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Impact of Feeding Calves on Rations Containing Different Levels of Distillers Dried Grains with Solubles (DDGS) on Ruminal Fermentation, Carcass Characteristics and Fatty Acid Profiles

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Abstract: This study was carried out to investigate the impact of replacing undecortecated cottonseed meal (UDCSM) with distillers dried grains (DDGS) on ruminal fermentation, carcass characteristics, fatty acid profiles of intramuscular fat in *longissimus dorsi muscullus*; and sensory panel traits in crossbred (Baladi x Friesian) calves. Thirty male calves were divided individually into three groups (10 calves in each). Animals received an experimental concentrate feed mixture (CFM) at 2% of their live body weight. CFM was offered twice daily in two equal portions at 8.30 a.m. and 14.30 p.m., while wheat straw was offered *ad libitum*. Calves fed for 90 days on CFM containing DDGS that replaced 0, 25 and 50% of the UDCSM (that incorporated in control ration (CFM_1) at 20% of total formula) in a completely randomized design. At the end of feeding trial, nine calves were randomly chosen, three calves from each group and slaughtered. The results showed that, different concentrate feed mixtures (CFM_1, CFM_2 and CFM_3) were isonitrogenous (14.61% CP in average) while, it slightly different in EE content (3.10, 3.49 and 3.87%). Replacement 25% or 50% of UDCSM by DDGS significantly ($P<0.05$) improved both total body weight gain and average daily gain compared to control ration. Dry matter intake insignificantly ($P>0.05$) increased with increasing level of DDGS. Feed conversion expressed as (kg DM intake/ kg gain) significantly ($P<0.05$) improved with inclusion DDGS in the rations (G_2 and G_3) compared to control (G_1). Inclusion DDGS in calve rations slightly decreased both ruminal pH and ammonia-nitrogen (NH_3-N) concentration, however, slightly increased ruminal total volatile fatty acids (TVFA's). While, had no significant ($P>0.05$) effect on molar proportion of VFA's and acetate: propionate ratio. Dietary treatments had no significant effect ($P>0.05$) on slaughter weight, digestive tract, empty body weight, edible offals, carcass weight, dressing percentages, carcass cuts, body fats, physical composition of best 9^{th}, 10^{th} and 11^{th} ribs, chemical analysis, physical analysis, eye muscle area, fatty acid profiles and external offals. It can be concluded that, undecortecated cotton seed meal (UDCSM) can be replaced until 50% of their content in calve rations by distillers dried grains with solubles (DDGS) with no adverse effect on growth performance, ruminal fermentation, carcass characteristics and fatty acid profile. We think that, another study must be carried out with increasing level of replacement from UDCSM with DDGS to decide the maximum level of replacement can be occurred.

Key words: Distillers Dried Grains with Solubles · Calves · Ruminal Fermentation · Carcass Characteristics · Fatty Acid Profile · Sensory Panel Traits

INTRODUCTION

An intensive development of bio-fuel industry causes an increased production of ethanol and its by-products. 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 [1]. This generates a necessity of utilization of this by-product. Distillers dried grain can be used as

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feed component in animal nutrition. It consists of non-fermentative grain fractions-protein, fat and fiber which are three-fold more concentrated than in raw grain [2]. Moreover, it contains yeast which is a source of protein of high biological value and vitamins. Distillers dried grain with solubles usually contains 20-30% of crude protein, of which about 50-55% is bypass protein [3, 4]. Most of the energy contained in distillers dried grain comes from fat and fiber. This reduces the risk of acidosis, when is fed in higher amounts [5]. Low structural value of this fiber can be increased by an addition of hay or straw [6]. 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 various though and depends mostly on the quality of the grain and the bio-fuel production process. The quantity of DDGS was estimated by 5.06 billion tons of DDGS if made from corn only in the USA and over 80% of this by-product is utilized as a feed component for cattle, of which 45% as feed for beef cattle [7]. In beef animal nutrition, corn DDGS can provide up to 40% of feed dry matter, which is twice as much as can be used in dairy cattle feeding [1, 5, 8].

Shurson and Noll [9] noted that for each 100 kg of corn fermented in a dry-grind ethanol plant, approximately 36 liters of ethanol, 32 kg of DDGS and 32 kg of carbon dioxide is produced. 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 oxidative rancidity [10].

Feeding DDG with or without solubles has resulted in variable effects on carcass characteristics, meat fatty acid profiles and sensory attributes in cattle [11-14].

