





# Nutritional Indices, Haematological and Biochemical Evaluation of Albino Rats Fed with Crunchy Snack Produced from Corn, Red Kidney Beans and Onion Flour

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| Abstract   | Article History  |
|--|--|
| <p>Corn is one of the most versatile grains with nutritional benefits and can be found all over the world. The use of indigenous raw materials like red kidney beans and onion serves as an alternative means to improve the nutritional and sensory qualities of corn flour without reducing the viability of its nutritional attributes. This study investigated the haematological, biochemical evaluation and nutritional indices of albino rats fed with crunchy snack produced from corn, red kidney beans and onion flour and the sensory evaluation of the formulated product using standard methods. White maize, red kidney beans and onions were obtained from Shasha market, Akure, Nigeria, other ingredients such as salt, sugar and pepper were purchased from Oba market, Akure, Nigeria. They were prepared at different proportions of WRKBO1 (white maize flour 70%, red kidney beans 25% and onion flour 5%), WRKBO2 (white maize flour 70%, red kidney beans 15% and onion flour 15%) and WRKBO3 (white maize flour 70%, red kidney beans 20% and onion flour 10%). The formulated blends were used to produce crunchy snacks in the laboratory of Food Science and Technology FUTA, Akure, Ondo State, Nigeria. The proximate analysis results showed that the moisture, fiber, protein and fat contents were higher in the formulated crunchy snacks than in the control snack. The following range of values were obtained for moisture (4.03-15.33%), fiber (14.92-18.45%) and fat (1.91-5.06%) and sample WRKBO3 had the highest value of 15.33%, 18.45% and 5.06% respectively and was significantly different (<math>p &lt; 0.05</math>) from the control. The protein content value ranged from (3.33-9.52%); sample WRKBO1 had the highest value of 9.52% and was significantly different from the control. The result of the sensory evaluation was based on a nine-point hedonic scale and it was observed that sample WRKBO1 (white maize flour 70%, red kidney beans 25% and onion flour 5%) was more acceptable to the panelists.</p> <p><b>Keywords:</b> Nutritional indices, haematological, biochemical, crunchy snack, corn, red kidney bean, onion flour</p> | <p>Received: 14 May 2024<br/>Accepted: 04 Jul 2024<br/>Published: 19 Jul 2024</p>  <p>Scan QR code to view*</p> <p>License: CC BY 4.0*</p>  <p>Open Access article.</p> |
| <p><b>How to cite this paper:</b> Adegbanke, O. R., &amp; Jeremiah, O. M. (2024). Nutritional Indices, Haematological and Biochemical Evaluation of Albino Rats Fed with Crunchy Snack Produced from Corn, Red Kidney Beans and Onion Flour. <i>IPS Journal of Nutrition and Food Science</i>, 3(3), 222–226. <a href="https://doi.org/10.54117/ijnfs.v3i3.52">https://doi.org/10.54117/ijnfs.v3i3.52</a>.</p>   |  |

## Introduction

The local production of corn (major raw material for crunchy snacks production) in Nigeria is far below domestic consumption due to unfavourable climatic conditions. Consequently, Nigeria like other tropical countries is still depending on importation to augment local production and this places a considerable burden on the economy of the country. In Nigeria, reliance on wheat flour in the pastry and bakery industries has over the years restricted the use of other cereals available to domestic use (Adegbanke and Ilesanmi, 2018). Legumes are often eaten together with cereals and used as a substitute source of protein and calorific value for humans and livestock (Ojuederie and Balogun, 2017).

Corn (*Zea mays*) is among one of the most consumed grains and it can contribute to more than 50% of the total caloric intake in sub-Saharan Africa. Cereals in general are relatively low-priced as compared to other food commodities and are cultivated and utilized all around the world by people belonging from all economic classes (Masood *et al.*, 2020).

