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Influence of the Consumption of Four Diets on the Biological Blood Parameters of Japanese Quail (*Coturnix japonica*) Farmed in Côte D'ivoire

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

To ensure that newly formulated food (A1, A2 and A3) based on local products and commercial love (AT), fed to quail reared in captivity for 9 weeks, did not affect their health biologicaly, biochemical blood analysis were carried out on them at the end of the experiment. The results obtained show that the quails fed with A3 and AT foods have the highest respective crude protein levels (55.67 ± 1.70 and 55 ± 0.82 g/l). In addition, the blood Ca/P ratio which represents the index of a good metabolism of these electrolytes, between 1 and 2, is in accordance with the recommendations in force. In addition, the average urea and creatinine levels of all the quails studied are identical to those of the control quails. Similarly, in quail fed with commercial food AT, uricemia is the highest (66 ± 0.82 mg/l) in this study. Quails fed with commercial food AT have the highest cholesterol level

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(2.24 ± 0.04 g/l). However, quails fed with feed A3 are those with the lowest level of triglycerides (6.80 ± 0.02 g/l). Thus, consumption of the newly formulated feeds A1, A2 and A3 by quails did not affect their renal, hepatic, pancreatic and heart health like that of quails fed the commercial feed AT.

Keywords: Food; quail; biological blood parameters; health; organs.

1. INTRODUCTION

Coturniculture is a recent activity. It has attracted the attention of specialists as a new way of diversifying poultry farming, offering consumers new tastes and improving meat production in order to meet the growing demand for animal protein [1]. However, it is worth pointing out that currently, there are no commercial feed formulas for quails in livestock feed industries in Côte d'Ivoire, where coturnic farmers generally use feed intended for chickens whence the high selling price of quail on the market [2,3]. The art of rearing and adapting animals to their dietary needs is one of the most significant crucial human activities.

Today, the main objective of the research addressed by this activity consists in developing techniques allowing not only the optimal expression of the performance of animal species subjected to breeding but also and above all guaranteeing their sanitary quality [4].

This study aims to assess the impact of the consumption of four foods including three (03) newly formulated foods (A1, A2 and A3) based on local products then a commercial food or control food (AT) and ingested at Japanese quail (*Coturnix japonica*) raised in captivity for 9 weeks in Côte d'Ivoire on their biological health

2. MATERIALS AND METHODS

2.1 Materials

2.1.1 Animal material

The animal material used for experimentation in this work is exclusively composed of one-day-old Japanese quail (*Coturnix japonica*).

The animal material used as animal protein sources are fish (*Sardinella maderensis*) and garden snail (*Achatina fulica*).

2.1.2 Plant material

The plant material used in this work consists on the one hand of yellow maize grains (*Zea mays L.*) and on the other hand of néré seeds and pulp (*Parkia biglobosa*) harvested at physiological maturity.

2.2 Methods

2.2.1 Receipt of the quails

Eighty (80) one-day-old quails were used for breeding in a farm in the village of Akouê Santai located in the commune of Bingerville (Côte d'Ivoire). These quails were labelled, weighed and divided into four (4) groups of twenty (20) quails. Finally, each group of animals was housed in a compartment according to the four (4) diets.

2.2.2 Formulation of diets

Three (3) types of food were formulated:

- Food A1: The animal protein powder is that of fish (*Sardinella maderensis*) (100%);
- Food A2: The animal protein powder is that of the snail (*Achatina fulica*) (100%) ;
- Food A3: The animal protein powder is that of a powder composed of snail (*Achatina fulica*) and fish (*Sardinella maderensis*) (50/50; W/W).

For each of these formulations, the main carbohydrate constituent is exclusively yellow corn (*Zea mays L.*) powder. Then, were added to these foods, the same quantities of *Parkia biglobosa* powder (grains and pulp) as well as the other usual inputs as detailed in the table.

2.2.3 Breeding procedure

From the first day of reception, the day-old quails (young quails) were fed according to the following method:

- The 1st group received food A1 ;
- The 2nd group received food A2 ;
- The 3rd group received food A3 ;
- The 4th group received the commercial food AT (control food).