Evaluating fatty acid profiles in ruminant derived muscle tissue is important because some saturated fatty acids in the human diet are directly related to elevated blood cholesterol, which has been related coronary heart disease [15] and anti-carcinogenic effects of conjugated linoleic acid (CLA) have been reported [16]. In addition, meat fatty acid composition can affect sensory panel traits [17, 18]. For example, Crouse and Ferrell [19] reported that flavor is highly correlated to 18:1 and 18:3 fatty acid concentrations.

The aim of this work was to study the effect of replacement of undecorticated cotton seed meal (UDCSM) with distillers dried grain with solubles (DDGS) at different levels (0. 25 and 50%) on ruminal fermrntation, carcass characteristics and fatty acid profiles of intramuscular fat in *longissimus dorsi muscullus*.

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, 33 El-Bohouth Street, Dokki, Giza, Egypt.

Experimental Animals and Feeds: Thirty male crossbred (Baladi x Friesian) calves with an average live body weight 322±3 kg were divided into three groups, each of 10 calves and each group individually received one of the experimental concentrate feed mixtures (CFM_1, CFM_2 and CFM_3) at 2% of their live body weight for 90 days. Experimental CFM was offered twice daily in two equal portions at 8.30 a.m. and 14.30 p.m., while wheat straw was offered *ad libitum*. The tested concentrate feed mixtures (CFM_1, CFM_2 and CFM_3) contained 0, 5 and 10% of distillers dried grains with solubles (DDGS) that equal replacing 0, 25 and 50% of undecorticated cotton seed meal (UDCSM), respectively. Fresh water and mineral blocks were available all time through the experimental period.

Composition of concentrate feed mixtures (CFM_1, CFM_2 and CFM_3) and chemical analysis of UDCSM, DDGS, wheat straw and CFM are presented in Table (1).

Slaughter Technique: At the end of feeding trial nine calves were slaughtered, three calves from each group to study the effects of replacement of UDCSM with DDGS on rumen parameters, carcass characteristics and fatty acid profile of intramuscular fat in *longissimus dorsi muscullus*.

Slaughtered animals were fasted for 16 hours before slaughtering, which was performed according to the Islamic rules. Animals were weighed just before slaughter, slaughter weight (SW) was recorded and as well as after complete bleeding. Head, skin and four legs were separated and weighed. Internal organs and offal's (heart, lungs, liver, testes, spleen, kidneys and digestive tract) were removed and individually weighed.

Digestive tract was separated into ruminant stomach (reticulo-rumen, omasum and abomasum), small and large intestine, where full and empty weights were recorded.

The carcasses were split carefully into two equal longitudinal halves. The left half of the carcass was divided into fore and hind quarters between the 11^{th} and 12^{th} ribs.

Table 1: Composition of concentrate feed mixtures (CFM) and chemical analysis of undecorticated cotton seed meal, distillers dried grain with solubles, wheat straw and CFM.

				Concentrate feed mixtures		
Item	UDCSM	DDGS	Wheat straw	CFM_1	CFM_2	CFM_3
Composition of the concentrate feed mixture:						
Yellow corn				54.5	54.5	54.5
Wheat bran				17	17	17
Soybean meal				5	5	5
Undecorticated cotton seed meal (UDCSM)				20	15	10
Distillers dried grain with solubles (DDGS)				0	5	10
Limestone				2	2	2
Sodium chloride				1	1	1
Vitamins and minerals mixture[1]				0.5	0.5	0.5
Chemical analysis of UDCSM, DDGS, wheat straw and the concentrate feed mixtures:						
Dry matter (DM)	87.88	87.48	94.21	89.59	89.56	89.55
Chemical analysis on DM basis:						
Organic matter (OM)	94.2	95.65	89.12	93.35	93.42	93.49
Crude protein (CP)	24.82	24.72	3.32	14.61	14.61	14.6
Crude fiber (CF)	27.75	8.1	38.54	8.91	7.93	6.95
Ether extract (EE)	2.71	10.42	1.78	3.1	3.49	3.87
Nitrogen-free extract (NFE)	38.92	52.41	45.48	66.73	67.39	68.07
Ash	5.8	4.35	10.88	6.65	6.58	6.51
Cell wall constituents:						
Neutral detergent fiber (NDF)	50.63	39.23	77.36	37.19	36.61	36.04
Acid detergent fiber (ADF)	36.18	19.68	53.18	26.29	25.46	24.64
Acid detergent lignin (ADL)	20.46	4.79	10.21	6.28	5.5	4.72
Hemicellulose2	14.45	19.55	24.18	10.9	11.15	11.4
Cellulose3	15.72	14.94	42.97	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]Hemicellulose = NDF - ADF. [3]Cellulose = ADF - ADL.

