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Effect of Inclusion of Distillers Dried Grains with Solubles (DDGs) on the Productive Performance of Growing Rabbits

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Abstract: The objectives of this study were to evaluate the feeding value of corn distillers dried grains with solubles (DDGs) for rabbits and its effects on rabbit's performance. The nutrients contents and the digestibility coefficients for DDGs were estimated using male rabbits "California x Newzeland" six months old. Thirty six male rabbits of six- weeks -old were used to determine the influence of feeding different levels of DDGs to growing fattening California x Newzeland rabbits on the productive traits. Treatments consisted of mixed diets containing 0, 10, 20 or 30% DDGs. The diets were iso-nitrogenous and iso-caloric (16.5% crude protein and 2620 kcal DE/kg diet). The nutrients content of DDGs under investigation showed the values of 25.2% CP, 7.6% CF, 16.6% EE, 38% NFE and 6.2% ash. Amino acids profile showed that lysine is the lowest amino acid in this DDGs sample comparing to soybean meal amino acids profile. The estimated digestibility coefficients as being determined by rabbits were 73.7, 73.3%, 76.8%, 48.9%, 84.5%, 76.0% and 44.7% for DM, OM, CP, CF, EE, NFE and ash content of the tested DDGs, respectively. Digestible energy (DE) value for corn DDGs under investigation was 3085 kcal/kg. Inclusion of 10, 20 and 30% DDGs lowered feed intake by 6%, 6.6% and 7.2%, respectively, compared to rabbits fed no DDGs. Weight gain did not differ among diets containing 0, 10, 20 or 30%DDGs. Feed conversion ratio (FCR) was significantly ($P<0.05$) improved for rabbits fed 10% and 20% DDGs (1.97 and 1.94) comparing to control one (2.09). Feeding 30% DDGs affected positively ($P<0,05$) feed conversion ratio (1.89) compared with those fed either 10% or 20% DDGs. Feeding up to 30% DDGs did not reduce growth performance and improved FCR of rabbits. Generally, it can be concluded, from the current study that, inclusion of up to 30% DDGs in the diets fed to growing-fattening rabbits resulted in improved performance and economic efficiency.

Key words: Rabbits · DDGs · Digestibility · Performance

INTRODUCTION

Dried distillers grains with solubles (DDGs) are a corn co-product obtained during the dry-milling process of corn to produce ethanol after the fermentation of corn starch by selected yeasts and enzymes. This raw material is being used in animal feeds to partially replace corn or soybean meal and even sources of phosphorus due to its high protein, high fat, high phosphorus and high fiber content due to concentrating effect of nutrients in the ethanol production [1]. Fuel ethanol production from corn can be accomplished very efficiently and at relatively low cost compared to other biomass sources. As a result, the production of DDGs will increase exponentially. With increasing DDGs production, local markets could be saturated making DDGs attractive to livestock and poultry producers as a low cost ingredient to replace corn and soybean meal, this encourages the use of DDGs at a greater percentage than has typically been used in the past [2]. According to Lumpkins *et al*. [3] DDGs can be safely used in broiler starter diets up to 6 and 12 - 15% in the grower and finisher period diets. Trails by Roberson *et al*. [4] showed no adverse effect on the performance of laying hen when feed include15% DDGs. The evaluation of DDGs from different sources for lactating dairy cow showed that it can be used safely up to 20% of the diet formula on dry matter basis [5]. The addition of 20% or 40% DDGs for finishing steer diet showed no adverse effects on carcass quality but suggested that the greater proportion of polyunsaturated fatty acids may lead to susceptibility to oxidative rancidity [6]. Historically, very little research has been conducted to evaluate the feeding value of DDGs for rabbits. One study was conducted in Spain by Villamide *et al*. [7] where they compared

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the nutrient digestibility of wheat bran, corn gluten feed and DDGs in "Newzeland x California" cross bred rabbits and revealed that the digestibility of energy, ADF and protein were higher in rabbits fed DDGs compared to rabbits fed wheat bran. Recently, Bernal-Barragn *et al*. [8] showed that DDGs can be included in rabbit diets for fattening up to 30% without affecting performance indicators. However, the need to verify the nutrients content of DDGs due to increasing supply of corn DDGs from different sources was stressed by Widyarante and Zijlstra [9]. Moreover, they revealed that attention should be paid for understanding of the digestible nutrient contents as a critical issue to achieve accurate diet formulation.

