p-ISSN 1410-5659 e-ISSN 2621-5144
Published by:
Unpad Press

Jurnal Ilmu Ternak Universitas Padjadjaran, December 2024, 24(2):186-194
DOI: 10.24198/jit.v24i2.61273
Available online at http://jurnal.unpad.ac.id/jurnalilmuternak

OPTIMIZING BROILER CHICKENS PERFORMANCE WITH BOILED SUNFLOWER (*Helianthus annuus*) SEED MEAL-BASED DIETS: A SUSTAINABLE SOLUTION

A. A. Saleh[1, a], N. B. Rano[1], I. O. Suleiman[1], H. A. Muhammad[1] and Z. A. Dankoli[1]
[1]*Department of Animal Science, Bayero University Kano, Nigeria*
[a]*email:* nbrano.asc@buk.edu.ng

Abstract
The research explored using boiled sunflower seed meal (BSSM) as a sustainable feed alternative for broiler chickens. It evaluated its impact on their growth and development, reducing the industry's reliance on resource-intensive feed ingredients. One hundred and fifty unsexed Ross broiler chicks were used for the study. The experiment was laid in a completely randomized design (CRD) in which BSSM was incorporated in the diets at 0, 2.2, 4.4, 6.6, and 8.8%, coded as Treatments 1, 2, 3, 4, and 5, respectively—each treatment comprised of 3 replicates of 10 birds. Birds were housed in floor pens containing wood shavings as litter material. The diets and fresh drinking water were provided *ad libitum* throughout the eight weeks of the experiment. Data were analyzed in a statistical analysis system (SAS) package. Results revealed significant differences ($p<0.05$) in all the growth parameters measured except for initial body weight, feed conversion ratio, and mortality. The packed cell volume (PVC) and white blood cells (WBC) were affected ($p<0.05$) by the treatment effect. Broiler chickens' health and productivity were not negatively affected by 6.6-8.8% BSSM inclusion in their diets, suggesting further research is needed on improving sunflower seed using alternative treatment options.
Keywords: ***Sunflower Seed, Broiler Chickens, Growth Performance, Haematology***

MENGOPTIMALKAN KINERJA AYAM BROILER DENGAN PAKAN BERBASIS BIJI-BIJIAN MATAHARI REBUS (Helianthus annuus) SEBAGAI SOLUSI BERKELANJUTAN

Abstrak
Penelitian ini mengeksplorasi penggunaan tepung biji bunga matahari rebus (BSSM) sebagai alternatif pakan berkelanjutan untuk ayam broiler. Penelitian ini mengevaluasi dampaknya terhadap pertumbuhan dan perkembangan ayam, untuk mengurangi ketergantungan industri pada bahan pakan yang membutuhkan banyak sumber daya. Penelitian ini menggunakan 150 ekor anak ayam pedaging Ross yang tidak dipisahkan berdasarkan jenis kelaminnya. Percobaan dilakukan dalam rancangan acak lengkap (RAL) di mana BSSM dimasukkan ke dalam pakan sebanyak 0, 2,2%, 4,4%, 6,6%, dan 8,8%, yang masing-masing dikodekan sebagai Perlakuan 1, 2, 3, 4, dan 5. Setiap perlakuan terdiri dari 3 ulangan yang terdiri dari 10 ekor ayam. Ayam ditempatkan di kandang lantai dengan alas serbuk kayu. Pakan dan air minum segar diberikan ad libitum selama delapan minggu percobaan. Data dianalisis dengan paket sistem analisis statistik (SAS). Hasil penelitian menunjukkan perbedaan yang signifikan ($p<0,05$) pada semua parameter pertumbuhan yang diukur, kecuali berat badan awal, rasio konversi pakan, dan mortalitas. Volume sel padat (PVC) dan sel darah putih (WBC) dipengaruhi ($p<0,05$) oleh perlakuan. Kesehatan dan produktivitas ayam broiler tidak terpengaruh secara negatif oleh penambahan 6,6-8,8% BSSM dalam pakann mereka, yang menunjukkan dibutuhkannya penelitian lebih lanjut tentang peningkatan biji bunga matahari menggunakan pilihan pengobatan alternative.
Kata kunci: Biji Bunga Matahari, Ayam Pedaging, Kinerja Pertumbuhan, Hematologi

INTRODUCTION

The livestock and poultry industry faces a significant challenge due to the unpredictable and rising costs of feed, which, combined with inconsistent supply, jeopardizes its long-term sustainability and viability (Nkukwana, 2019). Thus, unlocking the full potential of livestock production hinges on addressing nutritional deficiencies. Meanwhile, ensuring a steady supply of affordable, nutrient-rich feed is crucial for optimal animal growth and successful livestock production (Hafez & Attia, 2020). The largest expense in poultry production is the feed costs, accounting for more than half of the total cost (Onuwa *et al.*, 2021). Optimizing the supply of adequate and efficient sources of human and animal feed is a key priority for the industrial sector, and therefore 15% of total feed cost is provided by soybean meal and fish meal (Kim *et al*., 2019). Further, the long-standing high costs of goods like fish meal and groundnut cake, which are used in conventional protein feed sources, make it challenging for chicken farmers to maximise their profits and restrict the financial viability of their enterprises (Nkukwana, 2019).

