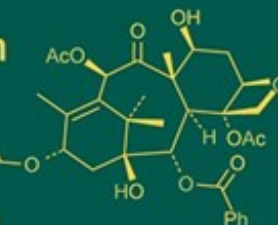
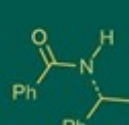
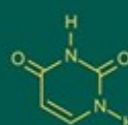


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Effect of herbal vitamins on growth performance and meat quality of broiler chicken

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ABSTRACT

An experiment was conducted with one hundred- and seventy-five-day old broiler chicks (Ven Cobb 430y strain) to assess the effect of dietary supplementation of herbal vitamins on meat quality of broiler chicken. The chicks were divided into control, positive control, T1, T2 and T3 having 5 replicates of seven chicks in each group. Chicks in control were given basal diet (BIS, 2007) without vitamins supplementation and positive control, T1, T2 and T3 were supplied with synthetic vitamin E (0.01 %) + synthetic vitamin C (0.02 %), herbal vitamin E (0.01 %), herbal vitamin C (0.02 %), herbal vitamin E (0.01 %) + herbal vitamin C (0.02 %) respectively. Improved performance was observed in vitamins supplemented group in terms of body weight gain, feed intake, feed conversion ratio. The pH, WHC, instrumental color profile and sensory evaluation was non-significantly ($P \geq 0.05$) different among experimental groups and control. The physico-chemical attributes such as cooking loss and sensory score in respect to colour differ significantly. Textural profile quality in respect to hardness differ highly significant ($P \leq 0.01$) among experimental groups and control. Based on findings, it could be concluded that supplementation of herbal vitamin E/Selenium (0.01%) + herbal vitamin C (0.02%) was improved the body weight gain, feed intake, feed conversion ratio and physico-chemical attributes, texture profile, instrumental color profile and sensory quality of meat.

Keywords: Herbal vitamins, Texture profile, Instrumental color profile, Physico-chemical quality, Sensory quality

Introduction

Chicken meat accounted for roughly 39% of world meat output (FAO, 2019) [1]. Total poultry has reached to 16.81% and total poultry production is 851.81 million. The total commercial poultry production is 534.74 million which has increased by 4.5% in 2019. India's agricultural industry is currently one of the fastest expanding sectors, with broiler production rising at an annual rate of 8 to 10% (APEDA, Annual report, 2020-21) [2]. Indeed, poultry breast meat, fits the modern consumer demand for low fat, sodium and cholesterol (Cavani *et al.*, 2009) [3]. Proteins, lipids and minerals make up the bulk of raw poultry flesh in proportions ranging from 18.4 to 23.4, 1.3 to 6.0, and 0.8 to 1.2%, respectively (Culioli *et al.*, 2003) [4].

Vitamin E is the primary lipid-soluble antioxidant present, performs a crucial role as a chain-breaking lipid antioxidant and free radical scavenger in the membranes of cells and subcellular organs (Young *et al.*, 2003). Natural vitamin E is physiologically and chemically distinct from manufactured vitamin E and it has the highest bioavailability in animals (Wilburn *et al.*, 2008) [5]. Due to the action of free radical sequestration, selenium and vitamin E can be used alone or in combination in broiler diets to reduce the effects of stress brought on by high temperatures and thereby enhance the performance of the birds' growth (Habibian *et al.*, 2013) [6]. The combination of vitamin E and selenium is known to influence biological functions, particularly as an antioxidant that can improve the flavour of meat (Dalia *et al.*, 2018) [7]. Vitamin E and selenium (Se) significantly contribute to the defence of cells against reactive oxygen species by lowering free radicals and limiting the peroxidation of lipids (Ghazi *et al.*, 2012) [8]. Selenium is a vital antioxidant mineral for animals and is known to have an impact on feather development and tissue cellular integrity in avian species (Surai, 2002) [9].

Vitamins C and vitamin E worked together to reduce the harmful effects of persistent heat stress in chickens (Sahin *et al.*, 2002) [10]. Tocopheroxy radicals converting back to their active form of vitamin E and improved antioxidant activity in the presence of vitamin C (Doba *et al.*, 1985) [11]. Vitamin E, Vitamin C and Vitamin E+C supplementation increased the number of lymphocytes and white blood cells (WBCs) in birds and lowered the number of heterophils and the heterophil/lymphocyte ratio (Ipek *et al.*, 2007) [12]. The properties of vitamin C are used to protect cells from oxidative damage and coupled with alpha-tocopherol are responsible for many of its physiological functions (Whitehead *et al.*, 2003) [13]. The holistic approach (from farm to fork) is crucial for the manufacture of meat and meat products that contain low initial quantities of

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bacteria because meat does not naturally possess intrinsic barriers that are sufficient to restrict the growth of microorganisms. Considering the above facts and in order to increasing health concern needs of consumers the experiment was carried out to study the efficacy of supplementation of herbal vitamins on meat quality of broiler chicken.

