**Nutritional characteristics of orange flesh sweet potato, sprouted African locust bean seed and wheat flour based doughnut pastry and its effect on the biochemical profile of albino rats**

**ABSTRACT**

The study evaluated the nutritional profile and effect of orange flesh sweet potato-African locust beans seed-wheat flour on the biochemical profile of Wister albino rats. Standard methods were used in raw materials preparation and analyses. Experimental samples were formulated from orange flesh sweet potato, sprouted African locust beans seed and wheat flour based on the following ratios: 100:0:0, 65:5:30, 60:10:30, 55:15:30 and 50:20:30 respectively. A total of 25 male Wister albino rats were randomly divided in 5 groups and were daily fed with formulated and control diet for twenty-one (21) days. After which blood samples were collected for clinical nutrition analyses after the feeding period. The inclusion of sprouted locust beans seed and wheat flour in orange fleshed sweet potato improved the nutritional profile as indicated by increase in protein (6.32-12.31%), ash (1.99-2.48%) and fat (22.85-28.30%). The moisture (6.86-8.05) and fibre (2.55-3.08%) also increased while carbohydrate (45.75-61.98) decreased. The study showed increase in all the minerals (Iron, Zinc, Potassium, Calcium and magnesium) analyzed. The inclusion of sprouted African locust beans seed and wheat flour in orange flesh sweet potato resulted to increase in feed consumption (29.23-51.44 g) and weight gain (10.06-14.44 g). Sprouted African locust beans and wheat flour inclusion in orange flesh sweet potato had significant effect on the serum and lipid profile of experimental rats fed with the flour diet. Serum total protein (7.13-7.89 g/dL), Albumin (4.56-5.01 g/dL), globulin (2.35-2.99 g/dL) and High-density lipoprotein (39.99-45.21 mg/100 g) increased while Total cholesterol (72.40-82.88 mg/dL) triglycerides (58.21-66.65 mg/dL) and low-density lipoprotein (20.37-25.21 mg/dL) decreased. The study showed that all the lipid profile parameters were within the acceptable range. The study established that the inclusion of sprouted African locust beans seed and wheat flour inclusion in orange flesh sweet potato can improve the nutritional profile of orange fleshed sweet potato without negative effect on health.

**Key words**: Orange flesh sweet potato, sprouted African locust beans, wheat, biochemical profile, lipid profile, nutritional content.

1.0 **INTRODUCTION**

The idea of reimagining traditional foods in new and inventive ways has led to the creation of many hybrid dishes that resonate with contemporary preferences. One such intriguing innovation is the concept of doughnut as pasta [1]. Doughnuts, which are usually deep-fried, are a popular treat known for their airy, soft texture, often glazed with sweetness or filled with ingredients like jam, cream, or chocolate [2]. Doughnut is usually prepared from wheat a cereal crop with good baking properties and poor nutritional quality. This has informed research aimed at enhancing human health through improved nutrition with the use indigenous and alternative food sources. Recently, there has been an increasing focus on the nutritional and bioactive properties of functional foods, especially those sourced from locally grown crops. Among these, orange-fleshed sweet potatoes (OFSP), locust bean seeds, and wheat have attracted attention for their potential health benefits, owing to their rich nutritional content and bioactive compounds.

Orange-fleshed sweet potato (*Ipomea batatas*) is now emerging as an important member of the tropical tuber crops having great possibility for being adopted as regular diet of the consumer food chain to tackle the problem of vitamin A deficiency. Thus, the poor people having only limited access to the expensive vitamin A rich animal foods like fish oil, egg, milk and butter, can meet the daily requirement of vitamin A along with some other essential nutrients through increased consumption of these roots. Being rich in β-carotene, a precursor of vitamin A, orange-fleshed sweet potatoes are now considered as an important biofortified crop in many developing countries in alleviating Vitamin A malnutrition and it also contain a plenty of energy yielding proximate nutrients [3].

African locust bean seeds (*Parkia biglobosa*) are perennial leguminous plants that are used to make iru, a fermented product used as a food condiment. Its nutritional potential includes the possession of relatively higher levels of methionine, lysine, tryptophan, phenylalanine, and valine than other legumes [4]. The African locust bean seeds are valued for their high polyphenol content, highlighting their therapeutic antioxidant and anti-inflammatory, antimicrobial, antidiabetic, and antihypertensive properties [4].

The consumption of wheat (*Triticum aestivum*) is increasing globally, including in countries with climates that are not suitable for wheat production. Wheat flour is suitable for baking due to the presence of gluten a protein with excellent baking properties with accompanied disadvantage of poor nutritional properties and high cost of importation [5].

Since wheat is often imported in some regions particularly Nigeria, incorporating OFSP and locust bean seeds promotes food security and encourages the use of locally available, nutrient-rich ingredients. Combining orange-fleshed sweet potato (OFSP), locust bean seeds, and wheat flour which are local crops offers several nutritional, functional, and economic benefits. The study is therefore aimed at evaluating the nutritional quality and effect of orange flesh sweet potato-African locust beans-wheat flour-based food on biochemical profile of albino rats.

**2.0 MATERIAL AND METHODS**

Orange fleshed sweet potato was obtained from Wadata Market Benue State, African Locust beans flour and wheat flour were obtained from Modern Market Makurdi Benue State. The raw materials were transported to the Food Science and Technology Laboratory at Centre for Food and Technology Research Benue State University Makurdi Benue State for further processing.

