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Research Article
Borassus aethiopum Mature Fruits' Dried Pulp Effect on Cobb 500 Broilers Growth Performance and Their Blood Plasma Cholesterol Contents

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Abstract

Objective: The study aimed to assess Borassus aethiopum mature fruits' dried pulp effect on growth performance and blood plasma lipids profile of Cobb 500 broilers. **Materials and Methods:** In this study 150 day-old Cobb 500 chicks were used, under a common starter diet for 3 weeks. Thereafter, 2 groups of 70 unsexed birds each were set. Data were collected weekly during grower and finisher phase, within a group, the weights were recorded by noting down the sex. The treatments were T0 (control diet, without *Borassus aethiopum*) and T1 (20% of the yellow corn was substituted by *Borassus aethiopum* ripe fruits dried pulp). At week7, 3 roosters fed on T0, 3 others fed on T1, 3 hens fed on T0 and 3 hens fed on T1 were slaughtered and the blood was collected for blood cell count and blood plasma lipids quantification. **Results:** Chickens fed on T1 diet showed lower growth performance. For example, weekly weight gain was 686.74 g in the male birds from T0 (MT0), whereas, male from T1 (MT1) had 532.86 g, thus a loss of 22.41%. Similarly, weekly weight gain in hens fed on T0 diet (FT0) was 502.48 g, while those from T1 (FT1) gained 458.14 g, thus 8.82% less growth performance. Regarding blood cells count, there was no significant difference between diets and sex, but the differences in plasma lipids profile were significant. Total cholesterol significantly declined from 128±4.31 (T0) to 109.17±4.31 mg dL^{-1} (T1) (-18.83 mg dL^{-1}, $p = 0.0042$). Likewise, HDL decreased by 15%, from 64.86±1.37 to 55.13±1.37 mg dL^{-1} (-9.73 mg dL^{-1}, $p<0.0001$). The LDL cholesterol decreased non-significantly by 17.19% from 46.93±4.02 to 38.86±4.02 mg dL^{-1} (-8.07 mg dL^{-1}, $p = 0.166$). **Conclusion:** *Borassus aethiopum* mature fruits' dried pulp can be incorporated into the diet of Cobb-500 broilers. It has no adverse effect. Moreover, it reduces the blood plasma cholesterols' concentrations.

Key words: *Borassus aethiopum*, cholesterols, Cobb-500 broilers, growth performance, poultry feed

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In Ivory Coast, the transition zone landscape between the forest and the savannah is dominated by *Borassus aethiopum* trees[1]. Giffard[2] observed that, roots of these plants are precious in traditional medicine, whereas the leafstalks are important in making roofs in the rural areas. The leaves and trunks are used by craftsmen to make baskets, beds and many other art works for house decorations. Unfortunately, an unsustainable economic activity such as making a sap wine on apical pod is dangerously causing the destruction of *Borassus aethiopum* forests[3,4]. By moving *Borassus aethiopum* forests away from the inhabitants' areas, dropped mature fruits collection is becoming more and more difficult for women. Of course, sap wine collection practice ruins the activity of collecting the dropped mature fruits for hypocotyl production[5], or for orange pulp flour productions[1], by destroying the trees. Due to their high nutritive value in terms of sugars, vitamins and polyphenols[6,7], the fruits are economically and nutritionally important. Unfortunately, industrial uses of *Borassus aethiopum* mature fruits for making wine are still limited. So, far away from habitats, a lot of dropped fruits are rotting in the wild. Mollet[3] studied the *Elaeis guineensis* plants and reported that, when an important source of revenue is clearly established for a tree, people tend to grow this species and preserve its natural forests. The present study was conducted to assess the use of *Borassus aethiopum* mature fruits' dried pulp in poultry feeds. So, the effect of *Borassus aethiopum* dried pulp on growth performance, the blood cells count and blood serum lipids profile of Cobb 500 broilers was determined.

MATERIALS AND METHODS

Diet preparation and broilers rearing: First of all, some *Borassus aethiopum* mature fruits were collected. Then, they were sorted and the undamaged fruits were stored for three or four additional days for better ripeness. Afterward, they were pilled and the fibrous pulp was removed and dried in ovens at 70°C until obtaining a constant weight[7]. Secondly, some dried yellow corn and commercial premix (Koudijs, Advanced Nutritional Products, De Heus Animal Nutrition, NL 14841, The Netherlands) for broilers were bought. During the first 3 weeks the chicks were fed on a starter diet. From week 4, the birds were allotted in two groups with two different diets (control and test diet) (Table 1). In T1, 20% of the yellow corn was substituted by *Borassus aethiopum* ripe fruits dried pulp.

