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EFFECT OF CORN DISTILLER'S DRIED GRAINS WITH SOLUBLES (DDGS) ON GROWING RABBIT PERFORMANCE.

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This study was conducted to evaluate the partially replacement of diet protein by corn distiller's dried grains with solubles (DDGS). Sixty, New Zealand White (NZW) growing rabbits (6 weeks old) with an average weight of 647±7.32 g were randomly assigned individually to six treatments of ten rabbits each. The control diet based on soybean meal (SBM) as the main protein source, whereas DDGS was incorporated in five diets to substitute 10, 20, 30, 40 and 50% of the control diet protein or 6.25, 12.50, 18.75, 25.00 and 31.25 of the total diet, respectively. All diets were formulated to be iso- protein, iso-digestible energy, and to satisfy the nutrient requirements according to Agriculture Ministry Decree (1996) recommendation. The experimental period lasted for 8 weeks.

The results showed that DDGS contained 27.20 % crude protein (CP), 10.2 ether extract (EE %) and 7.82 crude fiber (CF %). DDGS used in the present experiment was in normal range of aflatoxins and ochratoxins, according to FAO (1997), while fumonisin and deoxynivalenol were not detected. At the end of the experiment period, the lowest numerical live body weight and body weight gain and the worst feed conversion values, were for the rabbits fed on diet contained 50% substitution. However, all substitution levels had no adverse effects on growth performance as compared to the control diet, except for feed conversion values which were adversely affected by 40 and 50% substitution. The digestion coefficients of different nutrients and nutritive values of diets contained 30% DDGS substitution were better in general than control and others experimental groups. The digestion coefficients of nutrients and nutritive values were not decreased significantly than the control, except EE, NFE, TDN and DCP values due to 50% substitution. DDGS had no significant effect on carcass traits except edible giblets without a clear trend. Almost all oragnoleptic properties and overall acceptability were not affected significantly by DDGS substitution levels. There was a significant increase in both of cecum pH and ammonia due to 50% substitution. In addition, there were numerical increases in TVFA due to increasing DDGS substitution levels. Least caecum microbial counts, in general were noticed with 20% DDGS substitution. The least feed cost/ Kg body weight gain, economic efficiency and the best relative *economic efficiency were for 30% DDGS substitution, while the worst values were for 50% substitution.*

In conclusion, DDGS as a protein source in growing rabbit diets can be used economically without any adverse effects on growing rabbit performance till 30% substitution (or 18.75 of the diet).

Key words. DDGS, rabbits, growth performance, digestibility, carcass traits.

In feed formulation, nutritionists consider a wide range of ingredients and attempt to develop feed formulas that provide the desired level of nutrients at minimum cost , as feed represents approximately 70% of the live productions cost. Distiller's dried grains with solubles (DDGS) a co-product of the dry-mill ethanol industry is a dried residue remaining after the fermentation of the corn starch by selected yeasts and enzymes to produce ethanol. Each 100 Kg of corn produced 46.46 litters of ethanol and 33.31 Kg of DDGS. This by- product has received considerable attention recently as an acceptable feed ingredient where the supply of DDGS is increasing rapidly from beverage alcohol or recently from fuel alcohol production (Wang *et al*, 2007). Also, Togkgoz *et al.*, (2007) reported that the DDGS production will increase from 11 million tons in 2005 to be 40 million tons in 2009. Composition of DDGS has been of great interest to researchers which mostly due to technology used to produce DDGS (Waldroup *et al.*, 2007). Additional efforts are underway to further develop and standardize these methods to insure feed quality as these ethanol by-products become a larger share of the animal feed market (American Feed Industry Association, 2007). Although there are many factors affect nutrient composition of DDGS it is still very good source of protein (24-30%) and many amino acids (Spiehs *et al.,* 2002, Belyea *et al.*, 2004 and Kim *et al.*, 2008). Some studies indicated that broiler can fed on up to 25% of DDGS without a reduction in body weight or feed utilization (Waldroup *et al.*, 1981). Also, Wang *et al.* (2007) showed the effective use of diet with 15% of DDGS in broiler diets. Swine fed on 20% DDGS had no detrimental effects on pork muscle quality (Whitney and Shurson., 2004). During growing and finishing period of pigs fed on 0-25% wheat DDGS, gain, feed intake and nutrient digestibility declined as wheat DDGS increased but finished period was unaffected (Thacker., 2006).

The present study aimed to investigate the effect of partial replacement of diet protein by DDGS on growth performance, digestion coefficient, carcass traits and economical efficiency of growing rabbit diets.

MATERIALS AND METHODS

This experimental study was carried out at Gizerat El-Sheir Poultry Research Station El-Kanater EL-Khaireia, El-Kaluobia Government, Egypt, Ministry of Agriculture, May to July 2009. The Laboratory work was conducted at Laboratories of By-products Research Department, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt. The experiment aimed to evaluate corn distiller's dried grains with solubles (DDGS) as a non-conventional source of protein in growing rabbit diets.

