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EFFECT OF ADDING DISTILLERS' CORN WITH DRY SLURRIES (DDGS) AND ENZYMES ON PRODUCTIVE EFFICIENCY OF BROILER CHICKENS

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ABSTRACT

This study aimed to study the effect of adding distiller's dried grains with solubles (DDGS) with enzymes on production efficiency. 250 broiler chicks (Ross 308) were raised from 0-42 days old, without distinguishing between males and females. During this study, 5 feed mixtures were formulated, consisting of yellow corn, soybean meal 46%, DDGS and other feed supplements. These mixtures were equal in terms of protein values and other feed supplements and differed from each other by the presence of different proportions of DDGS, as they contained 5 levels of DDGS (0, 5, 10, 15 and 20%) with enzymes. The results of the experiment in the first week showed that the mixtures containing DDGS at (10, 15 and 20%) led to a decrease in the weight of the chicks. The groups that ate DDGS at a concentration of (0 or 5%) had a higher feed conversion ratio than the other groups. At the end of the experiment, the birds that ate DDGS (0, 5 or 10%) achieved a better feed conversion ratio, compared to the groups that fed DDGS at 15 or 20%. This study showed that the maximum level of DDGS used in starter mixes is 5% and can be increased to 10% during the growth and finishing period. We also found that carcass and breast dressing weights decreased when DDGS were added.

***Keywords**:* Corn distillates, DDGS, enzymes, broiler, production, efficiency, carcass specifications.

INTRODUCTION

Historically, distiller dried grains with solubles (DDGS) have been one of the by-products of alcoholic beverage fermentation, typically derived from grain-based processes. By the late 1930s, with the use of various grains in fermentation, feed producers began incorporating DDGS into livestock diets, though their use remained limited (Scott, 1970; Buenavista *et al.,* 2021). The production of DDGS was not confined to the alcoholic beverage industry. Ethanol plants, commonly referred to today as producers of biofuel or biodiesel, also generate DDGS as a by-product through the fermentation of grains such as corn, barley, wheat, sorghum, and rye, particularly through the dry milling process (Abd El-Hack, 2015).

In recent years, U.S. policymakers have encouraged ethanol production due to its cleaner combustion and higher energy output than petroleum. Ethanol producers responded to this demand in the mid-to-late 1990s by establishing new production facilities. As a result, the volume of yellow corn exported to consumer countries

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declined. Rising prices of corn and soybean meals prompted nutritionists to intensify efforts to formulate alternative feed mixes that could improve poultry feed efficiency (Alagawany and Attia, 2015; Ashour *et al.,* 2015). The growing demand for ethanol production led to the widespread availability of DDGS, which was utilized as livestock feed (Wood *et al.,* 2011; Liu *et al.,* 2011). Consequently, researchers turned to alternative feed ingredients, including ethanol by-products like DDGS, which became abundantly available in the feed industry (Batal and Dale, 2003; Buenavista *et al.,* 2021). DDGS production has increased dramatically, reaching an annual output of 37.2 million tons in 2022, according to the Renewable Fuels Association (2022).

The demand for DDGS has surged due to its low cost and high level of energy, phosphorus, and amino acids. DDGS are considered rich in energy, crude protein, amino acids, B-complex vitamins, biotin, and essential minerals, particularly phosphorus (Wang *et al.,* 2007; Purdum *et al.,* 2014; Koreleski & Świątkiewicz, 2006; Fries-Craft and Bobeck, 2019). DDGS contain all the nutritional components found in whole corn, except for starch, which is fermented and converted into ethanol and carbon dioxide (CO_2). As a result, DDGS typically contains about 27% crude protein, 10% fat, 0.8% phosphorus, and 0.7% sulfur (Pineda *et al.,* 2008).

The global demand for DDGS as alternative animal feed has risen significantly due to both its nutritional and economic advantages. However, the inclusion rate of DDGS in broiler feed formulations remains a matter of debate and varies depending on the age of the birds. Young broilers are particularly sensitive to feed quality, as their digestive systems do not fully develop until approximately two weeks of age. It is not advised to feed broiler chicks a lot of DDGS during the first two weeks after hatching, due to its high fiber content and comparatively low amino acid digestibility (Batal and Parsons, 2003). Due to the fermentation process and starch removal during ethanol production, the protein content in DDGS is nearly three times higher than that of unprocessed corn, with values ranging from 23% to 32% (Batal and Dale, 2006). Additionally, the concentration of non-starch poly-saccharides (NSPs) in DDGS is reported to be two to three times greater than that found in whole corn (Koreleski and Świątkiewicz, 2007).

In recent years, ethanol production has increased due to rising demand and declining reliance on petroleum. This has led to the generation of large quantities of distiller dried grains with solubles (DDGS) as a by-product of ethanol manufacturing, and DDGS has been incorporated into livestock and poultry feed (Salim *et al.,* 2010). Owing to the dramatic increase in DDGS production and its nutritional value, it may serve as a cost-effective alternative feed ingredient, partially replacing soybean meal and corn (Świątkiewicz *et al.,* 2014).

The main challenge in using DDGS in poultry feed formulations is the high variability in nutrient composition among DDGS sources, which has limited its use as a primary feed component for poultry. Nonetheless, nutrient content within DDGS is relatively consistent when sourced from the same processing plant (Noll *et al.,* 2007). This variability is attributed to differences in raw material composition (i.e., corn type), processing methods and standards, fermentation duration, the amount of condensed solubles added to wet distiller's grains, yeast activity during fermentation, drying conditions, and the dry milling process itself (Buenavista *et al.,* 2021; Liu *et al.,* 2011; Amezcua *et al.,* 2007; Wen *et al.,* 2010). So, nutritionists are advised to conduct a comprehensive chemical analysis of all nutrient components in each DDGS sample before formulating poultry diets (Spiehs *et al.,* 2002).

Corn-based DDGS are particularly high in NSPs, which can negatively impact nutrient digestibility. However, the use of specific enzymes can mitigate these adverse effects by enhancing the digestion and absorption of nutrients in poultry diets, especially those involving NSPs (Malkki, 2001). Historically, the inclusion of DDGS in broiler feed has been limited to around 5%, due to variability in its nutritional content (Noll *et al.,* 2001).

As previously mentioned, DDGS inclusion rates in broiler diets are variable and age dependent. Young broilers are particularly sensitive to feeding quality, because their digestive systems do not fully develop until around two weeks of age. The high fiber content and low amino acid digestibility of DDGS further discourage high inclusion levels during this early phase (Batal and Parsons, 2002).

The primary objective of this study is to determine the feasible levels at which DDGS can be used as an unconventional feed ingredient (in combination with enzymes) without negatively impacting the productive performance of broilers.

MATERIALS AND METHODS

A broiler feeding trial was conducted in a poultry farm near Idlib city under the supervision of the Faculty of Veterinary Medicine, University of Idlib, during April and May of 2018. The birds were raised in an open housing system with deep litter flooring. Lighting was provided continuously during the first three days, and then for 22 hours per day until day 42. Stocking density in the poultry house was 10 birds/m².

The experiment involved 250 one-day-old, unsexed broiler chicks, from a locally available commercial hybrid (Ross 308). They were randomly distributed into five treatment groups of 50 chicks each. The rearing period was divided into two phases**:** Phase I: from day 0 to day 21 and Phase II**:** from day 22 to day 42.

