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Original Article

Effect of Hydroponic Wheat Sprout on the Growth Performance, Carcass Characteristics, and Lipid Profiles of Broilers

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ABSTRACT

The aim of present study was to understand the dietary effect of hydroponic wheat sprout (WS) on the growth performance, carcass characteristics and lipid profiles of broiler chickens. Two independent feeding trials were conducted using Cobb 500 broiler DOC for the period of 0 to 32 days. In the first trail, 264 DOC were allocated into 4 treatments having 3 replications per treatment and 22 birds per replication to find out the suitable inclusion level of WS. In second trial, 384 broiler DOC were allocated into 4 treatments having 6 replications per treatment and 16 birds in each replication to assess the functional quality of WS. In first trial, the body weight (1692.33 g/bird), body weight gain (1644.96 g/bird) and FCR (1.47) were significantly ($p<0.05$) improved in the birds fed 50 g/kg WS compared to the other dietary groups but feed intake showed no significant ($p<0.05$) differences. Likewise, in second trial the birds fed commercial feed showed significantly ($p<0.05$) higher body weight (1649.50 g/bird) and weight gain (1601.88 g/bird) compared to the birds fed 50 g/kg WS. Feed intake and FCR showed no significance differences. Total cholesterol and triglycerides were significantly ($p<0.05$) lower (85.5 mg/dl and 84.32 mg/dl, respectively) however HDL was higher (111.86 mg/dl) in the birds received 50 g/kg WS. Taken all together, it can be concluded that the inclusion of 50 g/kg WS in broiler had positive effects on growth performance and blood lipid profile in commercial broilers.

INTRODUCTION

Started almost 3-4 decades back, the commercial broiler production has got a good shape, producing about 1.75-2.00 crore day-old chicks per week (WPSA-BB, 2020). Along with other sources of animal protein, broiler chicken meat also attributed significantly in supplying as the cheapest sources of animal protein to the nation. The per capita broiler meat consumption in Bangladesh has been reported to 6.3 kg (WPSA-BB, 2021). In recent days, consumers in Bangladesh are confused regarding the quality of broiler meat and claimed that the producers might incorporate objectionable drugs and additives in the way of broiler production, processing and marketing. Therefore, the production of safe and quality broiler meat is the demand of today's consumers. Poultry nutritionists have taken various attempts for production of safe and quality broiler meat by supplementations of probiotics, prebiotics, acidifiers, various medicinal plants, and herbs etc. as alternatives to traditional antibiotics, hormone or any other chemicals (Roy *et al.*, 2015). As like many other natural and safe feed supplements, hydroponic wheat sprout (WS) may be considered as one of the potential herbal feed supplements for the production of quality and safe broiler meat. WS has been used for many years to enhance immune modulation, improve intestinal health, meat quality and production performance of broiler chicken (El-Katcha *et al.*, 2014). Sprouting is a very simple technique for germination of seeds such as wheat, maize, barley etc. to improve their nutritive values (Khattak *et al.*, 2007). Sprouting caused a considerable change in the physical and chemical composition of wheat, which after feeding to pig and poultry, did not show any detrimental effects (Johnson & Taverner, 2019). Inclusion of hydroponic wheat sprout at 150 g/kg feed significantly improved overall growth performances of turkeys (Ali *et al.*, 2019). While sprouting, the complex compounds in particular sprouted gains are converted to simple and essential form that not only improves the nutritional values but also minimize the effect of anti-nutritional factor in poultry feeds (Fouad & Rehab, 2015). Cudderford (1989) reported that vitamin contents of sprouted grains can be improved up to 20 times. While sprouting is performed the minerals are merged with protein (chelated) and increased their biological functions. It has also been reported that germination eliminates the effect of phytic acid by the production of phytase enzymes (Shipard, 2005).

Cholesterol ester, a major constituent of plasma cholesterol, was significantly reduced with feeding malted wheat sprout (Fafiolu *et al.*, 2006). Although, some research findings suggest the inclusion of WS in poultry diets however, the basic information regarding production performance of broiler and blood profiles after inclusion of WS yet has not been investigated. The current study was therefore designed to examine the feasibility of inclusion WS in broiler diet and growth performance of commercial broiler fed WS in different levels. Further, the various changes in blood parameters and carcass quality of commercial broiler after inclusion of WS were also investigated.