Experimental diets:

The experimental product (DDGS) was obtained from Cairo Company of Poultry, then chemically analyzed to evaluate its nutritive values to formulate the experimental diets as shown in Table 1. Six diets contained 0, 6.25, 12.50, 18.75, 25.00 and 31.25% of DDGS by replacement of 0,10, 20, 30, 40 and 50% of diet protein, respectively. All diets were iso-protein, and iso-digestible energy, and to satisfy the nutrient requirements according to Agriculture Ministry Decree (1996) recommendations. The experimental period lasted for 8 weeks.

Animals and management:

A total number of 60 NZW weaned rabbits at 6 weeks of age about 647.15±7.32 g as an average body weight were assigned, individually, into 6 treatments of 10 rabbits each. Rabbits were housed in galvanized metal rabbit battery cages (60 x 50 x 40) supplied with separated feeders. Diets were offered in pellets form *ad libtum* and fresh water was available all times from automatic nipple drinkers. All animals were kept under the same managements and hygienic conditions. Both feed intake and live body weight were recorded weekly and then feed conversion ratio was calculated.

Chemical analysis:

Approximate analysis of different samples (experimental diets, feces), aflatoxins, ochratoxins, fumonisin, and deoxynivalenol of DDGS were determined according to the methods of A.O.A.C. (2000).

Digestibility trial:

At the end of the experimental period, digestibility trial was carried out using four rabbits of each treatment. Faeces were collected daily, weighed and dried at 60-70 o C for 24 hours, finely ground and stored for chemical analysis. Data of quantities and chemical analysis of feed and faeces were used to calculate the nutrients digestion coefficients and the nutritive values of the dietary treatments, as described by Cheeke *et al.* (1982).

Organoleptic evaluation of cooked rabbit meat:

Immediately after slaughtering and eviscerating, the same previous rabbits packed in air-tight plastic bags and stored in a deep freezer until used for the panel test.

Table 1. Composition and calculated analysis of the experimental diets for growing rabbits.

Items	Control	DDGS substitution (%)				
	(0)	10	20	30	40	50
Ingredients:						
Clover hay (12%CP)	30.00	28.50	26.10	22.80	25.09	27.62
Yellow corn	23.53	23.40	22.05	19.27	22.56	25.93
Soybean meal (44%CP)	18.70	15.40	11.84	8.23	6.50	4.39
DDGS	0.00	6.25	12.50	18.75	25.00	31.25
Wheat bran	21.34	20.00	21.00	24.41	14.21	4.00
Molasses	3.00	3.00	3.00	3.00	3.00	3.00
DL-Methionine	0.14	0.12	0.11	0.10	0.09	0.11
Hcl-Lysine	0.00	0.03	0.09	0.15	0.24	0.32
Vit..& Min. mix.*	0.30	0.30	0.30	0.30	0.30	0.30
Salt	0.50	0.47	0.44	0.41	0.38	0.36
Limestone	0.22	0.35	0.55	0.82	0.63	0.42
Di-Calcium. phosphate	2.27	2.18	2.02	1.76	2.00	2.30
Total	**100**	**100**	**100**	**100**	**100**	**100**
Calculated analysis: [1]						
Crude protein %	17.02	17.05	17.00	17.05	17.05	17.00
Digestible energy (Kcal/Kg)	2500.0	2500.0	2501.0	2500.0	2502.7	2502.3
C/P ratio	147	147	147	147	147	147
Ether extract %	2.72	3.22	3.73	4.27	4.65	5.04
Crude fiber %	13.25	12.90	12.49	12.03	12.02	12.09
NDF% [m]	37.63	37.40	37.13	36.83	36.82	36.87
ADF% [n]	21.52	21.20	20.82	20.40	20.39	20.46
Hemicellulose % [o]	16.11	16.20	16.31	16.42	16.43	16.41
Calcium %	1.10	1.10	1.10	1.10	1.10	1.10
Total Phosphorus %	0.80	0.80	0.80	0.80	0.80	0.80
Methionine %	0.36	0.35	0.34	0.35	0.34	0.36
TSAA	0.61	0.60	0.61	0.62	0.60	0.61
Lysine %	0.75	0.71	0.70	0.70	0.71	0.70

* **Each 1.5 Kg. of Vita. mix contained** : 10,000,000 IU Vit.A; 2,000,000 IU D_3; 10,000 mg Vit. E; 1000 mg Vit. K_3;1000 mg Vit.B_1; 5000 mg Vit.B_2; 15000 mg vit B_6; 10,0 mg vit;B_{12} ; 10,000 mg Vit. Panathonic acid; 30,000 g Nicotinic acid; 50 mg Biotin; 1.0 g Folic acid; 10,000 mg BHT. Each 1.5 Kg Min. mix contained 50 g Zn; 60 g Mn; 30 g Fe ; 4 g Cu; 0.1 g cobalt;0.1g Se and.0.3 gI;

[1] According to Feed Composition Tables for animal and poultry feedstuffs used in Egypt (2001) ,except the values of DDGS, which were determined (Table 2), Methionine (0.50) and lysine (0.73) vales were obtained from Wang *et al.* (2007) .

[nmo] Calculated according to Cheeke (1987), [m]% NDF = 28.924 + 0.657 (%CF), [n]% ADF = 9.432 + 0.912 (%CF) , [o]Hemicellulose = %NDF - % ADF.

