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Full Length Research

Effect of feed granulometry on haematological parameters of Japanese quail (*Coturnix japonica*) at different stages of growth in Côte d'Ivoire

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ABSTRACT: The study was carried at the ISMOREL farm of Adiaké in Côte d'Ivoire to determine the effect of feed's grain size (the granulometry) on haematological parameters of Japanese quail according to the age. Fourteen (14) days old quails were distributed in metallic cages into 5 sub-groups of 5 quails each, according to the type and the food granulometry. From 2 types of food (grower diet and layer diet), 5 different food types by their granulometry were developed. LD 100, LD 50 and LD 75 were developed for the layer diet, then GD 100 and GD 50 for the grower diet. Twenty-five quails on the whole were used in this study. Blood samples were taken on the 10, 28, 42 and 56th day of age in order to perform blood count of each animal. The results showed a significant impact ($p < 0.05$) of the feed granulometry on the white blood cells parameters. At weeks 4 and 6, a very highly significant increase ($p < 0.001$) in white blood cells as a whole was observed. The best value for this parameter was obtained in the LD 50 sub-group. At week 8, the best value was obtained in LD 100 for this same parameter. However, despite variations observed in the red blood cells, no influence of food granulometry on these parameters was noted.

Keywords: Feed's grain size, grower diet, layer diet, red blood cells, white blood cells.

INTRODUCTION

Japanese quail (*Coturnix japonica*) is a poultry which is generally bred for its eggs and flesh (Sokól et al., 2015). It belongs to the family of Phasianidae and the genus *Coturnix* (Mizutani, 2003). It's a poultry which presents several qualities. These include rapid growth, hasty sexual maturity, early and abundant laying, a short generation interval and the development of a good diseases resistance (Oluyemi and Robert, 1979; Shanaway, 1994; Biagini, 2006). All these assets make Japanese quail (domestic quail) a species constituting an important source of eggs and meat production. In Côte d'Ivoire, poultry farming is mainly focused on chicken eggs and meat production. According to Atsin (2017), from 2014 to 2015, it is about 240 billion turnover generated by the Ivorian poultry sector. Even if the results are currently satisfactory at this time in this field, the challenge will be to maintain the current production rate and then increase it in order to meet the needs for its demographic population in the future. Quail can, thanks to its qualities; help the country in this direction, by increasing the production of the poultry products. It will also offer a diversity of these foods in the markets. Thus, offering a wide range of choice to consumers. To achieve this, quails breeding in Côte d'Ivoire must move to an intensive production model, are therefore undertaken by Ivorian researchers. However, all these investigations relate to the bromatological composition of food. A food can act suitably on the body only if it is well assimilated by the animal. In this vein, it is

essential, in comparison with the size of the animal, to determine appropriate and suitable grain size of designed food for its production. Moreover, best feed granulometry will have to ensure a good health in the animal that consumes it by normally acting on the blood parameters of this one. For this reason, the evaluation of some haematological parameters of domestic quail will provide useful information about their health. These could help in the management of the possible blood cells modifications (Campbell, 2015; Sparling et al., 1999). Therefore, this study generally aims, to investigate the effect of the feed granulometry on haematological parameters of Japanese quail according to the age.

MATERIALS AND METHODS

Study area

The current study took place at the “ISMOREL farm”. This farm is located in Côte d’Ivoire, 2 km from Adiaké’s city (5° 17' 06" N of latitude and 3° 18' 07 W of longitude). The relative humidity and the temperature during the experimental period varied respectively from 75 to 95% and 23.7 to 32.2°C. According to tutiempo.net (2017), the annual precipitation was of 1689.54 mm.

Animals

Twenty-five 14 days old and non-sexed quails were used in this study. These locally produced animals weighed between 50 and 60 g. The quails were selected at 14 days of age, based on their weight (weight ranging between 50 and 60 g) and their health status (apparently healthy). According to the types of food to be tested, five sub-groups of five quails each were made up. These animals were placed individually in the metal cages measuring 15 X 20 X 40 cm. The temperature inside the building was maintained from 28 to 30°C with a relative humidity between 65 to 70%. These data were recorded on the experimentation site.

Feeds

For this study, two types of commercial feed were used. These were selected on the basis of result of an investigation aiming at determining the types of the most used feed in quail’s breeding farms in the Abidjan district. Using a crusher - mixer, some experimental diets was manufactured from the standard diet. The difference between the experimental feeds among themselves as well as with the standard diets was only the granulometry. Thus, three types of experimental diets were formulated from two main starting diets. These are:

Feed type 1 or layer diet (LD) which consisted of LD 100 = standard feed; LD 50 = LD 100 reduces by 50% and LD 75 = LD 50 reduced by 50%.

Feed type 2 or grower diet (GD) which was composed of GD 100 = standard feed; and GD 50 = GD 100 reduces by 50 %.

It’s important to note that the layer diet LD 100 and the grower diet GD 100 represent the controls of the layer diet group and grower diet group respectively. The layer diet LD 50 and the grower diet GD 100 have same granulometry. It is the same for GD 75 and GD 50.

At 2 days of age, the quails were distributed in two groups according to the experimental diets formulated (30 quails for layer diet group and 20 quails for grower diet group). From 2 to 10 days of age, quails from layer diet group were fed with the layer diet and those of grower diet group were fed with a grower diet. These two diets were at fluoric form for this period. All the quails were raised together under the same condition. The feeds were served *ad libitum*, twice in a day. From the 11th day of age, the quails were divided into 5 sub-groups of 5 quails each according to experimental feed formulated (LD 100, LD 50, LD 75, GD 100 and GD 50). Three days of feed transition was made from the 11th day of age to the 13th day for each type of experimental feed in order to facilitate its acceptance. From 14th day of age to the 56th day, the quails selected in each sub-group, received 100% of corresponding diet *ad libitum* one time per day. Figure 1 presents the photographs of the various types of feed used for this study. Table 1 presents the composition marked on their label.

Blood samples

Blood samples were taken at 08:00 am with 14 days interval. The collection time was consistent throughout the study. The experimentation began with a blood sample at 10 days from age (before the experimental food consumption). Other taking was carried out on the 28, 42 and 56th day of age. A 5 ml blood was taken from the wing vein of each animal using 5 cc syringes. The collected blood was transferred in a tube containing an anti-coagulant, the Ethylene Diamine Tetra-Acetic Acid (EDTA). It was quickly kept at 4°C then analyzed before 24 hours to determine haematological parameters. The haematological analyzes were carried out at the cytology laboratory of the urban hospital center (CHU) of Cocody commune in Abidjan. An automat of medical analyzes was used for that. The quails were kept under the conditions close as much as possible to the standards defined by the guide to good breeding practice of FAO and OIE (2009).