MATERIALS AND METHODS

Two independent feeding trials were conducted at Bangladesh Agricultural University Poultry Farm, Mymensingh, Bangladesh to observe the effect of WS on growth performance, carcass characteristics and lipid profiles of broiler chickens.

Feeding trial 1

Bird's management, experimental diets, and feed supply

A total of 264-day old chicks of Cobb-500 broiler were considered with 4 dietary treatment groups having 3 replications in each treatment and 22 birds per replication. The treatments were noted as FT_0 (FT refers as first trial) = control or basal diet (without WS supplementation); FT_1 = basal diet plus 25 g/kg WS; FT_2 = basal diet plus 50 g/kg WS; and FT_3 = basal diet plus 75 g/kg WS. Diets for each treatment was prepared separately, distributed into 4 treatments and then the feeds were kept treatment-wise in plastic buckets. Birds were reared in the open-sided gable type house under standard husbandry practices. The experimental room was cleaned and disinfected. Feeders and drinkers were properly cleaned, washed and disinfected before placement of the experimental birds. Vaccination and other routine activities were performed as per standard management guidelines. Experimental diets were formulated using commonly and locally available feed ingredients satisfying the requirements of the particular broiler strain. Starter diet was provided to the birds for first 15 days while the grower diet was supplied from 16 to 32 days in mash form. It can be noted that the broiler chicks did not consume WS at early age, thus the WS was supplied to the birds from 8 to 32 days along with main diet. Feed was supplied ad-libitum and clean drinking water was made available at all times.

Feeding trial 2

Bird's management, experimental diets and feed supply

A total of 384-day old chicks of Cobb-500 broiler were used for the second feeding trail, where the birds were allocated into 4 dietary treatment groups having 6 replications in each treatment and 16 birds per replication. The treatments were noted as ST_0 (ST refers as second trial) = basal diet (hand mixed feed); ST_1 = basal diet plus 50 g/kg wheat sprout; ST_2 = basal diet plus probiotic and finally ST_3 = readymade feed without any supplementation. Diets for each treatment was prepared separately and kept treatment wise in plastic buckets. The goal of this trial was to compare the efficacy between WS and probiotic on growth performance and serum lipid profile of broiler chickens. Birds were reared in the open-sided gable type house under standard husbandry practices. All other managemental practices were followed as mentioned in feeding trial 1.

Preparation, cultivation and harvest of hydroponic wheat sprout for feeding

Hydroponic WS was produced, harvested and collected from the "Aquaponics Oasis" Laboratory of the Department of Aquaculture, Faculty of Fisheries, BAU, Mymensingh. The galvanized trays (size 22" x

14" x 2.5"), bucket, gunny bag, watering jerry can, wheat seed and bleach solution purchased from local market were used for sprouting. The galvanized trays were washed with bleaching solution and tap water, sun dried and then used for sprouting. For sprouting, 300 to 1500 g fresh wheat seed was cleaned, washed 3-5 times with tap water and remove dead and floating seeds. Moreover, 5-10 drops of bleach solution were poured to the seeds containing bucket and kept for 15 minutes to prevent fungal infection in the growing sprouts. Then the seeds were again washed with clean water and soaked for 3-4 hours adding 2 g of raw salt to prevent browning leaf tip. After soaking 3-4 hours and drained water, the seeds were put in gunny bags and kept in bucket for 24 hours before spreading on the tray uniformly. Approximately 250 to 350 ml tap water sprayed three times daily on each tray and covered the trays with a gunny bag for 4 days to remain the seed in dark and kept moist. After 4 days, uncovered the tray and continued watering till harvest the WS at 7-8 days.

Supply and feeding of hydroponic wheat sprout to the experimental birds

The test ingredient WS was supplied to the experimental birds from day 8 to end of the feeding trial i.e., 32th day. WS was chopped and started to supply with feed at early age but the chicks did not intake sprout during the first week. They started to consume chopped WS properly from day 8 of experimentation. Thus, WS was supplied for the periods of 8 -32 days along with the basal diet. WS were chopped into small sizes with scissor, again weight according to the requirement and supplied with feed twice daily, morning and afternoon.

