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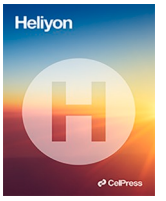

Evaluation of the effect of soaked false yam (*Icacina oliviformis)* tuber meal on the haematological indices and serum biochemistry of rabbits

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ABSTRACT

Background: The exploitations of non-conventional feeds for livestock have sparked great interest due to human-animal competition for conventional feedstuffs. The majority of animal feedstuffs are formulated with grains as the major ingredient, resulting in tautness and an increase in the costs of conventional feeds. This practice has underscored the necessity for an alternatively cheap and sustainable non-conventional feedstuff to salvage the feeding restraint to animal production. With this, the present study aimed at evaluating the effect of soaked false yam tuber meal (SFYTM) on the haematological indices and serum biochemical profile of weaner rabbits.

Methods: Sixteen local weaned rabbits of diversified breeds and sexes were randomly apportioned to dietary treatments containing 0, 10, 15, and 20 % of soaked false yam tuber in replacement for maize in a maize-fishmeal-based diet. Following feeding trials, blood samples from the rabbits were taken and analyzed using haematology and chemistry analyzers.

Results: The haematological assay revealed significant differences ($P < 0.05$) among treatments for red blood cells (RBCs), total white blood cells (TWBCs), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and monocytes. For haemoglobin (Hb), packed cell volume (PCV), mean corpuscular volume (MCV), platelet, lymphocytes, neutrophils, esoniphiles, and basophils, no significant differences ($P > 0.05$) were achieved. With the serum biochemical tests, significantly higher values were obtained for alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT), and sodium relative to the control. Despite some of the evaluated parameters having relatively high values, they tumbled within the normal range of values for a healthy weaned rabbit.

Conclusion: False yam tuber can therefore be exploited as a substitute for maize in rabbits' diets without detrimental effects on the haematological and biochemical markers of the farm animals.

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1. Introduction

The rabbit, being a monogastric herbivore has a fully developed hindgut. Due to the increased costs of traditional sources of meat including cattle, chevon, mutton, pork, and poultry, rabbit farming has recently attracted a lot of interest. Economically, rabbits have many promising prospects. They are very prolific and efficient converters of feed to meat [1], with a great prospect of generating high income on little feed intake, which is economically prudent for rabbit farmers. Rabbits can also be raised for non-food purposes such as high-grade wool production, which can contribute to job creation opportunities. When fed properly with balanced pellets, rabbits grow rapidly in the early stages of their life, with a feed conversion ratio typically around 1:3 [1]. Thus, young rabbits need around 3 kg of pelleted feed to gain 1 kg of added live weight. Young rabbits only consume milk for the first 18–20 days of their lives. After passing through this stage, they begin eating solid foods as the caecum's fermentative activity starts to develop and the enzymatic digestion activities display significant modifications [2]. Rabbits can consume diets dense in roughage and low in grains [3]. They have a short generation gap and reproduce year-round [4]. Therefore, rabbit farming needs to be approached as a serious operation that takes into account all of the many aspects of production. Due to this, a non-conventional feedstuff such as false yam tuber which is readily available with no direct competition with humanity is desired.

False yam with the Latin name of *Icacina oliviformis* belongs to the family Icacinaceae. It is a savannah shrub that is native to Central and West Africa [5]. False yam as an evergreen plant yields three different types of foods: fruits, seeds, and tuberous roots [6]. False yam is recognized as Takwara in Ghana, Pane in Sudan, Bankanas in Senegal, Manankaso in the Gambia, and Urumbia or Eriagbo in Nigeria [7]. The plant spreads quickly in the field and grows naturally, with an undergrowth that resembles yams. Depending on the season and locality, plant yields can be enormous and 20 tons of tubers can be produced [8]. According to studies by Dei et al. [9] and Ansah [6], the false yam tuber is nutrient-dense, containing roughly 74.5 % carbohydrates, 5.41 % crude protein, 1.60 % fat, and 4.2 % crude fiber. Hence, the tuber may possibly aid as a rich source of protein and carbohydrates for rabbits. Although the tubers can act as a good source of feed for animals; the feedstuff contains anti-nutritional components that require removal before use [10]. These anti-nutritional components or factors are not generally fatal but may reduce animal productivity. They however cause toxicity when consumed in large quantities by farm animals [11]. They include hydrocyanic acid, oxalic acid, alkaloids, phytic acid, and tannin with

