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Response of Calves to Diets Containing Different Levels of Distillers Dried Grain with Solubles (DDGS)

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Abstract: Thirty male crossbred (Baladi x Friesian) calves with an average body weight of 322.00±3.00 kg were divided into three experimental groups, each of 10 calves to investigate the effect of substitution undecortecated cotton seed meal (UDCSM) with distillers dried grains with solubles (DDGS) at levels 0, 25 and 50% on growth performance. Calves were housed individually in semi opened pens and reared for 90 days. Concentrate feed mixture (CFM) was offered at 2% of live body weight, while the wheat straw was offered *ad lib*. Acid insoluble ash (AIA) technique was used to determine nutrients digestibility coefficients of the experimental rations. The results showed that, DDGS contained the higher values of EE, NFE and hemicellulose (10.42, 52.41 and 19.55%) compared to UDCSM (2.71, 38.92 and 14.45%), while, values of OM and CP were in the same trend for DDGS and UDCSM. On the other hand, DDGS contained the lower values of CF, ash, NDF, ADF, ADL (8.10, 4.35, 39.23, 19.68 and 4.79%) in comparison with the UDCSM (27.75, 5.80, 50.63, 36.18 and 20.46%) for the same nutrients mentioned above, respectively. Different CFM was isonitrogenous (14.61% CP) and isocaloric (3.49% EE in average) approximately. All amino acids contents of DDGS were lower in comparison with UDCSM. Distillers dried grains with solubles was superior in calcium, sodium, zinc, manganese, iron and selenium contents compared to UDCSM, however, DDGS less than in their contents of phosphorus, magnesium, potassium, sulfur and cupper in comparison with UDCSM. Also, DDGS was superior in true protein nitrogen (TPN) and insoluble protein (In SP) values compared to UDCSM. Experimental rations (R_1, R_2 and R_3) composed of 66.7% CFM and 33.3% of wheat straw were isonitrogenous but slightly different in their contents of gross energy (4024, 4134 and 4149 kcal/ kg DM) for R_1, R_2 and R_3, respectively. Inclusion DDGS in the rations significantly ($P<0.05$) improved all nutrient digestibilities coefficients (DM, OM, CP, CF, EE and NFE) and nutritive values (TDN and DCP). Incorporation DDGS significantly ($P<0.05$) increased total body weight gain (TBWG) and average daily gain (ADG). Replacement UDCSM with DDGS at 0, 25 and 50% insignificant ($P>0.05$) increased DMI. Feed conversion expressed as (Kg DM intake/ kg gain) was significantly ($P<0.05$) improved. Water intake expressed as (L/h/d; L/ $kgW^{0.75}$; L/ 100 kg live body weight and L/ kg DM intake) insignificantly ($P>0.05$) increased with increasing level of DDGS in the rations. Feed cost (LE per kilogram gain) was depressed by 24.89% and 29.83% for R_2 and R_3, respectively, compared to control (R_1). Relative economic efficiency improved by 230.4% and 273.9% for R_2 and R_3 compared to control (R_1) when assuming that relative economic efficiency of control diet equals 100%. It can be concluded that distillers dried grains with solubles can be used as an excellent source of nutrients such as (protein, energy and fat supplementation) for calves' rations formulation. Incorporation DDGS up to 10% of ration formulation or replaced 50% of cotton seed meal (control ration contained 20% UDCSM) had no adverse effect and caused an improvement in growth performance, nutrient digestibilities coefficients and achieved better economic efficiency. Further studies should be carried out to discover for any suitable level can be used of DDGS in calve rations formulation.

Key words: Distillers Dried Grain with Solubles · Calves · Growth Performance · Digestion coefficient · Economic Evaluation

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INTRODUCTION

To meet the demands of legislation requiring the use the gasoline blended with ethanol, wheat, maize and another cereals were used for ethanol production in some countries with cooler climates such as Canada, France and the UK. Production of ethanol from grains has increased the availability of the co-product distillers dried grains with solubles (DDGS). The DDGS has higher gross energy content [1], a higher protein and fiber content and drastically reduced starch content compared to grain [2, 3]. This nutritional profile provides an opportunity to use DDGS primarily as a protein feedstuff in livestock feeding to mitigate feed cost, which is the largest variable cost of animal production [4].

Ethanol production from corn grain has been demonstrated to be an effective strategy to produce high quality and clean liquid transportation fuels. More specifically, the growth of the U.S. ethanol industry has provided an economic stimulus for U.S. based agriculture. The feed industry plays an integral role in this industry. For example, the primary product of the dry milling production process is ethanol but approximately one-third of the total dry matter is recovered in the form of byproducts. These byproducts are becoming an increasingly available feedstuff and, as a result, both producers and nutritionists should be sure to consider capturing any valuable opportunities. Distiller's grains or corn gluten feed may serve as excellent feedstuffs, but application of further understanding of these feeds also may lead to a more cost effective ration [5].

One of these products is distillers dried grain with solubles (DDGS) which is made of two dried post fermentation fractions. Processing of 100 kg of corn grain provides 40.2l of ethanol and 32.3 kg of DDGS [6]. This generates a necessity of utilization of this by-product.

