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Quality Evaluation of Maize-Peanut-Beetroot Flour Blends and Their Effect on Some Biochemical and Haematological Indices and Weight Changes of Albino Rats

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Albino Rats, Biochemical Indices, Composite Flour, Nutrition, Weight Changes

ABSTRACT

This study evaluates the qualities of flours made from wheat, maize-peanut-beetroot flour blends and their effects on biochemical, haematological, and body weight changes in albino rats. Six samples were formulated with the designations A, B, C, D, E and F, Saml A was 100% wheat, Sample B was 100% maize, C, D, E, F were 0:80:10:10, 0:70:20:10, 0:60:30:10 and 0:50:40:10. The study evaluated functional properties of the flour blends, wiles the flour blends and cookies were analysed for chemical, antioxidant, and sensory of flour blends and cookies. Serum Biochemistry, Haematological indices and body weight changes in rats fed flours were analyzed. The rats were fed for 24 days with the flour blends and administered clean water. The body wait changes of albino rats fed flours after 24 days ranged 10.52 – 55.75 while feed waste ranged from 176.00 – 50.00 and feed conversion ratio 14.80 – 2.90. Serum biochemistry profile revealed that ALT (U/L) did not differ significantly except samples C and D while ALB (g/L) did not differ significantly (37.5 - 41), total protein did not differ significantly across samples except samples B (63.5) and E (86.5) while total cholesterol did not differ significantly (2.9 – 6.25). The haematological indices of albino rats fed experimental diets were within acceptable ranges, PCV (38.5 - 49), HGB (12.85 – 16.35), RBC (6.425 – 8.18), MCV (60), MCH (20), MCHC (332.5 - 333), WBC (11.45 – 17.8), NEUT (14.5 – 27.5), LYMH (71 – 83), MONO (0.5 - 2), EOSI (0 – 2.5) while BASO (0). The composite flour performed better than wheat flour, the biochemical and haematological indices are within safe limits. It is therefore encouraged that composite flours from Maize-Peanut-Beetroots are a good substitute for wheat for people who are intolerant to gluten..

INTRODUCTION

The awareness on the use of composite flour in baked goods is on the increase. This has informed research on the use of different composite flour in the production of cookies. Raihan and Saini (2017) produced cookies from composite flour of oats, sorghum, amaranth and wheat flour with reported acceptability at 10% inclusion of mix flour in wheat flour. In another study by Okoye and Obi (2017), cookies were produced from wheat-African bread fruit composite. The study showed that African breadfruit flour could be used as a partial replacement for wheat flour at the levels of 10 to 50% in the production of cookies with improved nutritional and sensory properties.

LITERATURE REVIEW

Wheat, which comes from a type of grass called Triticum, is a very significant cereal because its seed is ground into products like flour, semolina, and other ingredients that are the foundation for bread and other bakery goods (cookies), as well as noodles and pasta. As a result, it serves as the primary source of nutrients for the majority of the world's population (Chowdhury *et al.,* 2020). Apart from high expense on wheat importation, excessive intake of wheat has been linked in various regions of the world to autoimmune reactions, allergies, asthma, diabetes, and gluten sensitivity (Adebayo *et al.,* 2021).

According to Adiaha (2018), one of the crops that is cultivated most frequently worldwide is maize. Almost two thirds (64%) of the maize produced in Nigeria. While 13% of Nigeria's maize crop is used to make industrial flour, corn flakes, and other confections, 6.5% of the crop is utilized by brewing enterprises. However, the percentage of maize consumed in households is only between 10% and 15% (Adiaha, 2018). Godswill *et al.* (2020) reported that maize contains a range of vitamins and minerals, including B vitamins (thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, and folate), vitamin C, vitamin E, calcium, iron, magnesium, phosphorus, potassium, zinc, manganese, and copper. Maize contains antioxidants, such as carotenoids (lutein and zeaxanthin), which contribute to eye health and protect cells from oxidative stress. Peanut is a significant crop farmed in Nigeria's dry and semi-arid regions. Cake-derived defatted peanut flour mixes easily and improves the nutritional value of wheat and other flours, including acha flour (Ubbor, 2020). The nutritional content of peanuts is crucial for the growth and calorie intake of human living things. In addition to being high in calories, peanuts also include several nutrients, minerals, antioxidants, and vitamins that are vital for human health (Dharsenda & Dabhi, 2020).

Beetroot, also referred to as beets, are members of the Chenopodiaceous family and come in a variety of forms, with yellow to red bulbs. Since ancient times, it

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has been utilized as medicine in addition to being a meal. Given the increased interest in using natural food colors, the vegetable is also used as a food colorant due to its attractive color (Ashwini Gangatharan 2015). Red beet consumption, being a high source of antioxidants, may help protect against age-related illnesses. Ravichandran *et al.* (2020) stated that red beetroot is among the vegetables with the highest antioxidant activity.