Table 1: Experimental diets

	Starter Diet	Finisher diet	
		Control (T0)	20% *B.a* (T1)
Ingredients	Week 1-3	Week 4-7	Week4-7
Yellow corn	56	64.29	44.29
Soya meal	22	-	-
Wheat bran	2	-	-
Fish meal	15	-	-
Egg shell meal	1	-	-
Premix Nutri-A, starter broilers	4	-	-
*Koudijs premix, grower broilers	-	35.71	35.71
Borassus aethiopum dried pulp	-	-	20
Total	100	100	100
Analysis data			
Dry matter (DM)	92.8	90.17	90.17
Crude protein (CP, DM%)	23	20	19
Crude fat (CF, DM%)	2.5	3	4
Ash (DM%)	11	14	15
Computed data			
Tot_Carb. (DM%)	63.5	63.0	62.0
M.E (kcal kg^{-1} DM)	3715.6	3620.7	3624.5
Lysine	nd	2.86	2.86
Methionine	nd	0.43	0.43
Methionine+cysteine	nd	0.64	0.64
Phosphorus	nd	0.41	0.41

Tot_Carb (total carbohydrate): 100% (Protein+Fat+Water+Ash)[8], M.E: Metabolizable energy, M.E (kcal kg^{-1} DM): [3.87×CP (%DM)+ 8.37×CF(%DM) +4.12×Tot_Carb (%DM)]×10^8, *B.a*: *Borassus aethiopum*

Broilers rearing: A total of 150 day-old Cobb-500 broiler chicks were bought from a hatchery in Abidjan, Côte d'Ivoire. The birds were housed at the graduate school of agriculture experimental station, at the National Polytechnic Institute Felix Houphouet Boigny (INP-HB) in Yamoussoukro. Before their arrival day, The chicks' house was prepared, sanitized and its floor was covered with wood chips and borders were covered with black plastic to protect birds from cold air. At night time, rearing area of 15 m^2 (5×3 m) was electrically heated with three electric lamps of 200 Watts each.

During daytime, electric lamps were turned off, the black plastics were raised up so that the outside warm air could be circulated and this starter period lasted for 3 weeks.

Chicks were fed two times a day to avoid the wastage of mashed feedstuffs. The daily ration was divided into two portions,1/3 and 2/3 and they were given at 8 am and 4 pm, respectively. When the feed quantities of the day were completely consumed, then the last quantity per chick was increased by 5 g. During the starting period, five chicks died. In absence of an expert in chicks sexing, all chicks were sexed on day 21. Chicks were sexed by body feather cover method and were individually weighted. On day 21, the females had enough feathers on their wings and whole body compared to males. Moreover, compared to females, males' crests were more developed. So that, the errors could be minimized.

Thereafter, they were transferred to the grower and finisher places and fed on 2 finishing diets (T0 and T1). Specifically, the chickens were raised on woods like traditional systems. So, the birds were not on the floor and all the birds' droppings were below. Based on the average mean and standard error, five out layer birds were discarded from the experimental group. Thereafter, 140 remaining birds were randomly allotted in 2 groups of 70 chickens each and the diet test lasted for 4 additional weeks. Thus, the experiment covered 7 weeks in total.

From day 22-35, feed quantities were Increased step by step, the quantity per bird per day was stabilized on 130 g from day 36-49. Within a diet group, males and females were peaking together. But, from day 28-49, the birds were weighed, the data were recorded by considering the diet and the gender of each bird. The rearing area was 20.24 square meters (4.6×4.4 m = 20.24 m^2) for each group. Thus, the chickens' density was less than 4 birds per square meter. Then, on days 28, 35, 42 and 49 the chickens were weighed. From day 21-49, the chickens were fed only once at 12 O'clock. They were weighed before feeding. During all the experiments the birds had *ad-libitum* access to water.