Dietary Treatments:
Five plant-based diets were formulated for each rearing phase. All diets were based on yellow corn and soybean meal and designed to meet the nutritional requirements of the Ross 308 strain. The treatment groups were as follows: Group 1 (Control): Basal diet without enzymes. Group 2: Basal diet + 5% DDGS + enzyme supplementation. Group 3: Basal diet + 10% DDGS + enzyme supplementation. Group 4: Basal diet + 15% DDGS + enzyme supplementation. Group 5: Basal diet + 20% DDGS + enzyme supplementation.

Table 1: Shows the nutrient composition of DDGS derived from corn, wheat, and barley (Salih and Abudabos, 2018).

Nutrients	UN	Lescano, 2013	NRC 1994		
		DDGS	Corn	Barley	Wheat
Dry Matter	%	89.72	89.00	89.00	88.00
Crude Protein	%	29.94	8.50	11.00	11.80
Crude Fiber	%	7.87	2.20	5.50	4.00
Ether Extract	%	8.34	3.80	1.80	1.50
Lysine	%	0.82	0.26	0.40	0.39
Methionine	%	0.61	0.18	0.18	0.26
Threonine	%	1.08	0.29	0.37	0.36
Tryptophan	%	0.21	0.06	0.14	0.14
Valine	%	1.49	0.40	0.52	0.51
Calcium	%	0.18	0.02	0.03	0.05
Total Phosphorus	%	0.84	0.28	0.36	0.30
Metabolizable Energy	kcal/kg	3507.75	3350	2900	3144

Enzyme Complex Used:

The enzyme blend included xylanases, β-glucanases, pectinases, mannanases, and phytase. Diet formulation and nutritional balancing were performed using a feed formulation software program.

Table 2: Presents the ingredient composition of the diets used in both the starter and grower-finisher phases.

	Stage 1 (0-21) days					Stage 2 (22-42)				
	G1	**G2**	**G3**	**G4**	**G5**	**G1**	**G2**	**G3**	**G4**	**G5**
Corn	٥٢,٤٩	٥٠,٧١	٤٩,٠٢	٤٧,٣٣	٤٥,٦٥	59.98	٥٨,٢٤	٥٦,٥٥	٥٤,٨٥	٥٣,١٣
Soybean Meal, 46% CP	٤٠.00	٣٦,٩٧	٣٣,٩٢	٣٠,٨٦	٢٧,٨٤	٣١,٤٥	٢٨,٤	٢٥,٣٥	٢٢,٣١	١٩,٢٧
DDGS	٠.00	٥.00	١٠.00	١٥.00	٢٠.00	٠.00	٥.00	١٠.00	١٥.00	٢٠.00
Vegetable oil	٢,٩٦	٢,٦٦	٢,٣٤	٢,٠٣	١,٧٢	٤,٨٢	٤,٥٥	٤,١٨	٣,٨٦	٣,٥٦
Dicalcium phosphate	١,٤٥	١,٤٥	١,٤٥	١,٤٥	١,٤٥	١,٢٥	١,٢٥	١,٢٥	١,٢٥	١,٢٠
Limestone	١,٥٠٦	١,٥٠٦	١,٥٠٦	١,٥٠٦	١,٥٠٦	١,١٨	١,١٨	١,١٨	١,١٨	١,١٨
Lysine	٠,١٢	0.18	٠,٢٤	٠,٣٠	٠,٣٦	٠,٠٥	٠,١١	٠,١٧	٠,٢٣	0.29
Methionine	٠,٤٠	٠,٤٠	٠,٤٠	٠,٤٠	٠,٤٠	٠,٢٩	٠,٢٩	٠,٢٩	٠,٢٩	٠,٢٩
Common Salt	٠,٢١	٠,٢١	٠,٢١	٠,٢١	٠,٢١	٠,٢١	٠,٢١	٠,٢١	٠,٢١	٠,٢١
Threonine	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,٠٤	٠,٠٤	٠,٠٤	٠,٠٤	٠,٠٤
Sodium Bicarbonate	٠,١١	٠,١١	٠,١١	٠,١١	٠,١١	٠,١١	٠,١١	٠,١١	٠,١١	٠,١١
Choline chloride	٠,٢٨٤	٠,٢٨٤	٠,٢٨٤	٠,٢٨٤	٠,٢٨٤	٠,٢٥	٠,٢٥	٠,٢٥	٠,٢٥	٠,٢٥
Vit & minerals	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥
Anti mycotoxins	٠,٢٥	٠,٢٥	٠,٢٥	٠,٢٥	٠,٢٥	٠,٢٥	٠,٢٥	٠,٢٥	٠,٢٥	٠,٢٥
Anticoccidial	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥	٠,١٥
Growth stimulant	٠,٠٢	٠,٠٢	٠,٠٢	٠,٠٢	٠,٠٢	٠,٠٢	٠,٠٢	٠,٠٢	٠,٠٢	٠,٠٢
Now Zimat	٠,٠٠	٠,٠٥	٠,٠٥	٠,٠٥	٠,٠٥	0.00	٠,٠٥	٠,٠٥	٠,٠٥	٠,٠٥

Each kilogram of the complete feed contained the following vitamins and trace minerals: Vitamin A: 15,000 IU, Vitamin D_3: 4,000 IU, Vitamin E: 30 IU, Vitamin B_{12}: 0.020 mg, Vitamin B_2: 9 mg, Niacin: 60 mg, Pantothenic acid: 15 mg, Vitamin K_3: 4 mg, Folic acid: 1.5 mg, Vitamin B_1: 4 mg, Vitamin B_6: 4 mg, Biotin: 0.150 mg, Selenium (Se): 0.3 mg, Manganese (Mn): 120 mg, Zinc (Zn): 100 mg, Iron (Fe): 40 mg, Copper (Cu): 20 mg, Iodine (I): 1 mg

Table 3: Outlines the calculated nutritional values of the diets for both rearing phases, including the energy-to-protein ratio (C/P*).

	Stage 1 (0-21) days					Stage 2 (22-42)				
	G1	**G2**	**G3**	**G4**	**G5**	**G1**	**G2**	**G3**	**G4**	**G5**
ME energy Kcal/Kg	٣٠٠١	٣٠٠٠	٣٠٠٠	٣٠٠٠	٣٠٠٠	٣٢٠٢	٣٢٠٠	٣٢٠٠	٣٢٠٠	٣٢٠٠
Protein %	٢٣,٠٠	٢٣,٠٠	٢٣,٠٠	٢٣,٠٠	٢٣,٠٠	١٩,٥٥	١٩,٥٥	١٩,٥٥	١٩,٥٥	١٩,٥٥
C/P*	١٣٠,٤٣	١٣٠,٤٣	١٣٠,٤٣	١٣٠,٤٣	١٣٠,٤٣	١٦٤,١٥	١٦٤,١٥	١٦٤,١٥	١٦٤,١٥	١٦٤,١٥
Fiber %	٣,٠٢	٣,١١	٣,٢١	٣,٣١	٣,٤٠	٣,١٦	٣,٢٦	٣,٣٥	٣,٤٥	٣,٥٤
Crude fat %	١,٦٢	١,٨٥	٢,٠٨	٢,٣١	٢,٥٤	١,٦٧	١,٦٣	٢,١٤	٢,٣٧	٢,٦٠
Lysine %	١,٤٤	١,٤٤	١,٤٤	١,٤٤	١,٤٤	١,١٥	١,١٥	١,١٥	١,١٥	١,١٥
Methionine %	٠,٧٤	٠,٧٥	٠,٧٥	٠,٧٦	٠,٧٦	٠,٦٥	٠,٦١	٠,٦١	٠,٦١	٠,٦١
Methionine +Cysteine %	١,٠٩	١,١٠	١,١٢	١,١٤	١,١٥	٠,٩٥	٠,٩٣	٠,٩٣	٠,٩٤	٠,٩٦
Calcium %	٠,٩٦	٠,٩٦	٠,٩٧	٠,٩٥	٠,٩٥	٠,٧٨	٠,٧٨	٠,٧٨	٠,٧٨	٠,٧٨
Total Phosphorus %	٠,٦٧	٠,٦٨	٠,٦٩	٠,٧٠	٠,٧١	٠,٦٠	٠,٦١	٠,٦٢	٠,٦٣	٠,٦٤
Available phosphorus %	٠,٥٥	٠,٥٦	٠,٥٧	٠,٥٨	٠,٦٠	٠,٥٠	٠,٥١	٠,٥٢	٠,٥٣	٠,٥٥
Sodium %	٠,١٨	٠,١٨	٠,١٨	٠,١٩	٠,١٩	٠,١٨	٠,١٨	٠,١٨	٠,١٩	٠,١٩

Chlorine %	٠,٢١	٠,٢٢	٠,٢٢	٠,٢٢	٠,٢٢	٠,١٩	٠,٢٠	٠,٢١	٠,٢٢	٠,٢٣

C/P* :Energy to protein ratio.