Dried distillers grain can be used as feed component in animal nutrition. It consists of non-fermentative corn grain fractions-protein, fat and fiber which are three-fold more concentrated than in raw corn grain [7].

Moreover, it contains yeasts which are a source of protein of high biological value and vitamins. Corn DDGS usually contains 20–30% of crude protein, of which about 50–55% is bypass protein [8, 9].

Most of the energy contained in dried distillers grain comes from fat and fiber. This results in a reduction of the risk of acidosis, when is fed in higher amounts [10]. Low structural value of this fiber can be increased by an addition of hay or straw [11].

DDGS is a valuable source of unsaturated fatty acids, which are up to 80% of total fatty acid amount. Chemical composition of distillers grain may be variable depending on the quality of the grain and the bio-fuel production process [12].

It has been estimated that in 2010 in European Union 6.3 billion liters of ethanol was produced [12]. That would give 5.06 billion tons of DDGS if made from corn only. In the USA over 80% of this by-product is utilized as a feed component for cattle of which 45% as feed for beef cattle [13]. Where corn DDGS can provide up to 40% of feed dry matter, which is twice as much as been used in dairy cattle feeding [6, 10, 14].

The main objectives of this study was to estimate the efficiency of calves fed concentrate feed mixture containing dried distillers grain with solubles that replaced cotton seed meal in control diet with DDGS at levels of 0, 25 and 50% on growth performance, nutrient digestibilities, water intake and economic efficiency.

MATERIALS AND METHODS

The present study was carried out at Research and Production Station, located in El-Emam Malik Village, El-Bostan, West of Nubaria and at laboratories of Animal Production Department, National Research Centre, Dokki, Giza, Egypt.

Animals and Diets: Thirty male crossbred (Baladi x Friesian) calves with an average body weight of 322.00+3.00 kg were divided into three experimental groups, each of 10 calves. Animals were housed in semi opened pens where they were individually fed.

The growth trial lasted for 90 days, offered and refused feeds were daily recorded. The experimental animals were bi-weekly weighed before feeding at 8.00 am to calculate the average daily gain. Offered feeds were adjusted according to changes of body weights.

The experimental animals were randomly assigned to receive one of the three tested rations. Calves fed on the tested feed mixture at 2% level of their live body weight, while the wheat straw offered *ad lib*. Tested diets were offered twice daily in two equal portions at 8.30 a.m. and 14.30 p.m. The distilleters dried grain with solubles (DDGS) was incorporation in tested diets to substitute of 0, 25 and 50% of undecorticated cotton seed meal. The tested diets were pelleted in factory for animal feed located in Kaha City, Quliobia.

Table 1: Chemical analysis of feed ingredients.

	Feed ingredients					
Item	DDGS	UDCSM	Yellow corn	Wheat bran	Soybean meal	Wheat straw
DM	87.48	87.88	91.30	90.20	89.78	94.21
Chemical analysis on DM basis						
OM	95.65	94.2	98.8	88.3	92.97	89.12
CP	24.72	24.82	9.3	14	44	3.32
CF	8.1	27.75	2.3	11.22	3.9	38.54
EE	10.42	2.71	3.5	3	2.82	1.78
NFE	52.41	38.92	83.7	60.08	42.25	45.48
Ash	4.35	5.8	1.2	11.7	7.03	10.88
Cell wall constituents						
NDF	39.23	50.63	32.63	44.21	35.18	77.36
ADF	19.68	36.18	22.45	32.16	26.72	53.18
ADL	4.79	20.46	2.13	4.05	6.84	10.21
Hemicellulose*	19.55	14.45	10.18	12.05	8.46	24.18
Cellulose**	14.94	15.72	20.32	28.11	19.88	42.97

DDGS: Distillers dried grain with solubles. UDCSM: Undecorticated cotton seed meal.
NDF = Neutral detergent fiber. ADF = Acid detergent fiber. ADL = Acid detergent lignin.
* Hemicellulose = NDF - ADF. ** Cellulose = ADF - ADL.

Table 2: Composition (%) and chemical analysis (%) of concentrate feed mixtures (CFM)

	Concentrate feed mixtures			
Item	CFM_1	CFM_2	CFM_3	Price L.E/ Ton
Composition of the experimental rations:				
Yellow corn	54.5	54.5	54.5	2300
Wheat bran	17	17	17	2100
Soybean meal	5	5	5	5000
UDCSM	20	15	10	3800
DDGS	0	5	10	3200
Limestone	2	2	2	150
Sodium chloride	1	1	1	250
Vitamins and minerals mixture[1]	0.5	0.5	0.5	10000
Price, L.E/ Ton	2676	2646	2616	
Chemical analysis of the concentrate feed mixtures on DM basis:				
Dry matter (DM)	89.59	89.56	89.55	
Organic matter (OM)	93.35	93.42	93.49	
Crude protein (CP)	14.61	14.61	14.6	
Crude fiber (CF)	8.91	7.93	6.95	
Ether extract (EE)	3.1	3.49	3.87	
Nitrogen-free extract (NFE)	66.73	67.39	68.07	
Ash	6.65	6.58	6.51	
GE (kcal/ kg DM)[2]	4256	4279	4302	
Cell wall constituents of the concentrate feed mixtures				
Neutral detergent fiber (NDF)	37.19	36.61	36.04	
Acid detergent fiber (ADF)	26.29	25.46	24.64	
Acid detergent lignin (ADL)	6.28	5.5	4.72	
Hemicelluose[3]	10.9	11.15	11.4	
Cellulose[4]	20.01	19.96	19.92	