With the growing need for high-quality food oils worldwide, growers of sunflowers are seeing a notable rise in production, making it an efficient way to make money (Gupta, 2014). With production volume and importance included, skanks are one of the top sources of oil in the world, ranking behind only cottonseed, soybeans, and rapeseed (Ditta & King, 2017). Ranking second in feed and protein reserves, third in oil consumption, and fourth in the production of oil seeds which are essential for meeting world demand, this plant is an invaluable resource (Gupta, 2014).

Sunflower meal (SFM) is a byproduct of sunflower oil extraction, rich in nutrients. It has a high nutritional value, containing crude protein, cellulose, and lignin (Chatterjee & Rajkumar, 2015; Mohammed *et al*., 2020). The sunflower seeds' kernel and hull (shell) have different protein contents, contributing to the overall nutritional composition of SFM (Ditta & King, 2017). The authors stated that the high hull content of the meal makes it less beneficial to feed animals and fowl. Sunflower meal's high fibre content is a significant obstacle to its use in broiler diets since it may impair growth performance and carcass production content (Molale, 2020; Waititu *et al*., 2018). As a result, according to Adesina (2018), sunflower seeds must be processed using a variety of techniques to improve its digestibility and nutritional value by using short-time boiling to overcome its high fiber content and anti-nutritional factors, both of which will improve the broiler's ability to utilise them.

This study fills a research gap by investigating the utilisation of sunflower seed meal in broiler chicken diets, by assessing different inclusion levels without compromising growth performance, carcass quality, or feed conversion efficiency. Overall, the study explores boiled sunflower seed meal (BSSM) as a cost-effective, environmentally, and economically sustainable alternative protein source in broiler diets, contrasting with expensive and market-dependent alternatives.

MATERIALS AND METHODS

Study Location

The experiment was performed in the Poultry Unit of Teaching and Research Farm of the Department of Animal Science at the Faculty of Agriculture at Bayero University, Kano, Nigeria. The farm is located in Nigeria's semi-arid zone at latitudes E008º25.420' and N11º59.039'. The study protocol complied with Bayero University's Animal Care, Use, and Research Ethics Committee requirements.

Experimental Design and Treatments

The experiment was laid in a completely randomized design (CRD) in which BSSM was incorporated in the diets at 0, 2.2, 4.4, 6.6, and 8.8%, coded as Treatments 1, 2, 3, 4, and 5, respectively. Each treatment comprised 3 replicates of 10 birds, deemed adequate regarding the context of the experiment and the minimum requirement for the analysis of variance. One hundred and fifty (150) one-day-old Ross broiler chicks were randomly allotted to five dietary treatment groups of thirty birds each. Each treatment was replicated three times with ten birds *per* replicate.

Processing of Sunflower Seeds and Diets Formulation

The test ingredient (Sunflower seeds) was sourced from an open market in Biu town, southern region of Borno State, Nigeria. Following modified procedures outlined by Tenyang *et al*. (2022), 25 kg of dried sunflower seeds were dipped into boiling water at approximately ˜99°C at a 1:5 seed-to-water ratio for 15 minutes. Following boiling, the seeds were sun-dried to a constant weight before being ground, separated into four portions, and mixed in at various levels (2.2, 4.4, 6.6, and 8.8%).

Diets were manufactured using the best practices from the Nigeria Institute of Animal Science (NIAS) to meet the 23 and 20% crude protein requirements of broiler chickens for starter and finisher phases, respectively. The ingredient composition of the experimental diets is presented in Table 1. Five iso-nitrogenous and iso-caloric experimental diets were formulated and tagged T_1, T_2, T_3, T_4, and

T_5 with BSSM incorporated at 0, 2.2, 4.4, 6.6, and 8.8% levels, respectively. Treatment one (T_1) did not contain the test ingredient, it served as a control.

