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Effects of housing systems and different dietary proprietary vitamin-mineral premixes on performance characteristics and haematology of pullets from weeks 10 to 21

[1]Ojelade, A. Y. P and O. A. [2]Ogunwole

[1]*Department of Agricultural Education, Federal College of Education (Tehnical), Akoka, Yaba, Lagos, Nigeria*
[2]*Agricultural Biochemistry and Nutrition Unit, Department of Animal Science, University of Ibadan, Ibadan, Nigeria*

Corresponding Author: *oa.ogunwole@ui.edu.ng*

Target Audience: *Poultry Farmers, Animal Nutritionists, Poultry Scientists.*

Abstract

Effects of two housing systems (HS) and five dietary Proprietary vitamin-mineral premixes (Pvmp) on performance characteristics, haematology and selected serum biochemical indices of pullets from week 10 to 21 of life was investigated. Bovan nera pullets (n = 576) aged 16 weeks were divided into two equal portions of 288 pullets. Each portion was managed in conventional battery cage systems (BCS) and an open-sided deep litter system (DLS), respectively. Pullets were allotted to six dietary treatments of 48 pullets per treatment both in BCS and DLS. Each treatment was replicated six times with eight pullets per replicate. Six isocaloric and isonitrogenous diets were formulated: T1 was without test premix, while T2, T3, T4, T5 and T6 were each supplemented appropriately with 0.25% premixes 1, 2, 3, 4 and 5, respectively. The experiment was a 2 x 6 factorial arrangement in a completely randomised design. Effect of HS on final liveweight (FLW), daily feed intake (DFI), number of eggs produced (EP) and hen day egg production (HDEP) were significant ($p<0.05$). The DFI of pullets increased linearly in DLS ($R^2=0.82$) ($p<0.05$) and BCS ($R^2=0.57$). The HDEP (%) in BCS (8.19) was higher ($p<0.05$) than in DLS (3.95). Dietary Pvmp increased ($p<0.05$) HDEP from 3.18 in pullets on T1 to 5.58 (T3), 5.90 (T4), 6.96 (T6), 7.24 (T5) and 7.54 (T2). Pullets in both BCS and DLS laid first egg at day 122 of life. However, dietary Pvmp led to significantly varied ($p>0.05$) onset of laying from 122 to 131 days. Effects of interaction of HS and Pvmp on FLW, EP and HDEP were significant ($p<0.05$). Haematological indices of pullets in both HS were similar ($p>0.05$) but varied significantly ($p<0.05$) with dietary Pvmp as well as interactions of HS and Pvmp. Therefore, effect of HS, type of dietary Pvmp and the interactions of HS and Pvmp influenced the performance characterics of pullets in this study.

Keywords: *Hen day egg production, Deep litter system, Battery cage system, Laying pullets, Blood differential counts*

Description of Problem

There is a current trend of managing laying chickens in modified deep litter system (DLS) for commercial egg production than in conventional battery cage system (BCS) in some advanced/developed countries because of the ethical and moral considerations in animal welfare policy (1). Management of laying chickens in DLS requires more floor space for birds' movement and exercise than those in conventional BCS. Birds generally retain natural behaviour of their wild counterparts (2,

3) as they prefer more space than is provided in BCS where feed trough and water line are provided with barren environment (4).

The natural behaviour of nesting, perching, roosting, scratching, foraging, dust-bathing, wing flapping, preening and exercising are strongly motivated by hormones (5). Such behaviours are important for well-being of birds but prevented in BCS because the wire floor deprives birds' the opportunity to express natural scratching behaviour. The domestic chickens are known to spend more than 50% of their active time scratching litter materials as a means of exploring the environment in search of food (6).

Birds in BCS are always provided with balanced diets *ad libitum* but still possess strong natural urge to scratch. In DLS, birds choose to search on litter floor rather than eat feed available in feeder (7). Birds in DLS could satisfy vitamins and minerals requirement by searching and feeding on litter materials, faeces and other natural feed materials (8). Non-provision of appropriate litter substrate was reported (9) to cause abnormal behaviour like feather pecking.

Vitamins and minerals are important micro-nutrients for growth and initiation of egg lay in growing pullets. The requirement for vitamins and minerals of chickens managed in different HS is critical to maintenance of healthy living and performance characteristics. Chickens are more susceptible to vitamin deficiencies because the microbial population inhabiting the intestinal tract synthesizes very little amount of vitamins and vigorously compete with host for dietary supply. Thus, deficiency of dietary vitamins and minerals in chickens cause specific disease (10). Deficiency symptoms of vitamins and minerals such as xerophthalmia, cage layer fatigue, rickets etc. were reported (11).