Data analyzes

Graphpad PRISM 8.0.1 software was used to make

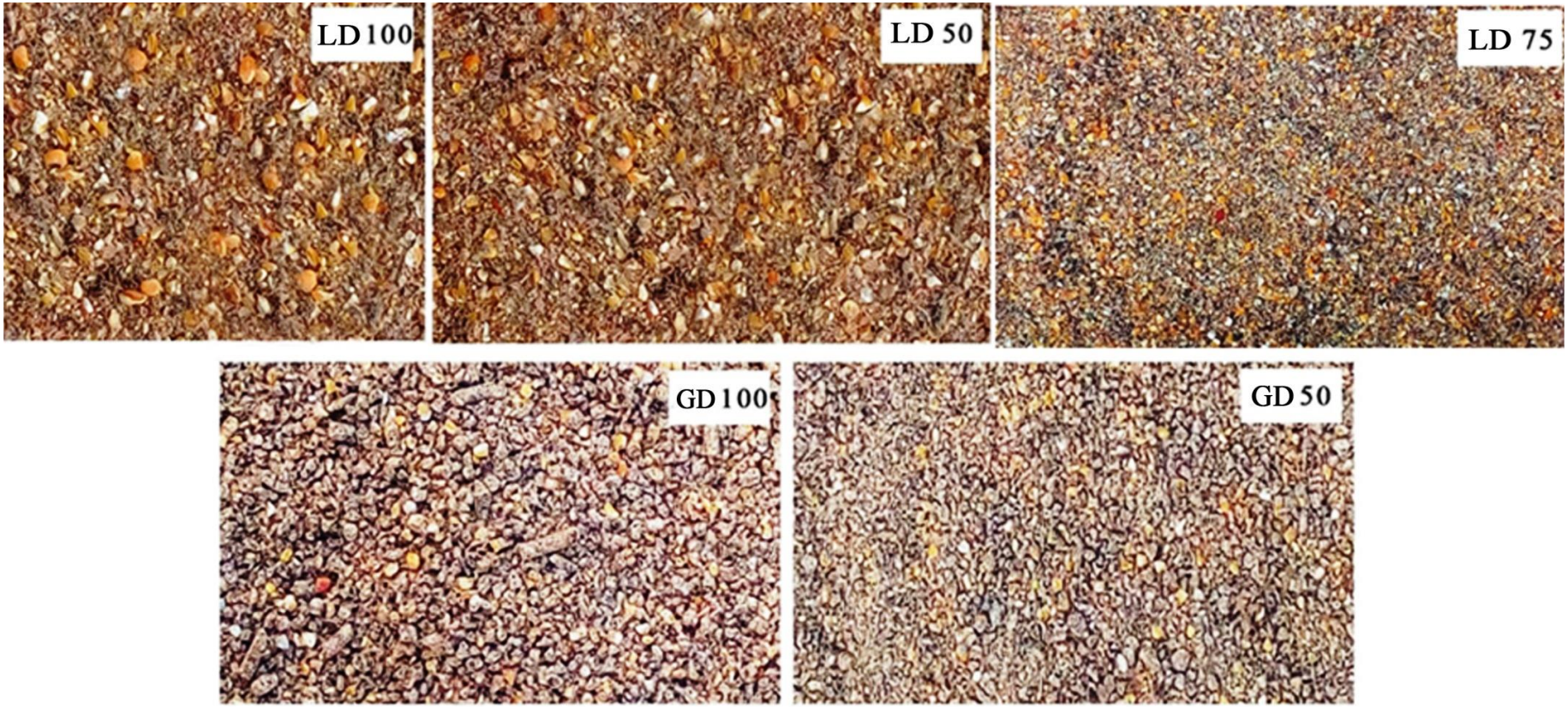

Figure 1. Experimental diets. **LD:** Layer diet; **GD:** Grower diet.

the statistical analyzes. The data have been presented as means followed by the standard error on the mean in tables and figures. In addition, the variance analyzes with one factor (duration of food consumption, under food types / ANOVA 1) and two factors (duration of food consumption and under food types / ANOVA 2) were carried out to compare the means of the groups of animals with each over. The Turkey test was used for the tests *post hoc* tests. The significance threshold used was of 5%.

RESULTS

Haematological parameters variation according to various foods for each period of growth

At 10 days of age

The means values obtained at the experience beginning (10 days of age), for each haematological parameters are shown in Table 2. LD 100 sub-group and GD 100 sub-group are respectively the control sub-group of LD and GD groups. The statistical analysis indicated a very highly significant difference ($p < 0.001$) between the means values of the animals' sub-groups for the leukocytes (WBC: white blood cells) as well as the platelets. The highest and smallest means for the WBC, were obtained respectively in GD 100 ($27.6 \pm 0.462\ 10^3/mm^3$) and LD 100 ($13.9 \pm 0.749\ 10^3/mm^3$) sub-groups. In the case of the platelets, these means were respectively obtained in LD 100

Table 1. Used diets composition.

Components	Layer diet (LD)	Grower diet (GD)
Metabolizableenergy (Kcal/kg)	2782	2567
Crudeprotein (%)	17	18
Crude fat (%)	5.2	4.4
Crudeash (%)	13.6	6.57
Crudefiber (%)	4.9	4.41
Calcium (g/kg)	36.5	10.73
Total phosphorus (g/kg)	5.8	6.31
Sodium (%)	0.17	0.18
Vit A (UI/kg)	9000	10000
Vit D3 (UI/kg) 9000	2250	2000
Vit E (UI/kg) 2250	16	20

Table 1. Mean values of haematological parameters distribution at 10 days of age.

