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THE PRODUCTIVE PERFORMANCE, HEMATOLOGICAL PARAMETERS, AND ECONOMIC EFFICIENCY EFFECTS OF FERMENTED SOYBEAN MEAL ON BROILER CHICKS

Mohamed, M.S.[1*], A.M. Abd El-Hady[2], S.S. A. Hassan[1], W.S. Habashy[1]

[1]Animal and Poultry Production Dep., Faculty of Agriculture, Damanhour University, Egypt. [2]Poultry Production Department, Faculty of Agriculture, Alexandria University (21545), Alexandria, Egypt

[*]**Corresponding Author: E-mail:** m.sami.elsanm@agr.dmu.edu.eg

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ABSTRACT

Identifying alternative replacements for soybean meal in a high quality and reasonable price is important in poultry production and physiological parameters. The study aimed to evaluate the impact of replacing soybean meal (SBM) with fermented soybean meal (FSBM) in the diets of broiler chicks on productive performance, hematological parameters, and economic efficiency. A total of one hundred fifty 1-day-old (*Cobb 500*) male broiler chicks were randomly assigned into three experimental groups with 5 replicates each with 10 chicks per replicate. Three diets with 0.0% FSBM as control, 20% FSBM, and 40% FSBM replacement levels of SBM were formulated from the first day of their life until day 35 of age. Results pointed out that body weight (d 35), body weight gain (d 1-35), feed consumption (d 1-35), and feed conversion ratio were significantly ($P \leq 0.05$) improved in groups using FSBM compared with the control group. Furthermore, FSBM groups significantly ($P \leq 0.05$) increased the values of RBCs, Hb, PCV, and WBCs compared with 0% FSBM. The groups that had received FSBM showed a greater number of

lymphocytes compared with the control group. While the 40%FSBM group showed significantly lower heterophils compared with other groups. The 20% FSBM group was reported to have higher feed cost significantly compared with other groups. However, the 40% group had the lowest body weight cost compared with other groups. The use of 40% FSBM group has made the highest total revenue. Notably, group 40% was greater in net revenue, economic efficiency, and European production efficiency index. In conclusion, replacing SBM with 40% FSBM in broiler chicks' diet as a source of protein had a considerably positive impact on growth performance, feed conversion ratio, hematological parameters, and economic efficiency at 35 d of old.

Keywords: Broiler, Fermented soybean meal, Performance, Hematological, Economic efficiency

INTRODUCTION

Soybean meal (SBM), a by-product of soybean oil extraction, is the most widely used source of feed protein in livestock feeds. However, there is a popular anti-nutritional factor (ANFs) in soybean meal, such as trypsin inhibitor (TI), non-starch polysaccharide, and soy galacto-oligosaccharide (GOS), which will limit the use of nutrients by animals (**He *et al.*, 2015**), increasing the farm animals' stress and related disease (**Irawan *et al.*, 2022**), reduces nutritional efficiency, reduced feed intake and increases the cost of feeding in the poultry industry, especially broilers (**Woyengo *et al.*, 2017**).

Several feeding practices have been developed with the goal of enhancing soybean meal utilization and producing commercial value-added by-fermentation with improved nutritional qualities (**El-Dakar *et al.*, 2023**). Fermentation, a dynamic process that combines microbes, substrates, and ambient conditions to change sophisticated substrates into simpler forms, is one of these innovative techniques (**Niba *et al.*, 2009**). Furthermore, using probiotic fermentation technology can boost the concentration of metabolites, enzymes, and probiotics in feed

(**Stanbury *et al.*, 2013**). Fermented feed application in chicken diets could improve nutritional properties by decreasing crude fiber and increasing crude protein contents (**Khempaka *et al.*, 2014; Sugiharto *et al.*, 2016**), while also eliminating many antinutritional factors and toxic components in feed ingredients (**Chiang *et al.*, 2010**). Additionally, it has phytate, which makes up more than half of the total phosphorus in SBM poorly utilized, as a result, external phosphorus must be added to satisfy the physiological needs of the birds (**Goebel and Stein, 2011**).