Every day at 5 p.m. the chicks received a very precise quantity of food (10g / day / head) during

the first week and (15g / day / head) during the second week. Water containing vitamin (VMD-Amin special) and dewormer (Norfloxacin 20%) were also served to them. Twenty-four (24) hours later, the refusals were collected and weighed before renewing the food. Every 2 days, at 5 p.m., the quails were weighed. The start-up period lasted 2 weeks, then the chicks were transferred to the cages reserved for the growth phase which lasted about 7 weeks. The activities carried out during this phase were identical to those of the previous phase. During this phase the quantities of food received per quail per day varied from 17 to 25g from the third to the seventh week. At the end of each rearing period, three quails from each batch were sacrificed, their viscera and feathers were extracted and then weighed, as well as their carcasses. All the weighings were carried out using an electronic balance (ACCULAB Sartoruis group-VICON 0.01g, CHINA).

2.2.4 Blood biochemical analysis

Blood samples and serum preparations: At the end of the nine (9) weeks of experimentation, three (3) quails from each batch were fasted for a period of sixteen (16) hours. After that, a volume of five (5) ml of blood was taken per quail subjected to fasting and put dry tubes (without anticoagulant). This blood was then centrifuged at 3000 rpm for 5 min in a centrifuge (SIGMA laborzentrifugen 3-16P, GERMANY). The serum obtained was stored in wells at –20°C for future biochemical analyzes using a Coulter ACT diff 2 (GEMANY) type automaton.

Dosage of serum proteins: The soluble serum proteins were assayed using the Biuret colorimetric method described by [5].

Dosage of serum glucose: Quail serum glucose was assayed using the colorimetric enzymatic method of [6]. The amount of serum glucose was calculated according to the following mathematical formula:

$$\mathrm{QG}\left(\frac{\mathrm{g}}{\mathrm{l}}\right) = \frac{DO\ sample}{\mathrm{DO\ standard}}\ X100$$

100 = standard concentration (mg/dL)
DO sample: absorbance obtained with quail blood serum;
DO standard: absorbance obtained with glucose (0.5 g/L) ;
QG: quantity of glucose (g/L).

Determination of serum urea: Quail serum urea assay was performed using the method previously described by [7] with some modifications. Ten (10) µl of quail blood serum and ten (10) µl of urea (6.66 mmol/L) (standard) were diluted in each case in 1 mL of reagent (urease solution). Then, the two reaction media were homogenized by manual stirring for 1 min at ambient temperature (28° C.), then incubated at 37° C in a water bath for 10 min. The color intensities of these reaction media were determined using a spectrophotometer (MS-V5100 visible, CHINA) at 590 nm against a control containing no urea. The urea rate was calculated from the following mathematical equation:

$$\mathrm{UREA}\ \left(\frac{\mathrm{g}}{\mathrm{l}}\right) = \frac{DO\ test}{\mathrm{DO\ standard}}$$

DO test: absorbance obtained with quail blood serum;
DO standard: absorbance obtained with urea (6.66 mmol/L).

Table 1. Centesimal composition of formulated foods A1, A2 and A3

Quantity per 100 kg of feed						
Ingredients	**Launch stage**			**Growth**		
	A1	**A2**	**A3**	**A1**	**A2**	**A3**
Corn	56	56	56	58	58	58
Nere pulp flour	3	3	3	3	3	3
Nere seed meal	20,8	20,8	20,8	19	19	19
Fishmeal	15	00	7,5	14.5	00	7,5
snail meal	00	15	7,5	00	14,5	7,5
Shell	2	2	2	2.2	2,2	2,2
Red oil	2	2	2	2	2	2
Vitamin complex	0.5	0.5	0.5	0.7	0.7	0.7
Salt	0.3	0.3	0.3	0.3	0,3	0.3
lysine	0.25	0.25	0.25	0.2	0.2	0,2
methionine	0.15	0.15	0.15	0.1	0.1	0,1

Dosage of uric acid: Uric acid was measured using the enzymatic method of [8].

$$\text{URIC ACID } \left(\frac{\text{mg}}{\text{100ml}}\right) = \frac{DO\ test}{\text{DO standard}} \times 6$$

6 = standard concentration (mg/dL)
DO test: absorbance obtained with quail blood serum;
DO standard: absorbance obtained with uric acid (6 mL /100 mL).