There is argument that chickens managed in DLS without dietary supplementation of Pvmp satisfy requirement of vitamin B12 and some minerals by scratching and feeding on litters materials and develop good leg strength due to regular exercise (12). Hence, chickens in BCS require more supply of dietary vitamins and minerals than those on DLS because of the limited opportunity to search and feed on litter materials (8). Chickens managed intensively either in DLS or BCS are more susceptible to vitamin and mineral deficiencies. Dietary supplementation of Pvmp is a normal feed milling practice at a level in order to provide safety for birds managed under stressful conditions of production (13, 14).

Quality vitamin-mineral premix is essential and indispensable to improve safety and reliability of productive performance, protect against deficiency diseases and sustain commercial egg production in the humid tropics (15). Therefore, any compromise or neglect to supplemental Pvmp in poultry feed as an attempt to minimize cost of feeding have been reported (16, 17, 18) to make chickens shut down all necessary metabolic processes leading to reduction or cessation of egg production; production of low quality eggs; high mortality and heavy economic losses.
Available reports clearly enunciated the effects of the different Pvmp (8, 10) and housing type (11, 19) on laying performance. Fewer documentations on effects of both factors on egg composition (20, 21) and quality indices (22) are in literature. However, there have been dearth of desired information on effects of both Pvmp and HS on haematology and laying onset performance of pullets which is the focus of this study.

Materials and Methods

Experimental location and allotment of birds

The experiment was carried out at the Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria. A total of 576 Bovan nera growing pullets at week 10 of life were randomly allotted to six dietary treatments of 48 pullets per treatment. Each treatment was replicated six times comprising eight pullets per replicate. Pullets (n=288) were raised on both the conventional BCS and a partitioned DLS, respectively. Each cage in the BCS measured 50 x 45 x 40cm^3 accommodated four pullets. The DLS was partitioned into 36 smaller pens with an average floor area of 3.32 m^2 to accommodate eight pullets per pen.

Test Proprietary vitamin-mineral premixes

The composition of the test proprietary vitamin-mineral premixes (Pvmp) have been documented (20, 21, 23; 24) and is shown in Table 1. The Pvmp were purchased from a commercial feed milling factory in Ibadan, Nigeria.

Table 1: Gross compositions/2.5kg of test proprietary vitamin-mineral growers premixes

	Proprietary vitamin-mineral premix				
Ingredients	1	2	3	4	5
Vitamin A(IU)	10,000,000	8,000,000	7,000,000	8,000,000	10,000,000
Vitamin D3(IU)	2,000,000	2,000,000	1,400,000	1,600,000	2,000,000
Vitamin E(mg)	12,000	8,000	5,000	5,000	20,000
Vitamin K3 mg	2,000	2,000	2,200	1,500	2,000
Vitamin B1(mg)	1,500	1,500	1,500	4,000	3,000
Vitamin B2(mg)	5,000	4,000	4,800	1,500	5,000
Vitamin B6(mg)	1,500	1,500	1,500	10	4,000
Vitamin B12(mg)	10	10	10	15	20
Niacin(mg)	15,000	15,000	15,000	5,000	45,000
Folic Acid (mg)	600	500	500	300	1,000
Biotin (mg)	20	20	20	20	50
Ca pantothenate (mg)	5,000	5,000	5000	5,000	10,000
Choline chloride (mg)	150,000	100,000	100,000	200,000	300,000
Antioxidants (mg)	100,000	125,000	125,000	125,000	120,000
Manganese (mg)	80,000	75,000	75,000	80,000	300,000
Iron (mg)	40,000	20,000	20,000	20,000	120,000
Zinc (mg)	60,000	45,000	45,000	50,000	80,000
Copper (mg)	8,000	4,000	5,000	5,000	8,500
Iodine (mg)	1,000	1,000	1000	1,200	1,500
Cobalt (mg)	250	500	200	200	300
Selenium (mg)	150	200	100	200	120

Experimental Diets

Six isocaloric and isonitrogenous growers' diets were formulated with T1 (without test Pvmp) and T2, T3, T4, and T5 each was supplemented with 0.25% respective test premix as shown below:

T1 – Basal diet + No Premix

T2 - Basal diet + 0.25% Premix 1 (Nutripoults)

T3 - Basal diet + 0.25% Premix 2 (Hi-Nutrient premix)

T4 - Basal diet + 0.25% Premix 3 (Agrited premix)

T5 - Basal diet + 0.25% Premix 4 (Daram vita-mix)

T6 - Basal diet + 0.25% Premix 5 (Micro-mix premix)

Detailed formulation and chemical composition of the experimental diet fed to pullets is shown in Table 2.

