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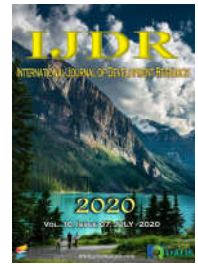
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RESEARCH ARTICLE

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DETERMINATION OF BLOOD PARAMETERS OF BREEDING PIGS IN CÔTE D'IVOIRE

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ABSTRACT

The purpose of this work is to determine the serum parameters and the hemogram of pigs reared in Côte d'Ivoire. This study involved 70 pigs (Large white, Landrace, Duroc, Pietrain, hybrid, Korhogo pig breeds) made up of 35 castrated males and 35 gilts from 14 farms whose ages vary between 8 and 10 months with an average live weight of 89.1 ± 13.6 kg. These animals, coming mainly from farms in the South, were selected at random. The blood of these animals was collected from the jugular vein in tubes with anticoagulant and tubes without anticoagulant and then analyzed in the laboratory. The mean values of glucose and total cholesterol obtained during the work are higher than the reference values indicated in the Vade-Mecum du Vétérinaire book, 16th edition by Fontaine and Cadore (1996) and the mean value of total proteins is similar to the reference value. The hemogram is similar to that indicated by Fontaine and Cadore (1996) in the book Vade-Mecum du Vétérinaire, 16th edition. This result confirms that the animals intended for stamping out, apparently healthy according to the ante-mortem examination, are indeed in good health and have a good nutritional status.

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INTRODUCTION

Côte d'Ivoire has significant agricultural potential to ensure significant food production for an estimated population of 23 million (INS, 2014). However, according to the Survey on the Monitoring of the Agricultural Season and Food Vulnerability (MAFV) carried out in 2018, 10.9 % of rural households are food insecure, including 20.8 % of the poorest households (MINADER, 2019). Côte d'Ivoire has a significant gap between production and demand for animal protein. According to MIRAH (2016), Côte d'Ivoire is highly dependent on imports of animal and animal products, apart from eggs. The dependency rate is respectively 58 %, 32 % and 46 % in 2011 for cattle, small ruminants, and pigs and fish, represents more than 60 % of the consumption of animal protein by Ivorian households. Per capita consumption is between 11 Kg on average per year, compared to an average of 17 kg per capita worldwide. For milk and dairy products, the dependency rate in Côte d'Ivoire was 83 % in 2011. The production of meat from ruminants and poultry, alone, cannot make up for the growing protein deficit, taking into account current and especially future constraints linked to these farms (Ndébi et al., 2009). The implementation of a development strategy for the

pork sector can be an alternative to protein feeding problems. It can play an important role in improving the nutritional status of the population. Pork production cannot increase until the problems linked, in particular to the management of pig farming and feeding, are resolved. Lack of control over the management of pigs through poor pig feeding and non-compliance with hygiene measures are often the cause of the deterioration of the general condition of pigs. A complementary laboratory diagnosis by assaying serum metabolites and blood count can help verify the nutritional and health status of pigs in order to take the appropriate measures. In addition, multiple breed crosses have occurred on farms in an uncontrolled fashion. However, little information is available on the values of the plasma constituents and the hemogram in pigs reared in Côte d'Ivoire. The objective of this work is to determine the biochemical and hematological profiles of pigs reared in Côte d'Ivoire.

MATERIAL AND METHODS

Material

Animal material: The animal material used in this study is all the breeds of pigs reared on pig farms in Côte d'Ivoire. These

pig breeds with 35 castrated males and 35 gilts consist essentially of Large white, Landrace, Piétrain, Duroc, Hybrids (crossed).

Technical material: The material of the slaughterhouse is made up of an individual pig tracking sheet, an EXA brand mechanical scale, Roman type, weighing 300 kg to weigh animals. A marker was used to identify live pigs and methylene blue for the identification of pig carcasses. The laboratory equipment consists of a refrigerated centrifuge (Alresa Orto, Spain), an auto-analyzer brand "HITACHI 902 - Roche, Japan" and a PLC automaton (Beckmann Coulter Act Diff 2).

