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Overview the concept of effect of dried distillers grains with solubles on ruminants

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Abstract
The dried distillers grains with solubles (DDGS) is most important ingredient are feed to animals which cheaply available. It is good source of protein and mineral as compared to other concentrates feed. DDGS improve the feed efficiency and growth rates in animals. It is also positive impact on lactating cows and metabolic disorders like post partum paralysis and rumen acidosis.

Keywords: Dried distillers grains with solubles (DDGS), feed efficiency, rumen, fermentation

1. Introduction
Dried distillers grains with solubles (DDGS), a co product of ethanol industry is becoming popular in the livestock feeding. It is cheaply available feed ingredient compare to traditional concentrate feeds. The high energy, high fibre and low starch, mid-protein and high digestible phosphorus content of DDGS provide diet formulation flexibility and allows it to partially replace a portion of forage or grain in diets with reduced risk of rumen acidosis compare to feeding grain based diets

2. Production of ethanol and co product (RDGS)
2.1. Particle size reduction of grain
The initial step in ethanol production is to reduce the particle size of grain by grinding it with a hammer mill. Particle size of the grain can affect ethanol yield (Kelsall and Lyons, 1999) [19] and therefore, ethanol producers tend to use finely ground grain to maximize ethanol yield.

2.2. Cooking and Saccharification
Water and recycled stillage are added to the ground rice which act as conditioners to begin leaching of soluble protein, sugars and non-starch bound lipids. Cooking is then used to hydrolyze starch into glucose along with the addition of amylolytic enzymes in order for yeast to convert glucose to ethanol. A critical step in converting starch to glucose involves the completeness of starch gelatinization.

2.3. Fermentation
Fermentation is the process where yeast converts sugars to alcohol. The most commonly used yeast is *Saccharomyces cerevisiae,* because it can produce ethanol to a concentration as high as 18% in the fermentation broth.

2.4. Distillation of ethanol
After fermentation, ethanol is collected using distillation columns. Ethanol collected from the fermenters is contaminated with water and is purified using a molecular sieve system to remove the water and produce pure ethanol.

2.4. Co-product production
The water and solids remaining after distillation of ethanol are called whole stillage. Whole stillage is comprised primarily of water, fibre, protein and fat. This mixture is centrifuged to separate coarse solids from liquid. The liquid, called thin stillage, goes through an evaporator to remove additional moisture resulting in condensed distiller's soluble (syrup) which contains approximately 30% dry matter. Condensed distillers solubles can be sold locally to cattle

feeders or combined with the coarse solids fraction and dried to produce dried distiller's grains with solubles.

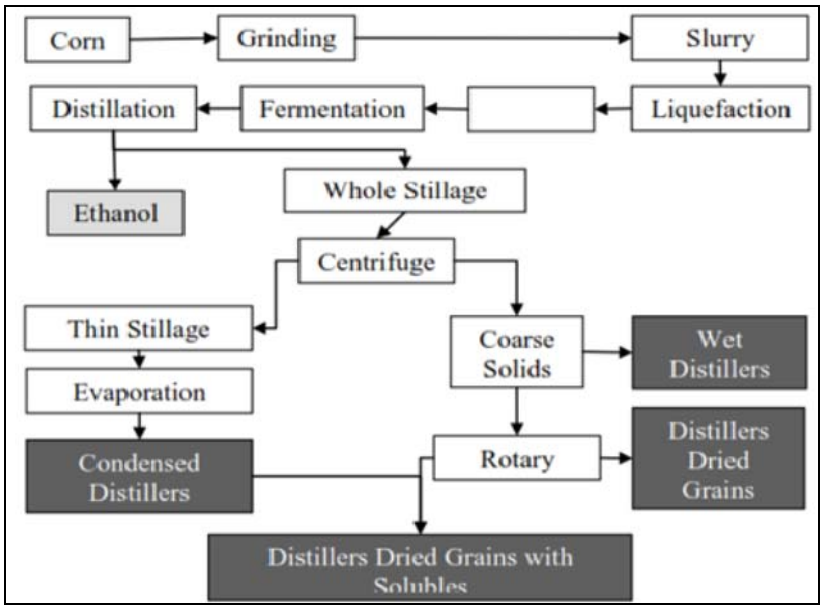

Fig 1: Dry-grind ethanol production processes and by products (Erickson *et al*., 2005) [10]