**2.1 Preparation of raw materials**

**2.1.1 Preparation of orange fleshed sweet potato (*Ipomea batatas*) flour**

The orange fleshed sweet (*Ipomea batatas*) potato flour was processed according to the methods described by Edun et al. [6] with modification. The root tubers (free from dirt, damaged and contaminated grains) were cleaned, peeled, sliced, steeped in hot water for 5 min to inactivate enzymes, shade dried for 3-5 days to avoid nutrient losses, milled and sieved through 0.5mm to obtain orange fleshed sweet potato flour. After which it was package in an airtight transparent Ziploc polyrthene bag for further use.

**2.1.2 Preparation of African locust beans seed flour**

African locust bean seeds (*Parkia bigblobosa*) flour was processed as described by Saater et. al. [7] with a slight modification. The seeds were cleaned, steeped for 24 h, sprouted for 7-12days, dehulled, oven dried at 60 0C for 12 h, allowed to cool, milled, sieved through 0.5 mm and package in an airtight transparent Ziploc polyrthene bag for further use.

**2.1.3 Preparation of wheat (*Triticum aestivum*) flour**

The wheat grains were sorted, cleaned, steeped for 1h, drained, sundry, milled, sieved through 0.5 mm and package in an airtight transparent Ziploc polyrthene bag for further use.

**2.3 Methods**

**2.3.1 Determination of proximate composition**

Moisture, fat, protein (% N x 6.25), ash and crude fibre contents were determined according to standard methods of AOAC [8]. Carbohydrate content was calculated by difference.

**Table 1: Orange fleshed sweet potato, sprouted African locust beans and wheat flour blends**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sample** | **Orange fleshed sweet potato flour** | **Locust bean flour** | **Wheat flour** |
| OFSP100LB0WF0 | 100 | 0 | 0 |
| OFSP 65LB5WF30 | 65 | 5 | 30 |
| OFSP 65LB5WF30 | 60 | 10 | 30 |
| OFSP55LB15WF30 | 55 | 15 | 30 |
| OFSP50LB20WF30 | 50 | 20 | 30 |

**KEY:** OFSP=Orange fleshed sweet potato, LB=Sprouted locust beans seed flour, WF=Wheat flour

**2.3.2 Determination of mineral content**

The mineral (calcium, phosphorus, magnesium, iron and zinc) contents of the composite flours will be determined using atomic absorption spectrophotometry according to AOAC [8] method.

**2.4 Experimental Animals and Design**

The method described by Onyeike et al. [9] was adopted in this experiment. A total of 25 male Wister albino rats were used for the feeding experiment which last for 21 days (3weeks). Male Wistar Albino Rats of ages 2 to 3 months weighing between 115 to 155g was used for the study. The rats were acclimatized for 7 days and weighed. The rats were allocated to 5 groups labeled A to E of 5 rats each in well-ventilated cages with facilities for food and water at libitum. Weight of animals was taken on weekly bases to determine weight change using the digital top loading weighing balances (Model Harvard Apparatus Ltd). After the experimental period, the animal weight, protein profile and lipid profile were determined.

**2.5 Animal study**

**2.5.1 Determination of feed intake**

Feed intake was tracked daily by weighing the leftover feed in the tray and subtracting the amount from the total feed allocated (110 g) to each cage. This process was carried out using a digital weighing scale (model: 18189c).

**2.5.2 Determination of Weight gain**

The body weight of each rat was assessed using an electronic weighing scale (model;18189c) once before commencement of experiment and was monitored after every four days, initial weight and final weight of the animals was recorded to observe the changes at the end of the experiment using an Analytical weighing balance [10].

**2.5.3 Blood sample collection**

At the end of the 21-day feeding trial, the animals were fasted overnight without access to water. Blood samples were then collected through ocular puncture using a capillary tube and placed in plain tubes to allow clotting. The ocular puncture method was chosen to prevent damage to the heart and safety of the rats because of further research usage. The blood samples were centrifuged at 3000 x g for 25 minutes to separate the sera, which were then stored in a deep freezer (-20°C) for further analysis of protein and lipid profile.

**2.5.4 Determination of Serum protein profile**

Serum Total Protein (TP) and Albumin (ALB) were determined using Randox TP and ALB reagents following the method described by George [11], while serum globulin was determined by subtracting the albumin fraction from the total protein fraction. The measurement was taken in g/dL.

**2.5.5 Determination of serum lipid profile**

Serum total cholesterol (TC), triglycerides (TG), and high-density lipoprotein (HDL) levels were measured using Agape TC, TG, and HDL reagents, following the method outlined by Ani and Besthshel [12]. Low-density lipoprotein (LDL) was calculated by subtracting the sum of HDL-c and TG from the total cholesterol.

**2.5.6 Statistical analysis**

The statistical analysis of the samples was performed using the statistical package for social scientists (SPSS 20.0 versions) The data generated from these investigations was analysed using analysis of Various (ANOVA) and mean separation was done using the Duncan multiple range test in mean separation.