RESULTS

Production Efficiency Indicators:

Growth rate and feed conversion ratio (FCR) are key factors that determine the efficiency of poultry production. Even minor improvements in these parameters can significantly reduce feed consumption and increase overall profitability.

Feed Intake and Feed Conversion Ratio (FCR):

Table (9) presents the weekly and cumulative feed intake per bird, weekly and cumulative feed conversion ratios, FCRs for the starter and finisher phases, and mortality rates.

- **Starter Phase (Days 0–21):**
  The highest average feed intake was recorded in Group 3 at 1,138 g/bird, while the lowest was in Group 5 at 1,025 g/bird.

- **Finisher Phase (Days 22–42):**
  Group 1 had the highest average feed intake at 3,380 g/bird, while the lowest was in Group 3 at 3,135 g/bird.
- **Total Feed Intake (Days 0–42):**
  At the end of the experiment, the highest total feed consumption was in Group 1 at 4,511 g/bird, and the lowest was in Group 4 at 4,249 g/bird.

Feed Conversion Ratio (FCR):

- **Starter Phase (Days 0–21):**
  The best FCRs were in Group 1 (control) and Group 2 (5% DDGS), both at 1.24, while the worst was in Group 5 (20% DDGS) at 1.42.
- **Finisher Phase (Days 22–42):**
  The best FCR was in Group 2 (5% DDGS) at 2.14, and the worst was in Group 5 (20% DDGS) at 2.49.
- **Overall (Days 0–42):**
  The best cumulative FCR was again in Group 2 (5% DDGS) at 1.64, while the worst was in Group 5 (20% DDGS) at 1.92.

Age (week)	Amount of Feel consumed per bird					Conversion factor				
	G1	G2	G3	G4	G5	G1	G2	G3	G4	G5
	Control	DDGS ٪٥+ enzyme	DDGS ٪١٠+ enzyme	DDGS ٪١٥+ enzyme	DDGS ٪٢٠+ enzyme	Control	DDGS ٪٥+ enzyme	DDGS ٪١٠+ enzyme	DDGS ٪١٥+ enzyme	DDGS ٪٢٠+ enzyme
First	١٧٠	٦٢	١٧٠	١٥٣	١٥٠	١,٠٤	١,٠٣	١,٠٩	١,٢١	١,٢٩
Second	٣٤٦	٣٤٤	٣٥٨	٣٥٠	٣٦٠	١,٢٩	١,٣٠	١,٣١	١,٣٥	١,٣٧

Table 4: Summarizes feed intake and feed conversion ratios.

Third	٦١٥	٦٠٥	٦١٠	٥٥٥	٥١٥	١,٤٠	١,٤٠	١,٤٥	١,٥٤	١,٦١
Fourth	٩٥٠	٨٩٣	٨٩٥	٨٢٠	٨٤٣	١,٦١	١,٥٨	١,٦٣	١,٦٧	٢,١٦
Fifth	١٠٧٠	١٠٣٥	٩٨٠	٩٦٠	٩٦٠	٢.00	٢.00	٢.00	٢,٢0	٢,٣0
Sixth	١٣٦٠	١٤٠٦	١٢٦٠	١٤١٠	١٤٤٠	٢,٣١	٢,٣١	٢,٢٩	٢,٣٩	٢,٤٦
The first stage	١١٣١	١١١١	١١٣٨	١٠٥٩	١٠٢٥	١,٢٤	١,٢٤	١,٢٨	١,٣٧	١,٤٢
The second stage	٣٣٨٠	٣٣٣٤	٣١٣٥	٣١٩٠	٣٢٤٣	٢,٣٢	٢,١٤	٢,١٩	٢,٢٧	٢,٤٩
Cumulative	٤٥١١	٤٤٤٥	٤٢٧٣	٤٢٤٩	٤٢٦٨	١,٦٦	١,٦٤	١,٦٦	١,٧٧	١,٩٢
Mortality rate	٪٢	٪٤	٪٢	٪٢	% ٢	٪٢	% ٤	% ٢	٪٢	٪٢

Weight gain

	G1	G2	G3	G4	G5
	Control	**DDGS ٪٥+ enzyme**	**DDGS ٪١٠+ enzyme**	**DDGS ٪١٥+ enzyme**	**DDGS ٪٢٠+ enzyme**

Starter Phase (Days 1–7):
Chicks fed 5% DDGS achieved weights comparable to the control group, with no significant differences. However, those fed diets containing 10%, 15%, and 20% DDGS showed reduced body weights, with statistically significant differences (P<0.05) (Table 5).

Grower Phase (Days 8–21):
Birds receiving 5% DDGS maintained weights similar to the control group, with no significant differences. Birds fed 10%, 15%, or 20% DDGS had significantly lower weights (P<0.05) (Table 5).

Finisher Phase (Days 22–42):
Birds receiving 5% and 10% DDGS had body weights comparable to the control group without significant differences. However, birds fed on 15% or 20% DDGS exhibited significantly lower body weights (P<0.05).
Birds fed 0%, 5%, or 10% DDGS achieved better feed conversion ratios (FCR) compared to those fed 15% or 20% DDGS. Notably, in the 10% DDGS group, a reduction in chick weight was observed during the starter phase (Day 7), but these birds were better able to tolerate higher DDGS levels in subsequent growth phases (Table 5).

Table 5: Shows bird weights ± standard deviation.

First week	٢٠٦ ٦±	١٩٥ ١٠ ±	*١٨٩ ١٠ ±	*١٧١ ٤,٨ ±	*١٦١ ٦,٤ ±
Second week	٥١٤ ٦ ±	٥٠٩ ٤ ±	*٥٠٦ ٨ ±	*٤٩٨ ٨ ±	*٤٥٠ ١٤ ±
Third week	٩٦٧ ٣٣ ±	٩٧١ ٢٢ ±	*٩٥٢ ١٨ ±	*٨٣٣ ٣٩ ±	*٧٩٠ ٢٥ ±
Fourth week	١٥٦٥ ٢٧ ±	١٥٣٧ ٦١ ±	١٥٠٠ ٤٣ ±	*١٣٢٥ ٤٠ ±	*١١٨٠ ٦٤ ±
Fifth week	٢١٣٥ ٨٢ ±	٢١٠٠ ٢١٢ ±	٢٠٣٠ ١٠٤ ±	*١٨٠٥ ٣٧ ±	*١٦٣٣ ٧٤ ±
Sixth week	٢٧٢٥ ١٦٦ ±	٢٧٠٠ ١٤٧ ±	٢٥٨٠ ١٢٨ ±	*٢٣٩٥ ٩١ ±	*٢٢٢٣ ٨٩ ±

*) indicates statistically significant differences (P<0.05) between the treatment group and the control in the same row.