Determination of creatinine: In fact, creatinine in quail blood serum was measured according to the method of Hare [9]. The absorbance corresponding to each reaction medium was determined from the following mathematical relationship:

DO = DO 1min – DO 30s.
DO 1min = density of the test 1 min after incubation of the reaction medium at 37°C in a water bath;
DO 30s = density of the test 30s after incubation of the reaction medium at 37°C in a water bath.

The creatinine level was obtained from the following equation:

$$\text{Creatinine level}\left(\frac{\text{mg}}{\text{dl}}\right) = \frac{\text{DO test}}{\text{DO standard}} \times 2$$

2 = standard concentration (mg/dl)
DO 30 s: absorbance obtained after 30 seconds of incubation;
DO 1 min: absorbance obtained after 1 min of incubation.

Dosage of total cholesterol: Quail blood serum cholesterol was determined according to the colorimetric method of [6] using cholesterase. The absorbance of each reaction medium (DO) was calculated according to the following mathematical formula:

DO = DO 30 sec - DO 1 min
DO: absorbance of the test or of the standard;
DO 30 s: absorbance obtained after 30 seconds of incubation;
DO 1 min: absorbance obtained after 1 min of incubation.

The quail blood serum cholesterol level was obtained from the following mathematical expression:

$$\text{Cholesterol level}\left(\frac{\text{mg}}{\text{dl}}\right) = \frac{(\text{DO sample})}{(\text{DO standard})} \times 200$$

200 = standard concentration (mg/dL)
DO sample: absorbance obtained with quail blood serum;
DO standard: absorbance obtained with cholesterol (5.17mmol/L).

Dosage of triglycerides: Quail blood serum triglycerides were measured according to the colorimetric method of [10] using glycerophosphate oxidase. The absorbance corresponding to each reaction medium was calculated from the following equation:

DO = DO 30s – DO 1min

DO: absorbance of the test or of the standard;
DO 30s: absorbance obtained after 30 seconds of incubation;
DO 1min: absorbance obtained after 1 min of incubation.

The quail blood serum triglyceride level was obtained from the following mathematical reaction:

$$\text{Triglyceride level}\left(\frac{\text{mg}}{\text{dl}}\right) = \frac{\text{DO sample}}{\text{DO standard}} \times 200$$

200 = standard concentration (mg/dL);
DO sample: absorbance obtained with quail blood serum;
DO standard: absorbance obtained with triglyceride (2.28 mmol/L).

Calcium dosage: Quail blood serum calcium was measured according to the colorimetric method of [11] Stern & Lewis (1957). The calcium level was calculated from the mathematical relationship :

$$\text{Calcium level}\left(\frac{\text{mg}}{\text{dl}}\right) = \frac{DO\ sample}{\text{DO standard}} \times n$$

n = standard concentration (mg/dl);
DO sample: absorbance obtained with quail blood serum;
DO standard: absorbance obtained with calcium (2.5 mmol/L).

Dosage of phosphorus: Quail blood serum phosphorus was measured according to the colorimetric method of [12]. The phosphorus rate was calculated from the following mathematical relationship:

$$\text{Phosphorus}\left(\frac{\text{mg}}{\text{dl}}\right) = \frac{DO\ sample}{\text{DO standard}} \times 50$$

50: standard concentration (mg/dL);
DO sample: absorbance obtained with quail blood serum;
DO standard: absorbance obtained with phosphorus (1.61 mmol/L).

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Protein and triglyceride levels

The blood serum protein levels of quail fed with newly formulated feed (A1, A2, A3) and commercial feed (AT) at the end of rearing are respectively 49 ± 0.51; 43 ± 1.01; 55.67 ± 1.70 and 55 ± 0.82 g/l. Those of the blood sera of quails fed with A3 and AT foods are statistically (P≥0.05) identical. They are statistically higher than the blood serum protein levels of quails fed the newly formulated feeds A1 and A2 (Fig. 1).

The blood serum triglyceride levels of quail fed with newly formulated feed (A1, A2, A3) and commercial feed (AT) at the end of rearing are respectively 13 ± 0.21; 9±1.11; 6.8 ± 1.09 and 11.9 ± 0.02 g/l. The descending order of blood serum triglyceride levels of quails fed with newly formulated growth feed A1, A2, A3 and commercial feed (AT) is as follows: triglyceride level of growth feed A1 > triglyceride level of commercial growth food AT > triglyceride level of growth food A2 > triglyceride level of growth food A3 (Fig. 1).