The objectives of the present study were to determine the nutrients digestibility of corn DDGs for rabbit and to determine the effect of feeding diets containing corn DDGs to growing-fattening diets on the performance traits.

MATERIALS AND METHODS

Ingredients: The corn DDGs sample (golden DDGs) was obtained from an unknown US origin source via the local market suppliers. The same DDGs batch was used in the digestibility and performance studies.

Experiment 1

Digestibility Study: Apparent digestibility of DDGs nutrients was conducted using six male rabbits "California x Newzeland" of 6 months age. They were divided into two groups of three rabbits each. The rabbits were housed in individual metabolic cages. The experimental period lasted 12 days, 7 days as a preliminary period for adaptation to experimental diets followed by 5 days collection of faeces and urine. The nutrients digestibility coefficients and digestible energy (DE) were determined using the (By the difference Method) described by Abou-Raya [10].

Experiment 2

Performance Study: Four diets were formulated, one control diet and three DDGs containing diets and used in the performance study with grower-fattening rabbits "California x Newzeland". The four experimental diets included either 0%, 10%, 20% or 30% DDGs replacing mainly a portion of soybean meal and corn. Diets were formulated using the digestible energy determined for DDGs sample in the digestibility study, to meet the rabbit requirements recommended by NRC [11]. A total of 36 male rabbits of 6 weeks age and averaging from 692 to 711 grams body weight were divided randomly into 4 groups of 3 replicates each, each replicate comprises three rabbits. Rabbits were individually caged in wire cages and fed *ad libtum* on one of the four tested diets shown in Table (1). Water was available during the whole duration of the study which lasted for 6 weeks (42 days). Rabbits were weighed at the beginning of the experimental period and weekly thereafter. Feed intake was recorded and the data were used to calculate average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (FCR).

Table 1: Composition and calculated analysis of the experimental diets.

Ingredients	Control	10% DDGs	20% DDGs	30% DDGs
Yellow corn	9.70	4.10	3.00	4.00
Soybean meal (44%)	16.20	10.90	5.70	0.80
Barley	20.10	23.10	19.75	13.30
Wheat bran	15.50	17.30	17.00	15.50
Choline chloride (50%)	0.10	0.10	0.10	0.10
Clover hay	33.9	30.0	30.00	32.00
DDGs	--	10.0	20.00	30.00
DL – methionine	0.255	0.20	0.17	0.14
L-Lysine HCl	--	0.10	0.28	0.37
Di-calcium phosphate	0.08	--	--	--
Limestone	0.57	0.68	0.61	0.49
Salt	0.295	0.22	0.09	--
Molasses	3.00	3.00	3.00	3.00
Vit. & Min. mixture*	0.30	0.30	0.30	0.30
Total (kg)	100	100	100	100
Chemical composition**				
Crude protein	16.53	16.57	16.50	16.51
DE (k.cal/kg)	2620	2619	2620	2620
Ether extract%	2.41	3.00	3.65	4.31
Crude fiber%	14.54	14.74	15.60	16.79
Calcium%	0.82	0.82	0.82	0.82
Total phosphorus%	0.50	0.53	0.55	0.55
Methionine%	0.44	0.40	0.38	0.35
Methionine + Cystine%	0.65	0.63	0.62	0.61
Lysine%	0.66	0.66	0.68	0.65
Sodium%	0.23	0.24	0.24	0.25

* Vitamins & Minerals mixture supplied per kg of diet: Vit. A, 10000 I.U; Vit.D_3, 900 I.U; Vit. E, 50 mg; Vit.k_3 2mg; Vit.B_1,2 mg; Vit.B_2,4 mg; Vit.B_6, 2 mg ;Vit.B_{12},10µg; Niacin,50 mg; Pantothenic acid,10 mg; Folic acid, 3 mg ; Biotin, 100µg; Copper, 30mg; Iodine, 0.5mg; Iron, 50mg; Manganese, 50mg; Zinc, 50mg; Cobalt, 0.1mg and Selenium, 0.2 mg.