Methods

Blood collection: The blood parameters of 70 Large White, Landrace, Piétrain, hybrid, Korhogo pigs from fourteen farms were estimated. These pigs, whose age varies between 8 and 10 months, consisted of castrated males (35 in numbers) and gilts (35 in numbers) with an average live weight of 89.1 ± 13.6 kg. These animals, most of which come from farms in the South, were selected at random. Blood samples were taken daily for four weeks. The blood of these animals was collected from the jugular vein in tubes containing anticoagulant (EDTA) and dry tubes, not containing anticoagulant. The samples were transported in a cooler to the central laboratory of the Treichville University Hospital for analysis. The tubes containing the anticoagulant made it possible to make the hemogram or the Numeration of the Blood Formula (NBF) and the dry tubes made it possible to make the assay of the blood metabolites.

Plasma constituents: The dry tubes are centrifuged at 3000 rpm in a refrigerated centrifuge. The serum is then collected in order to carry out the assays of the serum metabolites. The serum collected allowed the determination of serum metabolites such as glucose, triglycerides, total proteins, total cholesterol, HDL cholesterol, LDL cholesterol, urea, creatinine, uric acid, total bilirubin, conjugated bilirubin, alkaline phosphatase (ALP), aspartate amino transferase (ASAT), alanine amino transferase (ALAT), phosphorus, calcium, magnesium, iron, sodium and potassium. The assays are carried out using an auto-analyzer brand "HITACHI 902 - Roche, Japan" and a PLC automaton (Beckmann Coulter Act Diff 2).

Hemograms or Blood Formula Count (BFC): The blood samples were taken from the tubes containing an anticoagulant (EDTA) and used to determine the hematological parameters and the leukocyte formula, using a PLC (Beckmann Coulter Act Diff 2) automaton equipped with a volumetric system associated with a photometric system allowing the counting of different blood cells (leukocytes, red blood cells, hemoglobins, MCV, MCHC, AHC, platelets, neutrophils, eosinophils, basophils, lymphocytes and monocytes) in 60 seconds.

Statistical analyzes: The bulk of data was entered by Access software and data processing was carried out using Excel software and Statistica Package for the Social Sciences Personal Computer (SPSS / PC) software. Two means are significantly different if the probability resulting from the statistical tests is less than or equal to 0.05.

RESULTS AND DISCUSSION

Results

Average value of pig biochemical parameters: Table 1 presents the average values of the biochemical metabolites of pigs slaughtered at the SIVAC slaughterhouse. Regarding blood sugar, the average value of glucose obtained (2.38 ± 0.91 g / L) is higher than the reference values (0.666 - 1.152 g / L). As for the average value of total proteins (66.78 ± 11.52 g / L), it belongs to the range of reference values (48 - 103 g / L). The mean value of total cholesterol (1.18 ± 0.18 g / L) is higher than the reference values (0.378 - 0.63 g / L). The average value of urea (24.48 ± 5.05 g / L) is equal to the reference values (0.174 - 0.528 g / L). The same is true for the mean creatinine value (24.48 ± 5.05 mg / L) which falls within the range of the reference values (12.53 - 37.39 mg / L). The mean value of uric acid (29.94 ± 9.65 mg / L), on the other hand, is higher than the reference values. Finally, the value of total bilirubin (8.98 ± 2.86 mg / L) is greater than the reference values (0.054 - 1.476 mg / L).

Table 1: Average value of the biochemical parameters of pigs slaughtered at SIVAC Biochemical

Parameters	Average	Average value	*Reference value
Glucose (g / L)		2.38 ± 0.91	0.666 - 1.152
Total protein (g / L)		66.78 ± 11.52	48 - 103
Total cholesterol (g / L)		1.18 ± 0.18	0.378 - 0.63
Urea (g / L)		0.32 ± 0.15	0.174 - 0.528
Creatinine (mg / L)		24.48 ± 5.05	12.53 - 37.39
Uric acid (mg / L)		29.94 ± 9.65	1.08 - 20.34
Total bilirubin (mg / L)		8.98 ± 2.86	0.054 - 1.476

n=70= number of pigs

*Source : Fontaine et Cadore (1996)