Blood collection and serum sampling

Approximately 3 ml of blood was collected from the central vein of broiler chickens at 1st and 2nd weeks, and then from wing vein at 3rd week, 4th week and 32 days of age using clean and sterilized disposable syringe with needle. Samples were collected from three birds randomly selected in each treatment and the syringe with blood thereafter were placed in a slanting position (45° angles) at room temperature for clotting. After 2 hours separated blood serum was transferred to an eppendorf tube (1.5 ml) and centrifuged at 3000 rpm for 10 minutes. The supernatant was then transferred into another eppendorf tubes and preserved at -20°C until analysis. Eppendorf tubes were marked properly with permanent marker for easy identification during chemical analysis. Frozen serum sample was thawed at room temperature and analyzed for cholesterol, triglycerides and HDL using chemical kits (LINEAR CHEMICALS, S.L.U., Joaquim Costa, Spain) at Professor Mohammad Hossain Central Laboratory, Bangladesh Agricultural University. T80 UV/VIS Spectrometer was used to measure blood lipid profile. Whereas for cholesterol, assay conditions were set at 505 nm wavelength, 1 cm light path for cuvette and temperature at 25°C. After then the instrument was adjusted to zero with distilled water. Thereafter 100 µl reagents (Cholesterol MR) was pipetted into cuvettes. Then 10 µl standard and 10 µl samples was pipetted into standard cuvette and sample cuvettes respectively, and also a blank cuvette was kept with reagents only. These samples were mixed well and incubate for 10 minutes at 25°C. Then the absorbance was read for the serum samples and standard against the blank. The protocol for measurement of Triglyceride (TG) was almost similar with the measurement of cholesterol with only exception of the reagents, where Triglyceride MR was used in the determination of TG. For HDL level measurement, 100 µl reagents (HDL Cholesterol reagents) and 1 ml sample were pipetted into centrifuge tube and mixed well. Then allowed to stand for 10 minutes at 25°C. Mixed samples were then centrifuged at 4000 rpm for 20 minutes. Thereafter the supernatant was collected and proceed following the protocol as the determination of cholesterol.

Data collection, record keeping, and statistical analysis

Body weights were recorded on day 7, 14, 21, 28 and 32 days of experimentation. Feed consumption was determined along with the body weight records. The body weight gain was calculated by deducting initial body weight from the final body weight of the birds. Quantity of feed offered to the birds was weighed and recorded weekly. Residual feed was recorded to determine feed intake per birds. Subsequently, feed conversion ratio (FCR) was calculated weekly by dividing feed intake by weight gain. All the recorded and calculated data were statistically analyzed through analysis of variance (ANOVA) technique by computer using a SPSS statistical computer package program in accordance with the principles of Completely Randomized Design (CRD). Duncan multiple tests were calculated to compare significant variations among treatments where ANOVA showed significant differences.

RESULTS

Feeding trial 1

Growth performance and carcass characteristics of broiler fed different levels of wheat sprout

In first feeding trial, birds were given basal diet supplemented with 0 g/kg, 25 g/kg, 50 g/kg and 75 g/kg WS respectively in four treatment groups to find out the appropriate inclusion level of WS in broiler chickens. Changes in final body weight, body weight gain, feed intake, FCR and carcass characteristics of broilers fed different levels of WS are shown in Table 1 (a-b).

The results presented in Table 1 (a) showed that there were significant differences in body weight, body weight gain and FCR among the treatment groups. The average final body weight of 0 (control/basal), 25, 50 and 75 g/kg supplementations of WS were 1395.33, 1369.33, 1692.33 and 1370.80 g/bird, respectively. Results showed that the birds fed 50 g/kg WS attained significantly higher body weight as compared to other treatment groups. Likewise, the body weight gain was also found highest in 50 g WS/kg supplementation group (1644.96 g/bird), followed by the control (1348.53 g/bird) and 75 g WS/kg (1323.66 g/bird). The lowest body weight gain (1322.66 g/bird) however was recorded in the birds that received 25 g/kg WS in the diet. Overall feed intake along with the intake of WS were measured and recorded. The results revealed that there were no significant differences in feed intake among the experimental birds that received different levels of hydroponic WS during the entire experimental period. Although, the birds fed 50 g WS/kg feed showed numerically higher feed intake as compared to other dietary groups. Almost similar to the results of body weight and body weight gain, significant differences of final FCR were observed among the treatment groups. The better FCR was noted in the group fed 50 g WS/kg feed (FCR - 1.47) followed by the control and the highest values of FCR recorded for the groups that were supplement with 25 g and 75 g WS/kg feed.