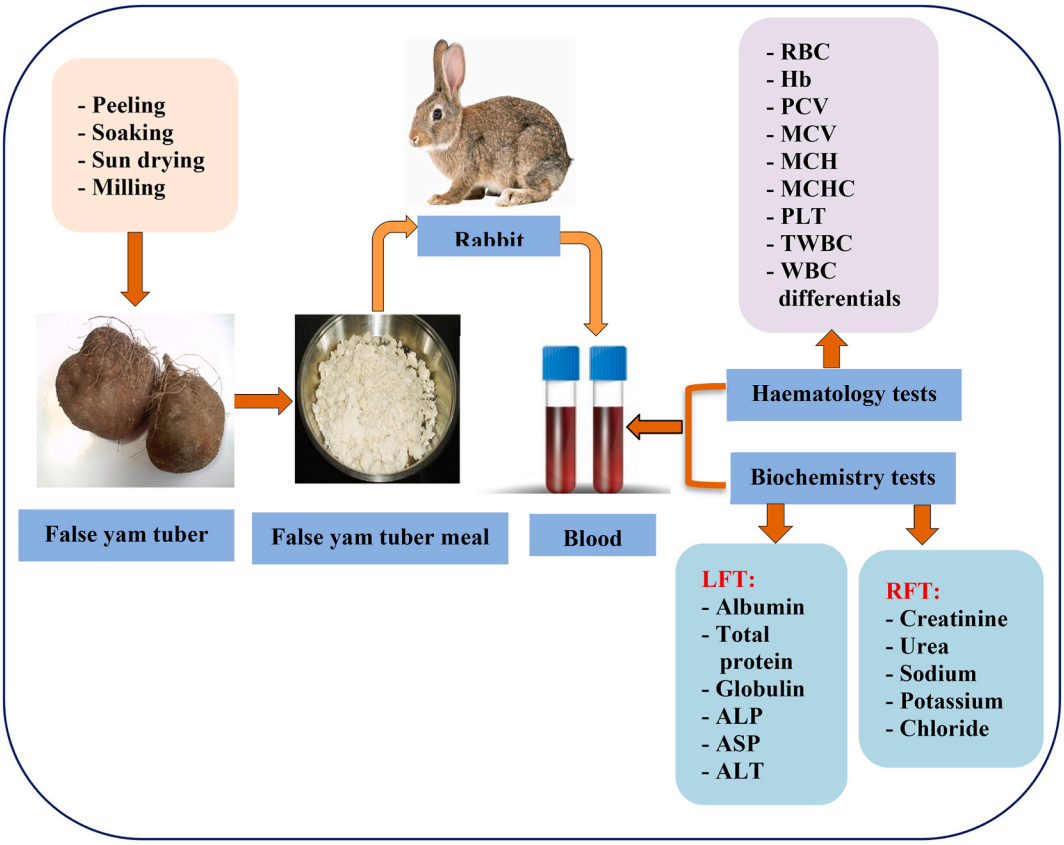

Fig. 1. Schematic representation of the various activities of the study. RBC = Red blood cell, Hb = Haemoglobin, PCV = Packed cell volume, MCV = Mean corpuscular volume, MCH = Mean corpuscular haemoglobin, MCHC = Mean corpuscular haemoglobin concentration, PLT = Platelet, TWBC = Total white blood cell, WBC = White blood cell, RFT = Renal function test, LFT = Liver function test, ALP = Alanine phosphatase, AST = Aspartate aminotransferase, ALT = Alanine aminotransferase. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

a bitter taste [12]. The undesirable anti-nutritional components of the false yam can be removed through processing methods such as soaking, boiling, fermentation, or charcoal treatments [9]. Among these methods, soaking has been established as the best approach to the removal of the anti-nutritional elements from false yam [9]. The soaking technique reduces the anti-nutritional elements in the yam while improving its nutritional quality [9]. Studies have investigated processed false yam tubers as feeds for rabbits, with demonstrated great performance in growth and carcass characteristics [13,14]. However, this type of feeding has not been studied in raw false yam, as the presence of the bitter anti-nutritional factors in the raw yam tubers inhibits rabbits from ingestion the feedstuff.