The 9^{th}, 10^{th} and 11^{th} ribs were frozen in polyethylene bags for later physical analysis (lean, fat and bone). The *longissimus dorsi* muscles of 9^{th}, 10^{th} and 11^{th} ribs were dried at 60 C° for 24 hrs. The air-dried samples were analyzed for DM, EE and ash according to the AOAC [20] methods, while CP percentage was determined by difference as recommended by O'Mary *et al.* [21].

Eye muscle fat was extracted with diethyl ether and evaporated from the extract and fat was kept under refrigeration for determination of fatty acid using gas liquid chromatography (GLC) technique according to Mason and Waller [22]. Body fats were also recorded.

Eye muscle lean (*longissimus dorsi*) area was measured by calk paper placed over cut surface and measured using Planemeter in squared centimeters, according to Henderson *et al*. [23]. Also, Eye muscle lean weight was recorded.

Physical Characteristics: Physical characteristics of eye muscle {pH, water holding capacity (WHC), cooking loss and tenderness} were determined.

pH Value: The pH was determined after 24 hrs from slaughter by using ORION RESEARCH digital pH meter (model, 201), as described by Aitken *et al.* [24].

Water Holding Capacity (WHC): Water holding capacity % was determined according to the method described by Grau and Hamm [25].

Cooking Loss Percentage: The samples of eye muscle lean were cutted into cubes (2 x 1 x 1 cm) and their weights were recorded (W1). Samples were put in boiling physiological solution (9 g sodium chloride/ L distillated water) for 30 minutes. Samples were taken away and left

until its temperature became equal to be cool at room temperature and weighted again (W2). The cooking loss % was calculated according to Grau and Hamm [25] as follows:

Cooking loss % = [(WI - W2) x 100] / W1.

Tenderness: Cooked samples, which were used in determination of cooking loss, were used to measure tenderness of eye muscle according to Grau and Hamm [25] by using Warner-Bratzler Shear Force (capacity 50 lb.).

Rumen Fluid Parameters: Rumen fluid samples were collected throughout slaughtering time; samples were filtered through four layers of cheesecloth. Rumen fluid samples were used to determine ruminal pH, ammonia nitrogen (NH_3-N), total volatile fatty acids (TVFA's) concentrations and molar proportion of VFA's.

Analytical Procedures: Representative samples of experimental concentrate feed mixture (CFM_1, CFM_2 and CFM_3), UDCSM, DDGS and wheat straw were analyzed according to AOAC [20] methods. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were also determined according to Goering and Van Soest [26] and Van Soest *et al.* [27].

Ruminal pH was immediately determined using digital pH meter. Ruminal total volatile fatty acids (TVFA's) concentrations were determined by steam distillation according to Kromann *et al.* [28]. Ruminal ammonia nitrogen (NH_3–N) concentrations were determined applying NH_3 diffusion technique using Kjeldahle distillation method according to AOAC [20]. Molar proportions of volatile fatty acids were determined according to Erwin *et al.* [29].

Fatty acid profiles were conducted through out extracted lipids by diethyl ether, while the extracted lipids were converted to methyl esters as described by AOAC [30, 31].

Statistical Analysis: Collected data of ruminal fermentation, carcass characteristics and fatty acid profiles were subjected to statistical analysis as one way analysis of variance according to SPSS [32]. Duncan's Multiple Range Test Duncan [33] 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 UDCSM and 3 = DDGS replaced 50% of UDCSM. e_{ij} = the experimental error.

RESULTS AND DISCUSSION

Chemical Composition: Data of Table (1) showed that UDCSM and DDGS were almost comparable in their contents of crude protein and cellulose; while, differed in their contents of crude fiber, ether extract, nitrogen-free extract, ash, neutral detergent fiber, acid detergent fiber, acid detergent lignin, hemicellulose percentages.

Also, data illustrated in Table (1) cleared that different concentrate feed mixtures CFM_1, CFM_2 and CFM_3 formulated was isonitrogenous (14.61% CP in average) and slightly different in EE content, It was noticed that, EE content slightly increased with increasing level of incorporation of DDGS in CFM formulation. The corresponding values of EE content were 3.10, 3.49 and 3.87%. While, crude fiber content was decreased with increasing replacement of UDCSM by DDGS, corresponding values of CF was 8.91, 7.93 and 6.95 for CFM_1, CFM_2 and CFM_3, respectively. On the other hand, ash content was in the same trend approximately. Incorporation DDGS in CFM slightly decreased NDF, ADF, ADL and cellulose contents. However, slightly increased hemicellulose contents. This different may be related to different the cell wall constituent's content of UDCSM compared to DDGS.