In the first week, the average live weight ranged from 161 to 206 grams, with the highest weights recorded in Group 1 (control) (Table 5 and Chart 1). Chart 1 also indicates that the lowest weights were observed in Group 5, which received a diet containing 20% DDGS + enzymes. In the second week, average weights varied between 450 and 514 grams, again with Group 1 showing the highest values. The lowest weights were in Group 5 (20% DDGS + enzymes) (Table 5 and Chart 2).

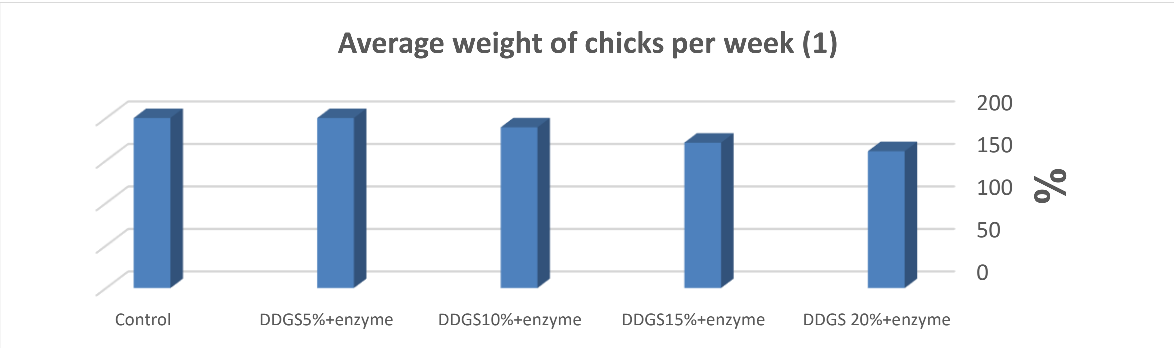

Chart No. (1) Average weights of chicks in week (1).

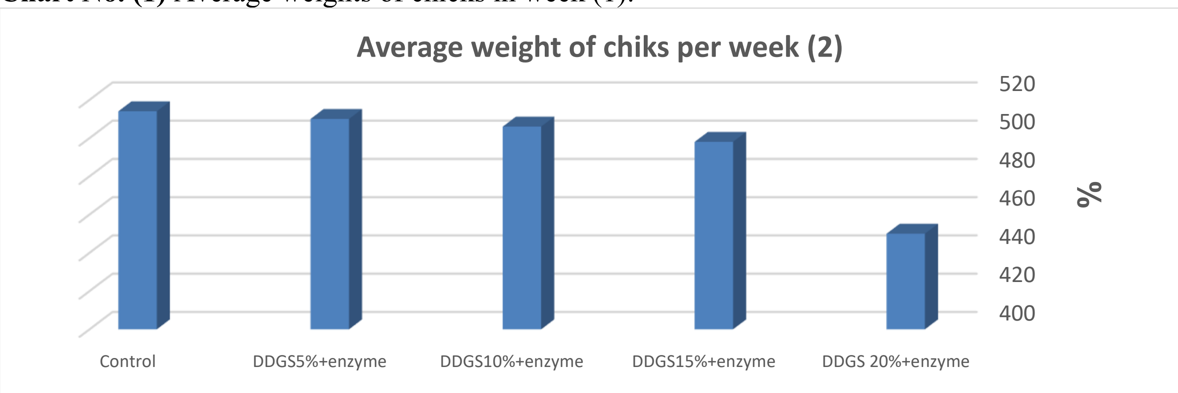

Chart No. (2) Average weight of birds per week (2)

In the third week, weights ranged from 790 to 986 grams, with Group 1 maintaining the highest average weight. Group 5 had the lowest weights (Table 5 and Chart 3). In the fourth week, average weights ranged from 1,181 to 1,565 grams, with Group 1 outperforming the others. Group 5 had the lowest average weight (Table 5 and Chart 4).

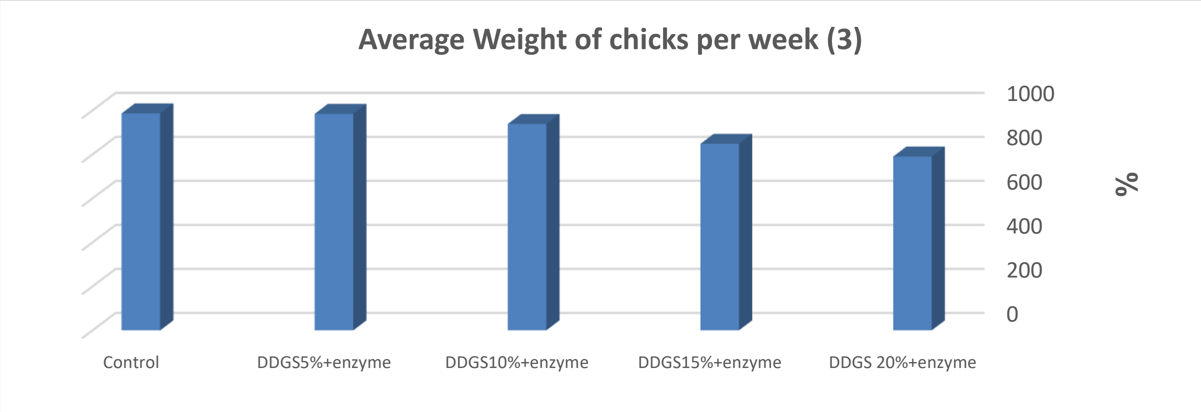

Chart No. (3) Average weight of birds per week (3)

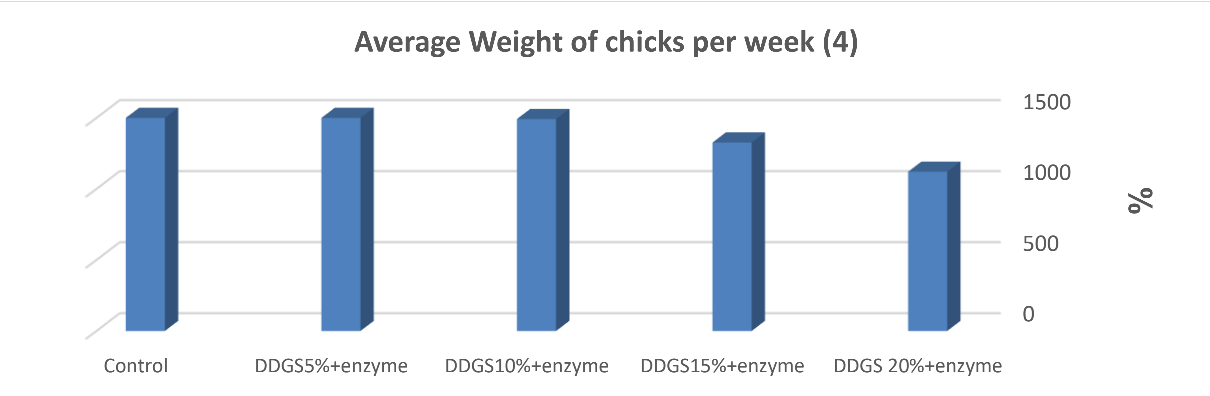

Chart No. (4) Average weight of birds in week (4)

In the fifth week, weights ranged from 1,633 to 2,173 grams, with Group 1 again showing the best results. Group 5 recorded the lowest weights (Table 5 and Chart 5). By the sixth week, final weights varied between 2,223 and 2,841 grams, with Group 1 maintaining the highest average. Group 5 (20% DDGS + enzymes) had the lowest overall weights (Table 5 and Chart 6).