Experimental Birds and Their Management

The study used one hundred and fifty unsexed Ross broiler chicks. The plastic sheet enclosures that held the broilers were strewn with the wood shavings that had been left on the floor. The diet was set in a way that each feed was tailored to three bird groups, such that a treatment pen had three pens and a balanced pattern around it. The diets and clean drinking water were provided on an *ad libitum* basis with plastic feeders and plastic drinkers throughout the eight weeks of the experiment. Feeders were replenished daily to guarantee feed was accessible at all times, and drinkers were cleaned and had water replaced every morning. Routine medications and vaccinations were also observed. Mortality was monitored and recorded when it occurred.

Growth Performance Trial

Measurements and calculations

Throughout the eight weeks of the study, weekly measurements of each bird's live weight (LW) for each group of birds were recorded. Broilers were weighed at the beginning (day 1) and end (day 56) of the experiment at weekly intervals. To guarantee that feed was always available, the feed was measured and offered daily and the leftovers were weighed after the feeding period. Daily feed intake was determined by the difference between the leftovers and the quantity offered during the previous day. FCR, which is the amount of feed consumed per unit weight gain, was calculated by dividing the quantity of feed consumed by the weight increase as:

$$\text{FCR} = \frac{\text{Feed consumed}}{\text{Weight gain}}$$

The weekly values for each replicate group's daily live weight gain (LWG), feed intake (FI), and feed conversion ratio (FCR) were then determined by processing the data in Microsoft Excel.

Blood Samples Collection

At the end of the feeding trial, there were three birds selected based on the pen weight from the replicate groups. The chickens were fasted for twelve hours to reduce the standard errors in values. The blood samples were drawn from the birds' wing veins and taken with sterile, disposable, 5-milliliter syringes and 21-gauge (G) needle. The sample from each treatment replicate was gathered using Ethylene Diamine Tetra-acetic Acid (EDTA)-filled test tubes and empty bottles. The haematologic parameters were measured in compliance with Sirois (2019) procedures and included packed cell volume, differential leucocyte counts, white blood cell and red blood cells, and haemoglobin concentration. The values of the erythrocyte were assessed using the standards of haematology such as the mean relative volume of the mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC).

Carcass Evaluation

At the end of the feeding trial, eight birds per treatment (i.e., 2 birds per replicate) were selected based on average pen weight for carcass studies. The birds were carefully dressed after being slaughtered. Following thorough bleeding, the birds were de-feathered by scalding in hot water as described by (Hahn & Spindler, 2002). De-feathered birds were labeled and eviscerated. The carcasses of chickens stripped of their neck and carcass weighed, were removed after their evisceration. Also, included were parts of the body such as the thighs, drumsticks, wings, breast muscles, and bone which were obtained using a butchering knife. After being cut into bits, the components were weighed and then assembled again.

The visceral organs were carefully removed and weighed. The drumsticks and thighs were removed in two ways: one cutting above the thigh and the other cutting through the thighs to the joint of the drumstick and thigh bones. A shoulder incision was used to remove a wing. The gizzard and crop were emptied before weighing.

Statistical Analysis

One-way analysis of variance (ANOVA) was used during the data analysis in the SAS package (SAS, 1999), along with Tukey's Multiple Comparison Test. The statistical significance was determined by the 95% confidence level.

Table 1: Ingredient Composition of Experimental Broiler Diets (0-8weeks of age)

Description	Diets (% BSSM)									
	Starter Phase (0-4 weeks of age)					Finisher Phase (5-8 weeks of age)				
Ingredients										
Maize	49.00	49.50	49.10	49.00	48.35	53.00	53.00	53.00	54.00	50.00
SBM	22.00	19.80	17.60	14.40	13.20	22.00	19.00	17.60	14.50	15.20
GNC	12.00	17.50	17.00	19.00	17.00	4.00	5.20	6.00	8.40	9.00
SFM	00.00	2.20	4.40	6.60	8.80	00.00	2.20	4.40	6.60	8.80
Wheat offal	12.50	7.50	7.80	7.30	7.85	16.50	16.00	15.00	12.00	15.00
Bone meal	2.00	2.10	2.00	2.00	2.30	2.50	2.50	2.50	2.50	2.50
Fish meal	1.50	0.40	1.10	0.70	1.50	1.00	1.00	0.50	1.00	0.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	1 00	100	100	100
Calculated nutrient composition										
ME (kcal/kg)	3001	3000	3000	3000	3001	2901	2901	2907	2900	2902
CP (%)	23	23	23	23	23	19.70	19.70	19.40	19.80	19.70
Crude fiber (%)	5.5	5.8	5.7	6.00	6.00	4.6	4.7	4.8	5.0	5.3
EE (%)	4.7	5.1	5.2	5.5	5.6	4.0	4.2	4.4	4.7	4.9
Lysine (%)	1.4	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2
Methionine (%)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Calcium (%)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Av. Phos. (%)	0.7	0.7	0.9	1.0	1.1	0.6	0.7	0.8	0.9	1.0

