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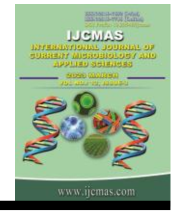

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Rice Distillers Dried Grains with Soluble (RDDGS) in Commercial Broiler Chicken Ration

Srikanth Kaninde[1], A. Ashok[1]*, K. Premavalli[2], C. Bandeswaran[3] and A. Arun Bharathi[1]

[1]Department of Poultry Science, Madras Veterinary College (MVC), Chennai, Tamil Nadu, India
[2]Research Institute of Animal Sciences, Kattupakkam, Tamil Nadu, India
[3]Department of Animal Nutrition, MVC, Chennai, Tamil Nadu, India

**Corresponding author*

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A B S T R A C T

In recent years, the feed cost of the poultry has increased and the farmers and feed mill owners are in constant search of alternate protein source to reduce the feed cost. Distillers Dried Grains with Solubles (DDGS) has always been an alternative feed ingredient. It can be used as an alternate protein source as it is has a crude protein of around 40 – 45 % and gross energy of around 3800 – 4200 kcal/ kg can be used in commercial broiler chicken ration. The mycotoxins if present in the parent grain while production will appear in the end product. The low lysine content and digestibility can be a hurdle in using the RDDGS as an feed ingredient.

Introduction

The poultry sector among accounts for about 1 per cent of the national GDP and about 14 % of the livestock GDP. The total poultry population is 851.8 million, whereas commercial poultry population is 534.74 million (DADH, 2019). The growth rate of commercial broiler market is around 8-10 % per annum.

The current demand for commercial poultry feed in India is approximately around 36 million tons and that of plant protein source is nearly 10 million tons. The poultry industry is in a state of crisis because of fluctuation in the price of maize and soyabean which are the common ingredients used to formulate the ration. There is a need for significant research to be carried out for an alternative protein source mainly to decrease the feed cost. Recently, crisis in supply of soyabean meal increased the feed cost and feed manufacturers were constantly in search for an alternative protein source to decrease cost of production, and had to import soyabean from other countries.

Distillers dried grains with solubes is co product of ethanol industry produced by dry milling. Corn, wheat, sorghum, barley, rice can be used for ethanol production (Dinani *et al.*, 2018), which can be used as an alternative plant protein source.

Ethanol production steps

Ethanol (C_2H_6O) is a simple liquid alcohol that is formed from the fermentation of sugars in their natural occurrences or being derived from starch-rich grains or lignocellulosic feedstocks. There are commonly three groups of materials that can be used for manufacturing ethanol, which are: (a) feedstocks which contain substantial amounts of readily fermentable sugars. Sugars are readily fermentable by the yeast *S. cerevisiae* to produce ethanol. During the fermentation process, the yeast produces the enzyme invertase and uses it to convert sucrose to glucose and fructose Ethanol production by *S. cerevisiae* is carried out via the glycolytic pathway (also known as the Embden-Meyerhof-Parnas or EMP pathway), (b) starches and fructans Corn is used almost exclusively for ethanol production where ethanol is produced from corn by either the wet-milling or dry-grind process., and (c) cellulosic materials Lignocellulosic feedstocks are also referred to as lignocellulosic biomass or simply biomass. (Hoang *et al.,* 2021)

Ethanol production from starch-bearing cereal grains will be produced from wet milling or dry grinding.

Dry grinding

Dry grind ethanol process is grouped into the ‘front-end’ processes convert the starch-rich cereal grain into ethanol as efficiently as possible. The ethanol-rich beer that is produced in the front-end operations is recovered in the ‘back-end’ distillation process and dehydrated to produce fuel ethanol. The residual suspension, called whole stillage, rich in nonfermentable dissolved and suspended solids, is processed in back-end dry house operations, usually producing distillers’ dried grains with solubles (DDGS) and thin stillage. (Monvceaux and Kuehner, 2009)