[1]Each 3 kg Vitamins and Minerals mixture contains: Vit. A 12500000 IU, Vit. D_3 2500000 IU, Vit. E 10,000 mg, Manganese 80000 mg, Zinc 60,000 mg, Iron 50000 mg, Copper 20000 mg, Iodine 5000mg, Cobalt 1000 mg and carrier ($CaCo_3$) add to 3000g. (Produced by Agri-Vet Comp)
[2]GE (Kcal/ Kg DM)[2]: Calculated according to Blaxter [15]. Each g CP= 5.65 Kcal, g EE= 9.40 Kcal and g (CF & NFE) = 4.15 Kcal.
DDGS: Distillers dried grain with solubles. UDCSM: Undecorticated cotton seed meal.
[3] Hemicellulose = NDF - ADF. [4]Cellulos = ADF - ADL.

Animals were raised under hygienic and managerial conditions. Fresh water and mineral blocks were available all time through the experimental period. Feed intake and body weight changes of the animals were recorded bi-weekly during the experimental period and feed conversion ratio was calculated according to the following equation:

Feed conversion ratio = Kg DM intake/ kg gain.

Chemical analysis and cell wall constituents (%) of feed ingredients are presented in (Table 1). While, composition, chemical analysis and cell wall constituents (%) of the tested diets are shown in (Table 2).

Digestibility Trials: Three metabolism trials were carried out at the end of the experimental period. Six animals for each group were randomly chosen to estimate the influence of tested diets on nutrient digestibilities.

Analytical Procedures: A grab sample method was applied at which acid insoluble ash (AIA) was used as an internal marker according to Van Keulen and Young [16] for determining nutrients digestibility. Samples of feces were taken for five days from each animal and sprayed with 10% sulphoric acid and 10% formaldehyde solutions and dried at 60° C for 24 hrs. Samples were mixed and stored for chemical analysis. Composite samples of feeds and feces were finely ground prior to analysis. The nutritive values expressed as the total digestible nutrient (TDN) and digestible crude protein (DCP) of the experimental rations was calculated by classical method.

Representative samples of ingredients and experimental rations were analyzed for DM, CP, CF, EE and ash according to AOAC [17] methods. Nitrogen free extract (NFE) was calculated by differences. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined in ingredients and tested diets according to Goering and Van Soest [18] and Van Soest *et al.* [19]. Hemicellulose was calculated as the difference between NDF and ADF, while cellulose was calculated as the difference between ADF and ADL.

True protein nitrogen was determined according to AOAC [17] methods. Non protein nitrogen (NPN) was calculated by subtracting the true protein nitrogen value from total nitrogen value. Insoluble protein was determined according to Waldo and Goering [20]. Soluble protein was calculated as the difference between total protein nitrogen and insoluble ones orderly.

Mineral were determined by digestion of part of sample in 10 ml of nitric acid overnight on a steam bath and subsequently digested with 70% perchloric acid. Calcium, P, Mg, K, Na, S, Zn, Mn, Cu, Fe and Se were analyzed by atomic absorption spectrophotometry using standard procedures of the AOAC [17]. Phosphorus was analyzed using method N-4C according to [21]. Finally, Selenium was determined with an autoanalyzer fluorometric selenium method described by Brown and Watkinson [22].

Fatty acid profiles were conducted through out extracted lipids by diethyl ether as described by the AOAC [23]. The extracted lipids were converted to methyl esters as described by AOAC [24] and analyzed for individual fatty acids (C14: 0 to C20: 4) using a gas chromatograph (3400, Varian Inc., Walnut Creek, CA) fitted with a flame ionization detector. Gas chromatography parameters were as follows: the column temperature was 50°C for 3 min and then increased to 220°C at 4°C/min and was held for 15 min. The injector temperature was 200°C and the detector temperature was 250°C. The flow rates of the carrier gases (hydrogen and oxygen) were 30 and 300 ml/min, respectively. Identification and quantification of individual fatty acids was made by using a standard fatty acid methyl ester mixture (2010, Matreya Biochemical LLC, Pleasant Gap, PA).

Amino acids composition was analyzed according to the method described by Millipore Cooperative [25] using HPLC and the modification of PICO-TAG methods.