An example of the most promising and effective ways to overcome these problems is soybean meal probiotic fermentation (like yeast, bacteria, or Fungi) in several ways (**Irawan *et al.*, 2022**). First, yeast can break down the carbohydrates in soybean meal into simpler sugars (**Wang *et al.*, 2012**). Second, yeast can produce enzymes that can break down the anti-nutrients in soybean meal making soybean meal more digestible and nutritious (**Mukherjee *et al.*, 2016**). Third, yeast can produce vitamins and other compounds during fermentation. For example, yeast can produce vitamin B_{12}, which is an essential vitamin that is not found in many plant foods (**Kustyawati *et al.*, 2020**). Yeast fermentation can also increase the levels of other vitamins and antioxidants in soybean meal (**Mukherjee *et al.*, 2016**).

Fermented soybean meal has been studied for its potential use in broiler diets as research has shown that partially replacing traditional soybean meal with fermented soybean meal can have beneficial effects on broiler growth performance and the cecal microbiota community (**Li *et al.*, 2020**). Studies have found that substituting soybean meal with fermented soybean meal can improve the body weight of broiler chickens, especially during the starter period (**Feng *et al.*, 2007**). The specific effects on factors such as average daily gain, feed intake, and feed conversion ratio can vary depending on the microbial strains used for fermentation.

Furthermore, there is evidence that double-fermented soybean meal can completely replace soybean meal in broiler rations, resulting in favorable impacts on performance, digestibility, amino acid transporters, and meat nutritional value (**Abdel-Raheem *et al.*, 2023**). This suggests that fermented soybean meal has the potential to be a viable alternative to traditional soybean meal in broiler diets. Therefore, this study aimed to conduct a potential benefit of feeding fermented soybean meal to broiler chicks on growth performance, hematological parameters, and economic efficiency.

MATERIALS AND METHODS

The current study was conducted at a private breeding broiler chicks farm in Hosh Issa city, Beheira governorate, Egypt from August to September 2023. All data and animal care procedures were approved by the Institutional Animal and Birds Care and Use Committee in Animal and Poultry Production Department, Faculty of Agriculture, Damanhour University had approved the experimental protocol.

The authors declare that the procedures imposed on the birds were carried out to meet the Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals and birds used for scientific purposes.

Preparation of fermented Soybean meal

The soybean meal was purchased commercially from a local supplier at Damanhour City, Egypt. The SBM was ground to a particle size by screen diameter (4 mm) then distilled water was mixed with it to adjust its moisture to 50% and commercial dry yeast, *Saccharomyces cerevisiae*, was added with a cell density of 2×10^9 cell g^{-1} (LESAFFRE®, Egypt). The mixture was homogenized with a mixer for 5 minutes. After 72 hours of fermentation, fermented soybean meal was dried at 50–60° C for 48h until moisture content reached 11.8%, then stored at room temperature until use in broiler ration formulation (**Abdel-Raheem *et al.*, 2023**).

Broiler and experimental design

A total number of one hundred fifty (*Cobb* 500) one-d-old male broiler chicks were obtained from a local commercial hatchery (Alwatania Company), with mean body weight (BW) of 45.0 g chicks were individually weighed to the nearest gram. All chicks were firstly numbered and then were housed randomly in 5 replicates floor breeding pens per each experimental treatment (10 birds per breeding pen). BW and feed intake (FI) were tracked weekly considering the pen as the experimental unit. The average daily gain (ADG), and feed-to-gain ratio (FCR) were calculated weekly using the data.