Feeding has been a major challenge in monogastric animals' production, particularly for rabbits. According to Dei et al. [15], maize has been the principal cereal grain used as a dietary source of energy, which forms the major fraction (40–70 %) of the diet of non-ruminants. In nations such as Ghana, maize, which makes up the majority of concentrate feed for livestock is in scarcity and costly due to human-animal competition. The inadequacy and rise in prices of maize have adversely struck the productivity of livestock farming. An effort to tackle this feed issue requires the use of a non-conventional feed ingredient such as false yam tuber as an alternate dietary source of energy for rabbits. Despite the enormous prospect of the false yam tuber as a substitute for maize in rabbit feedstuffs, it is crucial to evaluate the blood and chemistry biomarkers of rabbits fed with the prepared false yam tuber meal to ascertain the safety of the diet for the farm animals. According to Njidda and Isidahomen [16], the ingestion of a diversity of dietary ingredients has significant effects on blood components. Even though nutrient levels in the blood and bodily fluids may not be a reliable indicator of nutritional action at the cellular level, Negesse et al. [17] highlighted that they are regarded to be proximal indicators of long-lasting nutritional status. As a result, the current study aimed at exploring false yam tuber meal as a feed source for rabbits, and evaluate its resultant effect on the haematological profile and serum biochemical indices of weaner rabbits. The outcome of this study will substantiate false yam tuber as a less expensive, and economically valuable alternative feed for rabbits. Additionally, the haematology and chemistry assays on the soaked false yam tuber meal (SFYTM) fed rabbits will validate the safety of the feedstuff. However, the major limitation of the current study is the probable minute residue of the anti-nutritional factors in the false yam tubers, even after processing, which could affect the true reflection of the impact of the yam tubers on the blood parameters of the rabbits.

2. Materials and methods

2.1. Study design

The study was conducted at the Rabbitry Unit of the Department of Animal Science, Faculty of Agriculture of the University for Development Studies, Nyankpala in Ghana. The study solely focused on feed formulation, rabbits' management in cage houses, and laboratory investigations to evaluate the effect of the soaked false yam tuber meal on the haematological profile and serum biochemical indices of weaner rabbits. The schematic illustration in Fig. 1 recapitulates the specific activities that were undertaken to attain the goal of the study.

2.2. False yam collection and preparation

The false yam tubers for the study were manually harvested within the environs of the University for Development Studies, Nyankpala Campus, in the northern part of Ghana. The freshly harvested tubers were peeled with a knife and sliced into small pieces. Following the method described by Alagma [18] for false yam incorporation in broilers' diets, the sliced tubers were soaked in water

Table 1
Composition and chemical analysis of the experimental diets.

Diet ingredients	Inclusion levels of soaked false yam tuber meal			
	0 % SFYTM	10 % SFYTM	15 % SFYTM	20 % SFYTM
Maize	60	54	51	48
Soaked false yam tuber meal	0	6	9	12
Fishmeal (64 % CP)	6.5	6	6	6
Wheat bran	29.5	28	28	28
Soybean meal (48 % CP)	3	5	5	5
Oyster shell	0.8	0.8	0.8	0.8
Common salt	0.2	0.2	0.2	0.2
Total	100	100	100	100
Analyzed chemical composition (%)				
Crude protein	5.5	5.5	5.5	5.5
Crude fibre	7	7	7	7
Carbohydrate	84	84	85	85
Ether extract	1.2	1.2	1.2	1.2
Calcium	0.8	0.8	0.8	0.8
Phosphorus	0.7	0.7	0.6	0.6
Lysine	0.6	0.6	0.6	0.6
Methionine	0.3	0.3	0.3	0.3
Digestible energy (Kcal/kg)	2921	2869	2836	2807

*CP = Crude protein, SFYTM = Soaked false yam tuber meal.

for 12 days, with the water being changed every 3 days. After 12 days of soaking, it was then sun-dried on a concrete floor to a moisture content of about 12 %, milled, and stored in a clean container for the diet formulations.

