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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
TPI 2024; 13(2): 141-149

www.thepharmajournal.com
Received: 02-11-2023
Accepted: 07-12-2023

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Biological evaluation of Developed Supplement Feed (DSF) for egg quality parameters in LIT (Himsamridhi) birds

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DOI: https://doi.org/10.22271/tpi.2024.v13.i2c.25372

Abstract
The present study was conducted to analyse the effect of feeding diets containing different levels of Developed Supplement Feed (DSF) on egg quality and egg production traits in Low Input Technology (LIT) bird viz. Him-Samridhi (HS) under Confined Scavenging (CS) system of rearing. A total of 72 HS birds (23 weeks of age) were randomly divided into 3 dietary treatments with 3 replicates having 8-layer birds in each replicate. All the dietary groups were offered 20 gm corn per bird along with confined scavenging. Dietary treatments were T0 (control) group allowed confined scavenging while the treatment groups T1 & T2 were supplemented 10g and 20g/bird DSF respectively along with confined scavenging, for a period of 42 weeks. External egg quality parameters, internal egg quality parameters, egg yolk and albumin mineral profile and egg production traits were recorded using standard methods. Results showed that external egg quality traits as well as internal egg quality traits did not differ significantly by DSF supplementation except shape index. Albumen content was found numerically higher (5.1%) in DSF supplemented groups. Egg production trait like hen-day egg production (HDEP) was significantly ($P<0.05$) high in DSF supplemented treatment groups at all age groups examined (23, 40, 52 and 64 weeks of age). The mineral profile of egg was markedly influenced by DSF supplementation at 10 and 20 gm/ bird/ day. It was concluded that DSF supplement has the potential to improve egg quality traits, egg production and egg mineral profile and seems to be a potential feed supplement in LIT bird HS for producing eggs with high Se, Ca, Fe, Mn, K, Cu and Mg content in confined scavenging system of rearing.

Keywords: Albumen weight, Scavenging, Egg quality traits, Hen-day egg production, Himsamridhi, LIT birds

1. Introduction
Poultry is one of the fastest growing sectors within Indian agriculture. India produces 40 million ton of compound feed, out of which poultry feed accounts for a major share. According to the market research group, IAMRC, the Indian animal feed market reached Rs. 403.5 billion in 2020 and it is projected to touch Rs.933.3 billion by 2026 at CAGR (Compound annual growth rate) of 15%. Poultry feed accounts for 58% of total feed market in India. CAGR of poultry and agriculture sectors are around 8 and 1.8% respectively (Dinani *et al*. 2019) [11].

Poultry production in Himachal Pradesh has witnessed slower growth due to sluggish growth of organized commercial poultry. Compared to the national average of 79 eggs annually, the per capita egg availability of 14 eggs per year is stagnating. To supply the local need for eggs and poultry meat, backyard poultry farming has acquired acceptance among the state's farming community. Consequently, from 2012 to 2019, the state's overall chicken population has increased by 21.46%, reaching 1.341 million birds (Dinesh *et al*. 2021) [14]. Native chicken plays an important role in providing livelihood and food security to rural families (Roy *et al*. 2018) [40]. Despite their significant roles, low output potential of roughly 70 to 80 eggs per year, is a challenge, contributing little to the rural developments in country (Maddheshiya *et al*. 2019). Therefore, to increase the productivity of backyard poultry farming, improved varieties which are alike indigenous chickens are now being massively introduced (Singh *et al*. 2002) [43]. ICAR and GOI have been working on birds which resemble native chickens, suitable for rural production systems, these are low input technology (LIT) birds. Him-Smridhi (HS) is one of the LIT birds developed in CSK HPKV Palampur and is being promoted amongst farmers of HP for backyard farming. Currently, the LIT HS birds are reared with conventional feed ingredients which increase the cost of poultry production, thereby reducing the profit margins. Thus, the monetary benefit of achieving moderate production can be claimed only if feeding costs are reduced by utilization of new and locally available feed sources. In this context, the experiment was planned by formulating and developing a pelleted feed supplement using locally available non-conventional plant sources namely Urtica diocia (Bichubooti), Nasturtium officinalis (Choo grass), Rumex hastatus (Malori leaves) and vegetable waste (Cauliflower and Pea pods). Since little information exists on egg production and egg quality trait of LIT birds (HS), the experiment was thus designed to study the effect of feeding pelleted Developed supplement feed (DSF) exclusively using locally available plant sources on egg production and egg quality parameters in LIT (HS) birds.

