corn DDGS can provide significant digestible energy and crude protein when added to growing rabbit diets.

Dogs

There are limited studies to evaluate the addition of DDGS to dry, extruded dog foods. Early studies were conducted at the University of Illinois (Allen et al., 1981) to evaluate nutrient digestibility of diets containing DDGS for both adult and immature Pointer dogs. Supplementation of diets with low levels (4 to 8 percent) of DDGS had no effect on the apparent digestibility of dry matter and starch by adult dogs. Adding moderate levels (16.1 percent) of DDGS to the diet decreased dry matter digestibility, but had no effect on starch and energy digestibility. Feeding diets containing high levels (26.1 percent) of DDGS decreased dry matter and energy digestibility, but had no effect on crude protein digestibility in adult dogs. Growing puppies fed diets containing a moderate amount (14.1 percent) of DDGS had lower dry matter and energy digestibility, but digested more acid detergent fiber compared to puppies fed diets containing no DDGS. Nitrogen intake and fecal nitrogen were reduced when DDGS was supplemented in the diet, but there was no effect on urinary nitrogen, total nitrogen excretion, absorbed nitrogen or nitrogen retention.

A subsequent study conducted by Corbin (1984) showed that feeding a diet containing 10 percent DDGS to growing puppies had no effect on food intake, weight gain, gain:feed, increase in body length of final body weight after feeding for 10 weeks. Including DDGS in diets for older, more mature dogs can be advantageous for controlling weight gain because of its high fiber content. Weigel et al. (1997) suggested diets for mature dogs could include up to 25 percent DDGS depending on age and activity level to achieve good intestinal health.

More recently, de Godoy et al. (2009) evaluated the application of DDGS and other novel corn co-products and suggested that they had nutritional properties comparable to common protein and fiber sources used in animal nutrition. Silva et al. (2016) evaluated dry matter, crude protein, acid hydrolyzed ether extract, organic matter, and gross energy digestibility, with and without the addition of xylanase, and increasing inclusion rates of DDGS in dog diets (**Table 3**). Increasing diet inclusion rate up to 18 percent tended to slightly reduce energy and nutrient digestibility and metabolizable energy content of diets, but xylanase supplementation improves the digestibility of dry meatter, crude protein and organic matter of DDGS diets. However, adding 18 percent DDGS to dog diets improved palatability of diets for dogs.

Table 2. Apparent digestibility of dry matter (dry matter), crude protein (CP), ether extract (EE), gross energy (GE), digestible energy and digestible protein of DDGS sources fed to growing rabbits (adapted from Alagón et al., 2016)

Measure	Barley DDGS	Corn DDGS (Spain)	Corn DDGS (Brazil)	Wheat DDGS
Dry matter %	64.7^{b}	72.2^{ab}	68.4^{ab}	75.4^{a}
CP %	63.5	65.6	70.4	74.8
EE %	76.7^{a}	92.1^{b}	94.5^{b}	91.5^{b}
GE %	58.2^{c}	71.8^{ab}	65.3^{cb}	75.0^{a}
Digestible energy, MJ/kg dry matter	11.87^{a}	15.89^{b}	14.72^{b}	15.69^{b}
Digestible protein, g/kg dry matter	168^{a}	195^{ab}	221^{b}	263^{c}

^{abc}Mean with different superscripts are different (P less than 0.05)

Table 3. Total tract digestibility of dry matter (dry matter), crude protein (CP), acid hydrolyzed ether extract (AHEE), organic matter (OM), gross energy (GE), estimated metabolizable energy (ME) and fecal dry matter of dogs fed diets containing 0, 6, 12, or 18 percent DDGS with and without xylanase supplementation (adapted from Silva et al., 2016)

	0% DDGS		6% DDGS		12% DDGS		18% DDGS	
Measure	**No Enz**	**Enz**	**No Enz**	**Enz**	**No Enz**	**Enz**	**No Enz**	**Enz**
Dry matter %	85.1	85.8	84.1	85.2	81.5	82.6	80.6	83.2
CP %	87.6	88.3	87.3	88.3	85.6	87.8	85.1	87.3
AHEE %	93.0	93.2	92.7	92.8	89.6	90.7	90.0	91.3
OM %	88.5[a]	88.5[a]	88.5[a]	88.0[b]	85.0[b]	87.0[b]	83.1[b]	85.6[b]
GE %	89.6	89.6	89.2	88.3	85.7	87.3	83.6	85.5
ME, MJ/kg	19.55	19.78	19.14	19.41	18.98	18.54	18.89	18.67
Fecal dry matter, g/kg	395	392	363	362	352	352	347	353

[ab]Means with different superscripts within row are different (P less than 0.05)

Conclusions

Based upon the limited research information available, it appears DDGS is a very suitable ingredient for use in horse, rabbit, and dog diets. Current feeding recommendations are shown in **Table 4**.

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Table 4. Recommended maximum dietary inclusion rates for DDGS in diets for horses, rabbits, and dogs

Species	Maximum DDGS Inclusion Rate
Horses (mature)	Up to 20 percent of the diet
Horses (weanling)	Up to 15 percent of the diet depending on forage quality
Rabbits	Up to 20 percent of the diet
Growing puppies	Up to 10 percent of the diet
Adult dogs	Up to 25 percent of the diet depending on age and activity level

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