2.3. Experimental animals and design

Sixteen (16) local weaned rabbits of diversified breeds and sexes with similar ages (8 weeks) and weights (350.2 g) were purchased from rabbit farmers in Nyankpala in the northern part of Ghana. The zone is characterized by a wide diurnal temperature variation of 28–45 °C, with low day-time humidity (17–42 %) during the dry season from November to April. The rabbits were divided into four groups of four rabbits per group. The groups were tagged as A, B, C and D for 0 (control), 10, 15, and 20 % inclusion levels of the soaked false yam tuber meal respectively. Each group represents treatment with four replications per treatment in a complete randomized block design (CRBD). Soaked false yam tuber was used to replace maize (w/w) in maize-fishmeal-based diets at the different inclusion levels (0, 10, 15, and 20 %). Each replicate was allocated one of the treatment diets. Feed and water were provided *ad-libitum* (thus, as often as desired) to the rabbits for eight weeks.

2.4. Experimental diet formulation

The investigational diets were prepared to contain 0, 10, 15, and 20 % inclusion levels of the soaked false yam tuber. During the dietary formulations, the nutritional composition of the yam tuber was taken into consideration. The diets were formulated to have equivalent caloric contents and isonitrogenous. The composition and evaluated chemical analysis of the formulated diets of the study are shown in Table 1.

2.5. Experimental animals' management

The weaner rabbits were housed in wooden cages with a wire-mesh floor (0.52 m × 0.53 m = 0.28 m^2). The cages were kept in a cool, spacious, and well-ventilated chamber under a standard temperature (29 °C.), relative humidity (40 %), and light/dark cycle (12 h). Each cage had one rabbit. Rabbits were fed twice a day (morning and evening) with the formulated diets and water provided *ad-libitum*. Medication was administered when necessary and the rabbits were kept in a calm place to ensure maximum feed intake. The rabbits showed a positive attitude towards the experimental diets, which resulted in overall good well-being and maintenance of the live weight of the farm animals.

2.6. Rabbits' blood sample collection and analysis

At the climax of the eight weeks of feeding trials, four rabbits from each treatment were selected for blood collection. Blood samples were collected using the ear-vine procedure as described by Ansah and Aboagye [13] with slight modifications. The rabbit ear was punctured with a lancet and the flowing blood was collected into EDTA (Ethylenediaminetetraacetic acid) and clot activator (non--anticoagulant) tubes for the haematology and biochemistry tests respectively. The sample tubes were then labeled, kept in a cooled condition, and transported to the laboratory for analysis. Using the haemo-analyzer (Sysmex Haematology Analyser, XS-500i, Sysmex Europe GmbH, Norderstedt, Germany), the following haematological indices were evaluated: PCV, Hb, RBC, WBC, MCV, MCH, MCHC, TWBC, platelets, lymphocytes, monocytes, neutrophils, esoniphiles and basophils. The serum biochemistry analysis was conducted with the automated chemistry analyzer (AU480 Chemistry Analyzer, AU480, Beckman Coulter, Brea, California). Liver function parameters including total proteins, albumin, globulins, alkaline phosphate, aspartate aminotransferase, and alanine aminotransferase were assessed. Renal function biomarkers encompassing creatinine, blood urea, sodium, potassium, and chloride were also evaluated as part of the serum biochemical indices.

Ethical approval

Ethical authorization was obtained on February 15, 2018 from the Department of Animal. Science, Faculty of Agriculture of the University for Development Studies, Ghana. All experiments were inspected and approved by the appropriate ethics committee in acquiescence with the institutional ethics approved guidelines under globally acceptable best practice welfare standards for the safe keeping and usage of animals for scientific intents.

2.7. Statistical analysis

The experimental outcomes were presented as mean ± standard deviation (SD). Data were analyzed with GENSTAT (Version 3, Edition 8) statistical tool. A one-way ANOVA was employed in the statistical comparisons of mean values among treatments. An independent *t*-test was also used to test significant differences among treatments for each haematology and biochemical parameter. P-values less than 0.05 ($P < 0.05$) were considered statistically significant and were separated using the Least Significant Difference (LSD).