2. Materials and Methods

2.1 Experimental Plan

The research work was carried out in fabricated mesh wire enclosures of the Department of Animal Genetics and Breeding, DGCN College of Veterinary & Animal Sciences, CSK HP Agriculture University, Palampur, HP, India. The birds were reared in deep litter system up till 23 weeks of age and thereafter shifted to the wire mesh caged enclosures of the size 36 square feet. The enclosures were protected from rain and sunshine by placing PVC sheet on top of the wire mash. The experiment was conducted in 72 HS birds in confined scavenging system, birds were randomly allocated to 3 wire mesh sheds earmarked for each treatment. Each shed had partition to house 3 replicates in each treatment with 8 birds each. The birds were allowed to scavenge and stay in their designated place where they rest under a night shelter with ad-lib water. T0 shed served as positive control in which birds were offered only corn @20gm per bird and scavenging, T1 shed served as treatment offered with 20gram corn per bird + scavenging + DSF @ 10g/bird, T2 shed served as treatment offered with 20gram corn per bird + scavenging + DSF @ 20g/bird. The standard management practices were followed for rearing of birds in the CS system. Provision of 1 manual waterer and feeder was done per shed and nest boxes were provided per shed for the egg laying. Eggs were collected from 24 weeks of age up-to the completion of trial (64 weeks) and data was recorded on the same day of collection. A lighting schedule of 14-16 hours per day was applied during laying period. Standard procedures with respect to preventive vaccination and medication were followed during the study period.

The investigation of proximate principles of feed ingredients utilized in formulating DSF (Table:1) was done by employing standard AOAC (2005) [6] techniques. Metabolizable energy was calculated using the equation suggested by Lodhi *et al*. (1976) [26].

2.2 Measurement of traits

Parameters recorded were- Egg quality traits (External egg quality parameters like egg weight, egg length, egg width, shape index, shell thickness and internal egg quality parameters such as yolk width, yolk height, yolk weight, albumen length, albumen width, albumen height and albumen weight) were analysed using standard methods and egg production trait (HDEP) was estimated.

Eggs were weighed using electronic balance to an accuracy of 0.01 g (Danwer scales India). The egg length was measured using digital vernier calipers (Aerospace Inc.). The width of eggs was measured using digital vernier calipers (Aerospace Inc.). Shape index was calculated as the ratio of egg width to egg length X 100 by the method of Anderson *et al*. (2004) [5]. Shell thickness was measured using a micrometer.

Yolk width was measured using a digital vernier caliper (Aerospace Inc.). Yolk height was recorded using the vernier caliper (Aerospace Inc.). Yolk weight was measured by separating the yolk from albumen of egg and weighing it accurately. Albumen width was recorded using the digital vernier caliper (Aerospace Inc.). Albumen height was measured using spherometer in millimeters. Albumen weight was calculated by subtracting the shell and yolk weights from the egg weight. The height of albumen was recorded using spherometer.

HDEP was calculated using formula:

$$\text{Hen-Day Egg Production (HDEP)} = \frac{\text{Total number of eggs laid during a given period}}{\text{Average number of birds on hand during the same period}} \times 100$$

2.3 Preparation of DSF

DSF feed was prepared by using new feed resources namely *Urtica diocia* (Bichubooti), *Nasturtium officinalis* (Choo grass), *Rumex hastatus* (Malori leaves) and vegetable waste (Cauliflower and Pea pods) from local areas, followed by sun-drying and grinding.

2.4 Preparation of egg powder

Fresh good quality eggs were collected, washed and boiled in large beaker. After proper boiling, the eggs were deshelled and separated into egg yolk and egg albumen. The samples were later oven dried at 60 °C for 6-7 days until their complete drying and allowed to cool. The egg yolk of each group was grinded in mixer grinder and collected as egg yolk powder in separate marked sealed sample bags for further investigation. Similar procedure was adopted for egg albumen powder.

2.5 Mineral analysis of eggs

Digestion of the samples for mineral estimation was done using QLAB microwave digestion system: Questron Technologies Corp. (Canada). 0.2 gm of the homogenised egg powder sample was taken in digestion tube (eVHP TFM liner). Acids used were nitric acid: hydrogen peroxide: perchloric acid in ratio 7: 1.5: 1.5 mL respectively. Sample was mixed with acids recipe and the vessels were placed in the microwave digestion assembly and digested. The temperature of vessels was raised to 90 °C in 3 minutes (Ramp time) and the same temperature was maintained for 2 minutes (Hold time) in the first step. In the second step, temperature was raised to 160 °C from 90 °C in 10 minutes (Ramp time) and maintained at same temperature for 5 minutes (Hold time). After completion of digestion procedure, all heat and radiations generated were removed from apparatus itself and vessels were allowed to cool down at room temperature for half an hour. Safety valves of the eVHP vessels were opened in the fume hood to evacuate the hazardous fumes produced by the action of different acids on samples digested. The acid extract was then filtered using Whatman filter paper grade 1 (Diameter 125 mm) after giving washings to vessel and further diluted in a 100 mL volumetric flask with deionised water.