The test was carried out to evaluate rabbit meat properties as colour, taste, aroma, texture and overall acceptability by boiling the rabbits for 20 minutes in the water without addition of any flavor enhancers. Twenty participants (staff members of Animal and Poultry Nutrition Research Section, Animal Production Research Institute, Agriculture Research Center Ministry of Agriculture, Dokki, Giza, Egypt) were asked in the panel test to give numerical values to indicate their evaluation of the tested samples. Numerical values from 1 to 9 were used by the panelists to evaluate the tested properties. Organoleptic evaluation of the tested meat samples was determined according to Molander (1960).

Caecum activities:

Samples of caecum contents from the same slaughtered rabbits under each treatment were taken and used immediately for the estimation of caecum pH and caecum microflora (bacteria) *aerobic total count*, *fecal coliforms*, *escherichia coli count*, *bacillus cereus*, *enterobacter*, *clostridium sp.*, *enterococcus*, *yeasts*, *salmonella* and *shigella*. Another sample of caecum content was strained through four folds of gauze and divided into two portions. The first portion was used immediately for the estimation of ammonia nitrogen concentration. The second portion was preserved by addition of 1 ml N/10 HCL and 2 ml orthophosphoric acid to each 2 ml of caecum contents juice for determination of total volatile fatty acids. The pH of the caecum contents was measured immediately by using a digital pH meter. The microbial content was studied in their selective media, as described by Postage (1969) for aerobic total bacterial counts and Difco (1989) for fecal coliforms and *E. coli*, while, the methods described by Baired Parker (1962) and Kim and Goepfert (1971) were used for *enterococcus* and *bacillus cereus*, respectively and Difco (1989) for *enterobacter*, *clostridium* sp.; while the method described by Lodder (1952) was used for yeasts determination. *Salmonella* and *Shigella* were enumerated according to the methods described by A.O.A.C.(1998). Technique of colony forming unit (CFU) was adopted. Incubation took place at 30°C for 2-7 days. The ammonia nitrogen concentration was determined by applying Conway method (1958).The total volatile fatty acids were determined by steam distillation of the distillate as mentioned by Eadie *et al.* (1967).

Economic efficiency:

The economic efficiency of ingredients of the experimental diets was calculated as the ratio between income (price of weight gain) and cost of feed consumed, calculated according to the price of the Egyptian market.

Statistical analysis:

The data were analyzed using General Linear Models (GLM) procedure of SAS Institute (2001).

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where: Y_{ij}= An observation, μ = Overall mean of Y_{ij}, T_i = Effect of treatment(i = 1,…and 6), e_{ij} = Random error.

Variables having a significant F-test were compared using Duncan's Multiple Rang Test (Duncan,1955).

RESULTS AND DISCUSSIN

Chemical analysis:

Chemical composition of DDGS shown in Table (2), revealed that DDGS has a good nutritive profile, where it contained 27.20 % crude protein (CP) on dry matter (DM) basis, which was in the range (25-30%) reported by NRC. (1998), Spiehs *et al*.(2002), Martinez *et al.* (2004) , Batal and Dale (2006), Shurson and Spiehs , (2005) and Kim *et al*., (2008). DDGS ether extract (EE %) and crude fiber (CF %) values (10.2 and 7.82) were almost close to the values (10.7and 7.2) obtained by Shurson and Spiehs (2005) and (11.6 and 8.89) obtained by Kim *et al*., (2008). Wang *et al.* (2007) reported that DDGS content of methionine and lysine were 0.50 and 0.73 respectively which are lower than those of soybean meal (0 .65 and 2.95) as a reported by Feed Composition Tables for Animal and Poultry Feedstuffs used in Egypt (2001).

Table 2. Chemical analysis of Dried distilled grains with soluble (DDGS) as compared to Soy bean meal (SBM) on air dry basis.

Items	SBM*	DDGS
Moisture %	13.0	11.02
Dry matter (DM %)	87.0	88.98
Crude protein (CP %)	44.0	27.20
Ether extract (EE %)	1.50	10.20
Ash (%)	6.50	5.01
Organic matter (OM %)	80.5	83.97
Nitrogen free extract (NFE %)	27.7	38.75
DE (kcal / kg) [k]	3200	2700
Crude fiber (CF %)	7.3	7.82
Neutral detergent fiber (NDF%)[l]	15.0	23.28
Acid detergent fiber (ADF%) [m]	10.0	9.26
Hemicellulose (%) [n]	5.0	14.02
Calcium (%)	0.3	0.30
Total Phosphorus (%)	0.65	0.86
Methionine (%)	0.65	0.50
Lysine (%)	2.95	0.73

kDE (kcal/g) = 4.36 – 0.0491 (%NDF) .

Calculated according to Cheeke (1987).

Determinated according to Van Soest (1983).

l . NDF = cellulose + hemicellulose + lignin, m ADF = cellulose + lignin

n Hemicellulose (%) = NDF – ADF

* The values were obtained from Feed Composition Tables for Animal and Poultry Feedstuffs used in Egypt (2001).

Methionine and lysine values of DDGS were obtained from Wang *et al.* (2007) .