Birds from the first group were fed the basic feed without FSBM as the control group (0% FSBM), while the 2nd (20% FSBM) and the 3rd (40% FSBM) groups were fed diets with replacing SBM by 20% and 40% FSBM in diet formulation, respectively. All diets were formed according to (**NRC, 1994**) nutrient recommendations of chickens for starter (1-14 days), grower (15-28 days) and finisher (29-35 days) periods, diets were formulated in **Table 1.**

Housing management

All the chicks were housed in floor pens, each pen measured 1.0 m × 1.0 m lined with fresh wood shavings and a gas heater was used to supply the heat needed for brooding, in a semi-opened ventilated system. All birds remained under the same administrative, hygienic, and environmental conditions. Birds of all experimental groups where preventative program was used to vaccinated against Newcastle via drinking water at the age of 7, 18, and 28 d of old. They were also vaccinated against Gambro at 12 days of age via drinking water were raised from the first day to 7th d together and under the same conditions. The ambient temperature reached 30-32^{o}C during the 1st week and then gradually decreased by 3^{o}C weekly for the following three weeks. During the 4th and the 5th week, the temperature was maintained at 22-24^{o}C and 53.2 to 64.5%, respectively. A similar light schedule to commercial condition was used; 23h light from 8 until 35 days of age.

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The experimental diets were fed to all the birds, *ad libtium*, and provided unlimited accessibility to fresh water. Started feeding from 1 to 14 d followed by a grower period from 15 to 28 d and followed by finisher period from 29 to 35 d. Ingredients and nutrient composition of basal feed mixtures and experimental treatments were composed and calculated in **Table 1**. All diets were formulated to meet NRC (1994) nutrient recommendations for broiler chickens.

Table 1. Composition and calculated analyses of experimental diets.

Ingredients	**Starter diet, 1-14 d of age**			**Growing diet, 15-28 d of age**			**Finishing diet, 29-35 d of age**		
Yellow corn, kg	541	547	551	601	606	610	660	663	667
Soybean meal (46% CP), kg	368	289	211	302	237	173	249	196	143
Corn gluten meal, kg	34	34	34	40	40	40	37	37	37
FSBM, kg	0	74	148	0	61	122	0	50	100
Vegetable oil[1], kg	18	17	17	19	18	17	19	19	18
Limestone, kg	15	15	15	14	14	14	12	12	12
Mono-Ca phosphate, kg	13.75	13.75	13.75	13.75	13.75	13.75	12.25	12.25	12.25
Premix[2], kg	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
NaCl, kg	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
DL-Methionine, kg	1.75	1.75	1.75	1.5	1.5	1.5	1.25	1.25	1.25
L-Lysine (HCL), kg	1.75	1.75	1.75	2.00	2.00	2.00	2.00	2.00	2.00
Threonine, kg	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00
Choline Chloride, kg	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**
CP, %	23.08	23.06	23.07	21.05	21.04	21.07	19.05	19.05	19.05
ME, kcal/kg	2925	2924	2926	3005	3005	3001	3071	3074	3072
Ca, %	0.92	0.92	0.92	0.87	0.86	0.86	0.76	0.76	0.76
Available P, %	0.44	0.44	0.44	0.43	0.43	0.43	0.40	0.40	0.40
CF, %	3.80	3.79	3.78	3.48	3.46	3.46	3.24	3.22	3.21
Methionine, %	0.55	0.55	0.55	0.50	0.50	0.50	0.45	0.45	0.45
Lysine, %	1.33	1.32	1.32	1.20	1.19	1.19	1.07	1.06	1.05

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[1] A mixture of soybean oil, cotton seed oil and sunflower at 33.33% of each. [2]Premix as Vitamin +Minerals mixture provides per kg of the diet: vitamin A (retinyl acetate) 24mg, vitamin E (dl-α-tocopherol acetate) 20mg, menadione 2.3mg, Vitamin D_3 (cholecalciferol) 0.05mg, riboflavin 5.5mg, calcium pantothenate 12mg, nicotinic acid 50mg, choline chloride 600mg, vitamin B12 10µg, vitamin B6 3mg, thiamine 3mg, folic acid 1mg, d-biotin 0.50mg. Trace mineral (mg per kg of diet): Mn 80 Zn 60, Fe 35, Cu 8, Se 0.60. ME, metabolic energy; CP, crude protein; Ca, calcium.