Blood collection and its cells count: In each diet (T0 and T1), the two genders were considered. For data collection, 6 birds of similar weight ($\mu\pm\delta$, $\alpha = 0.05$) (3 females and 3 males) were randomly selected per diet, a total 12 broilers. The birds were slaughtered and blood samples were collected into tubes containing some ethylene diamine tetra-acetic acid (EDTA) as anticoagulant[9]. The tubes were manually shaken to avoid the clots formation. The blood count was performed with a SYSMEX KX 21N hematology machine (Zhejiang Xinke Medical Technology Co., Ltd, Zhejiang city, China), at the national blood transfusion center in Yamoussoukro (Côte d'Ivoire). The hematological parameters such as hemoglobin (HGB), packed cell volume (PCV), red blood cells (RBC), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), white blood cells (WBC), platelet (PLT), lymphocytes, monocytes, granulocytes percentage, respectively LYM%, MON% and GRAN% were analyzed.

Blood plasma lipids profile: During the growing and finishing periods, the chickens were fed one time at 12 O'clock each day. Then, the birds were slaughtered at 8 am for the blood collection using the Friedewald *et al.*[10] approach. So, blood samples of birds were collected 20 h after the last meal. The blood was collected in dry tubes, containing clots activation agent, such as Factor XII (Hagemann Factor), kept at room temperature for 20 min for precipitation. Thereafter, it was centrifuged for 5 min. Then, the plasma was collected and stored in a refrigerator at 4°C. As soon as possible, the cholesterols' contents reading was noted.

For total cholesterol assessment (Tot. C, Eq. 1), Cypress Diagnostics, (Ref: HB 006 Lot: 191 reagent, Hulshout, Belgium) was used[11]. So, to get the working solution, reagent 2 was poured in 1. Then, 1 mL of this working solution was put in each used graduated tube. Thereafter, the standard solution was made by pouring 10 µL of the standard solution in one tube, containing 1 mL of the working solution. Likewise, the blank was made by pouring 10 µL distilled water into each tube. Finally, 10 µL of the plasma was poured in each graduated tube, except in the blank and the standard. Then, the readings were proceeded by using a UV-visible spectrophotometer set at 500 nm (Shimadzu UV-1601 PC, Kyoto, Japan).

Again, following Kouassi *et al.*[11] approach, for high density lipoprotein cholesterol (HDL.C, Eq. 2), Cypress Diagnostics was used, (Ref: HB 007 Lot: 322 reagent from Belgium). Only 1 mL of the plasma was mixed with 100 µL of HDL.C reagent. The newly gained medium was centrifuged. Then, 10 µL were collected and similarly for Tot. C steps, the preparations were done for readings. Finally, the cholesterol content was computed. Friedewald *et al.*[10] equation was used to compute the low-density lipoprotein cholesterol (LDL.C, Eq. 4) content and the ratio of triglycerides over 5 is also known as the very low-density lipoprotein cholesterol (VLDL.C, Eq. 4). The results were expressed in milligram per deciliter (mg dL^{-1}). For triglycerides determination (Eq. 3), after preparing the corresponding working solution, the process remained the same as in Tot.C assessment. So, Tot.C, HDL. C and triglycerides absorbance were assessed by using a UV-visible spectrophotometer (Shimadzu UV-1601 PC, Kyoto, Japan) set at 505 nm.

$$\text{Tot.C}_{(\text{mg dL}^{-1})} = \frac{\text{Sample}_{\text{Abs}} - \text{Blank}_{\text{Abs}}}{\text{Standard}_{\text{Abs}} - \text{Blank}_{\text{Abs}}} \times 200 \quad (1)$$

$$\text{HDL.C}_{(\text{mg dL}^{-1})} = \frac{\text{Sample}_{\text{Abs}}}{\text{Stand}_{\text{Abs}}} \times 50 \quad (2)$$

$$\text{Triglycerides}_{(\text{mg dL}^{-1})} = \frac{\text{Sample}_{\text{Abs}}}{\text{Standard}_{\text{Abs}}} \times 200 \quad (3)$$

$$\text{LDL.C}_{(\text{mg dL}^{-1})} = \text{Tot.C} - \text{HDL.C} - \frac{\text{TG}}{5} \quad (4)$$

where, 200 and 50 were the standard concentrations

After cholesterols and triglycerides analysis, blood plasma total protein was checked (Eq. 5). Also, Cypress Diagnostics was used (Ref: HB 0193 and lot TP 00331). Its working solution was previously prepared. So, the plasma was diluted in distilled water (DW), (Plasma/DW, 1/1, v/v). In this way, 200 µL of plasma was put in 200 µL of DW. Alike the previous steps, 10 µL of the newly made medium was collected and using the working solution, the samples were prepared for readings, using a UV-visible spectrophotometer (Shimadzu UV-1601 PC, Kyoto, Japan) set at 546 nm.