Red kidney beans (*Phaseolus vulgaris L.*) are a variety of the common bean (*P. vulgaris*), so named because of its kidney-like shape and its colour. Red kidney beans have extraordinary health benefits due to high quantities of folic acid, calcium, carbohydrates, fibre, and proteins amongst the proper functioning of the body (Noah and Banjo, 2020). The seed coat

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of red kidney beans indicates that it may be a good source of polyphenols (Sutedja *et al.*, 2020).

Over the years, onions (*Allium cepa*. L.) have been valued for their medicinal as well as gastronomic qualities. (Bala *et al.*, 2021). It is among the initially cultivated crops of the world probably due to its greater shelf life and portability (Masood *et al.*, 2020). Phenols, flavonoids, and antioxidants are much more abundant in the skin. Because of their bioactive components, onions and their byproducts have a number of positive health effects both in vitro and in vivo (Sagar and Pareek, 2021).

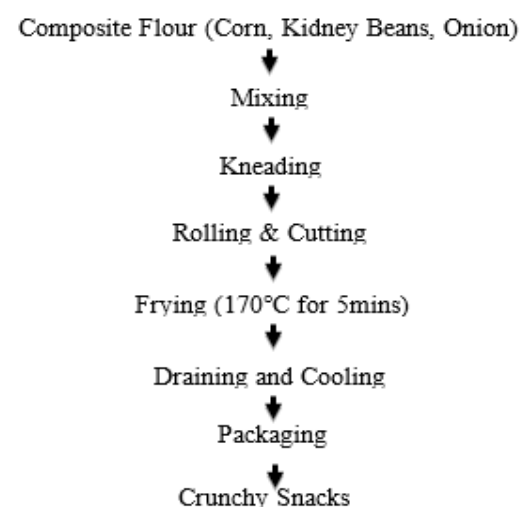
## Materials and Methods

### Source of Materials and Animals

Corn, red kidney beans and onion bulbs were obtained from Shasha market in Akure, Ondo state. Other materials and equipment were obtained from the Food Processing laboratory of the Department of Food Science and Technology, FUTA. Twenty-five (25) healthy weanling male Albino Wistar rats used in this study were obtained from the Department of Biochemistry, FUTA, Nigeria. The study was approved by the Federal University of Technology Akure ethical committee under the ethical number FUTA/SAAT/2016/015. All reagents used were of analytical grade.

### Sample Preparation

The raw materials were bought, prepared and portioned into different blending ratios. They were then kept in an air tight container prior to use.



**Figure 1:** Flowchart for the Production Process of Crunchy Snacks Source: (Akoja *et al.*, 2017).

## Determination of Proximate Composition of Crunchy Snacks

The proximate composition of 3 crunchy snacks formulated from corn, red kidney beans and onion flour was carried out using the methods outlined by AOAC (2012).

### Animal Experimental Design

Twenty-five healthy weanling male albino Wistar rats were obtained from the Department of Biochemistry Animal Laboratory, Federal University of Technology Akure. The rats were randomly distributed in metabolic cages and fed with normal rat pellets for 7 days for acclimatization before commencement of the experiments (Oluwajuyitan *et al.*, 2021).

### Collection of Blood Sample

At the end of 28-day experimental period, the Albino rats were fasted overnight with access to water ad libitum and sacrificed under chloroform anaesthesia. The blood samples were stored in a deep freezer prior to haematological and biochemical analyses (Oluwajuyitan *et al.*, 2021).

### Sensory Evaluation of the Crunchy Snacks from White Corn, Red Kidney Beans and Onion

The sensory evaluation carried out on the samples were appearance, taste, aroma, shape, crunchiness mouth feel and overall acceptability. Thirty panel members evaluated them using a nine-point Hedonic scale (da Silva *et al.*, 2013).

### Statistical Analysis

Determinations were made in triplicates and data generated were subjected to One-Way Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 23.0. The means were separated using New Duncan Multiple Range Test (NDMRT) at 95% confidence level ( $p \leq 0.05$ ).