Notes: *SBM = Soybean meal, SFM= Sunflower seed meal, GNC= Groundnut cake.ME= Metabolizable energy, CP= Crude protein, EE= Ether extract, Av. Phos. = Available Phosphorus.*
**1 kg of premix (Vitamin-Mineral mixture) contains: Vitamins A (5, 000, 000 I.U), Vitamin D3 (1000000 I.U), Vitamin E (16000 mg), Vitamin K3 (800 mg), Vitamin B1 (1200 mg), Vitamin B2 (22000 mg), Niacin (22000 mg), Calcium pontothenate (4600 mg), Vitamin B6 (200 mg), Vitamin B12 (10 mg), Folic acid (400 mg), Biotin (32 mg), Choline chloride (200000 mg), Manganese (948000 mg), Iron (40000 mg) Zinc (32000 mg), Copper (3400 mg), Iodine (600 mg), Cobalt (120 mg), selenium (48 mg), Anti-Oxidant (48000 mg).*

RESULTS AND DISCUSSION

Growth performance indices

There were differences in different parameters measured, except for initial live weight, FCR, and mortality, during the starter and finishing phases. The body weight of the chickens was the same across treatment groups at the starter phase. The birds on T5 spent more time-consuming feed than the control diet (T1). The values for DFI obtained in this study were lower than the values reported by (Attia *et al*., 2016) who reported DFI of 49.75 to 51.55 g in broiler chicks fed diets containing 0 to 7.5 % sunflower seed meal and attributed the difference to the differences in the variety of sunflower used. Total live weight gain of birds fed Diets 1, 2, and 3 (369.00, 357.50, and 402.33g/b) were significantly affected by the dietary treatments. When comparing birds given T5 to those fed control diet T1, a similar pattern in feed intake (DFI and TFI) was seen during the finisher phase. The TFI values at the finisher stage reported in this study varied from 1975.00g to 3501.70g. A similar trend was observed for TLWG at the starter phase (Figure 1) which increased linearly across the treatments with an increase in BSSM inclusion. The TLWG of birds ranged from 1051.30g in T1 to 1254.53g in T5. In comparison to the SFM-based diet, researchers (Aziz and Rashid, 2023) observed that birds fed the control diet had higher feed intake and live weight gain. Overall, the FCR and mortality were not affected by dietary treatments.

As mentioned by Alagawany *et al*. (2015) when broilers were fed different amounts of SFM-based diets, multiple authors have shown equivalent feed efficiency across all treatments. Chickens on the T5 diet had a better appetite than those on a control diet due to the larger feed consumed during the starter period. Diet T5 could have brought about a higher feed intake as it could contribute to greater appetite and feed palatability. To determine whether improved growth efficiency may not have been a direct result of raised FI, it is critical to consider the lack of distinct FCR and mortality variations. On the other hand, decreased mortality may indicate safe diets and effective management, emphasizing that the hens were reared following standard management procedures for Ross broilers, which are deemed most effective for promoting optimal growth performance in broiler chickens.

Haematological Indices

Haematological indices such as PCV, Hb, and RBC are greatly influenced by nutrition (Etim *et al*., 2014). All the haematological parameters in this study were not affected (p>0.05) by dietary treatments except for PCV and WBC (Table 3).

The PCV value of broilers fed T5 was 33.70%, while those fed the T1 control diet had the lowest value (25.30%). The PCV range of values (25.30–33.70%) obtained in this study is consistent with the usual range of values (25–45%) for hens (Etim *et al*., 2014; Kamboh *et al*., 2018). A study found that an animal's diet had no detrimental effects on it during the trial if its haematological indices remained within the normal range (Etim *et al*., 2014). The bodies of the birds could impact the PCV levels in this investigation. This is the reason that larger birds of the same age and species have more blood in them than smaller ones. The PCV values obtained in this study are higher than the earlier data reported by previous studies (Okonkwo & Esiegwu, 2018) for broiler finishers (32.66-36.33% and 23.32-32.33%), and slightly lower than the values (35-55%) reported by (Etim *et al*., 2014) typical for birds. Birds in the study showed elevated PCV and WBC values, suggesting they are healthy without exhibiting signs of nutritional deficiencies, disorders, or poisoning and are in quite good agreement with the broiler chicken reference ranges.