Haematological parameters	Layer diet (LD)			Grower diet (GD)		P-value
	LD 100	LD 50	LD 75	GD 100	GD 50	
WBC (10^3/mm^3)	13.9 ± 0.749 ^{c}	14.3 ± 1.22 ^{c}	14.8 ± 1.02 ^{c}	27.6 ± 0.462 ^{a}	19.0 ± 0.302 ^{b}	< 0.001
Heterophiles (10^3/mm^3)	5.97 ± 0.323 ^{c}	6.16 ± 0.527 ^{c}	6.40 ± 0.441 ^{c}	11.9 ± 0.199 ^{a}	8.17 ± 0.130 ^{b}	< 0.001
Eosinophils (10^3/mm^3)	0.188 ± 0.01 ^{c}	0.194 ± 0.017 ^{c}	0.202 ± 0.014 ^{c}	0.375 ± 0.006 ^{a}	0.258 ± 0.004 ^{b}	< 0.001
Basophils (10^3/mm^3)	0.071 ± 0.004 ^{c}	0.073 ± 0.006 ^{c}	0.076 ± 0.005 ^{c}	0.141 ± 0.002 ^{a}	0.097 ± 0.002 ^{b}	< 0.001
Monocytes (10^3/mm^3)	0.327 ± 0.018 ^{c}	0.337 ± 0.029 ^{c}	0.350 ± 0.024 ^{c}	0.651 ± 0.011 ^{a}	0.447 ± 0.007 ^{b}	< 0.001
Lymphocytes (10^3/mm^3)	7.35 ± 0.397 ^{c}	7.58 ± 0.648 ^{c}	7.87 ± 0.542 ^{c}	14.6 ± 0.245 ^{a}	10.0 ± 0.160 ^{b}	< 0.001
Platelets (10^3/mm^3)	118 ± 2.55 ^{a}	109 ± 2.94^{bc}	101 ± 0.341 ^{c}	108 ± 0.447^{bc}	111 ± 2.12 ^{ab}	< 0.001
RBC (10^6/mm^3)	3.88 ± 0.201	3.84 ± 0.181	3.54 ± 0.191	3.70 ± 0.032	3.87 ± 0.078	0.483
Hemoglobin (g/dL)	13.4 ± 0.342	14.5 ± 0.343	13.4 ± 0.292	13.4 ± 0.051	13.6 ± 0.245	0.052
Hematocrit (%)	38.1 ± 0.982	37.3 ± 1.48	37.2 ± 1.02	37.1 ± 0.194	37.8 ± 0.533	0.944
MCHC (g/dL)	35.9 ± 0.230	35.9 ± 0.206	35.9 ± 0.321	36.1 ± 0.04	35.8 ± 0.114	0.932
MCH (pg)	34.6 ± 0.734	34.8 ± 0.418	35.5 ± 0.388	35.4 ± 0.089	34.9 ± 0.184	0.542
MCV (fl)	96.1 ± 0.638 ^{b}	96.3 ± 0.745 ^{b}	98.4 ± 0.557 ^{ab}	100 ± 0.92 ^{a}	97.6 ± 0.347 ^{ab}	0.002

WBC: White Blood Cells (leukocytes); RBC: Red Blood Cells; MCHC: Mean corpuscular hemoglobin concentration; MCH: Mean corpuscular hemoglobin; MCV: Mean corpuscular volume; a, b, c: Statistically different groups for $p < 0.05$.

(118 ± 2.55 10^3/mm^3) and LD 75 (101 ± 0.341 10^3/mm^3). Very significant differences ($p < 0.01$) were also observed on mean corpuscular volume (MCV) mean of various sub-groups. The highest MCV value was observed in GD 100 (100 ± 0.92 fl), while the smallest was revealed in sub-group LD 100 (96.1 ± 0.638 fl). Intra-groups comparisons, differences were shown in LD group for platelets. Thus, a significant difference ($p < 0.05$) was

Table 3. Mean values of haematological parameters distribution at 28 days of age.

Haematological parameters	Layer diet (LD)			Grower diet (GD)		P-value
	LD 100	LD 50	LD 75	GD 100	GD 50	
WBC (10^3/mm^3)	92.7 ± 0.705 ^{c}	98.5 ± 0.354 ^{a}	84.1 ± 1.62 ^{d}	94.8 ± 0.523^{bc}	97.0 ± 0.280 ^{ab}	< 0.001
Heterophiles (10^3/mm^3)	40.0 ± 0.304 ^{c}	42.4 ± 0.153 ^{a}	36.2 ± 0.7 ^{d}	40.9 ± 0.225^{bc}	41.8 ± 0.121 ^{ab}	< 0.001
Eosinophils (10^3/mm^3)	1.26 ± 0.01 ^{c}	1.34 ± 0.005 ^{a}	1.14 ± 0.022 ^{d}	1.29 ± 0.007^{bc}	1.32 ± 0.004 ^{ab}	< 0.001
Basophils (10^3/mm^3)	0.473 ± 0.004 ^{c}	0.502 ± 0.002 ^{a}	0.429 ± 0.008 ^{d}	0.484 ± 0.003^{bc}	0.495 ± 0.001 ^{ab}	< 0.001
Monocytes (10^3/mm^3)	2.19 ± 0.017 ^{c}	2.32 ± 0.008 ^{a}	1.98 ± 0.038 ^{d}	2.24 ± 0.012^{bc}	2.29 ± 0.007 ^{ab}	< 0.001
Lymphocytes (10^3/mm^3)	49.2 ± 0.373 ^{c}	52.2 ± 0.188 ^{a}	44.6 ± 0.861 ^{d}	50.3 ± 0.277^{bc}	51.4 ± 0.148 ^{ab}	< 0.001
Platelets (10^3/mm^3)	74.0 ± 2.59	79.0 ± 4.46	82.6 ± 1.57	79.4 ± 0.245	74.5 ± 4.98	0.337
RBC (10^6/mm^3)	2.02 ± 0.049 ^{b}	2.92 ± 0.246 ^{a}	3.18 ± 0.282 ^{a}	1.90 ± 0.195 ^{b}	2.50 ± 0.071 ^{ab}	< 0.001
Hemoglobin (g/dL)	16.6 ± 0.568 ^{cd}	23.6 ± 1.10 ^{a}	15.0 ± 0.025 ^{d}	18.9 ± 0.084^{bc}	20.3 ± 0.237 ^{b}	< 0.001
Hematocrit (%)	27.7 ± 0.588 ^{b}	39.1 ± 2.01 ^{a}	25.4 ± 0.270 ^{b}	24.9 ± 2.17 ^{b}	33.8 ± 0.129 ^{a}	< 0.001
MCHC (g/dL)	59.9 ± 0.363 ^{a}	60.5 ± 0.105 ^{a}	51.6 ± 2.85 ^{b}	53.1 ± 2.60 ^{ab}	60.1 ± 0.7 ^{a}	0.002
MCH (pg)	82.6 ± 0.611 ^{a}	80.8 ± 0.587 ^{ab}	62.9 ± 3.27^{bc}	57.4 ± 9.35 ^{c}	81.6 ± 1.09 ^{ab}	< 0.001
MCV (fl)	138 ± 0.548 ^{a}	134 ± 1.22 ^{ab}	121 ± 1.36 ^{c}	133 ± 1.05 ^{b}	136 ± 0.447 ^{ab}	< 0.001

WBC: White Blood Cells (leukocytes); RBC: Red Blood Cells; MCHC: Mean corpuscular hemoglobin concentration; MCH: Mean corpuscular hemoglobin; MCV: Mean corpuscular volume; a, b, c: Statistically different groups for $p < 0.05$.

indicated between LD 100 (118 ± 2.55 10^3/mm^3) and LD 50 (109 ± 0.341 10^3/mm^3). This difference was very highly significant ($p < 0.001$) between LD 100 and LD 75 (101 ± 2.55 10^3/mm^3). In this group, the highest and smallest mean values were respectively recorded in LD 100 and LD 75 sub-groups.