Material and Methods

The experiment was conducted at experimental broiler shed of College of Veterinary and Animal Sciences, Udgir (Maharashtra).

Dietary formulation

The experimental diet was designated and mentioned as per the table. 1 as control, positive control, T₁, T₂ and T₃ in that control served as (with no vitamin supplementation) while positive control (synthetic

vitamin E (0.01 %) + synthetic vitamin C (0.02 %), T₁ (Herbal vitamin E/ selenium (0.01 %), T₂ (Herbal vitamin C (0.02 %) and T₃ (Herbal vitamin E/ selenium (0.01 %) + Herbal vitamin C (0.02 %). Herbal vitamin E, selenium and vitamin C was collected from Indian Herbs Specialities Private Limited, C215, 2nd floor, Elante offices, Industrial and business park, Chandigarh and Synthetic vitamin E and Vitamin C was procured from Motera Biotech Udgir, (Maharashtra).

Table 1. Dietary treatments allotted for various experimental groups

Sr. No	Ingredients	Experimental groups (%)				
		Control	Positive Control	T1	T2	T3
1	Synthetic vitamin E	-	0.01	-	-	-
2	Synthetic vitamin C	-	0.02	-	-	-
3	Herbal vitamin E/Se	-	-	0.01	-	0.01
4	Herbal vitamin C	-	-	-	0.02	0.02

Experimental design

Day old one hundred and seventy-five broiler chicks were randomly divided into five equal groups. The experiment was conducted for the period of six weeks (42 days) by adopting standard managerial practices. The 1 sq. ft. space was allotted per chick and remaining space was used for drinkers and feeders. Brooder area was stabilized for 95 °F temperature before arrival of chicks. Biosecurity measures were followed in order to avoid infection to arriving chicks. Pre-starter, starter and finisher broiler feeds were prepared at farm feed mill before arrival of chicks as per BIS (2007). The recommended

vaccination schedule was followed for all the experimental chicks to prevent them from various diseases. Feed formulation was done according to BIS, (2007) and mentioned as per the table. 2. Procured feed ingredients were grinded in feed mill situated at college farm and diets were prepared as pre-starter (1st week), starter (2-3 weeks) and finisher (4-6 weeks) and formulation of the same is given to feed. At the end of the experiment four birds from each treatment group were randomly selected and sacrificed. All activities were carried out in Poultry Processing Unit of Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Udgir (Maharashtra).

Table 2. Composition of experimental diet of pre-starter, starter and finisher phase

Ingredients g/kg	Prestarter	Starter	Finisher
Maize	518.1	536.2	586.1
Soyabean DOC	418.1	392.9	333.2
Vegetable Oil	27.2	36.2	45.3
Di-calcium phosphate	15.4	16.3	17.2
Limestone powder	9.1	7.2	7.6
Salt	2.7	2.7	2.7
DL-Methionine	1.5	1.7	1.9
Lysine	1.4	1.2	1.3
Trace -mineral mixture	0.9	0.9	0.9
Coccidiostat	0.4	0.4	0.4
Vitamin B complex	0.1	0.4	0.4
Toxin binder	0.9	0.9	0.9
Acidifier	1.3	1.3	1.3
Choline chloride	0.5	0.5	0.5

Experimental procedure

A) Determination of growth performance

i) Weekly body weight gain

Individual chick weights were taken at the beginning of the experiment and then every week for the following six weeks.

ii) Weekly feed intake

Every day record of the feed offered and rejected was kept. The feed consumption was measured by deducting the total feed supplied on the previous day from the refuse. The daily average feed consumption

over specific weeks was added to determine the weekly feed consumption.

iii) Feed conversion ratio (FCR)

Feed conversion ratio was calculated by dividing the weekly feed consumption by weekly weight gain.

$$\text{FCR} = \frac{\text{Total feed consumed (g)}}{\text{Total body weight gain (g)}}$$

B) Physico-chemical characteristics of broiler chicken meat

i) pH

The pH of fresh chicken meat was determined by the method of Trout *et al.*, (1992) [14]. A digital pH meter (Systronics pH System 362) was used to measure the pH of a fine suspension prepared from 10 g of chicken breast meat and 50 ml of distilled water.

ii) Cooking loss (%)

A water bath was used to boil the fresh chicken sample until it reached an internal temperature of 70 °C. After 20 minutes, it was removed and weighed. Cooking loss was calculated by method as described by Yang *et al.*, (2006) [15].

$$\text{Cooking loss (\%)} = \frac{A - B}{A} \times 100$$

Where,

A- Precooked sample weight

B- Cooked sample weight

iii) Water holding capacity (WHC)

The filter paper press method suggested by Grau *et al.* (1953) [16] was used to determine the meat sample's ability to contain water with certain modifications. A folded Whatman No. 41 filter paper was used to contain about 300 mg of muscle tissue. Two glass slides were retained, one on top of the folded filter paper and the other beneath it. A 100-gm weight was left on the top of the glass slide for three minutes, applying downward pressure to the muscle tissue. A hard-top table was used throughout the entire procedure. Using a measuring scale, the area of the force-induced impressions on each half of the filter paper was calculated and expressed in square centimetres.

