Original Research Article

EFFECT OF FEEDING ALBINO RATS WITH ACHA- ORANGE FLESHED SWEET POTATO BLENDS ON THE BLOOD GLUCOSE LEVEL AND HEMATOLOGICAL PARAMETERS

ABSTRACT

Aims: To investigate the the health as well as the physiological status of farm animals.

Study design: We formulated seven (7) samples from acha and orange fleshed sweet potato mixture with two (2) samples serving as control.

Place and Duration of Study: Department of Food Science and Technology, Faculty of Agriculture and Life Sciences, Federal University Wukari between February 2022 and May 2022.

Methodology: The orange fleshed sweet potato flour was mixed with acha flour separately at different proportions (100:0, 95:5, 90:10, 85:15, 80:20, 75:25 and 0:100) while one hundred percent (100%) acha flour and orange fleshed sweet potato was used as the control. Bone meal(10%), blood meal(10%) and salt(5%) were added to each sample. The albino rats were kept in a cage in five (5) segments and the blends were fed to the rats for 21 days and 100g of the formulated feed were weighed into plates in each segment. The daily weight of the albino rats was measured.

Bioassay parameters including feed and water intake, and body weight were evaluated. Hematological properties including hemoglobin, red blood cell, white blood cell, mean cellular volume, mean cellular hemoglobin, and mean cellular hemoglobin concentration of the albino rats were also measured.

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Comment [D4]: Evaluated bioassay parameters including feed and water intake, and body weight.

Results: Result of feed intake/weight gain revealed that the rats fed with 0% OFSP showed highest values for the duration of 21 days. The weight of kidney, liver and heart of the albino rats decreased from 1.23 to 1.05, 5.65 to 2.65 and 1.28 to 0.23g, respectively, while the carcass increased from 104.55 to 111.55g upon OFSP substitution.

Conclusion: The result of this study revealed that locally available food commodities such as acha and orange fleshed sweet potato can be utilized to produce a protein-rich complementary food that is capable of combating malnutrition among children. A protein and carbohydrate rich weaning food that is comparable to commercial weaning food (cerelac) can be strategically formulated from the blends of acha and orange fleshed sweet potato (75:25).

Keywords: feed Intake; hematological properties; orange-fleshed sweet potato; rat study; weight gain.

Introduction

Acha (*D. exilis*) also known as fonio is of considerable importance in Nigeria where it is commonly eaten, often in preference to other cereals, as many as three times a day as a porridge, couscous or non-alcoholic beverage, valued as a weaning food because of its low bulk and high caloric density with minimal processing requirement, and it can be used as livestock feeds, (e.g. feeding of albino rat using acha and orange fleshed sweet potato).

Acha (*D. exilis*) is an annual, erect herbaceous plant of the family Graminae which reaches stature heights from 30 to 80 centimetres. The ears consist of two to five narrow part ears, which are up to 15 centimetres long. The spikelet comprises a sterile flower and a fertile flower, the latter of which gives rise to the fonio grain [1]. The grain is a caryopsis, which remains surrounded by glumes and husks. Its size is very small, only 1.5 mm (around 2000 seeds to 1 gram). It grows in fresh water condition and even where rainfall and soil fertility

Comment [D5]: **Results:** The result of feed intake/weight gain revealed that the rats fed with 0% OFSP showed the highest values for 21 days.

Comment [D6]: The kidney, liver and heart weight of the albino rats decreased from 1.23 to 1.05, 5.65 to 2.65 and 1.28 to 0.23g, respectively, while the carcass increased from 104.55 to 111.55g upon OFSP substitution.

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Comment [D14]: Acha (*D. exilis*) is an annual, erect herbaceous plant of the family Graminae, reaching stature heights from 30 to 80 centimetres.

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are poor and can be stored in closed containers for many years without need of preservatives and this makes it suitable for livestock production [2]. Despite its valuable characteristics and widespread cultivation, fonio has generally received limited attention research and development, which is also why the species is sometimes referred to as an underutilized crop [1]. Acha is one of the oldest African cereals and is classified as an underutilized crop [3]. The grain is uniquely rich in methionine and cystine, and evokes low sugar on consumption [4].