2.5.1 Determination of Elements in the Digested Liquor

Egg samples were digested using different acid combinations and the acid extracts obtained from digestion method were used for the analysis of elements present with the help of fully automated and software controlled Atomic Absorption Spectrophotometer (AAS AA8000 LABINDIA). Calcium, magnesium, potassium, manganese, iron and zinc were estimated in AAS using flame mode of AAS, while the trace elements, copper and selenium were estimated employing graphite and hydride mode of AAS. All the above-mentioned elements were determined at their respective wavelengths accordingly.

2.6 Statistical Analysis

All the recorded and calculated data were subjected to analysis of variance (ANOVA) as explained by Snedecor and Cochran (1968) [44]. A 5 percent level of significance was used to evaluate the outcomes.

3. Results and Discussion

The overall results for average weight of eggs laid (g), egg length (mm), egg width (mm), shape index (%) and shell thickness (mm) from 22-64 weeks of age in T_0, T_1 & T_2 group for confined scavenging system has been presented in Table 2.

Perusal of the results revealed that egg weight (gm), egg length (mm), egg width (mm), shape index (%) and shell thickness (mm) in T_0, T_1 & T_2 was (48.29, 46.87, 49.13), (53.02, 53.16, 52.18), (39.96, 40.38, 40.41), (75.22, 78.28, 79.51) and (0.36, 0.38, 0.38) respectively. The results for shape index exhibited significant ($p<0.05$) difference in treatment groups T_1 and T_2 compared to control T_0, whereas no significant ($p>0.05$) difference was recorded for parameters namely egg weight, egg length, egg width and shell thickness. The evaluation of egg parameters envisaged periodic analysis of eggs over 42 weeks and revealed a numeric advantage of egg weight (gm) and egg width compared to control.

Rearing of birds in confined scavenging limits the availability of the natural food, affecting the egg quality parameters. Results of the experiment revealed a positive influence on egg quality consequent to the nutrients supplied by DSF, which was formulated using locally available new feed resources and have been reported to contain nutraceutical properties (Hari Prasad Devkota, 2022) [48]. Supplementation of DSF at a rate of 20 gm per bird responded by 1.70, 1.11 and 5.26 numeric increase in egg weight, egg width and shell thickness compared to control group. Results revealed the highest numeric response by DSF supplementation in eggshell thickness (5.26%) whereas 1.70 percent improvement in egg weight compared to control was recorded over a period of 42 weeks. Dinesh *et al*. (2023) [12] reported egg weight of 40.35 g at 24 week of age to 51.85 g at 50 week of age in HS birds. The results reported by Dinesh *et al*. (2023) [12] were based on rearing HS birds in deep litter with daily allowance of 125 gm commercial pelleted feed whereas in our study, average egg weight at 52 weeks of age was numerically higher (52.02 gm) with 20 gm DSF supplementation only. Results of the experiment were encouraging since no commercial feed was offered to the trial birds and were solely reared on DSF substantially reducing the cost of production. DSF formulation was based on new feed resources and seems to support the nutritional needs for egg weight. Kalita *et al*. (2017) [21] reported egg weight of 48.60 g and 54.62 g in Dahlem Red birds at 40 and 52 weeks of age under intensive system of rearing. Variation in egg weight is also strain specific with many of the authors reporting lower egg weight in mid laying phase. Kumar *et al*. (2022) [23] demonstrated lower egg weight of 41.70±0.55 g and 40.59±0.55 g in LIT birds namely Aseel and Kadaknath chicken at mid laying phase respectively.