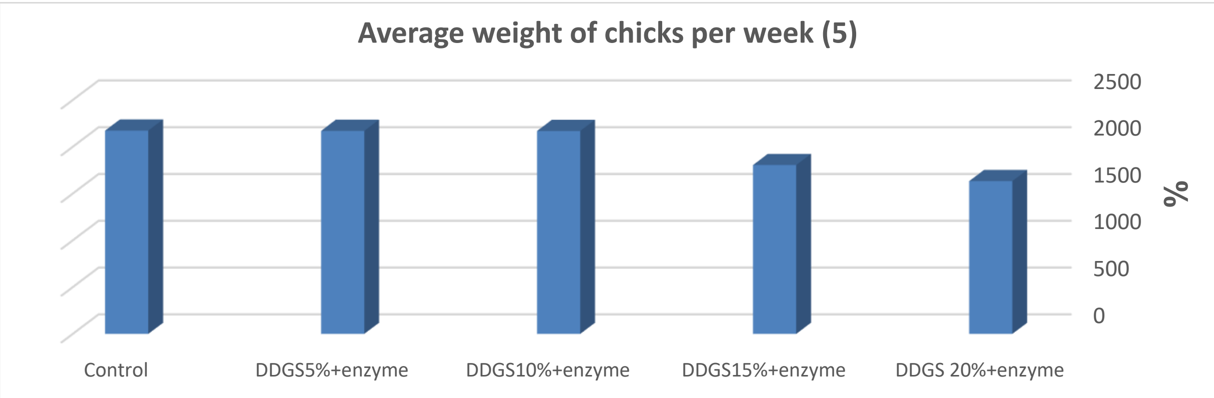

Chart No. (5) Average weight for week (5).

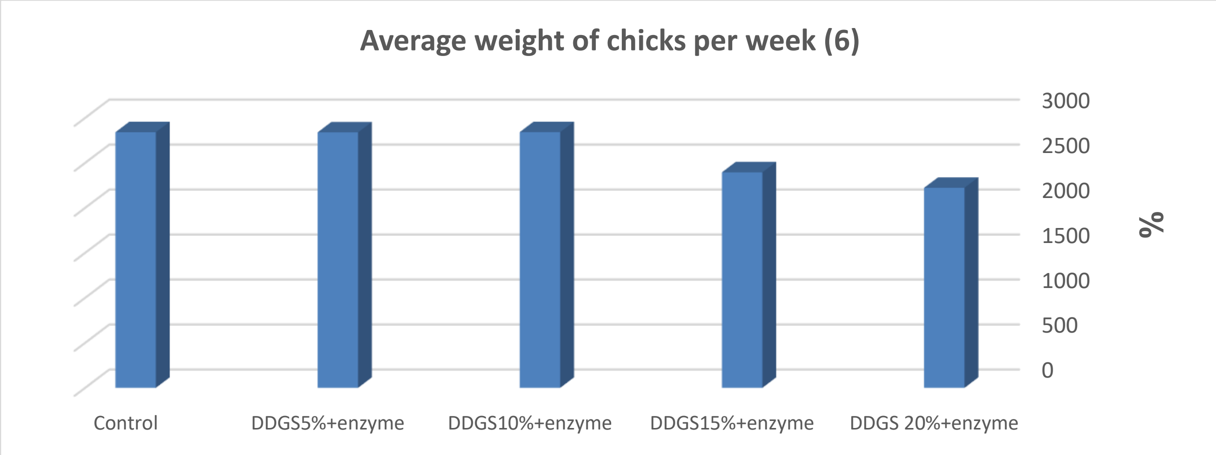

Chart No. (6) Average weight of birds for week (6)

Carcass Trait Measurements:
Carcass measurements were conducted at the end of the experiment (week six). Ten birds (five males and five females) were randomly selected. Each bird was weighed live, fasted for 12 hours, and then slaughtered following the method of Beukovic *et al.* (2012). The carcass yield, breast meat, and thigh meat were recorded after deboning. The weights of breast and thigh meat were adjusted to the live weight to allow accurate comparison between birds. Additionally, the liver, heart, and abdominal fat were weighed using a precision electronic scale (±0.001 g), and their relative weights were calculated as follows:

Relative organ weight (%) = (Organ weight / Live weight) × 100

Carcass Yield:
Birds in Groups 1 (control) and 2 (5% DDGS) had significantly higher carcass yields compared to other groups (P<0.05). The lowest average yield was in Group 5 (73.1%), and the highest was in Group 1 (76.6%). Carcass yield decreased in birds fed diets containing 15% and 20% DDGS (Table 6, Chart 7).

Breast Percentage:
Groups 1 and 2 showed significantly higher breast percentages (29.2%) than the other groups (P<0.05). Group 5 had the lowest average (26.3%). Breast percentage declined in groups fed 15% and 20% DDGS (Table 6, Chart 8).

Table No. (6) shows the percentage of carcass parts

Percentage	Group 1	Group 2	Group 3	Group 4	Group 5
Clearing %	76.5 ±0.42	76.6 ±0.18	76.3* ±0.12	74.3* ±0.26	73.1* ±0.24
Chest %	29.2 ±0.2	29.2 ±0.1	28.3* ±0.2	26.6* ±0.1	26.3* ±0.4
Upper thigh %	15.5* ±0.13	15.7* ±0.08	16.3 ±0.15	16.8 ±0.16	17.0 ±0.18
Lower thigh % (pin)	13.1 * ±0.13	13.3* ±0.15	13.9 ±0.12	14.4 ±0.19	14.6 ±0.27
Upper leg meat % (cutlet meat)	12.5* ±0.14	12.7* ±0.06	13.3 ±0.11	13.5 ±0.14	13.8 ±0.09
Lower leg meat (pin meat) % (drumstick meat)	9.3* ±0.09	9.4* ±0.12	9.8 ±0.05	9.9 ±0.12	10.0 ±0.08
Fat%	2.9* ±0.07	3.0* ±0.05	3.2 ±0.08	3.5 ±0.14	3.6 ±0.10
Liver %	2.3* ±0.24	2.4* ±0.14	2.7 ±0.19	2.8 ±0.07	2.9 ±0.12
Heart %	0.94 ±0.07	0.95 ±0.07	0.97 ±0.04	0.97 ±0.04	0.98 ±0.03