Table 1 (a) – Overall production performances of broiler chicken after supplementation of WS at different levels.

Parameters	Treatments					
	FT_0	FT_1	FT_2	FT_3	*p*-Value	LS
Body weight (g/bird)	1395.33b±3.52	1369.33b±9.82	1692.33a±12.44	1370.80b±21.40	0.000	**
Body weight gain (g/bird)	1348.53b±3.37	1322.66b±9.99	1644.96a±12.48	1323.66b±21.65	0.000	**
Feed intake(g/bird)	2254.10±24.73	2227.24±21.55	2316.16±20.63	2288.07±2.06	0.232	NS
FCR	1.64b± 0.01	1.71a±0.01	1.47c±0.01	1.72a±0.03	0.000	**

a,b,c means with different superscripts within the same row differ significantly, * = Significant ($p<0.05$), ** = Significant ($p<0.01$). Where, NS = Non-significant, LS = Level of Significance, FT_0 = control/basal diet (without WS supplementation); FT_1 = 25 g; FT_2 = 50 g; FT_3 = 75 g WS /kg feed.

The carcass characteristics of experimental broiler chickens fed different levels of WS shows in Table 1 (b). Results showed that there were no significant differences for various carcass parameters among the treatment groups.

Table 1 (b) – Changes in the carcass characteristics of broiler fed different levels of WS..

Parameters (in relation to body weight)	Carcass characteristics of broilers					
	FT_0	FT_1	FT_2	FT_3	*p*-Value	LS
DP (%)	72.38 ± 0.14	73.37± 0.48	73.77 ± 0.31	73.39 ± 0.74	0.280	NS
Thigh (%)	11.96 ± 2.12	14.38 ± 2.98	14.91 ± 0.80	14.69± 0.41	0.676	NS
Drumstick (%)	9.15 ± 0.97	11.49± 0.53	11.47± 0 .13	10.93± 0.07	0.056	NS
Breast (%)	28.55 ± 0.36	29.95 ± 0.53	28.42 ± 0.36	29.37± 0.40	0.104	NS
Wing (%)	8.17 ± 0.85	10.41± 0.54	9.05± 0 .37	9.67± 0.19	0.096	NS
Head (%)	1.35 ± 0.02	1.34 ± 0.08	1.38 ± 0.05	1.42± 0.08	0.809	NS
Liver (%)	3.41 ± 0.17	3.25 ± 0.03	3.29 ± 0.11	3.49± 0.15	0.602	NS
Gizzard (%)	2.04 ± 0.02	2.20± 0.10	2.21± 0.10	2.42± 0.09	0.097	NS
Heart (%)	0.63 ± 0.04	0.57 ± 0 .04	0.69 ± 0.05	0.68 ± 0.01	0.212	NS
Abdominal fat (%)	1.11 ± 0.04	1.26 ± 0.09	1.18 ± 0.08	1.08 ± 0.11	0.496	NS
Neck (%)	5.98 ± 0.22	6.58 ±0 .02	6.06 ± 0.28	6.18 ± 0.53	0.598	NS
Shank (%)	3.70 ± 0.64	4.7 ± 0.40	4.95 ± 0.09	5.01 ± 0.33	0.173	NS

Where, NS = Non-significant, LS = Level of Significance, FT_0 = control/basal diet (without WS supplementation); FT_1 = 25 g; FT_2 = 50 g; FT_3 = 75 g WS/kg feed.

Feeding trial 2

Growth performance of broiler chickens fed wheat sprout, probiotic or commercial diets

In second trial, average final changes in body weight, body weight gain, feed intake and FCR of broilers fed WS, probiotic and commercial feed are shown in Table 2.