Growth Performance: Effect of dietary treatments on weights, feed intake and feed conversion by experimental group calves is illustrated in Table (2). Replacement 25 or 50% of UDCSM with DDGS significantly ($P<0.05$) improved both total body weight gain and average daily gain compared to control ration not contained DDGS. While, dry matter intake of CFM, wheat straw and total dry matter intake insignificantly ($P>0.05$) increased with increasing level of replacement of UDCSM by DDGS. On the other hand, feed conversion expressed as (kg DM intake/ kg gain) significantly ($P<0.05$) improved with inclusion DDGS in the rations (G_2 and G_3) in comparison with control (G_1).

These results were in agreement with those obtained by Szulc *et al.* [34] who, noted that, the effect of extracted rapeseed meal replaced with corn DDGS on performance of Polish Holstein-Friesian bulls caused significant increase in average daily gain and feed conversion

Table 2: Growth performance of experimental group calves

	Experimental groups			
Item	G_1	G_2	G_3	SEM
1- Weights of experimental group calves:				
Initial weight, kg	325	319	322	3
Final weight, kg	382	395.5	406	3.58
Total body weight gain, kg (TBWG)	57.00[b]	76.50[a]	84.00[a]	2.76
Duration period, day	90 days			
Average daily gain, kg	0.633[b]	0.850[a]	0.933[a]	0.046
2- Daily 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, kg	6.265	6.378	6.605	0.118
3- Feed conversion as:				
Kg DM intake/ kg gain	9.897b	7.504a	7.079a	0.41

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

G_1: calves received ration contained 20% undecorticated cotton seed meal (UDCSM) and expressed as control.

G_2: calves received ration contained 5% distillers dried grain with solubles (DDGS) that equal replacement 25% of UDCSM percentage in control ration.

G_3: calves received ration contained 10% DDGS that equal replacement 50% of UDCSM percentage in control ration.

Table 3: Effect of the dietary treatments on the basic patterns of rumen fermentation by the experimental groups

	Experimental groups			
Item	G_1	G_2	G_3	SEM
pH value	6.14	6.12	6.09	0.02
Ammonia nitrogen concentration, NH3-N (mg/dl)	28.63	27.12	27.41	0.68
Total volatile fatty acids, TVFA's (mEq/dl)	8.38	8.62	8.82	0.45
Molar proportion of VFA's(%) and acetate: propionate ratio:				
Acetate	62.19	61.84	61.22	0.39
Propionate	19.52	19.62	20.03	0.4
Acetate: Propionate ratio	3.19	3.15	3.06	0.07
Butyrate	13.21	13.64	13.92	0.39
Isobutyrate	1.4	1.35	1.33	0.02
Valerate	2.06	2	1.98	0.09
Isovalerate	1.62	1.55	1.52	0.17

SEM: Standard error of means.

compared to control. Also, it was noted that addition of DDGS in heifers rations had higher gain and feed conversion ratio than hefiers fed with corn grain [35-37].

In contrast, many researchers did not tracd any significant improvement of an average daily gains and feed conversion when animals were fed with dried distillers grain [38-40].

Rumen Fermentation: Data of Table (3) showed that replacement UDCSM by DDGS at levels 0, 25 and 50% had no significant effect (P>0.05) on ruminal parameters [pH value, ammonia nitrogen (NH_3-N) concentration, total volatile fatty acids (TVFA's) concentration and Molar proportion of TVFA's (%)]. Otherwise, inclusion DDGS in calves ration slightly decreased both ruminal pH and ammonia-nitrogen (NH_3-N) concentration, however, slightly increased ruminal total volatile fatty acids (TVFA's). These results were in agreement with those obtained by Willms *et al.* [41] who found that, increases in digestion of OM increased TVF'A concentration and lowered pH. Ham *et al.* [35] noted that, diets containing wet distillers grains, dried distillers grains and dry-rolled corn had similar effects on ruminal pH and total VFA's concentrations of steers.

On the other hand, based on *in vitro* and *in vivo* studies, Fron *et al.* [42] demonstrated that inclusion of condensed distillers by-products altered microbial activities increased ruminal populations of starch and lactate utilizing bacteria) and increased the rate of fermentation of lactic acid; however, ruminal pH was unaffected.

Also, Waller *et al.* [43] found that patterns of ammonia release did not differ between treatments when they used distillers feed as protein sources for growing ruminants.