While acha are cereal crops, orange fleshed sweet potato (*Ipomoea batatas*) are root and tuber crops, the play a significant role in agriculture and facilitate food security in many developing countries. In the year 2017 worldwide, 494.6 million tons of roots and tubers (including potato) are produced [5]. Roots and tubers are part of diet for majority of the global population, with world average per capita consumption of 19.4 kg/year (2013–2015) and projecting to achieve 21.0 kg/year by 2025 [6] and also contributing to animal feeds and industrial needs (starch source). Among the roots and tubers, orange fleshed sweet potato (*Ipomoea batatas*) is very important on the basis of production and consumption. Sweet potato is a dicotyledon associated with Convolvulaceae family and ranks worlds' seventh most important food crop [7]. It is a potential energy contributor and considered as fifth essential crop (fresh weight basis) after rice, wheat, maize, and sorghum [8]. Currently, its cultivation was reported in more than 115 nations [5], and SP was recognized as the secondary staple food and possess significant role in diet of humans in many underdeveloped countries [9]. In contrast to the other staple food crops, [10] defined that orange fleshed sweet potato possess special attributes such as adoptability in wider topography, ability to grow in subsidiary circumstance, good productivity in short durations, and balanced nutritional composition. Sweet potato was reported to have good sensory acceptability due to the eye-pleasing colors and sweet taste. This high sensory acceptability of some varieties was suitable

Comment [D17]: It grows in fresh water condition and even where rainfall and soil fertility are poor and can be stored in closed containers for many years without preservatives, making it suitable for livestock production [2].

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in malnutrition management and facilitating food security in underdeveloped nations [11]. Orange fleshed sweet potato is considered as the food security crop due to its low agriculture input requirements and high yields in wider climatic conditions [12]. It is recently changing from a sustainable low-input, low-output crop to a significant cash crop. As a food security crop, it can be harvested at the point of demand as gradually [13], also contributing to a reliable source of food and revenue to pastoral farmers who are frequently susceptible to regular crop damages. The utilization of acha orange fleshed sweet potato in the food product will lead to improvement of protein, minerals, antioxidant, and vitamin content level of albino rat fed with it. Orange fleshed sweet potato has considerable potential to contribute to a food-based approach to tackle the problem of nutrient deficiency, a major public health concern of the poorer sections. Thus, there is a great possibility of this subsistence crop for being adopted as regular diet of the consumer food chain to supplement as an alternative staple food source for the resource poor farmers in the era of extensive population growth and nutrition crisis. However, a large number of consumers are not aware of the nutritive value of some high yielding orange-fleshed sweet potato cultivars. Moreover, the biochemical constituent of orange-fleshed sweet potato varies among the genotypes. Therefore, assessment of the nutritional contribution of this crop is essential for creating awareness of its high nutritional benefits. In 2020, TAAT [14] Clearing house hosted a program in Africa with the goal of improving cultivation, storage and utilization of potato. One of TAAT's priority commodities is the Orange Fleshed Sweet Potato (OFSP). They described it as "a biofortified crop with huge potential to improve food and nutritional security across Africa". In the course of its development, ProPAS has accumulated several technologies that specifically address this commodity and compiled them into a "technology toolkit" designed to advance understanding and encourage adoption and investment into the proven agricultural solutions that advance this crop. Orange Fleshed Sweet Potatoes (OFSPs) is an excellent nutrition

Comment [D31]: In 2020, TAAT [14] Clearing house hosted a program in Africa to improve cultivation, storage, and utilization of potato.

sensitive function food. It contains dense amount of carotene and is also rich in proximate nutrients. A wide number of cultivars of OFSPs has been developed worldwide, particularly in sub-Saharan Africa and Asia and several researches targeting Vitamin A deficiencies have been conducted on it [9, 15, 16, 17, 18]. However, to the best of our knowledge, no study has focused on its proximate composition and nutritional qualities aside from vitamin. No study has also utilized it with acha (fonio).

Therefore, this study investigates the relevance of orange fleshed sweet potato in alleviating malnutrition and complementary to this study, assessment of nutritional quality of the orange-fleshed sweet potato mixed with acha (fonio) were made for promoting its consumption using albino rats as test animals.

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Material and Methods

Materials

Acha grains (*Digitaria exilis*) and orange fleshed sweet potato were purchased from a local market in Wukari. The Albino rats were bought from a local livestock production site in Calabar, Cross River, Nigeria. The cage for keeping the albino rats were locally made in Wukari.

Sample preparation

Preparation of Acha Flour

Acha flour was produced using the method described by [19]. Acha grains were winnowed to remove chaff and dust. Adhering dust and stones were removed by washing in water (sedimentation) using local calabashes and floating foreign materials by decanting. The washed and destoned grains were drained and dried in a cabinet drier (Model: CD0005, FT3) at 40 ^{0}C to a moisture content of about 12%. The dried grains were milled using Attrition

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milling machine (Inch15HP Super 150-180 Kilogram Tw-HM-1016) and sieved (0.3 µm aperture size). The flour was packaged in polyethylene bag and stored at 5°C as acha flour for later use.