Data collection for productive performance

All chicks were individually weighed (g) for BW estimation at 1 d at the beginning of the experiment period and at 35 d body weight gain (BWG), chicks were not fed for 12 to 14 hours before being weighed and feed consumption (FC) of broiler chicks were recorded for each replicate at the end of the experimental period. The feed conversion ratio (FCR, g feed/ g gain) was calculated subsequently based on the body BWG and FC during the same period.

Blood constituents

At the end of the experimental period, ten chicks from each treatment (2 from each replicate) were randomly chosen at 5:00 and 6:00 Am, and about three milliliters of blood samples were collected from the brachial wing vein into vacationer tubes with K_3-EDTA (1 mg/mL) for hematological analysis.

Hematological parameters

Immediately following blood collection, it was used to estimate hematological parameters which is complete blood count. Red blood cells count (RBCs, $10^6/ml^3$) was counted by using a hemocytometer under a light microscope with 1200X magnification power, and white blood cell counts (WBCs, $10^3/ml^3$) were counted according to (**Feldman *et al.*, 2000**). Hemoglobin (Hb) concentration (g/dl) and the percentage of packed cell volume (PCV %) were measured according to (**Drew *et al.*, 2004**).

A little drop of blood was used to create a thin blood film. The Giemsa stain was used when the blood film had fully dried. The film was washed in distilled water and dried. Differential leucocyte counts were examined in each blood film by using a light microscope with 1200x magnification power. Blood WBC differential count was recorded by determining the percentages of lymphocytes (L) and heterophils (H) at 1000x magnification as described by (**Feldman *et al.*, 2000**). The ratio of the Heterophils to lymphocytes (H/L) was calculated by dividing the total count of heterophils by the total number of lymphocytes.

Economic efficiency

Live body weight (BW) at the first day (IBW), BW at the final experimental period (FBW) and FC of broiler chickens were weighed in each treatment at 1d to 35 d of age. BWG and FCR for each treatment were calculated. The mortality rate was recorded daily and with the obtained data the percentage of survival rate was calculated at the end of the experimental period.

Economic efficiency for production was calculated from the input-output analysis of the money, based on the differences in both growth rate and feeding costs. For analysis of performance indicators such as: BW, BWG, FC, FCR, survival rate, net revenue, total revenue, total feed cost, economic efficiency, and relative economic efficiency were used as following formulas:

BWG (g) = FBW (g) - IBW (g)

FCR (kg feed/ kg gain) = Cumulative FC (kg)/ Total BWG (kg).

Survival (%) = (Chicks remaining at the end of experimental period / Total chicks numbered at beginning experimental period) x 100.

Economic efficiency for production was calculated from the input-output analysis of the money, based on the differences in both growth rate and feeding cost. The value of economic efficiency was calculated as net revenue per unit of total feed costs. The prices of the experimental diets and live body weight were calculated according to the prices with the local Egyptian pound (L.E.) market at the time of the experiment period in August of the year 2023.

Net revenue (C) = Total revenue (A) – Total cost (B).

Total revenue (A, the selling cost of the obtained gain) = BWG × Price per kg BW

Total cost (B, the cost of this gain) = Total FC (D) + Purchase price of chicks+ other cost (E)

Total feed cost (D) = Total FC/ kg (total feed consumption) x Price per kg FC.

Other cost (E) = Petty cash and heating expenses

Economic efficiency (EE) (%) = (C/B) ×100.

European production efficiency index (EPEI): The equation used to calculate EPEI is as follows:

$$EPEI = \frac{(\text{Final live body weight (kg)} \times \text{\% survival rate}) \times 100}{\text{Feed conversion ratio} \times \text{age at the end period (day)}}$$

Statistical analyses

Statistical. analysis was performed using the general linear models (GLM) procedure of the statistical analysis software of SAS. Institute (**SAS, 2009**) by employing one-way analysis of variance (ANOVA) according to the following formula:

$Y_{ij} = \mu + F_i + e_{ij}$, where Y_{ij} is the dependent of the statistical variable, μ is the overall mean; F_i is the effect of FSBM treatments, and e_{ij} is the experimental random error. All statements of significance were based on $P \leq 0.05$.