The WBC levels varied from 94.58 in T1 and 102.67 in T5. The WBC values for each treatment group revealed a comparable pattern. It increased with an increase in the level of BSSM inclusion. The precise mechanism underlying the rise in WBC may indicate that the dietary treatments may have impacted the birds' haematologic parameters (Figure 2), but further research is needed to ascertain these findings.

Carcass and Internal Organs Characteristics

Except for FLW and dressed weight, all of the parameters under investigation did not exhibit any significant (p>0.05) variations. This finding is in agreement with the report of (Sangsoponjit *et al*., 2017) who found no impact on the birds' cut yield and carcass percentage when sunflower meal was added to diets for broilers. Broilers fed diet T5 (8.8% BSSM) had the highest FLW (1761.20g) followed by birds fed on T4 (6.6% BSSM) (1745.18g) (Table 4). The breast weight which ranged from 340.74 g for birds fed diet T1 to 387.34g for those fed diet T4, was similar across the experimental groups. Also, broilers in the treatment groups had the same back weight (P>0.05). As body weight gain was higher at 6.6 and 8.8% BSSM levels, the dressed weight was also higher in birds fed these two levels than 0 and 2.2% inclusion diets, resulting in lower dressed weight.

The inclusion of BSSM had no effect (p>0.05) on the weight of internal organs obtained in this investigation, and the weight varied among the treatments. The cause of the discrepancy is not entirely apparent. Nonetheless, the outcome is identical to that of Vasilachi *et al*. (2019) who observed that feeding low-fiber sunflower meal (LF-SFM) or adding enzymes did not affect the carcass's features, breast yield, or visceral organ weight. Similarly, Dhakal *et al.* (2015) found that giblet weight and other carcass features were statistically equivalent (P>0.05). The slightly increased fibre content of the diets (Table 1-calculated nutrients composition) may have contributed to the numerically larger empty gizzard value shown in T3 and T4, increasing the gizzard's activity, as reported by (Alu *et al*., 2020). It can be inferred from this that the gizzard's weight might have gone higher as a result of the addition of 6.6 and 8.8% BSSM, possibly through fibre accumulation and delayed transit of fibre fractions.

The weight of the intestines, bile duct, and heart did not differ significantly (P>0.05); nevertheless, the 8.8% resulted in a numerically greater weight level. The fibre content in BSSM is slightly higher, but its economic value has decreased. Research by Kieffer *et al*. (2016) suggests that increased activity may lead to liver growth, resulting in weight gain. Authors believe that the chickens' increased weight came about due to increased kidney and cardiorenal metabolism brought on by anti-nutritional substances (Kieffer *et al*., 2016). Conversely, Araújo *et al*. (2014) discovered that including up to 24 percent sunflower meal in chick diets impaired carcass features and performance. There is nothing to be concerned about because adding 8.8% BSSM did not adversely affect broiler chicken production, as demonstrated in the preceding discussion. Generally speaking, the 2.2% BSSM inclusion had an effect that was comparable to the 0% BSSM of the control diet. Because adding BSSM to the diet of broiler chickens will increase their earnings, farmers can, therefore, utilize up to 8.8% BSSM level without appearing to be at risk.

Table 2: Growth Performance Characteristics of Broiler Chickens (0-8 weeks of age)

Parameters	Treatments (% BSSM)					
	T1 (0)	T2 (2.2)	T3 (4.4)	T4 (6.6)	T5(8.8)	SEM
Starter Phase						
Initial live weight (g/b)	127.90	127.90	127.93	127.93	127.90	0.059
Daily feed intake (g/b)	38.75^{b}	43.33^{ab}	37.20^{a}	42.86^{ab}	47.68^{a}	1.99
Total feed intake (g/b)	1085.00^{b}	1213.33^{ab}	1321.67^{a}	1200.00^{ab}	1335.00^{a}	55.78
TLWG (g/b)	369.00^{ab}	357.50^{ab}	402.33^{ab}	349.97^{b}	541.63^{a}	16.28
Final body weight (g/bird)	496.90^{ab}	485.40^{ab}	530.27^{ab}	477.90 ^{b}	541.63 ^{a}	16.26
Feed conversion ratio	2.96	3.40	3.33	3.42	3.42	0.20
Mortality (No)	3.00	4.00	1.00	3.00	3.00	
Finisher Phase						
Daily feed intake (g/b)	70.54^{b}	76.00^{b}	125.06^{a}	93.27^{ab}	119.81^{a}	11.04
Total feed intake (g/b)	1975.00^{b}	2127.98^{b}	3501.70^{a}	2611.55^{ab}	3345.79^{a}	309.05
TLWG (g/b)	1051.30^{b}	1117.92^{b}	1238.43^{a}	1238.51^{a}	1254.53^{a}	31.20
Final live weight (g/b)	1557.53^{b}	1624.62^{b}	1745.10^{a}	1745.18^{a}	1761.20^{a}	31.23
Feed conversion ratio	1.90	1.91	2.82	2.09	2.68	0.26
Mortality (No)	0.00	0.00	0.00	0.00	0.00	