C) Textural profile analysis

Texture profile analysis (TPA) of fresh meat was carried out with a texturometer (TA. HD Plus, Texture Analyser) (Stable Micro Systems) described by Aljumaah *et al.* (2020) [17] with slight modification. The texture analysis was determined using standardized cylinders oriented perpendicular to the direction of the muscle fibres. A cylindrical piston P/36R of 36 mm in diameter was used to compress the sample during two test cycles and compressed the sample up to 80% from the original height within a time span of five seconds between the cycles. The velocities of 2.0 mm/s pre-test, 5.0 mm/s during the test, and 5.0 mm/s post-test and trigger force of 10 g was used for

textural analysis. The following parameters were recorded hardness (Hard; N), springiness (Spring; %), resilience (adm), cohesiveness (Cohes; adm), gumminess (Gum; N).

D) Instrumental color profile analysis

Instrumental color profile analysis of fresh meat was carried out by method described by Liu *et al.* (2003) [18] with colorimeter (Colour Flex EZ standards Box, Hunter Lab). The instrument was calibrated against blank and white references prior to use. Two random readings (either side) per sample were taken and averaged. *L** (lightness), *a** (redness), and *b** (yellowness) were measured for the sample.

E) Sensory evaluation

Chicken breast and thigh meat was used for sensory evaluation by a panel of 10 judges from College of Veterinary and Animal Sciences, Udgir. The chicken breast and thigh meat samples were cooked for 20 minutes at 85 °C and served at 50 °C. Sensory attributes such as colour, odour, flavour, juiciness and overall acceptability were determined according to a reported method by Skrivan *et al.* (2011) [19]. Water was used between two samples when the flavour of cooked chicken meat was evaluated. A nine-point hedonic scale was used for the assessment (1-like extremely and 9-dislike extremely).

F) Statistical analysis

The data obtained in the study on various parameters were statistically analysed on 'SPSS-20.0' software package as per standard methods of (Snedecor and Cochran (1995)). The experiments were conducted in four replications each and the collected data were subjected to One Way ANOVA (analysis of variance) and Duncan's Multiple Range Test (DMRT) for comparing the means to find the effects between samples at 5 % level.

Results

Effect of dietary herbal vitamins on growth performance

The body weight gain, feed intake and feed conversion ratio of broiler chicken meat under different treatment groups are presented in Table 3, 4, and 5 respectively. The average body weight and body weight gain of 1st, 2nd and 3rd week of age was increased non-significantly ($P \geq 0.05$) after incorporation of vitamin E/selenium, vitamin C and combination in broiler feed and significantly ($P \leq 0.05$) increase in 4th and 5th week of age. Further, highly significant ($P \leq 0.01$) increase in body weight on 6th week of age. The feed intake of broiler birds was non-significantly ($P \geq 0.05$) increased with incorporation of vitamin E/selenium, vitamin C and combination as compared to control in 1st, 2nd and 3rd week of age between control and experimental groups and highly significant ($P \leq 0.01$) increase in 4th week of age. Further, significantly ($P \leq 0.05$) increase in feed intake at 5th and 6th week of age. The average feed conversion ratio of broiler birds in 1st, 2nd, 3rd and 5th week of age increased non-significantly ($P \geq 0.05$) due to incorporation of vitamin E/selenium, vitamin C and combination whereas significantly ($P \leq 0.05$) increased in 4th and 6th week of age.

Table 3. Mean $\pm$ SE values of Body weight gain of broilers fed with herbal vitamins

Treatments	Body weight gain					
	1 st Week	2 nd Week	3 rd Week	4 th Week	5 th Week	6 th Week
Control	97.03 $\pm$ 4.12	265.60 $\pm$ 4.70	375.09 $\pm$ 4.91	564.01 ^b $\pm$ 1.53	644.84 ^b $\pm$ 0.91	561.21 ^b $\pm$ 0.91
Positive control	98.67 $\pm$ 4.18	264.85 $\pm$ 3.87	375.17 $\pm$ 4.74	567.20 ^{ab} $\pm$ 1.54	644.66 ^{ab} $\pm$ 0.92	560.62 ^b $\pm$ 0.94
T1	102.37 $\pm$ 4.93	264.02 $\pm$ 4.80	375.38 $\pm$ 4.00	569.25 ^a $\pm$ 1.69	647.37 ^a $\pm$ 0.87	560.85 ^b $\pm$ 0.81
T2	100.04 $\pm$ 3.18	263.67 $\pm$ 5.14	375.00 $\pm$ 5.11	569.39 ^a $\pm$ 1.51	647.48 ^a $\pm$ 0.89	559.27 ^b $\pm$ 0.62
T3	103.75 $\pm$ 4.33	265.17 $\pm$ 4.16	376.91 $\pm$ 5.06	569.89 ^a $\pm$ 1.58	644.03 ^{ab} $\pm$ 0.73	564.27 ^a $\pm$ 0.88
SE Mean	100.37 $\pm$ 1.75	264.66 $\pm$ 1.82	375.51 $\pm$ 1.90	567.95 $\pm$ 0.79	645.68 $\pm$ 0.48	561.24 $\pm$ 0.50
F Value	0.421 ^{NS}	0.031 ^{NS}	0.028 ^{NS}	2.375*	3.490*	4.72*