3. Chemical composition and nutritive value of RDGS

Cromwell *et al.* (1993) [8] evaluated the proximate composition and fibre fractions of RDGS, the value ranged between 23.4 to 28.7% CP, 2.9 to 12.8% fat, 8.8 to 36.9% ADIN, 28.8 to 40.3% NDF, 10.3 to 18.1% ADF and 3.4 to 7.3% ash. Lysine concentrations of the RDGS ranged from 0.43 to 0.89%. The chemical composition of RDGS (DM basis%) reported by Spiehs *et al.* (2002) [31] was crude protein 30.9, crude fat 10.7, crude fibre 7.2, ash 6.0 and calculated ME 3810 kcal /kg. Dimova *et al.* (2009) [9] identified the chemical composition of RDGS (% on DM basis) as 90.8, 33.9, 5.5, 6.7 and 4.7 for DM, CP, EE, CF and ash respectively. Sally Noll (2013) [26] also reported the chemical composition of RDGS as dry matter 91.75, crude protein, 28.96, crude fat 11.94 and ash 5.26 percent. Further, Gross energy, apparent metabolizable energy and true metabolizable energy were 5090, 3079 and 3397 kcal/kg respectively.

Abdelrahim *et al*. (2014) [1] reported that chemical composition of RDGS (DM basis%) was CP 26.6 to 33.9, EE 10 to 15.9, NDF 28.6 to 38.4, starch 2.45 to 9.25, phosphorus 0.77 to 1.06 and sulphur 0.46 to 0.83, respectively

Table 1: Nutrient composition (% as fed basis) of RDGS produced from various sources

Grain	DM	CP	EE	Ash
Sorghum	91.2	32.7	8.0	11.9
Wheat	91.68	38.48	4.63	5.28
Corn	91.3	28.4	10.1	2.75

(Urriola *et al.* 2009) [32]

4. Effect of dietary inclusion of RDGS on growth performance of ruminants

Zelinsky *et al*. (2006) [34] studied the effect of corn or soybean hull diets supplemented with RDGS on finishing lamb performance and carcass merit. Lambs were fed the corn or soybean hull based concentrate where RDGS served as protein supplement in both diets. Feed intake (DI) and feed efficiency (F/G) was greater for the soybean hulls versus corn based diets (DI: 4.9 vs 4.1lbs; F/G: 6.7 vs 5.1 lbs respectively). This data suggested that soya bean hulls supplemented with RDGS are suitable replacement for corn in finishing lamb diets. Huls *et al*. (2006) [17] studied the efficacy of RDGS as a replacement for soybean meal and portion of the corn with RDGS in finishing lamb diets on growth performance, carcass characteristics. They reported that average daily gain, DMI, gain: feed and carcass characteristics were not significantly different ($p>0.05$) between dietary treatments. Held (2006) [16] reported no significant difference in ewe body condition score and suckling lamb weight gain when RDGS was used instead of soya bean meal as a protein supplement in lactating ewe diets. Inclusion of RDGS at 25% of the diet resulted in a 12% improvement in reared lamb growth for ewes, nursing triplets, but there were no effects for ewes nursing twin and single lambs. Zelinsky *et al*. (2006) [34] studied the effect of corn or soybean hull diets supplemented with RDGS on finishing lamb performance and carcass merit. No treatment difference was observed in lamb growth. Feed intake (DI) and feed efficiency (F/G) was greater for the soya bean hulls versus corn based diets (DI: 4.9 vs 4.1lbs; F/G: 6.7 vs 5.1 lbs, respectively). These data suggested that soybean hulls supplemented with RDGS are suitable replacement for corn finishing lamb diets. Schauer *et al*. (2008) [28] studied the effect of replacement of barley and soybean meal with the RDGS at 0, 20, 40, and 60% of the diet on a DM basis on feed intake and carcass traits in sheep. They reported that feed intake increased linearly as level of RDGS inclusion increased with no negative effects on carcass traits.