The egg Shape Index (SI) is the ratio of the short diameter of the egg to the long diameter and is graded as sharp (<72), normal (72-76) and round (>76). Eggs with low SI have been reported to be male and high SI hatch into female chicks (Mohammed *et al*., 2023) [30]. DSF supplementation (20 gm) significantly increased the SI (79.50) categorized as round. The results hold significance since only female chicks are used in layer hens, usually hatched male chicks are killed. It is estimated that around 7 billion chicks per year are killed immediately after hatching. In addition to being unethical, this situation also causes great financial losses (Mohammed *et al*., 2023) [30]. According to Dinesh *et al*. (2022) [13] SI ranged from 73.09 at 50 weeks of age to 76.14 at 36 weeks of age in HS birds which is comparable to present study. Padhi *et al*. (2013) [33] observed shape index value of 76.49, 75.29, 75.57 and 76.00 percent at 28, 40, 52 and 64 weeks of age in Vanaraja male line (PD1). The shape index values reported by Rajkumar *et al*. (2014) [37] in Aseel native chicken at 32 week (75.74), 40 week (76.49) and 72 week (78.40) were higher than the present estimate. The higher shape index value indicates better uniformity in the eggs which is essential for good hatchability and healthy chick production.

Average egg width in present study was recorded to be 1.11 percent higher in 20-gram DSF supplemented treatment (40.41 mm) compared to control (39.96 mm). Dinesh *et al*. (2022) [13] also reported egg width of 37.23±0.29 mm at 24 week of age to 40.34±0.24 mm at 50 weeks of age in HS birds. Sapkota *et al*. (2020) [41] reported egg width of 40.35 mm in Sakini chicken breed in Nepal comparable to the present study.

Perusal of the results for shell thickness revealed numerically 5.62 percent increase in shell thickness with 20 gm DSF supplementation in T_1 (0.38 mm) compared to control T_0 (0.36 mm). The higher shell thickness helps in preventing the damage during handling and also improves the keeping quality of the eggs. Dinesh *et al*. (2022) [13] reported mean shell thickness as 0.36 mm in HS birds with commercial feed. The mean shell thickness of 0.34–0.38 mm (Padhi *et al*. 2013) [33] in Vanaraja male line (PD1), 0.34–0.36 mm in PB-2 (Rajaravindra *et al*. 2015) [35] and 0.40 mm in Vanaraja female line (Rajkumar *et al*. 2020) [36] were comparable to shell thickness observed with DSF supplementation in present study.

The results for albumen length (mm), albumen width (mm), albumen height (mm), yolk height (mm), yolk width (mm), yolk weight (g) and albumen weight (g) from 22-64 weeks of age in T_0, T_1 & T_2 group for confined scavenging system has been presented in Table 3. Perusal of the results revealed non-significant ($p>0.05$) difference for all the listed internal egg parameters amongst in treatment groups compared to control though, albumen weight (gm) was numerically higher (5.38%) with 20 g/bird DSF supplementation in T_2 (28.19) compared to control T_0 (26.75) from 22-64 weeks of age. However, lower estimates of albumen weight were reported in indigenous non-descriptive Tellicherry chicken (24.35 g) (Kumar *et al*., 2013) [24] and Nicobari fowl (23.02 gm-Choudhuri *et al*., 2014) [9].

Higher albumen height indicates the freshness of egg (Behra *et al*., 2016) [7]. Albumen height is influenced by genetic factors, storage as well as nutrition. It is accepted that, lesser the surface of egg white, dense and the more its height, the better is the egg. In our study, the average albumen height varied between 8.17 to 8.46 mm whereas, Dinesh *et al*. (2023) [12] reported albumen height of 6.77±013 mm in HS birds fed commercial feed at 50 weeks of age, which is lower than present study. Similarly, lower estimate (5.74mm) was reported by Choudhuri *et al*. (2014) [9] in endangered Nicobari fowl and its crosses under intensive and backyard system of Andaman and Nicobar Islands (India).

The result for HDEP from 22 weeks up-to 64 weeks of age in T_0, T_1 & T_2 for confined scavenging system results revealed that HDEP up-to 32, 40, 52 and 64 weeks of age in confined scavenging system in T_0, T_1 & T_2 was (9.69, 11.43, 13.51), (26.34, 29.07, 31.29), (53.32, 62.42, 66.91) and (82.28, 87.27, 101.86) respectively. Results exhibited significant ($p<0.05$) difference for HDEP amongst T_0, T_1 & T_2 groups from 22-64 weeks of age (Table 4). DSF supplementation significantly ($p<0.05$) increased HDEP at all age groups examined i.e. 22, 40, 52 and 64 weeks of age with DSF supplementation compared to control (Fig. 3).

In the present study, significantly ($p<0.05$) highest HDEP was recorded in 20 gm DSF supplemented group i.e. 31.29 up-to 40 weeks, 66.91 up-to 52 weeks and 101.86 up to 64 weeks, whereas Dinesh *et al*. (2021) [14] reported HDEP of 83.23 in HS birds up-to 40 weeks reared in deep litter system. Dinesh *et al*. (2021) [14] reported HDEP of 66.91 in Himsamridhi birds up-to 52 weeks reared in deep litter system whereas, Kalita *et al*. (2009) [19] recorded lower egg production for indigenous chicken up to 72 weeks of age as 65.30±1.45.