Ruminal pH is one of the most important factors affecting the fermentation and influences its functions. It varies in a regular manner depending on the nature of the diet and on the time it is measured after feeding and reflects changes of organic acids quantities in the ingesta. The level of NH_3-N and TVFA's as end products of fermentation and breakdown of dietary protein, have been used as parameters of ruminal activity by Abou-Akkada and Osman [44].

The results of ruminal fermentations revealed that increasing TVFA's might be related to the more utilization of dietary energy and positive fermentation in the rumen. It should be noted that, TVFA's concentration in the rumen is governed by several factors such from the rumen to the other parts of the digestive tract and the microbial population in the rumen and their activities [45]. Increasing of ruminal TVFA's concentration is an indicator for better utilization of dietary carbohydrate was noticed by Fadel *et al.* [46]. Also, Briggs et *al.* [47] observed that an increasing in ruminal TVFA's concentration caused a reduction in ruminal pH value.

The reduction of ammonia nitrogen in the rumen liquor appears to be the result of increased incorporation of ammonia nitrogen into microbial protein and it was considered as a direct result to stimulated microbial activity. While, increasing TVFA's might be related to the more utilization of dietary energy and positive fermentation in the rumen. Addition of more fermentable carbohydrate to ruminant rations causes a decrease in rumen ammonia [48] probably due to a greater uptake of ammonia by rumen as dry matter digestibility, rate of absorption, rumen pH and transportation of the digesta microorganisms in support of enhanced microbial growth. The rate of TVFA's production may in this situation exceed the rate of TVFA's absorption through the rumen epithelium and TVFA's concentration in the rumen juice is increased [49].

Also Data of Table (3) showed that inclusion DDGS in calves ration had no significant ($P>0.05$) effect on molar proportion of VFA's and acetate: propionate ratio. These results were in agreement with those noted by Clark and Armentano [50] who observed that feeding Holstein cows on diets contained (12.7% DDG) compared with another diet contained the same percentage 12.7% of whole cotton seed (WCS) had no significant effect on molar proportion of ruminal volatile fatty acids. The corresponding value of acetate (61.6 and 62.8); propionate 22.9 and 22.1); butyrate (11.5 and 10.6) isobutyrate (0.80 and 1.0); valerate 1.5 and 1.5); isovalerate (1.7 and 2.0) and acetate: propionate ratio (2.74 and 2.95) for DDG and WCS groups, respectively.

Ham *et al.* [35] reported an increase in propionate concentrations when 20% thin stillage was infused or when 15% condensed distillers solubles was fed to finishing steers. Also, Trejo *et al.* [51] suggested that an alteration of microbial populations, specifically a reduction of the protozoa populations, may have caused the increased propionate.

Karkoodi and Khalajzadeh [52] stated that, calves received ground wheat had higher total volatile fatty acids, acetate, propionate, butyrate, ammonia nitrogen, rumen wall thickness, papilla width and density ($P<0.05$). While, calves fed dry-rolled wheat experienced lower rumen pH ($P<0.05$) throughout the experiment.

Carcass Characteristics: Data of Table (4) cleared that replacement UDCSM by DDGS at 25% or 50% had no significant effect ($P>0.05$) on slaughter weight, digestive tract, empty body weight, edible offals, carcass weight, dressing percentages, carcass cuts, body fats and physical composition of best 9^{th}, 10^{th} and 11^{th} ribs.

These results were in agreement with those obtained by Depenbusch *et al.* [38] and Gunn *et al.* [53] who did not find any differences in the same parameters between animals fed with addition of DDGS and control group. Also, Buckner *et al.* [54] stated that no differences in carcass characteristics were observed when steers fed diet containing 0, 10, 20, 30, 40 and 50% DDGS.

The present results of carcass characteristics are approximately similar to those found by Gunn *et al.* [53] and Gordon *et al.* [55] who, reported no differences in dressing percentage, however the aforementioned data set found linear and quadratic decreases in hot carcass weight with increasing levels of DDGS in the diet. Gibb *et al.* [56] stated that feeding cattle on DDGS containing diets did not affect carcass weight and dressing percentage.

On the other hand, Trejo *et al.* [51] recorded that carcasses of steers fed DDGS and WDG (stored and fresh) weighed approximately 16 kg more than carcasses of steers fed the high-corn diet. However, no difference ($P>0.05$) was detected between the HCW of steers fed the high corn diet and wet or dried distillers grains. Also, Vander Pol *et al.* [57] found a difference of approximately 15 kg in HCW between steers fed a diet with 30% wet distillers grains and those fed on control

Table 4: Effect of dietary treatments on organs, empty body weight, carcass weight, dressing percentages, carcass cuts, body fats and physical composition of best 9th, 10th and 11th ribs.