Table 2: Gross composition (%) of experimental diets

Ingredients	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**
Maize	50.00	50.00	50.00	50.00	50.00	50.00
Soybean meal	20.00	20.00	20.00	20.00	20.00	20.00
Wheat bran	15.00	15.00	15.00	15.00	15.00	15.00
Palm kernel cake	11.33	11.08	11.08	11.0	11.08	11.08
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Di-calcium phosphate	1.20	1.20	1.20	1.20	1.20	1.20
Limestone	1.50	1.50	1.50	1.50	1.50	1.50
Biotronics	0.30	0.30	0.30	0.30	0.30	0.30
Mycofix	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.15	0.15	0.15	0.15	0.15	0.15
Lysine	0.12	0.12	0.12	0.12	0.12	0.12
Premix 1	-	-	-	-	-	-
Premix 2		0.25				
Premix 3			0.25			
Premix 4	-	-	-	0.25		
Premix 5	-	-	-	-	- 0.25	
Premix 6						0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated nutrient values						
ME (Kcal/kg)	2,694.31	2,687.56	2,687.56	2,687.56	2,687.56	2,687.56
Crude protein (%)	17.72	17.67	17.67	17.67	17.67	17.67
Crude fibre (%)	5.40	5.37	5.37	5.37	5.37	5.37
Fat (%)	4.26	4.25	4.25	4.25	4.25	4.25
Lysine (%)	0.98	0.98	0.98	0.98	0.98	0.98
Meth+Cyst (%)	0.74	0.74	0.74	0.74	0.74	0.74
Calcium (%)	1.11	1.11	1.11	1.11	1.11	1.11
Phosphorus (%)	0.76	0.76	0.76	0.76	0.76	0.76

Meth + Cyst - Methionine plus Cystiene

Birds Management and Performance Characteristics

Pullets were weighed prior to allotment to dietary treatments. The feed consumption per replicate was obtained by subtracting the leftover from the quantity of feed offered to the pullets. Pullets in each replicate were weighed individually and the mean live weights of pullets in each replicate were used to determine the live weight gains. Live weight gain was determined by subtracting initial from the final live weight. Feed conversion ratio was obtained by dividing feed intake (kg) by the weight gain (kg). Feed cost/gain and percentage mortality were also determined. Routine medication, vaccination and husbandry practices were administered on them. The feeding period lasted 6 weeks within which the pullets were given feed and water *ad libitum*. The experiment was a 2 x 6 factorial arrangement in a completely randomized design.

Blood collection and haematological determination

At week 14, six pullets per housing system were randomly selected and blood collected using 5 mL syringes via the jugular vein. Blood samples were collected and drained into heparinized bottles. Packed cell volume (PCV) was determined using micro-haematocrit method, while haemoglobin (Hb) concentration was measured spectrophotometrically by the method of cyanomet haemoglobin as described (25). red blood cell and white blood cell were estimated using haemocytometer (26). Mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration were estimated by calculation according formular (27). White cell differential counts like eosinophils, monocytes, platelet, lymphocytes, basophil and heterocyst were estimated by blood staining techniques

Statistical Analysis

Data were subjected to a two-way analysis of variance (ANOVA) at $\alpha_{0.05}$ using the General Linear Model procedure of SAS Institute Inc. (28) while significant means were separated by Duncan multiple range option of the same software.