Many of the earlier research reports have also highlighted the benefit of incorporating phyto-biotics in poultry feeding. Feeding peppermint to laying birds has been reported to improve their ability to convert digested material into eggs (Adel-Wareth and Lohakare, 2014) [14]. Similarly, inclusion of dried Rosemary Leaf Meal (RLM) at a level of 5.2% ($p<0.05$) significantly improved the hens' day egg production compared to control (Kedir *et al*. 2023) [21]. Additionally, the bioactive components (Flavonoids, phenolic acids, amino acids, carotenoids, organic acids) in the herbal plants of DSF include antioxidant and antibacterial qualities (Gulcin *et al.* 2004 and Grauso *et al*. 2019) [49, 15] and are essential for the breakdown and assimilation of nutrients may have enhanced the production performance parameters of laying hens.

Higher content (ppm) of Ca, Cu, Mg, Mn & K (Table 5) in egg yolk of treatment groups in CS system was recorded which was numerically 45.29, 52.17, 108.44, 21.56 and 66.66 percent higher with 20 g/bird DSF supplementation. Similarly egg albumen content (ppm) of Ca, Cu, Fe, Mg, K were 26.35, 64.71, 54.90, 49.42 and 19.14 percent higher and was significant ($p<0.05$) for Se with 20 g/bird DSF supplementation.

Selenium is a trace element essential for animal and human health. Selenium has been documented to enhance laying hen reproductive performance, antioxidant and immunomodulatory function (Meng *et al*. 2019, Qiu *et al*. 2021) [29, 34]. Results of the experiment revealed significantly ($p<0.05$) higher Se deposition in egg albumen with DSF supplementation but conversely the deposition was low in egg yolk. DSF was plant based (Table: 1) or phytogenic and natural categorized as organic with an analyzed selenium content of 27.37ppb. As per reports, organic Se absorption is greater than that of the inorganic form and soluble Se compounds have been found to be efficiently absorbed in the gastrointestinal tract of rats to the extent of 92, 91 and 81% of selenite, seleno-methionine and selenocysteine, respectively. Compared to organic Se, the transfer efficiency of inorganic Se to eggs is lower. The total amount of Se and the proportions present in the yolk and white of eggs are influenced by the Se status of the hen's diet and by the chemical form in which dietary Se is supplied. Arnold *et al*. (1972) [50] observed that egg Se concentrations increased from 0.05 ppm for hens receiving practical diet containing 0.05 ppm of naturally occurring Se to a maximum of 1.7ppm in 12 days when this diet was supplemented with 8 ppm Se as selenite. Tufarelli *et al*. (2016) [45] suggested that supplementation of organic selenium (2-hydroxy-4-methyl selenobutanoic acid) improved the selenium status of egg yolk. Many of the earlier reports cited differences in movement of selenium in eggs depending upon the farming conditions of the feed resources. Chantiratikul *et al*. (2018) [8] reported that hydroponically produced Se-enriched kale sprout was more efficient in selenium depositing in egg as compared to that of sodium selenite and selenium enriched yeast. Kralik *et al*. (2016) [22] reported that supplementing selenium enriched wheat to laying hens improved the micronutrient supply to consumers through eggs. In same line, biofortification of eggs with selenium, evidenced by high selenium level in albumen have been explored (Han *et al*. 2017 and Lu *et al*. 2020) [16, 26]. In our study the Se concentration was significantly ($p<0.05$) increased in egg albumen by DSF supplementation. Further, Se in most of the plants derived foods and feedstuffs is generally moderately bioavailable whereas, Se is poorly bioavailable in materials of animal origin (Le Russel Mcdowells). This explains partly for the results exhibited for low Se in egg albumen of control group having access only to the natural insect-based protein compared to the treatment groups supplemented with DSF.

