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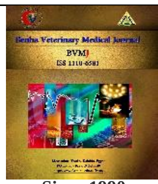

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Original Paper

Effect of express soymeal and full fat soymeal addition in diet of Hubbard broiler chicks on biochemical blood analysis and liver histomorphology

Reda Hamed Zahran[1*], Tahia Ahmed[1], Liza Sabry Mohammed[2], Nasser Khedr[1]

[1]*Department of Nutrition and Clinical Nutrition, Faculty of Veterinary Medicine, Benha University, Benha 13736, Egypt.*

[2] *Veterinary Economics and Farm Management, Department of Animal Wealth Development, Faculty of Veterinary Medicine, Benha University, Benha 13736, Egypt*

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ABSTRACT

The purpose of this study was to assess how different processing techniques for soybeans affected broiler farming, by using expeller soybean (EESB), full-fat soybean (FFSB), and solvent soybean meal (SBM) on the chicken's meat physicochemical characteristics, biochemical blood characteristics, and liver histomorphology. Hubbard efficiency plus chicks (two hundred twenty-five 1 day chicks) were distributed to 5 treatments: (45 chicks / treatment) each had a different diet as follows : D1 (a basal diet containing SBM 46 %), D2 (SBM 46 % + EESB 0.75 kg starter, 1.5 kg grower, and 3 kg finisher /10 kg), D3 (SBM 46 %+ EESB 0.5 kg starter, 1 kg grower, and 2 kg finisher /10 kg), D4 (SBM 46 %+ FFSB 0.75 kg starter, 1.5 kg grower, and 3 kg finisher /10 kg), and D5 (SBM 46 % + FFSB 0.5 kg starter, 1 kg grower, and 1.5 kg finisher /10 kg).Three chickens from each group were slaughtered to evaluate meat quality on day 35. The result indicated non-significant differences in PH, tenderness, water losses, and color except hue Angle significantly increased ($p < 0.05$) in D5 in comparison to D1, D2, and D3. According to MDA showed a significant increase ($p < 0.05$) in D2 compared to D1, D3, D4, D5. Biochemical blood characteristics showed non-significant difference in serum proteins and albumin / globulin (AG) ratio, triglyceride, and Serum cholesterols. but D5 significantly increased LDL cholesterol in comparison to D2 and D4. Regarding liver histomorphology showed no negative effect of treated groups. In conclusion, the inclusion of EESB and FFSB does not negatively affect meat quality nor causes any fundamental change in liver histomorphology and biochemical blood characteristics.

1. INTRODUCTION

In the chicken industry, feed is the most expensive variable expense. Energy is the primary component of a chicken's diet, followed by protein derived from vegetables and lastly from animal sources. Concern has switched to plant protein sources, particularly SBM, for broiler Because animal protein concentrates are scarce, prone to infectious illnesses, and expensive (Erdaw et al., 2016). Soybeans are the most widely utilized vegetable protein supplements used in bird feed because of elevated protein quantity and balanced composition of amino acids, and ease of accessibility However, the presence of antinutritional elements in raw soybean seeds precludes their direct use in animal feeds. Antinutritional elements in raw soybean seeds such as trypsin and lectins are components sensitive to heat (Ebrahimi et al., 2011). Heating treatment is one method for removing antinutritional factors and increasing the nutritive value of raw soybeans (Machado et al., 2008). Extrusion not only decreases the level of antinutrients but also increases protein and starch digestibility (Konieczka et al., 2020). SBM, EESBM, and FFSBM are the most common industrial soybean commodities in feed for chicken (Fasina et al., 2003).