$$\text{Total protein}_{(\text{g dL}^{-1})} = \frac{\text{Sample}_{\text{Abs}}}{\text{Standard}_{\text{Abs}}} \times (\text{standard concentration}) \quad (5)$$

Statistical analysis: The weekly weight gain (WWG) was assessed through Excel trend line model, equation chart and r^2 value on chart were displayed (Eq. 6). Thereafter, the weekly weight gain was determined using Eq. 6 first derivate. The confidence interval was set 95% for the examination of broilers' live weight.

$$\text{WWG}_{\text{sex}\times\text{diet}} = \frac{\partial f(\text{growing model})}{\partial(\text{Day})} \quad (6)$$

For blood plasma profile quantification, 2 blood samples were collected and 2 readings were made by sample. So, we got in total 4 readings for each combination (diet×gender) per chicken. Also, the data were submitted to a factorial analysis of variance (two-ways, ANOVA), using XLSTAT 2014. The least squares means were separated using Duncan's multiple range tests. For hematological parameters and blood plasma lipids profile analysis (cholesterol, triglycerides and protein) the confidence interval was set at 99%.

RESULTS AND DISCUSSION

Broilers' growth performance: For a given diet, the male broilers tended to grow faster than females (T0 versus T1, Fig. 1). For instance, from 4-7 week, T1 male broilers had a lower growth rate than those of the control group T0. Remarkably, the difference between these two groups of males was highly significant ($p<0.0001$). T0 (FT0, female birds) tended to grow faster than those of T1 (FT1, female birds, $p<0.0001$). Even if, 7 days after the diets test implementation (day 28), the weight differences between MT0 (1100.32±35.51 g), MT1 (1006.76±33.91 g) and FT0 (1003.29±30.88 g) were not significant, from week 5 (day 35) to week 7 (day 49), MT0 group showed higher weight than those of MT1 and FT0. Interestingly, all Excel derived models on growing curves were supported by equations with high coefficient of determination ($r^2 \geq 98.87\%$). With such goodness of fit, weekly weight gain (WWG) was deducted with the first derivative (Eq. 7).

$$\text{WWG}_{\text{MT0}} = \frac{\partial(686.74\text{Day} + 373.86)}{\partial(\text{Day})} = 686.74 \times \frac{\partial(\text{Day})}{\partial(\text{Day})} + \frac{\partial(373.86)}{\partial(\text{Day})} = 686.74 + 0 = 686.74 \quad (7)$$

Figure 1 shows that the weekly weight gain for MT0, FT0, MT1 and FT1 was 686.74, 502.48, 532.86 and 458.14 g, respectively. Similar result was reported by Panigrahy *et al.*[12]

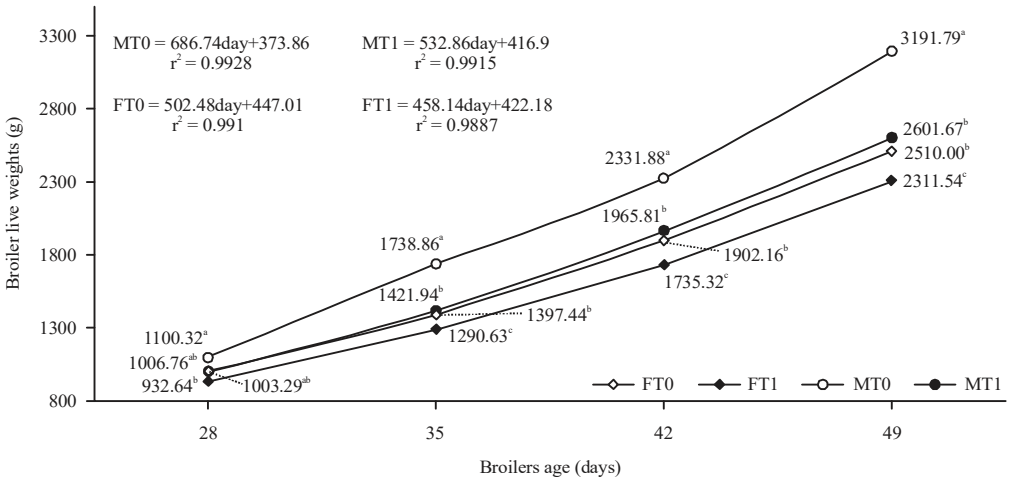

Fig. 1: Broilers live weights from week 4-7 (diet×age×sex)