The market for cookies is expanding quickly, and they are popular everywhere in the world. Cookies are the second most popular food in the world after bread. Numerous academics are looking into how to fortify cookies to boost their nutritional value and act as a successful public health intervention (Pakhare *et al.,* 2016). Composite flours are described as a combination of starch- and protein-rich flours (Qumbisa, 2019). (Adegunwa *et al.,* 2012). In commercial cookies, essential nutrients like proteins, dietary fibre, and vitamins are insufficient. As a result, inclusion of protein and lipids from other sources that are high in necessary amino acids and fatty acids may be crucial to enhancing the nutritional value of foods like cookies (Chowdhury *et al.,* 2020).

The primary purpose of blood, a crucial unique circulatory tissue, is to maintain homeostasis. Blood is made up of cells suspended in a fluid intercellular material called plasma (Isaac *et al.,* 2013). When it comes to feed components that affect farm animals' blood and overall health, haematological parameters—which include leucocytes, red blood cells, white blood cells, mean corpuscular volume, mean corpuscular haemoglobin, and mean corpuscular haemoglobin concentration—are invaluable for assessing feed toxicity (Etim *et al.,* 2014).

MATERIALS AND METHODS

Source of Raw Materials

Maize grains and peanuts were purchased from Wadata market Makurdi, Benue State. Beetroots were purchased from local sellers in Jos, Plateau State.

Samples Preparation

Preparation of Maize Flour

Maize flour wereprepared following the description of Awofadeju and Olapade 2020 method as shown in figure 1. About 10 kg of maize grains were obtained and sorted. The maize grains were cleaned of any remaining dust and small particles by washing them with water, after which they were conditioned and oven dried. The dried grains were ground into flour using a commercial grinder (Heavy-duty electric Grinder, Model MG182/00), the maize flour weresieved using 0.5 mm sieved size. The sieved flour were packaged in Ziploc high-density polyethylene bags for further use.

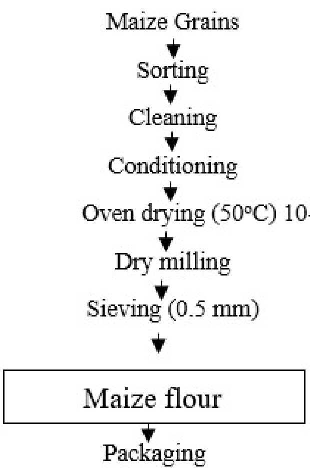

Figure 1: Flow chart for the production of maize flour

Preparation of Defatted Peanut Flour

Defatted groundnut flour was made using a modified method of Adjou *et al.* (2012), with the exception that the cake was ground into flour. Whole peanuts were dehulled, the hulls were separated from the kernel, the kernels were sorted to remove any foreign matter, and the kernels were toasted at 150 oC for 15 minutes. Toasted seeds will then be ground using clean GX160 hammer mill. Peanut cakes were formed by shaping the paste and frying it in the extracted oil after it had been crushed in a mortar with the addition of boiling water to improve oil extraction. The oil will then be removed using a large spoon. In the end, a GX 160 attrition mill were used to produced peanut cake flour. The flour was oven dried at 50 oC for one hour and sieved for 0.5 mm screen sieve.

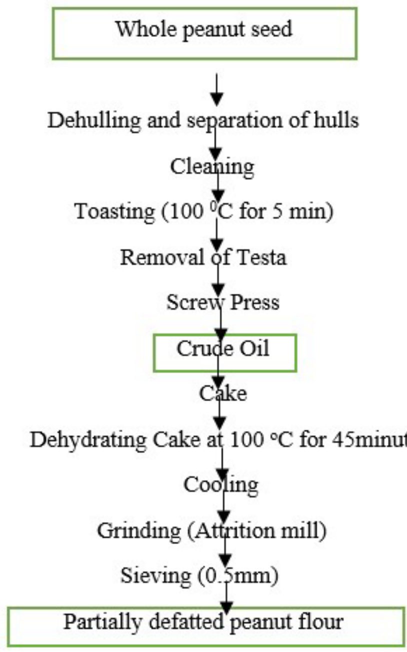

Figure 2: A Typical Processing Chart for Defatted Peanut Flour Production and Oil Extraction (modified)
Source: As described by Ranko Romanić (2020) with modification

Production of Beetroot Flour

Beet root wereproduced according to the method of Adegunwa (2012) as shown in Figure 3.3. After the beets werecleaned, trimmed, and sorted, the roots wereroasted for 40 minutes, then they werepeeled, sliced, and dried in a hot air oven set at 60 oC for ten hours. Finally, the dried chips wereground into flour using a BLG-595 MK2 blender and sieved through a 0.5 mm wire mesh. The flour werestore in Ziploc high-density polyethylene bags for further use.