The results presented in the Table 2 indicates significant differences in body weight and body weight gain among the dietary treatments groups. At the end of feeding trial, body weight as well as body weight gain were highest in the birds fed commercial diet as compared to control and probiotic groups. No significance differences were observed in between the birds fed 50 g WS/kg and probiotic in diets. The lowest results however were found in the control diet during the rearing period. The average final body weight of control, 50 g WS/kg, probiotic and commercial feed were 1527.41, 1591.35, 1596.91 and 1649.50 g/bird, respectively. On the contrary, no significant effect on feed intake and FCR were found among the dietary treatment groups.

Table 2 – Production performances of broiler in different dietary groups.

Parameters	Treatments					
	ST_0	ST_1	ST_2	ST_3	*p*-Value	LS
Body weight (g/bird)	1527.41^c ±4.54	1591.35^b ±6.56	1596.91^b ± 4.24	1649.50^a ± 3.48	0.000	**
Body weight gain (g/bird)	1479.80^d ±4.50	1529.71^c ±7.12	1549.31^b ± 4.23	1601.88^a ± 3.50	0.000	**
Feed intake(g/bird)	2715.17±69.38	2669.71±39.66	2721.51 ±60.64	2744.68 ±65.39	0.844	NS
FCR	1.83 ± 0.05	1.74 ± 0.03	1.75 ± 0.04	1.71 ± 0.04	0.191	NS

a,b,c means with different superscripts within the same row differ significantly, * = Significant (p<0.05), ** = Significant (p<0.01). Where, NS = Non-significant, LS = Level of Significance, ST_0 = Control, ST_1 = 50 g WS/kg feed, ST_2 = Probiotics, ST_3 = Commercial feed.

Blood lipid profile of broiler chickens fed different experimental diets

Data on different blood lipid profiles such as total cholesterol, triglycerides and HDL values of broiler at 1st, 2nd, 3rd, 4th weeks and also 32th day were examined, recorded and finally analyzed. Weekly changes in total cholesterol level, triglycerides and high-density lipoprotein (HDL) of broilers fed WS, probiotic and commercial feed is presented in Figure 1 (a-c). The total cholesterol level of broiler chickens fed different experimental diets is shown in Figure 1-a. Overall blood cholesterol levels for all the birds in different treatment groups were higher at beginning of the experiment and then gradually decreased with increase the age of birds except in the commercial diet-based group, which remained almost equal during the entire rearing period. The levels of total cholesterol were significantly lower at 4th week (88.47 mg/dl) and 32th day of age (85.5 mg/dl) in the birds fed 50 g WS/kg feed. The highest level of cholesterol was observed in the birds fed commercial diet at 4th week (142.36 mg/dl) and at 32th days of age (148.63 mg/dl). No significant differences however were found at 1st, 2nd and 3rd weeks of age among the treatment groups. Changes in the triglyceride (TG) of experimental birds fed different diets showed in Figure 1-b. The overall TG levels were significantly decreased in all treatment groups except the birds that received commercial feed, in which the TG level remains almost unchanged during the whole experimental period. The lowest TG levels were recorded in 50 g WS/kg feed at 3rd week (92.53 mg/dl), 4th week (87.13 mg/dl) and 32th day

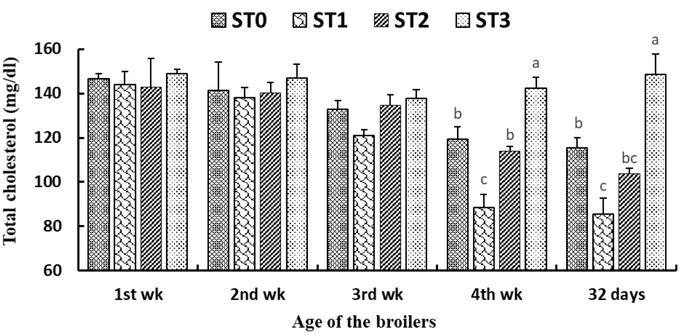

Figure 1-a – Changes in total cholesterol (mg/dl) after dietary supplementation.

Where, ST_0 = Control, ST_1 = 50 g WS/kg feed, ST_2 = Probiotics, ST_3 = Commercial feed. Bars within a time class not sharing a common letter are significantly different (p<0.05). [a,b,c] means with different superscripts within the same row differ significantly.