**3.0 RESULTS AND DISCUSSION**

**3.1 Proximate composition of pastry from orange flesh sweet potato, Sprouted African locust beans seeds and wheat flour blends.**

The result of the proximate composition of Orange fleshed sweet potato, sprouted locust bean seed and wheat flours and their blends are shown in Table 2. The crude protein content ranged from 6.31-12.31% and increased with the inclusion of sprouted locust bean seed and wheat flour in the blends. The increase in crude protein could be attributed to the inclusion of sprouted Africa locust beans seed flour which is reportedly higher in protein content as compared to orange flesh sweet potato flour. The result agreed with Elechi, [13] and Oke et al. [14] who reported protein content range of 7.40-13.13% and 2.98-12.00% in mango and breadfruit fortified wheat doughnut.

The moisture ranged from 6.86-8.08 % and significantly (p<0.05) increased with the inclusion of sprouted African locust beans and wheat flour. The 100:0:0 sample had the least value while sample 50:20:30 had the highest value for moisture content. The moisture content reported by this study was lower than the 3.80 – 4.80% reported for maize-soybeans and orange fleshed sweet potato chin-chin by Ndife et al. [15]. The values were within the range reported to have no adverse effect on quality attribute of the product [16]. The low moisture content exhibited by the doughnut samples is an indication that the products will have shelf stability [15]. The ash content of the flour blends doughnut significantly (p<0.05) increased with inclusion of orange sweet potato and wheat flour in the blends and ranged from 1.99-2.39 %. This could be due to supplementation of the flour with sprouted African locust beans flour. The result agreed with the report of Oke et al. [14] who reported ash content in the range of 2.00-2.28%. in wheat-bread fruit doughnut. The significant increase in ash content could be attributed to the fact that locust bean seed is a rich source of minerals [7]. The ash content of a product indicates a rough estimate of its mineral content. [17]. Minerals are essential micronutrients that serve a variety of essential functions in metabolism and are among the parts of biomolecules such as hemoglobin, deoxyribonucleic acid (DNA), and adenosine triphosphate (ATP) [18].

**Table 2: Proximate composition (%) of Orange Fleshed Sweet potatoes, Sprouted African locust bean seed and wheat flour blends**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| OFSP:LB:WF | Protein | Moisture | Ash | Fat | Fibre | Carbohydrate |
| 100:0:0 | 6.32e±0.04 | 6.86d±0.02 | 1.99d±0.12 | 22.85e±0.03 | 2.55e±0.01 | 61.98a±0.09 |
| 65:5:25 | 7.86d±0.04 | 6.88d±0.04 | 2.05d±0.01 | 23.93d±0.01 | 2.65d±0.03 | 56.63b±0.15 |
| 60:10:30 | 8.20c±0.02 | 7.20c±0.02 | 2.20c±0.04 | 24.08c±0.11 | 2.86c±0.05 | 55.46b±0.18 |
| 55:15:30 | 10.27b±0.03 | 7.86b±0.04 | 2.39b±0.03 | 26.21b±0.01 | 2.99b±0.35 | 50.28c±0.10 |
| 50:20:30 | 12.31a±0.04 | 8.08a±0.03 | 2.48a±0.02 | 28.30a±0.03 | 3.08a±0.04 | 45.75d±0.18 |
| LSD | 0.10 | 0.10 | 0.08 | 0.08 | 0.08 | 0.38 |

KEY: OFSP=Orange fleshed sweet potato, Sprouted locust beans seed flour, WF= Wheat flour, LSD= Least significant difference

**Table 3: Mineral composition (mg/100g) of Orange fleshed sweet potato, locust bean seed and wheat flour blends doughnut**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| OFSP:LB:WF | Iron | Zinc | Potassium | Calcium | Magnesium |
| OFSP100AL0WF0 | 0.67e±0.01 | 36.98e±0.01 | 25.23e±0.04 | 23.93c±0.09 | 13.36e±0.15 |
| OFSP65AL5WF30 | 0.72d±0.07 | 37.49d±0.55 | 26.25d±0.01 | 24.21c±0.01 | 13.97d±0.01 |
| OFSP65AL5WF30 | 0.77c±0.05 | 38.24c±0.02 | 28.27c±0.02 | 25.18b±0.11 | 14.43c±0.32 |
| OFSP55AL15WF30 | 0.86b±0.04 | 40.47b±0.64 | 29.96b±0.03 | 25.85b±0.21 | 14.99b±0.02 |
| OFSP50AL20WF30 | 0.93a±0.01 | 42.11a±0.16 | 30.48a±0.11 | 26.76a±0.65 | 15.67a±0.07 |

KEY: OFSP=Orange fleshed sweet potato, LB =Sprouted locust beans flour, WF= Wheat flour, LSD= Least significant difference

The results showed that the fat content ranged from 22.85% in 100:0:0 (Orange fleshed sweet potato) to 28.30 % in 50:20:30 (Orange fleshed sweet potato, sprouted locust bean seed and wheat flours) and increase with the addition of African locust beans and wheat flour. The increase in fat content could be due to the inclusion of African locust beans and wheat flour in the blends. The fat content reported by this study agreed with the report of Elechi et al. [13] and Oke et al. [14] in doughnut produced from wheat-carrot-mango-date fruit flour and wheat-breadfruit respectively. Fat is a concentrated form of energy. It is very essential in an infant’s diet because it supplies essential fatty acids (linoleic acid (LA), alpha-linolenic (ALA), docoxahexanoic acid (DHA), and arachidonic acid (ARA)) and enables absorption of fat-soluble vitamins. Fats provide energy to the liver, muscles, heart, and brain

The fibre content ranged from 2.55-3.08% across samples and increased with inclusion of Sprouted African locust beans and wheat flour. Crude fiber, which comprised of indigestible carbohydrates such as cellulose, hemicellulose, pectin, and lignin, reduces the rate of release of glucose into the bloodstream and reduces inter-colonic pressure, thereby reducing the risk of colon cancer [19]. The relatively high percentage of crude fibre content was contributed from the hemicelluloses in the flour produced from sprouted African locust beans and wheat flour. The result agreed with 1.62-5.20% fibre content reported by Elechi et al. [13] in wheat-carrot-mango-date fruit flour doughnut.