3. Results and discussion

3.1. Haematological indices

Haematological indices are a measure of the impacts of dietary actions on an animal, regarding the nature and quantity of feedstuff consumed by the animal to meet its physical, chemical, and biological processes [19]. Table 2 displays the findings of the effect of soaked false yam tuber meal (SFYTM) on the haematological indices of weaner rabbits. The results showed that all three treatments of the SFYTM (100, 150, and 200 g/kg) significantly increased the number of red blood cells (RBCs), total white blood cells (TWBCs), and monocytes count, particularly at the highest dose of 200 g/kg. The RBC, TWBC, and monocytes count findings, while higher than the control, all fell within the accepted range of values reported by Hein and Hartmann [20] for normal weaned rabbits: RBC (5.36 - 8.13 $\times 10^{12}$/l), TWBC (3.012 - 11.9 $\times 10^{9}$/l) and monocytes count (15–25 %). The RBC, TWBC, and monocyte parameters were established to increase with an increase in SFYTM levels in diets. Increased RBC readings that are within the normal range may be associated with high-quality food protein and animals that are disease-free [16]. RBCs are involved in the transportation of oxygen from the respiratory organs to other bodily tissues, hence there would be smooth transportation of oxygen through the circulatory system of the SFYTM-fed rabbits.

Monocytes form the largest proportion of WBCs. They are recognized as one of the body's defense mechanisms against harmful pathogens. The TWBCs and monocytes in the blood of the experimental animals were higher than those in the control group, but they still fell within the normal range, indicating that the animals were healthy and not battling any form of infection. According to Ahamefule et al. [21] elevated values of WBCs (leucocytosis) in the blood indicate the presence of a recent infection, whereas allergic conditions, anaphylactic shock, and certain parasitisms are all indicated by a decrease in the number of WBCs below the normal range. False yam tuber has been reported to contain some anti-nutritional factors [13,22]. These anti-nutritional factors might have possibly caused some stresses as well as triggered certain immunological reactions in the SFYTM-fed rabbits, leading to a rise in their TWBC and monocyte values and not necessarily the influence of the false yam tubers. Such stresses may result from underscoring infections, insufficient food ingestion, and high environmental inducements such as heat waves, which might have influenced the immunity of the rabbits. Franci et al. [23] conducted a study on the influence of thermal and dietary stress on the immune response of rabbits and discovered that heat stress and dietary constraint have a significant impact on the functionality of rabbits' immune cells.

A substantial decrease in mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were observed among treatments compared to the control in contrast to the RBC, TWBC, and monocyte counts. The decrease in MCH and MCHC was inversely proportional to an increase in SFYTM levels in diets. Thus, the higher the amount of SFYTM in formulated diet, the lower the MCH and MCHC. MCH represents the mass of haemoglobin present in flowing red blood cells. A low MCH value below the reference range depicts low haemoglobin production or the existence of iron deficiency anaemia [24]. MCHC refers to the measurement of the amount of hemoglobin present in a specific quantity of packed red blood cells. It gives the RBCs' average hemoglobin concentration. A reduced MCHC in the blood of an organism indicates possible hypochromic microcytic anaemia [25]. However, since the MCH and MCHC all fell within the normal range of values (MCH: 18.37–28.06 Pg and MCHC: 11.3–38.5 g/dL) reported by Hein and Hartmann [20] for a healthy weaned rabbit, their reduced levels could not cause any major threat to the rabbits.

Aside from the RBCs, TWBCs, MCH, MCHC, and monocytes that revealed significant differences ($P < 0.05$) relative to the control, the other haematological indices (Hb, PCV, MCV, platelet, lymphocytes, neutrophils, eosinophils and basophils) did not display any

Table 2
Effect of soaked false yam tuber meal on haematological indices of weaner rabbits.