In the dry-grind process, after grinding, water and a thermostable α-amylase are added to the ground corn. In the next step, which is called pre-liquefaction, the slurry then is brought up to 60–70 ◦C (warm cook) or 80–90 ◦C (hot cook). The slurry, is held at these temperatures for about 30–45 min. The swelling and hydration of the starch granules cause increase of the slurry viscosity and loss of crystallinity of the granule structures. The next step is called liquefaction, where the mash is maintained at 85–95◦ C for a period or forced through a continuous jet cooker at 140–150 ◦C. At the end of the liquefaction, starch is hydrolyzed to short chain dextrin’s (two to four glucose units). The temperature of the mash is lowered to 32^{o} C and the pH adjusted to approximately 4.5. The mash then is placed in a fermentor. Glucoamylase and the yeast culture from the yeast propagation tank are also added. The process combining enzymatic hydrolysis and fermentation is called simultaneous saccharification and fermentation (SSF) (Hoang and Ngheim, 2021).

The starch is converted into ethanol and carbon dioxide. The rest of the grain constituents (protein, lipids, fiber, minerals, and vitamins) are unchanged chemically, but concentrated. These residual components all end up in a coproduct known as distillers dried grains with solubles (DDGS). During coproduct recovery, the nonvolatile components following the distillation step, known as whole stillage, are usually centrifuged to produce a liquid fraction (thin stillage) and a solid fraction (distiller’s wet grains, or DWG). A significant portion (15% or more) of the thin stillage is recycled as backset to be used as processing water to slurry the ground grain. The remaining thin stillage is concentrated through evaporation into condensed distiller solubles (CDS), which are mixed with DWG to become distiller’s wet grains with solubles (DWGS) and then dried into DDGS (Liu, 2011).

Chemical Composition

The major obstacle to the use of DDGS in diets for animals is the wide variation in the nutritional content of DDGS produced in different distilleries due to differences in ethanol processing methods (Liu, 2009). The color is a strong indicator of the nutritional value of DDGS, particularly of corn

DDGS. An incorrect processing method (i.e., higher drying temperatures) results in darker DDGS which have lower nutritional value conditioning their use in animal feeds (Fastinger *et al.,* 2006).

DDGS is very low in starch but higher in non-starch polysaccharides (NSP) content as compared to their parent grains used. DDGS is higher in gross energy than parent grain.

DDGS contain all the nutrients from grain in a concentrated form and majority of starch has been utilised in fermentation process during ethanol production . This will concentrate all nutrients about three-fold present in the cereal since two third to three fourth portion of cereal content is starch (Swiatkiewicz and Koreleski, 2008).

The nutrient composition of Rice DDGS (RDDGS) varies depending on the source of grain and the methods of RDDGS production. Generally, RDDGS contains approximately 44% crude protein, 5% fat, 6% crude fiber. The chemical composition of RDDGS analyzed by different authors is given in Table 1

Gupta *et al.,* (2016), Kumar *et al.,* (2017), Dinani *et al.,* (2018), and Talsani *et al.,* (2021) who reported a crude protein content between 44 % to 45 % in RDDGS. A high crude protein content of 61.41 % in RDDGS was reported by Ranjan *et al.,* (2017), and a low crude protein content 28.55 % in RDDGS was observed by Xue *et al.,* (2012).

The range of crude fiber 1.23 to 5.33 % and ether extract content was 3.19 to 7.67 %. A crude fiber content (4.89 to 10.85 %) and ether extract (2.24 to 8.90 %) was also observed by the above reported authors. The variation in the crude fiber and ether extract content of RDDGS may be due to variation in the nutrient content of the DDGS produced from different sources of grains and due to differences in ethanol processing methods and drying methods of DDGS (Pedersena *et al.,* 2014). Moisture content of the samples ranged from as analyzed by different authors were ranged between 7 to 11 %, crude protein percent was as high as 61 %. Based on the analysis of 8 samples obtained from different parts of Telangana and Tamil Nadu by Kaninde (2022) and observed that the moisture content varied between 14 to 19 % and crude protein was 39 % to 47 %, gross energy ranged between 3980 to 4227 K cal / kg. Crude fiber content ranged from (1.23 – 5.33 %) and variation was high. The coefficient of variation in the crude fiber (53 %) and ether extract (30 %) was high.