Control: Basal diet (BIS, 2007), Positive control: Synthetic vitamin E (Alpha-Tocopherol) (222.22 IU) and Synthetic vitamin C (L-Ascorbic acid) (4000 IU), T1: Herbal vitamin E (Alpha-Tocopherol)/Se(149.25 IU), T2: Herbal vitamin C (L-Ascorbic acid) (4000 IU), T3: Herbal vitamin E (Alpha-Tocopherol)/Se(149.25 IU), + Herbal vitamin C(L-Ascorbic acid) (4000 IU)

NS- $P \geq 0.05$; *- $P \leq 0.05$; **- $P \leq 0.01$

SEM, pooled standard error of means, Data are means of 4 replicate cages with 1 bird per cage

Table 4. Mean $\pm$ SE values of Feed intake of broilers fed with herbal vitamins

Treatments	Feed intake					
	1 st Week	2 nd Week	3 rd Week	4 th Week	5 th Week	6 th Week
Control	124.09 $\pm$ 3.87	348.54 $\pm$ 3.80	570.46 $\pm$ 3.37	896.71 ^c $\pm$ 3.26	1116.10 ^b $\pm$ 3.58	1210.49 ^b $\pm$ 3.56
Positive Control	125.47 $\pm$ 3.87	349.30 $\pm$ 3.93	572.20 $\pm$ 3.56	899.24 ^{bc} $\pm$ 3.24	1121.34 ^b $\pm$ 3.73	1215.69 ^{ab} $\pm$ 3.49
T1	128.75 $\pm$ 3.54	352.64 $\pm$ 3.25	575.88 $\pm$ 4.41	908.26 ^{ab} $\pm$ 2.99	1127.31 ^{ab} $\pm$ 3.29	1221.96 ^b $\pm$ 3.41
T2	126.75 $\pm$ 3.86	350.00 $\pm$ 3.89	573.78 $\pm$ 4.70	905.86 ^{abc} $\pm$ 3.59	1124.46 ^{ab} $\pm$ 3.43	1217.51 ^{ab} $\pm$ 3.72
T3	132.00 $\pm$ 4.26	355.67 $\pm$ 3.26	578.71 $\pm$ 4.36	912.07 ^a $\pm$ 3.02	1133.24 ^a $\pm$ 3.43	1226.74 ^a $\pm$ 3.22
SE Mean	127.41 $\pm$ 1.70	351.23 $\pm$ 1.56	574.20 $\pm$ 1.76	904.43 $\pm$ 1.83	1124.49 $\pm$ 1.91	1218.48 $\pm$ 1.88
F Value	0.601 ^{NS}	0.642 ^{NS}	0.609 ^{NS}	3.867**	3.396*	3.132*

Control: Basal diet (BIS, 2007), Positive control: Synthetic vitamin E (Alpha-Tocopherol) (222.22 IU) and Synthetic vitamin C (L-Ascorbic acid) (4000 IU), T1: Herbal vitamin E (Alpha-Tocopherol)/Se(149.25 IU), T2: Herbal vitamin C (L-Ascorbic acid) (4000 IU), T3: Herbal vitamin E (Alpha-Tocopherol)/Se(149.25 IU), + Herbal vitamin C(L-Ascorbic acid) (4000 IU)

NS- $P \geq 0.05$; *- $P \leq 0.05$; **- $P \leq 0.01$

SEM, pooled standard error of means, Data are means of 4 replicate cages with 1 bird per cage

Table 5. Mean $\pm$ SE values of Feed conversion ratio of broilers fed with herbal vitamins