Archibeque *et al*. (2008) [4] demonstrated that, feeding RDGS improves amino acid nutrition of lambs consuming moderate quality forages. Schauer *et al*. (2008) [28] fed 240 Rambouillet wither and ewe lambs (31.7 kg BW) with diets containing alfalfa hay, soybean meal, barley and trace mineral supplement. RDGS replaced barley and soybean meal at 0, 20, 40, and 60 percent of the diet on a DM basis. Feed intake increased linearly as the level of RDGS inclusion increased.

These results suggest that feeding high dietary levels of RDGS results in acceptable lamb performance with no negative effects on carcass traits.

Gurung *et al*. (2009) [14] studied the effect of dried grain with soluble on feed intake, growth performance, gain efficiency and carcass quality of growing kid and Spanish male goats and reported no effect of RDGS on plasma urea nitrogen (p=0.17). Serum cholesterol concentrations increased linearly (p<0.001) with increasing level of RDGS. They concluded that RDGS is a viable feed stuffs for meat goats and upto31% of RDGS can be included in the diet on a DM basis for growing goats without any compromise in DM intake, growth performance and carcass quality. Gutierrez *et al*. (2009) [15] fed Suffolk lambs 3 dietary levels of RDGS (0, 15, or 30%, DM basis). Feed intake was similar among RDGS levels, but body weight gain was reduced when lambs were fed 30% RDGS diet (0.221 kg/d) compared with feeding the 0 and 15% RDGS diets (0.284 and 0.285 kg/d, respectively) suggesting that a much lower RDGS feeding level (15%) be used for lambs.

Kleinschmit *et al.* (2006) [20] conducted a study to evaluate the effects of feeding total mixed diets containing 20% RDGS from 3 different sources on milk production and composition in dairy cows. The RDGS replaced a portion of the ground corn and soybean meal in the diets and they had a forage-to-concentrate ratio of 55:45. Dry matter intake (21.4 kg/d) was similar among diets, but cows fed diets containing RDGS had greater milk yield (34.6 vs. 31.2 kg/d), 4% fat corrected milk (32.7vs.29.6 kg/d), and energy-corrected milk (35.4 vs.32.3) compared with cows fed the diet with no RDGS. Cows fed RDGS had improved feed efficiency compared with cows fed the control diet (1.78 vs.1.63). Results from this study suggest that the RDGS sources used in this study did not affect lactation performance. Anderson *et al.* (2006) [3] determined the effects of feeding 10% or 20% dried or wet distiller's grains with soluble in 25% corn silage, 25% alfalfa hay and 50% of concentrate mixes to dairy cows on lactation performance. Feeding dried or wet distiller's grains with solubles improved feed efficiency and energy-corrected milk/kg of DMI by increasing yield of milk, protein and fat while dry matter intake tended to decrease. Felix *et al*. (2012) [11] fed diets containing 0, 20, 40, or 60% RDGS to growing lambs and reported that RDGS can be fed to sheep up to 60% of the diet dry matter without affecting dry matter intake, but higher dietary inclusion rates may decrease ADG, they also observed that feeding high inclusion rates of RDGS may affect marbling score and reduce hot carcass weight and they recommended that feeding of diets containing 20% RDGS is optimal. Yossifov *et al* (2012) [33] reported that final body weight and average daily gain were significantly affected by RDGS (p<0.001) included diets in lambs. Total DMI was greater in lambs fed RDGS diet as compared with lambs fed sunflower meal diet. They indicated that RDGS is viable feed stuff for fattening lambs without any compromise to performance.