RESULTS

Growth performance

The effects of FSBM on the initial at 1 d and final at 35 d BW, BWG, FC, FCR, and survival rate (SR) from 1 to 35 d of old broiler chicks are presented in **Table 2**. Data showed no difference in the initial BW of broiler chicks at the start of the experimental period. FSBM groups had significantly ($P \leq 0.05$) increased the final BW at d 35, BWG, and FC compared with the control group. Treatment 40% FSBM showed greater final BW and BWG at 35 d compared with 20% FSBM and basal diet as the control group. The 20% FSBM group increased FC with other treatments. With no difference in FC between 40% FSBM and control groups, the 40% FSBM broiler chicks showed the best FCR compared with the 0% FSBM group. All of the treatments were within a normal percentage of mortality rate with no abnormal symptoms.

Table (2). Effect of fermented soybean meal on body weight, body weight gain, feed consumption, and feed conversion ratio of broiler chicks.

Items	**FSBM (%)**			SEM	***P*- value**
	0	**20**	**40**		
BW at 1d, g	45.26	45.20	44.77	0.278	0.738
BW at 35d, g	2075^{b}	2245^{a}	2296^{a}	20.39	0.001
BWG from 1 to 35d, g	2030^{b}	2200^{a}	2251^{a}	20.41	0.001
FC from 1 to 35d, g	2856^{b}	3020^{a}	2936^{ab}	19.70	0.006
FCR ratio	1.41^{a}	1.37^{a}	1.31^{b}	0.010	0.001
SR, %	100	100	100	-	-

Means within the same row with different superscript letters are significantly different at $P \leq 0.05$. FSBM, fermented soybean Meal; SEM, standard error of mean; BW, body weight; BWG, body weight gain; FC, feed consumption; FCR, feed conversion ratio.

Hematological parameters

The data presented in **Table 3** illustrates the effect of FSBM on RBCs, Hb, PCV, WBCs, lymphocyte, heterophils, and H/L ratio values at 35 days old broiler chicks. The results pointed out a significant increased (*P*≤ 0.05) in the values of RBCs, Hb, and PCV% in the group that received 40% FSBM compared with 20% FSBM group or the control group. Both FSBM groups 20% and 40 % had higher WBCs count compared with the control group. While the 40% FSBM group showed a significantly lower heterophils compared with other groups. However, the FSBM groups showed a significantly higher percentage of lymphocytes compared with the control group. On the other hand, 40% FSBM was lower significant level of H/ L ratio compared with other groups. Data of hematological parameters showed improved RBCs, Hb, and PCV% values by 13.95, 23.60, and 23.90%, respectively in the high level of FSBM-treated broiler chicks group compared with the control group. The haematological analysis showed that the diet with fermented soybean meal, especially the 40% FSBM treatment, had a positive impact on red blood cell parameters.

Table 3: Effect of fermented soybean meal on hematological parameters of broiler chicks at 35 days of age

Items	**FSBM (%)**			SEM	***P*- value**
	0	**20**	**40**		
RBCs, 10^6/mm^3	2.15^c	2.29^b	2.45^a	0.023	0.001
Hb, g/dI	10.51^c	12.39^b	12.99^a	0.193	0.001
PCV, %	33.18^c	39.04^b	41.11^a	0.662	0.001
WBCs, 10^3/mm^3	33.57^b	36.62^a	36.73^a	0.357	0.001
Lymphocytes, %	39.51^b	40.40^a	40.46^a	0.123	0.001
Heterophils, %	27.83^a	27.40^a	26.58^b	0.153	0.001
H/L ratio	0.70^a	0.68^b	0.66^c	0.005	0.001

Means within the same row with different superscript letters are significantly different at $P \leq 0.05$. FSBM, fermented soybean Meal; SEM, standard error of mean; RBC, red blood cells; Hb, hemoglobin; PCV, packed cell volume; WBC, white blood cells; H/L ratio, heterophile to lymphocytes ratio.