3.1.2 Phosphorus and calcium levels

The phosphorus levels of the blood serums of the quails fed with the newly formulated feeds A1, A2, A3 and the commercial feed AT at the end of rearing are respectively 0.051 ± 0.04; 0.051 ± 0.10; 0.050 ± 0.01 and 0.046 ± 0.12 g/l. Those of the blood sera of the quails fed with the newly formulated food A1, A2 and A3 are statistically (P≥0.05) identical to that of the quails fed with the commercial food AT (Fig. 2).

The calcium levels of the blood serums of the quails fed with the newly formulated feeds A1, A2, A3 and the commercial feed AT at the end of rearing are respectively 0.094 ± 0.01; 0.095 ± 0.02; 0.097 ± 0.01 and 0.093 ± 0.03 g/l. All these calcium levels are statistically (P≥0.05) identical to each other (Fig. 2).

3.1.3 Ca/P ratios

The Ca/P ratios of the blood sera of the quails fed with the newly formulated growth feeds A1, A2, A3 and the commercial feed AT at the end of rearing are respectively 1.82 ± 0.04; 1.86 ± 0.12; 1.94 ± 0.19 and 2.03 ± 1.03. They are statistically (P≥0.05) all identical (Fig. 3).

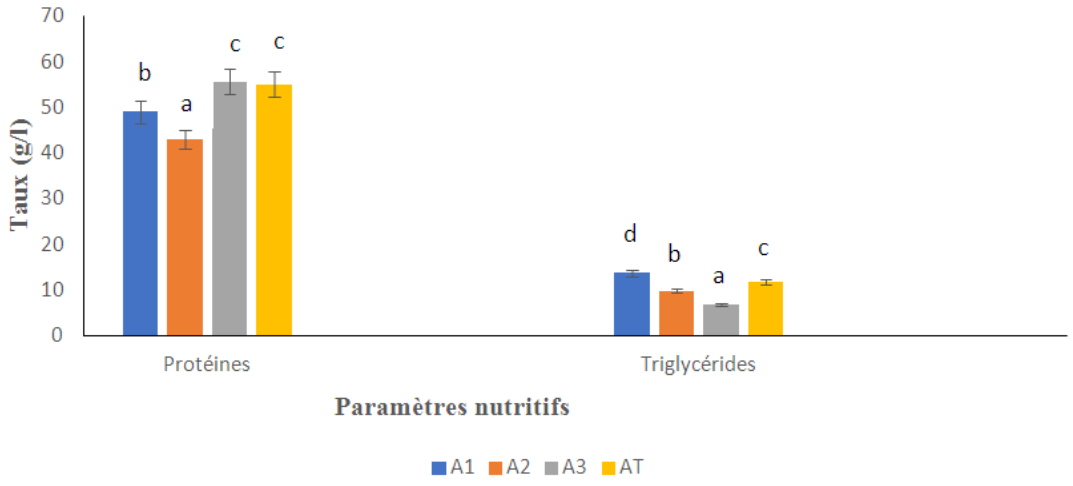

Fig. 1. Protein and triglyceride levels of blood serum of quails fed with newly formulated feed and commercial feed

The same letters assigned to the means mean that they are not different at the 5% threshold.
A1: food whose major animal protein source is only Sardinella maderensis fish powder (100%);
A2: food whose main animal protein source is only the powder of the Achatina fulica snail (100%);
A3: food whose major animal protein source is powder composed of snail (Achatina fulica) and fish (Sardinella maderensis) (50/50; w/w);
AT: Commercial food (control food)

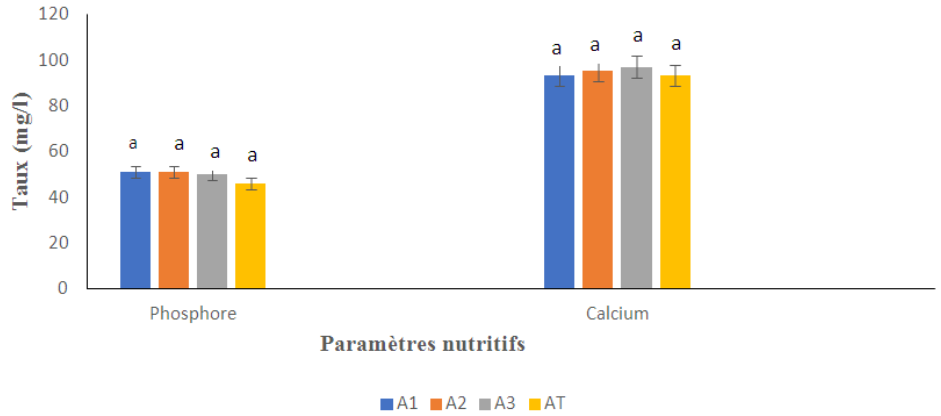

Fig. 2. Phosphorus and calcium levels in blood serum of quails fed with newly formulated feed and commercial feed