Preparation of Orange Fleshed Sweet Potato flour

Fresh Matured orange fleshed sweet potato tuber were obtained. Washed, sorted, peeled, sliced and steam blanched (Hughes Blancher Model #:02-1471) for 3min. The sliced orange fleshed sweet potato tuber were dried at 40°C in oven (San-Del Model 50) and milled using attrition mill (Inch15HP Super 150-180 Kilogram Tw-HM-1016) and sieved (0.3µm aperture size). Packaged in a polyethylene bag and stored (at temperature 5 °C). This was done as described by [20].

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Formulation of flour blends

The orange fleshed sweet potato flour was mixed with acha flour separately at different proportions as shown in table 1 below using a completely randomized design (CRD). Bone meal (10%), blood meal (10%) and salt (5%) were added to each sample. The flours were thoroughly mixed using a Kenwood blender to a uniform blend by [21].

Table 1: Acha-Orange flesh sweet potato blend formulation

Samples	Acha	OFSP
AO1	100	0
AO2	95	5
AO3	90	10
AO4	85	15
AO5	80	20
AO6	75	25
AO7	0	100

OFSP is orange-fleshed sweet potato

Feeding of Albino Rats

The feeding of albino rat was done for 21 days in a cage which was contracted into 5 segments with each segment carrying three albino rats. They were fed with acha-orange fleshed sweet potato blends. 100g of the formulated feed were weighed into plates in each segment. Leftovers of the feed were measured to know the amount of feed consumed by the albino rats. Plastic bottles were constructed for water intake on each segment of the cage with openings that permit sucking from the bottle. The daily weight of the albino rats was measured. After feeding the rats for 21 days, the albino rats were then sacrificed using mechanical method of making them unconscious and were dissected to get out the heart, liver, kidney and carcass. The weight of the organs and carcass were also measured and recorded.

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Rats, Housing, Diets and Experimental plan:

Fifteen (15) albino rats (male and female) of the Wistar strain (*Rattus norvegicus*) were purchased from Gboko, Benue state, Nigeria. The rats were divided into 5 major groups (0, 5, 10, 15, 20, 25 % acha – orange fleshed sweet potatoes flour blends) which were apportioned into separate cages. The rats were housed in metabolic cages and fed diets and tap water *adlibitum* for 21 days. All the rats were initially fed commercial rat diet for four days for acclimatization and then weighed. The quantity of feed and water consumed were measured daily from the quantity of feed and water supplied the previous day and the quantity remaining after 24 h.

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Proximate Composition Determination

The proximate analysis of samples for moisture content, crude protein, ash, Crude fat, Carbohydrate and crude fiber was carried out on the flour formulations using the standard AOAC [22] procedure.

Evaluation of Bioassay Parameters

Evaluation of feed and Water Intake: The quantity of feed and water consumed was measured daily from the quantity of feed and water supplied the previous day and the quantity remaining after 24 h.

Body weight measurement: The increase in body weight was measured each for 21 days study period with standard weighing balance. The nutritional qualities of the acha-orange fleshed sweet potato flour was determined using the parameters including: Feed efficiency ratio (FER), protein efficiency ratio (PER) and energy value (EV). The feed efficiency ratio (FER) and protein efficiency ratio (PER) were mathematically calculated as follows using the recommendations of AOAC [22] ;

FER=Total weight gain (g)/Total feed intake (g)

PER=Total weight gain (g)/ Total amount of protein in total feed intake.

Hematological Properties (WBC, RBC, HB, FBS and PCV)

The blood samples were collected from the rat tail veins by ocular method. The concentration of glucose was determined using glucometer. Packed cell volume (PCV) was determined by the microhematocrit method [23]. The hemoglobin concentration was determined by the cyanmethemoglobin method [24]. Red blood and white blood counts was determined by the method described by [23]. Hematological properties (body weight, pack cell volume, blood glucose level, total white blood cell, red blood cell, hemoglobin) of fed animal (rat) were determined [25].

Comment [D46]: The microhematocrit method determined the packed cell volume (PCV) [23].

Comment [D47]: Red blood and white blood counts were determined by [23] method.

Statistical Analysis

All analyses were conducted in duplicates. The data were subjected to analysis of variance using Statistical Package for Social Science (SPSS) software version 23, 2021. Means were separated by the least significant difference (LSD) test. Significant difference was accepted at P=.05.