Statistical Analysis: Data collected of feed and water intake, live body weight gain, average daily gain, feed conversion and nutrient digestibility coefficients were subjected to statistical analysis as one way analysis of variance according to SPSS [26]. Duncan's Multiple Range Test Duncan [27] was used to separate means when the dietary treatment effect was significant according to the following model: $Y_{ij} = \mu + T_i + e_{ij}$ Where:

Y_{ij} = observation. μ = overall mean. T_i = effect of tested diet levels for i = 1–3, 1 = (Control, 0% DDGS), 2 = DDGS replaced 25% of undecorticated cotton seed meal and 3 = DDGS replaced 50% of undecorticated cotton seed. e_{ij} = the experimental error.

RESULTS AND DISCUSSION

Results revealed (Table 1) that DDGS showed the best values of EE, NFE and hemicellulose (10.42, 52.41 and 19.55%) compared to UDCSM (2.71, 38.92 and 14.45%), while, values of OM and CP of DDGS and UDCSM were in the same trend. On the other hand, DDGS recorded the lower values of CF, ash, NDF, ADF and ADL contents (8.10, 4.35, 39.23, 19.68 and 4.79%) in comparison with the UDCSM (27.75, 5.80, 50.63, 36.18 and 20.46%) for the same nutrients, respectively. These results were in agreement with those recorded by Arosemena *et al.* [28]. Also, they noted that the variability in fiber and protein content could significantly affect the energy value of DDGS and the variability among sources is likely due to the type of grain that is used in the production of alcohol. While, Konoff and Janicek [5] found that DDG contained 88% DM, 31% CP; 13% Fat, 34% NDF, 17% ADF and 5% ADL. On the other hand, Clark and Armentano [29] noted that DDGS contained 27%, 9.5%, 31.5% and 16.3% of CP, Fat, NDF and ADF, respectively.

The fiber content of by-products varies according to processing methods. High protein DDGS, for instance, are produced when the germ is removed from the main grain. Such material, therefore, contains less fiber and higher protein compared to conventional DDGS [30]. Nevertheless, neutral detergent fiber (NDF), acid detergent fiber (ADF) and total dietary fiber are approximately three times higher than those in the main grain. While in ruminant animals these fiber fractions can be readily digested due to high fibrolytic activities of rumen microbes, non-ruminants are unable to break down non-starch polysaccharides (NSP) because of the absence of such activities in their small intestine [31].

The composition of DDGS is highly variable, depending on such factors as the base grain used, the age of the manufacturing plant, the distillation process and the preparation of the final product, especially drying and packaging [32-35].

Also, the nutrients composition of DDGS sample studied by Babcock *et al.* [36] showed that the CP, CF and EE contents are relatively high compared to yellow corn because DDGS is a by-product of a process primarily aimed at the production of ethanol. Also, they stated that the process of all the nutrients from corn grains is concentrated except the majority of starch. 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 [37]**.** On the other hand, Salim *et al*. [38] analyzed about 395 samples of DDGS and they noted that CP content ranged from 25.87to 30.41%. On the other hand, Dale and Batal [39] reported that CP content of DDGS can vary from 24 to 29%. While, Cromwell *et al.* [40] suggested that differences in processing procedure can be responsible for a substantial amount of the variability in the nutritional value of DDGS. Singh and Cheryan [41] found that the DDGS had 26.28% of protein content and 13.68% of fat contents. Batal and Dale [42] reported that fat content values ranging from 2.5 to 16% for corn DDGS samples. Also, Distillers by products contains 10-15% fat, 40-45% neutral detergent fiber, 30-35% crude protein and 5% ash [43].

Composition and chemical analysis of the different concentrate feed mixtures (CFM) illustrated in Table (2). The data showed that, different CFM was isonitrogenous (14.61% CP) and isocaloric (4279 Kcal/ kg DM of feeds in average) approximately. Cell wall constituents (NDF, ADF, ADL and cellulose) values were slightly decreased, whoever, hemicellulose slightly increased with increasing level of DDGS in the CFM formulation. This may be related to the differences in cell wall composition of DDGS than UDCSM.

Also, one of the main observations of Table (1) we noticed that DDGS was a high content of fat (10.42%) which could be a reflection of nutrient content of original cereal grain with high fat content. Shurson [44] revealed that fat content of corn DDGS from high fat corn source was 15.3%. Also, Batal and Dale [42] reported that fat content values ranging from 2.5 to 16% for corn DDGS samples. The high fat content is a major contributor to increase the gross energy value of CFM with increasing the DDGS in CFM formulation. 4256, 4279 and 4302 kcal/ kg DM for CFM_1, CFM_2 and CFM_3, respectively (Table 2). Pedersen *et al*. [45] 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.

Amino acids, fatty acid profile and minerals contents of DDGS and UDCSM are presented in Table (3). One of the main observations of the present study is the lower values of all amino acids contents of DDGS compared to UDCSM (Table 3). These results were in agreement with those found by Fastinger *et al*. [46] who, reported that the production of DDGS usually includes a drying step that may damage amino acids. Also, our results of amino acids of DDGS were in agreement with those obtained by Cromwell *et al*. [40]; NRC [47]; Arosemena *et al*. [28].

Also, the present results within the range of values previously published [37, 42, 46, 49, 50].