Different letters within a day show statistical difference (α = 0.05), by Duncan's multiple ranges test

Table 2: White blood cell (WBC), Red blood cell (RBC),Hemoglobin (HGB), Hematocrit (HCT), Mean corpuscle (cell) volume (MCV), Mean corpuscular hemoglobin (MCH), Mean corpuscular hemoglobin concentration (MCHC), Platelets (PLT), Mean platelet volume (MPV), according to the diet and the sex ($\alpha = 0.01$)

Items	WBC (10^3 µL^{-1})	LYM (%)	MON (%)	GRAN (%)	RBC (10^6 µL^{-1})	HGB (g dL^{-1})
FT0	45.70±1.07	88.13±0.90	6.63±0.43	5.27±0.49	2.37±0.09	12.77±0.57
MT0	43.83±1.07	90.10±0.90	6.00±0.43	3.90±0.49	2.23±0.09	12.00±0.57
FT1	43.80±1.07	88.80±0.90	6.73±0.43	4.47±0.49	2.34±0.09	12.43±0.57
MT1	45.07±1.07	89.03±0.90	6.37±0.43	4.60±0.49	2.09±0.09	11.33±0.57
µ±SE	44.60±1.07	89.02±0.90	6.43±0.43	4.56±0.49	2.26±0.09	12.13±0.57
p-value	0.4681≤p≤0.9830	0.4609≤p≤0.8598	0.5633≤p≤0.8735	0.2707≤p≤0.5889	0.1789≤p≤0.8358	0.3519≤p≤0.6913
T0	44.77±0.76	89.12±0.64	6.32±0.30	4.58±0.34	2.30±0.06	12.38±0.40
T1	44.43±0.76	88.92±0.64	6.55±0.30	4.53±0.34	2.22±0.06	11.88±0.40
µ±SE	44.60±0.76	89.02±0.64	6.43±0.30	4.56±0.35	2.26±0.06	12.13±0.40
p-value	0.7634	0.8305	0.6023	0.9209	0.3417	0.4077
F	44.75±0.76	88.47±0.64	6.68±0.30	4.87±0.34	2.35±0.06	12.60±0.40
M	44.45±0.76	89.57±0.64	6.18±0.30	4.25±0.34	2.16±0.06	11.67±0.40
µ±SE	44.60±0.76	89.02±0.64	6.43±0.30	4.56±0.35	2.26±0.06	12.13±0.40
p-value	0.7864	0.2586	0.2786	0.2419	0.0630	0.1416
Items	HCT (%)	MCV (fL)	MCH (pg)	MCHC (g dL^{-1})	PLT (10^3 µL^{-1})	MPV (fL)
FT0	26.70±1.12	113.07±0.89	53.90±0.81	47.80±0.53	74.33±6.74	6.37±0.20
MT0	25.80±1.12	115.90±0.89	53.73±0.81	46.47±0.53	60.00±6.74	6.13±0.20
FT1	26.23±1.12	112.43±0.89	53.13±0.81	47.33±0.53	60.00±6.74	6.17±0.20
MT1	24.37±1.12	116.37±0.89	53.93±0.81	46.40±0.53	60.33±6.74	6.23±0.20
µ±SE	25.78±1.12	114.44±0.89	53.67±0.81	47.00±0.53	63.67±6.74	6.23±0.20
p- value	0.3939≤p≤0.8415	0.0549≤p≤0.7211	0.6137≤p≤0.9833	0.2321≤p≤0.9308	0.1799≤p≤1.000	0.6477≤p≤0.9331
T0	26.25±0.80	114.48±0.63	53.82±0.57	47.13±0.37	67.17±4.76	6.25±0.14
T1	25.30±0.80	114.40±0.63	53.53±0.57	46.87±0.37	60.17±4.76	6.20±0.14
µ±SE	25.77±0.80	114.44±0.63	53.68±0.57	47.00±0.37	63.67±4.76	6.23±0.14
p-value	0.4229	0.9279	0.7348	0.6267	0.3292	0.8076
F	26.47±0.80	112.75±0.63^b	53.51±0.57	47.57±0.37	67.17±4.76	6.27±0.14
M	25.08±0.80	116.13±0.63^a	53.83±0.57	46.43±0.37	60.17±4.76	6.18±0.14
µ±SE	25.78±0.80		53.68±0.57	47.00±0.37	63.67±4.76	6.23±0.14
p-value	0.2538	0.0053	0.7043	0.0632	0.3262	0.6858