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Results and Discussion

Proximate Composition of Acha–Orange Fleshed Sweet Potato Flour Blends

The proximate composition is presented in table 2 below. The carbohydrate and moisture content increased from 69.15 to 79.42 and 8.02 to 10.17 %. The increase in moisture could be due to the high moisture content of OFSP, while the increase in carbohydrate could also be due to the higher level of carbohydrate content present in both acha and OFSP. The ash, fat, protein and fibre content decreased from 3.40 to 0.69, 2.29 to 0.38, 15.41 to 8.69 and 1.73 to 0.65%, respectively, with increase (0-25%) in the added OFSP. The effect of adding OFSP to acha are generally significant, p<0.05. 100% OFSP had the highest value for carbohydrate and moisture content while the 100% acha samples had the highest value for protein, fat, fibre and ash.

Table 2:Proximate Composition of Acha–Orange Fleshed Sweet Potato

Values are Means ± standard deviation of triplicate determinations. Means within the same column with different letters are significantly different at $p<0.05$.

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The decrease in crude protein content could be due to the poor protein content of OFSP. The crude fibre decreased with increase in OFSP which could be due to the poor dietary fibre content in OFSP [26]. Measuring the fibre content of foods is critical to making a sound

Acha : OFSP	Moisture (%)	Crude Protein (%)	Fat (%)	Crude Fibre (%)	Ash (%)	Carbohydrate (%)
100:0	8.02±0.35^{b}	15.41±0.25^{a}	2.29±0.85^{a}	1.73±0.04^{a}	3.40±0.00^{a}	69.15±0.22^{c}
95:5	8.48±0.99^{ab}	14.97±0.87^{a}	1.20±0.01^{b}	1.33±0.16^{b}	2.99±0.00^{a}	71.03±0.14^{b}
90:10	9.10±0.21^{ab}	14.62±1.11^{a}	0.98±0.00^{b}	1.14±0.02^{c}	2.59±0.00^{a}	71.57±1.30^{b}
85:15	9.08±0.11^{ab}	13.22±1.21^{a}	0.82±0.12^{b}	1.08±0.01^{c}	2.09±0.00^{a}	73.51±1.30^{b}
80:20	9.24±0.45^{b}	10.85±0.49^{b}	0.76±0.01^{b}	1.05±0.01^{c}	1.77±0.00^{a}	76.32±0.04^{c}
75:25	9.71±0.51^{b}	10.05±0.22^{bc}	0.53±0.35^{a}	0.96±0.00^{ac}	1.42±0.00^{a}	77.33±0.04^{c}
0:100	10.17±1.10^{a}	8.69±0.13^{c}	0.38±0.00^{b}	0.65±0.01^{d}	0.69±0.00^{a}	79.42±0.98^{c}

benefit claim, including nutrient claim, structure-function claim, or health claim [27]. Proteins play a part in the organoleptic properties of the sample and also act as a source of amino acids in the food.

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Ash content indicates the presence of mineral matter in food. Decrease in ash content indicates that samples with low percentage of ash and will be a poor source of minerals. The results obtained in this study are within the ranges earlier reported for acha [28, 21]. Food with high ash content is expected to have high concentration of various mineral elements.

Feed Intake/Weight Gain of Rats fed with Acha–Orange Fleshed Sweet Potato

Figure 1 below shows the feed intake/weight gain of rats fed with acha-orange fleshed sweet potato. Result revealed that rats fed with 0% OFSP had the highest Feed Intake/Weight Gain (fd/wi ratio) over the duration of 21 days, followed by those fed with 5% OFSP. There was a steady increase in fd/wi in rats fed with 15% OFSP and 20% OFSP from day 5.

In the work of [29], it was observed that when rats were fed with diet in liquid form, the weight gain was not different from that of meal-fed or nibbling rats. Also, pair-feeding rats the liquid diet with a group of rats which had been fed with ad-libitum meal throughout the experiment did not change the weight gain. However, rats allowed to consume the diet in liquid form gained more weight than the force-fed rats or the rats which had been restricted for the first week and then fed with ad-libitum for 3 weeks. It also appeared that feeding a high-carbohydrate diet in liquid form may increase body weight gain in some, but not all, situations [29].

The feed intake is the single most important piece of information that a nutritionist can use to minimize feed costs, while ensuring performance is maintained. The factors affecting feed intake by dairy cows may include nutrition, milk production, rumen health, heat stress, balanced diet, age, pregnancy, and level of exercise [30]. Feed intake is important in attaining target growth rates in animals and has a significant impact on efficiency of production [31]. Weight gain is an increase in body weight. This can involve an increase in muscle mass, fat deposits, excess fluids such as water or other factors. Weight gain is important in lowering the risk of heart disease, stroke, diabetes and high blood pressure [32].

Comment [D51]: Results revealed that rats fed with 0% OFSP had the highest Feed Intake/Weight Gain (fd/wi ratio) over 21 days, followed by those fed with 5% OFSP. There was a steady increase in fd/wi in rats fed with 15% OFSP and 20% OFSP from day 5.