Table (3) showed that aflatoxins and ochratoxins values were in the normal range as reported by FAO (1997), while, fumonisin and deoxynivalenol values were not detected. Yanhong *et al.* (2009) measured mainly aflatoxins, deoxynivalenol, fumonisins, T-2 toxin, and zearalenone for 235 samples of DDGS collected from 20 ethanol plants in the midwestern United States and 23 export shipping containers from 2006 to 2008 using state-of-the-art analytical methodologies. The results suggested that (1) none of the samples contained aflatoxins or deoxynivalenol levels higher than the U.S. Food and Drug Administration (FDA) guidelines to use in animal feed; (2) no more than 10% of the samples contained fumonisin levels higher than the recommendation for feeding equids and rabbits, (3) most samples contained zearalenone levels lower than the detection limit, and no FDA guidance levels are available for zearalenone; and (4) the containers used for export shipping of DDGS did not seem to contribute to mycotoxin production.

Table 3. Mycotoxins content of the experimental DDGS diets.

<table>
<tr><th>Items</th><th>Aflatoxins (ppb)</th><th>Ochratoxins (ppb)</th><th>Fumonisin</th><th>Deoxynivalenol</th></tr>
<tr><td>Normal range*</td><td>20</td><td>15</td><td rowspan="2">ND</td><td rowspan="2">ND</td></tr>
<tr><td>DDGS</td><td>7.5</td><td>10</td></tr>
</table>

ND: Not detected) *According to FAO, (1997)

Growth performance

Live body weight and body weight gain:

Table (4) showed that up to 50% DDGS substitution had no adverse effect on both live body weight and body weight gain values during (6-10) and (6-14) weeks of age, while 30, 40 and 50% DDGS substitution decreased body weight gain significantly ($P \leq 0.05$) as compared with the control diet, during 10-14 weeks of age.

These results were in agreements to those obtained by Cromwell *et al.* (1985) who reported that higher inclusion levels of DDGS (30 and 40%) in the grower and finisher diets of pigs adversely affected the growth. Whitney *et al* (2006) determined the maximal inclusion rate of corn distillers dried grain with solubles (DDGS) in grower and finisher pig diets to be less than 20% DDGS for optimal performance. Also, Wang *et al.* (2007) found that inclusion of 30% DDGS reduced overall broiler performance traits due to a deficiency of some amino acids (A.A) that weren't accounted in formulation with this level of DDGS. Waldroup (2007) revealed that as greater quantities of DDGS were used in the diet, it becomes increasingly essential that accurate nutrient values be assigned to the product.

Results also, indicated that the best viability rate was (100) for 30% DDGS substitution whereas the worst (60) was for the 50% DDGS substitution these results may be due to the increase of ether extract in 50% DDGS substitution diet relate to the increase DDGS content of ether extract.

Table 4: Rabbits performance values (µ ±SE) as affected by DDGS diets.

Items	Control 0%	DDGS substitution(%) 10	20	30	40	50
Live body weight(g)						
Initial Weight (g)	650.50 ± 07.32	650.50 ± 07.40	652.00 ± 06.02	638.50 ± 04.41	638.89 ±10.16	652.50 ± 06.59
10 weeks	1137.00 [c] ± 28.73	1185.63 [bc] ± 24.45	1223.57 [abc] ± 39.38	1265.00 [ab] ± 22.37	1283.33 [a] ± 31.98	1211.57 [abc] ± 9.74
14 weeks	1702.50 [bc] ± 20.29	1732.88 [ab] ± 23.88	1780.00 [a] ± 21.82	1757.50 [ab] ±23.95	1718.33 [ab] ± 19.78	1645.50 [c] ±09.45
Body weight gain (g)						
6-10 weeks	486.50 [b] ± 27.25	535.13 [b] ± 27.04	571.57 [ab] ± 38.05	626.50 [a] ± 23.99	644.44 [a] ± 24.31	559.07 [ab] ±19.85
10-14 weeks	565.50 [a] ±27.85	547.25 [a] ±19.62	556.43 [a] ± 18.92	492.50 [ab] ± 32.08	435.00 [b] ± 41.63	433.93 [b] ± 22.97
6-14weeks	1052.00 [ab] ± 23.55	1082.38 [ab] ± 23.47	1128.00 [a] ± 22.29	1119.00 [a] ± 25.13	1079.44 [ab] ± 29.15	993.00 [b] ± 15.30
No of dead rabbits/10	2	2	3	0	3	4
Viability rate (%)	80 [ab]	80 [ab]	70 [bc]	100 [a]	70 [bc]	60 [c]
Feed intake						
6-10 weeks	2115.00 ± 38.04	2090.25 ± 23.93	2225.43 ± 58.23	2242.30 ± 53.01	2189.50 ± 54.19	2139.71 ±111.10
10-14 weeks	2534.75 ± 29.60	2550.50 ± 34.45	2714.00 ± 59.17	2351.80 ±88.35	2499.50 ± 205.79	2613.67 ± 63.79
6-14weeks	4649.75 ± 54.21	4640.75 ± 43.98	4939.43 ± 109.85	4594.10 ± 57.17	4689.00 ± 247.29	4753.38 ±162.48
Feed conversion						
6-10 weeks	4.35 ± 0.31 [a]	3.91 ±0.19 [ab]	3.89 ± 0.21 [ab]	3.58 ±0.13 [b]	3.40 ± 0.12 [b]	3.83 ±0.20 [b]
10-14 weeks	4.48 ± 0.22 [b]	4.66 ±0.19 [b]	4.88 ±0.23 [b]	4.78 ±0.35 [b]	5.45 ±0.85 [a]	6.02 ±0.35 [a]
6-14weeks	4.42 ± 0.13	4.29 ±0.11	4.38 ±0.10	4.11 ±0.10	4.34 ±0.28	4.79 ±0.16