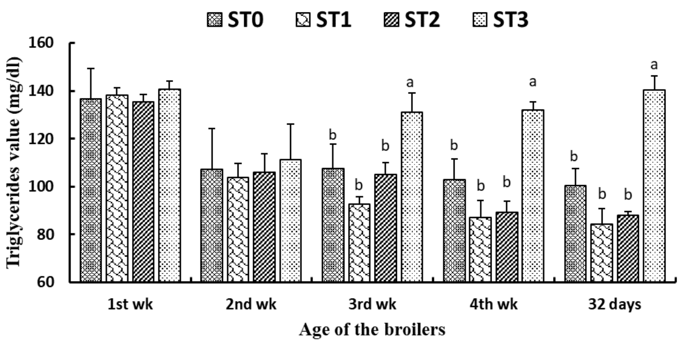

Figure 1-b – Changes in triglycerides (mg/dl) after dietary supplementation.

Where ST_0 = Control, ST_1 = 50 g WS/kg feed, ST_2 = Probiotics, ST_3 = Commercial feed. Bars within a time class not sharing a common letter are significantly different (p<0.05). [a,b,c] means with different superscripts within the same row differ significantly.

(84.32 mg/dl) of rearing. The highest TG levels were found in the birds fed commercial diet at 4th week (131.14 mg/dl), 3rd week (132.14 mg/dl) and 32th day 140.31 mg/dl) of rearing. Unlike total cholesterol and triglyceride, the levels of high-density lipoprotein (HDL) were gradually increased from the beginning to end of the experiment for all treatment groups (Figure 1-c). Significantly higher HDL levels (111.86 mg/dl) were observed in the birds that received 50 g WS/kg feed as compared to probiotic, control and commercial diet groups. As a usual phenomenon of blood parameters for broiler experiments, HDL levels showed statistically insignificant at 1st, 2nd and 3rd weeks of age among the treatment groups.

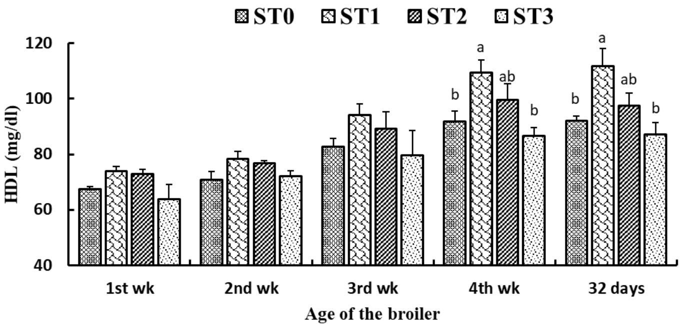

Figure 1-c – Changes in HDL (mg/dl) after dietary supplementation.

Where ST_0 = Control, ST_1 = 50 g WS/kg feed, ST_2 = Probiotics, ST_3 = Commercial feed. Bars within a time class not sharing a common letter are significantly different (p<0.05). [a,b,c] means with different superscripts within the same row differ significantly.

DISCUSSION

Results of first feeding trial revealed that the overall growth performances (body weight, body weight gain, FCR) were significantly improved in broiler chickens after inclusion of WS @ 50 g/kg in diet. Previous published data by Hamid (2001) confirmed the improvement of broiler growth performance by feeding germinated seeds. Muhammad *et al.* (2013) also reported about 80 g/kg improvement of body weight in broiler chickens fed sprouted grains. Sprouting wheat and barley added a beneficial effect on the various villi parameters of broiler chickens, which could be led to better utilization of feed, improve the microflora and reduce harmful bacteria in the gut (Afsharmanesh *et al.*, 2013). In recent report of Linh *et al.* (2020) mentioned about 0-75 g/kg linear improvements in daily weight gain and feed conversion as the level of sprouted rough rice in the feed increased. Further, there are reports also suggest the significant improvement of growth performances of experimental broilers by supplementation of dietary herbs (Cross *et al.*, 2007; Bampidis *et al.*, 2005), which are almost resemble to the results of present study. Thus, it is likely that the growth performances of broiler chickens are improved with dietary inclusion of WS. Several published reports suggest that the process of sprouting may initiate the de novo synthesis of starch-degrading enzymes, such as α-amylase and α-glucosidase, in the scutellum and aleurone cells (Ayernor & Ocloo, 2007; Duke and Henson 2009; Saman *et al.*, 2008; Xu *et al.*, 2012), which might enhance in the growth of experimental birds. Donkor *et al.* (2012) mentioned that the protein contents of wheat might be increased about of 50 to 100 g/kg after sprouting the seeds. Functionally, vitamin C has pivotal role in the rearing of poultry and livestock, particularly in poultry it has common use to minimize the various stresses during high ambient temperature, transportation of birds, molting, debeaking, vaccination etc. Despite the facts that the level of vitamin C is very low or sometimes undetectable in cereal grains, however we do extrapolate a possible contribution of this vitamin, as its level can be improved or biologically more actives by sprouting the cereal grains. Published reports also supports the hypothesis that the vitamin C is synthesized de nevo (Yang *et al.*, 2001; Coulibaly & Chen, 2011), leading to increase its level about 5 to 55 mg/100 g in sprouted wheat (Lintschinger *et al.*, 1997; Yang *et al.*, 2001).