Results and Discussion

Effects of housing systems and proprietary vitamin-mineral premixes on performance of pullets

Effect of HS and Pvmp on performance characteristics of pullets is shown in Table 3. The HS affected ($p<0.05$) FLW, DFI, EP and HDEP. The DFI(g/b/d) and FLW(kg/bird) in DLS (88.00 1.73, respectively) were higher ($p<0.05$) than in BCS (86.86 and 1.68, respectively). This could be because, pullets in DLS were able utilise feed more efficiently judging from observed FCR of 7.70 to attain higher FW ($p<0.05$) compared with those in BCS with FCR of 8.44. However, similar LWC ($p>0.05$) of 11.43 and 10.29 g/bird, respectively, were obtained for pullets in DLS and BCS. Earlier reports (19, 29) indicated that HS (BCS and DLS) affects feed consumption and live weight. The DFI of pullets increased linearly in DLS (R^2=0.82) ($p<0.05$) and BCS (R^2=0.57) in response to the need for more metabolisable energy requirement, increase in body size, preparation for egg laying, and maintanenace requirement for activity and exercise (14). This higher ($p<0.05$) DFI of pullets in DLS could imply higher demand of nutrients for maintanenace requirement of movement and exercise due to more floor space allowance. However, similar relationships (R^2=0.98) between live weight and age of pullets were obtained for pullets in both BCS and DLS (Figure 1) which indicated that pullets properly utilized feed for growth in the two HS.

Table 3: Effects of housing systems and proprietary vitamin-mineral premixes on performance characteristics of point of lay pullets

Factors	ILW (kg/b)	FLW (kg/b)	DFI (g/b/d)	LWC (g/b/d)	FCR	A (days)	EW (g)	EP	HDEP (%)	M (%)
BCS	1.32	1.68^{b}	86.86^{b}	10.29	8.44	122	32.00	4.55^{a}	8.19^{a}	1.74
DLS	1.33	1.73^{a}	88.00^{a}	11.43	7.70	122	31.83	2.30^{b}	3.95^{b}	0.00
SEM	0.01	0.01	1.25	0.07	0.04	0	0.12	0.43	0.78	1.23
T1	1.34	1.73^{ab}	87.15	11.14	12.44	129	30.00	1.78^{b}	3.18^{b}	2.08
T2	1.36	1.74^{a}	87.37	10.86	12.87	122	31.00	4.18^{a}	7.54^{a}	2.08
T3	1.32	1.69^{b}	87.62	10.57	13.24	129	34.00	3.13^{ab}	5.58^{ab}	0.00
T4	1.30	1.69^{b}	87.98	11.14	12.64	131	31.00	3.31^{ab}	5.90^{ab}	1.04
T5	1.31	1.69^{b}	87.81	10.86	12.95	124	32.00	4.00^{a}	7.24^{a}	1.04
T6	1.32	1.69^{b}	86.31	10.57	13.08	122	32.00	3.86^{a}	6.96^{a}	1.04
SEM	0.01	0.02	0.33	0.11	0.16	1.62	0.56	0.75	1.35	0.32
(P-value)										
Pvmp x HS	0.0057^{NS}	0.5515^{*}	0.9541^{NS}	-	-	-	-	0.4958^{*}	0.4904^{*}	-

[a b] Means with different superscripts within the same vertical column are significantly different ($p<0.05$)

HS-Housing Systems, Pvmp-Proprietary vitamin-mineral premix, BCS-Battery Cage System, DLS-Deep Litter System, ILW–Initial Live Weight, FLW–Final Live Weight, DFI–Daily Feed Intake, LWC–Live Weight Change, FCR–Feed Conversion Ratio, A–Age of pullet at 1st egg lay, EW–Egg Weight at 1st egg lay, EP-Number of Egg Production, HDEP-Hen Day Egg Production, M–Mortality, SEM- Standard Error of Means

The possibility of pullets in DLS obtaining extra natural feed materials rich in protein, amino acids, vitamins and minerals from the litter and feaces cannot be ruled out. This could explain the reason for higher FW attained by pullets DLS. Pullets in DLS grew heavier ($p<0.05$) than those in BCS. Pullets in DLS had comparative advantage of starching and feeding on natural litter materials and excreta that could contained exogenous nutrients such as vitamins and minerals which stimulate appitites and made them eat more feed.