Average enzyme activity in slaughtered pigs: According to Table 2, the enzymes studied are Alkaline Phosphatase (ALP), Aspartate Amino-transferase (ASAT) and Alanine Amino-transferase (ALAT). The average ALP activity (297.56 ± 79.96 IU / L) is higher than the reference values (35 - 110 IU / L). The same is true for that of ASAT (89.73 ± 65.49 IU / L), which is higher than the reference values recorded in Table II. ALAT's average activity (91.01 ± 37.9 IU / L) is also higher than the reference values (10 - 45 IU / L).

Table 2. Average activity of enzymes in pigs slaughtered at SIVAC

Enzymes	Average value	* Reference value
Alkaline phosphatase (ALP) (UI/L)	$297,56 \pm 79,96$	35 - 110
Aspartate amino transferase(ASAT) (UI/L)	$89,73 \pm 65,49$	30 - 61
Alanine amino transferase(ALAT) (UI/L)	$91,01 \pm 37,9$	10 - 45

n=70= number of pigs

*Source : Fontaine et Cadore (1996)

Table 3. Average value of electrolytes from pigs slaughtered at SIVAC

Electrolytes	Average value	*Reference value
Ca ²⁺ (mg/L)	116 ± 13.48	414 - 522
P ⁵⁺ (mg/L)	40.47 ± 7.21	324 - 540
Mg ²⁺ (mg/L)	28.64 ± 6.22	162 - 252
Na ⁺ (mEq/L)	138.26 ± 2.28	139.26 - 152.5
K ⁺ (mEq/L)	4.08 ± 0.49	4.4 - 6.5

n=70= number of pigs; *Source : Fontaine et Cadore (1996)

Average value of electrolytes in slaughtered pigs: The plasma concentrations of calcium (Ca^{2+}), phosphorus (P^{5+}), magnesium (Mg^{2+}), sodium (Na^+) and potassium (K^+) ions are shown in Table 3. The mean value of the blood calcium concentration ($116 \pm 13.48 \text{ mg/L}$) is lower than the reference values (414 - 522 mg / L). Concerning the mean value of serum phosphorus ($40.47 \pm 7.21 \text{ mg/L}$), it is also lower than the reference values (324 - 540 mg / L).

The same is true for the mean values of serum magnesium ($28.64 \pm 6.22 \text{ mg/L}$) and serum sodium ($138.26 \pm 2.28 \text{ mEq/L}$), respectively below the reference values (162 - 252 mg / L) and ($139.26 - 152.5 \text{ mEq/L}$). As for the mean value of serum potassium ($4.08 \pm 0.49 \text{ mEq/L}$), it is also lower than the reference values (4.4 - 6.5 mEq / L).

Hemogram of pigs slaughtered at SIVAC: Table 4 presents the hemogram of pigs slaughtered at SIVAC.

Table 4. Hemogram of pigs slaughtered at SIVAC

Numeration of the Blood Formula(NBF)	Average value	* Reference value
White blood cell or leukocyte($\times 10^3/\mu\text{L}$)	9.96 ± 1.08	11 - 22
Erythrocyte($\times 10^6/\mu\text{L}$)	8.04 ± 0.9	5 - 7
Hemoglobin (g/dL)	12.86 ± 1.13	9 - 13
Hematocrit (%)	49.06 ± 5.26	36 - 43
Mean corpuscular volume (MCV) (fL)	61.5 ± 6.98	52 - 62
Mean corpuscular hemoglobin content (MCHC) (pg)	16.44 ± 1.34	17 - 24
Average Corpuscular Hemoglobin Concentration (ACHC) (g/dL)	26.43 ± 2.59	29 - 34
Platelets ($\times 10^3/\mu\text{L}$)	289.05 ± 178.52	200 - 500
Polynuclear Neutrophils(%)	32.13 ± 6.77	20 - 70
Eosinophils Polynuclear(%)	0.47 ± 0.6	0 - 15
Polynuclear basophils(%)	0	0 - 3
Monocytes (%)	6.1 ± 2.85	0 - 10
Lymphocyte (%)	61.33 ± 6.44	35 - 75

n=70= number of pigs; CCMH: Average Corpuscular Hemoglobin Concentration; TCMH: Mean corpuscular hemoglobin content