The chicken sector is considered the fastest growing protein source, and it has become critical to global food supplement. So new feeds for chicken are being developed to meet their nutritional requirements (Hasted et al., 2021). According to Augustyńska-Prejsnar and Sokołowicz (2014), customers are primarily concerned with sensory quality, which includes color, tenderness, juiciness, and scent (intensity and desirability). Consumers place importance on meat color, which is also a simple criterion to assess. Color changes are frequently the first visible signs of nutrient value loss and quality degradation. The flesh of fresh fowl should have a pale crimson hue. The most crucial factor determining meat quality is tenderness. It is altered by age and is evaluated in terms of its perceived hardness, flexibility, or elasticity (Zdanowska-Sąsiadek et al., 2016). Furthermore, the appearance and texture of chicken flesh are the most critical features because they have a major impact on consumers' initial choices and ultimate satisfaction with products. Furthermore, color is a major contributor to appearance (Fletcher et al., 2000).
The aim of this study was to ascertain how extruded-expeller soybeans and full-fat soybeans affected the physicochemical characteristics of breast meat, such as color, PH, water holding capacity, cooking loss, drip loss, tenderness, and malondialdehyde (MDA), biochemical blood analysis

* Corresponding author: reda.hamed@fvtm.bu.edu.eg

including lipid and protein profile in serum and liver histomorphology of Hubbard broiler chickens.

2. MATERIAL AND METHOD:

This research was conducted under the ethical number (NO BUFVTM 05-12-22) at the centre of Experimental Animal Research, Faculty of Veterinary Medicine, Benha University, Egypt.

Birds and housing :

This experiment caried out at the centre of Experimental Animal Research, Faculty of Veterinary Medicine, Benha University.two hundred twenty-five one-day-old Hubbard efficiency plus chicks were split into five groups at random, each one containing forty-five chicks distributed into three replicates, with fifteen chicks per replicate. All chicks were raised under equivalent environmental and hygiene standards. fresh and clean floor was made of wood shavings fresh and clean. Food and water were always available for the experiment. Water and food were always available during the experiment (35 days) according to Zahran et al. (2020). During the trial period, the feeding plan was divided into three stages: starter (day one: ten), grower (day eleven: twenty-two), and finisher (day twenty-three: thirty-five) .

Experimental diet :

Five diets were formulated for all groups as follows: D1 (control group received a basal diet containing solvent SBM, D2 (received a diet containing Express ® SBM at the level of 0.75 , 1.5 , 3 kg /10 kg for starter, grower, and finisher respectively), D3 (received a diet containing Express ® SBM at the level of 0.5 , 1 , and 2 kg /10 kg for starter, grower, and finisher respectively), D4 (received a diet containing FFSBM at the level of 0.75 , 1.5 , 3 kg /10 kg for starter, grower, and finisher respectively), and D5 (received a diet containing FFSBM at the level of 0.5 , 1 , and 1.5 kg / 10 kg for starter, grower, and finisher respectively), All diet were iso-nitrogenic isocaloric. Diets were formulated according to Hubbard's requirement (2022), and all nutrients were addressed, as indicated in Table1 .

Table 1. Ingredients in kg / 10 KG of starter, grower, and finisher broiler diets (as fed basis)