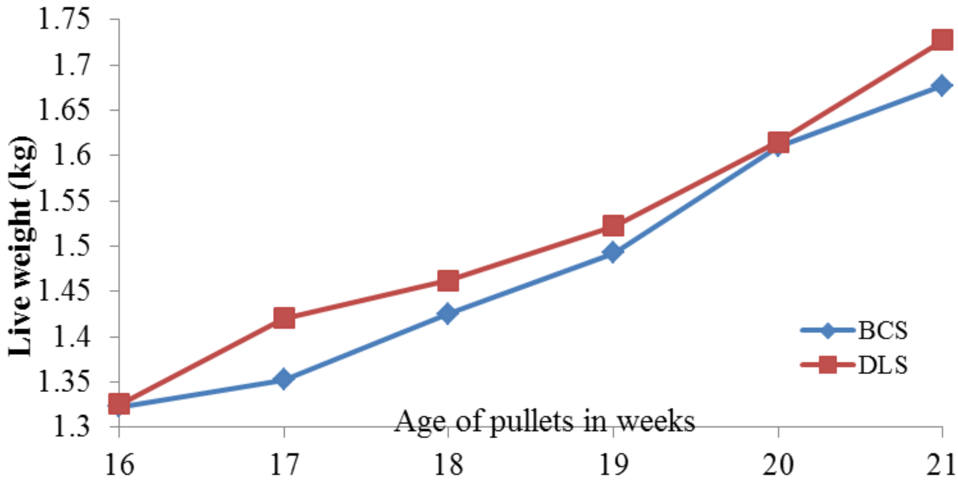


Figure 1: Effect of two housing systems on body weight changes of pullets

The Pvmp did not have any significant effect ($p>0.05$) on DFI and LWC but varied ($p<0.05$) with FLW of pullets. This implies that pullets fed different Pvmp grew at different rates during the period of study (Figure 2). The FLW of pullets fed T2 (1.74) is similar to those on T1 (1.73) but different ($p<0.05$) compared with pullets on T3 (1.69), T4 (1.69), T5 (1.69) and T6 (1.69). This could be because T2 contains sufficient vitamin and trace mineral to promote higher FLW. Pullets on T3, T4, T5 and T6 reduced in FLW compared with those on T1. Lower or excess of thiamine, biotin, cyanocobalamin (B_{12}) folic acid and zinc impairs utilisation of macro-feed nutrients like carbohydrate, fat and proteins (14). This possibly explains the reduction ($p<0.05$) of FWL by pullets on T3, T4, T5 and T6.

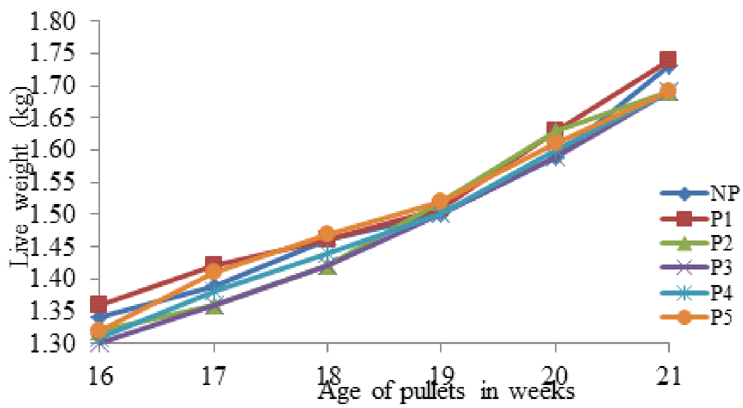
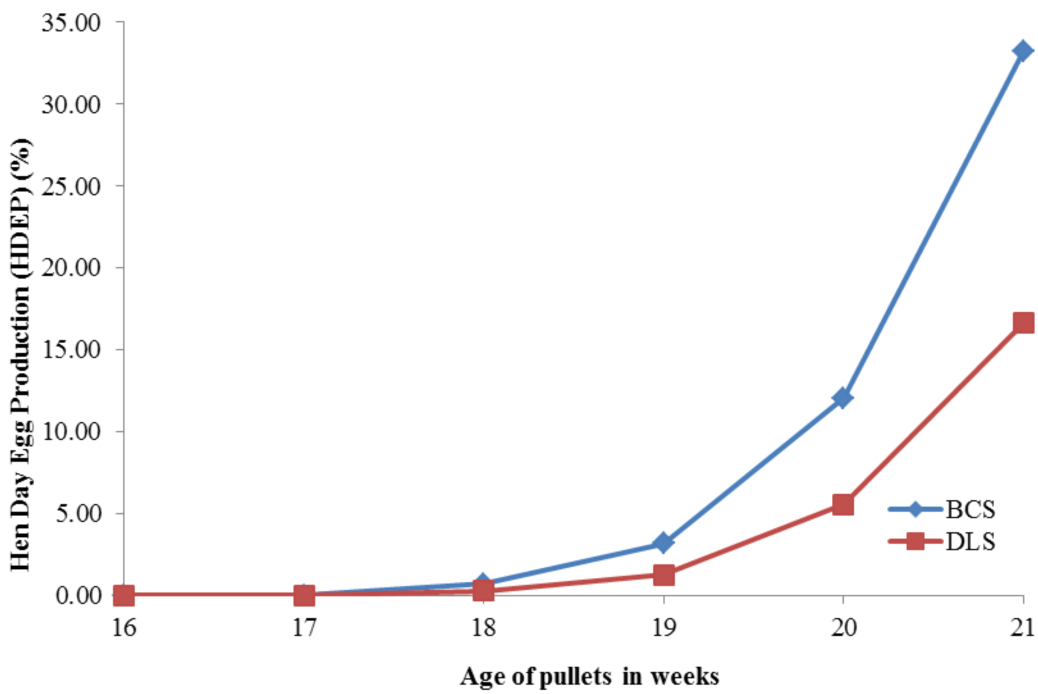