The same letters assigned to the means mean that they are not different at the 5% threshold.
A1: food whose major animal protein source is only Sardinella maderensis fish powder (100%);
A2: food whose main animal protein source is only the powder of the Achatina fulica snail (100%);
A3: food whose major animal protein source is powder composed of snail (Achatina fulica) and fish (Sardinella maderensis) (50/50; w/w);
AT: Commercial food (control food)

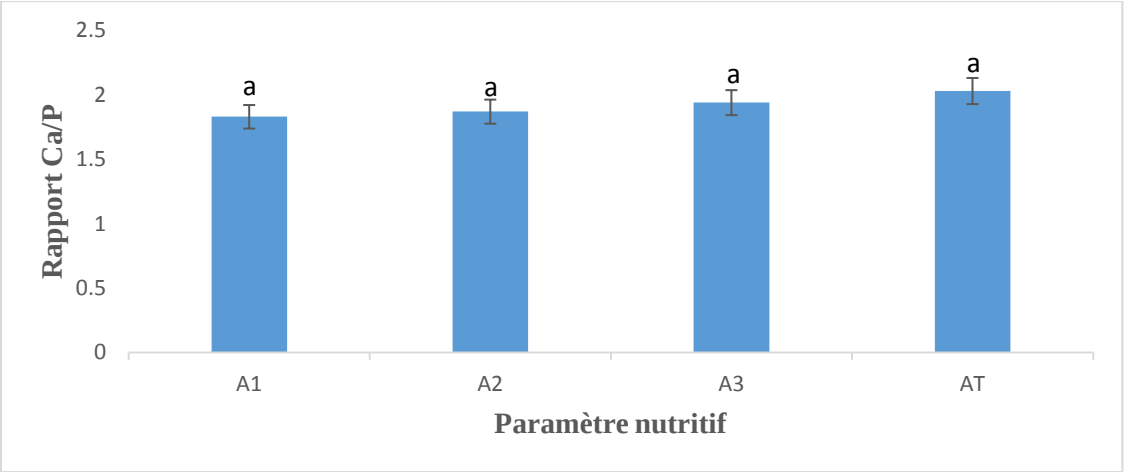

Fig. 3. Ca/P ratios of blood serum of quail fed with newly formulated feed and commercial feed

The same letters assigned to the means mean that they are not different at the 5% threshold.
A1: food whose major animal protein source is only Sardinella maderensis fish powder (100%);
A2: food whose main animal protein source is only the powder of the Achatina fulica snail (100%);
A3: food whose major animal protein source is powder composed of snail (Achatina fulica) and fish (Sardinella maderensis) (50/50; w/w);
AT: Commercial food (control food).

3.1.4 Glycemic and cholesterol levels

The blood serum glycaemia levels of quails fed with newly formulated feed (A1, A2, A3) and commercial feed AT at the end of rearing are respectively 2.04 ± 1.07; 1.97 ± 1.10; 2.06 ± 1.09 and 1.48 ± 0.40 g/l. Those of the blood sera of the quails fed with the newly formulated foods A1, A2 and A3 are statistically (P≥0.05) the same. They are higher than that of the blood serum of quails fed with commercial growth food AT (Fig. 4).

The blood serum cholesterol levels of quails fed with the newly formulated feed (A1, A2, A3) and the commercial feed AT at the end of rearing are

respectively 1.87 ± 0.07; 1.85 ± 0.10; 1.83 ± 0.09 and 2.24 ± 0.02 g/l. Those of the blood sera of the quails fed with the newly formulated foods A1, A2 and A3 are statistically (P≥0.05) identical. They are statistically lower than those of the blood sera of quails fed with commercial food AT (Fig. 4).