Parameter	Inclusion levels of soaked false yam tuber meal				P-value	Normal Range (Ref)
	Control diet (0 % SFYTM)	100 g/kg (10 % SFYTM)	150 g/kg (15 % SFYTM)	200 g/kg (20 % SFYTM)		
RBC (10^{12}/L)	5.30 ± 0.01^{b}	5.60 ± 0.04^{ab}	5.82 ± 0.25^{b}	6.10 ± 0.30^{a}	0.013*	5.36 - 8.13
Hb (g/dL)	13.60 ± 0.20	11.20 ± 0.01	11.30 ± 0.01	11.70 ± 0.21	0.206	11.33 - 17.13
PCV (%)	37.30 ± 0.04	38.70 ± 0.02	37.70 ± 0.20	41.90 ± 0.01	0.272	36–55
MCV (f/L)	70.30 ± 0.12	70.70 ± 0.23	69.30 ± 0.07	68.60 ± 0.12	0.837	59.3–75.6
MCH (Pg)	25.50 ± 0.01^{a}	19.80 ± 0.14^{b}	18.72 ± 0.20^{b}	17.10 ± 0.00^{b}	0.016*	18.37 - 28.06
MCHC (g/dL)	36.00 ± 0.02^{a}	30.00 ± 0.01^{b}	28.00 ± 0.14^{b}	25.00 ± 0.02^{b}	0.001*	11.3–38.5
PLT (10^{9}/L)	198.00 ± 0.24	199.00 ± 0.22	204.00 ± 0.05	206.00 ± 0.11	0.204	193–725
TWBC (10^{9}/L)	3.92 ± 0.03^{b}	5.17 ± 0.02^{b}	6.60 ± 0.33^{ab}	7.24 ± 0.01^{a}	0.003*	3.012 - 11.9
Lymphocytes (%)	13.80 ± 0.04	17.80 ± 0.14	11.10 ± 0.20	15.10 ± 0.05	0.210	32–81
Monocytes (%)	11.50 ± 0.22^{b}	13.20 ± 0.12^{b}	15.40 ± 0.04^{ab}	17.90 ± 0.14^{a}	0.021*	15–25
Neutrophils (%)	73.80 ± 0.05	70.30 ± 0.25	73.70 ± 0.01	70.90 ± 0.16	0.528	15–86
Eosinophils (%)	0.53 ± 0.01	0.38 ± 0.11	0.39 ± 0.28	0.39 ± 0.01	0.106	0–1
Basophils (%)	0.34 ± 0.50	0.67 ± 0.06	0.68 ± 0.32	0.74 ± 0.01	0.151	0–7

RBC = Red blood cells, Hb = Haemoglobin, PCV = Packed cell volume, MCV = Mean corpuscular volume, MCH = Mean corpuscular haemoglobin, MCHC = Mean corpuscular haemoglobin concentration, PLT = Platelet, TWBC = Total white blood cells, Ref = Reference for normal range of values [20]. *SFYTM = Soaked false yam tuber meal.* Data are presented as mean ± SD. * = Parameters with significant differences ($P < 0.05$) among treatments. Means of inclusion levels of soaked false yam tuber meal in a row containing different letter superscripts (a & b) are significantly different ($P < 0.05$), whereas those with the same letter superscripts (a & a or b & b) are not significantly different ($P > 0.05$).

significant difference (P > 0.05) among treatments. The PCV, Hb, and MCHC are the most reliable blood indices for determining an animal's health status, according to Njidda and Isidahomen [26]. The obtained result for these reliable parameters coupled with the other indices, all tumbling within the normal range of values for a healthy weaned rabbit, indicates that the SFYTM could not pose any negative effect on the overall health of the experimental animals. A similar trend of findings was reported by Mia et al. [27] who investigated the influence of false yam tuber meal on the haemato-biochemical changes in growing broilers. Although their study employed broilers as opposed to rabbits in the present study, the three reliable blood indices (PCV, Hb, and MCHC) for determining the overall health status of farm animals were statistically unaffected at 9 % inclusion levels of the SFYTM. Hence, false yam tuber can be incorporated into the diet of rabbits as a safe alternative feedstuff to conventional ingredients.

3.2. Serum biochemistry

3.2.1. Liver function test

The blood biochemical profile reflects the physiological status of an animal resulting from nutrition, pathogenic agents' actions, and welfare level or breeding technology [28]. The result of the liver function test on the SFYTM-fed rabbits is presented in Fig. 2. The liver enzyme, alkaline phosphatase (ALP), aspartate aminotransferase (AST), alkaline phosphatase (ALP), and alanine aminotransferase (ALT) were the only parameters that recorded a significantly higher result than the control, which occurred at the 20 % (200 g/kg) and 15 % (150 g/kg) inclusion levels of the SFYTM. The 20 % inclusion level gave a considerably higher value in all the three liver enzymes assessed, relative to the control. The 15 % inclusion level of the SFYTM gave a greater value than the control only in the ALT test. Even though the above liver enzymes findings of the study were quite higher than the control, they all fell within the normal and reference range for healthy weaned rabbits (ALP: 0–397 U/L, AST: 10–280 U/L, and ALT: 20–109 U/L) [20]. With the 10 % (100 g/kg) inclusion level of the SFYTM, no significant difference (P > 0.05) was recorded, except for the ALP analysis, where a substantially lower value was obtained compared to the control experiment. However, the relatively low value of the 10 % inclusion level for the ALP test also fell within the normal range of values for a healthy weaned rabbit. Hence, could not pose any detrimental effect on the health of the rabbits.