Means within the same column and in the same category (FT0, MT0, FT1, MT1), (T0, T1), (F, M) carrying different superscripts are significantly different at 99% interval of confidence, by Duncan's multiple ranges test, µ±SE: Mean±standard error, or p-value when there was a significative difference

who studied the growth performances of male and female broiler birds. Indeed, with Cobb-500 broilers, on day 28, Panigrahy *et al.*[12] observed no significant difference in live weight between roosters and hens fed with the same diet. However, after day 28, males tended to grow faster than females, even with native chickens[11]. This tendency was already observed by Shim *et al.*[13] who reported that on the day 48, after slaughtering commercial broilers, the males were heavier (3.57 kg) than females (2.98 kg).

Based on difference of live weight at 7th week between cocks (MT0 versus MT1, +590.12 g, +22.68%, p 0.0001) and hens (FT0 versus FT1, +198.46 g, +8.59%, p = 0.0283), it was noteworthy that dried pulp of *Borassus aethiopum* was well accepted by Cobb-500 broilers. Obviously, MT1 could not catch up MT0 because of the diet structure. Chewning *et al.*[14] observed lower growth performance in birds fed with mash diet as compared to pellet or corn with particle size of around 0.3 and 0.6 mm. For example, Chewning *et al.*[14] reported that mash, pellet and corn particle size of 0.3 and 0.6 mm led to body weight of 2,733, 3,227, 2,981 and 2,979 g, respectively in males and 2,239, 2,626, 2,440 and 2,415 g, respectively in females. Since 20% of the yellow corn was replaced by *Borassus aethiopum* dried pulp, thus density of T1 was reduced. So, this density reduction could explain the reason why MT0 birds grown faster than those of MT1. But male birds fed on low density diet T1 tended to grow faster than hens fed on high density diet T0. Therefore, it can be concluded that the hormones are more effective on sex dimorphism than diet. Numerically, MT1 grown faster than FT0, for 2601.67 versus 2510 g (+91.67 g, +3.52%). These weights were not statistically different (p = 0.2212).

Blood cells count: Table 2 shows the hematological qualities. Kuttappan *et al.*[9] assessed white striation in broiler breast fillets and found no significant difference between treatments (T0 and T1). Nonetheless, the values of parameters were quite different from those of their normal chickens. Since they worked only on males. For example, the white blood cells (WBC), in the present study was 43.83 and 45.07×10^3 µL^{-1}, for MT0 and MT1, while Kuttappan *et al.*[9] found the value 24.04×10^3 µL^{-1} for white blood cells. For body immunology, WBC count observed in the current study (44.45×10^3 µL^{-1})

was higher (84.90%) than that noted by Kuttappan *et al.*[9]. Normally, their WBC count on day 62 should have to be higher than that observed in the present study which was counted on day 49. In fact, Tehrani *et al.*[15] clearly demonstrated that WBC content increases with the bird age. A similar opinion was expressed by Tehrani *et al.*[15] and Kuttappan *et al.*[9] who stated that hematological parameters such as WBC, RBC, HGB, MCH, MCHC and platelet were not affected by the diets. As a result, means in each column were not statistically different ($0.4388 \leq p \leq 0.9830$). In contrast, after using some *Lepidium sativum* seed powder as feed additive in Cobb 500 broiler diets, Shawle *et al.*[16] observed that plasma hematology can significantly change at different incorporation levels. Lymphocytes percentage (LYM %), for MT0 (90.10±0.9%) and MT1 (89.03±0.9%), followed the results of Tehrani *et al.*[15] and Kuttappan *et al.*[9]. These results were not statistically different ($p = 0.43$). Tehrani *et al.*[15] and Kuttappan *et al.*[9] stated that lymphocytes percentage among WBC is always the highest. Even though hens' lymphocyte percentages were numerically lower (88.13±0.9%) than those of the roosters (88.8±0.9%) for FT0 and FT1, these outputs were neither different between hens ($p = 0.62$), nor between females and cocks ($0.46 \leq p \leq 0.86$).