The carbohydrates content ranged from 45.75% in 50:20:30 to 61.98 % in 100:0:0 There was a significant (p<0.05) difference among samples. The result contradicts the report of Oke et al. [14] who reported increase in carbohydrate content in wheat-breadfruit doughnut. The difference in raw materials used in flour formulation and doughnut production could account for the variation in result. The carbohydrate content reported by this study indicates that the product is a significant source of energy.

**Table 4: Feed intake and mean body weight changes of experimental rats fed with orange fleshed sweet potato, sprouted locust bean seed and wheat flour blends**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| OFSP: LB:WF | Feed intake | WK1 | WK2 | WK3 |
| OFSP100LB0WF0 | 29.23e±35.35 | 8.44e±0.01 | 9.88e±0.01 | 10.06e±0.08 |
| OFSP65LB5WF30 | 51.44a±0.01 | 8.80d±0.04 | 10.13d±0.11 | 10.75d±0.04 |
| OP65LB5WF30 | 49.98b±0.01 | 8.98c±0.01 | 11.23c±0.02 | 12.44c±0.01 |
| OFSP55LB15WF30 | 42.14c±0.04 | 9.17b±0.08 | 11.78b±0.01 | 13.23b±0.03 |
| OFSP50LB20WF30 | 40.33d±0.16 | 9.45a±0.01 | 12.33a±0.16 | 14.44a±0.01 |
| LSD | 0.64 | 0.09 | 0.18 | 0.10 |

KEY: OFSP=Orange fleshed sweet potato, LB=Sprouted locust beans flour, WF= Wheat flour, LSD= Least significant difference

**Table 5: Serum protein profile (g/dL) of rats fed with Orange fleshed sweet potato, locust bean seed and wheat flour blends**

|  |  |  |  |
| --- | --- | --- | --- |
| OFSP:LB:WF | Total Protein | Albumin | Globulin |
| OFSP100LB0WF0 | 7.13e±0.01 | 4.56±d0.01 | 2.35e±0.15 |
| OFSP65LB5WF30 | 7.40d±0.07 | 4.78c±0.16 | 2.56d±0.01 |
| OFSP65LB5WF30 | 7.56c±0.01 | 4.90b±0.01 | 2.67c±0.11 |
| OFSP55LB15WF30 | 7.68b±0.05 | 4.89b±0.13 | 2.89b±0.03 |
| OFSP50LB20WF30 | 7.89a±0.03 | 5.01a±0.08 | 2.99a±0.01 |
| LSD | 0.03 | 0.16 | 0.02 |

KEY: OFSP=Orange fleshed sweet potato, LB=Sprouted locust beans flour, WF= Wheat flour, LSD= Least significant difference

**Table 6: Serum lipid profile (mg/dL) of rats fed with Orange fleshed sweet potato, locust bean seed and wheat flour blends**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| OFSP:LB:WF | Total cholesterol | Triglyceride | High Density Lipoprotein | Low Density Lipoprotein |
| OFSP100LB0WF0 | 82.88a±0.16 | 66.65a±0.28 | 45.21a±0.01 | 25.21a±0.01 |
| OFSP65LB5WF30 | 81.95b±0.07 | 65.13b±0.01 | 42.13b±0.45 | 22.15b±0.07 |
| OFSP65LB5WF30 | 81.21b±0.01 | 63.12c±0.51 | 41.21c±0.02 | 21.21c±0.01 |
| OFSP55LB15WF30 | 80.13c±0.18 | 62.06d±0.08 | 40.29d±0.06 | 21.02d±0.02 |
| OFSP50LB20WF30 | 72.40d±0.22 | 58.21e±0.01 | 39.99e±0.01a | 20.37e±0.1 |
| LSD | 0.89 | 0.34 | 0.08 | 0.14 |

KEY: OFSP=Orange fleshed sweet potato, Sprouted locust beans flour, WF= Wheat flour, LSD= Least significant difference

**3.1.2 mineral composition of Orange fleshed sweet potato, locust bean seed and wheat flour blends doughnut**

The mineral composition of the samples is presented in Table 3. The iron content ranged from 0.67-0.93 mg/100g with control 100% orange fleshed sweet potato recording the lowest while the highest was recorded in 50:20:30 (orange fleshed sweet potato: sprouted locust bean seeds). The increase in iron content could be due to inclusion of African locust beans flour in the blends. Ikhimalo, [20] reported high iron and other mineral content in sprouted African locust beans flour. The result showed low iron content as compared to the 4.87-8.90 mg/100g reported by Elechi et al. [13] in doughnut produced from wheat, carrot, mango and date fruit-based doughnut. The variation in result is probably because of the raw materials used in blends formulation for doughnut production.