a, b and c Means on the same row with different superscripts are significantly different ($P \leq 0.05$).
SE = Standard error.

Feed intake and feed conversion:

The results of this study in Table (4) indicated that the amount of feed intake were not affected adversely due to DDGS inclusion up to 50% substitution in growing rabbit diets. These differences between feed intake values were not significant compared to the control diet (Table 4). Some studies indicated that voluntary feed intake (VFI) may be reduced when corn DDGS is included in swine diets (Wahlstrom and Libal 1980; Whitney and Shurson 2004). The same authors added that reasons for this reduction in VFI remain unclear and dietary inclusion of DDGS seemed to negatively affect palatability, factors, which are unfavorable for the palatability and feed intake, may be due to mold spores, which can be concentrated in DDGS, during fermentation. Other possibilities causing a reduced VFI include a significant AA (amino acids) imbalance, including an increase in level of non-essential AA (NEAA) (Henry *et al*., 1992; Henry., 1995 and Hahn *et al*., 1995). Finally, high energy density due to relatively high fat content of DDGS (Azain 2001). Noll and Brannon (2006) found that there was no significant difference between 10 and 20% DDGS of the diet compared with the control on feed conversion ratio (feed/ gain of turkey). The differences in feed consumption and feed conversion may be due to reducing of bulk density of the diets with the higher levels of DDGS as reported by Wang *et al.* (2007).

Table (4) showed that increasing the level of DDGS substitution improved feed conversion values during the first weeks of experiment (6-10 weeks of age), while during the period from (10-14 weeks of age) increasing the DDGS level more than 30% substitution impaired feed conversion values ($P \leq 0.05$). The values were 5.45 and 6.02 for 40 and 50% substitution vs. 4.48 for the control diet, respectively. During the total period (6-14 weeks of age) there were no significant differences between feed conversion values, where 50% substitution scored the worst feed conversion value.

Digestion coefficients of nutrients and nutritive values:

The results presented in Table 5, showed significant differences between groups in the digestion coefficients of different nutrients and nutritive values. The digestion coefficients of different nutrients and nutritive values of diets contained 30% DDGS substitution were better in general than control and others experimental groups. The digestion coefficients of nutrients and nutritive value were not decreased significantly than the control except EE, NFE, TDN and DCP values due to 50% substitution.

Results were in agreement with Leaflet (2008) who reported that nitrogen retention was higher significantly ($P \leq 0.05$) for hens fed corn DDGS, wheat middlings, or soybean hulls compared to hens fed the control diet. Also, Thacker (2006) reported that, the digestibility of dry matter, crude protein and energy declined($P< 0.01$) as the level of wheat DDGS decreased in pig diets. The non adverse effect on digestibility coefficient of nutrients and nutritive values for diets containing DDGS may be due to the good nutritive value of DDGS and the balance of soluble and insoluble fiber which improved gastrointestinal health. Soluble fiber has high water holding capacity, readily forms gel, increases luminal viscosity, and is easily degraded by micro- flora in the large bowel. On the contrarily, insoluble fiber

Table 5: Digestion coefficients of nutrients and nutritive values (μ ±SE) as affected by DDGS diets.

Treatment groups	Digestibility (%)						Nutritive values[k]	
	DM	OM	CP	CF	EE	NFE	TDN	DCP
DDGS substitution								
0% (Control)	68.18[b] ±0.62	67.50[c] ±0.26	73.95[b] ±0.74	43.83[bc] ±0.21	81.38[b] ±0.51	77.55[a] ±0.30	66.88[b] ± 0.21	12.58[b] ±0.13
10%	70.23[a] ±0.24	68.18[bc] ±0.73	74.10[b] ±0.86	44.25[bc] ±0.25	83.18[ab] ±0.76	78.60[a] ±0.39	67.23[b] ±0.45	12.61[b] ±0.14
20%	69.85[a] ± 0.35	68.20[bc] ±0 .48	74.98[ab] ±0 .54	45.15[b] ±0.65	82.48[ab] ±0.22	78.25[a] ± 0.31	67.65[ab] ±0.30	12.76[b] ±0.09
30%	70.30[a] ±0.61	70.35[a] ±1.07	76.60[a] ±0.33	48.43[a] ±1.01	83.95[a] ±0.65	78.20[a] ±0.42	68.50[a] ±0.71	13.06[a] ±0.05
40%	69.85[a] ±0.17	70.15[ab] ±0.69	74.45[b] ± 0.62	48.78[a] ± 1.21	81.78[b] ±0.72	78.45[a] ± 0.37	68.38[a] ±0.37	12.72[b] ±0.11
50%	71.13[a] ±0.55	69.58[ab] ±0.23	71.53[c] ±0.11	42.00[c] ±0.81	74.25[c] ±0.89	73.85[b] ±0.38	64.98[c] ±0.60	12.20[c] ±0.02

a,b and c Means on the same column with different superscripts are significantly different ($P \leq 0.05$).
[k] Calculated according to Cheeke *et al.* (1982).

has little water holding capacity, decreases transit time, is only partially degraded by micro- flora, and increases fecal bulk (Swanson *et al.*, 2001).