At 4 weeks of age

Table 3 presents mean values of each haematological parameter for each group of animals at 28 days of age. The statistical analysis showed a very highly significant differences ($p < 0.001$) for the white blood cells (WBC), red blood cells (RBC), hemoglobin (Hb), hematocrit (Hct), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular hemoglobin (MCH) and mean corpuscular volume (MCV). LD group obtained the highest and smallest average values for: WBC (LD 50 = 98.5 ± 0.354 10^3/mm^3 and LD 75 = 84.1 ± 1.62 10^3/mm^3); Hb (LD 50 = 23.6 ± 1.10 g/dL and LD 75 = 15.0 ± 0.0025 g/dL); MCHC (LD 50 = 60.5 ± 0.105 % and LD 75 = 51.6 ± 2.85 %) and MCV (LD 100 = 138 ± 0.548 fl and LD 75 = 121 ± 1.36 fl). For RBC, Hct and MCH, highest and smallest mean values respectively were obtained in LD 75 (3.18 ± 0.282 10^6/mm^3) and GD 100 (1.9 ± 0.195 10^6/mm^3) for RBC; in LD 50 (39.1 ± 2.01 %) and LD 100 (24.9 ± 2.17 %) for Hct; in LD 100 (82.6 ± 0.611 pg) and GD 100 (57.4 ± 9.35 pg) for MCH.

Intra-group comparison showed differences in LD group for WBC, RBC, Hb, Hct, MCHC, MCH and MCV. In GD group, some differences were observed only for Hct and MCH. Differences observed in LD group for WBC, were very significant ($p < 0.01$) between LD 100 (92.7 ± 0.705 10^3/mm^3) and LD 50 (98.5 ± 0.354 10^3/mm^3) then very highly significant ($p < 0.001$), between LD 100 and LD 75 (84.1 ± 1.62 10^3/mm^3) and between LD 50 and LD 75. For RBC, a significant difference was observed between LD 100 (2.02 ± 0.049 10^6/mm^3) and LD 50 (2.92 ± 0.246 10^6/mm^3). Difference was very highly significant between LD 50 and LD 75 (3.18 ± 0.282 10^6/mm^3). In the case of Hb, some very highly significant differences ($p < 0.001$) were observed between LD 100 (16.6 ± 0.568 g/dL) and LD 50 (23.6 ± 1.10 g/dL) then between LD 50 and LD 75 (15.0 ± 0.025 g/dL). Sub-groups GD 100 (24.9 ± 2.17 g/dL) and GD 50 (33.8 ± 0.129 g/dL) also presented a significant difference ($p < 0.05$) for this same parameter. The MCHC was significantly different ($p < 0.05$) between LD 50 (60.5 ± 0.105 %) and LD 75 (51.6 ± 2.85 %) like between LD 100 (59.9 ± 0.363 %) and LD 75. The TCMH presented a significant difference ($p < 0.05$) between LD 100 (82.6 ± 0.611 pg) and LD 75 (62.9 ± 3.27 pg). A highly significant

Table 2. Mean values of haematological parameters distribution at 42 days of age.

Haematologicalparameters	Layer diet (LD)			Grower diet (GD)		P-value
	LD 100	LD 50	LD 75	GD 100	GD 50	
WBC (10^3/mm^3)	101 ± 1.74 ^{b}	258 ± 1.99 ^{a}	98.8 ± 2.39 ^{b}	101 ± 1.02 ^{b}	93.5 ± 1.66 ^{b}	< 0.001
Heterophiles (10^3/mm^3)	43.4 ± 0.751 ^{a}	44.9 ± 0.472 ^{a}	42.6 ± 1.03 ^{ab}	43.4 ± 0.439 ^{a}	40.3 ± 0.714 ^{b}	0.004
Eosinophils (10^3/mm^3)	1.37 ± 0.024 ^{a}	1.42 ± 0.015 ^{a}	1.34 ± 0.0325 ^{ab}	1.37 ± 0.014 ^{a}	1.27 ± 0.023 ^{b}	0.004
Basophils (10^3/mm^3)	0.514 ± 0.009 ^{a}	0.531 ± 0.006 ^{a}	0.504 ± 0.012 ^{ab}	0.514 ± 0.005 ^{a}	0.477 ± 0.009 ^{b}	0.004
Monocytes (10^3/mm^3)	2.38 ± 0.041 ^{a}	2.46 ± 0.026 ^{a}	2.33 ± 0.056 ^{ab}	2.38 ± 0.024 ^{a}	2.21 ± 0.039 ^{b}	0.004
Lymphocytes (10^3/mm^3)	53.4 ± 0.923 ^{a}	55.2 ± 0.58 ^{a}	52.4 ± 1.27 ^{ab}	53.4 ± 0.540 ^{a}	49.6 ± 0.878 ^{b}	0.004
Platelets (10^3/mm^3)	87.0 ± 2.70 ^{a}	89.0 ± 1.79 ^{a}	84.0 ± 1.82 ^{a}	66.0 ± 0.707 ^{b}	60.4 ± 3.33 ^{b}	< 0.001
RBC (10^6/mm^3)	3.38 ± 0.252	3.30 ± 0.235	2.90 ± 0.265	3.00 ± 0.114	2.80 ± 0.270	0.356
Hemoglobin (g/dL)	24.7 ± 1.03	23.9 ± 1.19	21.4 ± 1.81	23.2 ± 0.657	18.9 ± 2.01	0.065
Hematocrit (%)	48.1 ± 2.40 ^{a}	44.8 ± 1.60 ^{ab}	41.2 ± 1.82 ^{ab}	39.9 ± 1.55 ^{b}	38.2 ± 1.43 ^{b}	0.006
MCHC (g/dL)	51.4 ± 0.628^{bc}	53.4 ± 0.4 ^{b}	51.6 ± 0.696^{bc}	57.8 ± 1.48 ^{a}	49.5 ± 0.638 ^{c}	< 0.001
MCH (pg)	73.6 ± 2.03 ^{ab}	73.2 ± 0.783 ^{ab}	70.1 ± 0.958 ^{b}	77.9 ± 1.52 ^{a}	68.7 ± 1.19 ^{b}	0.001
MCV (fl)	143 ± 1.08 ^{a}	137 ± 0.707^{bc}	138 ± 1.45 ^{abc}	133 ± 1.58 ^{c}	139 ± 1.05 ^{ab}	< 0.001