*Source: Fontaine et Cadore (1996)

Table 5. Average value of biochemical parameters of castrated male and female pigs slaughtered at SIVAC

Biochemical parameters	Castrated males	Females	Probabilities
glucose (g/L)	2.44 ± 0.96	2.29 ± 0.84	0.49
Total protein (g/L)	66.51 ± 12.42	67.17 ± 10.55	0.81
Total cholesterol (g/L)	1.15 ± 0.17	1.23 ± 0.18	0.06
Urea (g/L)	0.3 ± 0.09	0.35 ± 0.2	0.18
Creatinine (mg/L)	23.37 ± 3.77	26.06 ± 6.24	0.02
Uric acid (mg/L)	29.43 ± 9.91	30.64 ± 9.57	0.61
Total bilirubin (mg/L)	9.36 ± 2.91	8.43 ± 2.79	0.18

n=70= number of pigs; Each average is followed by its standard deviation; Student's t-test at the level of 5 % (0.05)

Table 6. Average activity of enzymes in male and female pigs

Enzymes	Castrated males	Females	Probabilities
Alkaline phosphatase (ALP) (UI/L)	316.21 ± 78.97	271.17 ± 76.43	0.02
Aspartate amino transferase (ASAT) (UI/L)	88.82 ± 59.15	91 ± 75.63	0.89
Alanine amino transferase (ALAT) (UI/L)	100.48 ± 42.07	77.62 ± 27.29	0.01

n=70= number of pigs; Each average is followed by its standard deviation; Student's t-test at the level of 5 % (0.05)

Table 7: Average value of electrolytes in castrated male and female pigs

Electrolytes	Castrated males	Females	Probabilities
Ca^{2+} (mg/L)	115.48 ± 13.02	116.72 ± 14.53	0.71
P^{5+} (mg/L)	40.56 ± 8.23	40.34 ± 5.74	0.9
Mg^{2+} (mg/L)	27.97 ± 5.98	29.58 ± 6.63	0.29
Na^+ (mEq/L)	138.36 ± 2.08	138.10 ± 2.6	0.64
K^+ (mEq/L)	4.07 ± 0.5	4.07 ± 0.5	0.99

n=70= number of pigs; Each average is followed by its standard deviation; Student's t-test at the level of 5 % (0,05)

Table 8. Hemogram of neutered male and female pigs

Numeration of the Blood Formula (NBF)	Castrated males	Females	Probabilities
White blood cell or leukocyte ($10^3/\mu\text{L}$)	9.97 ± 1.18	9.93 ± 0.96	0.89
Erythrocyte ($10^6/\mu\text{L}$)	7.99 ± 1.22	8.11 ± 0.9	0.56
Hemoglobin (g/dL)	12.74 ± 1.22	13.02 ± 1.01	0.31
Hematocrit (%)	48.08 ± 5.04	50.43 ± 5.41	0.06
Mean corpuscular volume (MCV) (fL)	60.65 ± 6.23	62.7 ± 7.97	0.23
Mean corpuscular hemoglobin content (MCHC) (pg)	16.42 ± 1.3	16.45 ± 1.44	0.92
Average Corpuscular Hemoglobin Concentration (ACHC) (g/dL)	26.8 ± 2.24	25.88 ± 3.01	0.14
Platelets ($10^3/\mu\text{L}$)	295.78 ± 191.54	279.55 ± 164.63	0.71
Polynuclear Neutrophils (%)	32.29 ± 7.31	31.89 ± 6.17	0.81
Eosinophils Polynuclear (%)	0.56 ± 0.67	0.34 ± 0.48	0.14
Polynuclear basophils (%)	0	0	
Monocytes (%)	5.82 ± 3.04	6.48 ± 2.59	0.35
Lymphocyte (%)	61.31 ± 6.62	61.34 ± 6.39	0.98

n=70= number of pigs; Each average is followed by its standard deviation; Student's t-test at the level of 5 % (0,05); CCMH : Average Corpuscular Hemoglobin Concentration; TCMH :Mean corpuscular hemoglobin content