Treatments	Feed conversion ratio					
	1 st Week	2 nd Week	3 rd Week	4 th Week	5 th Week	6 th Week
Control	1.27 $\pm$ 0.03	1.31 $\pm$ 0.04	1.52 $\pm$ 0.04	1.58 ^b $\pm$ 0.00	1.73 $\pm$ 0.00	2.15 ^b $\pm$ 0.00
Positive control	1.27 $\pm$ 0.03	1.31 $\pm$ 0.04	1.52 $\pm$ 0.04	1.58 ^{ab} $\pm$ 0.00	1.73 $\pm$ 0.00	2.16 ^{ab} $\pm$ 0.00
T1	1.25 $\pm$ 0.04	1.33 $\pm$ 0.04	1.53 $\pm$ 0.04	1.59 ^{ab} $\pm$ 0.00	1.74 $\pm$ 0.00	2.17 ^{ab} $\pm$ 0.00
T2	1.26 $\pm$ 0.04	1.32 $\pm$ 0.05	1.53 $\pm$ 0.04	1.59 ^{ab} $\pm$ 0.00	1.73 $\pm$ 0.00	2.17 ^{ab} $\pm$ 0.00
T3	1.27 $\pm$ 0.05	1.34 $\pm$ 0.04	1.53 $\pm$ 0.06	1.60 ^a $\pm$ 0.00	1.74 $\pm$ 0.00	2.17 ^a $\pm$ 0.00
SE Mean	1.26 $\pm$ 0.01	1.32 $\pm$ 0.01	1.52 $\pm$ 0.01	1.59 $\pm$ 0.00	1.73 $\pm$ 0.00	2.16 $\pm$ 0.00
F Value	0.051 ^{NS}	0.067 ^{NS}	0.016 ^{NS}	1.719*	0.055 ^{NS}	1.72*

Control: Basal diet (BIS, 2007), Positive control: Synthetic vitamin E (Alpha-Tocopherol) (222.22 IU) and Synthetic vitamin C (L-Ascorbic acid) (4000 IU), T1: Herbal vitamin E (Alpha-Tocopherol)/Se(149.25 IU), T2: Herbal vitamin C (L-Ascorbic acid) (4000 IU), T3: Herbal vitamin E (Alpha-Tocopherol)/Se(149.25 IU), + Herbal vitamin C(L-Ascorbic acid) (4000 IU)

NS- $P \geq 0.05$; *- $P \leq 0.05$; **- $P \leq 0.01$

SEM, pooled standard error of means, Data are means of 4 replicate cages with 1 bird per cage

Effect of dietary herbal vitamins on physico-chemical attributes

Effect of dietary herbal vitamins on physico-chemical attributes are given in table 6. There is non significant ($P \geq 0.05$) increased in pH and water holding capacity of meat between control and experimental

groups after incorporation of vitamin E/selenium, vitamin C and combination in broiler diet. The cooking loss was decreased significantly ($P \leq 0.05$) between control and experimental groups with incorporation of vitamin E/selenium, vitamin C and combination in broiler diet.

Table 6. Mean $\pm$ SE values of Physico chemical attributes of broiler chicken meat fed with herbal vitamins

Treatments	Physico-chemical attributes		
	pH	Cooking Loss (%)	WHC (Sq.cm)
Control	6.37 $\pm$ 0.57	19.25 ^a $\pm$ 0.67	0.47 $\pm$ 0.00
Positive control	6.38 $\pm$ 0.57	17.24 ^{ab} $\pm$ 0.72	0.47 $\pm$ 0.00
T ₁	6.42 $\pm$ 0.47	15.70 ^b $\pm$ 0.86	0.48 $\pm$ 0.00
T ₂	6.40 $\pm$ 0.44	17.90 ^{ab} $\pm$ 0.87	0.47 $\pm$ 0.00
T ₃	6.45 $\pm$ 0.40	16.40 ^b $\pm$ 0.90	0.48 $\pm$ 0.00
SE Mean	6.40 $\pm$ 0.19	17.30 $\pm$ 0.43	0.47 $\pm$ 0.00
F Value	0.004 ^{NS}	2.828*	0.453 ^{NS}

Control: Basal diet (BIS, 2007), Positive control: Synthetic vitamin E (Alpha-Tocopherol) (222.22 IU) and Synthetic vitamin C (L-Ascorbic acid) (4000 IU), T₁: Herbal vitamin E (Alpha-Tocopherol)/Se(149.25 IU), T₂: Herbal vitamin C (L-Ascorbic acid) (4000 IU), T₃: Herbal vitamin E (Alpha-Tocopherol)/Se(149.25 IU), + Herbal vitamin C (L-Ascorbic acid) (4000 IU)

NS- $P \geq 0.05$; *- $P \leq 0.05$; **- $P \leq 0.01$

SEM, pooled standard error of means, Data are means of 4 replicate cages with 1 bird per cage

Effect of dietary herbal vitamins on texture profile analysis

Effect of dietary herbal vitamins on texture profile analysis is given in table 7. The hardness of breast meat revealed highly significant ($P \leq 0.01$) increase between experimental groups after incorporation of vitamin E/selenium, vitamin C and combination in broiler diet. Hardness of breast meat of experimental group was more that might

be due to decrease in the ability of the chicken breast meat to return to its original shape after compression when supplemented with vitamin C. The springiness, resilience, cohesiveness, gumminess of breast meat was little increase non-significantly ($P \geq 0.05$) after incorporation of vitamin E/selenium, vitamin C and combination in broiler diet compare to control.