Economic efficiency

The results in **Table 4** indicated that the effect of FSBM on FC cost, BW cost, total revenue, net revenue, economic efficiency (EE), and EPEI. Data showed that FC cost of broiler chicks fed dietary 20% FSBM was significantly higher than other groups. However, the BW cost of chicks fed FSBM was decreased than the control group. The birds fed 40% FSBM group of the diet had the lowest BW cost by 8.13% than that of birds fed control diet. Birds fed 40% FSBM of the diet had higher total revenue, Net revenue, EE, and EPEI by 10.64, 25.99, 23.78, and 19.29% than that of birds fed the control diet.

Table 4: Effect of fermented soybean meal on Economic efficiency of broiler chicks

Items	**FSBM (%)**			SEM	***P*- value**
	0	**20**	**40**		
FC cost, L.E	63.11^{b}	66.43^{a}	64.44^{b}	0.421	0.016
BW cost, L.E/ kg Bw	39.08^{a}	37.62^{b}	35.94^{c}	0.283	0.001
Total revenue, L.E	128.66^{b}	139.20^{a}	142.35^{a}	1.263	0.001
Net revenue, L.E	47.55^{c}	54.76^{b}	59.91^{a}	1.084	0.001
EE, %	58.70^{c}	64.89^{b}	72.66^{a}	1.260	0.001
EPEI	422^{c}	468^{b}	503^{a}	7.223	0.001

Means within the same row with different superscript letters are significantly different at $P \leq 0.05$. FSBM = Fermented soybean Meal; SEM = standard error of mean; FC=Feed Cost; BWC=Body Weight Cost; EE=Economic efficiency EPEI= European production efficiency index.

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DISCUSSIONS

Growth performance

In our study is worthy to note that the inclusion of FSBM instead of soybean meal in broiler chick's rations triggered better feed efficiency and hematological parameters that improved the birds' weight gain, nutrient digestibility, and muscle nutritional value. **Feng *et al.* (2007)** discovered that chicks fed FSBM had a higher average daily growth than chicks given SBM. **Kim *et al.* (2016)** revealed that dietary treatments had no effect on BW during the starting period, but that BW after 14 days was considerably greater in broiler chicks given 3% FSBM. Higher levels of FSBM (9% and 10%) in the diet of turkeys boosted development performance and had a favorable effect on the histology of the small intestine, according to (**Chachaj *et al.*, 2019**).

Soumeh *et al.* (2019) found that FSBM treatment improved body weight gain for the entire grow-out period of chickens. Furthermore, **Li *et al.* (2020)** noticed that replacing 25% of the SBM in the diet promoted average daily gain during the growth and whole phases of broiler chickens. More research is needed to support the use of double-fermented soybean meal (DFSBM) as a complete replacement for SBM, as the quality of fermented feed is heavily influenced by the microbiological load and enzymatic activity that occurs during fermentation (**Ibrahim *et al.*, 2020**).

Our obtained results were in accordance with those of other research carried out by **Abdel-Raheem *et al.* (2023)** who found that broiler chickens fed higher levels of DFSBM had increased growth performance and apparent nutritional digestibility, including phosphorus and calcium, as well as pancreatic digestive enzyme activity. When compared to the control group, those fed 50 and 100% DFSBM had considerably higher final body weight and weight gain. The improvement in growth in chicks fed some FSBM is most likely due to a decrease in anti-nutritional factor content or changes in peptide size caused by fermentation. Soybean proteins are transformed during fermentation into more readily available, low molecular weight, watersoluble peptides. This procedure decreases trypsin inhibitors, phytic acid, oligosaccharides, and allergenic proteins, all of which interfere with nutrient digestion, absorption, and utilization (**Liu *et al.*, 2017**).