Avila stagno *et al.* (2013) [5] assessed the effect of replacing barley grains with wheat DDGS (WDDGS) on the growth performance and fatty acid profile of adipose tissue in lambs. Increasing WDDGS (0, 20% and 40%) in the diet affected eating rate, total daily intake and average daily gain. Total saturated fatty acids, monounsaturated fatty acids, the poly unsaturated fatty acids in subcutaneous fat were unaltered, but proportions of linolenic acid were increased. They also reported that a concentrated diet containing 40% WDDGS fed to lambs as replacement of barley grain, improved lamb intake and growth performance as compared to barley based diet.

Buckner *et al*. (2007) [6] conducted a study to evaluate the effects of feeding increasing levels of RDGS to finishing steers on growth performance and carcass characteristics and reported no effect of increasing levels of RDGS on dry matter intake, 12 rib fat depth, loin muscle area and marbling score but there was a quadratic effect in ADG and hot carcass weight and a quadratic trend for gain efficiency. Feeding value increases substantially compared to corn, when RDGS is added to the diet, and declines with increasing dietary inclusion rate. Janicek *et al*. (2008) [18] conducted two studies to evaluate the effects of feeding 0%, 10%, 20%, and 30% RDGS, where RDGS replaced a portion of the forage and concentrates in the diets of dairy cows. Dry matter intake increased when feeding 30% RDGS compared to 0% RDGS, but milk production, and the percentages of milk fat and protein was not different between the control and RDGS diets. These results suggested that lactating dairy cow rations can contain as much as 30% RDGS and support satisfactory lactation performance and milk composition. Sasikala *et al*. (2008) [27] compared the effectiveness of using 10% and 20% corn condensed distiller's solubles (CCDS) with 18.5% RDGS and a combination of 18.5% RDGS and 10% CCDS on dry matter intake, milk yield and milk composition of lactating Holstein cows. The diets were formulated to provide 17% crude protein with variation in acid detergent fibre, neutral detergent fibre and fat concentration (2 to 4%). Their results showed that CCDS is as effective as DDGS in replacing soybean meal and corn grain in the total mixed ration. Schingoethe *et al*. (2009) [29] summarized the feeding value of distiller's grains with solubles for dairy cattle as it is a good source of crude protein (>30% CP on a dry matter basis) which is high in ruminally undegradable protein (55% of crude protein). Distiller's grains with soluble are also an excellent source of energy (net energy for lactation is approximately 2.25 M cal/kg of dry matter). The intermediate fat concentration (10% on a dry matter basis) and readily digestible fibre (39% neutral detergent fibre) contribute to the high energy content in RDGS. Lactating dairy cow diets can contain 20% or more RDGS on a dry matter basis as long as diets are nutritionally balanced. Feeding RDGS diets containing up to 30% RDGS provide similar or increased milk production compared with cows which are fed traditional feeds.

McKeown *et al*. (2010) [23] showed that RDGS from corn, wheat or triticale can replace a mixture of barley grain and canola meal at 20% of diet dry matter without adversely affecting dry matter intake, growth rate, or carcass characteristics of growing lambs, but wheat RDGS may reduce feed: gain and triticale RDGS may improve the fatty acid profile of carcass fat. Van Emon *et al*. (2011) indicated that, RDGS can be included in the diets of finishing lambs at levels up to 50% of dry matter intake without negatively affecting growth performance.

Charles *et al*. (2012) [7] reported that the diet preference of lambs varies when concentrate with different proportion of wheat DDGS (WDDGS) was supplemented. Lambs had higher feed intake of diets supplemented with WDDGS compared to barley grain control. This was because of feed novelty, variety and palatability and higher crude protein

content of WDDGS. Performance of calves was approximately equal when fed RDGS and canola meal as ingredients of pelleted protein concentrate or as separate ingredient in a starter mixture of whole maize grain (WMG), pelleted RDGS, pelleted canola meal and pelleted mineral-vitamin premix. When pelleted RDGS and pelleted canola meal is available, it is possible to use them directly as components of starter, instead of buying protein concentrate with the same protein sources. Starter feed containing whole maize grain, pelleted RDGS, pelleted canola meal, and pelleted mineral-vitamin premix was the cheapest, compared to the other tested starter feeds.