The zinc content was lowest (36.98 mg/100g) in the control sample (100:0:0%) and highest (42.11mg/100g) in 50:20:30 formulation. The significant (p<0.05) increase in zinc content could be attributed to high zinc content of African locust beans flour.

Potassium content ranged from 25.23 mg/100g in 100:0:0 to 30.48 mg/100g in 50:20:30. The increase in potassium with inclusion of sprouted African locust beans flour also confirmed that Sprouted African locust beans flour is high in potassium as reported by Ikhimalo [20]. The result showed low potassium content as compared to the 76.10-236.14 mg/100 g reported by Elechi et al. [13] in doughnut produced from wheat, carrot, mango and date fruit-based doughnut. The variation in result is probably because of the raw materials used in blends formulation for doughnut production.

Calcium contents were lowest in 100:0:0 sample (23.93 mg/100g) and highest in 50:20:30 sample (26.76 mg/100g). Similarly, the magnesium content was least in 100:0:0 (13.36 mg/100g) sample and highest in 50:20:30 (15.67mg/100g). The increase in calcium and magnesium content could be attributed to high magnesium content in sprouted African locust beans flour. Ndife et al. [15] reported higher calcium (122.75 mg/100g to 286.15 mg/100 g) and magnesium (88.62 mg/100g – 178.05 mg/100 g) content in chin-chin from maize, soybeans and orange fleshed sweet potato. Magnesium is essential to good health because it helps to maintain normal muscle and nerve function, keeps heart rhythm steady, supports a healthy immune system and keeps bones strong [21].

**3.1.3** **Mean body weight changes of experimental rats fed orange fleshed sweet potato, sprouted locust bean seed and wheat flour blends**

The result for average feed consumption and weight change analysis is presented in Table 4. The average feed intake significantly (p<0.05) differed and increased with inclusion of sprouted African locust beans flour and wheat flour. The average feed intake ranged from 29.33-51.44 g. The result showed that the group fed the formulation 65:5:30 (orange fleshed sweet potato flour, 5% sprouted locust bean seeds flour and 30% wheat flour) consumed higher food while the group fed 100% orange flesh sweet potato flour consumed the least food. The chemical composition aroma and diet palatability are reported to have effect on the diet consumption by experimental rats [22]. The high and low food consumption could be attributed to palatability and unpalatability of diet respectively. Sylvester et al. [23] reported higher food consumption (62.92-68.59 g) in albino rat fed maize-cassava-soybeans flour blends. The nature of food raw materials used in the formulation could account for the variation in result.

The mean weekly weight change is of albino rats fed with orange fleshed sweet potato, sprouted African locust beans flour and wheat flour blends as presented in Table 4 showed appreciable weight increase in week 1, 2 and 3. The mean weight change in week 3 represents the actual weight gain. The weight gain ranged from 10.06-14.44 g and increased with level of African locust beans flour inclusion in the blends. This implies that African locust beans flour supported weight gain probably because of better nutritional profile (high protein content) as weight gain is a measure of nutritional content of food and growth index in healthy animals [10]. The 100% orange fleshed sweet potato flour diet supported the least weight gain. This could be due to poor nutritional content especially protein which is reported to support growth of experimental rats. On the other hand, the increase in weight gain with level of sprouted African locust beans flour inclusion is an indication of improved nutritional profile of the flour blends. The weight gain reported by this study agreed with the 2.56 – 37.62 g reported by Sylvester et al. [23] in albino rat fed maize-cassava-soybeans flour blends. The study showed that the inclusion of sprouted African locust beans flour could improve the nutritional content orange fleshed sweet potato as indicated by weight gain with level of inclusion.

**3.1.4 Serum protein profile of rats fed Orange fleshed sweet potato (OFSP), African locust bean seed and wheat flour blends**

The serum protein profile of rats fed with Orange fleshed sweet potato, locust bean seed and wheat flour blends is presented in Table 5. The total protein, albumin and globulin significantly (p<0.05) increased with inclusion of Sprouted African locust beans seeds in the blends. The total protein, albumin and globulin ranged from 7.13-7.89 g/dL, 4.56-5.01 g/dL and 2.35-2.99 g/dL respectively. The serum total protein was least group fed with orange fleshed sweet potato and increased with level of sprouted African locust beans flour addition. The sample with 50% OFSP, 20% African locust beans flour addition had higher total serum protein. The result agreed with the report of Sylvester et al. [23] who reported low level of total serum protein in group fed with maize flour and high level of total serum protein in group fed with maize-soybeans flour blends and Adejuwon et al. [24] who observed a similar trend of total serum protein profile of rats fed with control and formulated diet of sorghum‐soybean‐orange flesh sweet potato complementary diet. The low level of serum total protein in group fed 100% OFSP could be attributed to poor nutritional profile or low feed consumption. Serum total protein plays a key role in transporting hormones, lipids, and ions, as well as supporting immune function. Elevated levels may suggest dehydration, inflammation, chronic infections, or certain cancers, while low levels can indicate issues like intestinal malabsorption, liver disease, severe burns, or protein loss through the kidneys [25]. The serum total protein levels in all groups fell within the normal range of 6.20 to 7.30 g/dL, suggesting that there were no signs of kidney or liver diseases associated with abnormal protein levels.