	Starter (day 1-10)					Grower (day 11-22)					Finisher (day 23-35)				
Ingredient	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Yellow corn	5.313	5.418	5.438	5.278	5.384	5.668	5.762	5.837	5.506	5.722	6.112	5.863	6.094	5.432	6.043
Wheat bran	0.15	0.15	0.2	0.14	0.19	0.15	0.14	0.14	0.14	0.14	0.16	0.19	0.25	0.30	0.08
Soybean meal 46	3.5	2.77	2.85	2.99	2.89	3.37	1.99	2.34	2.35	2.4	2.66	0.48	0.78	0.61	1.59
Express soymeal	-	0.75	0.5	-	-	-	1.5	1	-	-	-	3.00	2.00	-	-
Full- fat soymeal	-	-	-	0.75	0.5	-	-	-	1.5	1	-	-	-	3.00	1.50
Vegetable oil	0.145	-	-	-	-	0.195	-	-	-	-	0.224	-	-	-	-
Limestone	0.136	0.137	0.137	0.14	0.14	0.133	0.134	0.134	0.14	0.139	0.125	0.127	0.127	0.142	0.133
Dicalcium phosphate	0.16	0.16	0.16	0.155	0.158	0.147	0.145	0.146	0.137	0.142	0.122	0.115	0.119	0.1	0.114
Corn gluten meal	0.42	0.45	0.54	0.365	0.56	0.175	0.19	0.25	0.074	0.29	0.44	0.12	0.5	0.27	0.38
Vit & min mixture	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Sodium chloride	0.023	0.023	0.023	0.023	0.023	0.023	0.025	0.024	0.024	0.023	0.023	0.03	0.025	0.024	0.023
DL-Methionine	0.032	0.029	0.029	0.032	0.03	0.032	0.027	0.028	0.032	0.03	0.024	0.018	0.018	0.025	0.024
Sodium bicarbonate	0.029	0.027	0.029	0.028	0.028	0.024	0.02	0.023	0.023	0.027	0.026	0.011	0.02	0.028	0.025
L_Lysine	0.033	0.03	0.035	0.03	0.038	0.025	0.019	0.024	0.02	0.03	0.028	-	0.02	0.019	0.025
Choline chloride	0.011	0.01	0.011	0.009	0.01	0.01	0.009	0.009	0.007	0.008	0.01	0.007	0.009	0.005	0.007
Ant-mycotoxin	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Emulsifier	-	-	-	-	-	0.005	0.002	0.005	0.005	0.005	0.005	0.002	0.002	0.002	0.005
L_Threonine	0.011	0.009	0.01	0.01	0.012	0.006	0.0002	0.002	0.005	0.007	0.005	-	-	0.005	0.005
Ant-oxidants	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01
Energy enzyme	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ant-colesterdia	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Phytase enzyme	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Protease enzyme	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Physicochemical analysis of breast meat

On 35th day of the experiment, three chicks from each treatment were slaughtered using the Islamic method after fasting for 12 hours from the feed and free access to water. The PH, color, water holding capacity, cooking loss, drip loss, tenderness, and MDA of the pectoralis major muscle of breast meat were all measured .

PH and color

The pH was measured with a calibrated pH meter through penetration of an electrode at three various points in the pectoralis major muscle of broiler chicken according to Özbek et al. (2020), Three samples from Breast meat of each group were collected, and values of meat color were measured. Minolta color values of breast meat were measured for lightness (L*), redness (a*), and yellowness (b*) according to Shim et al. (2018). Chroma (C*) and hue angle (h°) were determined as functions of a* and b* using the formulas described by Mancini et al. (2020).

$$C^* = \sqrt{(a^2 + b^2)}$$

$$H° = \tan^{-1}\left(\frac{b^*}{a^*}\right)$$

Water holding capacity, cooking loss, drip loss, and tenderness.

Three samples from each group were weighted and used for determination of water holding capacity (WHC) according to Soliman et al. (2020) with some modification, using 15 mL falcon tubes filled with 0.6 M sodium chloride solution, meat samples were mixed for a duration of one minute. tubes are centrifuged at 10,000 rpm and 5 °C for ten min., then meat samples dried with filter paper and weighed again.

The formula was used to calculate the water uptake(%) :

Water holding capacity =

$$100 - \left(\frac{W1 - W2}{W1} \times 100\right)$$

Where W1=Initial weight of the meet sample and W2= weight of the solid material at bottoms of the tube following centrifugation.