	Experimental groups			
Item	G_1	G_2	G_3	SEM
Slaughtered calves number	3	3	3	-
Slaughter weight (SW), kg	365	368	370	3.75
Digestive tract, kg				
Full	66.72	67.27	67.64	0.69
Empty	20.72	21.27	20.64	0.21
Content	46	46	47	0.47
Empty body weight (EBW), kg*	319	322	323	3.27
Organs weight (edible offals), kg				
Liver	4.15	4.19	4.2	0.04
Heart	1.56	1.58	1.58	0.06
Kidneys	1.69	1.71	1.71	0.06
Spleen	.0.80	0.81	0.81	0.008
Tests	0.26	0.26	0.26	0.002
Total	8.46	8.55	8.56	0.17
Hot carcass weight, kg (CW1)	185.21	186.66	187.68	1.91
CW1 + edible offals, kg (CW2)	193.67	195.21	196.24	2.03
Dressing percentage (DP)%				
DP1	50.74	50.72	50.72	0.01
DP2	58.06	57.97	58.11	0.04
DP3	60.71	60.62	60.76	0.03
Carcass cuts				
Half carcass weight (CW), kg	93	94	94	0.96
Fore quarter, kg	47.9	48.69	48.88	0.51
Hind quarter, kg	45.1	45.31	45.12	0.46
Body fats				
Kidney fats, kg	0.8	0.84	0.86	0.01
Caul fats, kg	1.5	1.52	1.56	0.02
Total body fats, kg	2.3	2.36	2.42	0.03
Physical composition of best 9, 10 and 11th ribs				
Ribs weight, g	2482	2500	2516	25.4
Lean weight, g	1489	1500	1510	15.24
Fat weight, g	308	310	312	3.2
Bone weight, g	685	690	694	6.96
Lean, % of best ribs	59.99	60	60.02	---
Fat, % of best ribs	12.41	12.4	12.4	---
Bone, % of best ribs	27.6	27.6	27.58	---

SEM: Standard error of means.

*EBW: Empty body weight = Slaughter weight - digestive tract content.

DP [1]: Dressing percentages calculated as (CW_1 / SW).

DP [2]: Dressing percentages calculated as CW_1 / EBW).

DP [3]: Dressing percentages calculated as (CW_2 / EBW).

diet that had high moisture and dry-rolled corn. In addition, Al-Suwaiegh *et al.* [58] reported heavier carcasses for steers fed wet distillers grain diets compared with those fed a corn-based diet, while, Whitney and Braden [59] reported that inclusion of DDG in lamb-finishing diets has shown no negative effect on carcass characteristics, thus it could serve as a plausible substitute for cotton seed meal in lamb-finishing diet.

The present results of Table (4) showed that inclusion of DDGS in the diet slightly increased body fat content with increasing level of DDGS. This result in

Table 5: Effect of dietary treatments on external offals and digestive tract.

	Experimental groups			
Item	G_1	G_2	G_3	SEM
External offals weight, kg				
Blood	17.81	17.96	18.06	0.18
Head	21.83	22.01	22.13	0.22
Four legs	10.51	10.6	10.66	0.11
Skin	41.98	42.32	42.55	0.43
Lungs and trachea	10.18	10.27	10.3	0.1
Digestive tract weight, kg				
Rumen:				
Full	47.74	48.13	48.4	0.49
Empty	12.22	12.69	12.01	0.13
Content	35.52	35.44	36.39	0.37
Small intestine:				
Full	11.57	11.67	11.73	0.12
Empty	5.4	5.45	5.48	0.05
Content	6.17	6.22	6.25	0.06
Large intestine:				
Full	7.41	7.47	7.51	0.07
Empty	3.1	3.13	3.15	0.03
Content	4.31	4.34	4.36	0.04
Total digestive tract:				
Full	66.72	67.27	67.64	0.69
Empty	20.72	21.27	20.64	0.21
Content	46	46	47	0.47

SEM: Standard error of means.

contrast with those noticed by Szulc *et al.* [34] who found that increasing addition level of dried distillers grain caused a decrease of fat amount. The cause of this phenomenon was probably the lower final body weight of heifers fed with DDGS supplementation. While increasing percentage of DDGS in feed, dry matter intake was decreasing, causing lower body weight at slaughter and less fattened carcass.