Serum albumin reflects the amount and type of protein in the blood, providing insight into nutritional and health status. It also serves as a marker for protein levels [26]. Albumin is responsible for transporting various substances through the bloodstream and plays a crucial role in maintaining blood pressure within blood vessels. Elevated levels may suggest dehydration, while decreased levels are associated with chronic inflammation, liver disease, kidney disease, malnutrition, and blood loss [26]. The albumin of the control sample was significantly lower (4.56g/dL) than the flour blend sample with 20% African locust beans flour inclusion. The finding by this study agreed with the report of Sylvester et al. [23] and Eteng et al. [27]. The albumin content reported in this study is however slightly higher than the albumin values (3.07-4.40g/dL) reported by Adejuwon et al. [24] for sorghum‐soybean‐orange flesh sweet potato complementary diet.

Similarly, the intake of the flour blends significantly increased the serum globulin levels from 1.95 to 2.09 g/dL (100% OFSP flour) to 2.99 g/dL (20% African locust beans flour inclusion). This result agreed with the report of Sylvester et al. [23] in rats fed maize and maize-cassava-soybeans flour blends.

Serum proteins provide information about the condition of body cells, tissues, and organs, as well as the metabolism of the animal's diet. Elevated serum protein levels indicate high-quality protein in the animal's feed, while a decrease in these levels suggests severe malnutrition [26].

**3.1.5 Serum lipid profile (mg/dL) of rats fed Orange fleshed sweet potato, locust bean seed and wheat flour blends**

The levels of total cholesterol, triglycerides, high-density lipoprotein (HDL) and low-density lipoprotein (LDL) in rats are shown in Table 6. The results indicate that the formulated diet had significant (p<0.05) effect on the lipid profile. The HDL cholesterol (HDL-C) levels increase with inclusion of sprouted African locust beans seeds and wheat flour in orange fleshed sweet potato flour while a decrease in total cholesterol, triglycerides and LDL was observed in the blends. Sylvester et al. [23] also observed a similar trend in results from rats fed maize flour and maize-cassava-soybeans flour blends.

Serum total cholesterol levels, HDL, triglycerides and LDL ranged from 72.40 to 82.88 mg/dL. A significant (p<0.05) increase in total cholesterol was observed across the samples. The lowest serum total cholesterol was obtained in 50:20:30 flour blends (72.40 mg/dL) while the highest was obtained in 100% maize flour (82.88 mg/dL). The result was notably higher than the 45.24 mg/dL reported in rats that were fed rice-based composite flour cookies reported by Eteng et al. [27] but lower that the 86.33-92.51 g/dL reported by Sylvester et al. [23] in maize and maize-cassava-soybeans flour blends fed rats. The low total cholesterol levels obtained in this study are favourable, as they fall within the recommended range of 37-95 mg/dL. Cholesterol is essential for hormone synthesis, but elevated levels are considered a risk factor for cardiovascular disease. On the other hand, low cholesterol levels can indicate liver disease, malnutrition, kidney disease, pancreatitis, diabetes, and hypothyroidism [28]. This implies that the flour blends this does not pose risk of cardiovascular disease since the total cholesterol is within the acceptable range.

A significant (p<0.05) decrease in serum triglyceride (TG) levels was observed with inclusion of sprouted African locust beans and wheat flour in the blends. The group fed 50:20:30 flour blends had the least (58.21 mg/dL) while the group fed 100% maize flour had the highest (66.65 g/dL) TG value. The result was lower than the 96.55 to 136.4 mg/dL and 69.69-82.15 mg/dL reported by Egbung et al. [29] and Sylvester et al. [23] in rats fed Vernonia amygdalina supplementation with Vigna subterrenea (bambara groundnut) pudding and maize-cassava-soybeans flour blends.

The decrease in triglyceride levels observed in the flour blends samples may be associated with the sprouted African locust beans-based diet. Nevertheless, the triglyceride levels in all experimental groups were within the normal range of 20-160 mg/dL. Triglycerides are essential for fat storage and the release of fatty acids in the body. High levels increase the risk of heart disease and metabolic syndrome, while low levels may indicate starvation or malnutrition.

A significant (p<0.05) increase in HDL-c was observed with inclusion of sprouted African locust beans flour in the blends. The least HDL-c was obtained in the 100% maize flour and increased with level of sprouted African locust beans flour inclusion in the blends. Egbung et al. [29] also reported an increase in HDL levels in rats following a leguminous diet. The HDL-c levels in all groups were within the normal range of 36.78 to 56.65 mg/dL, which is considered healthy. The increase in HDL-c levels observed in this study is beneficial, as it helps remove cholesterol from tissues and transport it to the liver for breakdown and excretion. Additionally, HDL-c carries excess cholesterol back to the liver, where it is converted into bile acids and excreted in the small intestine [28]. Due to its various functions, HDL-c is considered "good" cholesterol, and higher levels reduce the risk of heart disease by preventing LDL-c, or "bad" cholesterol, from accumulating in the arteries [30].