Figure 2: Effect of different proprietary vitamin-mineral premixes on live weight of pullets

Housing systems did not affect ($p>0.05$) initiation of first egg lay since pullets produced the first egg at 122 days in both BCS and DLS. The EP of 4.55 and HDEP of 8.19 % by pullets in BCS were higher ($p<0.05$) than corresponding 2.30 and 3.95% in DLS as indicated in Figure 3. This could connote a more effective utilization of feed by pullets in BCS for on-set of egg laying. Pullets possibly utilized feed to initiate egg preparation in BCS than DLS. This is in line with the assertions (19, 30) that laying chickens in BCS enjoyed comparative advantges of spatial density, control of micro-climate, less contact with feacal materials as sources of disease infection and better health condition and reduced feed wastage to improve ($p<0.05$) feed efficiency, egg laying capacity (+25.5%) and number of eggs produced than those in DLS.

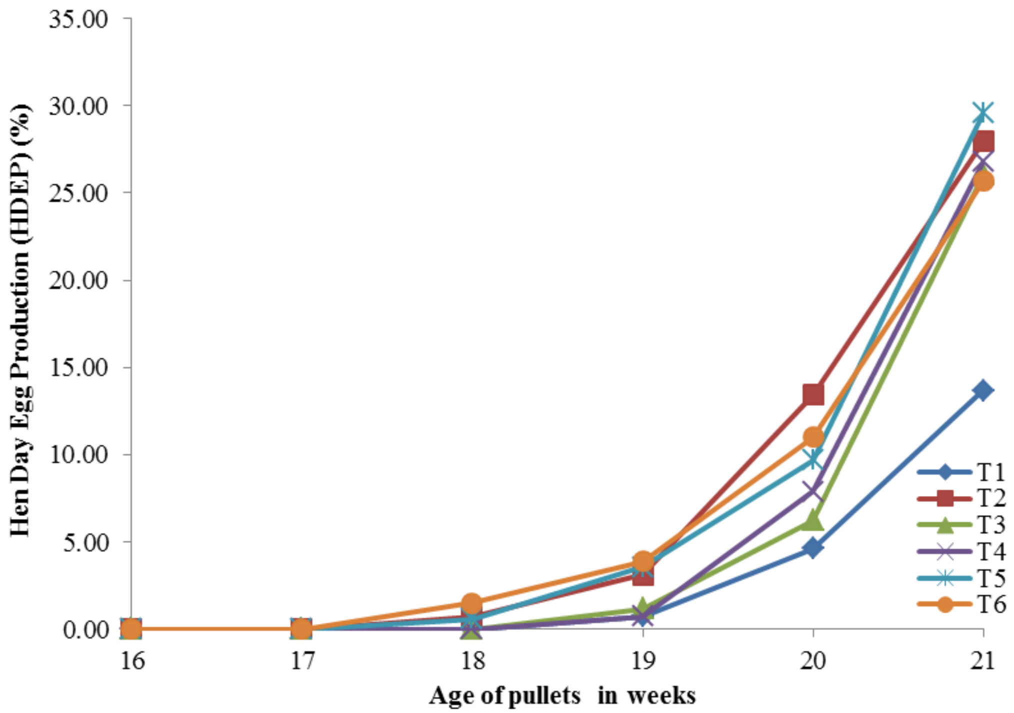


T1-Diet without premix, T2-Diet with premix 1, T3-Diet with premix 2, T4-Diet with premix 3, T5-Diet with premix 4 and T6-Diet with premix 5

Figure 3: Effect of housing systems on the egg production of pullets

The type of dietary Pvmp did not affect ($p>0.05$) the onset of first egg lay. Pullets fed different Pvmp initiated first eggs between ages 122 and 131 days with eggs weighing 00-34.00 g. Figure 4 shows that pullets on T2 and T6 initiated first egg lay that weighed 31.00 and 32.00 g, respectively at age 122 days. However, pullets on T4 delayed first egg lay till age 131 days and laid egg which weighed 31.00 g.