Carcass traits:

Effects of DDGS diets and control diet on carcass traits are shown in Table (6). DDGS levels had no significant effect on carcass traits, except edible giblets weight percentage with no clear trend. Thacker (2006) found that dressing weight percentage was reduced as the level of wheat DDGS increased in diet, whereas, other carcass traits were unaffected. Also, Wang *et al.* (2007) indicated that good quality DDGS could be used in broiler diets at levels of 15 to 20% with little adverse effect on live performance but might result in some loss of dressing percentage or breast meat yield. They reported that birds fed diets containing 15% DDGS did not differ significantly in dressing percentage or carcass characteristics as compared with birds fed diets with high levels of DDGS, whether fed on a continuous basis or alternated weekly. While 30% DDGS reduced breast yield, which may be due to deficiency of some amino acids. Also, Johnson (2009) discussed the utilization of biofuel co-products as feeds for pigs and its good effect on carcass

Table 6. Carcass traits values (μ ±SE) of rabbits as affected by DDGS diets.

Treatment groups	Carcass traits					
DDGS substitution (%)	Empty Carcass weight	Liver weight	Kidney weight	Heart weight	Giblets weight	Dressing weight
	%	%	%	%	%	%
0	56.21±1.24	3.09±0.08	0.92±0.03	0.47±0.02	4.48±0.09[a]	60.69±1.25
10	54.92±0.50	2.80±0.13	0.89±0.01	0.39±0.02	4.08±0.13[c]	59.00±0.61
20	59.75±1.56	3.01±0.08	0.90±0.01	0.43±0.02	4.41±0.08[ab]	64.16±1.54
30	57.82±1.59	2.91±0.15	0.85±0.03	0.41±0.03	4.18±0.17[bc]	62.00±1.76
40	54.81±2.16	2.71±0.07	0.91±0.02	0.47±0.01	4.01±0.08[c]	58.91±2.09
50	53.62±1.38	2.79±0.07	0.95±0.01	0.45±0.04	4.18±0.11[abc]	57.79±1.40

A,b and c Means in the same column with different superscripts are significantly different (P ≤ 0.05).
Total edible parts wt (Dressing wt).= Empty carcass wt. (without head) + Edible giblets wt.
Edible giblets wt.= Liver wt. + Kidney wt.+ Heart wt.
Total edible parts % = Total edible parts wt. / fasted wt. *100

traits. Walter (2010) found that dressing percentage of market hogs increased significantly in a linear fashion with wheat DDGS inclusion level and in a quadratic fashion (P=0.01) as corn DDGS inclusion, while other carcass traits were not affected by DDGS diets.

Caecum activity:

Data in Table (7) showed the effect of using DDGS levels in rabbit diets on caecum activity pH, ammonia and TVFA which were determined, at the end of the growing period (14 weeks of age), and the results showed that DDGS substitution had significant (P≤ 0.05) effect on caecum pH and ammonia concentration. The values of pH were ranged between 4.73- 6.61 for treatments groups vs. 4.02 for control, while ammonia concentration values ranged between 6.48 – 8.44 mg/100 ml for treatments vs. 7.46 mg/100 ml for control. Ammonia concentration decreased till 30% DDGS and increased again till 50% DDGS. Rabbits fed on DDGS diets gave higher caecum pH than the control. The least (P≤ 0.05) values of ammonia concentration were for 20 and 30% DDGS substitution. Results indicated that DDGS had insignificant effect on total volatile fatty acids (TVFA) values of caecum. Values were ranged between 3.48-3.77(ml eq/100ml) for treatments vs. 3.41 (ml eq/100ml) for control. The previous results may be due to not only the common composition such as protein, fat and ash but also, cellulose, xylan and starch content of DDGS diets, which increased the

Table 7. Caecum activity values (μ±SE) of rabbits as affected by the experimental diets.

Treatment groups	Caecum activity values		
	pH	Ammonia (mg/100ml)	TVFA (ml eq/100ml)
DDGS substitution (%)			
0% (Control)	4.02 ± 0.65^{e}	7.46 ± 0.14^{b}	3.41 ± 0.19
10	5.34 ± 0.13^{b}	7.36 ± 0.24^{b}	3.48 ± 0.19
20	4.73 ± 0.25^{cd}	6.66 ± 0.27^{c}	3.65 ± 0.22
30	5.08 ± 0.27^{bc}	6.48 ± 0.15^{c}	3.64 ± 0.10
40	4.22 ± 0.24^{de}	7.74 ± 0.09^{b}	3.77 ± 0.15
50	6.61 ± 0.11^{a}	8.44 ± 0.07^{a}	3.75 ± 0.11

a,b ,c,d and e Means on the same column with different superscripts are significantly different ($P\leq 0.05$).
SE = Standard error.

fermentation in monogastric such as swine and poultry as recorded by Kim *et al.* (2008).