Data of Fatty acid profile presented in Table (3) cleared that**,** linoleic acid (C18: 2) and poly unsaturated fatty acids (PUSFA) contents in DDGS were higher than the same fatty acid in UDCSM.

The corresponding value (54.16 and 56.25% vs. 48.70% and 53.73%) for DDGS and UDCSM, respectively. However DDGS contained less C16: 0 (14.03%) and total saturated fatty acids (TSFA, 16.65%) compared to UDCSM that contained (16.50% and 19.35%) of C16: 0 and TSFA, respectively. On the other hand the other fatty acids contents were in the same range among DDGS and UDCSM. These results were in agreement with those noticed by Arosemena *et al*. [28].

Table 3: Amino acids, fatty acid profile and minerals contents of dried distillers grain with solubles (DDGS) and undecorticated cotton seed meal (UDCSM)

Amino acids				Fatty acids				Minerals			
DDGS		UDCSM		DDGS		UDCSM		DDGS		UDCSM	
Essential amino acids	%	*Essential* amino acids	%	Fatty acid profiles	%	Fatty acid profiles	%	Macro elements	g/kg DM	Macro elements	g/kg DM
Arginine	1.20	Arginine	6.59	C14: 0	0.07	C14: 0	0.05	Calcium (Ca)	5.10	Calcium (Ca)	2.20
Histidine	0.91	Histidine	1.28	C16: 0	14.03	C16: 0	16.5	Phosphorus (P)	9.20	Phosphorus (P)	11.9
Isoleucine	0.85	Isoleucine	4.26	C16: 1	0.16	C16: 1	0.20	Magnesium (Mg)	2.80	Magnesium (Mg)	6.30
Leucine	3.07	Leucine	7.64	C18: 0	1.76	C18: 0	2.10	Potassium (K)	11.1	Potassium (K)	16.6
Lysine	0.58	Lysine	4.79	C18: 1	26.31	C18: 1	26.2	Sodium (Na)	3.60	Sodium (Na)	0.36
Methionine	0.73	Methionine	2.13	C18: 2	54.16	C18: 2	48.7	Sulfur (S)	4.00	Sulfur (S)	5.80
Phenylalanine	1.26	Phenylalanine Theronine	5.68	C18: 3	1.82	C18: 3	1.50				
Theronine	0.90	Valine	4.30	C20: 0	0.39	C20: 0	0.30				
Valine	1.01		5.45	C20: 1	0.33	C20: 1	0.30				
Non essential amino acids	%	*Non essential amino acids*	%	C20: 2	0.02	C20: 2	0.02	Micro elements	Mg/kg	Micro elements	Mg/kg
				C22: 0	0.22	C22: 0	0.20	Zinc (Zn)	72	Zinc (Zn)	66
Aspartic	1.48	Aspartic	5.80	C22; 1	0.30	C22; 1	0.22	Manganese (Mn)	54	Manganese (Mn)	14
Serine	1.07	Serine	7.20	C24: 0	0.18	C24: 0	0.20	Cupper (Cu)	9	Cupper (Cu)	17
Cystine	0.74	Cystine	5.40	Others	0.25	Others	3.51	Iron (Fe)	202	Iron (Fe)	165
Glutamic	3.76	Glutamic	8.02					Selenium (Se)	312	Selenium (Se)	220
Glycine	0.96	Glycine	6.08	TSFA	16.65	TSFA	19.35				
Alanine	1.80	Alanine	3.70	MUSFA	27.10	MUSFA	26.92				
Tyrosine	1.23	Tyrosine	4.15	PUSFA	56.25	PUSFA	53.73				
Proline	1.34	Proline	8.85								

SFA: Saturated fatty acids
MUSFA: Mono unsaturated fatty acids
PUSFA: Poly unsaturated fatty acids (PUSFA)
DDGS: Distillers dried grain with solubles.
UDCSM: Undecorticated cotton seed meal.

Data of Table (3) was also showed that, DDGS superior in calcium, sodium, zinc, manganese, iron and selenium contents compared to UDCSM, however, DDGS less than in their contents of phosphorus, magnesium, potassium, sulfur and cupper in comparison with UDCSM. These results were agreement with those obtained by Arosemena *et al*. [28] and Whitney and Braden [51]. On the other hand, Konoff and Janicek [5] found that DDG contained 11 and 5 g/ kg DM of phosphorus and sulfur, respectively.

Data of Table (4) showed that DDGS and UDCSM were contained almost the same value of total nitrogen (3.96 VS. 3.97 g/100 g) for DDGS and UDCSM, respectively. While, DDGS was superior in true protein nitrogen (TPN) and insoluble protein (In SP) values compared to UDCSM. The corresponding values of TPN and In SP were (3.94 and 3.95 vs. 3.50 and 3.45 g/100g) for DDGS and UDCSM, respectively. This result cleared that DDGS is good quality source of protein can be used in animal ration formulation as alternative source of protein compared to UDCSM.