Effects of interaction of HS and Pvmp on EP and HEDP was significant ($p<0.05$). These results underscored the importance and sensitivity of vitamin and trace mineral nutrition in poultry production. Feedstuff may contain inconsistent and widely varying composition of vitamins and minerals, therefore, the essence of supplementing poultry diets with Pvmp. The requirements of vitamins A, D, E, K, riboflavin, thiamin, pantothenic acid, niacin, pyridoxine, folic acid, biotin and cyanocobalamin (B_{12}) for egg production, embryonic development of chicks and hatchability are critically important (22). This assertion agree with reported study (14) that marked deficiency of any one or more of calcium, manganese, vitamins A, D, riboflavin and choline cause reduction or even ceassation of egg production. The balanced vitamins and trace minerals content in premix 1 which probably were supplied in adequate amount for egg production probably was indicative of higher HDEP ($p<0.05$) of pullets on other diets (T2, T3, T4, T5 and T6) compared with those on T1(diet without premix).



T1-Diet without premix, T2-Diet with premix 1, T3-Diet with premix 2, T4-Diet with premix 3, T5-Diet with premix 4 and T6-Diet with premix 5

Figure 4: Effect of five proprietary vitamin-mineral premixes on egg production of pullets

Effects of housing systems and proprietary vitamin-mineral premixes on haemato-logical and biochemical indices of point of lay pullets

Effects of HS and Pvmp on haematotological indices of pullets are shown in Tables 4 and 5. The HS did not affect ($p>0.05$) haemalogical indices of pullets but Hb, PCV, RBC varied ($p<0.05$) with Pvmp. The Hb (g/dL) of 8.93 recorded for pullets on T1 was similar to 8.13, 8.22, 7.72 and 8.33 for those on T2, T3, T4 and T6, repesctively but higher ($p<0.05$) than 7.62 for those on T5. The PCV (%) of pullets on T1 (26.83) was the highest but similar to 24.08, 26.67 and 24.17 for those on T2, T3 and T6, repesctively but higher ($p<0.05$) than 21.50 and 23.16 for those on T4 and T5, respectively. Pullets on T4 had 4.40 x10^{6}IU/L RBC similar to 26.83, 4.20, 4.10 and 3.76 for those on T1, T3, T5 and T6, respectively but higher ($p<0.05$) compared with 3.57 for those on T2. The MCV (fl) and MCH (pg) were similar across dietary treatments. Effects of interaction of Pvmp and HS on Hb, PCV, RBC and MCV were significant ($p<0.05$). Haematological values were within the reference ranges for healthy chickens as reported (31). The variations in haematological indices could be due to observed differences in the composition of vitamin and trace mineral contents of the test Pvmp. The PCV in this study indicates that pullets were not stressed (32), and well adapted to prevailing cnvironmental conditions in the housing systems (33).

Table 4: Effects of housing systems and dietary vitamin-mineral premixes on haematological indices of point of lay pullets

Factors	Hb (g/dL)	PCV (%)	RBC (10^{6} IU/L)	MCV (fl)	MCH (pg)	MCHC (%)
BCS	8.13	24.08	3.99	61.58	20.85	33.86
DLS	8.18	24.72	4.05	62.57	20.62	33.84
SEM	0.24	0.64	0.13	2.47	0.90	1.40
T1	8.93^{a}	26.83^{a}	4.11^{ab}	66.44^{a}	22.17^{ab}	33.35
T2	8.13^{ab}	24.08^{ab}	3.57^{b}	68.43^{a}	22.90^{a}	34.24
T3	8.22^{ab}	26.67^{a}	4.20^{ab}	64.84^{a}	20.30^{ab}	30.86
T4	7.72^{ab}	21.50^{b}	4.40^{a}	49.86^{ab}	17.77^{b}	36.46
T5	7.62^{b}	23.16^{b}	4.10^{ab}	57.82^{ab}	18.91^{ab}	33.23
T6	8.33^{ab}	24.17^{ab}	3.76^{ab}	65.05^{a}	22.37^{a}	35.01
SEM	0.42	1.02	0.23	4.27	1.57	2.43
(P-value)						
Pvmp x HS	0.7092^{*}	0.2546^{*}	0.2539^{*}	0.0948^{*}	0.3679^{*}	0.8346^{NS}