The average concentration of white blood cells or leukocytes ($9.96 \pm 1.08 \cdot 10^3 / \mu\text{L}$) is lower than the reference values ($11 - 22 \cdot 10^3 / \mu\text{L}$). The granulocytes composed of neutrophils, basophils and eosinophils have average proportions of $32.13 \pm 6.77\%$; 0% and $0.47 \pm 0.60\%$ respectively. These three values are, in the same order, equal to the reference values ($20 - 70\%$); ($0 - 15\%$) and ($0 - 3\%$). As for the proportions of blood in monocytes ($6.1 \pm 2.85\%$) and in lymphocytes ($61.33 \pm 6.44\%$), they are respectively equal to the reference values ($0 - 10\%$) and ($35 - 75\%$). Concerning the average concentration of red blood cells or erythrocytes ($8.04 \pm 0.9 \cdot 10^6 / \mu\text{L}$), it is higher than the reference values ($5 - 7 \cdot 10^6 / \mu\text{L}$). The average blood hemoglobin concentration ($12.86 \pm 1.13 \text{ g / dL}$) is equal to the reference values ($9 - 13 \text{ g / dL}$). The average hematocrit value ($49.06 \pm 5.26\%$) is higher than the reference values ($36 - 43\%$). Regarding the average blood concentration in MCV ($61.50 \pm 6.98 \text{ fL}$), it equals the reference values ($52 - 62 \text{ fL}$). As for the average blood concentrations in MCHC ($16.44 \pm 1.34 \text{ pg}$) and in AHC ($26.42 \pm 2.59 \text{ g / dL}$), they are respectively below the reference values ($17 - 24 \text{ pg}$) and ($29 - 34 \text{ g / dL}$). The blood concentration for platelets ($289.06 \pm 178.52 \cdot 10^3 / \mu\text{L}$) is equal to the reference values ($200 - 500 \cdot 10^3 / \mu\text{L}$).

Average value of the biochemical parameters of the neutered male and female pigs: Table 5 indicates that the mean values of glucose, total protein, total cholesterol, urea, uric acid and total bilirubin of castrated males are not statistically different ($p > 0.05$) from those of female pigs. In contrast, the mean creatinine value in castrated males is statistically lower ($p \leq 0.05$) than that of female pigs.

Average enzyme activity of castrated male and female pigs slaughtered at SIVAC: The results recorded in Table 6 indicate that the average activity of alkaline phosphatases ($316.21 \pm 78.97 \text{ IU / L}$) of the castrated males is higher ($p \leq 0.05$) than that ($271.17 \pm 76, 43 \text{ IU / L}$) of females. Regarding the average activity of aspartate amino transferase ($88.82 \pm 59.15 \text{ IU / L}$) of males, it is not statistically different ($p > 0.05$) from that ($91 \pm 75.63 \text{ IU / L}$) females. As for the average activity of alanine amino transferase ($100.48 \pm 42.07 \text{ IU / L}$) of males, it is statistically higher ($p \leq 0.05$) than that ($77.62 \pm 27.29 \text{ IU / L}$) females.

Average value of electrolytes in castrated male and female pigs slaughtered at SIVAC: According to Table 7, the average values of electrolytes (calcium, phosphorus, magnesium, sodium, potassium) of the castrated males are not statistically different ($p > 0.05$) from those of the female pigs.

Hemogram of neutered male and female pigs: According to Table 8, there is no significant difference ($p > 0.05$) between the average blood concentrations of leukocytes, erythrocytes, hemoglobin, platelets, neutrophils, eosinophils and basophils, monocytes and lymphocytes of castrated males and those of females. This is also the case for hematocrit, average blood volume and average corpuscular hemoglobin content.