Also, data of Table (4) showed that inclusion DDGS in concentrate feed mixture (CFM) was improved the values of True protein nitrogen (TPN) and Insoluble protein (In SP). The corresponding values of TPN were (1.79, 1.99 and 2.21 g/ 100 g,) while values of (In SP) were (1.80, 1.89 and 1.92 g/ 100 g) for CFM_1, CFM_2 and CFM_3, respectively.

Chemical analysis of the experimental rations is illustrated in Table (5). The results indicated that, different experimental rations (R_1, R_2 and R_3) composed of 66.7% CFM and 33.3% of wheat straw, experimental rations were isonitrogenous but slightly different in their contents of gross energy (4024, 4134 and 4149 kcal/ kg DM) for R_1, R_2 and R_3, respectively. This variation in gross energy contents related to high content of fat in DDGS (10.42% EE) compared to UDCSM (2.71% EE). Different nutrients of cell wall constituents (NDF, ADF, ADL, hemicellulose and cellulose) and non fibrous carbohydrates (NFC) were almost in the same trend for different experimental rations (R_1, R_2 and R_3).

Nutrient digestibilities coefficients and nutritive values by the experimental groups are shown in Table (6). Results showed that dietary treatments had significant ($P<0.05$) effect on nutrient digestibilities coefficients and nutritive values.

Inclusion DDGS in the rations significantly ($P<0.05$) improved all nutrient digestibilities coefficients (DM, OM,

Table 4: Nitrogen fraction, soluble and insoluble protein of DDGS, UDCSM and different concentrate feed mixtures

			Concentrate feed mixtures		
Item	DDGS	UDCSM	CFM_1	CFM_2	CFM_3
Nitrogen fraction					
Total nitrogen (TN) g/ 100 g	3.96	3.97	2.34	2.34	2.34
True protein nitrogen (TPN), g/ 100 g	3.94	3.5	1.79	1.99	2.21
Non protein nitrogen (NPN), g/ 100 g	0.02	0.47	0.55	0.35	0.13
TPN of TN %	99.49	88.16	76.5	85.04	94.44
NPN of TN %	0.51	11.84	23.5	14.96	5.56
Soluble and insoluble protein					
Total nitrogen (TN) g/ 100 g	3.96	3.97	2.34	2.34	2.34
Insoluble protein (In SP), g/ 100 g	3.95	3.45	1.8	1.89	1.92
Soluble protein (SP), g/ 100 g	0.01	0.52	0.54	0.45	0.42
In SP of TN %	99.75	86.9	76.92	80.77	82.05
SP of TN %	0.25	13.1	23.08	19.23	17.95

DDGS: Distillers dried grain with solubles. UDCSM: Undecorticated cotton seed meal.
CFM_1: Concentrate Feed Mixture No.1 contained 0% DDGS CFM_2: Concentrate Feed Mixture No.2 contained 5% DDGS
CFM_3: Concentrate Feed Mixture No.3 contained 10% DDGS

Table 5: Chemical analysis of the experimental rations

	Experimental rations		
Item	R_1	R_2	R_3
Concentrate : Roughage ratio	66.70: 33.30		
Chemical analysis of the experimental rations on DM basis:			
Dry matter (DM)	91.13	91.11	91.1
Organic matter (OM)	91.94	91.99	92.04
Crude protein (CP)	10.85	10.85	10.85
Crude fiber (CF)	18.77	18.12	17.47
Ether extract (EE)	2.66	2.92	3.17
Nitrogen-free extract (NFE)	59.66	60.1	60.55
Ash	8.06	8.01	7.96
GE (kcal/ kg DM)[1]	4024	4134	4149
Cell wall constituents of the experimental rations			
Neutral detergent fiber (NDF)	50.57	50.18	49.8
Acid detergent fiber (ADF)	35.25	34.69	34.14
Acid detergent lignin (ADL)	7.59	7.07	6.55
Hemicelluose[2]	15.32	15.49	15.66
Cellulose[3]	27.66	27.62	27.59
Non fibrous carbohydrates (NFC)[4]	27.86	28.04	28.22

[1]GE (Kcal/ Kg DM)[1]: Calculated according to Blaxter [15]. Each g CP= 5.65 Kcal, g EE= 9.40 Kcal and g (CF & NFE) = 4.15 Kcal.
[2]Hemicellulose = NDF - ADF, [3]Cellulose = ADF - ADL.
[4]Non fibrous carbohydrates (NFC) were calculated according to Calsamiglia *et al.* [52] using the following equation:
NFC = 100 - {CP + EE + Ash + NDF}.
R_1: Experimental ration contained 20% UDCSM and fed to calves in group No. (1).
R_2: Experimental ration replaced 25% of UDCSM with DDGS and fed to calves in group No. (2).
R_3: Experimental ration replaced 50% of UDCSM with DDGS and fed to calves in group No. (3).