**Calculated according to tables of CLFF [28].

Housing: Animals used in the digestibility study were housed in wire metabolism cages measuring 405x510x320 mm that allowed separation of faeces and urine. A cycle of 12 hours of light and 12 hours of darkness was used throughout the experiment. Forced ventilation system allowed the building temperature to be maintained at 23°C to 28°C throughout the experimental period. The growing animals used in the performance study were housed in cages 250x600x330 mm and were kept under the same light and temperature conditions.

Chemical Analysis: Chemical analysis were conducted for ingredients, feed and faeces which were analyzed for dry matter (DM), crude protein (CP), ash, crude fat (EE) and crude fiber (CF) according to AOAC [12]. Amino acids content of DDGs was determined according to the method described by Duranti and Cerlietti [13] using the Spackman amino acid analyzer model 118/119 CL [14]. Methionine and cystine were detected by the procedure described by Moore [15]. Gross energy value of DDGs, feed and faeces were determined using an adiabatic oxygen bomb calorimeter (Gallen-kamp).

Economic Efficiency: Economic efficiency and relative economic efficiency for adding DDGs in the diet of growing fattening rabbit were calculated using the data of available feed ingredients prices available at the time of conducting this study and the results of final weight of rabbits.

Statistical Analysis: Data for digestibility and performance studies were analyzed using the general linear model procedures of SAS [16]. A simple one- way classification analysis was used followed by LSD test for testing the significance between means.

RESULTS AND DISCUSSION

Nutrients Contents and Digestibility: The nutrients composition of corn DDGs sample used in this study are shown in Table 2. The CP, CF and EE contents are relatively high compared to corn because DDGs is a by-product of a process primarily aimed at the production of ethanol. In this process all the nutrients from corn grains are concentrated except the majority of starch [17]. However, the values obtained in this study may differ from other results obtained by other researchers because the DDGs that is produced is characterized by the grain that was used to produce the ethanol and the several production factors used to produce DDGs [18]. Salim *et al*. [19] analyzed 395 samples imported to Korea from USA and found that their CP content ranged from 25.87 to 30.41% with 3.72 coefficient of variation. Dale and Batal [20] reported that CP content of DDGs can vary from 24 to 29%. One of the main observations of the present study is a lower lysine content of DDGs comparing with soybean meal amino acids pattern (Table 3). These results are in agreement with the finding of Dong *et al*. [21] who reported that chemical score revealed that lysine was the most limiting amino acid of DDGs. Spiehs *et al*. [18] reported that the first two limiting amino acids in poultry diets are lysine and methionine. Fastinger *et al*. [22] reported that the production of DDGS usually includes a drying step that may damage amino acids, notably lysine. Lysine content of the protein is particularly low (2.1-2.8% of the protein). A significant amount of lysine could had been destroyed during processing and made the DDGS darker [20]. However, Cromwell *et al*. [23] suggested that differences in processing procedure can be responsible for a substantial amount of the variability in the nutritional value of DDGs. Another observation on the corn DDGs sample in this study was a high content of fat (16.6%) which could be a reflection of nutrient content of original cereal grain with high fat content. Shurson [24] revealed that fat content of corn DDGs from high fat corn source was 15.3%. Batal and Dale [25] reported fat content values ranging from 2.5 to 16% for corn DDGs samples. The high fat content is a major contributor to the gross energy value of the DDGs sample in this study (4870 kcal/kg). Pedersen *et al*. [26] showed a wide range of variation among 10 samples of corn DDGs in their gross energy value (5272 to 5434 kcal/kg DM) which is greater than energy concentration in corn (4496 kcal/kg DM). However the nutrient composition of the DDGs sample in this study reflect the nutrient content of original grain with a higher concentration of remaining nutrients following starch removal and obviously the results of nutrient composition varied from previous studies.