Cooking loss was analyzed according to López et al. (2011), samples were put in food-safe tightly sealed containers and submerged for twenty min. in an 80 °C water bath.
The samples were removed from the water bath, cooled, dried, weighed, and calculated by formula:
Cooking loss=

$$\frac{\text{weight before cooking} - \text{weight after cooking}}{\text{weight before cooking}} \times 100$$

Meat samples were weighed individually, put in a sealed polyethylene bag, and kept at 4 °C for 48 hours for determination of drip loss, as described in Petracci and Baéza (2011). After removing any visible liquid buildup on samples using a piece of paper towels, the samples were weighed at 24 hours (W24) and 48 hours (W48), as calculated by the following formula :
Drip loss(%) =

$$\frac{\text{Initial weight} - \text{weight after storage}}{\text{initial weight}} \times 100$$

For tenderness measurement six rectangular samples were sliced from cooked meat that has a 1 cm^2 cross-section at a right angle parallel to muscle fiber and analyzed for tenderness using a Texture analyzer (Dadgar et al., 2010). The maximum force recorded was used to calculate the razor blade shear force (RBF, N), while the area under the force deformation curve from the start of the test to its completion was used to calculate shear energy. (RBE, N*mm) according to Cavitt et al. (2004) .
Lipid peroxidation is expressed as malondialdehyde (MDA) concentration, estimated by HPLC analysis According to the method of Karatas et al. (2002).

Biochemical blood analysis

Serum separated from blood samples according to Kokore et al. (2021) for analysis of total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), triglycerides (TG), total protein, albumin, globulin, and albumin: globulin ratio (A:G ratio).

Liver Histomorphology Assessment

Samples from the left lope of liver were taken from slaughtered birds for histomorphological studies as described by Abdul Basit et al. (2020). The samples from the left lope of liver were fixed in 10 % neutral buffered formalin (pH 7.0). After dehydration and clearance, the tissues embedded in paraffin and sectioned in 5 µm thickness. The serial sections were subjected to staining with hematoxylin and eosin then the tissues were examined under a light microscope.

Statistical analysis

The data that were gathered were examined using SPSS IBM Corp. Released 2019. IBM Corp. Armonk, NY, published IBM SPSS Statistics for Windows, Version 26.0. (SPSS, 2019). First, the Shapiro-Wilk test was used to establish that the data was distributed normally. After that, a one-way ANOVA was carried out, and Tukey's test was used to assess the mean differences. The mean and standard error were used to represent the data variance, with a level of significance of ($p < 0.05$).

3. RESULTS

The results of the physical analysis of breast meat in broiler chicken are presented in Table 2, which showed a non-significant difference ($p > 0.05$) in the percentage of drip loss after 24 and 48 hr., cooking loss, water holding capacity, PH, and maximum comprehensive load (N), Energy at maximum comprehensive load (J) " related to tenderness". In addition, the color of breast muscle indicated a significant increase ($p < 0.05$) in Hue Angle in D5 that recorded 76.60 compared to D1, D2, D3, and D4 that recorded 73.37 °, 71.90 °, 72.13 ° and, 75.90 ° respectively. But l* (lightness), a* (redness), b* (yellowness) and c* (Chroma) showed non-significant differences between different groups. According to oxidation in muscle, MDA significantly decreased ($p < 0.05$) in D1, D3, D4, and D5 that recorded 35.34, 41,37, 43.44 and, 32.25 nmol /g muscle respectively. But MDA recorded its highest level in D2 48.39 nmol /g muscle.

Table 2. Effect of dietary inclusion of extruded expelled soybean (ESBM) and extruded full-fat soybean (EFFSB) on physicochemical meat quality.