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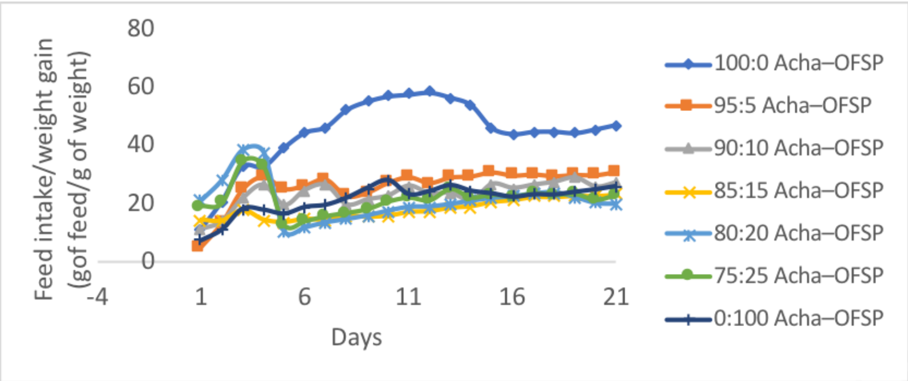

Figure 1: Daily mean feed intake/weight gain of rats fed with acha-orange fleshed sweet potato.

Feed Efficiency Ratio (FER) and Protein Efficiency Ratio (PER) of Rats fed with Acha–Orange Fleshed Sweet Potato

The feed and protein efficiency ratio of albino rats are shown in table 3 below. The feed efficiency ratio (FER) value increased from 0.02 to 0.04 while protein efficiency ratio (PER) increased from 0.13 to 0.44 respectively with increase in percentage of added OFSP. The effect of adding orange fleshed sweet potato to acha are significant, p=0.05. The 25% orange fleshed sweet potato (75:25) had the highest value for FER. The protein efficiency ratio increased as the levels of substitution of orange fleshed sweet potato with acha increased (5-25%). The findings agreed with that of [33].

Feed efficiency ratio (FER) is the mass of the input divided by the output (thus mass of feed per mass of milk or meat). FER is important because it helps to know how much amount of feed will be required in the growth cycle of animals. This serves as a powerful tool by letting one know what choices he should make in order to maximize the profitability of his business. The factors affecting FER could be parity order, body weight, body condition score, rumen acidosis, genetics and reproduction.

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Table 3: Effect of Added OFSP on the FER and PER of Albino Rat

TREATING Acha : OFSP	FER	PER
100:0	0.02 ± 0.00^{a}	0.13 ± 0.00^{a}
95:5	0.03 ± 0.00^{b}	0.22 ± 0.01^{ab}
90:10	0.04 ± 0.01^{bc}	0.03 ± 0.01^{abc}
85:15	0.05 ± 0.00^{bcd}	0.29 ± 0.00^{abc}
80:20	0.05 ± 0.01^{cd}	0.38 ± 0.00^{abc}
75:25	0.05 ± 0.00^{de}	0.26 ± 0.29^{abc}
0:100	0.04 ± 0.00^{e}	0.44 ± 0.00^{bc}

Values are Means ± standard deviation of triplicate determinations. Means within the same column with different letters are significantly different at P=.05.
OFSP = Orange Fleshed Sweet Potato

Protein Efficiency Ratio (PER) is the weight gain of test group/protein consumed by the test group. PER measures the nutritive value of protein sources. The higher the PER value of a protein, the more beneficial it is to the animal. PER is an important factor because an abnormally increased intake of one of the essential amino acids can exert toxic effects in the body. Thus, a protein will have a high biological value if it has the following characteristics: It should contain all the essential amino acids in sufficient amounts [34]. The factors affecting PER could be disproportionate amounts of amino acids in the diet (excess or shortage), protein source, feed processing and antagonism.

Weight Gain of Organs / Carcass of Albino rat fed with acha-orange fleshed sweet potato

The body weight gain of albino rat fed with acha-orange fleshed sweet potato is shown in table 4 below. The weight of kidney, liver and heart of the rats decreased from 1.23 to 1.05g, 5.65 to 2.65g and 1.28 to 0.23g, respectively as a result of the increase in level of OFSP substitution. However, the carcass of the albino rat increased from 104.55 to 111.55g upon OFSP substitution. The 100% acha sample (100:0) had the highest value for kidney, liver and heart while the 100% OFSP (0:100) had the highest value for carcass. The effect of adding OFSP are significant, p=0.05. These observations further showed that the formulated diets were better in protein quality and may be suitable as a complementary food to support growth

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of children. This finding agreed with the report on the nutritional qualities of foods that were formulated from the combinations of two or more plant-based food materials [35].