According to Tehrani *et al.*[15] and Kuttappan *et al.*[9] the values of red blood cells (RBC) count were 2.98 and 2.69×10^6 µL^{-1}, respectively, whereas, according to the results of the current study the (RBC) count was 2.26×10^6 µL^{-1} for T0 and T1 together. Thus, herein results were quite lower. Hematocrit values were 25.8, 24.37, 26.25 and 25.30% for MT0, MT1, T0 and T1, respectively, these values are lower than the results of previous studies which were 33.7%[14] and 35.88%[9] Despite we also reared Cobb 500 broilers, in T1, HGB, MCV and MCH were generally higher than those reported by Shawle *et al.*[16]. For instance, herein results were 11.88 g dL^{-1}, 114.4 fL and 53.53 pg, respectively for HGB, MCV and MCH, versus 9.28 g dL^{-1}, 103 fL and 32.3 pg reported by Shawle *et al.*[16], when 2.25% of *Lepidium sativum* seed powder was added in the diet. So, for the above parameters, keeping the same order, their results were increased by 28.05, 11.07 and 65.74%. We may deduce that substituting 20% of the yellow corn by *Borassus aethiopum* dried pulp, induced bigger red blood cell size (MCV), thus carrying higher hemoglobin quantity per cell (MCH). Within the gender, there was a significant difference between cocks and hens. Of course, while the hens had a MCV of 112.75±0.63 fL, the roosters had 116.13±0.63 fL ($p = 0.0053$). Thus, on the overall view, the cocks had bigger red blood cells than the hens. So, the roosters got a better health benefit than the hens. In a similar experience, opposite tendency of inducing bigger red cells was observed where *Borassus aethiopum* pulp has induced the reduction of red blood cells number. For example, Shawle *et al.*[16] numbered 3.17, 3.1 and 2.88×10^6 RBC per microliter (µL) for 0.75, 1.5 and 2.25% dietary inclusion levels of *Lepidium sativum*. Herein, the results were 2.22×10^6 µL^{-1}, after substituting 20% of the yellow corn by some dried pulp. Comparatively their results were less than 27.31%.

Blood Plasma lipids profile: At first glance, total cholesterol and HDL cholesterol were not gender sensitive (Table 3). In fact, at the gender level (F, M), total cholesterol and HDL cholesterol LDL cholesterol and proteins concentrations did not decrease significantly. Thus, the means were, 118.59±4.31 mg dL^{-1} ($p = 0.3414$), 59.99±1.37 mg dL^{-1}

Table 3: Blood plasma lipids profile, Total cholesterol (Tot.C), HDL cholesterol (HDL.C), Triglycerides, LDL cholesterol (LDL.C) and Protein contents at day 49, according to the diet (T0 and T1) and the gender (F: female and M: male) ($\alpha = 0.01$)

Items	Tot.C (mg dL^{-1})	HDL.C (mg dL^{-1})	Triglycerides (mg dL^{-1})	LDL.C (mg dL^{-1})	Protein (g dL^{-1})	VLDL.C (mg dL^{-1})
F	121.53±4.31	60.15±1.37	82.80±1.87^{a}	44.81±4.02	5.06±0.05	16.56±0.37^{a}
M	115.65±4.31	59.83±1.37	74.20±1.87^{b}	40.98±4.02	4.88±0.05	14.84±0.37^{b}
µ±SE	118.59±4.31	59.99±1.37		42.90±4.02	4.97±0.05	
p-value	0.3424	0.8687	0.0028	0.5047	0.0255	0.0028
T0	128.00±4.31^{a}	64.86±1.37^{a}	81.08±1.87	46.93±4.02	5.00±0.05	16.22±0.37
T1	109.17±4.31^{b}	55.13±1.37^{b}	75.92±1.87	38.86±4.02	4.94±0.05	15.18±0.37
µ±SE			77.64±1.87	42.89±4.02	4.97±0.05	15.70±0.37
p-value	0.0042	0.0001	0.0602	0.1660	0.4406	0.0602
FT0	121.77±6.10^{a}	63.62±1.93^{ab}	84.83±2.65^{a}	41.18±5.69	5.15±0.08	16.97±0.53^{a}
MT0	134.23±6.10^{a}	66.09±1.93^{a}	77.34±2.65^{ab}	52.68±5.69	4.85±0.08	15.47±0.53^{ab}
FT1	121.29±6.10^{a}	56.68±1.93^{bc}	80.77±2.65^{ab}	48.45±5.69	4.97±0.08	16.15±0.53^{ab}
MT1	97.06±6.10^{b}	53.57±1.93^{c}	71.07±2.65^{b}	29.27±5.69	4.91±0.08	14.21±0.53^{b}
µ±SE				42.89±5.69	4.97±0.08	
p-value	$0.0008 \leq p \leq 0.0084$	$0.0024 \leq p \leq 0.0045$	0.0046	$0.0316 \leq p \leq 0.6030$	$0.0462 \leq p \leq 0.5959$	0.0046