Results revealed higher trace elements deposition in egg subsequent to DSF supplementation. There was an increased deposition of manganese (ppm) in egg yolk and egg albumen in treatment groups T_1 (0.76, 0.35) and T_2 (0.62, 0.20) compared to control group T_0 (0.51, 0.35) by DSF supplementation. The manganese level in DSF was estimated to be 0.66 ppm exhibiting enhanced deposition of Mn in egg yolk and egg albumen. Similarly, analysis of egg yolk and egg albumen for copper content (ppb) revealed an increase in treatment T_1 (254.47, 251.76) and T_2 (353.89, 287.62) compared to control group T_0 (233.62, 170.73) whereas the content of copper (ppb) in DSF was estimated to be 442.64. The results are encouraging and indicate the movement and deposition of Mn and Cu in egg yolk. Manganese (Mn) is an important trace element for laying hen's nutrition, which is required in small amounts in the diet. Mn is a cofactor for a wide range of metalloenzymes and its deficiency results in lowered egg production, reduced eggshell strength and abnormal eggshell ultrastructure (Zarghi *et al*. 2023) [46]. Copper is an essential trace mineral in the poultry diet. It plays a critical role in supporting immune function, antioxidant defense, bone strength, iron metabolism, haemoglobin synthesis, erythrocyte production etc., subsequently leading to optimal growth and productive performance in poultry (Lee Russell McDowell).

Table 1: Composition of DSF:

Physical Composition		Chemical Composition		Mineral Composition	
Ingredients	**Part**	**Proximate Principles**	**Percent**	**Elements**	**Concentration**
Urtica diocia (Bichu-booti)	10	Dry Matter	88.22	Ca (ppm)	44
Nasturtium officinalis (Choo grass)	10	Crude Protein	16.23	P (%)	0.5
Rumex hastatus (Malori leaves)	10	Ether Extract	2.42	Cu (ppb)	442.64
Cauliflower waste	10	Crude Fibre	4.89	Fe (ppm)	4.77
Pea pods	10	NFE	52.66	Mg (ppm)	64.51
Yellow Corn	25	Total Ash	23.80	Mn (ppm)	0.66
Cane Molasses	5	Acid Insoluble Ash	10.42	K(ppm)	602.00
Lime- Stone Powder	2	NDF	53.41	Zn (ppm)	0.53
DCP	2	ADF	28.45	Se (ppb)	27.37
DORB	16	ME (Kcal/Kg)	2416.42		

*Added garlic 20 gm + Salt-270 gm + Soybean-Oil 100 mL for preparing final pellet.

Table 2: External Egg Quality Parameters from 22-64 weeks of age.

Parameters	T_0	T_1	T_2
Egg weight (g)	48.29±1.88	46.87±1.81	49.13±2.54
Egg length (mm)	53.02±0.64	53.16±0.73	52.18±0.89
Egg width (mm)	39.96±0.47	40.38±0.55	40.41±0.76
Shape Index (SI) (%)	75.22^a±0.27	78.28^b±0.52	79.51^b±0.39
Shell thickness (mm)	0.36±2.34	0.38±2.97	0.38±1.38

Table 3: Internal Egg Quality Parameters from 22-64 weeks of age.

Parameters	T_0	T_1	T_2
Albumen length (mm)	75.62±1.90	72.85±2.00	75.06±1.81
Albumen width (mm)	61.11±1.14	58.07±1.73	61.25±1.06
Albumen height (mm)	08.46±0.33	08.17±0.45	08.39±0.46
Yolk height (mm)	18.48±0.61	19.51±0.35	19.10±0.53
Yolk width (mm)	38.39±0.50	37.22±0.94	37.84±0.36
Yolk weight (g)	15.12±0.83	15.80±0.97	14.43±0.71
Albumen weight (g)	26.75±1.05	25.90±0.33	28.19±1.02

Table 4: Overall Effect of DSF Supplementation on HDEP up-to 64 wks.

	T_0	T_1	T_2
HDEP UP-TO 32 weeks	9.69^a±.38	11.43^b±.44	13.51^c±.68
HDEP UP-TO 40 weeks	26.34^a±.55	29.07^b±.45	31.29^c±.46
HDEP UP-TO 52 weeks	53.32^a±1.28	62.42^b±.30	66.91^c±1.13
HDEP UP-TO 64 weeks	82.28^a±.50	87.27^b±.52	101.86^c±.32

a, b, c Values with different superscripts differ significantly ($p<0.05$).