Table 4: Weight Gain of Organs / Carcass of Albino rat fed with acha-orange fleshed sweet potato

Acha : OFSP	Kidney (g)	Liver (g)	Heart (g)	Carcass (g)
100:0	1.23±0.01^{ab}	5.65±0.07^{a}	1.28±0.04^{a}	104.55±0.78^{b}
95:5	1.19±0.04^{a}	4.45±0.07^{b}	0.38±0.04^{b}	106.80±1.13^{b}
90:10	1.15±0.07^{c}	4.05±0.07^{c}	0.35±0.01^{c}	108.70±0.56^{ab}
85:15	1.13±0.01^{a}	3.80±0.07^{d}	0.29±0.02^{a}	110.30±0.42^{a}
80:20	1.11±0.02^{a}	3.15±0.07^{b}	0.27±0.04^{c}	110.70±1.27^{a}
75:25	1.08±0.21^{a}	2.90±0.07^{a}	0.25±0.01^{b}	110.95±1.21^{ab}
0:100	1.05±0.07^{bc}	2.65±0.07^{e}	0.23±0.04^{c}	111.55±1.91^{a}

Values are Means ± standard deviation of triplicate determinations. Means within the same column with different letters are significantly different at P=.05.
OFSP = Orange Fleshed Sweet Potato

Similarly, Osundahunsi and Aworh [36] reported a lower weight for some vital organs in rats fed with the basal diet singly which is an indication of some forms of abnormal development thereby corroborating the low organ weight obtained in *ogi* and corn starch fed groups. The averages weight for kidney, liver and heart are 0.62, 4.23 and 0.65g, respectively as reported in literature [37].

The factors affecting weight gain may include the following: genetics, cultural background, medical conditions and disability, mental ill-health and parturition, genetics, method of breeding, breeds of animal, housing, feeding, fasting, extreme climatic conditions, stress, exercises, transport, castration.

Hematological Profiles of Albino Rat fed with Acha-Orange Fleshed Sweet Potato

Haematological parameters such as haemoglobin (HB), haematocrit (HCT), red blood cell (RBC), white blood cell (WBC), and haematological indices such as mean cellular volume (MCV), mean cellular haemoglobin (MCH), and mean cellular haemoglobin concentration (MCHC) are commonly examined to assess the toxic stress induced by aquatic pollutants.

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The haematological properties are shown in Table 5 below. The result showed that at week 1, HB, PCV and RBC increased from 8.27 to 8.67 g/dl, 22.00 to 27.33% and 258.33 to 314 L^{-1}, respectively as a result of OFSP substitution, while FBS and WBC decreased from 57 .67 to 24.7% and 131.33 to 101.33 L^{-1}, respectively. At week 2, HB, PCV, WBC and RBC decreased from 38.53 to 9.53 g/dl, 33.33 to 30.33%, 236.33 to 122.0 L^{-1} and 340.33 to 284.67 L^{-1}, respectively, while FBS increased from 10.73 to 35.76%. At week 3, FBS, HB, PCV, WBC and RBC had decreased value ranging from 56.67 to 23.33%, 9.60 to 7.93 g/dl, 31.67 to 25.0%, 86.00 to 70.33 L^{-1} and 329.33 to 292.0 L^{-1}, respectively.

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The effect of OFSP on the haematological parameters was significant, p=0.05, for WBC, PCV, RBC and HB. The high concentration of PCV, HB, RBC, and RBC of the experimental rats fed on 100% OFSP further established nutritional quality of these products. This finding agrees with the report of [38] who established that diets containing quality protein and iron usually enhance production of hemoglobin and immunity in animals. In contrary, low FBS and HB that were observed in 100% and 25% OFSP may lead to poor production of hemoglobin and, hence, could cause anemia [35].

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Comment [D76]: On the contrary, low FBS and HB observed in 100% and 25% OFSP may lead to poor production of hemoglobin and, hence, cause anemia [35].