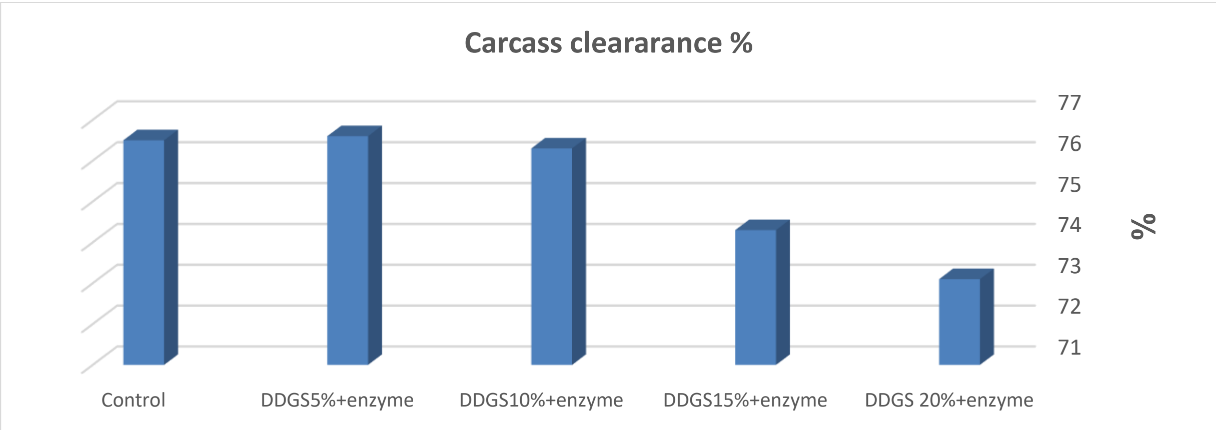

Chart No. (7) Show the percentage of carcass purity %

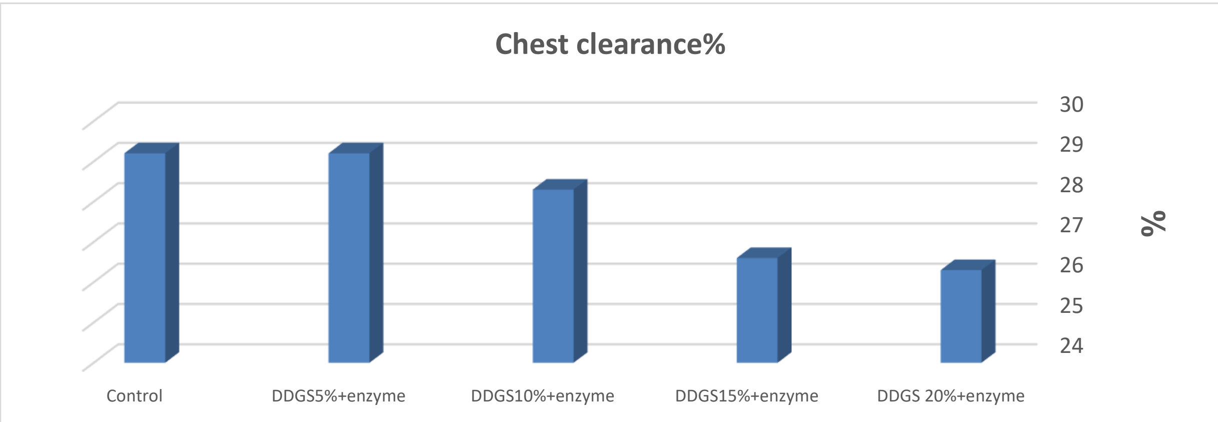

Chart No. (8) Show the percentage of chest clearance %

Upper Thigh Percentage (Thigh Cutlet): Groups 1 and 2 again had significantly lower percentages (P<0.05), with Group 1 at 15.5% and Group 5 at 17%. Thigh cutlet percentages increased with higher DDGS inclusion (Table 6, Chart 9).

Lower Thigh Percentage (Drumstick): Groups 1 and 2 had significantly lower percentages compared to the other groups (P<0.05). Group 1 had the lowest average (13.1%), and Group 5 had the highest (14.6%). Drumstick percentage increased in birds fed 15% and 20% DDGS (Table 6, Chart 10).

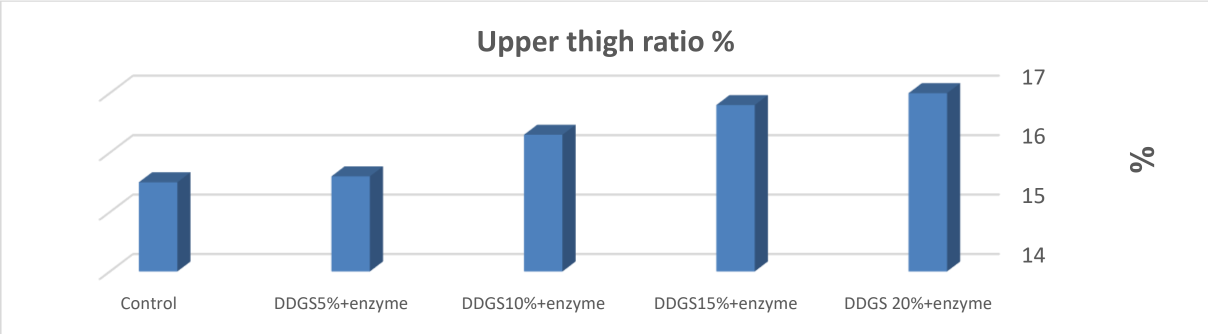

Diagram No. (9) Shows the percentage of lower thigh (pin) %

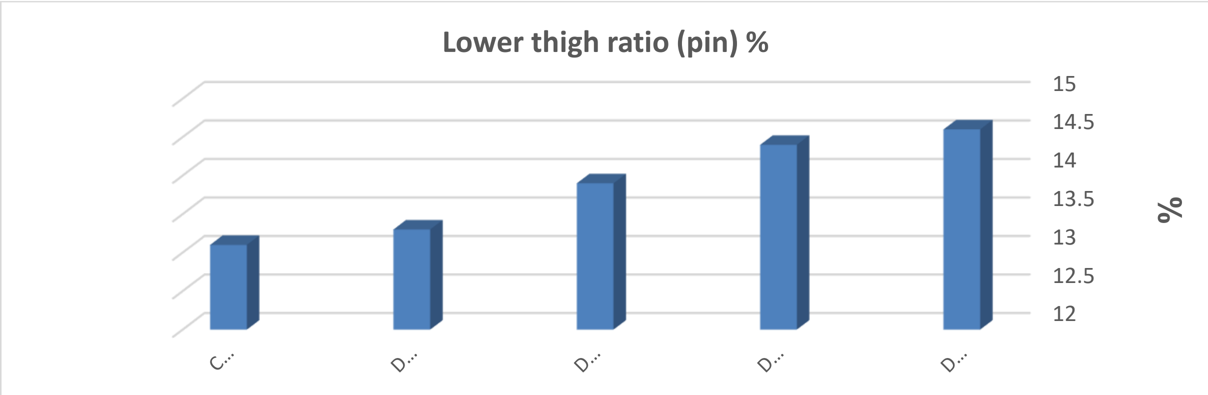

Chart No. (10) shows the upper thigh percentage %

Upper Thigh Meat: Similar trends were observed with Group 1, showing the lowest meat yield (12.5%) and Group 5 the highest (13.8%). Birds fed 15% and 20% DDGS showed increased thigh meat percentages (Table 6, Chart 11).

Lower Thigh Meat (Drumstick Meat): Group 1 had the lowest percentage (9.3%) and Group 5 the highest (10%). A significant increase in lower thigh meat was observed with higher DDGS levels (P<0.05) (Table 6, Chart 12).