## Results and Discussion

Proximate composition of the crunchy snacks is presented in Table 1. The data reviewed that the moisture contents of the formulated snack samples were lower than the moisture content (16.66%) of rice snack reported by (Folorunso *et al.*, 2016). The highest level of protein was observed in sample WRKBO1 (9.52%) having white maize flour 70%, red kidney beans 25% and onion flour 5%. The combined consumption of beans and cereals can ensure a balanced protein diet due to the nutritional complementation of essential amino acids (Hayat *et al.*, 2014).

### Nutritional Quality and Relative Weight of Rats Fed with Crunchy Snacks

The nutritional quality of crunchy snack produced from corn, red kidney bean and onion composite flour depicting the protein quality and relative weight gain of experimental animals is shown in Table 2.

**Table 1:** Proximate Composition of Crunchy Snacks

| Samples | Moisture Content   | Crude Fibre        | Crude Protein     | Ash                | Fat               | Carbohydrate       |
|---------|--------------------|--------------------|-------------------|--------------------|-------------------|--------------------|
| WRKBO1  | 5.92 <sup>c</sup>  | 15.42 <sup>c</sup> | 9.52 <sup>a</sup> | 9.50 <sup>b</sup>  | 1.91 <sup>d</sup> | 57.73 <sup>b</sup> |
| WRKBO2  | 10.81 <sup>b</sup> | 17.71 <sup>b</sup> | 7.42 <sup>b</sup> | 6.74 <sup>c</sup>  | 2.98 <sup>b</sup> | 54.36 <sup>c</sup> |
| WRKBO3  | 15.33 <sup>a</sup> | 18.45 <sup>a</sup> | 5.39 <sup>c</sup> | 9.60 <sup>b</sup>  | 5.06 <sup>a</sup> | 46.16 <sup>d</sup> |
| CONTROL | 4.03 <sup>d</sup>  | 14.92 <sup>d</sup> | 3.33 <sup>d</sup> | 10.67 <sup>a</sup> | 2.41 <sup>c</sup> | 64.64 <sup>a</sup> |

Mean value with the same superscript across the same column are not significantly different ( $p < 0.05$ )

**Keys:** CNTL: Oyato crunchy snack; **WRKBO1:** Corn: Red Kidney Bean: Onion (70:25:5%); **WRKBO2:** Corn: Red Kidney Bean: Onion (70:15:15%); **WRKBO3:** Corn: Red Kidney Bean: Onion (70:20:10%).

**Table 2:** Nutritional quality and relative weight of rat fed with crunchy snacks

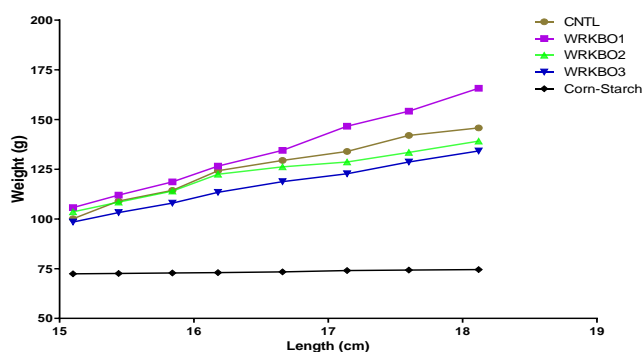
| Parameters                  | Corn-starch         | CNTL                | WRKBO1              | WRKBO2              | WRKBO3              |
|-----------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Weight gained (g)           | 2.13 <sup>d</sup>   | 45.70 <sup>b</sup>  | 60.03 <sup>a</sup>  | 35.58 <sup>c</sup>  | 35.75 <sup>c</sup>  |
| Food intake (g)             | 270.85 <sup>e</sup> | 651.41 <sup>c</sup> | 886.15 <sup>a</sup> | 775.70 <sup>b</sup> | 589.20 <sup>d</sup> |
| Feed Efficiency Ratio       | 0.01 <sup>d</sup>   | 0.07 <sup>a</sup>   | 0.06 <sup>b</sup>   | 0.05 <sup>c</sup>   | 0.06 <sup>b</sup>   |
| Nitrogen Retention          | 0.81 <sup>e</sup>   | 2.63 <sup>d</sup>   | 5.81 <sup>a</sup>   | 3.76 <sup>b</sup>   | 3.49 <sup>c</sup>   |
| Biological Value (%)        | 31.09 <sup>e</sup>  | 71.33 <sup>b</sup>  | 81.05 <sup>a</sup>  | 65.29 <sup>c</sup>  | 60.11 <sup>d</sup>  |
| Net Protein Utilization (%) | 30.38 <sup>e</sup>  | 70.98 <sup>b</sup>  | 79.60 <sup>a</sup>  | 64.97 <sup>c</sup>  | 59.06 <sup>d</sup>  |
| Protein Efficiency Ratio    | 0.31 <sup>e</sup>   | 2.03 <sup>b</sup>   | 2.20 <sup>a</sup>   | 1.98 <sup>c</sup>   | 1.72 <sup>d</sup>   |