Notes: *a, b, means in the same row with different superscript differ significantly (P<0.05), SEM= Standard error of means, TLWG= Total live weight gain.*

Table 3: Influence of Boiled Sunflower Seed Meal on Haemotological Indices of Broiler Chickens

Parameters	Treatments (% BSSM)					
	T1 (0)	T2 (2.2)	T3 (4.4)	T4 (6.6)	T5 (8.8)	SEM
PCV (%)	25.30^{b}	30.63^{ab}	29.60^{ab}	29.97^{ab}	33.70^{a}	1.87
RBC (g/dl)	1.56	2.16	2.01	1.53	1.89	1.058
Hb (g/dl)	7.26	9.200	8.40	6.10	8.600	4.56
WBC (x109/l)	94.58^{c}	96.68^{bc}	96.76^{bc}	101.08^{ab}	102.67^{a}	0.79
MCV (fl)	116.87	117.37	123.97	125.53	125.57	6.94
MCH (Pg)	46.63	42.53	41.86	56.8	45.17	26.90
MCHC (%)	27.36	25.76	26.83	34.00	27.83	16.373

Notes: *a, b, c= Means in the same row with different superscript differ significantly (P<0.05), SEM=Standard Error of Means, PCV=Packed Cell Volume, Hb=Haemoglobin; RBC=Red Blood Cell, WBC= White Blood Cells, MCV=Mean Corpuscular Volume, MCH=Mean Corpuscular Haemoglobin, MCHC=Mean Corpuscular Haemoglobin Concentration.*

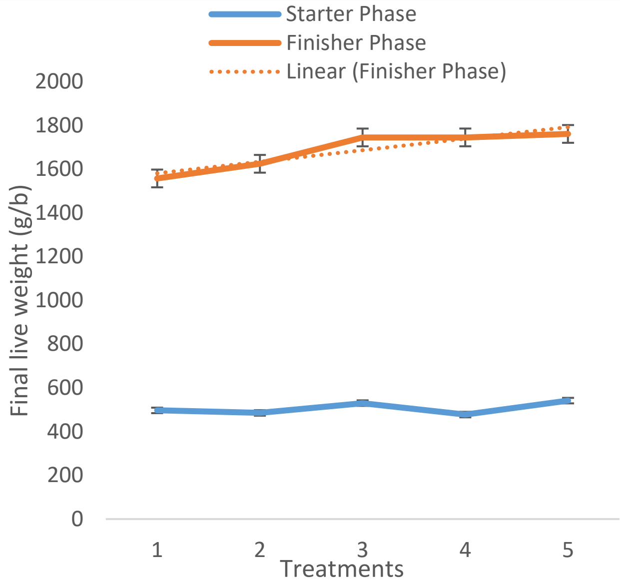

Figure 1: *Comparative performance of broiler*

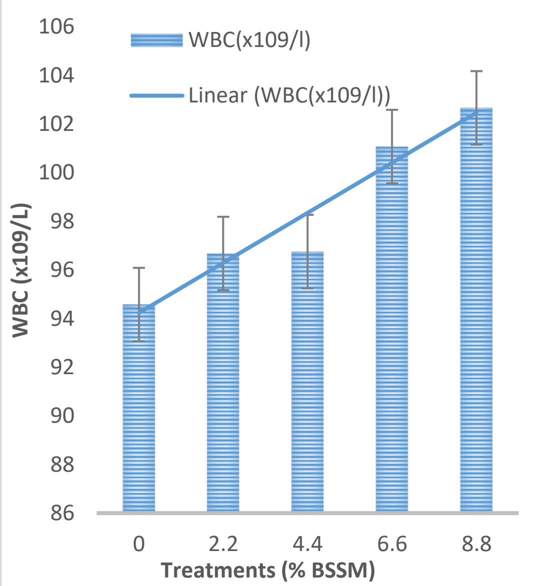

Figure 2: *Effect of BSSM on WBC of broiler*

Table 4: Carcass and Internal Organs Characteristics of Broiler Chickens Fed BSSM-Based Diets