The Low-density lipoprotein cholesterol (LDL-c) levels significantly (p<0.05) decreased with the addition of sprouted African locust beans flour in the blends implying that sprouted African locust beans flour had significant (p<0.05) effect on low-density lipoprotein cholesterol (LDL-c) levels. The decrease in LDL-c levels observed in this study is consistent with earlier findings by Sada et al. [31]. The lower LDL-c levels reported by this study are beneficial because LDL cholesterol, often referred to as "bad" cholesterol, deposits fat in the artery walls and can combine with white blood cells to form plaque, which narrows the arteries and restricts blood flow [32]. However, the LDL-c levels in all groups were within the acceptable range of 15.58 to 35.09 mg/dL, which is considered desirable, especially for diabetic patients or those with heart disease, as highlighted by Chigbo [33].

**4.0 CONCLUSION**

The study established that the inclusion of sprouted African locust beans seed and wheat flour in orange flesh sweet potato flour resulted to increase in nutritional quality (protein, fat and ash content) and mineral content of the flour blend doughnut.

The study showed that the experimental rat group consumed more of the formulation with 10% sprouted African locust beans flour inclusion diet. However, all the experimental group rat showed weight gain which indicate the ability of the flour to support growth.

The study showed that the inclusion of sprouted African locust beans seed and wheat flour in orange flesh sweet potato flour resulted to increase serum protein profile of the experimental rat group. The study further showed that all the lipid profile parameters were within the acceptable range for experimental rats indicating that the formulation does not pose health risk to consumers.

The study therefore established that nutritious and healthy food can be formulated from blends of orange flesh sweet potato, sprouted African locust beans and wheat flour.

**Ethical Approval**

The study was conducted with ethical approval (MOH/STA/204/VOL.1/238) from the Ministry of Health and Human Services, Benue State, Nigeria. The animals were treated in accordance with the rules and regulations governing the use of animals in research.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

**RFERENCES**

1. Martinez-Cruz, P. (2019). *Food fight!: Millennial Mestizaje meets the culinary marketplace*. University of Arizona Press.
2. Emun, H. (2022). Sensory Evaluation of Doughnuts made with Dates instead of Sugar as Sweetener. Proceedings of the LASUSTECH 30th iSTEAMS Multidisciplinary Innovations Conference, 2022ISBN- 978-978-57388-7-2
3. Abewoy, D., Megersa, H. G., Banjaw, D. T., & Lemma, D. T. (2024). Major Nutritional Content of Orange Fleshed Sweet Potato (OFSP) and It’s Importance. *Glob. Acad. J. Agriculture Biological Sci*ience *6*, 1-7.
4. Popoola, J. O., Ojuederie, O. B., Aworunse, O. S., Adelekan, A., Oyelakin, A. S., Oyesola, O. L. and Omonhinmin, C. A. (2023). Nutritional, functional, and bioactive properties of african underutilized legumes. *Frontiers in Plant Science*, *14*, 1105364.
5. Erenstein, O., Jaleta, M., Mottaleb, K. A., Sonder, K., Donovan, J., & Braun, H. J. (2022). Global trends in wheat production, consumption and trade. In *Wheat improvement: food security in a changing climate* (pp. 47-66). Cham: Springer International Publishing.
6. Edun, A. A., Olatunde, G. O., Shittu, T. A. and Adeogun, A. I. (2019). Flour, dough and bread properties of wheat flour substituted with orange-fleshed sweetpotato flour. *Journal of Culinary Science & Technology*, *17*(3), 268-289
7. Saater, Ape, Eke Mike Ojotu, Akpensuen Mfe Samuel, Akua Simon Iordye, Igbua Francis Zashachia, and Odey Bessie Agwu. 2025. “Quality Characteristics of Yellow Maize-Based Ogi Incorporated with Treated African Locust Bean Seeds Flour”. Asian Food Science Journal 24 (2):1-17.
8. AOAC International (2016). Official methods of analysis of AOAC international. (20th Edn.). Gaithersburg, MD, USA: AOAC International. 3172
9. Onyeike, E. N., Monanu, M. O. and Okoye, C. N. (2012). Changes in the Blood Lipid Profile of Wistar Albino Rats fed Rich Cholesterol Diet: *Annals of Biological Research*, 3(11):5186-5191
10. Ikya, J.k., Mzahan, E. H, and Shalem, S. (2019) Serum biochemistry pprofiles, haematological indices of albino rats fed Markurdi *Dakuwa* Meal. *International Journal of Resaerch and Scientific Innovation Volume* 4(4) [www.rsisinternational.org](http://www.rsisinternational.org)