The post-extraction fermentation procedure of soybean meal, which was employed to make our mix, reduced the quantity of trypsin inhibitors (**Chachaj *et al.*, 2019**). Growth enhancement may also be ascribed to favorable changes in the microbial makeup of the gastrointestinal tract. **Kim *et al.* (2007)** observed that feeding fermented soybean meal at 3% during the early phase positively improved the future development performance in broiler chickens. While **Cheng *et al.* (2019)** found that FSBM supplementation in the diet did not influence broiler chicken development performance. **Wu *et al.* (2020)** found no significant difference in chick final weight between treatments fed 5%, 10%, and 15% FSBM and control groups. Furthermore**, Guo *et al.* (2020)** discovered that including FSBM at 2.5%, 5%, and 7.5% in broiler diets did not affect final body weight. However, **Wu *et al.* (2020)** discovered that at 21 days of age, the final weights of birds given 5%, 10%, and 15% FSBM were lower than those of chicks fed 0% FSBM.

Hematological parameters

In the current experiment, FSBM outperformed SBM and gave superior features. According to the haematological investigation, the fermented soybean meal diet, specifically the 10% FSBM therapy, improved red blood cell parameters, as evidenced by an increase in RBC count, Hb level, and PCV value (**Chachaj *et al.*, 2019**). **Zakaria *et al.* (2022)** discovered that fish fed fermented soybean meal had considerably greater (p 0.05) RBC and WBC. **Taufek *et al.* (2016)** attribute the elevated WBC to an increase in antigen in the circulatory system. Increased WBC and RBC levels in the circulatory system can improve oxygen transport capacity and promote animal immune systems (**Abdul Kari *et al.*, 2021**). Furthermore, the immunostimulatory effects of FSBM are visible due to higher WBC in the 40% FSBM diet group, which is compatible with their growth metrics. As a result, FSBM supplementation improved haematological markers in broiler chicks, resulting in improved growth performance and health conditions. **Czech *et al*. (2021)** discovered that the haemoglobin content and white blood cell counts in the blood of piglets fed 8% dried fermented soybean meal were significantly higher than in the control group. However, there were no significant variations in erythrocyte counts or % Ht across groups. The increased number of red blood cells may be due to the availability of iron, which is the main element in the formation of red blood cells, in broiler chicks fed a 40% FSBM diet were positively associated with increased blood haemoglobin content when compared to the control group.

Economic efficiency

In chicken production, dietary FSBM has been linked to higher net income and a higher European production efficiency index. Because feed expenses account for 70-80% of broiler raising costs, enhancing the nutritional quality of the feed may reduce production costs or increase feed efficiency (**Louw *et al.*, 2013**). A prior study found that FSBM improved economic efficiency (**Feng *et al.*, 2020**), indicating that adding FSBM to finishing pig feed accelerated their growth to some extent. In finishing pigs given FSBM, the FCR was reduced by 0.16%, which would help to lower animal production expenses and increase economic efficiency. Microbial fermentation with bacillus, lactobacillus, and yeast has also been shown to raise SBM protein content from 8.2% to 18.9% (**Li *et al.*, 2020**), as well as eliminate antinutrient compounds and improve nutrient utilization (**Shi *et al.*, 2017**). These positive benefits improved broiler growth performance, feed efficiency, and economic efficiency. Furthermore, **Ibrahim *et al.* (2021)** demonstrated that groups fed 7.5 and 15% enzymatically fermented olive pomace (FOPII) obtained the highest net profit and profitability ratio as well as the lowest cost feed/kg body gain. The findings of this study suggested that including 15% FOPII in the diet of broiler chickens could improve their growth performance and economic efficiency. Furthermore, fermentation is a cost-effective method for improving the nutritional content of innovative unconventional feed ingredients as well as improving immunological function and growth performance in broiler chickens (**Sugiharto and Ranjitkar, 2019**). Exogenous enzymes added during fermentation could also increase chicken production efficiency by boosting the digestion of low-quality products and lowering nutrient waste, with likely economic benefits (**Costa *et al.*, 2008**). Furthermore, broilers fed 10% fermented dried brewer grains outperformed the control group in terms of economic efficiency (**Al-Khalaifah *et al.*, 2020**). Thus, utilizing low-cost economical feed for broiler chicks, such as fermented soybean meal, could compensate for the negative effects of increased traditional diet prices and improve economic efficiency. **Mohamed *et al.*, (2021**) discovered that 2% FSBM had a positive influence on bird growth performance while being economically efficient. Our findings showed that 40% FSBM had a positive effect on bird growth performance while also being economically efficient.