Table 5: Hematological Profiles of Albino Rat fed with Acha-Orange Fleshed Sweet Potato

DAYS	PARAMETERS	100:0	95:5	90:10	85:15	80:20	75:25	0:100
WEEK 1	FBS (%)	57.67±39.27^{c}	55.70±5.03^{c}	52.34±2.03^{c}	50.67±16.26^{c}	45.72±8.12^{c}	41.67±12.90^{c}	24.7±5.03^{c}
	HB (g/dl)	8.27±0.70^{c}	8.28±0.20^{e}	8.32±0.10^{ab}	8.40±1.11^{d}	8.51±0.11^{cd}	8.58±1.14^{d}	8.67±0.30^{d}
	PCV (%)	22.00±2.51^{c}	23.10±1.00^{d}	23.76±1.23^{c}	24.00±4.00^{cd}	24.06±2.56^{d}	25.67±4.04^{cd}	27.33±1.53 ^{c}
	WBC (L^{-1})	131.33±55.22^{b}	124.67±8.39^{b}	121.71±7.95^{b}	113.00±15.87^{b}	112.52±12.22^{b}	109.67±9.87^{b}	101.33±12.86^{b}
	RBC (L^{-1})	258.33±19.63^{a}	261.33±15.01^{a}	266.96±13.15^{a}	272.00±28.58^{a}	283.03±26.01^{a}	298.00±43.86^{a}	314.00±3.46^{a}
WEEK 2	FBS (%)	10.73±1.21^{c}	16.00±34.77^{bc}	17.62±7.32^{b}	20.33±1.53^{c}	22.34±12.33^{c}	30.67±77.60b^{bc}	35.76±19.60^{c}
	HB (g/dl)	38.53±49.77^{c}	30.33±1.14^{c}	27.25±6.17^{b}	21.27±1.01^{c}	15.22±0.44^{b}	10.33±0.42^{c}	9.53±0.31^{c}
	PCV (%)	33.33±1.53^{c}	32.90±3.61^{c}	32.06±3.23^{c}	31.67±2.52^{c}	31.36±1.73^{c}	31.00±1.00^{c}	30.33±1.15^{c}
	WBC (L^{-1})	236.33±13.80^{b}	196.00±44.14^{b}	174.13±16.19^{b}	154.00±54.11^{b}	134.17±17.05^{b}	128.33±15.31^{b}	122.00±36.04^{b}
	RBC (L^{-1})	340.33±24.11^{a}	338.33±64.14^{a}	327.68±12.16^{a}	321.00±24.43^{a}	316.92±23.25^{a}	313.00±10.44^{a}	284.67±40.28^{a}
WEEK 3	FBS (%)	56.67±4.51^{c}	52.0±5.57^{e}	49.25±5.13^{c}	47.00±40.85^{c}	33.01±5.03^{c}	27.10±4.35^{c}	23.33±1.53^{c}
	HB (g/dl)	9.60±0.80^{c}	9.40±0.40^{d}	8.96±0.50^{ab}	8.73±1.62^{c}	8.50±0.67^{cd}	8.04±0.20^{c}	7.93±0.81^{c}
	PCV (%)	31.67±5.13^{c}	30.00±1.00^{c}	29.07±1.23^{c}	28.67±5.13^{c}	28.20±3.17^{c}	26.00±1.00^{c}	25.00±3.00^{c}
	WBC (L^{-1})	86.00±2.00^{b}	80.00±4.00^{b}	79.33±6.55^{b}	77.13±11.68^{b}	75.15±15.25^{b}	72.00±74.94^{b}	70.33±7.09^{b}
	RBC (L^{-1})	329.33±29.67^{a}	317.33±10.26^{a}	311.26±11.25^{a}	303.33±66.37^{a}	301.24±22.13^{a}	299.00±14.42^{a}	292.00±21.17^{a}

Values are Means ± standard deviation of duplicate determinations. Means within the same column with different letters are significantly different at $p<0.05$.

* FBS – Fasting blood Sugar, HB – Haemoglobin, PCV - Packed Cell Volume, WBC - White Blood Cell, RBC - Red Blood Cell

The PCV, HB and RBC values reported in this work were lower than 30-45%, 10-15g/dl and 5.0–10.0x106/mm^3, respectively documented in Merck Manual [39]. Mitruka and Rawnsley [40] reported the normal range of value for rabbits as follows: PCV: 30–35%, HB: 9.3–19.3g/dl and RBC: 4.00–8.60x10^{6}mm^3. Anonymous [41] reported the following range of values for rabbits: PCV: 31.0–50.0%, RBC: 5.0–8.0(x10^6/mm^3), WBC: 3.0–12.5(x10^6/mm^3), HB: 8.0 – 17.0(g/dl). White Blood Cells Count (WBC) of 5 – 13(x10^9/l) is considered to be within the normal range by [42] for rabbit. Poole [43] reported a PCV range of 30 – 50% for rabbits.

Comment [D77]: Mitruka and Rawnsley [40] reported the normal range o values for rabbits: PCV: 30–35%, HB: 9.3–19.3g/dl and RBC: 4.00–8.60x10^{6}mm^3.

Comment [D78]: Poole [43] reported a 30 – 50% PCV range for rabbits.