		D1	D2	D3	D4	D5	P Value
Drip loss after 24h %		3.93 ^{a} ±o.79	3.74 ^{a} ±0.14	4.20 ^{a} ±0.2	3.52 ^{a} ±0.36	2.78 ^{a} ±0.35	0.265
Drip loss after 48h %		6.48 ^{a} ±1.56	5.72 ^{a} ±0.57	6.37 ^{a} ±0.05	4.71 ^{a} ±0.39	4.19 ^{a} ±0.71	0.273
Cooking loss%		5.10 ^{a} ±0.61	6.77 ^{a} ±1.05	7.22 ^{a} ±1.37	5.85 ^{a} ±0.33	6.04 ^{a} ±0.61	0.504
WHC%		89.04 ^{a} ±0.87	87.85 ^{a} ±0.85	84.06 ^{a} ±1.7	87.89 ^{a} ±1.08	86.86 ^{a} ±2.49	0.270
PH		5.53 ^{a} ±0.14	5.75 ^{a} ±0.23	5.57 ^{a} ±0.12	5.71 ^{a} ±0.04	5.77 ^{a} ±0.09	0.660
Tenderness	N	58.50 ^{a} ±1.36	60.40 ^{a} ±1.44	61.58 ^{a} ±1.98	59.42 ^{a} ±1.06	59.63 ^{a} ±0.84	0.614
	J	0.26 ^{a} ±0.01	0.27 ^{a} ±0	0.28 ^{a} ±0.01	0.26 ^{a} ±0.01	0.27 ^{a} ±0	0.231
Color	l*	55.95 ^{a} ±4.79	55.92 ^{a} ±0.43	57.23 ^{a} ±2.14	60.64 ^{a} ±5.47	55.33 ^{a} ±0.87	0.809
	a*	2.76 ^{a} ±0.12	2.82 ^{a} ±0.05	2.80 ^{a} ±0.1	2.54 ^{a} ±0.14	2.63 ^{a} ±0.27	0.667
	b*	8.89 ^{a} ±0.33	8.61 ^{a} ±0.31	8.70 ^{a} ±0.41	10.35 ^{a} ±0.35	10.00 ^{a} ±0.63	0.045
	c*	9.30 ^{a} ±0.31	9.03 ^{a} ±0.32	9.13 ^{a} ±0.41	10.67 ^{a} ±0.35	10.33 ^{a} ±0.54	0.044
	h°	73.37 ^{bc} ±0.8	71.90 ^{c} ±0.32	72.13 ^{c} ±0.28	75.90 ^{ab} ±0.47	76.60 ^{a} ±0.8	0.000
MDA nmol/g muscle		35.44 ^{c} ±1.11	48.39 ^{a} ±0.83	41.37 ^{b} ±1.33	43.44 ^{b} ±0.53	32.25 ^{c} ±0.42	0.000

Means carrying a, b, c are significantly different among different groups of the same row.

The impact of the addition of express SBM and full-fat SBM in the diet of chicken on protein and lipid profile in the serum of birds are presented in Table 3 indicating non-significant difference ($p > 0.05$) in serum protein, albumin, globulin, and A / G ratio. Regarding lipid profile showed a significant increase in LDL cholesterol in D5 (66.13 mg/dl) compared to 56.27, 45.67, 51.17, and 47.00 for D1, D2, D3, D4 respectively. While Serum cholesterol, Triglyceride, HDL cholesterol, and VLDL cholesterol revealed non-significant difference ($p > 0.05$) between groups.

Table 3. Effect of dietary inclusion of extruded expelled soybean (ESBM) and extruded full-fat soybean (EFFSB) on biochemical blood characteristics.