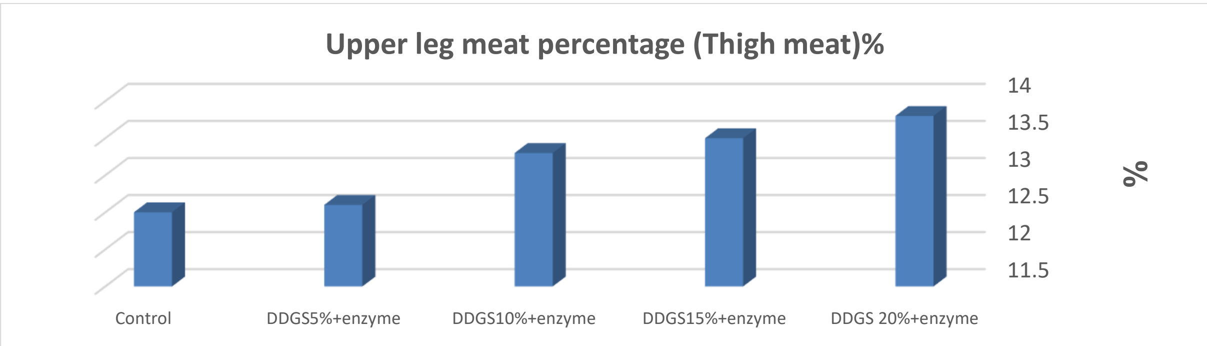

Chart No. (11) shows the percentage of upper thigh meat %

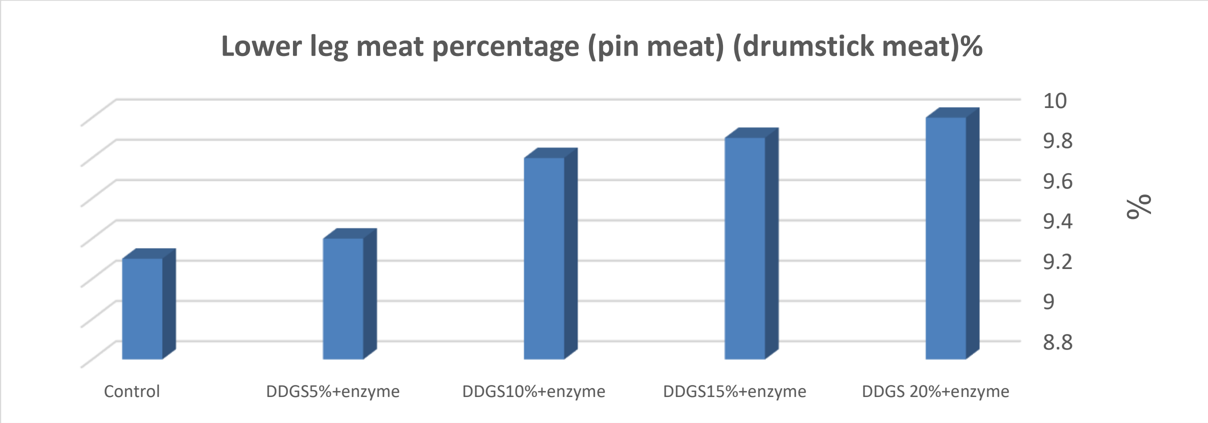

Chart No. (12) shows the percentage of lower leg meat (pin meat) %

Fat Percentage:
Birds in Groups 1 and 2 had significantly lower fat percentages (2.9%) compared to Group 5 (3.6%) (P<0.05). Fat deposition increased in diets with 15% and 20% DDGS (Table 6, Chart 13).

Liver Percentage:
The liver percentage was lowest in Group 1 (2.3%) and highest in Group 5 (2.9%), with significant differences (P<0.05) (Table 6, Chart 14).

Heart Percentage:
No statistically significant differences were found among the groups (P>0.05). The lowest value was in Group 1 (0.94%) and the highest in Group 5 (0.98%)—a numerical, not statistically different (Table 6, Chart 15).