Mean value with the same superscript across the same row are not significantly different ( $p < 0.05$ )

**Keys:** CNTL: Oyato crunchy snack; **WRKBO1:** Corn: Red Kidney Bean: Onion (70:25:5%); **WRKBO2:** Corn: Red Kidney Bean: Onion (70:15:15%); **WRKBO3:** Corn: Red Kidney Bean: Onion (70:20:10%).

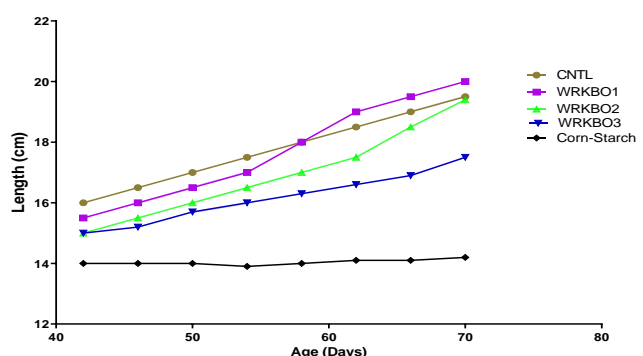
### Growth Performance of Experimental Rats Fed with Crunchy Snacks

The nutritional status in terms of the growth performance of experimental rats fed with crunchy snacks is shown in Figures 1, 2 and 3 respectively. In the present study, the growth pattern and performance of animals fed with WRKBO1 was better than those of the other groups performance Hence, a low cost food that is high in protein and energy-density such as WRKBO1 may be a desirable substitute for expensive imported foods and low qualities local foods (Oluwajuyitan and Ijarotimi, 2019).



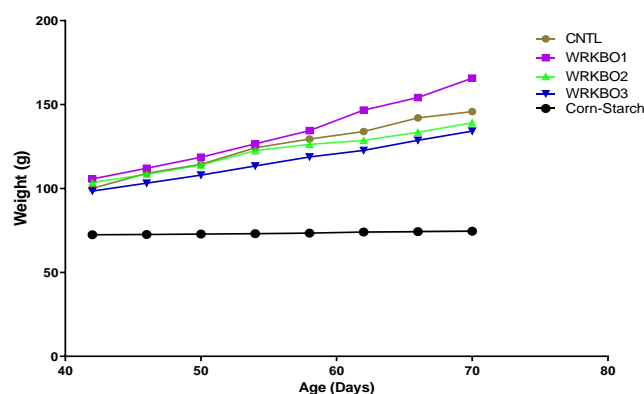
**Figure 1:** Weight-For-Length (wasting) of rats fed with crunchy snacks.

**Keys:** CNTL: Oyato crunchy snack; **WRKBO1:** Corn: Red Kidney Bean: Onion (70:25:5%); **WRKBO2:** Corn: Red Kidney Bean: Onion (70:15:15%); **WRKBO3:** Corn: Red Kidney Bean: Onion (70:20:10%); **Corn starch:** Animal fed with corn starch.