Table 6: Nutrient digestibilities coefficients and nutritive values (%) by the experimental groups

	Experimental rations			
Item	R_1	R_2	R_3	SEM
Nutrient digestibilities coefficient				
Dry matter (DM)	96.45b	97.11b	98.10a	0.24
Organic matter (OM)	84.41c	88.21b	91.61a	0.96
Crude protein (CP)	79.32b	86.40a	88.44a	1.33
Crude fiber (CF)	77.66c	82.81b	86.92a	1.31
Ether extract (EE)	71.60b	81.16a	86.29a	2.37
Nitrogen-free extract (NFE)	88.04c	90.51b	93.81a	0.76
Nutritive value				
Total digestible nutrient (TDN)	79.99c	84.11b	87.74a	1.02
Digestible crude protein (DCP)	8.61b	9.38a	9.60a	0.15

a, b and c: Means in the same row having different superscripts differ significantly (P<0.05).
SEM: standard error of the mean.

Table 7: Growth performance and water intake of the experimental groups

Item	Experimental rations R_1	R_2	R_3	SEM
1. Growth performance of the experimental groups				
Initial weight, kg	325	319	322	3
Final weight, kg	382	395.5	406	3.58
Total body weight gain, kg (TBWG)	57.00b	76.50a	84.00a	2.76
Average daily gain, kg	0.633b	0.850a	0.933a	0.046
Average body weight, kg	353.5	357.3	364	3
Metabolic body weight (kgW0.75)	81.53	82.18	83.33	0.52
Feed intake				
DM intake of concentrate feed mixture (CFM), kg	4.106	4.179	4.328	0.077
DM intake of wheat straw, kg	2.159	2.199	2.277	0.041
Total DM intake as				
Kg/h/day	6.265	6.378	6. 605	0.118
Kg/kg$W^{0.75}$	0.077	0.078	0.079	0.002
Kg/ 100 kg live body weight	1.772	1.786	1.815	0.035
Feed conversion				
Kg DM intake/ kg gain	9.897b	7.504a	7.079a	0.41
2. Water intake by the experimental groups				
L/h/d	16.8	17.6	18.3	1.14
L/ kg$W^{0.75}$	0.206	0.214	0.22	0.01
L/ 100 kg body weight	4.752	4.926	5.027	0.33
L/ kg DM intake	2.682	2.665	2.869	0.178

a and b: Means in the same row having different superscripts differ significantly (P<0.05).
SEM: standard error of the mean.

CP, CF, EE and NFE) and nutritive values (TDN and DCP). Increasing level of DDGS in rations caused significantly (P<0.05) increasing in all nutrient digestibilities and nutritive values.

These results were not agreement with those found by Santos *et al.* [53] who reported a non significant decrease in total tract OM digestibility by cows supplemented with DDG (63.6%) compared with lactating diary cattle supplemented with SBM (68.0%). Also, ZoBell *et al.* [54] stated that DM and NDF digestibilities were not affected (P>0.05) by treatments contained 10.5 or 16.5% DDGS in finishing beef steers. On the other hand, McGinn *et al.* [55] noted that using DDGS in beef cattle rations may actually be of advantage to the ruminant animal industry as the product has been shown to reduce methane emission by nearly 20% when included in beef cattle diets. While, Firkins *et al.* [56] demonstrated that diets containing DDG had less ruminal NDF digestion compared to a diet containing dry corn gluten feed, but the total tract NDF digestion was greater for DDG diet suggesting greater hindgut fermentation.

Growth performance and water intake by the experimental groups are presented in Table (7). Results cleared that incorporation DDGS in calve rations significantly (P<0.05) increased total body weight gain (TBWG) and average daily gain (ADG), however, it caused not significant (P>0.05) increasing in final weight (FW). The corresponding values were 57.00, 76.50 and 84.00 kg of total body weight gain; 0.633, 0.850 and 0.933 kg of (ADG) and 382, 395.5 and 406 kg of (FW) for R_1, R_2 and R_3, respectively.

Inclusion of DDGS in the rations had no significant (P>0.05) effect on feed intake of CFM, wheat straw and total dry matter intake that expressed as (Kg DMI/h/day, kg DMI/ kg$W^{0.75}$ and kg DMI/ 100 kg live body weight. However, replacement UDCSM with DDGS at 0, 25 and 50% insignificantly (P>0.05) increased DMI (Table 7).

Also, data of Table (7) showed that with increasing level of DDGS, feed conversion that expressed as (Kg DM intake/ kg body weight gain) was significantly (P<0.05) improved. The corresponding values were 9.897, 7.504 and 7.079 Kg DM intake/ kg gain for R_1, R_2 and R_3, respectively. These results were similarly obtained by [12, 57] who conducted that fattening beef cattle from 257 to 370 kg body weight caused a significant increase in average daily gain. Also, they observed higher feed conversion ratio in all groups of beef cattle fed diets containng corn DDGS. The same authors suggested that the higher DDGS addition caused lower dry matter intake, which partially can explain higher feed conversion ratio in animals fed on corn DDGS. In contrast to our study DDGS containing rations insignificantly (P>0.05) increased DMI. Also, similar result was observed in experimental fattening of heifers with initial body weight of about 265 kg [58]. Who noted that when heifers fed 0.56 kg DDGS containing diet increased body weight gain and had higher feed conversion compared to control.

Table 8: Economic evaluation for the experimental rations.