Table 2: Chemical composition of DDGs sample (determent).

Item	Moisture %	CP %	CF %	EE %	NFE %	Ash %
DDGs	6.40	25.20	7.60	16.60	38	6.20

Table 3: Amino acids content% of DDGs compared to soybean meal values.

Amino acids	DDGs*	Soybean meal**
Arginine (%)	1.07	3.14
Histidine (%)	0.56	1.17
Lysine (%)	0.72	2.69
Phyenylalanine (%)	1.17	2.16
Phyenylalanine+Tyrosine (%)	2.19	4.07
Methionine (%)	0.33	0.53
Methionine + Cystine (%)	0.77	1.07
Threonine (%)	0.88	1.41
Isoleucine (%)	0.70	1,56
Leucine (%)	2.58	2.75
Valine (%)	1.06	1.65
Glycine+Serine (%)	2.25	3.42

* Determined. ** According to tables of NRC[29].

The apparent digestibility coefficients of the corn DDGs sample used in this study are shown in Table 4. The digestible energy (DE) of DDGs sample in this study was 3085 kcal/kg. Crude fiber (CF) and CP digestibility of DDGs were 48.9% and 76.8%, respectively.

Table 4: Apparent Nutrient Digestibility (%) and digestible energy (kcal DE/kg) of DDGs sample

Item	DM %	OM %	CP %	CF %	EE %	NFE %	Ash %	DE (Kcal DE/kg)
Apparent digestibility	73.7	73.3	76.8	48.9	84.5	76.0	44.7	3085

Table 5: Effect of inclusion of DDGs in the diet of growing- fattening rabbits on the performance traits

	Treatments				
Item	Control	10% DDGs	20% DDGs	30% DDGs	SE ±
Initial body weight (g/rabbit)	692	705	711	708	8.34
Final body weight (g/rabbit)	2456	2470	2488	2518	23.22
Total weight gain (g/rabbit)	1764	1765	1767	1810	17.75
Average daily gain (g/rabbit/ day)	41.99	42.02	42.31	43.09	0.42
Total feed intake (g/rabbit)	3689^{a}	3468^{b}	3447^{b}	3426^{b}	38.81
Average feed intake (g/rabbit/ day)	87.9^{a}	82.6^{b}	82.1^{b}	81.57^{b}	0.92
Feed conversion ratio(g feed /g gain)	2.09^{a}	1.97^{b}	1.94^{c}	1.89^{d}	0.01

a, b, c… means with different superscript (s) in the same row are significantly different (P< 0.05).

The DM and OM digestibility were 73.7 and 73.3%, respectively, while EE digestibility was 84.5%. Villamide *et al*. [7] compared the digestibility of wheat bran and corn gluten feed with DDGs in rabbits. Although the fiber content of the diet was similar, they found that energy and ADF digestibility was highest for rabbits fed DDGs diets (74% and 58.3%) compared to wheat diets. They recorded a value of 70.1% protein digestibility for rabbits fed DDGs. The digestible energy (DE) value for DDGs (Table 4) is lower (3085 k.cal /kg) than the DE of corn (4088 k.cal/kg) as reported by Pedersen *et al*. [26] despite the higher gross energy of the tested DDGs (4870 k.cal/kg) than their tested corn (4496 kcal /kg). It seems that due to the wide variation in DDGs nutrients contents, it is advisable to use energy system to get the advantage of high fat and excess protein content of DDGs.