Table 7. Mean $\pm$ SE values of Texture profile analysis of broiler chicken meat fed with herbal vitamins

Treatments	Texture profile analysis				
	Hardness (N)	Springiness (%)	Resilience (adm)	Cohesiveness (adm)	Gumminess (N)
Control	23.65 ^c $\pm$ 0.64	98.80 $\pm$ 0.30	3.48 $\pm$ 0.04	0.47 $\pm$ 0.04	11.41 $\pm$ 1.44
Positive control	27.20 ^{ab} $\pm$ 0.65	99.53 $\pm$ 0.33	3.62 $\pm$ 0.04	0.48 $\pm$ 0.04	13.05 $\pm$ 1.42
T ₁	25.39 ^{bc} $\pm$ 0.66	99.49 $\pm$ 0.29	3.51 $\pm$ 0.04	0.51 $\pm$ 0.04	12.94 $\pm$ 1.46
T ₂	26.35 ^{ab} $\pm$ 0.63	99.55 $\pm$ 0.24	3.54 $\pm$ 0.04	0.52 $\pm$ 0.04	13.70 $\pm$ 1.56
T ₃	28.25 ^a $\pm$ 0.62	99.58 $\pm$ 0.26	3.61 $\pm$ 0.04	0.54 $\pm$ 0.04	14.74 $\pm$ 1.45
SE Mean	26.17 $\pm$ 0.44	99.39 $\pm$ 0.13	3.55 $\pm$ 0.02	0.50 $\pm$ 0.01	13.17 $\pm$ 0.63
F Value	7.470**	1.312 ^{NS}	2.103 ^{NS}	0.394 ^{NS}	0.682 ^{NS}

Control: Basal diet (BIS, 2007), Positive control: Synthetic vitamin E (Alpha-Tocopherol) (222.22 IU) and Synthetic vitamin C (L-Ascorbic acid) (4000 IU), T₁: Herbal vitamin E (Alpha-Tocopherol)/Se (149.25 IU), T₂: Herbal vitamin C (L-Ascorbic acid) (4000 IU), T₃: Herbal vitamin E (Alpha-Tocopherol)/Se (149.25 IU), + Herbal vitamin C (L-Ascorbic acid) (4000 IU)

NS- $P \geq 0.05$; *- $P \leq 0.05$; **- $P \leq 0.01$

SEM, pooled standard error of means, Data are means of 4 replicate cages with 1 bird per cage

Effect of dietary herbal vitamins on instrumental colour profile

Effect of dietary herbal vitamins on instrumental colour profile is given in table 8. The redness (a^*) and lightness (L^*) values of meat tend to increase non-significantly ($P \geq 0.05$) after incorporation of vi-

itamin E/selenium, vitamin C and combination in broiler diet as compared to control where as yellowness (b^*) values of meat were decrease non-significantly ($P \geq 0.05$).

Table 8. Mean $\pm$ SE values of Instrumental colour profile of broiler chicken meat fed with herbal vitamins

Treatments	Instrumental colour profile		
	Lightness (L^*)	Redness (a^*)	Yellowness (b^*)
Control	49.30 $\pm$ 1.11	4.82 $\pm$ 0.04	13.56 $\pm$ 0.05
Positive Control	49.12 $\pm$ 1.03	4.90 $\pm$ 0.03	13.52 $\pm$ 0.04
T ₁	49.01 $\pm$ 1.05	4.91 $\pm$ 0.04	13.50 $\pm$ 0.04
T ₂	48.75 $\pm$ 0.91	4.92 $\pm$ 0.04	13.40 $\pm$ 0.04
T ₃	49.52 $\pm$ 1.08	4.95 $\pm$ 0.04	13.40 $\pm$ 0.06
SE Mean	49.14 $\pm$ 0.41	4.90 $\pm$ 0.019	13.47 $\pm$ 0.02
F Value	0.078 ^{NS}	1.343 ^{NS}	2.040 ^{NS}

Control: Basal diet (BIS, 2007), Positive control: Synthetic vitamin E (Alpha-Tocopherol) (222.22 IU) and Synthetic vitamin C (L-Ascorbic acid) (4000 IU), T₁: Herbal vitamin E (Alpha-Tocopherol)/Se (149.25 IU), T₂: Herbal vitamin C (L-Ascorbic acid) (4000 IU), T₃: Herbal vitamin E (Alpha-Tocopherol)/Se (149.25 IU), + Herbal vitamin C (L-Ascorbic acid) (4000 IU)

NS- $P \geq 0.05$; *- $P \leq 0.05$; **- $P \leq 0.01$

SEM, pooled standard error of means, Data are means of 4 replicate cages with 1 bird per cage

Effect of dietary herbal vitamins on sensory quality

Effect of dietary herbal vitamins on sensory quality is mention in [table 9](#). The data clearly indicated that colour score of meat was increased significantly ($P \leq 0.05$) after incorporation of vitamin

E/selenium, vitamin C and combination in broiler diet whereas the odour, flavour, juiciness and overall acceptability score of meat was increased non-significantly ($P \geq 0.05$).