Table 5: Mineral content of Egg Yolk and Egg Albumen:

	T_0	T_1	T_2		PSE
		Ca (ppm)			
EY	2.87	3.75	4.17	NS	1.08
EA	4.06	6.43	5.13	NS	0.98
		Cu (ppb)			
EY	233.62	254.47	353.89	NS	47.92
EA	170.73	251.76	287.62	NS	44.84
		Fe (ppm)			
EY	3.46	3.14	1.13	NS	0.81
EA	1.53	2.55	2.37	NS	0.85
		Mg (ppm)			

EY	10.07	17.67	20.99	NS	8.23
EA	25.19	34.39	37.64	NS	6.09
Mn (ppm)					
EY	0.51	0.76	0.62	NS	0.07
EA	0.35	0.35	0.20	NS	0.09
K (ppm)					
EY	0.21	0.38	0.35	NS	0.10
EA	0.47	0.46	0.56	NS	0.13
Zn (ppm)					
EY	2.79	2.66	1.42	S	0.34
EA	2.30	2.03	0.76	NS	0.64
Se (ppb)					
EY	26.79	20.75	22.53	NS	2.46
EA	2.07	2.95	4.53	S	0.56

EY: Egg yolk, EA: Egg albumen

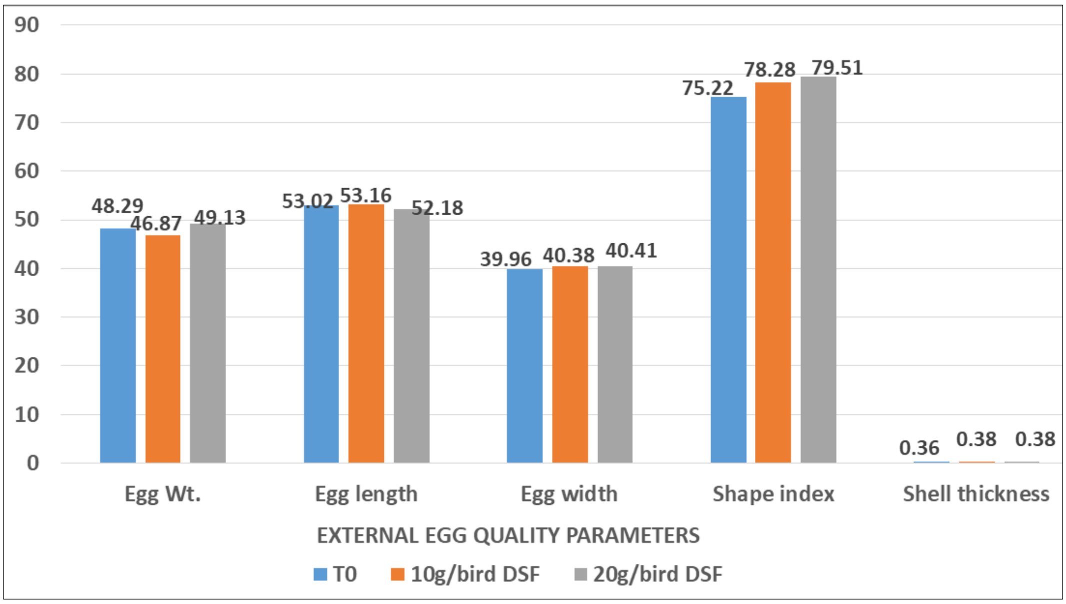

Fig 1: Overall Effect of DSF Supplementation on Egg External Quality Parameters from 22-64 weeks (42 weeks) of age