Parameter	Treatments (% BSSM)					
	T1(0)	**T2(2.2)**	**T3(4.4)**	**T4(6.6)**	**T5(8.8)**	**SEM**
Carcass Components						
Final live weight (g/b)	1557.53^{b}	1624.62^{b}	1745.10^{a}	1745.18^{a}	1761.20^{a}	31.23
Dressed weight (g/b)	1448.33^{d}	1616.70^{b}	1531.3^{c}	1477.59^{d}	1718.46^{a}	46.76
Breast (g)	340.74	342.42	338.65	387.34	321.57	26.13
Back (g)	124.28	140.00	129.97	157.39	133.55	9.59
Neck (g)	54.25	61.03	54.56	62.46	51.65	3.33
Wings (g)	198.25	216.81	211.05	228.32	191.16	6.52
Thighs (g)	302.09	324.19	316.40	332.68	286.05	9.61
Drumsticks (g)	256.71	285.99	284.30	302.00	264.17	10.16
Internal Organ Components						
Liver (g)	33.45	36.01	38.59	36.57	31.02	2.00
Heart (g)	8.36	9.48	6.43	8.81	7.57	0.51
Empty gizzard (g)	42.50	59.56	62.36	63.47	55.27	3.03
Intestine (g)	118.47	141.21	129.48	139.39	106.32	9.91
Abdominal fat (g)	17.33	24.33	22.33	23.67	19.00	3.04

Notes: *^{a,b,c,d} means in the same row with different superscripts differ significantly (P<0.05), SEM= Standard error of means*

CONCLUSION

In conclusion, the 6.6–8.8% BSSM inclusion in the diets of broiler chickens during both the starter and finisher periods enhanced the birds' performance without a negative impact on their health or productivity. This implies that more investigation is needed to increase the quantity of sunflower seeds fed to broiler chickens that are treated with other options.

REFERENCES

Adesina, S. (2018). Effect of processing on the proximate composition of sunflower (*Helianthus annuus*) seeds. *17*(3), 27–33. https://doi.org/10.4314/as.v17i3.5

Alagawany, M., Farag, M. R., Abd El-Hack, M. E., and Dhama, K. (2015). The practical application of sunflower meal in poultry nutrition. *Nexusacademicpublishers.com* https://doi.org/10.14737/journal.aavs/2015/3.12.634.648

Alu, S. E., Oseze, F. S., and Ogoshi, E. J. (2020). Nutritional value of tiger nut (*Cyperus esculentus*) offal on the performance of broiler chickens. *Nigerian Journal of Animal Production, 2020•njap.org.ng*, https://njap.org.ng/index.php/njap/article/view/227

Araújo, W. A. G. de, Albino, L. F. T., Rostagno, H. S., Hannas, M. I., Pessoa, G. B. S., Messias, R. K. G., Lelis, G. R., Ribeiro, Jr V. (2014).. Sunflower meal and enzyme supplementation of the diet of 21-to 42-d-old broilers. *Brazilian Journal of Poultry Science, 2014•SciELO Brasil*. m https://www.scielo.br/j/rbca

Attia, G., Hassanein, E., El-Eraky, W., and El-Gamal, M. (2016). Effect of dietary inclusion of sunflower meal on performance, carcass traits, litter moisture and economic efficiency of broiler chickens. *Zagazig Veterinary Journal, 2016•journals.Ekb.Eg*, *44*(3), 234–243. https://doi.org/10.21608/zvjz.2016.7877

Aziz, S. R., and Rashid, S. A. (2023). Impact of using sunflower seed meal in broiler male diets on performance traits and carcass characteristics. https://doi.org/10.32649/ajas.2023.179726. *12*(1), 148-157.

Chatterjee, R. N., and Rajkumar, U. (2015). An overview of poultry production in India. *Anim. Hlth*, *54*(2), 89–108.

Dhakal, H., Sah, R., Karki, D., Yadav, J., and Tiwari, M. (2015). *Replacement effects of soybean meal with different levels of sunflower meal with or without enzyme on performance of Cobb-500 broilers*. https://www.cabidigitallibrary.org/doi/full/10.5555/20163045007

Ditta, Y., and King, A. J. (2017). Recent advances in sunflower seed meal as an alternate source of protein in broilers. *World's Poultry Science Journal, 2017•cambridge.org*.

Etim, N. A. N., Akpabio, U., Okpongete, R. O., and Offiong, E. E. (2014). Haematological Parameters and Factors Affecting Their Values. *Agricultural Science*, *2*(1), 37–47. https://doi.org/10.12735/as.v2i1p37

Gupta, M. K. (2014). Sunflower oil and its applications. *Lipid Technology*, *26*(11–12), 260–263. https://doi.org/10.1002/LITE.201400068

Hafez, H. M., and Attia, Y. A. (2020). Challenges to the Poultry Industry: Current Perspectives and Strategic Future After the COVID-19 Outbreak. *Frontiers in Veterinary Science*, *7*. https://doi.org/10.3389/FVETS.2020.00516/FULL

Hahn, G., and Spindler, M. (2002). Method of dissection of turkey carcases. *World's Poultry Science Journal*, *58*(2), 179-197. *cambridge.org*.