Caecum microbial counts (log-1 CFU/ml) as affected by experimental diets were presented in Table (8). Results showed that caecum length (Cm) of rabbit groups received diet containing DDGS decreased significantly ($P\leq0.05$) as compared with control diet. Caecum weights (g) were not affected significantly in rabbits received diets contained DDGS compared with control diets. Least caecum microbial counts, in general were noticed with 20% DDGS substitution. Yeast counts increased when compared with the control diet except 10% DDGS. These results may be due to the method of DDGS production where an aqueous slurry of yeast cells and residuals from the ground corn kernels remain after fermentation pass through a stripper where the ethanol is removed (Kim *et al.*, 2008). Salmonella was not detected in all experimental diets.

Organoleptic properties of rabbit meat:

The results of the organoleptic properties of rabbits meat are presented in Table 9. Almost all oragnoleptic properties and overall acceptability were not affected significantly by DDGS substitution levels.

Table 8. Caecum length and microbial counts (log^{-1} CFU/ml) as affected by DDGS diets.

Items	DDGS substitution (%)						
	Control 0%	10	20	30	40	50	Sig.
Caecum weight (g)	142.50	125.00	130.00	122.5	131.75	118.50	NS
Caecum length (Cm)	67.50	55.00	58.75	57.00	58.25	54.00	*
Caecum microbes (Microbe CFU/ml)[1]							LSD (0.05)
Aerobic total count	8.081	5.375	5.028	8.686	9.380	8.704	1.862
Fecal coliforms	6.105	3.657	3.070	5.820	4.734	5.883	1.279
E.Coli	7.298	3.657	2.465	6.363	5.820	6.435	1.544
Bacillus cereus	4.450	4.984	6.016	4.752	4.583	4.735	1.319
Enterobacter	5.696	4.183	3.293	5.028	4.930	3.720	1.233
Clostridium sp	2.314	1.993	1.637	1.940	1.851	2.064	1.636
Enterococcus	4.058	3.996	3.738	3.764	3.435	3.720	1.500
Yeasts	5.028	4.930	5.105	5.776	6.586	6.194	1.490
Salmonella&Shigella	ND	ND	ND	ND	ND	ND	-

Each value is an average of 4 observations, LSD between treatments df (0.05).
ND =Not detected , Number of bacterial cells per gram of caecum content (log10^{-1} CFU/ml).
[1] CFU (Colony forming unite) NS: Not significant). * Significant

Organoleptic properties of rabbit meat:

Table 9. Organoleptic properties values (μ±SE) of cooked rabbits meat as affected by DDGS diets .

DDGS substitution	Colour	Taste	Aroma	Texture	Over all acceptability
0% (Control)	6.65± 0.18^{a}	6.45±0.29	6.60±0.25	6.60± 0.23	6.30± 0.23
10%	5.85± 0.23^{b}	6.65±0 .22	6.30± 0.20	6.85± 0.24	6.75± 0.22
20%	6.60± 0.24^{a}	6.60± 0.17	6.90± 0.24	6.90± 0.23	6.90± 0.24
30%	6.80± 0.26^{a}	6.85± 0.27	6.45± 0.20	7.00± 0.28	7.05± 0.15
40%	6.10± 0.24^{ab}	6.55± 0.21	6.30± 0.22	6.75± 0.28	6.70± 0.23
50%	6.70± 0.22^{a}	6.85± 0.22	6.60± 0.22	6.75± 0.18	6.85± 0.24

a and b Means on the same column with different superscripts are significantly different ($P \leq 0.05$). SE = Standard error.

Economical efficiency:

Results in Table (10) showed that the least feed cost/ Kg body weight gain, economic efficiency and the best relative economic efficiency were for 30% DDGS substitution, while the worst values were for 50% substitution.

Table 10. Economical efficiency of experimental diets for growing rabbits as affected by different treatment groups, during period (6-14 weeks).

Items	Control 0%	DDGS (%) 10	20	30	40	50
Price / kg diet (pt)	135.88	134.84	134.99	134.80	132.97	132.15
Total feed intake/rabbit (gm)	4649.75	4640.75	4939.43	4594.10	4689.00	4753.38
Total feed cost/rabbit (LE)	6.32	6.26	6.67	6.19	6.23	6.28
Total weight gain/rabbit(gm)	1052.00	1082.38	1128.00	1119.00	1079.44	993.00
Feed cost / kg gain	6.01	5.78	5.91	5.53	5.78	6.33
Total revenue/rabbit(LE)	12.62	12.99	13.54	13.43	12.95	11.92
Net revenue/rabbit (LE)	6.31	6.73	6.87	7.24	6.72	5.63
Economical efficiency(EE)	1.00	1.08	1.03	1.17	1.08	0.90
Relative EE%	100	107.78	103.20	117.06	104.96	89.86