Amino acid composition of RDDGS

RDDGS contain all the nutrients from grain in a concentrated form and majority of starch has been utilized in fermentation process during ethanol production (Babcock *et al.,* 2008). This will concentrate all nutrients about three-fold present in the cereal since two third to three fourth portion of cereal content is starch (Swiatkiewicz and Koreleski, 2008). The amino acid profile of RDDGS showed lower lysine (0.64 – 1.23 %) content than soya bean meal (2.99 – 3.22 %) and the other amino acids were well within the range. Luu *et al.,* (2000); Xue *et al.,* (2012); Gupta *et al.,* (2016); Kurcheriya *et al.,* (2019); Yang *et al.,* (2019), who observed that the lysine content was lesser than soyabean meal. This phenomenon may possibly be due to variation in amino acid composition of the parent grains used for ethanol production, compared with soya protein amino acid profile (Lim *et al.,* 2008). The variation in the nutrient content is related to drying process, uneven mixing of CDS and DWG during drying process which will result in change in nutrient variability in DDGS, and due to high temperature, which may reduce the protein quality. (Liu, 2011). The amino acid profile of RDDGS analyzed by different authors are given in Table 2.

Rice DDGS in commercial broilers

Contraindicatory reports were given by the authors on the growth performance of the commercial broilers fed with the RDDGS is presented in Table 3.

Growth performance

ICAR CARI annual report (2014-15) showed that the body weight and body weight gain in 5% inclusion level was more during first three weeks but no change was observed during six weeks of age. However negative reports were given by Dingore *et al.,* (2015) in body weight and body weight gain in 15 % inclusion levels. Thein *et al.,* (2019) observed that inclusion of RDDGS up to 20 % had no effect on the body weight gain. Singh *et al.,* (2020) included showed that the average body weight was non-significant at 35 days of age.

More recently Dang *et al.,* (2021) carried out experiment in Ri – DABCO colored broilers and reported that up to 10 % inclusion there was no significant difference in the body weight. Khose *et al.,* (2021) included up to 15 % of RDDGS in the commercial broiler diets with multienzyme at 400 g/ton of feed and found that there was no significant difference in weight gain. Shirisha *et al.,* (2021) also included RDDGS up to 16 % with and without enzyme and reported that 12 % inclusion with enzyme and 16 % without enzyme during finisher phase had positive effect on the body weight gain. Kumar *et al.,* (2022) carried out an experiment Kuroiler chicken fed with 0, 7.5, 15, 22.5 % of RDDGS and reported that the highest body weight gain (1640.29 g) was observed in 7.5 % inclusion of RDDGS when compared to control.

Feed intake and FCR

Dingore *et al.,* (2015) in their trial with commercial broilers chickens fed with 0, 5, 10, 15 % rice DDGS reported that there was decreased feed intake and FCR as the levels of rice DDGS increased. Thein *et al.,* (2019) fed commercial broilers with 20 % rice DDG showed better FCR in comparison with other treatments. Khose *et al.,* (2021) included 0, 5, 10, 15 % of RDDGS in the commercial broiler diets with multienzyme @ 400 g/ton of feed and found that there was no significant difference in feed intake and FCR. In a recent study by Shirisha *et al.,* (2021) revealed that commercial broilers fed with rice DDGS up to 16 % with or without enzyme and the results showed that feed consumption was significantly higher in 8 % and 12 % of rice DDGS with enzyme and cumulative FCR was better in 16 % inclusion level without enzyme supplementation.

Carcass traits

ICAR - CARI annual report, 2014-15, showed that carcass traits of commercial broiler chickens fed with RDDGS up to 10 % had no adverse effect. Similarly, Dinani *et al.,* (2018) concluded that the same. Raju *et al.,* (2022) found that the use of two different types of RDDGS having high (57 %) and medium (47 %) crude protein (CP) contents were evaluated separately at 5 and 10 % levels in the diet of Vanaraja chicks, did not affect carcass yields and organ weights.

Hematological and serum biochemical parameters

Dinani *et al.,* (2018) who reported no significant difference in the hematological parameter’s when commercial broilers were fed with RDDGS up to 15 %. Similarly, RDDGS along with rice gluten meal in combination with or without enzymes in commercial broilers diet had no effect on the hematological parameters (Dinani *et al.,* 2019). Likewise, Gupta (2016) reported improvement in PCV and hemoglobin % when including RDDGS in layers diet up to 30 %.