External Offals and Digestive Tract: Data of Table (5) showed that, dietary treatment had no significant ($P<0.05$) effect on external offals (included blood, head, four legs, skin and lungs and trachea). It had no significant ($P<0.05$) effect on digestive tract weight (included rumen, small intestine and large intestine). Suárez *et al.* [60] reported that differences in carbohydrate composition would influence rumen development.

The level of fiber and the physical nature of dry feed have been found to influence intake and consequently rumen growth, in young calves [61] and greater forage NDF and bulk of fibrous feed could provide mechanical stimuli to enhance rumen weight and volume in calves [62, 63]. On the other hand, Jun *et al.* [64] suggested that replacing forage fiber with DDGS did not affect rumen development when it provided adequate fiber and energy.

Also, Jun *et al.* [64] noticed that papillae length and ruminal wall thickness from ventral sac were not affected ($P>0.05$) by the supplemented DDGS in the calves diets. However, additional DDGS significantly influenced ($P<0.05$) the papillae width from the ventral sac. Also, they reported that papillae width and ruminal wall thickness from the dorsal sac were not affected ($P>0.05$), but increasing the DDGS concentration significantly increased ($P<0.05$) papillae length from the dorsal sac. The higher papillae width and length could be attributed to volatile fatty acids (VFA) with the inclusion of a diet with more concentrated NDF fermentation in young calves [63, 65]. Young calves benefit from good quality forages because of the effective fiber and carbohydrate fermentation end products (i.e., VFA's) that stimulate development of the rumen epithelium that noted by Harrison *et al.* [66]; however, DDGS is also a good source of digestible fiber for ruminant and digestible fiber may be needed for proper ruminal tissue growth [67]. Rumen papillae length, width and surface area have been reported to decrease linearly as DDGS increases [68] and rumen papillae growth is stimulated by the end products of grain fermentation [66], especially the function of butyric acid [69].

Table 6: Effect of dietary treatments on weight, area, chemical and physical analysis and fatty acid profiles of eye muscle (*longissimus dorsi muscle)* of experimental group calves.

	Experimental groups			
Item	G_1	G_2	G_3	SEM
Eye muscle weight, g	149	150	152	1.54
Eye muscle area Cm^2	40.15	40.48	40.7	0.41
Chemical analysis (%)				
Moisture	68.15	67.92	66.81	1.13
Chemical analysis (%) on DM basis				
Crude protein (CP)	66.36	64.68	64.25	2.15
Ether extract (EE)	30.32	31.89	32.12	1.84
Ash	3.32	3.43	3.63	0.15
Physical analysis				
pH	5.69	5.65	5.6	0.01
Cooking losses	18.62	18.09	17.66	1.11
Water holding capacity	42.56	41.02	40.62	0.72
Tenderness	3.56	3.5	3.45	0.02
Fatty acid profiles of eye muscle lipids				
C10: 0	0.07	0.06	0.06	0.001
C12: 0	0.07	0.07	0.06	0.001
C14: 0	2.65	2.63	2.61	0.029
C14: 1	0.54	0.6	0.62	0.013
C15: 0	0.34	0.36	0.37	0.004
C16: 0	21.05	20.86	20.8	0.061
C16: 1	2.61	2.8	2.85	0.045
C17: 0	1.02	0.95	0.93	0.019
C17: 1	0.63	0.64	0.65	0.007
C18: 0	18.33	17.53	17.13	0.14
C18: 1	36.55	36.88	36.93	0.16
C18: 2	4.42	4.56	4.61	0.086
C18: 3	0.37	0.36	0.3	0.003
C20: 0	0.09	0.13	0.14	0.001
C20; 2	0.15	0.16	0.17	0.002
C20: 3	0.07	0.08	0.08	0.001
C20: 4	0.13	0.12	0.11	0.009
Others	10.91	11.21	11.58	0.092
Total saturated fatty acids	43.62	42.59	42.1	0.032
Total unsaturated fatty acids (UFA)	56.38	57.41	57.9	0.056
Mono unsaturated fatty acids (MUFA)	40.33	40.92	41.05	0.02
Poly unsaturated fatty acids (PUFA)	16.05	16.49	16.85	0.092

SEM: Standard error of means.

Eye Muscle Weight and Area; Chemical and Physical Analysis and Fatty Acid Profiles: Data illustrated in Table (6) showed that inclusion DDGS in calve rations had no significant (P>0.05) effect on eye muscle weight and eye muscle area. These results of *longissimus dorsi* muscles in agreement with those stated by Gunn *et al.* [53]; Gordon *et al.* [55] and Gibb *et al.* [56] who reported no differences in dressing *longissimus dorsi* muscles area.