Based on prices of the Egyptian market during the experimental period (2009).
The price of one ton of clover hay (12% CP), , yellow corn, soybean meal(44%CP), wheat bran, molasses, lysine, methionine, vitamins & minerals mix., salt, lime stone and Di-cal. phosphate were 500,1400, 2700, 1400, 400,25000, 42000, 1250,185, 160 and 1100 LE, respectively.
The price of one ton DDGS on selling was 1700 LE , Initial price of rabbit 12, Net revenue / rabbit (LE) = (Total revenue / rabbit (LE)) -- (Total feed cost / rabbit (LE))
Economical efficiency = (Net revenue/rabbit (LE)) / (Total feed cost/rabbit (LE)
Feed cost / kg gain = Total feed cost/rabbit (LE) *1000 / Total weight gain/rabbit (gm).

These results were in agreement with Amanda (2008) who found lower costs associated with DDGS as a supplement expressed as unit of body weight change, and that sows supplemented with DDGS put on more weight than sows supplemented with a commercial range pellet, at 20% less the cost per day.

Coclusively, DDGS diets as protein source in growing rabbit diets can be used economically without any adverse effects on growing rabbits performance till 30% substitution or 18.75 of diet.

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تأثير المنتجات العرضية لتقطير حبوب الاذرة الجافة بالسوائل علي أداء ا لأرانب النامية

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تهدف هذه الدراسة لتقيم اثر الاستبدال الجزئي لبروتين العليقة بالمنتج العرضي لتقطير حبوب الاذرة الجافة بالسوائل (DDGS) .حيث استخدم ستون أرنب سلالة نيوزيلندي أبيض (عمر ٦ أسابيع) بمتوسط وزن ٦٤٧±٣٢و٧جم قسمت عشوائيا إلي ٦ مجموعات تجريبية بحيث احتوت كل مجموعة منها على ١٠ أرانب . احتوت العليقة الكنترول علي كسب فول الصويا كمصدر بروتيني رئيسي حيث استبدل بالمنتج العرضي لتقطير حبوب الاذرة الجافة بالسوائل في خمس علائق بنسب استبدال ١٠ و ٢٠ و ٣٠ و ٤٠ و ٥٠ % من بروتين العليقة اوكنسبة ٢٥و٦ ، ٥٠و١٢ ، ٧٥و١٨ ، ٠٠و٢٥ ، ٢٥و٣١ % من العليقة علي التوالي. كانت الاحتياجات الغذائية طبقا لتوصيات القرار الوزاري لسنة ١٩٩٦ وقد كانت العلائق متساوية في محتواها من الطاقة والبروتين واستمرت التجربة لمدة ٨ أسابيع.

وقد أظهرت النتائج أن (DDGS) احتوي علي ٢٠ و٢٧ بروتين خام ، ٢و١٠ دهن ، ٨٢و٧ ألياف خام . كما أوضح التحليل الكيماوي خلو المنتج من دي اوكسي نيفالينول (deoxynivalenol) و فيومونيسين (fumonisin) وكان أيضا محتواه من الافلاتوكسينات(aflatoxins) والاوكراتوكسينات ,(ochratoxins) في المستوي الطبيعي طبقا لقرارات منظمة الفاو ١٩٩٧. أظهرت النتائج أن أقل وزن حي ووزن مكتسب وأسوأ قيم للكفاءة التحويلية كانت للمجموعة التي احتوت علي ٥٠% من DDGS، وعامة كانت أسوأ كفاءة تحويلية لنسب الاحلال ٤٠ و ٥٠% بينما كانت أفضل قيم للمجموعة التي احتوت علي ٣٠% من DDGS بالمقارنة بالعليقة الضابطة . لم تتأثر قيم معاملات الهضم معنويا بين المجاميع المختبرة فيما عدا كل من معامل هضم الدهون والكربوهيدرات الذائبة والمركبات المهضومة الكلية والبروتين المهضوم، حيث انخفضت مع نسبة الاحلال ٥٠% من DDGS . لم تتأثر مواصفات الذبيحة معنويا باستخدام DDGS فيما عدا الاجزاء المأكولة بدون اتجاه واضح.لم تتغير خصائص التذوق بشكل معنوي مع نسب الاحلال. كانت هناك زيادة معنوية في كلا من pH وتركيز الامونيا ، كما كان هناك زيادة رقمية في تركيز الاحماض الدهنية الكلية الطيارة في الاعورمع زيادة مستويات الاستبدال. سجلت نسبة الاحلال ٢٠% DDGS أقل عدد ميكروبي لمحتويات الاعور.كانت أفضل العلائق اقتصاديا تلك التي أحتوت علي ٣٠% DDGS علي حين كانت نسبة الاحلال ٥٠% من بروتين العليقة هي الاسوأ أقتصاديا.

التوصية : يستخلص من هذه الدراسة أنه يمكن اقتصاديا احلال DDGS كمصدر بروتيني فى علائق الارانب حتي نسبة احلال ٣٠% من بروتين العليقة أو ٧٥و ١٨ من مكونات العليقة دون حدوث تأثيرات عكسية علي النمو في الأرانب.