ALP as a liver enzyme triggers biological processes in the body of an organism. The liver, kidneys, bones, and intestines all contain significant amounts of ALP. According to Stacy et al. [29] variables including age, gender, and blood type affect the levels of the ALP enzyme in the blood. Therefore, factors other than the SFYTM, such as the rabbits' age, gender, blood type, bones, and intestines, could be accountable for the reduced ALP in the blood of the 10 % inclusion level of the SFYTM-fed rabbits.

AST enzyme aids in the metabolic processes of amino acids. They are present not only in the liver organ but also in the kidney, lungs, brain, heart, and skeletal muscles [30]. AST is transported into the blood if any of these tissues are injured. With this, the obtained high values of AST, particularly with the 20 % inclusion level of the SFYTM relative to the control could be ascribed to the release of AST enzymes from other bodily tissues and not necessarily to the effect of the SFYTM on the experimental rabbits' livers. With ALT enzymes, they are typically present in liver cells. They are crucial for producing bile, storing nutrients, and the removal of toxins. Although high ALT levels are problematic, they do not always signify a major liver threat. High ALT levels in the blood might suggest an acute ailment as well as mild or critical liver damage [31].

Apart from the liver enzymes (ALP, AST, and ALT) that recorded some high and low values compare to the control, the other liver

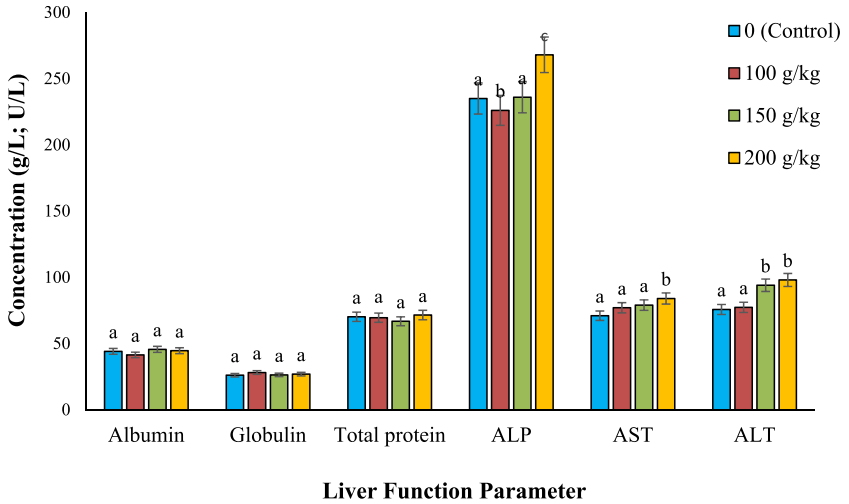

Fig. 2. Effect of soaked false yam tuber meal on liver function parameters of weaner rabbits. 0 (Control) = 0 % SFYTM, 100 g/kg = 10 % SFYTM, 150 g/kg = 15 % SFYTM, 200 g/kg = 20 % SFYTM. ALP = Alkaline phosphatase (U/L), AST = Aspartate aminotransferase (U/L), ALT = Alanine aminotransferase (U/L). The letters a, b and c are used to denote significant differences among treatments. Thus, parameters with different letters (a & b or a & c or b & c) for individual treatments are significantly different (P < 0.05), whereas those with the same letters (a & a or b & b) are not significantly different (P > 0.05) statistically.

parameters (albumin, globulin, and total protein) did not show any significant differences ($P > 0.05$) relative to the control. According to Njidda and Isidahomen [16] and Onifade and Tewe [32] an organism's protein ingestion has a significant impact on the levels of albumin, globulin, and total proteins. The values for total proteins, albumin, and globulin in this study were analogous to that of the control, which indicates the nutritional adequacy of the dietary proteins in the SFYTM.

3.2.2. Renal function test

The renal function test encompasses a group of examinations performed to assess abnormalities in the kidney. The test is typically used to evaluate the kidney's functioning capacity. The experimental outcome of the renal function assessment of the SFYTM-fed rabbits is presented in Fig. 3. Except for sodium, where a significant difference ($P < 0.05$) existed between treatments (10, 15, and 20 % of the SFYTM) and the control, the other biochemical parameters (creatinine, urea, potassium, and chloride) did not show any significant differences ($P > 0.05$). Thus, the sodium level in the individual treatments was significantly higher relative to the control.