Table 9. Mean $\pm$ SE values of Sensory evaluation of cooked chicken meat fed with herbal vitamins

Treatments	Sensory evaluation of cooked chicken meat				
	Colour	Odour	Flavour	Juiciness	Overall acceptability
Control	4.20 ^a $\pm$ 0.11	3.65 $\pm$ 0.10	3.70 $\pm$ 0.14	4.90 $\pm$ 0.17	5.30 $\pm$ 0.10
Positive Control	4.00 ^{ab} $\pm$ 0.14	3.80 $\pm$ 0.13	3.65 $\pm$ 0.13	4.80 $\pm$ 0.18	5.20 $\pm$ 0.10
T ₁	3.90 ^{ab} $\pm$ 0.17	3.75 $\pm$ 0.12	3.55 $\pm$ 0.13	4.60 $\pm$ 0.15	5.20 $\pm$ 0.09
T ₂	3.80 ^{ab} $\pm$ 0.11	3.80 $\pm$ 0.11	3.60 $\pm$ 0.11	4.70 $\pm$ 0.16	5.25 $\pm$ 0.12
T ₃	3.70 ^b $\pm$ 0.10	3.70 $\pm$ 0.14	3.50 $\pm$ 0.13	4.55 $\pm$ 0.13	5.10 $\pm$ 0.12
SE Mean	3.92 $\pm$ 0.06	3.74 $\pm$ 0.05	3.60 $\pm$ 0.05	4.71 $\pm$ 0.07	5.21 $\pm$ 0.04
F Value	2.044*	0.261 ^{NS}	0.354 ^{NS}	0.764 ^{NS}	0.472 ^{NS}

Control: Basal diet (BIS, 2007), Positive control: Synthetic vitamin E (Alpha-Tocopherol) (222.22 IU) and Synthetic vitamin C (L-Ascorbic acid) (4000 IU), T₁: Herbal vitamin E (Alpha-Tocopherol)/Se (149.25 IU), T₂: Herbal vitamin C (L-Ascorbic acid) (4000 IU), T₃: Herbal vitamin E (Alpha-Tocopherol)/Se (149.25 IU), + Herbal vitamin C (L-Ascorbic acid) (4000 IU)

NS- $P \geq 0.05$; *- $P \leq 0.05$; **- $P \leq 0.01$

SEM, pooled standard error of means, Data are means of 4 replicate cages with 1 bird per cage

F value describes significance between treatments determined by ANOVA.

Discussion

The primary goal of the study was to assess the effects of dietary supplementation with herbal vitamins on broiler chicken growth performance and meat quality. The results observed by [Rindhe et al., \(2016\)](#) [20] showed non-significant ($P \geq 0.05$) difference in first, second and third week of age for body weight gain and significant ($P \leq 0.05$) difference in fourth, fifth and sixth week of age after incorporated with vitamins in the diet. The improvement in body weight gain might be due to better chain breaking ability of antioxidant vitamin E and selenium that leads to protection of cells and tissues from lipo-peroxidative damage [Lin et al. \(2006\)](#) [21]. The dietary addition of synthetic and natural antistressors, such as vitamin C, results in an increase in body weight gain and improved summertime growth in birds. ([Sahin et al., 2003](#); [Sapkota et al., 2006](#)) [22, 23]. The results of [Florou-Paneri et al. \(2005\)](#) and [Rindhe et al. \(2016\)](#) [20] who observed non-significant ($P \geq 0.05$) difference between the experimental group and control group for first, second and third week of age for feed intake and significant ($P \leq 0.05$) difference in last three weeks of age. Stress in broilers results in decline in feed consumption and overall feed efficiency. Decreased feed consumption was closely related to the extra heat load accumulated in the course of heat stress [Suk et al. \(1995\)](#) [24]. Similar line of findings of feed intake and feed efficiency were reported by [Sinurat et al. \(1987\)](#) [25]. The results by [Flurou-Paneri et al. \(2005\)](#) who showed incorporation of vitamin E, C and their combi-

nation had significantly ($P \leq 0.05$) better feed conversion ratio at 4th, 5th and 6th week of age in treatment groups as compared to control group. In the same way, [Rindhe et al. \(2016\)](#) [20] that showed incorporation of vitamin C had higher feed conversion ratio in 6th week of age compared to control group. Identical results were observed by ([Abd El-Hack et al., 2017](#); [Ipek et al., 2006](#)) [26, 27] who showed that in heat stress supplementation of vitamin E and selenium showed significantly ($P \leq 0.05$) improved feed conversion ratio in broiler birds. This increased feed conversion ratio may be attributable to vitamin E antioxidant activity that guards the liver and other organs from oxidative damage and reflects a healthy metabolism and feed utilisation of nutrients. This was a beneficial effect against heat stress, which damages other organs and causes liver dysfunction by increasing membrane lipid peroxidation in liver cells ([Bollengier-Lee, 1999](#)) [28]. It was experimented that group T₃ showed better body weight gain, feed intake and feed conversion ratio in all the weeks followed by group T₁, T₂, positive control and control.