Means within the same column and in the same category (FT0, MT0, FT1, MT1), (T0, T1), (F, M) carrying different superscripts are significantly different at 99% interval of confidence, by Duncan's multiple ranges test, µ±SE: Mean±standard error

($p = 0.8687$), 42.90±4.02 ($p = 0.5047$) and 4.97±0.05 mg dL^{-1} ($p = 0.0255$), respectively. However, from the hens to the roosters, the triglycerides concentrations dropped significantly from 82.80±1.87 to 74.20±1.87 mg dL^{-1} ($p = 0.0028$). It may be deduced that hens tend to have more triglycerides, thus more fat than roosters. Since VLDL.C concentrations are one-fifth of those of triglycerides[10], their progression was like that of triglycerides. In contrast, blood plasma lipids were diets sensitive. For example, total cholesterol and HDL cholesterol decreased significantly from T0-T1. In fact, total cholesterol decreased from 128.00±4.31 mg dL^{-1} to 109.17±4.31 mg dL^{-1} and this loss (18.83 mg dL^{-1}) was significant ($p = 0.0042$). Similarly, HDL cholesterol also decreased from 64.86±1.37 mg dL^{-1} to 55.13±1.37 mg dL^{-1} and this reduction (9.73 mg dL^{-1}) was highly significant ($p<0.0001$).

Thus, the *Borassus aethiopum* dried pulp incorporation at the level of 20% decreased total and HDL cholesterols by 14.71 and 15% from the highest, respectively. The interactions between diets and gender caused some changes. Specifically, some great changes were observed among male groups.

Results of the present study showed that MT0 and MT1, Total and HDL cholesterol contents were 134.23±6.10, 97.06±6.10 mg dL^{-1} (-27.69%, $p = 0.0008$) and 66.09±1.93, 53.57±1.93 mg dL^{-1} (-18.94%, $p = 0.0004$), respectively. While MT0 always exhibited the highest values and MT1 showed the lowest and the averages were highly different.

Subsequently, total cholesterol and HDL cholesterols decreased by 37.17 mg dL and 12.52 mg dL^{-1}, respectively, within the roosters alongside the diets. Though, the results for LDL cholesterol were not statistically different, it decreased by 17.19% from T0 (46.93±4.02 mg dL^{-1}) to T1(38.86±4.02 mg dL^{-1}) ($p = 0.166$).

Adding plant parts such as the leaves, the bulbs or the seeds powder in broiler diets tend to depress total, HDL and LDL cholesterols contents. For instance, Zanu *et al.*[17] added up to 15% of *Moringa oleifera* leaves powder in broilers diet and observed 18.09% decrease for total cholesterol (from 3.04-2.49 mmol L^{-1}), 23.75% for HDL cholesterol (from 2.4-1.83 mmol L^{-1}), while LDL cholesterol remained unchanged (0.13 mmol L^{-1}). Also, Shawle *et al.*[16] included 0.75% of *Lepidium sativum* seed powder in the diet and observed decrease in total cholesterol content from 125-101 mg dL^{-1} (19.2%). Dey and De[18] observed a decrease in total LDL (9.85 and 33.04%) and increase in HDL cholesterol (21.16%) contents when 0.4% of *Moringa oleifera* leaves powder was added in broiler diets. Inclusion of 20% *Borassus aethiopum* dried pulp in broilers' diet depressed total cholesterol by 14.71%, HDL cholesterol by 15% and LDL cholesterol by 17.19%, it may be a good functional food.

CONCLUSION

Borassus aethiopum mature fruits' dried pulp significantly reduced the cholesterols contents in the bloodstream. But, considering the poor growth performance observed in broiler birds fed on diet containing 20% of the dried pulp, it would be good to seek the optimum incorporation rate which would not affect growth performance. Moreover, because *Borassus aethiopum* mature fruits' dried pulp is sweet, the reducing sugars content in the broilers' meat may be assessed.

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