WBC: White Blood Cells (leukocytes); RBC: Red Blood Cells; MCHC: Mean corpuscular hemoglobin concentration; MCH: Mean corpuscular hemoglobin; MCV: Mean corpuscular volume; a, b, c: Statistically different groups for $p < 0.05$.

difference ($p < 0.01$) was also observed for this same parameter between GD 100 (57.4 ± 9.35 pg) and GD 50 (81.6 ± 1.09 pg). MCV value of LD 75 (121 ± 1.36 fl) was very highly lower ($p < 0.001$) than those of LD 100 (138 ± 0.548 fl) and LD 50 (134 ± 1.22 fl).

At 6 weeks of age

Table 4 indicates mean values of haematological parameters studied for each sub-group of animals at 42 days of age. WBC as whole, platelets, MCHC and MCV presented some very highly significant differences ($p < 0.001$) between the animal sub-groups. Other very significant differences ($p < 0.01$) were also observed for WBC, hematocrit (Hct) and MCH, from one group to another. LD 50 animals presented highest average values for WBC (258 ± 1.99 10^3/mm^3) and the platelets (89 ± 1.79 10^3/mm^3). Those of LD 100's sub-group presented highest mean values for Hct (48.1 ± 2.4 %) and MCV (143 ± 1.08 fl). For MCHC and MCH, highest means were obtained in GD 100. They were respectively 57.8 ± 1.48% and 77.9 ± 1.52 pg. Smallest mean values were observed in GD 50 for WBC, platelets, Hct, MCHC and MCH. These means were 93.5 ± 1.66 10^3/mm^3 for WBC; 60.4 ± 3.33 10^3/mm^3 for platelets; 38.2 ± 1.43 % for Hct; 49.5 ± 0.638 % for MCHC and 68.7 ± 1.19 pg for MCH. In the MCV case, smallest means were obtained in GD 100 sub-group and were 133 ± 1.58 fl. In LD group, mean highest and smallest values were respectively obtained in LD 50 (258 ± 1.99 10^3/mm^3) and LD 75 (98.8 ± 2.39 10^3/mm^3) for WBC. For this parameter, intra-group comparison showed some differences between LD, like those of GD group. Compared to LD 100 then LD 75, differences with LD 50 were very highly significant ($p < 0.001$). In GD group, GD 100 presented highest mean values for all parameters except MCV. Statistical analysis showed significant differences ($p < 0.05$) between 2 sub-groups for each WBC type. Other differences were also observed between these two sub-groups for MCHC, MCH and MCV. The difference was very highly significant ($p < 0.001$) for CCMH; very significant ($p < 0.01$) for MCH and significant ($p < 0.05$) for MCV.

At 8 weeks of age

Table 5 shows mean values of haematological parameters studied for various animals groups and sub-groups at 64 days of age. For the 5 sub-groups of animals, some differences were indicated for WBC, platelets, RBC, Hct and MCHC. Highest and smallest mean values for each one of these parameters were respectively revealed in LD 100

Table 3. Mean values of haematological parameters distribution at 56 days of age.

Haematologicalparameters	Layer diet (LD)			Grower diet (GD)		P-value
	LD 100	LD 50	LD 75	GD 100	GD 50	
WBC (10^3/mm^3)	292 ± 2.85 ^{a}	258 ± 1.99 ^{c}	272 ± 6.35^{bc}	290 ± 2.07 ^{a}	282 ± 5.36 ^{ab}	< 0.001
Heterophiles (10^3/mm^3)	126 ± 1.23 ^{a}	111 ± 0.856 ^{c}	117 ± 2.74^{bc}	125 ± 0.893 ^{a}	121 ± 2.31^{ab}	< 0.001
Eosinophils (10^3/mm^3)	3.98 ± 0.039 ^{a}	3.50 ± 0.027 ^{c}	3.69 ± 0.086^{bc}	3.94 ± 0.028 ^{a}	3.83 ± 0.073 ^{ab}	< 0.001
Basophils (10^3/mm^3)	1.49 ± 0.014 ^{a}	1.31 ± 0.01 ^{c}	1.39 ± 0.032^{bc}	1.48 ± 0.011 ^{a}	1.44 ± 0.027 ^{ab}	< 0.001
Monocytes (10^3/mm^3)	6.90 ± 0.067 ^{a}	6.08 ± 0.047 ^{c}	6.41 ± 0.150^{bc}	6.83 ± 0.049 ^{a}	6.65 ± 0.127 ^{ab}	< 0.001
Lymphocytes (10^3/mm^3)	155 ± 1.51 ^{a}	136 ± 1.05 ^{c}	144 ± 3.37^{bc}	153 ± 1.10 ^{a}	149 ± 2.84 ^{ab}	< 0.001
Platelets (10^3/mm^3)	60.3 ± 1.65 ^{a}	36.1 ± 4.91 ^{b}	55.0 ± 2.02 ^{a}	56.0 ± 0.707 ^{a}	54.6 ± 1.17 ^{a}	< 0.001
RBC (10^6/mm^3)	2.90 ± 0.217 ^{ab}	2.07 ± 0.079 ^{b}	2.50 ± 0.324 ^{ab}	3.24 ± 0.276 ^{a}	2.83 ± 0.238 ^{ab}	0.029
Hemoglobin (g/dL)	14.5 ± 0.826	11.7 ± 1.67	10.9 ± 0.927	10.4 ± 0.770	12.8 ± 1.02	0.1
Hematocrit (%)	40.6 ± 1.62 ^{ab}	29.6 ± 1.76 ^{c}	34.7 ± 2.80^{bc}	45.3 ± 2.60 ^{a}	39.8 ± 2.12 ^{ab}	< 0.001
MCHC (g/dL)	32.9 ± 0.418 ^{ab}	38.1 ± 2.72 ^{a}	31.4 ± 0.752 ^{b}	34.1 ± 0.868 ^{ab}	33.1 ± 0.311 ^{ab}	0.024
MCH (pg)	44.8 ± 0.434	54.9 ± 5.97	43.4 ± 1.09	47.9 ± 0.543	44.6 ± 0.794	0.05
MCV (fl)	141 ± 2.08	141 ± 3.12	139 ± 1.85	141 ± 3.60	141 ± 1.92	0.974

WBC: White Blood Cells (leukocytes); RBC: Red Blood Cells; MCHC: Mean corpuscular hemoglobin concentration; MCH: Mean corpuscular hemoglobin; MCV: Mean corpuscular volume; a, b, c: Statistically different groups for $p < 0.05$.