Conclusion

The findings of this study demonstrate that replacing soybean meal (SBM) with fermented soybean meal (FSBM) at a 40% inclusion level significantly enhances broiler performance, hematological parameters, and economic efficiency. Broilers fed diets containing 40% FSBM exhibited the highest body weight, improved feed conversion ratio, and superior hematological indices, indicating better physiological status. Additionally, the economic analysis revealed that the 40% FSBM group achieved the highest net revenue, economic efficiency, and European production efficiency index, making it the most cost-effective feeding strategy.

Overall, these results suggest that incorporating FSBM into broiler diets can be a viable alternative to conventional SBM, offering both performance and economic benefits. Future research should focus on optimizing fermentation conditions and evaluating long-term effects to maximize the potential of FSBM in poultry nutrition.

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الملخص العربي

تأثير كسب فول الصويا المتخمر على الأداء الإنتاجي والقياسات الهيماتولوجية والكفاءة الاقتصادية على بدارى اللحم

[1] محمد سامي محمد – [2] أحمد محمد عبد الهادي – [1] صابر شحاته - [1] وليد حبشي

[1] قسم الإنتاج الحيواني والداجني – كلية الزراعة – جامعة دمنهور 2 قسم إنتاج دواجن – كلية الزراعة – جامعة الأسكندرية

تهدف هذه الدراسة لتقييم تأثير استبدال كسب فول الصويا بكسب فول الصويا المتخمر على الكفاءة الإنتاجية ومقاييس الدم والكفاءة الاقتصادية لكتاكيت اللحم الكب. تم توزيع 150 كتكوتًا ذكر عمر يوم بشكل عشوائي إلى 3 مجموعات كل مجموعة تحتوي على 5 مكررات تجريبية وتمت التغذية على علائق تم استبدال كمية كسب فول الصويا المستخدم بها بـ 0 و20 و40 % كسب فول صويا متخمر وذلك من عمر يوم إلى عمر 35 يوماً. توضح النتائج أن وزن الجسم عند 35 يوماً ووزن الجسم المكتسب خلال عمر 1-35 يوماً وكذلك كمية العلف المستهلك في نفس الفترة أعلى معنوياً من مجموعة الكنترول التي لم تغذى على كسب فول صويا متخمر. بالإضافة إلى أن المجموعة التي تغذت على 40 % كسب فول صويا متخمر أعطت أقل قيمة معنوية أفضل لمعدل التحويل الغذائي. زاد عدد كرات الدم الحمراء ومحتوي الهيموجلوبين والنسبة المئوية لخلايا الدم الحمراء وعدد كرات الدم البيضاء. وزادت نسبة كرات الدم البيضاء المتعادلة في مجموعة الكنترول مقارنة مع مجموعتي المعاملات. ونسبة كرات الدم البيضاء الليمفاوية كانت أعلى معنوياً في مجموعات كسب فول صويا المتخمر مقارنة مع مجموعة الكنترول. بينما لم يكن هناك فرق معنوي في نسبة كرات الدم البيضاء المتعادلة إلى الليمفاوية. وأظهرت مقايس الكفاءة الاقتصادية أن مجموعة 20% أعلى تكلفة للعلف المستخدم على الرغم من أن مجموعة 40% كانت الأقل في تكلفة إنتاج الكيلو الحي للحم. بالإضافة إلى أن استخدام كسب فول الصويا المتخمر أعطى أعلى عائد كلي وبخاصة مجموعة 40% أعطت أعلى صافي دخل ونسبة عائد على الاستثمار ومعدل الإنتاج الأوربي. والخلاصة، أن استخدام كسب فول الصويا المتخمر كاستبدال من نسبة كسب فول الصويا المضاف وبخاصة نسبة استبدال 40% حسنت من الكفاءة الإنتاجية والصفات الطبيعية للدم والكفاءة الاقتصادية