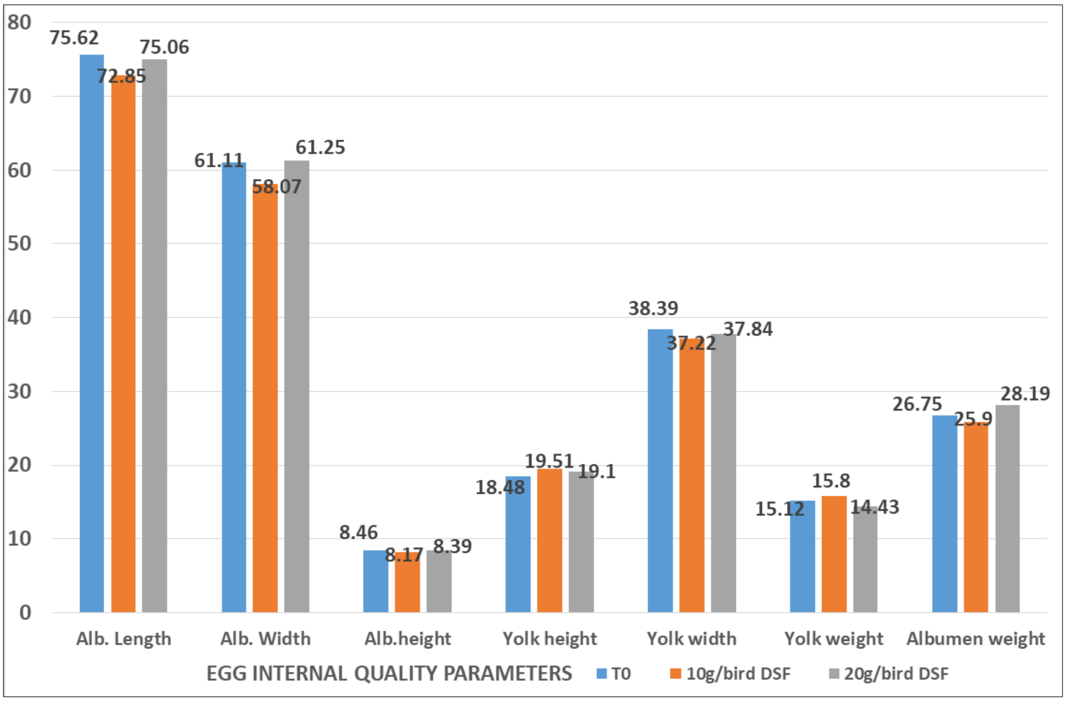

Fig 2: Overall Effect of DSF Supplementation on Egg Internal Quality Parameters from 22-64 weeks (42 weeks) of age

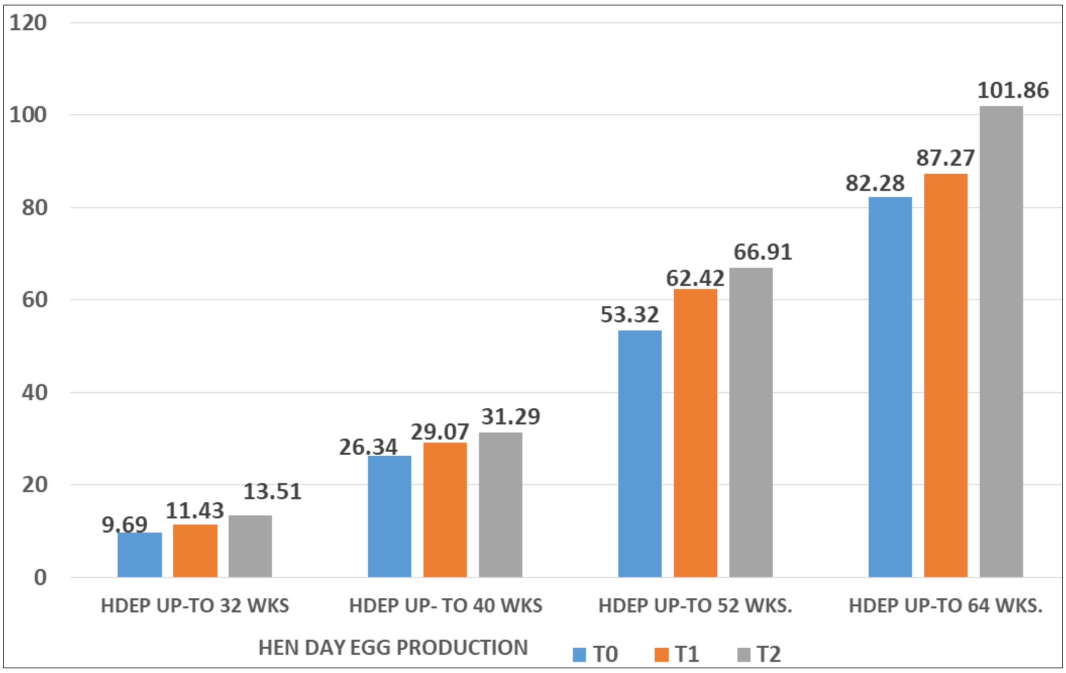

Fig 3: Overall Effect of DSF Supplementation on HDEP from 22-64 weeks of age

3. Conclusion

From the present study, it can thus be concluded that Developed Supplemented Feed supplementation at the rate of 20 gram per bird per day added with confined scavenging to Him-Samridhi layer birds belonging to the category of LIT revealed tangible impact on egg weight, shape index, shell thickness, albumen weight and albumen height. DSF supplementation significantly increased HDEP at all age groups examined i.e. 23, 40, 52 and 64 weeks of age. Hence, it was concluded that DSF supplement has the potential to improve egg quality traits, egg production and egg mineral profile. The mineral profile of egg was markedly influenced by DSF supplementation at 10 and 20 gm/ bird/ day. The DSF therefore seems to be a potential feed resource in LIT bird HS for producing eggs with high Se, Ca, Fe, Mn, K, Cu and Mg content in confined scavenging system of rearing.

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