(292 ± 2.85 10^3/mm^3) and LD 50 (258 ± 1.90 10^3/mm^3) for WBC; LD 100 (60.3 ± 1.65 10^3/mm^3) and LD 50 (36.1 ± 4.91 10^3/mm^3) for platelets; GD 100 (3.24 ± 0.0276 10^6/mm^3) and LD 50 (2.07 ± 0.079 10^6/mm^3) for RBC; GD 100 (45.3 ± 2.6 %) and LD 50 (29.6 ± 1.76 %) for Hct then in LD 50 (38.1 ± 2.72 %) and LD 75 (31.4 ± 0.752 %) for MCHC. Statistical analysis indicated some very highly significant differences ($p < 0.001$) between animal sub-groups mean values. These differences were observed for WBC, platelets and Hct. RBC and MCHC mean values were significantly ($p < 0.05$) for sub-groups.

In LD group, some differences were observed between means of sub-groups. These differences were very highly significant ($p < 0.001$) and significant ($p < 0.05$), for WBC (respectively between LD 100 and LD 50 then between LD 100 and LD 75). Platelets mean values in this group were very highly significant between LD 100 and LD 50 like between LD 50 and LD 75. Statistical analysis also showed a significant difference ($p < 0.05$) between LD 100 and LD 50 mean for Hct. This same significatively was also observed for MCHC between LD 50 and LD 75. No significant difference was however observed in GD group, for each studied parameter.

Changes of each haematological parameter according to each feed for all growth periods

RBC, Hb and Hct

During the growth of quails, RBC dropped in all animal sub-groups compared to control period (Figure 2). At week 4, this decrease was very highly significant ($p < 0.001$) in LD 100, GD 100 and GD 50, but significant ($p < 0.05$) in LD 50. At week 6, decrease was recorded compared to control and was very significant ($p < 0.01$) in GD 50. At week 8, decrease was significant ($p < 0.05$) in LD 100, very significant ($p < 0.01$) in GD 50 and very highly significant ($p < 0.001$) in LD 50.

Hemoglobin recorded a drop during growth of quails (Figure 2). At 4 weeks of age, a significant increase ($p < 0.05$) was observed in LD 100. This rise was very significant ($p < 0.01$) in GD 50 and very highly significant ($p < 0.001$) in LD 50 and GD 100. At 6 weeks of age, increase in rate of Hb was very highly significant ($p < 0.001$) in all sub-groups except in GD 50 where it was significant ($p < 0.05$). This value dropped then at 8 weeks of age. At this level, only GD 100 recorded a very significant drop ($p < 0.01$).

Hct mean at week 4 dropped in a very significant way ($p < 0.01$) for LD 100, LD 75 and GD 100. At week 6, these rates increased significantly ($p < 0.05$) in LD 75 and very significantly ($p < 0.01$) in LD 100. A significant decrease ($p < 0.05$) was also observed in LD 50 at week 8 (Figure 2).

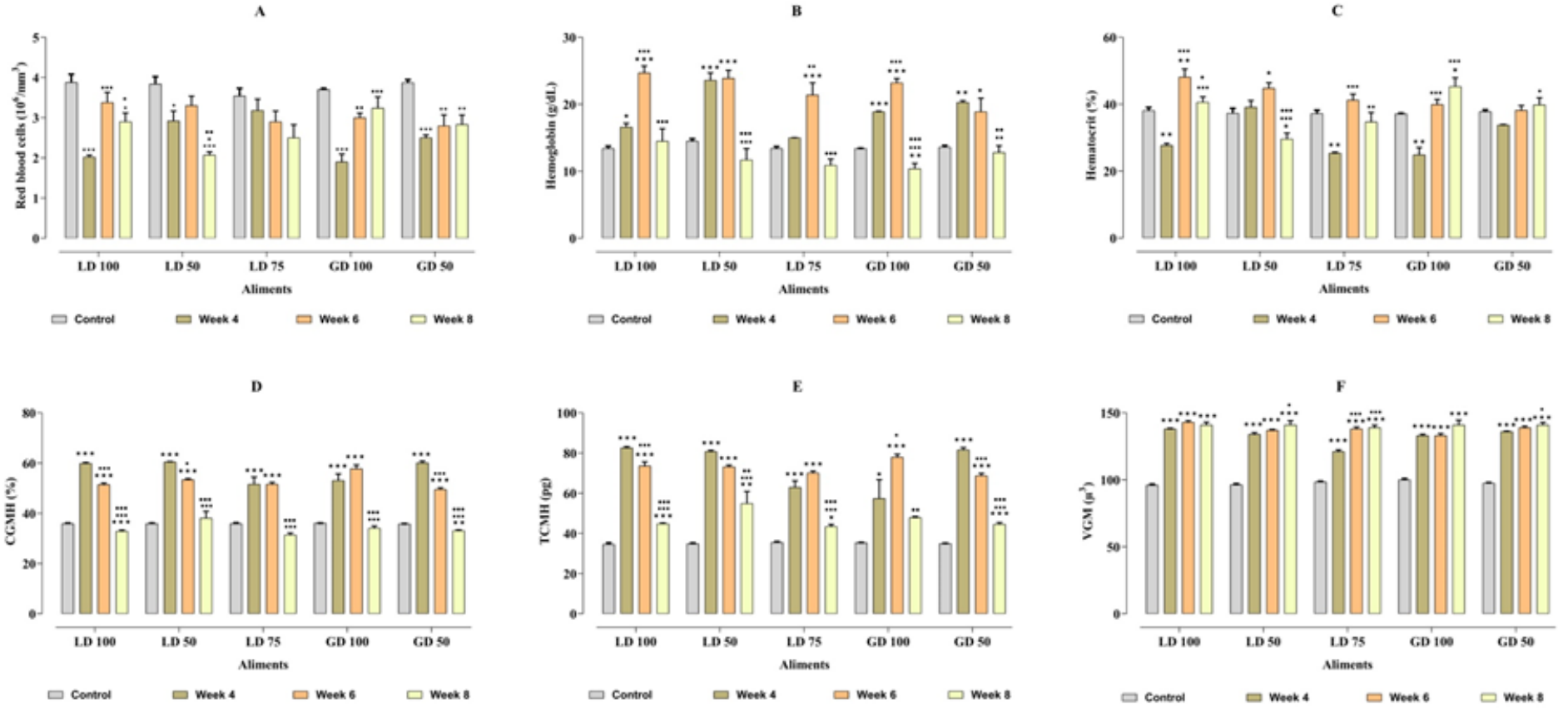

Figure 2. Erythrocyte parameters variation for each feed according to growth periods.