3.1.5 Urea, uric acid and creatinine levels

The blood serum urea levels of quail fed with newly formulated growth feed A1, A2, A3 and commercial feed AT at the end of rearing are respectively 0.18 ± 0.03; 0.2±0.12; 0.17±0.03 and 0.16±0.05 g/l. They are statistically (P≥0.05) all identical (Fig. 5).

The uric acid levels of the blood serum of the quails fed with the newly formulated growth feeds A1, A2, A3 and the commercial feed AT at the end of rearing are respectively 0.05 ± 0.01; 0.05 ± 0.00; 0.05 ± 0.00 and 0.07 ± 0.00 g/l. They are statistically (P≥0.05) identical to each other (Fig. 5).

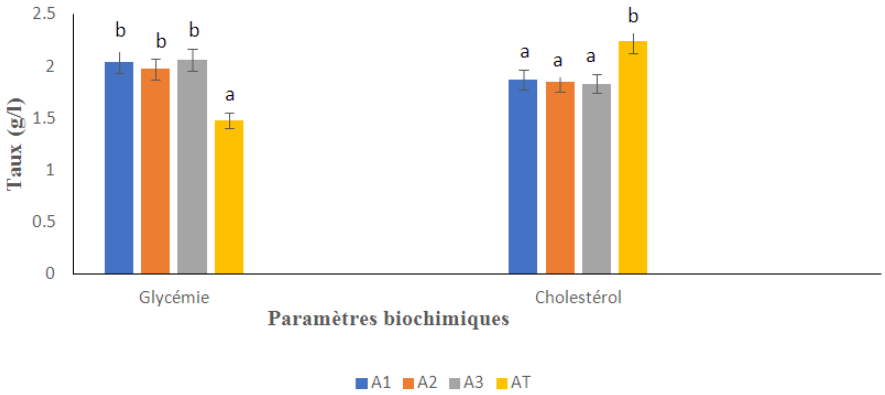

Fig. 4. Blood serum glucose and cholesterol levels of quail fed the newly formulated Feed and the commercial feed

The same letters assigned to the means mean that they are not different at the 5% threshold.
A1: food whose major animal protein source is only Sardinella maderensis fish powder(100%);
A2: food whose main animal protein source is only the powder of the Achatina fulica snail(100%);
A3: food whose major animal protein source is powder composed of snail (Achatina fulica) and fish (Sardinella maderensis) (50/50; w/w);
AT: Commercial food (control food)

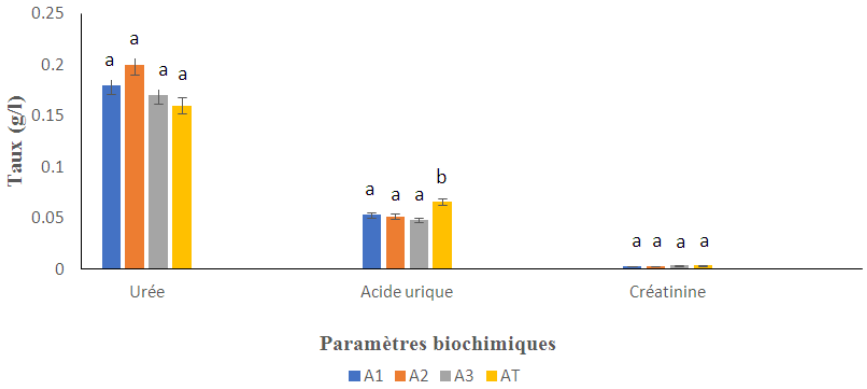

Fig. 5. Levels of urea, uric acid and creatinine in the blood serum of quails fed with the newly formulated feed and the commercial feed

The same letters assigned to the means mean that they are not different at the 5% threshold.
A1: food whose major animal protein source is only Sardinella maderensis fish powder (100%);
A2: food whose main animal protein source is only the powder of the Achatina fulica snail (100%);
A3: food whose major animal protein source is powder composed of snail (Achatina fulica) and fish (Sardinella maderensis) (50/50; w/w);
AT: Commercial food (control food)

The creatinine levels of the blood serums of the quails fed with the newly formulated growth feeds A1, A2, A3 and the commercial feed AT at the end of rearing are respectively 0.03 ± 0.01; 0.03 ± 0.00; 0.03 ± 0.00 and 0.03 ± 0.01g/l. They are statistically (P≥0.05) identical (Fig. 5).