	D1	D2	D3	D4	D5	P Value
Total protein (g /dl)	$3.63^{a}\pm0.12$	$3.47^{a} \pm0.22$	$3.73^{a} \pm0.09$	$3.40^{a} \pm0.12$	$3.70^{a} \pm0.1$	0.389
Albumin (g /dl)	$2.41^{a} \pm0.24$	$2.12^{a} \pm0.22$	$2.19^{a} \pm0.21$	$2.05^{a} \pm0.06$	$2.53^{a} \pm0.12$	0.365
Globulin (g /dl)	$1.22^{a} \pm0.27$	$1.35^{a} \pm0.09$	$1.54^{a} \pm0.14$	$1.35^{a} \pm0.16$	$1.17^{a} \pm0.07$	0.564
AG ratio (g /dl)	$2.23^{a} \pm0.56$	$1.59^{a} \pm0.2$	$1.48^{a} \pm0.29$	$1.57^{a} \pm0.25$	$2.17^{a} \pm0.2$	0.365
Serum cholesterol (mg /dl)	$111.00^{a} \pm2.65$	$94.67^{a} \pm6.44$	$105.67^{a} \pm1.76$	$103.33^{a} \pm2.6$	$116.67^{a} \pm8.01$	0.085
Triglyceride (mg /dl)	$88.67^{a} \pm2.19$	$79.67^{a} \pm3.38$	$89.67^{a} \pm3.84$	$83.33^{a} \pm2.19$	$79.33^{a} \pm6.01$	0.237
HDL cholesterol (mg /dl)	$37.00^{a} \pm1.73$	$33.00^{a} \pm1.73$	$36.57^{a} \pm0.81$	$39.67^{a} \pm2.85$	$34.67^{a} \pm1.45$	0.191
LDL cholesterol (mg /dl)	$56.27^{ab} \pm1.43$	$45.67^{b} \pm4.58$	$51.17^{ab} \pm3.02$	$47.00^{b} \pm2.19$	$66.13^{a} \pm5.61$	0.017
VLDL cholesterol (mg /dl)	$17.73^{a} \pm0.44$	$15.93^{a} \pm0.68$	$17.93^{a} \pm0.77$	$16.67^{a} \pm0.44$	$15.87^{a} \pm1.2$	0.237

Means carrying a, b, c are significantly different among different groups of the same row.

The impact of the inclusion of different types of SBM in a broiler diet on liver histomorphology is shown in Figure 1 showed that the Liver of bird fed D1, D4, D5 showed normal hepatocytes with marked cytoplasmic eosinophilia around the central vein, D2 and D3 showing normal hepatocytes with mild cytoplasmic vacuolation around the central vein with proliferation of von Kupfer cells.