Conflicting reports were given by different authors on serum biochemical parameters, Kucheriya (2019) who reported that RDDGS partial replacement of soyabean meal up to 10 % had no significant effect on the serum biochemical parameters.

Table.1 Chemical composition of rice DDGS analyzed by different authors

Chemical composition	Gupta *et al.*, (2016)	Kumar *et al.*, (2017)	Ranjan *et al.*, (2017)	Dinani *et al.*, (2018)	Xue *et al.*, (2012)	Talasani *et al.*, (2021)
Moisture (%)	8.28	-	7.56	8.65	-	-
Dry matter (%)	91.72	90.11	92.44	91.35	-	92.81
Crude protein (%)	45	44	61.41	44.68	28.55	45
Ether extract	4.49	8.9	2.24	6.47	6.44	7.93
Crude fibre (%)	4.89	9.1	5.71	9.12	10.85	6.71
Total ash (%)	10.22	4.9	6.09	4.01	-	13.31
Acid insoluble ash (%)	4.28	-	2.67	1.27	-	1 .96
Calcium (%)	0.73	-	-	0.62	0.75	0.07
Phosphorus (%)	0.77	-	-	0.83	0.41	0.7
Gross energy	4097 (kcal/kg)	-	4739.73 (cal/g of DM)	4232 (kcal/kg)	4513 (kcal/kg)	-
Metabolizable energy	-	2851*	-	2880*	-	3500*

* Calculated values

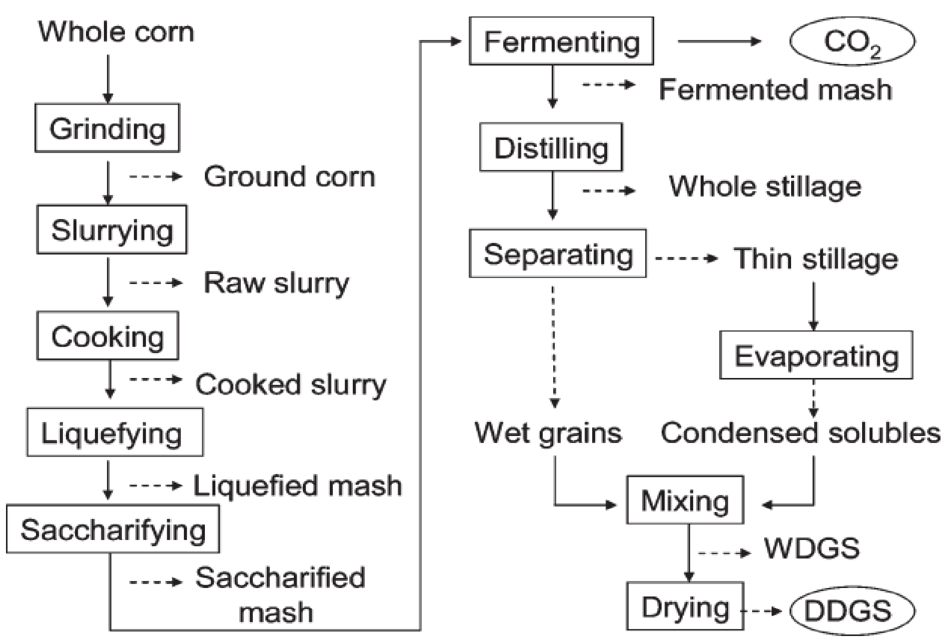
Table.2 Amino acid profile of RDDGS analysed by different authors