**Figure 2:** Length-For-Age (stunting) of rats fed with crunchy snacks.

**Keys:** CNTL: Oyato crunchy snack; **WRKBO1:** Corn: Red Kidney Bean: Onion (70:25:5%); **WRKBO2:** Corn: Red Kidney Bean: Onion (70:15:15%); **WRKBO3:** Corn: Red Kidney Bean: Onion (70:20:10%); **Corn starch:** Animal fed with corn starch.



**Figure 3:** Weight-For-Age (underweight) of rats fed with crunchy snacks

**Keys:** CNTL: Oyato crunchy snack; **WRKBO1:** Corn: Red Kidney Bean: Onion (70:25:5%); **WRKBO2:** Corn: Red Kidney Bean: Onion (70:15:15%); **WRKBO3:** Corn: Red Kidney Bean: Onion (70:20:10%); **Corn starch:** Animal fed with corn starch.

### Haematological Properties of Rat Fed with Crunchy Snacks

The haematological property of the crunchy snack (Table 3) shows that the packed cell volume (PCV) and red blood cells (RBC) obtained from the rats fed with the formulated snacks were significantly higher compared with animal fed with commercial crunchy snack and corn-starch. It was also observed that rats fed with formulated crunchy snack Red Blood Cell ( $6.48 \pm 0.03$  to  $8.36 \pm 0.02$ ) and White Blood Cell ( $6.89 \pm 0.02$  to  $8.70 \pm 0.03$ ) were within the recommended normal range of 6.76-9.75 and 6.6-12.6 respectively It was observed from the present study that the developed samples show high percentage of packed cell volume and were within the recommended value of 37.60–50.60% for healthy rat (Diana, 2007).

### Biochemical Parameters of Rat Fed with Crunchy Snacks

The creatinine and urea values of rats fed with crunchy snacks and the urea values of rats fed with corn-starch and commercial crunchy snack were observed to be within the normal range (Table 4), in line with what was reported by (Giannini *et al.*, 1999), which implies that the formulated diets had no negative side effect on the kidney functionality and was observed to be lower than the creatinine value (2.1) as reported by (Oluwajuyitan *et al.*, 2021). The AST and ALP values for experimental food samples were within the normal range values (45.70–80.80 and 56.80–128.00 U/L) respectively (Giannini *et al.*, 1999; Diana, 2007) and was observed to be

lower than the AST (55.2) and ALP (114.8) values as reported consumption of these food samples may not damage liver by (Oluwajuyitan *et al.*, 2021). This observation implies that cells. the crunchy snacks may be suitable for consumption, and that