The pH of meat was non significantly ($P \geq 0.05$) increased with incorporation of vitamin E/selenium, vitamin C and combination in diet. Comparable results were observed by [Pecjak et al. \(2022\)](#) [29] and [Mazur-kusnierk et al. \(2019\)](#) [30] revealed that the pH values of the breast muscle tested 15 minutes and 24 hours after post mortem were unaffected by the various vitamin E levels. The group T₁ showed lower cooking loss than T₂, T₃, positive control and control. Parallel results were observed by [Zhang et al. \(2013\)](#) [31] that showed dietary

supplementation with 200 mg/ kg vitamin E significantly ($P \leq 0.05$) reduced cooking loss and increased meat quality. It may be due to supplementation of vitamin E leads to reduced natural drip loss and improved water holding capacity of breast muscle resulted lower cooking loss as compare to control (not administered with antioxidants) and exposed to high temperature as reported by Mazurkiewicz *et al.* (2019) [30]. Vitamin E effectively maintains cell membrane integrity and meat juice loss that eventually leads to better effect on water holding capacity Petracci and Cavani, (2011) [32] and protects the cell from endogenous free radicals Rahman (2003) [33]. Vitamin C functions in carnitine synthesis that essentially serves in fatty acid transport from cytosol to mitochondria in fat biosynthesis therefore water holding capacity in vitamin C treatment was lower than that of vitamin E Tugiyant *et al.* (2014) [34]. The results were agreed with Leskovec *et al.* (2019) [35] who found non-significant ($P \geq 0.05$) effect for water holding capacity of breast meat after supplementation with vitamin E in diet. Young *et al.* (2003) reported non-significant ($P \geq 0.05$) effect on water holding capacity of breast meat of female chickens (Ross 208) when supplemented with 200 ppm of alpha tocopherol and 1000 ppm of ascorbic acid.

The group T₃ showed higher hardness, springiness, resilience, cohesiveness and gumminess of chicken meat than T₁, T₂, positive control and control. Hardness of breast meat of group T₃ is more it might be due to decrease in the ability of the chicken breast meat to return to its original shape after compression when supplemented with vitamin C. Similar results were observed by Saracila *et al.* (2021) [36] that suggests dietary supplementation with CrPic + Vitamin C leads to significant decrease in ability of chicken breast meat to return to its original shape and stated no effect on springiness, resilience, cohesiveness and gumminess of chicken breast meat. Miezeliene *et al.* (2011) [37] showed addition of vitamin E and selenium resulted in higher hardness and no effect on springiness, cohesiveness of chicken breast meat. Higher hardness might be due to vitamin E effectively maintains cell membrane integrity and meat juice loss that eventually affects water holding capacity of meat (Petracci and Cavani, 2012).

The results observed by Ryu *et al.* (2005) [38] that showed surface meat colour lightness (L^*), redness (a^*) and yellowness (b^*) values were unaffected by different dietary supplementation with selenium and alpha-tocopherol and stated that the level of surface met-myoglobin accumulation was un-affected by different concentration of dietary vitamin E/selenium supplementation and showed similar rate of discolouration. Supplementation of alpha-tocopherol or selenium did not have additional effect in improving meat lightness (L^*), redness (a^*) and yellowness (b^*) of breast muscles Kim *et al.* (2010). Vitamin E supplementation in diet does not influence poultry breast meat color values Zouari *et al.* (2010) [39]. Comparable results were reported by Leskovec *et al.* (2019) [35] that did not show any synergistic effect of vitamins E, C and selenium on the color values of breast muscles.

The group T₃ showed better colour, odour, flavour, juiciness and overall acceptability of chicken meat than T₁, T₂, positive control and control. Similar results observed by Bou *et al.* (2001) [40] that showed clear positive influence of vitamin E on sensory quality of dark chicken meat. Equivalent line of findings observed by Skrivan *et al.* (2011) [19] that showed vitamin C had no influence on sensory characteristics (flavour, aroma, acceptability) of broiler chicken meat. Basmacioglu *et al.* (2004) [41] showed no effect of dietary supplementation of rosemary, thyme oil and alpha tocopherol acetate on meat sensory analysis at different levels (for taste, odour, tenderness and overall acceptability. Adediran *et al.*, (2022) [42] showed better juiciness might be due to lower cooking loss and better water holding capacity when supplemented with vitamin E in diet.

Conclusion

The result of the present experiment revealed that there was significantly better growth performance in broilers due to supplementation of herbal vitamin E, C and selenium in different combinations that showed better body weight gain, feed intake and feed conversion ratio

and better meat quality parameters and it was concluded that incorporation of herbal vitamin E/Selenium (0.01 %) + herbal vitamin C (0.02 %) could improve growth performance and meat quality parameters of broiler meat.

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Declaration of interest statement

The authors declare that there is no conflict of interests regarding the publication of this article.

Authors' contribution

All authors contributed equally to this study.

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