11. George, R. K. (2009). Biochemistry Laboratory. Philadelphia [www.jbc.org](http://www.jbc.org/)

1. Ani, C. O. and Bethshel, J. A. (2016). Investigation of the Blood Pressure Reducing Property of Different Varieties of Lycopersicon Esculentum in Wistar Rats. Journal of African Association of Physiological Sciences, 4(2): 114- 115.
2. Elechi, J.O. (2022). Product development, nutritional characteristics and consumers acceptability studies of doughnut partially substituted with carrot (*Daucus carota*) and mango (*Mangifera indica* l) flour fortified with date (Phoenix dactylifera L) fruits syrup as sweetener. *Food and Applied Bioscience Journal*, *10*(2), pp.1-22.
3. Oke, E.K., Tijani,O.A., Abiola,O.T., Adeoye,A.K. and Odumosu. (2018). Effects of partial substitution of wheat flour with breadfruit flour on Quality attributes of fried Doughnut. The journal of Agricultural Sciences. 13(1): 72-80.
4. Ndife J, Abasiekong KS, Nweke B, LinusChibuezeh A, Ezeocha VC. “Production and comparative quality evaluation of chinchin snacks from maize, soybean and orange fleshed sweet potato flour blends.” *Fudma Journal ofScience* 2020;4(2):300–307.
5. Adebayo-Oyetoro, A.O., Ogundipe, O.O., Lofinmakin, K.F., Akinwande, F.F., Aina, D.O.and Adeyeye, S. A. O. (2017). Production and acceptability of chin-chin snack made from wheat and tigernut (Cyperus esculentus) flour. *Cogent Food and Agriculture*, 3: 1-9.
6. Adelekan, E. O., Adegunwa, M. O., Adebowale, A. A., Bakare, H. A., and Alamu, E. O. (2019). Quality evaluation of snack produced from black pepper (Piper nigrum L.), plantain (Musa paradisiaca L.), and tigernut (*Cyperus esculentus* L.) flour blends. *Cogent Food & Agriculture*, *5*(1), 1614285
7. Twinomuhwezi, H., Awuchi, C. G., & Rachael, M. (2020). Comparative study of the proximate composition and functional properties of composite flours of amaranth, rice, millet, and soybean. *American Journal of Food Science and Nutrition*, *6*(1), 6-19
8. Ezeocha, V. C., Nnanna, J. O. and Ajah, C. M. (2023). Physicochemical and Sensory Properties of Breakfast Meals Produced from Germinated Rice (Oryza sativa) and Pigeon Pea Flour Blends (Cajanus cajan). *Nigeria Agricultural Journal*, *54*(1), 188-197.
9. Ikhimalo, O. P. (2019). African Locust Beans: More than just a condiment. *Journal of Underutilized Legumes*, *1*(1), 99-111.
10. Hasan, M. (2022). *A review on boosting immune system by healthy lifestyle* (Doctoral dissertation, Brac University).
11. Oibiokpa, F. I., Akanya, H. O., Jigam, A. A., Saidu, A. N., & Egwim, E. C. (2018). Protein quality of four indigenous edible insect species in Nigeria. Food Science and Human Wellness, 7(2), 175-183
12. Adejo, S., Kukwa, R., Ape, S. and Igbua, F. (2025). Impact of Consuming Maize-Cassava-Soybean Flour Blends on the Nutritional Value and Safety of the Diet in Wistar Rats. Nutrition and *Food Sciences Research* 11(1), 1-17
13. Adejuwon KP, Osundahunsi OF, Akinola SA, Oluwamukomi MO, Mwanza M. Effect of fermentation on nutritional quality, growth and hematological parameters of rats fed sorghum‐soybean‐orange flesh sweet potato complementary diet. Food Science & Nutrition. 2021 Feb;9(2):639-50.
14. Augustine, C., Kwari, I.D., Igwebuike, J.U., Adamu, S.B. Medugu, C.I., Obidah L.U., Khobe D., and Babale, D.A.M. (2017). Economic evaluation of carcass characteristics and organ weights of broiler chickens fed graded levels of raw tropical sickle pod (Senna obtusifolia) seed meal based-diets. *Nigeria Journal of Animal Production*, 44(4):207-215.
15. Charles, O.O., Kehinde, O.S., Olalekan, C.O. and Monsuru, O. T. (2017).Studies on haematology, serum chemistry and histology of liver and kidneys of male wistar strain albino rats fed graded levels of raw pigeon pea (*Cajanus c*ajan) seeds. *EC Nutrition*, 8(3): 75-84
16. Eteng, O., Stella, O. B., Ude, C., Onor-Obasi, A.N., Ada, Nneoyi-Egbe. And Mbeh, E. (2022). Under-utilization of composite flour and wheat flour cookies: effect on some biochemical parameters in wistar rat model. *Dutse Journal of Pure and Applied Sciences*, 8(3a): 87-98
17. Charles, P. D. (2019). Creatinine (low, high, blood test results explained). Retrieved September 12, 2019, from [www.onhealth.com](http://www.onhealth.com).
18. Egbung, G. E., Nyakno, A. E., Mgbang, I.E. and Egbung, J.E. (2019). Serum lipid and electrolyte profiles of Wistar rats fed with V. amygdalina supplemented V. subterranea (Bambara groundnut) pudding. *Calabar Journal of Health Sciences*, 3(2): 40-45
19. Mitaigiri, T.B., Jaspreet, K., Vishesh, B., Jyoti, S. and Kartik, S. (2021). Role of consumption of composite flour in management of lifestyle disorders. *Plant Archives*, 21(2):201- 214
20. Sada, N.H., Tanko, Y., Gidado, N.M., and Mohammed, A. (2016).Antidiabetic effect of fermented pennisetum glaucum(millet) supplemented in alloxan induced hyperglycemic wistar rats. *Bayero Journal of Pure and Applied sciences*, 9(1): 138-141.
21. Dashti, M., Kulik W., Hoek F., Veerman, E.C., Peppelenbosch M.P., and Rezaee F. (2011). “A phospholipidomic analysis of all defined human plasma lipoproteins”. Scientific Reports, 1(139):1-5.
22. Chigbo, D.C. (2023). Quality evaluation of therapeutic noodle from water yam, millet and wheat composite flour and its effects on lipid profile and blood glucose concentration using albino rats. *World Journal of Advanced Research and Reviews*, 19(03):1428-1437.

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