**Table 3:** Haematological Properties of Rat Fed with Crunchy Snack

| Parameters                               | Corn-starch             | CNTL                    | WRKBO1                               | WRKBO2                  | WRKBO3                  | *NR       |
|--|-------------------------|-------------------------|--------------------------------------|-------------------------|-------------------------|-----------|
| PCV (%)                                  | 14.80±0.08 <sup>e</sup> | 30.27±0.03 <sup>d</sup> | 45.80±0.07 <sup>a</sup>              | 34.70±0.06 <sup>c</sup> | 38.93±0.03 <sup>b</sup> | 37.6-50.6 |
| Hb (g/dl)                                | 5.30±0.02 <sup>e</sup>  | 12.90±0.05 <sup>d</sup> | 16.00±0.02 <sup>a</sup>              | 13.84±0.02 <sup>c</sup> | 15.00±0.02 <sup>b</sup> | 11.5-16.1 |
| WBC (x10 <sup>3</sup> mm <sup>-3</sup> ) | 3.00±0.03 <sup>e</sup>  | 6.28±0.03 <sup>d</sup>  | 8.70±0.03 <sup>a</sup>               | 6.89±0.02 <sup>c</sup>  | 7.51±0.06 <sup>b</sup>  | 6.6-12.6  |
| RBC (x10 <sup>3</sup> mm <sup>-3</sup> ) | 4.84±0.01 <sup>e</sup>  | 5.28±0.04 <sup>d</sup>  | 8.36±0.02 <sup>a</sup>               | 6.48±0.03 <sup>c</sup>  | 7.99±0.05 <sup>b</sup>  | 6.76-9.75 |
| MCHC (g/dL)                              | 28.91±0.02 <sup>e</sup> | 31.61±0.05 <sup>d</sup> | 33.90±0.01 <sup>a</sup>              | 32.46±0.02 <sup>c</sup> | 33.48±0.04 <sup>b</sup> | 28.2-34.1 |
| MCH (pg)                                 | 17.30±0.03 <sup>e</sup> | 19.20±0.02 <sup>d</sup> | 22.75±0.04 <sup>a</sup>              | 20.88±0.03 <sup>c</sup> | 22.31±0.02 <sup>b</sup> | 16.0-23.1 |
| MCV (fl)                                 | 61.40±0.07 <sup>e</sup> | 70.81±0.03 <sup>d</sup> | 74.13±0.01 <sup>a</sup>              | 71.95±0.04 <sup>c</sup> | 72.07±0.03 <sup>b</sup> | 50.0-77.8 |
| Neutrophils (%)                          | 3.05±0.03 <sup>e</sup>  | 14.50±0.05 <sup>d</sup> | 26.09±0.05 <sup>a</sup>              | 18.22±0.03 <sup>c</sup> | 20.67±0.03 <sup>b</sup> | 5.3-38.1  |
| Lymphocytes (%)                          | 45.60±0.06 <sup>e</sup> | 53.85±0.05 <sup>d</sup> | 69.84±0.07 <sup>a</sup>              | 57.80±0.05 <sup>c</sup> | 62.39±0.05 <sup>b</sup> | 56.7-93.1 |
| Monocytes (%)                            | 0.00±0.00 <sup>d</sup>  | 0.00±0.00 <sup>d</sup>  | 3.00±0.01 <sup>a</sup>               | 1.00±0.03 <sup>c</sup>  | 2.00±0.02 <sup>b</sup>  | 0.00-7.7  |
| Eosinophils (%)                          | 0.00±0.00 <sup>c</sup>  | 0.00±0.00 <sup>c</sup>  | 2.00 <sup>a</sup> ±0.00 <sup>a</sup> | 1.00±0.00 <sup>b</sup>  | 1.00±0.00 <sup>b</sup>  | 0.0-3.4   |
| Basophils (%)                            | 0.00 <sup>a</sup>       | 0.00 <sup>a</sup>       | 0.00 <sup>a</sup>                    | 0.00 <sup>a</sup>       | 0.00 <sup>a</sup>       | 0.0-0.4   |

Mean (±SD) with the same superscript across the same row are not significantly different (p>0.05)

**Key:** CNTL: Oyato Crunchy Snack; **WRKBO1:** White Maize: Red Kidney Bean: Onion (70:25:5%); **WRKBO2:** White Maize: Red Kidney Bean: Onion (70:15:15%); **WRKBO3:** White Maize: Red Kidney Bean: Onion (70:20:10%); **Cornstarch:** animal fed with corn starch  
\*NR: Anonymous (1996); Giannini *et al.* (1999); Diana (2007).