Although, the precise mechanisms of increased growth performance in broiler chickens after supplementation of WS in diet remain unclear however it might be possible that the process of spouting improved overall nutritional and functional properties of bioactive compounds in sprouted grains, lunches de nevo synthesis of various nutrients, broken down some anti-nutritional factors in feed, produced beneficial enzymes for better digestion and also enhanced various villi parameters in gut for better nutrients utilization, which all together attributed in improved growth performances of the birds observed in present study.

In second feeding trial, changes in various lipid profiles in the serum of experimental broiler chickens fed WS @ 50 g/kg were examined. The levels of triglyceride and total cholesterol were significantly decreased and HDL level was increased after inclusion of WS in the diet of broiler chickens clearly indicated the positive impact of WS on the lipid profiles of experimental birds. The impacts of sprouted grains on plasma lipid profiles become a matter of concerns to the scientists across the world, as because sprouting produced bioactive compounds which somewhat linked to reduce the risk of cardiovascular diseases in human. In recent study, Younis *et al.* (2019) revealed the significant reduction of serum cholesterol and triglyceride in Japanese quail after inclusion of germinated sorghum in the diets. The levels of total blood serum cholesterol and LDL were also reduced, and HDL was increased in Japanese quails fed the diets supplemented with different levels of germinated Moringa oleifera seeds (Mousa *et al.*, 2016). Wu *et al.* (2013) suggested that the sprouting of brown rice has a greater effect on reducing blood serum cholesterol as compared to its non-sprouted counterpart. The level of total cholesterol was also significantly reduced by the inclusion of sprouted brown rice in the experimental rats fed high cholesterol diet (Roohinejad *et al.*, 2010). Sprouted buckwheat was also significantly reduced hepatic total cholesterol in hamsters (Lin *et al.*, 2008). In recent study, Mattioli *et al.* (2016) demonstrated that the supplementation of alfalfa and flax sprout to laying hens reduced cholesterol in plasma and egg yolk, which might be induced by the transfer of bioactive compounds from fresh sprout to the laying hens as well as their egg yolk. Thus, the reduction of total cholesterol and increased level of HDL in blood of the broiler chickens fed WS might be because of some bioactive compounds present in WS. Further research can be conducted to isolate the bioactive compound(s) from the WS and observe the efficacy of the isolated compounds on poultry/animal models by direct application through feed or water.

The levels of blood serum cholesterol and triglycerides were almost unchanged in the birds fed commercial diet during the entire experimental period. It remains unclear why the lipid profiles did not alter in commercial feed group, however data showed that the overall body weight, feed intake and feed utilization were highest in this group, suggesting a possibility of consumption and/or utilization of higher quantity of cholesterol and triglycerides, which eventually attributed in their serum levels. Since the details chemical composition of commercial feed unknown, it also be possible the presence of some feed additives in the diet that might trigger the elevated levels of cholesterol and triglycerides in the particular group.

CONCLUSION

Taken all together, it may be concluded that the inclusion of 50 g WS/kg diet positively affects growth parameters, lowered serum cholesterol and triglycerides but elevated HDL level in broiler chickens. Thus, the test ingredient hydroponic WS can be recommended for commercial broilers at the rate 50 g/kg of mixed feed.

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