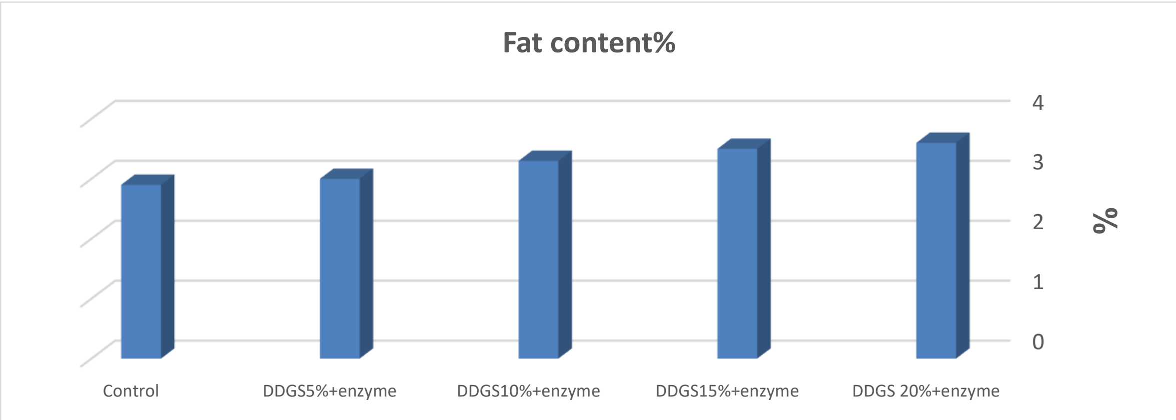

Chart No. (13) shows the percentage of fat purity %

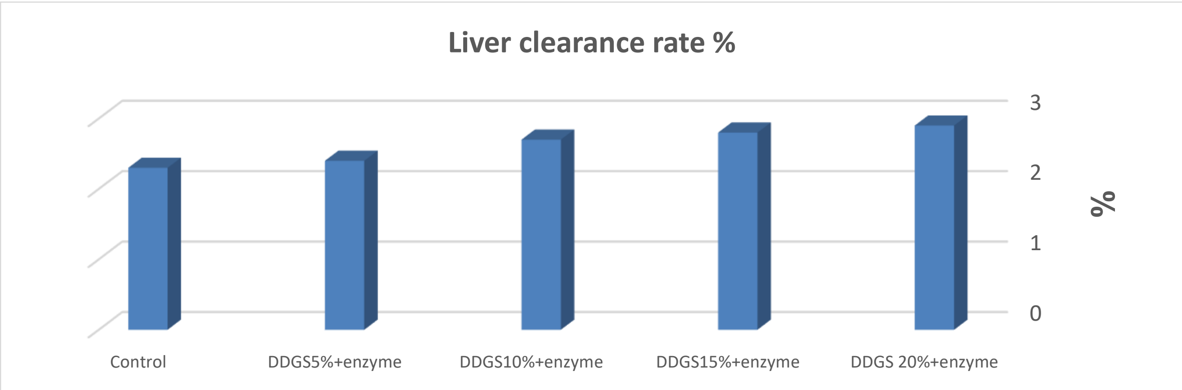

Chart No. (14) shows the percentage of liver purification %

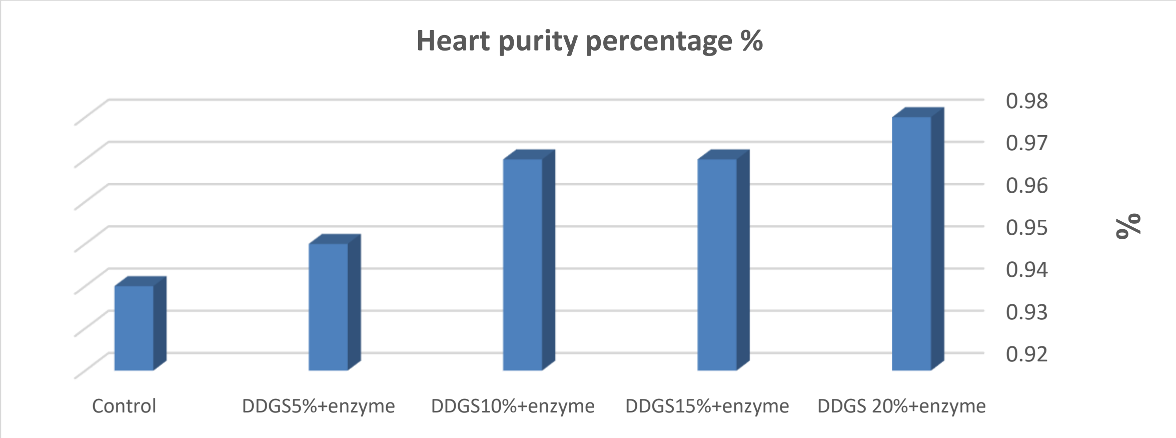

Chart No. (15) shows the percentage of heart purity %

DISCUSSION

In our study, during the starter and grower phase in the first 3 weeks, chicks fed 5% DDGS achieved weights comparable to the control group. However, higher doses showed significantly reduced body weights. In the Finisher Phase (Days 22–42), birds adapted the 10% DDGS and had body weights comparable to the 5% and the control group. However, birds fed 15% or 20% DDGS exhibited significantly lower body weights (P<0.05). The control group and birds fed 5%, or 10% DDGS achieved better feed conversion ratios (FCR) compared to those fed 15% or 20% DDGS. Similar results had been reported before in case of lower DDGS inclusion level (8%) in broiler diets, where no significant differences were noticed among the groups in terms of body weight, feed consumption, or feed conversion efficiency (Loar *et al.,* 2010). Our study supported the adverse effects of higher doses, as reported by Wang *et al.,* (2007), who reported that the control and 15% groups significantly outperformed the third group (30%) in terms of body weight, feed intake, and feed conversion ratio at 42 days of age. However, another study reported that using four levels of DDGS in broiler (Cobb 500) diets did not result in any significant differences in body weight, feed intake, or feed conversion ratio (Cheon *et al.,* 2008).

Lumpkins *et al.* (2004) conducted two experiments evaluating DDGS inclusion in broiler diets. In the first experiment, DDGS was included at levels of 15% from day 1 to day 18, and no significant differences were observed in body weight or feed conversion. In the second experiment, birds were fed DDGS at 6%, 12%, and 18% from day 1 to day 42. No significant differences were found in production efficiency or carcass characteristics, except when birds were fed 18% DDGS during the starter phase, which resulted in a slight lysine deficiency. The authors recommended maximum inclusion levels of 9%, 12%, and 15% for starter, grower, and finisher diets, respectively. Wang *et al.* (2007b) reported that DDGS inclusion ranging from 5% to 25% in broiler diets resulted in similar body weight gains at days 14, 35, and 49. However, feed conversion was poorer in diets containing 25% DDGS at days 35 and 49.

Wang *et al.* (2007b) formulated broiler diets based on amino acid content, incorporating DDGS at levels of 5%, 10%, 15%, 20%, and 25% from day 1 to day 49. Their results indicated that inclusion levels between 15% and 20% had no adverse effects on performance. Liu *et al.* (2010) observed that including 20% DDGS during the grower-finisher phase (days 22–42) led to a decrease in feed conversion efficiency.

Our findings are consistent with previous studies. Wang *et al.* (2007b) formulated diets containing 5%, 10%, 15%, 20%, and 25% DDGS, and birds fed DDGS showed slightly lower carcass and breast meat yields compared to non-DDGS diets. Similar trends were also reported by Jean *et al.* (2024), who examined graded levels of DDGS (4%, 8%, 12%, and 16%). This aligns with the findings of Salih and Abudabos, (2018), who used 6% DDGS in the starter phase and 12% in the grower phase, reporting comparable results, such as lower carcass and breast meat percentages and higher thigh, liver, fat, and heart weights in birds fed DDGS.

Although the nutritive value of DDGS, its inclusion at 15% and 20% DDGS in broiler diets during both phases led to noticeable reductions in feed efficiency and body weight gain (Salih and Abudabos, 2018). Moreover, when birds were fed 18% DDGS during the starter phase, it resulted in a slight lysine deficiency. Wang *et al.* (2007a) formulated broiler diets containing two levels of DDGS (15%, and 30%) from day 0 to day 42. They reported no negative effects at the 15% inclusion level, while the 30% DDGS diet led to reduced performance due to an arginine deficiency and a low arginine-to-lysine ratio.

Some researchers recommended very low doses, such as Świątkiewicz & Koreleski (2006), where the optimal DDGS inclusion rate in broiler diets is 2% during the starter phase and 5% during the grower phase. However, Lumpkins *et al.* (2004) recommended maximum inclusion levels of 9%, 12%, and 15% for starter, grower, and finisher diets, respectively. Jung *et al.* (2009) also reported that caution should be considered when feeding broilers 9% DDGS during the starter period (0 to 21 days) due to its potential negative effects on production efficiency. Parsons and Baker (2006) concluded that 20% of soybean meal in broiler diets could be replaced with DDGS without the need for lysine supplementation. However, at 30% replacement, lysine supplementation became necessary. Cheon *et al.* (2008) conducted an experiment on Cobb-500 broilers using three DDGS inclusion levels (5%, 10%, and 15%). No significant differences in performance were observed among the groups, suggesting that up to 15% DDGS can be used in broiler diets without negatively impacting productivity.

The reduced performance at higher inclusion levels is likely due to the physiological sensitivity of young broiler chicks to feed quality. The immaturity of the digestive system during the first two weeks post-hatch makes chicks less capable of efficiently digesting high-fiber and low-amino-acid-availability ingredients such as DDGS (Batal and Parsons, 2002).

Conclusions and Recommendations:

No health risks were observed in broiler chickens during the course of the study. Based on the experimental results, particularly feed conversion ratios (FCR) and body weight gains. In addition, the DDGS can be safely incorporated into broiler diets at 5% during the starter phase and 10% during the second phase without negatively affecting performance.

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تأثير إضافة الذرة المقطرة مع الذوائب الجافة (DDGS) والانزيمات على الكفاءة الإنتاجية ومواصفات الذبيحة عند دجاج اللحم

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تهدف هذه الدراسة إلى دراسة تأثير إضافة (DDGS) مع الانزيمات على الكفاءة الإنتاجية، حيث تم تربية ٢٥٠ كتكوت (روس ٣٠٨) من عمر ٠-٤٢ يوماً دون تمييز الذكورعن الاناث. تم خلالها تركيب ٥ خلطات علفية، تتألف من الذرة الصفراء وكسبة فول الصويا ٤٦ % وDDGS والمتممات العلفية الأخرى، تتساوى هذه الخلطات من حيث قيم البروتين والمتممات العلفية الأخرى، وتختلف فيما بينها بوجود نسب مختلفة من DDGS حيث احتوت على ٥ مستويات من DDGS (٠، ٥، ١٠، ١٥ و٢٠٪) مع أنزيمات ، بينت نتائج التجربة في الأسبوع الأول ان الخلطات التي تحتوي على DDGS على(١٠و ١٥ و٢٠٪) أدت إلى انخفاض في وزن الصيصان، بينما المجموعات التي تناولت DDGS بتركيز(٠ أو ٥ %) كان معامل التحويل العلفي لديها اعلى من المجموعات الأخرى. بنهاية التجربة, حققت الطيورالتي تناولت DDGS بتركيزات (٠ أو ٥ أو ١٠٪) معامل تحويل علفي أعلى مقارنةً بـ المجموعات التي تناولت DDGS بنسبة (١٥ أو ٢٠٪) ، تبين لنا من خلال هذه الدراسة أن الحد الأقصى لمستوى DDGS المستخدم في خلطات البادئ هو ٥٪، ويمكن زيادته خلال فترة النمو والإنهاء إلى ١٠٪.

الكلمات المفتاحية: نواتج تقطير الذرة،DDGS ، الانزيمات، دجاج اللحم، كفاءة إنتاجية، مواصفات الذبيحة.