3.2 Discussion

Blood biochemical parameters refer to substances synthesized by the body whose concentrations are relatively constant. However, the serum biochemical parameters of some birds could vary depending on several factors, including diet, age, breed, sex, physiological state and husbandry management [13,14]. Their variations make it possible to assess the functional state of the organism [15,16]. Consequently, an excess or a deficit of production of a substance synthesized by an organ is indicative of a dysfunction of this one. It is both a means of indirect exploration of the regulatory organs of metabolism and a means of assessing nutrient metabolism [17]. Proteins that are polymers of amino acids include albumin, globulins and fibrinogen. They are important in that they exert a beneficial effect on health through the maintenance of osmotic pressure, the transport of molecules, the purification of plasma, the strengthening of the immune system and the coagulation of blood [18, 19]. In this study, quails fed A3 and AT feeds show the highest respective crude protein levels (55.67 ± 1.70 and 55 ± 0.82 g/l). These high levels of serum proteins obtained in these quails could be justified by the high levels of proteins contained in the A3 and AT feeds consumed by these birds. Our results corroborate those of [20]. Indeed, these authors, in their work on breeding systems, mentioned that proteinemia is higher in the conventional breeding system. Additionally, [5] then [21] reported that the level of total serum protein depends on the protein content of the diet. Thus, a high protein diet would lead to an increase in serum total protein content beyond the recommended ranges. In this work, the serum protein levels obtained could reassure us as to the good health of the quails studied.

Plasma electrolytes (calcium and phosphorus) play an important role in the growth of bones and teeth. They are involved in maintaining the body's hydrodynamic balance [22]. In this study, quails fed the newly formulated diets showed higher levels of these electrolytes compared to quails fed the commercial diet. In addition, the blood Ca/P ratio which represents the index of a good metabolism of these electrolytes, between 1 and 2, is in agreement with the recommendations of [22].

Urea and creatinine are metabolites resulting from the catabolism of total serum proteins and creatine synthesized by muscles and the brain. Their determination makes it possible to evaluate the effect of the consumption of food formulations on the glomerular function of the kidneys of subjects [23]. The average levels of urea and creatinine of all the quails studied are identical to those of the control quails; which could indicate normal kidney function in the quails studied. This result is supported by the determination of the blood uric acid of the quails. Indeed, this substance is the main end product of nitrogen metabolism in birds. Its secretion takes place mainly in the liver [24], and in the renal tubules [25]. The determination of plasma uric acid concentrations is widely used in birds for the purpose of assessing renal function. The highest serum uric acid level in this study is that obtained in quail fed with commercial food AT (66 ± 0.82 mg/l). This further substantiates that the newly formulated foods would not negatively affect kidney function.

Quails fed the newly formulated feeds had increased blood glucose levels compared to those fed the control feed. This increase could be due to the incorporation of nere pulp (*Parkia Biglobosa*) into newly formulated feeds. Indeed, néré pulp is said to be very rich in carbohydrates (60-85%) [26,27].

The determination of cholesterol and triglyceride levels also made it possible to evaluate the effect of food consumption on the health status of the quails. Indeed, cholesterol and triglycerides are all fatty substances found in blood, bile and brain tissue [28]. They serve as precursors to the formation of bile acids, steroids and vitamin D [28]. It appears from the statistical analysis that there is no significant difference in the level of cholesterol levels of quails fed with the newly formulated feeds A1, A2 and A3 at the 5% threshold. Quails fed with commercial food AT have the highest cholesterol level (2.24 ± 0.04 g/l). Quails fed with feed A3 are those with the lowest level of triglycerides (6.80 ± 0.02 g/l). Consumption of the newly formulated feeds A1, A2 and A3 by quails would be beneficial as it could protect the animals against many metabolic and coronary diseases such as diabetes mellitus, nephropathy, biliary

obstruction and various metabolic abnormalities due to to endocrine disorders [24].

4. CONCLUSION

The objective of this study is to ensure that newly formulated feeds made from local products and fed to quail raised in captivity for 9 weeks did not affect their biological health. The biochemical blood analysis carried out at the end of the experiment revealed to us that the quails fed with the newly formulated feed have good renal, hepatic, pancreatic and cardiac health like that of the quails fed with the commercial feed AT.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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