MCV, *MCH and MCHC*

MCV increased with each period of growth (Figure 2). This increase was very highly significant ($p < 0.001$) compared to the control. MCH increased with each period of growth compared to control. At weeks 4 and 6, increase was very highly significant ($p < 0.001$) in all animal sub-groups except GD 100. In this group indeed, MCH increased to a significant degree ($p < 0.05$). At week 8, although having decreased compared to weeks 4 and 6 values, MCH increased significantly ($p < 0.05$) in LD 75 compared to control. Also, an increase was observed in LD 50, LD 100 and GD 100. This increase was very significant ($p < 0.01$) for the first quoted and very highly significant ($p < 0.001$) for the two last.

Animals MCHC increase was very highly significant ($p < 0.001$) in all animal sub-groups at weeks 4 and 6 compared to control period, before dropping at week 8. In LD 100 and LD 50, this decrease was respectively very highly significant ($p < 0.001$) and very significant ($p < 0.01$) (Figure 2).

All WBC and platelets

Figure 3 presents the changes of each WBC and platelets parameter according to each feed for all growth periods. Feeds used during this study, as a

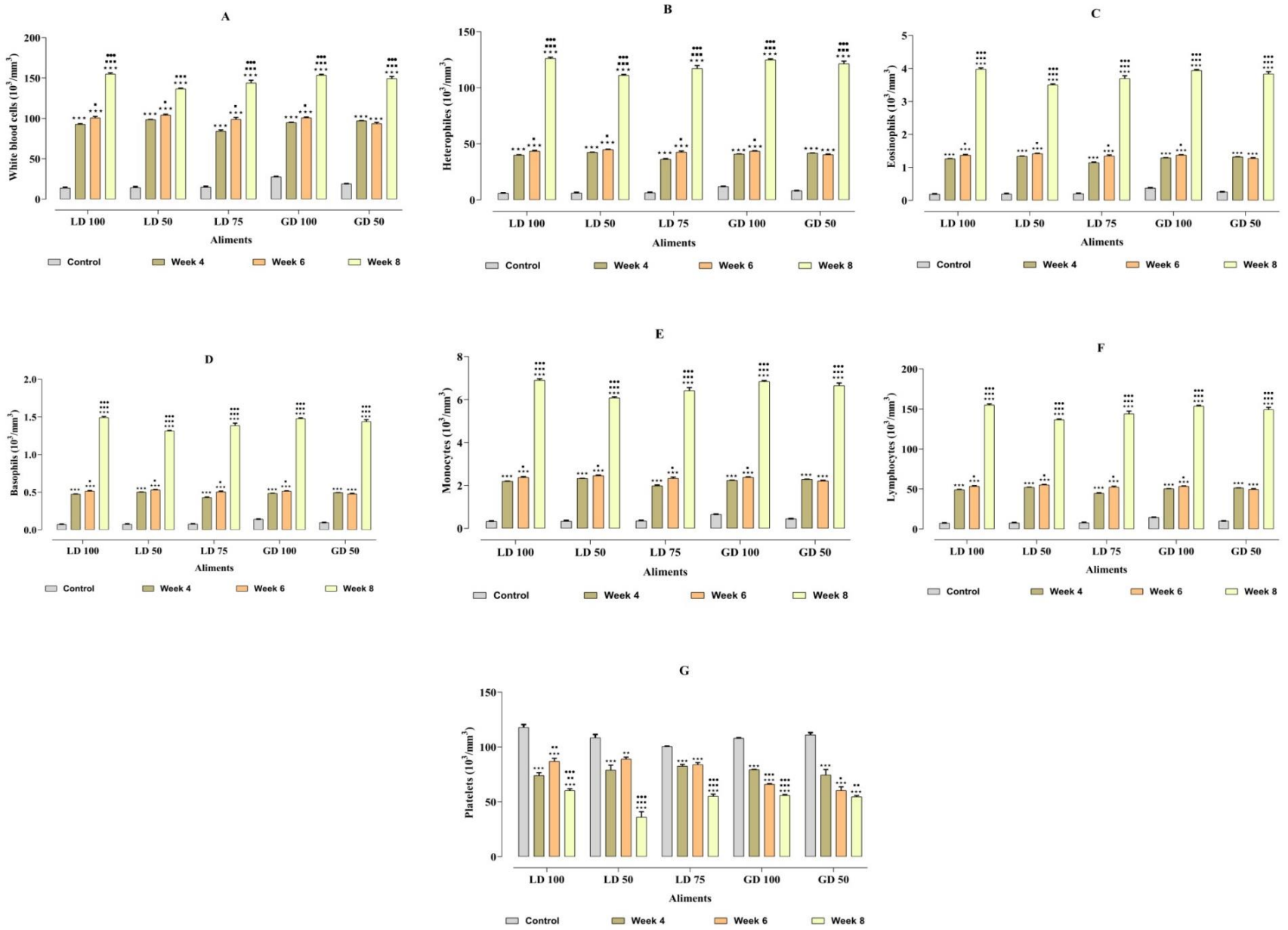

Figure 3. White blood cells and thrombocyte parameters distribution for each feed according to growth periods.

whole induced an increase in WBC. Statistical analysis indicated that compared to control period, this increase was very highly significant ($p < 0.001$) at each growth period of the animals subjected to the various foods. Platelets number dropped during the experimentation. That was observed in all animal sub-groups. This decrease was very highly significant ($p < 0.001$).

DISCUSSION

Some modifications observed in group LD for WBC, RBC, hemoglobin, hematocrit, MCHC, MCH, MCV. Inter-group comparison does not show significant differences between the obtained values that could translate independent effects of the food composition and its granulometry. Then, these changes would be due to the intrinsic parameters of quails. LD 50 food which significantly increases WBC, hemoglobin, hematocrit and MCHC appears as that which would as well as possible stimulates the hematopoiesis in quails for these various parameters at 28 days of age. Compared to the values obtained at 10 days of age (control), a very highly significant increase in WBC (as a whole) is observed in all sub-groups of animals, except in GD 50. This result could be explained by the fact that the quail organism considered each food as a potentially dangerous foreign body. It is likely that these foods caused stress in these animals. Ritchie et al. (1994) state that birds normally have a large number of lymphocytes circulating in the blood. They are therefore likely to develop leukopenia and lymphopenia as an initial response to stress.