Kamboh, A. A., Khan, M. A., Kaka, U., Awad, E. A., Memon, A. M., Saeed, M., Korejo, N. A., Bakhetgul, M., and Kumar, C. (2018). Effect of dietary supplementation of phytochemicals on immunity and haematology of growing broiler chickens. *Italian Journal of Animal Science*, *17*(4), 1038–1043. https://doi.org/10.1080/1828051X.2018.1438854

Kieffer, D. A., Martin, R. J., and Adams, S. H. (2016). Impact of dietary fibers on nutrient management and detoxification organs: gut, liver, and kidneys. *Elsevier*. https://www.sciencedirect.com/science/article/pii/S2161831322007943

Kim, S., Less, J., Wang, L., Yan, T., Kiron, V., Kaushik, S. J., and Lei, X. G. (2019). undefined. (2019). Meeting global feed protein demand: challenge, opportunity, and strategy. *Annual Review of Animal Biosciences, 2019•annualreviews.org*, *7*, 221–243. https://doi.org/10.1146/annurev-animal-030117-014838

Mohammed, A. B., Doma, U. D., Bello, K. M., Yusuf, S. Z., and Alhassan, N. M. (2020). Performance and Economics of Production of Broiler Chickens Fed Dietary Levels of Toasted Full Fat Sunflower Seed Meal (*Helianthus annuus*). *3*(2), 197–205. http://www.njast.com.ng/index.php/home/article/view/94

Molale, G. (2020). Influence of enzyme supplementation on growth performance, serum biochemical parameters and meat quality of broilers fed diets of varying levels of sunflower meal. https://repository.nwu.ac.za/handle/10394/35087

Nkukwana, T. T. (2019). Global poultry production: Current impact and future outlook on the South African poultry industry. *South African Journal of Animal Science*, *48*(5), 869. https://doi.org/10.4314/sajas.v48i5.7

Okonkwo, V. N., and Esiegwu, A. C. (2018). Haematological and serum biochemical indices of finisher broilers fed Spondias mombin leaf meal. *Journal of Animal Science Veterinary Medicine, 2018•scholar.archive.org*, *3*(5), 165–170. https://doi.org/10.31248/JASVM2018.107

Onuwa, G., Mgbojikwe, A., Emmanuel, B., Okeke-Agulu, K., and Chizea, C. (2021). Comparative analysis of growth parameters of soybean and sunflower feed rations in broiler production. *Food and Environment Safety Journal, 2021•fens. Usv. Ro*, *XIX*, 316–322. http://fens.usv.ro/index.php/FENS/article/view/754

Sangsoponjit, S., Suphalucksana, W., and Srikijkasemwat, K. (2017). Effect of feeding sunflower meal on the performance and carcass characteristics of broiler chickens. *Cetjournal.ItS Sangsoponjit, W Suphalucksana, K SrikijkasemwatChemical Engineering Transactions, 2017•cetjournal.it*. http://www.cetjournal.it/index.php/cet/article/view/CET1758141

Sirois, M. (2019). *Laboratory Manual for Laboratory Procedures for Veterinary Technicians E-Book: Laboratory Manual for Laboratory Procedures for Veterinary Technicians E*. https://books.google.co.uk/books?hl

Tenyang, N., Ponka, R., Tiencheu, B., Tonfack Djikeng, F., and Womeni, H. M. (2022). Effect of boiling and oven roasting on some physicochemical properties of sunflower seeds produced in Far North, Cameroon. *Food Science & Nutrition*, *10*(2), 402-411. *Wiley Online Library* https://doi.org/10.1002/fsn3.2637

Vasilachi, A., Ciurescu, G., Grosu, H., and Grigore, D. (2019). Growth performance, carcass traits, and blood biochemistry of broiler chicks fed with low-fibre sunflower meal and phytase. *journals.co South African Journal of Animal Science, 2019•journals.co.za*, *2019* (4), 735–745. https://doi.org/10.4314/sajas.v49i4.15

Waititu, S. M., Sanjayan, N., Hossain, M. M., Leterme, P., and Nyachoti, C. M. (2018). Improvement of the nutritional value of high-protein sunflower meal for broiler chickens using multi-enzyme mixtures. *Elsevier. Poultry Science, 2018•Elsevier*. https://www.sciencedirect.com/science/article/pii/S0032579119309903