Sodium plays an essential role in functions including muscular contractions, nerve impulse productions, and fluid homeostasis activities. Blood pressure can rise as a result of sodium and fluid retention in bodily tissues and blood, which may further impair weak kidneys [33]. A chronic renal disease may develop if there is an increase in serum sodium levels outside of the normal range [33]. The obtained high result of sodium compared to the control, however, tumbled within the normal and acceptable range of values (139–149 mmol/L) [20] for a healthy weaned rabbit, hence could not pose any serious risk to the kidney of the experimental rabbits.

The comparatively high levels of sodium in the serum of the experimental rabbits to that of the control could be attributed to insufficient water intake by the rabbits during management inside the cage. According to He et al. [34], insufficient fluid intake or excessive water loss confers hypernatremia (high sodium concentration). Apart from sodium, the other biochemical parameters (creatinine, urea, potassium, and chloride) assessed did not show any significant differences among treatments and the control, with all outcomes tumbling within the established normal range of values for healthy weaned rabbits (creatinine: 34–166 mmol/L, urea: 2.05–8.42 mmol/L, potassium: 3.7–6.3 mmol/L and chloride: 93–109 mmol/L) [20]. The result of the renal function test implies that the inclusion of the SFYTM in the feed of the rabbits could not pose any substantial negative effect on the kidneys of the animals, warranting the safety of the yam tuber incorporation in the rabbits' feed.

4. Conclusion

This study investigated the impact of soaked false yam tuber meal (SFYTM) on the haematological indices and serum biochemical markers of weaner rabbits. The inclusion of 100, 150, and 200 g/kg of false yam tuber as an alternate for maize in the diets of the rabbits had no undesirable impact on the blood parameters assessed. Although some of the parameters including RBC, MCH, MCHC, TWBC, ALP, AST, ALT, and sodium were found to be higher, particularly at the 200 g/kg inclusion level but had no significant impact on the overall health status of the rabbits. Hence, soaked false yam tubers could potentially replace maize in rabbits' diets without endangering the well-being of the farm animals. Further studies on disease conditions and causal rudiments such as changes in the environment (new cage, new location, etc) that may cause stresses in rabbits and alter blood parameters are recommended. Moreover, other treatment methods such as boiling, fermentation, and charcoal treatment in aid of the anti-nutritional constituents' removal should be investigated to ascertain safety and maximize the ingestion of the false yam feeds by rabbits.

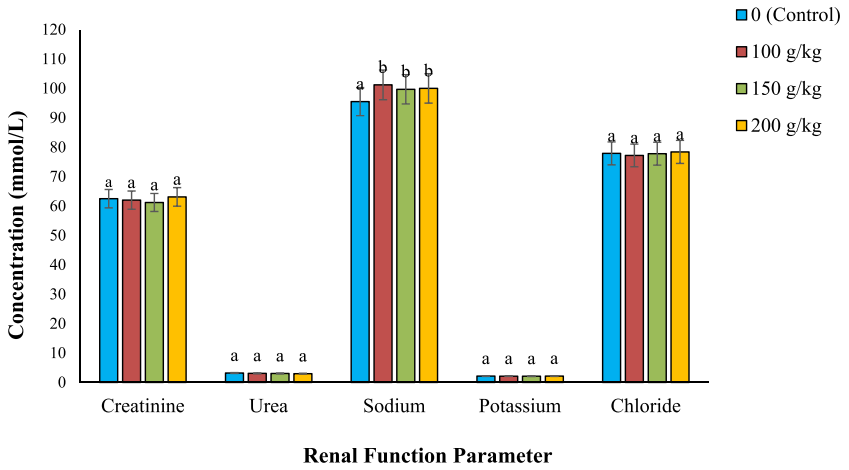

Fig. 3. Effect of soaked false yam tuber meal on renal function parameters of weaner rabbits. 0 (Control) = 0 % SFYTM, 100 g/kg = 10 % SFYTM, 150 g/kg = 15 % SFYTM, 200 g/kg = 20 % SFYTM. Different letters (a & b) indicate a statistically significant difference ($P < 0.05$) among treatments, whereas those with the same letters (a or b) are not significantly different ($P > 0.05$).

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Data will be made available upon request.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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