Compared to the values obtained at week 4, a significant growth of WBC (as a whole) is observed in all sub-animals groups, except in GD 50. Considering 32 days after starting of the experimental food distribution, this rate does not stop growing in a very highly significant way, it is possible that this result observed is due to the temperature (27 to 30°C) having prevailed on the experimentation site. According to Msaid (2017), a rise of the temperature supports indeed, the appearance of disease-causing agents. This induces an increase in WBC like active immune system. Platelets differed in a very highly significant way between the various groups of animals, when comparing these values with those obtained at the beginning of experiment. Compared to week 4, the increase in platelets is very significant in LD 100. This result could translate the presence in the blood of immature platelets having been taken into account during automat counting. On another side, platelets and WBC in blood increased at the same time in LD 100. That could mean the presence of vascular lesions or a vascular disseminated coagulation in the subjects of this sub-group for this period. Indeed, platelets react by forming a thrombus plate in answer to a vascular lesion and WBC generally flows to the places of lesion in order to prevent the development of infectious agents in the body. LD 100 feed seems to cause internal vascular lesions in the subjects which consume it between 4 weeks and 6 weeks of age.

Compared to obtained values at week 6, WBC increases strongly in great majority of animal sub-groups. That could confirm likely influence of temperature having prevailed during the experimentation on hematopoietic process of quails. Platelets decreases in a very highly significant way in all sub-groups except in GD 50. Obtained values at 8 weeks of age for this parameter are very highly low in LD 50 compared to other animal sub-groups. This obtained value in present study ($36.1\ 10^3/mm^3$) approaches as well as possible the interval of values defined by Martin (2010). For this author, platelets vary between 20.10^3 and $30.10^3/mm^3$ in birds.

The erythrocytes and their indices decrease as a whole. However, this reduction should be compared with the normal values in quails, to know if the used food would have a possible anemic capacity. Otherwise, in this study the animals did not show any anemia's sign.

During the experimentation period (10 days to 8 weeks of age), WBC increase in a very highly significant way. The increase in WBC was done continuously in all animal sub-groups at all growth periods. The quail would thus produce a great quantity of WBC in order to constitute an active immune system. That would extremely probably translate an immuno-competence of these animals. This statement would check the fact that the quail is so rustic, as listed by some researchers having undertaken studies on this animal. Some authors such as Nunn et al. (2000) affirm that a WBC great number in blood indicates a solid immune system of animals. This increase in WBC also brings back a reduction of the mortality risk associated with the food (Ommen et al., 1997; Reddan et al., 2003). Lymphocytes were most abundant of counted WBC during this study. This result corroborates that of Bounous et al. (2000) which affirm that WBC most abundant in the poultries is lymphocytes. Martin (2010) abounds in same order of idea by affirming that in the birds, lymphocytes represent the most important population of WBC in blood. That can be due to physiological or reactive reasons (Jain, 1993).

Platelets in blood dropped during the experimentation period. This report was made in all animal sub-groups. This significant decrease observed at the various periods of quails growth could mean that platelets decrease in the blood with these animals age. According to Martin (2010) in bird's blood, platelets are higher at youngest subjects.

RBC gradually dropped from 10 days of age to 8 weeks. That shows clearly that RBC falls with age of the animals. On the other hand, no related impact of used food is noted. The decrease of RBC on 10 days to week 4 interval of age, corroborates obtained results by Oluwasanmi and Temitayo (2014) during same period. In the period going to 10 days of age at week 8, hemoglobin mean dropped in all sub-groups except in LD 100. In this last group hemoglobin increased not significantly. The fact that

hemoglobin gradually increased at weeks 4 then 6 could mean that this parameter increases with age until sexual maturity. The significance of this increase noticed in the majority of the animal sub-groups at this period (to 10 days at 6 weeks of age) differs from those obtained by Oluwasanmi and Temitayo (2014). Indeed, this author did not notice any significant variation of hemoglobin according to age at this same period. In LD 50 and GD 100 sub-group, hematocrit respectively decreased and increased to a significant degree. Observed drop of hematocrit in LD 50 could be attributed to a joint effect of a suitable food and a stress factors minimization. Similar results to this study were obtained by Mingoas et al. (2017) in terms of hematocrit increase in the GD 100.

Mean corpuscular concentration in hemoglobin (MCHC) dropped in all animal sub-groups except in LD 50. Mean corpuscular in hemoglobin (MCH) increased in all animal sub-groups. Mean corpuscular volume (MCV) increased in a very highly significant way during the experimentation period. That could be explained by an acceleration of the erythropoiesis. Indeed, when iron is abundant in body, erythropoiesis acceleration can increase MCV value thanks to the simulative effects of the erythropoietin on erythropoiesis. This phenomenon is generally observed after a serious and severe hemorrhage or a haemolytic anaemia. However, this case did not arise during the experimentation. Thus, the fact that hemoglobin did not significantly vary in the near total of sub-groups of animals, could be the reason about it. Generally, MCV reduction occurs when the iron deficit becomes severe in the body (Groscurth and Filgueira, 1998). During hemoglobin formation indeed, erythropoiesis consumes iron. The acceleration of this formation involves a fall of MCV ineluctably. In the case of this study, the results did not show any significant growth of hemoglobin. That could be clearly based on the MCV increase noticed in sub-groups. Obtained values of MCV in this study for each sub-group are similar to those of Coenen et al. (1994) like those of Ayub et al. (2012). These values are considered to be normal. The very highly significant increase in MCV and the decrease in MCHC does not reflect the presence of macrocytosis and/or hypochromy. The drop in hemoglobin in the majority of subgroups does not reflect an anemia case in the subjects either.

Conclusion

At the end of this study, it appears that the granulometry of food influences WBC and thrombocytic parameters. For WBC, the best values were obtained with LD 50 food at weeks 4 and 6 then with LD 100 food at week 8. In general, RBC and their indices were not influenced by the granulometry of used food. The fall of hematocrit in LD 50 subjects at weeks 4 and 6, indicates that this food would be most adequate at these periods in terms of balance in quails. However, investigations will have to be carried out in order to explain the reduction in erythrocytes and their indices, not explained in this study.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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