$^{a\ b}$ Means with different superscripts within the same column are significantly different ($P<0.05$)
HS-Housing systems, PVMP-Proprietary vitamin-mineral premix, BCS-Battery Cage System, DLS-Deep Litter System, Hb-Haemoglobin, RBC-Red blood cells, PCV- Pack cell volume, MCV-Mean Corpuscular Volume, MCH- Mean corpusular Volume, MCHC-Mean Corpuscular Haemoglobin Concentration, SEM-Standard Error of Means

In Table 5, HS influence ($p<0.05$) white blood cells counts but caused no variation ($p>0.05$) in the differential cell counts of pullets. The WBC of 24.01 x 10^{3}IU/L of pullets in DLS was higher ($p<0.05$) than 20.84 x 10^{3}IU/L in BCS. Aside from eosinophil, and basophil, the different dietary Pvmp affected ($p<0.05$) differential cell counts. Highest

WBC, monocytes and platelet of 29.33 x 10^3IU/L, 3.83 % and 2.82 x 10^5 , respectively were in pullets on T4, while those on T1 had highest lymphocyte of 56.33%. Heterophil was highest in pullets on T2 (43.58 %). The effects of interaction of Pvmp and HS on WBC and differential cell counts were siginifcant ($p<0.05$) except basophils. The differences observed in WBC, lymphocytes and some differential count could be due to alteration in nutrient partitioning or detered metabolic process associated with growth and egg production (34). The differences in WBC and differential cell counts could also be because of the different vitamins and minerals content in test Pvmp. This assertion corroborates the report (Wunyastuti *et al.*, 1993) that selenium, copper,iron and zinc are involved in production, transport and storage hepatic protein and alteration of various components of immune systems.

Table 5: Effects of housing systems and dietary vitamin-mineral premixes on white blood cell and differential cell counts of point of lay pullets

Factors	WBC (10^3 IU/L)	Lym (%)	Het (%)	Mon (%)	Eos (%)	Bas (%)	Pla (10^5)
BCS	20.84^b	52.86	38.17	2.94	3.67	0.33	2.01
DLS	24.01^a	54.67	40.39	3.17	4.19	0.44	2.27
SEM	0.72	1.87	1.79	0.15	0.34	0.15	0.10
T1	21.25^{bc}	56.33^{ab}	36.33^{ab}	3.00^b	4.00	0.33	2.30^{bc}
T2	21.66^{bc}	51.17^{ab}	43.58^a	3.00^b	3.08	0.17	2.41^{ab}
T3	22.47^b	55.17^{ab}	38.17^{ab}	2.83^b	3.67	0.50	2.00^{bc}
T4	29.33^a	50.50^{ab}	41.67^{ab}	3.83^a	4.50	0.33	2.82^a
T5	21.75^b	49.67^b	42.50^a	3.00^b	4.33	0.83	1.84^{cd}
T6	18.06^c	49.67^b	33.42^b	2.67^b	4.00	0.17	1.49^d
SEM	1.24	3.24	3.11	0.26	0.58	0.26	0.17
(P-value)							
Pvmp x HS	0.0008^*	0.0133^*	0.0111^*	0.3273^*	0.2477^*	0.6797^*	0.0293^*

[a b c d] Means with different superscripts within the same column are significantly different ($P<0.05$)
HS- Housing Systems, Pvmp-Proprietary vitamin-mineral premix, BC-Battery Cage System, DLS-Deep Litter System, WBC-White Blood Cells, Lym-Lymphocytes, Het-Heterocyst, Mon-Monocytes, Eos-Eosinophil, Bas-Basophil, Pla-Platelets, SEM -Standard Error of Means

Conclusion

- Housing system or type did not affect the onset of laying of pullets and the haematological indices in this study
- However, the type of Pvmp used in the dietary formulation as well as the effect of Interaction of housing system and type of Pvmp determined when pullets started to drop eggs.

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