DISCUSSION

The average glucose value obtained during this work is higher than the reference values indicated in the Vade-Mecum du Vétérinaire book, XVIth edition by Fontaine and Cadore (1996). This high average glucose value could be explained by the fact that the feeds formulated by breeders and made

available to pigs are essentially energy. However, the interpretation of variations must remain cautious, taking into account individual factors, the timing of sampling versus food intake and handling stress (Mauget *et al.*, 1988). Concerning the total proteins, the results are in accordance with the reference values presented in the book Vade-Mecum du Vétérinaire, XVIth edition by Fontaine and Cadore (1996). The average value of total cholesterol is higher than the reference values ($2.1-3.5 \text{ mmol / l}$). This could be explained by the sign above all of a diet rich in saturated fats. The maximum level of cholesterol reflects a maximum of fat stores and the lowest cholesterol level is observed in situations of severe food restriction (Walsh *et al.*, 1987; Mauget *et al.*, 1988). These results are in agreement with those of Amoikon *et al.* (2006) who conducted an experiment in LSU, USA, to assess the effect of chromium tripicolinate (TPC) and lysine on growth, carcass and plasma metabolite levels in pigs. Plasma cholesterol levels were reduced by lysine levels in pre-prandial and post-prandial animals. At the end of the test, the levels of non-esterified fatty acids were elevated by lysine, as were those of total proteins. The enzymes studied are Alkaline Phosphatase (ALP), Aspartate Amino-transferase (ASAT) and Alanine Amino-transferase (ALAT). Their mean values are relatively higher than those of the reference values obtained by Fontaine and Cadore (1996). However, these high average values do not suggest a hepatitis problem, since it requires an increase in transaminases between 2 and 10 times normal. This slight increase observed is linked to phenomena that increase membrane permeability such as anoxia, septicemia, trauma, abdominal inflammation (Casseleux, 2007). The results of the blood count (NBF) indicate that the average proportions of blood in granulocytes composed of neutrophils, basophils and eosinophils are equal to the reference values. The same applies to the proportions of blood in monocytes and in lymphocytes which are equal to the reference values. These results are similar to those obtained by Fontaine and Cadore (1996) and Klem *et al.* (2010). According to Klopfenstein *et al.* (2007), the variation in the response of animals subjected to a pathogenic agent is explained by the activity of various cells of the immune system.

The main blood cells involved in immune function are lymphocytes, macrophages, neutrophils and eosinophils. The average concentration of these cells obtained by the NBF shows that the animals intended for slaughter and which are considered healthy according to the ante-mortem examination, are indeed in good health. The average values of hematocrit and hemoglobin remain practically identical to the reference values indicated by Klem *et al.* (2010). The average values of the biochemical parameters (glucose, total protein, total cholesterol, urea, uric acid, total bilirubin) of the castrated male pigs are statistically equal ($p > 0.05$) to those of the female pigs, apart from the average value of creatinine in males which is statistically lower ($p \leq 0.05$) than that in females. This is also the case for the average values of electrolytes (calcium phosphorus magnesium sodium potassium) and the hemogram of castrated male pigs which are statistically equal ($p > 0.05$) to that of female pigs. There is no significant difference between the two sexes ($p > 0.05$). These results are in agreement with those of Elbers *et al.* (1992) who observed differences in value between the blood profiles of castrated males and females. However, these differences were not significant. For the average activities of alkaline phosphatases and alanine aminotransferase, there is a significant difference ($p \leq 0.05$) between castrated males and

females. The mean creatinine value of males is statistically lower ($p \leq 0.05$) than that of females. These results are consistent with those obtained by Klopfenstein *et al.* (2007) who showed that several blood characteristics were different between the two sexes. The difference in blood characteristics is probably a reflection of the differences in zootechnical performance that are well known and documented for males and females (Klopfenstein *et al.*, 2007).

Conclusion

The values of the serum constituents and those of the hemogram obtained through the study are similar to the usual values indicated by Fontaine and Cadore (1996) in the book Vade-Mecum du Veterinary, 16th edition and Klopfenstein *et al.* (2007). These results attest that the animals intended for slaughter, considered healthy according to the ante-mortem examination, are indeed in good health and have a good nutritional status.

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