Also, data of Table (6) cleared that incorporation of DDGS in the diet had no significant (P>0.05) effect on chemical analysis (included CP, EE and ash contents) and physical analysis (included pH, cooking losses, water holding capacity and tenderness of eye muscle). These results were in agreement with those established by Whitney and Braden [59] who noted that incorporating DDG in the lamb finishing diet resulted in less cooking loss.

Also, Whitney and Braden [59] reported that initial and sustained juiciness scores quadratically increased (P<0.05) in unison with greater DDG in the diet and meat from lambs fed diet complete replacement cotton seed meal with 100% DDG had greater initial and sustained juiciness than meat from lambs fed 0% DDG. Greater juiciness was also reported by Leupp *et al.* [70] but not by Roeber *et al.* [71] when analyzing sensory attributes of steaks from steers fed DDG. Considering the

linear increase in initial and sustained juiciness scores, tenderness would also be expected to linearly increase due to a halo effect as described by Roeber *et al.* [72]; increased sustained juiciness creating a generalized notion of increased tenderness by the panelists. Roeber *et al.* [72] documented that consumers generalized displeasure in tenderness based on decreased juiciness of the sample.

Fatty acid profiles of eye muscle lipids are presented in Table (6). The results showed that inclusion of DDGS in calve rations had no significant (P>0.05) effect on Fatty acid profiles of eye muscle lipids, however it slightly increased mono unsaturated fatty acids(MUFA) and poly unsaturated fatty acids (PUFA). Szulc *et al.* [34] showed that, replacing extracted rapeseed meal with corn DDGS in Polish Holstein-Friesian bulls diets indicated an improvement of fatty acid composition, including increased level of C18:2 fatty acid in intramuscular fat in *longissimus dorsi* muscullus. Gill *et al.* [12] found a relation between beef cattle feeding with DDGS and fatty acid profile. Irrespectively of plant used to its production (corn or sorghum), DDGS in feed increased level of C18:1 trans-11 fatty acid which is a precursor of certain forms of conjugated linoleic acid (CLA). Moreover, highly significant increase was observed in the level of one of conjugated linoleic acid forms (C18:2 trans-10, cis12) in trial animals fat comparing to those, which diet did not contain corn or sorghum DDGS. Also highly significant influence was found due to total amount of poly-unsaturated fatty acids and percentage of other forms of conjugated linoleic acid in intramuscular fat. On the other hand, Depenbusch *et al.* [13] showed that, the higher level of DDGS was given to animals, the higher level of poly unsaturated fatty acids was found in their fat.

On the other hand, with lambs Whitney and Braden [59] stated that weight percentages of 14:0, 16:1, 18:0 and 20:0 acids were not affected by diet, but 16:0 was greater in meat from lambs fed 0% DDG vs. 100% DDG (complete replacement of cotton seed meal). Feeding DDG to cattle has resulted in variable meat stearic fatty acid responses [12, 13]. Also, Whitney and Braden [68] noted that total percentage of fat in eye muscle or *(longissimus dorsi)* muscle linearly increased as DDG increased in the diet and *longissimus dorsi* muscle from lambs fed 100% DDG had 1.4 times greater fat than *longissimus dorsi* from lambs fed 0% DDG. Furthermore, Whitney and Braden [68] observed that, total saturated fatty acids concentrations were not different among diets, which agrees with others who reported similar meat saturated fatty acids concentrations in cattle fed DDG with solubles. For humans, dietary intake of some saturated fatty acids are directly linked to elevated concentrations of blood cholesterol, which can increase the risk for coronary heart disease [15] but 18:0 has been reported to be neutral in relation to human health [73-75]. Cobb [76] suggested that stearic acid should be considered separately from other saturated fatty acids when discussing dietary control of cholesterol. Viapond *et al.* [77] reported that feeding lamb's of malt distillers grains increased meat cis-9, cis-12 isomer of 18:2, but did not affect 16:0, 16:1, 18:0, or 18:1 fatty acids.

CONCLUSION

Generally, it can be concluded that undecortecated cotton seed meal (UDCSM) can be replacement until 50% of their content in calve rations by distillers dried grains with solubles (DDGS) with no adverse effect on growth performance, ruminal fermentation, carcass characteristics and fatty acid profiles. Also, another study must be carried out with more replacement of UDCSM with DDGS to decide the maximum level of replacement can be occurred.

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