Item	Experimental rations		
	R_1	R_2	R_3
Daily feed intake (fresh, kg) of			
Concentrate feed mixture (CFM)	4.583	4.666	4.833
Wheat straw (WS)	2.034	2.072	2.145
Value of 1- kg feed (LE) of			
Concentrate feed mixture	12.26	12.35	12.64
Wheat straw	1.83	1.86	1.93
Daily feeding cost (LE)[a] of (CFM + WS)	14.09	14.21	14.57
Average daily gain (kg)	0.633	0.85	0.933
Value of daily gain (LE)[b]	18.99	25.5	27.99
Daily profit above feeding cost (LE)	4.9	11.29	13.42
Relative economical efficiency[c]	100	230.4	273.9
Feed cost (LE/kg gain)	22.26	16.72	15.62

LE = Egyptian pound equals 0.143 USS approximately.

[a] Based on prices of year 2014.

[b] Value of 1- kg live body weight equals 30 LE (2014)

[c] Assuming that the relative economic efficiency of control diet equals 100

Feeding more amount of dried distiller grain (about 2.2 kg) did not show the expected effect. This observation was confirmed also by Depenbusch *et al.* [59] who defined an optimal level of DDGS supplementation at 15% of feed dry matter, also, Szulc *et al.* [12] found that corn DDGS was about 17% of all dry matter intake (concentrate and straw). On the other hand, many researchers did not find a significant improvement of an average daily gains and FCR in finishing period (initial body weight about 350–370 kg) when animals were fed with dried distillers grain addition[57, 60, 61]**.** However, Ham *et al.* [62] found effect of DDGS on gains and improvement of fodder intake, while Peter *et al.* [63] stated that feeding heifers on corn dried distillers grain had higher ADG and feed conversion ratio. Also, when finishing cattle fed DDGS at levels ranging from 10 t0 20% improved palatability [64-66].

Water Intake by the Experimental Groups: Water intake by the experimental groups is presented in Table (7). Results recorded that, dietary treatment had no significant effect (P>0.05) on water intake, however, water intake expressed as (L/h/d; L/ kg$W^{0.75}$; L/ 100 kg live body weight and L/ kg DM intake) was insignificantly (P>0.05) increased with increasing level of DDGS in the rations. The corresponding values of water intake were 16.80, 17.60 and 18.30 L/h/d for R_1, R_2 and R_3, respectively. These results are in agreement with those noted by Thickett et *al.* [67] and Kertz *et al.* [68] who observed simultaneous increases of water and calf starter intake. While, Jenny *et al.* [69] indicated that physical capacity was not limiting water.

Economic Evaluation for the Experimental Rations: Economic efficiency was represented by daily profit over feed cost. The costs were based on average values of year 2014 for feeds and live body weight. Feeding costs and profit above feeding costs are shown in Table (8). Inclusion DDGS in calves rations caused slightly increasing in total daily feeding costs of experimental rations by 0.85% for R_2 while, 3.41% for R_3 compared to control diet R_1. Meanwhile, average daily gain, daily profit above feeding cost and relative economical efficiency for R_2 and R_3 were improved in comparison with control (R_1). Feed cost (LE per kilogram gain) was depressed by 24.89% and 29.83% for R_2 and R_3, respectively, compared to control (R_1). Relative economic efficiency improved by 230.4 and 273.9% for R_2 and R_3 compared to control (R_1) when assuming that relative economic efficiency of control diet equals 100%. These results were in agreement with those obtained by [64-66] who noted that feed cost of gain will be reduced if the cost of DDGS is not greater than cost of corn grain on a dry basis. For each $0.25 increase in corn price, but, the value of DDGS (90% dry matter) as a feed for finishing cattle increases $9.50/ ton.

Also, results in this study were in agreement with those found by Youssef *et al.* [50] who stated that 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 feed conversion of growing rabbits. On the other hand, Konoff and Janicek [5] reported that in work by beef nutritionists has evaluated the economics of wet distiller's grains in ruminant feed systems. Generally the price of wet distiller's grains is 90 percent to 95 percent of the current price of corn at the ethanol plant. In addition other factors that may influence the price of this feedstuff may include: proximity of the production plant to feeding location, shrink or feed volume loss that was purchased, potential increased handling and delivering costs and inclusion rate.

CONCLUSION

Generally, it can be concluded that distillers dried grains with solubles can be an excellent source of nutrients such as (protein, energy and fat supplementation) for calves' rations formulation. Incorporation DDGS up to 10% or replaced 50% of cotton seed meal (control ration contained 20% UDCSM) caused an improvement in growth performance, nutrient digestibilities coefficients and economic efficiency. Also, replacement of cotton seed meal with DDGS in concentrate feed mixture for fattening (Baladi x fresian) cross breed calves recorded a higher average daily gain compored to control, increased dry matter intake and improved feed conversion ratio. Relative economic efficiency improved by 230.4 and 273.9% for R_2 that replaced 25% of UDCSM in control ration with DDGS and R_3 that replaced 50% of UDCSM in control with DDGS.

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