Amino acids (%)	Luu *et al.*, (2000)	Xue *et al.*, (2012)	Gupta (2016)	Kucheriya (2019)	Yang *et al.*, (2019)
Arginine	1.42	1.47	3.06	2.63	1.45
Histidine	-	1.01	1.04	1.07	0.63
Isoleucine	1.12	0.93	1.89	1.62	1.38
Leucine	2.02	2.94	3.60	3.64	2.49
Lysine	0.99	0.64	1.23	1.19	1.27
Methionine	0.52	0.61	1.19	1.03	0.66
Phenylalanine	1.35	1.28	2.32	2.07	0.98
Threonine	1.24	0.92	1.67	1.43	1.23
Tryptophan	-	0.24	-	0.41	-
Valine	1.53	1.39	2.64	2.27	1.71
Alanine	1.81	1.84	2.56	2.24	1.80
Aspartic acid	2.26	1.94	3.91	3.31	2.75
Cysteine	0.61	0.62	0.98	0.88	0.44
Glutamic acid	4.52	4.08	7.48	6.65	4.77
Glycine	1.23	1.10	1.92	1.72	1.46
Proline	1.22	1.86	2.10	2.17	1.66
Serine	1.21	1.34	2.20	1.95	1.44
Tyrosine	-	1.08	-	1.08	0.65
Crude protein	23.1	28.55	45.0	43.75	-

Table.3 Effect of including RDDGS in commercial broiler ration

Authors	Maximum inclusion level	Age of the birds and species	BW and BWG	Feed intake	FCR	Carcass traits
Dingore *et al.*, (2015)	15 %	Six weeks, commercial broilers	Decreased	Decreased	Increased	Negative impact
Thein *et al.*, (2019)	20 %	Six weeks commercial broilers	Not affected	Not affected	Not affected	-
Raju *et al.*, (2020)	10 %	Six weeks, Vanaraja	Increased	Increased	Increased	Not affected
Khose *et al.*, (2021)	15 %	Six weeks commercial broilers	Not affected	Not affected	Not affected	-
Shirisha *et al.*, (2021)	16 % along with or without enzymes	Six weeks commercial broilers	Increased	Increased	Decreased	-
Talasani *et al.*, (2021)	20 %	Six weeks, Japanese quails	Increased	Increased	Decreased	-
Kumar *et al.*, (2022)	22.5 %	Eight weeks	Not affected	Not affected	Not affected	-

Fig.1 Liu *et al.*, (2011) Schematic diagram showing dry grinding process.



Vanaraja chicken fed with high protein RDDGS had no negative effect on total protein and cholesterol (Raju *et al.,* 2021). Serum cholesterol and triglyceride levels decreased significantly when commercial broilers fed with 15 % RDDGS when compared to control (Dinani *et al.,* 2018). However, Shirisha *et al.,* (2021) observed that there was significant increase in the serum cholesterol and total protein when commercial broilers fed with RDDGS up to 16 % with or without enzyme supplementation.

Economics

Feed cost per kg and feed cost per kg live weight decreased as the level of inclusion of RDDGS increased (Thein *et al.,* 2020). The similar findings were reported by Gupta *et al.,* (2016) who mentioned that feed cost reduced when RDDGS level increased up to 10 %. Likely Dingore *et al.,* (2015) reported low feed cost in 15 % included ration. Dinani *et al.,* (2018) reported feed cost per kg live weight decreased significantly in RDDGS included birds when compared to control. Similarly, Kaninde, (2022) also reported decreased feed cost and feed and cost per kg live weight

Constraints

The major issue with DDGS as feed ingredient is the high content of mycotoxins if present in parent grain, then they may appear in the end product.

The availability of RDDGS varies as the rice is used for human consumption. The major constraints in using RDDGS is nutrient variability, digestibility. The drying process followed at the distillers should be efficient, or else if the moisture content is high then it may cause mold growth in the feed.

Future aspects

The Government of India has announced ethanol blending program up to 20 % in petroleum, in this regard, a greater number of distillers will produce ethanol from sugarcane, maize, rice, sorghum, wheat etc., so the DDGS production will be increased. Most of the researches are restricted to broilers. Moreover, studies investigating the effect of RDDGS must be taken up in layers, breeders, and backyard poultry. Developing effective detoxification methods for grains used for ethanol production can also be taken up.

Based upon the results of studies of different authors it can be concluded that RDDGS is a highly acceptable feed ingredient for commercial broiler chicken which can be include up to 15 % along with enzymes. However, replacing of RDDGS may affect the dietary levels of several important amino acids.

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