**Table 4:** Biochemical Parameters of Rat Fed with Crunchy Snacks

| Parameters          | Corn-starch             | CNTL                    | WRKBO1                  | WRKBO2                  | WRKBO3                  | *NR       |
|---------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-----------|
| Creatinine (mg/dl)  | 2.06±0.03 <sup>a</sup>  | 1.01±0.01 <sup>b</sup>  | 0.82±0.02 <sup>c</sup>  | 0.54±0.02 <sup>e</sup>  | 0.73±0.02 <sup>d</sup>  | 0.2-0.8   |
| Urea (mg/dl)        | 19.22±0.01 <sup>a</sup> | 10.86±0.09 <sup>b</sup> | 7.82±0.06 <sup>c</sup>  | 5.95±0.09 <sup>e</sup>  | 6.46±0.02 <sup>d</sup>  | 7 -20     |
| Total protein(g/dL) | 2.69±0.05 <sup>e</sup>  | 4.71±0.05 <sup>d</sup>  | 5.22±0.05 <sup>c</sup>  | 6.38±0.03 <sup>a</sup>  | 5.90±0.07 <sup>b</sup>  | 5.6-7.6   |
| Albumin (g/dL)      | 2.29±0.07 <sup>e</sup>  | 3.91±0.07 <sup>d</sup>  | 4.12±0.02 <sup>c</sup>  | 4.53±0.07 <sup>a</sup>  | 4.37±0.02 <sup>b</sup>  | 3.8-4.8   |
| Globulin (g/dL)     | 0.40±0.02 <sup>e</sup>  | 0.80±0.03 <sup>d</sup>  | 1.10±0.01 <sup>c</sup>  | 1.85±0.02 <sup>a</sup>  | 1.53±0.09 <sup>b</sup>  | -         |
| AST (µ/L)           | 73.69±0.08 <sup>a</sup> | 51.78±0.06 <sup>b</sup> | 46.33±0.02 <sup>c</sup> | 40.01±0.09 <sup>d</sup> | 40.08±0.03 <sup>d</sup> | 45.7-80.8 |
| ALT (µ/L)           | 67.48±0.06 <sup>a</sup> | 52.84±0.05 <sup>b</sup> | 49.57±0.05 <sup>c</sup> | 43.77±0.08 <sup>e</sup> | 45.50±0.03 <sup>d</sup> | 17.5-30.2 |
| ALP (µ/L)           | 98.69±0.06 <sup>a</sup> | 84.70±0.09 <sup>b</sup> | 73.27±0.07 <sup>c</sup> | 51.29±0.03 <sup>e</sup> | 68.59±0.09 <sup>d</sup> | 56.8-128  |
| AST/ALT ratio       | 1.09±0.00 <sup>a</sup>  | 0.98±0.01 <sup>b</sup>  | 0.93±0.01 <sup>c</sup>  | 0.91±0.01 <sup>c</sup>  | 0.88±0.02 <sup>c</sup>  | <1.0      |

Mean (±SD) with the same superscript across the same row are not significantly different (p>0.05)

**Key:** CNTL: Oyato Crunchy Snack; **WRKBO1:** White Maize: Red Kidney Bean: Onion (70:25:5%); **WRKBO2:** White Maize: Red Kidney Bean: Onion (70:15:15%); **WRKBO3:** White Maize: Red Kidney Bean: Onion (70:20:10%); Chow: animal fed; AST: Aspartate Aminotransferase; ALP: Alkaline Phosphate; ALT: Alanine Aminotransferase.  
\*NR: Anonymous (1996); Giannini *et al.* (1999); Diana (2007).

**Sensory Evaluation of the Crunchy Snacks from White Corn, Red Kidney Beans and Onion.**

Sensory evaluation refers to a collection of techniques that seek to differentiate between a range of products based on all of their sensory characteristics and to determine a quantitative description of all the sensory attributes that can be identified,

not just the defects. The sensory evaluations carried out on the samples were appearances, taste, aroma, shape, crunchiness mouth feel and overall acceptability. It could be deduced from the Table 5 that WRKB01 was the most preferred.