Rao *et al.* (2016) [24] studied the effect of dietary incorporation of dried distillers grain with soluble on feed intake and nutrient utilization in Deccani Ram lambs and reported that the RDGS can be included up to 30% level in concentrate sorghum stover based complete ration, which was optimal level of inclusion without affecting growth rate, performance and feed efficiency.

5. Effect of dietary inclusion of RDGS on voluntary intake and nutrient digestibility

Gibb *et al.* (2008) [12] stated that wheat RDGS has similar feeding value as barley when included at 20% of diet DM in feedlot cattle, but digestibility and energy content were declined with higher levels of inclusion. Leupp *et al.* (2009) [22] evaluated the effects of feeding increasing levels of corn RDGS on intake, digestion and rumen fermentation in steers fed 70% concentrate diets. They reported that dry-rolled corn can be replaced with RDGS up to 60% level with no adverse effects on organic matter digestibility. Organic matter intake was reduced when 60% RDGS was added to the diet. They concluded that adding 45% RDGS to growing steer diets maximized digestion and rumen fermentation. Aldai *et al.* (2010) [2] compared the effects of feeding wheat versus corn RDGS to feedlot cattle on meat quality and observed that wheat DGS had no negative effects on meat quality but corn DGS had some positive effects on meat quality such as improved tenderness and palatability compared to beef from cattle fed the barley based control diet.

Koger *et al.* (2010) [21] fed Angus crossbred steers with diets containing 20 or 40% wet or dry distillers grains with solubles to replace all of the soybean meal and some of the cracked corn. Carcasses of steers fed distillers grains had greater fat thickness, higher yield grades than steers fed the dry-rolled corn, soybean meal, and alfalfa hay control diet. McKeown *et al.* (2010) [23] reported that DGS from corn, wheat or triticale can replace a mixture of barley grain and canola meal at 20% of diet dry matter without adversely affecting dry matter intake, growth rate or carcass characteristics of growing lambs, but wheat DDGS may reduce feed: gain and triticale DDGS may improve the fatty acid profile of carcass fat. Shwerab (2010) [30] studied the effect of using RDGS in sheep feeding. Three total mixed rations (TMR) were formulated to contain 10, 20 and 30% RDGS compared with the control TMR (no DDGS). Feeding ewes 20% RDGS ration resulted in more lamb's birth weight, weaning weight, gain and ADG compared with other tested rations. In the meantime, ewes showed increased milk production with 4% FCM and feed conversion efficiency. These were reflected on milk fat, protein and SNF contents. They recommended that RDGS can be included up to 20% in the TMR's for ewes in order to get better performance and feed efficiency.

Sahin *et al.* (2013) [25] evaluated the effects of RDGS incorporation at 0, 10 and 20% level by substituting soybean meal in the concentrate ration for growing lambs on weight gain, food consumption and efficiency, nutrient digestibility and some rumen parameters. Dietary RDGS addition has exhibited negative effects neither on growth performance, food intake of forage or concentrate and food efficiency nor on rumen parameters and the digestibility rates of dry and organic matters. The digestibility of crude protein was significantly depressed when 10% DDGS used. The results indicated that RDGS can be used at 20% level as a protein source in the growing lamb diet. Abdelrahim *et al.* (2014) [1] studied the effect of including two levels of RDGS on performance and carcass characteristics of lambs. RDGS was added to the finishing diets at either 12.4 or 25.4 percent of the dietary DM to replace corn and soybean meal in basal diet. DM intake and final body weights were not different between treatments. They concluded that corn and SBM can be substituted by RDGS up to 25.4% without any adverse effect on carcass characteristics.

6. Conclusion

It is concluded that the use of dried distillers grains with solubles as feed in ruminant. RDGS is cheap and easily available and also reduce the negative impact on environment. It used as feed cattle especially postpartum period, to overcome the metabolic disorders like the postpartum paralysis, rumen acidosis and also increases the feed intake. In small ruminant such as sheep and goat, the concentrations of RDGS increases in ration, then increase the body weight.

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