The Packed Cell Volume (PCV) is a measurement of the proportion of blood that is made up of cells. The value is expressed as a percentage or fraction of cells in blood. Generally, a normal range is considered to be: For men, 38.3 to 48.6 percent. For women, 35.5 to 44.9 percent.

White Blood Cell (WBC) is type of blood cell that is made in the bone marrow and found in the blood and lymph tissue. A white blood cell (WBC) count of less than 4x10^9/L indicates leukopenia. A WBC count of more than 11x10^9/L indicates leukocytosis. The major functions of the white blood cell are to fight infections, defend the body by phagocytocis against invasion by foreign organisms and to produce or at least transport and distribute antibodies in immune response. Animals with low white blood cells are exposed to high risk of disease infection, while those with high counts are capable of generating antibodies in the process of phagocytocis and have high degree of resistance to diseases [44] and enhance adaptability to local environmental and disease prevalent conditions [45].

Comment [D79]: White Blood Cell (WBC) is a type of blood cell made in the bone marrow and found in the blood and lymph tissue.

Red Blood Cells (RBC) are the most common type of blood cell and the vertebrate's principal means of delivering oxygen to the body tissues—via blood flow. Red blood cells (erythrocytes) serve as a carrier of haemoglobin. It is this haemoglobin that reacts with

Comment [D80]: hemoglobin

oxygen carried in the blood to form oxyhaemoglobin during respiration [46]. Generally, a normal range for RBC is considered to be: Male: 4.3-5.9x10^{12}/L Female: 3.5-5.5x10^{12}/L. A reduced red blood cell count implies a reduction in the level of oxygen that would be carried to the tissues as well as the level of carbon dioxide returned to the lungs [47].

Haemoglobin is the iron-containing oxygen-transport metalloprotein in red blood cells of almost all vertebrates as well as the tissues of some invertebrates. Generally, a normal range is considered to be: Male: 2.09-2.71 mmol/L Female: 1.86-2.48 mmol/L. The expected values for normal fasting blood glucose concentration are between 70 mg/dL (3.9 mmol/L) and 100 mg/dL (5.6 mmol/L).

Generally, haematological factors are affected by several factors which include physiological, environmental condition, dietary content, fasting, age, administration of drugs, anti-aflatoxin treatment and continuous supplementation of vitamin affect the blood profile of healthy animal. Others include health of the animal, degree of physical activity, sex, breeds of animal, diseases and stress factors, climate, geographical location, season, day length, time of day, life habit of species, oestrus cycle, and pregnancy.

In a study on haematological parameters of rabbit breeds and cross in humid tropics conducted by [46] it was reported genotype influence on PCV, WBC, MCH and ESR; RBC, HBC and MCHC values were identical in all genotypes, pointing similar cellular haemoglobin content in blood samples obtained. In a study conducted by [48] on variation in haematological parameters of Nigerian native chickens; normal-feathered birds had higher mean values compared to frizzled feather and native neck genotype.

Chineke *et al.* [46] also reported that apart from genotype, age, sex, differences in haematological indices may be caused by nutritional, environmental and hormonal factors. According to Radostits *et al.* [49] low nutritional grassland, pasture, stress, parturition,

Comment [D81]: This hemoglobin reacts with oxygen carried in the blood to form oxyhaemoglobin during respiration [46].

Comment [D82]: hemoglobin

Comment [D83]: hematological

Comment [D84]: vitamins

Comment [D85]: animals

Comment [D86]: hematological

Comment [D87]: [46], genotype

Comment [D88]: hemoglobin

Comment [D89]: and sex,

Comment [D90]: hematological

climatic factors among others greatly alter the blood values of goats and sheep, as well as other farm animals.

Comment [D91]: According to Radostits *et al*. [49], low nutritional grassland, pasture, stress, parturition, and climatic factors greatly alter the blood values of goats and sheep and other farm animals.

Conclusion

Haematological parameters can be used to assess the health as well as the physiological status of farm animals under consideration. Changes of these parameters have been studied in albino rats fed with acha - orange fleshed sweet potato. The result of this study revealed that locally available food commodities such as acha and orange fleshed sweet potato can be utilized to produce a protein-rich complementary food that is capable of combating malnutrition among children. A protein and carbohydrate rich weaning food that is comparable to commercial weaning food (cerelac) can be strategically formulated from the blends of acha and orange fleshed sweet potato (75:25). Most of the assessed haematological parameters fall within the required standard for healthy animal, hence the food blend can be accepted for animals and human consumption.

Comment [D92]: in

Comment [D93]: This study revealed that locally available food commodities such as acha and orange fleshed sweet potato can be utilized to produce a protein-rich complementary food

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Comment [D94]: delete

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