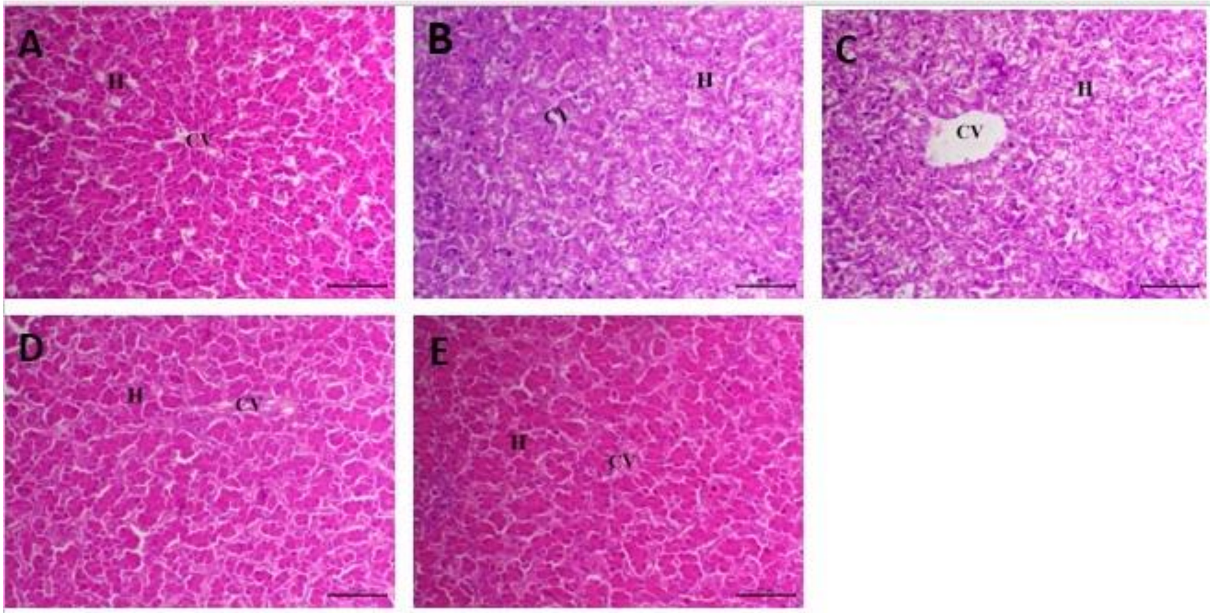

Fig 1. Effect of dietary inclusion of extruded expelled soybean (ESBM) and extruded full-fat soybean (EFFSB) on liver histomorphology. liver histomorphology of D1 showing normal hepatocytes with marked cytoplasmic eosinophilia around the central vein (A). liver histomorphology of D2 showing normal hepatocytes with mild cytoplasmic vacuolation around the central vein with proliferation of von Kupfer cells (B) liver histomorphology of D3 showing normal hepatocytes with mild cytoplasmic vacuolation around the central vein with proliferation of von Kupfer cells (C). liver histomorphology of D4 showing normal hepatocytes with marked cytoplasmic eosinophilia around the central vein (D). liver histomorphology of D5 showing normal hepatocytes with marked cytoplasmic eosinophilia around the central vein(E)

4. DISCUSSION

Many variables determine meat quality, such as sensory characteristics, hygienic and toxicological characteristics physico–chemical parameters, and technical features of meat (Gornowicz et al., 2017). Meat color is a crucial factor that purchasers consider and one that is considered while judging meat meals while they are being consumed (Magdelaine et al., 2008). In our study, the meat was analyzed to determine meat color and indicated a significant increase ($p < 0.05$) in Hue Angle in D5 compared to D2 and D3. but l* (lightness), a* (redness), b* (yellowness) and c* (Chroma) showed non-significant differences between different groups. Similar results, Janocha et al. (2022) who stated that the color of the pectoralis muscles was shown to be unaffected by the dietary addition of EESBM and FFSBM in terms of their lightness (L*). On the other hand, The chicken breast muscles that were fed soybean expeller cake-based feed rations exhibited almost twice as much red value (a*), yellow value (b*), and chroma (C*) as the muscles of the other groups ($p < 0.05$), Customer preference is lower for darker-colored meat that has a higher PH and a larger percentage of oxidized myoglobin as reported by Zdanowska-Sasiadek et al.(2013) .

Janocha et al. (2022) mentioned that the measurement of the PH of the breast meat muscles was done 15 minutes after the slaughter. Again after 24 hours of chilling showed non-significant ($p > 0.05$) influence of various soybean raw materials in different groups, but the PH of extruded full fat fed group was more acidic than expeller SBM fed groups. This result showed similarity to the result in our study that revealed non-significant difference ($p > 0.05$) between groups. Mehaffey et al. (2006) suggest a connection between the rate at which the final pH drops and the meat's quality. Meat may develop the PSE (pale, soft, exudative) fault if pH falls rapidly. Nonetheless, DFD (dark, firm, dry) meat will arise from a high after-death PH. In terms of adaptability to technology, both kinds of meat are unsatisfactory. Broiler chickens should have an ideal pH 24 oscillation between 5.35 and 6.10, meaning that the assessed meat should be categorized as good meat.

WHC, according to Orkusz (2015), can improve the juiciness, shelf life, color, and texture of meat. The isoelectric point of muscle proteins (pH range 5.1- 5.3), which is connected to the response of meat, is where the lowest value of water-holding capacity is found. Muscle proteins have a larger ability to store water when the pH deviates from the isoelectric point, which increases thermal drip and drip loss. Therefore, as meat juice flow rises in the packing, microbial contamination, and drying susceptibility rise. In our study, WHC showed non-significant difference between groups. This result was similar to Milczarek and Osek (2019) who demonstrated that using full-fat SBM in broiler diets did not influence breast muscle WHC. Also, Zhang et al. (2019) used non-genetically modified (non-GM) and genetically modified (GM) soybean meals in broiler feed and noticed no impact on the WHC and thermal drip of broiler chicken muscles.