Performance Study: The effect of diets containing different levels of corn DDGs (10, 20 and 30%) on growth performance of rabbits during the six weeks experimental period is shown in Table 5. The average daily feed intake was almost the same for rabbits fed diets with 10, 20 and 30% DDGs but less (P<0.05) than the control group by 6.0, 6.6 and 7.2%, respectively. Consequently, the dietary digestible energy intake decreased for the treatments received DDGs in their diets compared to the control diet although the dietary concentration of digestible energy of the diets was the same. As for weight gain, rabbits fed diets containing different levels of DDGs showed no significant difference (P> 0.05) between treatments and control group, despite the highest weight gain recorded for the group received a diet containing 30% DDGs (1.81 kg) which accounted for 2.6% more value than the control group. That may be due to increasing the level of adding synthetic lysine with decreasing the level of SBM in diets. However, Aburto *et al*. [27] reported that soybean meal quality is very sensitive to processing procedure; both the analytical values and digestibility of lysine were reduced by prolonged heating. As a consequence, feed conversion expressed as gram of feed intake per gram of weight gain was significantly (P<0.05) better for groups fed 10, 20 and 30% DDGs which showed a values of 1.97, 1.94 and 1.89 respectively. Recently, Bernall-Barragn *et al*. [8] tested the inclusion rates of 10, 20 and 30% DDGs in fattening diets of rabbits "Negro Azieca x Chinchilla" and found that performance indicators were not affected by using up to 30% DDGs. The values reported by the authors for average daily gain and feed conversion were not close to the values obtained in this study. They reported a daily weight gain of 19-22 gram and a feed conversion from 4.32-5.24. Inclusion of DDGs did not affect mortality rate during growing- fattening period in the present study.

The physical appearance, chemical composition and nutrient digestibility of DDGs can vary considerably depending on source and processing and drying procedures [23]. Variations may exist among samples of DDGs for energy content and availability of essential amino acids (especially lysine) content and bioavailability of phosphorus and variation in sodium content. The acceptance of high levels of DDGs as seen in the present study may be associated with the apparent high nutrient quality of the sample used in the present study. It is of interest to note that the digestibility of fat in DDGs was

Table 6: Effect of inclusion of DDGs in the diet of growing- fattening rabbits on economic efficiency

	Treatments			
Item	Control	10% DDGs	20% DDGs	30% DDGs
Feed price (LE/ Kg)	1.96	1.95	1.92	1.85
Total feed cost (LE/ rabbit)	7.23	6.76	6.62	6.34
Final weight (Kg/ rabbit)	2.46	2.47	2.49	2.52
Price of product (LE/ rabbit)	31.98	32.11	32.37	32.76
Net revenue (LE/ rabbit)	24.75	25.35	25.75	26.42
Economic efficiency (Ec.E)	3.42	3.75	3.89	4.17
Relative economic efficiency (REc.E)	100	109.6	113.7	121.9

Net revenue = Price of rabbit (LE) – Total feed cost (LE)
Economic efficiency = Net revenue / Total feed cost (LE*)*

high (84.5%) due to unsaturated fatty acids and this could be reflected on the performance values obtained for this particular study.

Economic Efficiency: Simple calculations to study the economic efficiency due to using DDGs in rabbit diets are shown in Table 6. Data showed that values of economic efficiency (Ec.E) and relative economic efficiency (REc.E) for diets with different DDGs levels were markedly higher than those for control diet. The evident improvement in economic evaluation is due to decreased cost of total feed consumed with increasing the level of DDGs up to 30% and associated with improved FCR.

CONCLUSION

The usage of DDGS in diets fed to growing rabbits could be applied up to 30% inclusion rate without any deleterious effect on the performance parameters. However, the risk of producing fattened rabbit with soft bellies needs further research to investigate the influence of high inclusion rate on belly firmness of rabbits. Likewise, it is important that diets containing DDGs be carefully formulated based on digestibility of its nutrient content as measured on rabbits. Further research should be conducted to confirm this high inclusion rate with a range of DDGs samples and to evaluate the influence of DDGs on carcass composition. Generally, it can be concluded, from the current study that, inclusion of up to 30% DDGs in the diets fed to growing-fattening rabbits resulted in improved performance and economic efficiency.

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