**Table 5:** Sensory Evaluation of Crunchy Snacks Produced from Corn, Red Kidney Beans and Onion Flour

| Samples                      | WRKBO1                    | WRKBO2                   | WRKBO3                    | CNTL                     |
|------------------------------|---------------------------|--------------------------|---------------------------|--------------------------|
| <b>Appearance</b>            | 6.60 ± 1.48 <sup>c</sup>  | 7.00 ± 1.05 <sup>b</sup> | 6.03 ± 1.73 <sup>d</sup>  | 7.53 ± 1.52 <sup>a</sup> |
| <b>Taste</b>                 | 6.63 ± 1.59 <sup>b</sup>  | 7.47 ± 1.07 <sup>a</sup> | 6.08 ± 1.19 <sup>d</sup>  | 6.57 ± 1.65 <sup>c</sup> |
| <b>Aroma</b>                 | 6.30 ± 1.51 <sup>c</sup>  | 6.57 ± 1.45 <sup>a</sup> | 6.50 ± 1.46 <sup>ab</sup> | 6.27 ± 1.55 <sup>c</sup> |
| <b>Shape</b>                 | 6.30 ± 1.42 <sup>c</sup>  | 6.73 ± 1.26 <sup>b</sup> | 6.73 ± 1.33 <sup>b</sup>  | 7.37 ± 1.43 <sup>a</sup> |
| <b>Crunchiness</b>           | 7.07 ± 1.39 <sup>c</sup>  | 7.43 ± 1.22 <sup>b</sup> | 7.43 ± 1.00 <sup>b</sup>  | 7.60 ± 1.25 <sup>a</sup> |
| <b>Mouth Feel</b>            | 6.87 ± 1.28 <sup>d</sup>  | 7.57 ± 1.04 <sup>a</sup> | 7.13 ± 1.10 <sup>bc</sup> | 7.20 ± 1.37 <sup>b</sup> |
| <b>Overall Acceptability</b> | 7.00 ± 1.22 <sup>cd</sup> | 7.60 ± 1.12 <sup>a</sup> | 7.07 ± 1.04 <sup>c</sup>  | 7.33 ± 1.63 <sup>b</sup> |

Mean value ± Standard deviation with the same superscript across the same row are not significantly different (p<0.05)

**Keys:** CNTL: Oyato crunchy snack; **WRKBO1:** Corn: Red Kidney Bean: Onion (70:25:5%); **WRKBO2:** Corn: Red Kidney Bean: Onion (70:15:15%); **WRKBO3:** Corn: Red Kidney Bean: Onion (70:20:10%).



## Conclusion

Results from this study revealed that the crunchy snacks produced from blends of white corn, red kidney beans and onion flour possessed high crude protein and promoted growth on experimental rats used in this study. The implication of this research therefore is that a careful selection of indigenous plant protein sources could be of nutritional benefit in terms of reducing malnutrition. It is apparent from the study that red kidney beans and onion incorporated into the flour blend increased the quality of the formulated crunchy snack. The red kidney beans used is projected by the findings of this work to be promising cheap source of nutrients that are lacking in some crunchy snack products and could also play a key role in the acceptability and the nutritional value of monotonous diets in the world at large.

## Declarations

### Competing Interest

The authors declare no competing interest.

### Authors' Contributions

The authors contributed equally to the research process, literature writing, review and editing of the article.

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## FEATURED PUBLICATIONS

### Antioxidant and Dietary Fibre Content of Noodles Produced From Wheat and Banana Peel Flour

This study found that adding banana peel flour to wheat flour can improve the nutritional value of noodles, such as increasing dietary fiber and antioxidant content, while reducing glycemic index.

DOI: <https://doi.org/10.54117/ijfns.v2i2.24>

Cite as: Oguntuyinbo, O. O., Olumurewa, J. A. V., & Omoba, O. S. (2023). Antioxidant and Dietary Fibre Content of Noodles Produced From Wheat and Banana Peel Flour. *IPS Journal of Nutrition and Food Science*, 2(2), 46–51.

### Impact of Pre-Sowing Physical Treatments on The Seed Germination Behaviour of Sorghum (*Sorghum bicolor*)

This study found that ultrasound and microwave treatments can improve the germination of sorghum grains by breaking down the seed coat and increasing water diffusion, leading to faster and more effective germination.

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