Color, palatability, tenderness, and juiciness are the factors that define the sensory quality of chicken flesh. The sensory characteristics of the muscles under evaluation changed significantly when SBM was replaced with expeller SBM or full-fat SBM (Janocha et al., 2022). But in our study tenderness did not show any significant differences between groups. Our results were similar to Milczarek and Osek (2019) who found no evidence of any effects on the sensory characteristics of breast muscles when full-fat SBM was used in place of SBM in the feed regimens for broiler chickens.

Lipid peroxidation is the process by which polyunsaturated fatty acids in bio membranes oxidatively deteriorate, producing a range of aldehydic compounds, among them malondialdehyde (MDA). It has been demonstrated that the generation of MDA serves as a pertinent indication that lipid peroxidation occurs in biological systems (Karatas et al., 2002). Meat and meat products can lose quality due to lipid oxidation, which also creates rancidity and unwanted smells and aromas that detract from the meat's functional, sensory, and nutritional qualities (Ruize et al., 2001). According to Guo et al. (2003), MDA concentration is an excellent measure of the degree of lipid oxidation and displays the Thio barbituric acid reactive substance (TBARS) value. In our study, MDA significantly decreased ($p < 0.05$) in D1, D3, D4, and D5 and significantly increased in D2. Lu et al. (2019) found that increased reactive oxygen species (ROS) generation, oxidative stress induction, and poor growth performance may be associated with heated SBMs (HSBMs)

Regarding the biochemical characteristics of blood serum, there was non-significant difference ($p > 0.05$) in serum protein, albumin, globulin, and AG ratio. LDL cholesterol showed a significant increase in D5 in comparison to D2 and D4. while Serum cholesterol, Triglyceride, HDL cholesterol, and VLDL cholesterol revealed non-significant difference ($p > 0.05$) between groups. Some researchers disagree with our result such as Korosh Taslimi et al. (2021) who revealed that the greatest blood triglyceride concentrations were seen in birds fed the control diet (no extruded soybean meal). Replacement dosages of 25, 75, and 100% extruded soybean meal lowered serum triglycerides considerably ($P < 0.05$). also, Zhaleh et al. (2014) noticed a substantial ($P < 0.05$) drop in the amounts of triglycerides and LDL in blood serum at dietary levels of EFFSB increased at 42 days of age. Soybeans have the potential to lower blood triglycerides due to their isoflavonoids (Yousef et al., 2003). Additionally, extrusion may have additional effects due to its influence on protein's amino acid composition, which may alter the metabolism of triglycerides and cholesterol (Alsaftli et al., 2015).

Broiler chicken livers are more prone to morphological alterations, which should likely be linked to high levels of hepatic metabolism (Szarek et al., 2000). Histomorphology of the liver in our study showed normal hepatocytes in all groups, there was no marked difference between different groups. In agreement with our result, Milczarek and Osek (2019) found no inflammatory abnormalities were seen in the tested chicken livers. There were no discernible variations in the quantity and distribution of neutral fat between the groups when neutral fat staining was performed. There was just a little rise in the quantity of lipids in the extruded lupine (EL) and distillers dried grains (DDGS) groups not in the Extruded full-fat SBM group and raw full-fat SBM group.

4. CONCLUSIONS

From this study, we conclude that the inclusion of extruded expeller SBM and extruded full-fat SBM in the diet of broiler did not negatively affect PH, tenderness, water losses, and color but hue angle increased in groups fed full-fat SBM than in other groups. MDA increased in the group fed EESB at level of 0.75 kg starter, 1.5 kg grower, and 3 kg finisher/10 kg than other groups. Also, serum protein, albumin, globulin, albumin/globulin (AG) ratio, triglyceride, and Serum cholesterols not affected by inclusion of EESB and FFSB, but group fed FFSB at level of 0.5 kg starter, 1 kg grower, and 1.5 kg finisher/ 10 kg showed an increase in LDL cholesterol than other groups. In addition, liver histomorphology was not negatively affected by inclusion of EESB and FFSB.

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