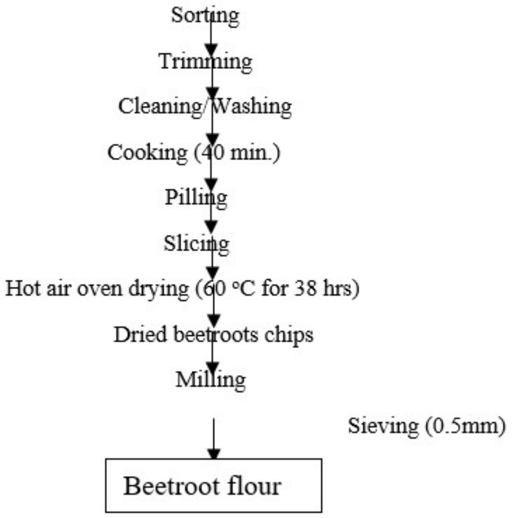

Figure 3: Flow Chart Showing the Production of Beetroot Flour
Source: Adegunwa et al. (2012) (modified)

Blend Formulation

Wheat, Maize, defatted peanut and beetroot flour samples were mixed into proportions of 100:0:0:0, 0:100:0:0, 0:80:10:10, 0:70:20:10, 0:60:30:10 and 0:50:40:10 respectively. The combination was labeled A, B, C, D, E, F respectively (Table 3.1).

Proximate Analysis of Flour Blends and Cookies

Moisture content weredetermined using the oven drying method as outlined by AOAC (2012) method. The amount of protein weredetermined by total-Kjeldahl Nitrogen method according to AOAC (2012) method. Crude fat content was determined by the Soxhlet extraction method as outlined by AOAC (2012) method. Total ash content weredetermined by dry ashing according to AOAC (2012) method. The total carbohydrate content wereestimated by the difference as described by Onwuka (2005). The total energy value was calculated using the Atwater general factor according to FAO (2001)

Animal Study

Ethical Clearance of Animal Rights

The study protocol for the present work was approved while the ethic clearance issued to the investigators from the Ethical Committee for Laboratory Animals, College of Veterinary Medicine, Joseph Tarka University Makurdi (Former Federal University of Agriculture Makurdi), Nigeria with protocol number JOSTUM/CVM/ETHICS/2024/30.

Diet Formulation for Animal Study

The experimental diet was formulated as shown in Table 3.2. The composite samples was added to the ingredients at varying percentages according to the blend ratio. The ingredient: Vitamin/mineral mixture, vegetable oil, salt, non-digestive fibre (cellulose) and cray fish was used to improve the nutritional composition of the diet. The controls was 100% Wheat and 100% Maize.

Feeding Trial

The feeding trial was done using Wister albino rats for twenty-eight (24) days following a modification of the method described by Stephen *et al.* (2025). Twenty-Four Wistar albino rats was randomly distributed in six cages labelled A, B, C, D, E and F with four animals per cage. Each of the experimental rats' group was daily fed with weighted fifty-five (55)g of formulated diet and water ad libitum. Blood samples was randomly collected and subjected to Serum Biochemistry Profiles and Haematological Indices analyses after 28 days. Also, weight changes (final minus Initial weight), feed waste and feed conversion ratios were recorded and subjected to statistical analysis.

Weight Changes

The weighing of albino rats was done as described by Stephen *et al.* (2025). Weight was monitored after every four days and 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.

3.10 Haematological Analyses

Packed cell volume was determined by the method of Serah *et al.* (2015). PCV value was calculated as the ratio of the height of the cells to the total height of fluid in the tube. Red blood counts were determined as outlined by Stephen *et al.* (2025). : The total number of red cells = N X 10,000. N is the number of red cells found in 80 squares. The method outlined by Stephen *et al.* (2025) was used to determine the white blood cell. The total number of white blood cells = N X 10,000. N is the number of white cells found in 80 squares. Platelets were determined according to the method of Serah *et al.* (2015). The haemoglobin (Hb) content was determined as outlined by Serah *et al.* (2015). The method outlined by Stephen *et al.* (2025) was used in determination of total protein, cholesterol content, Aspartate Amino Transferase (AST), Alanine Amino Transferase, Serum Albumin. The statistical analysis of each sample was performed using the statistical package for social scientists (SPSS 20.0 versions). The data generated from these investigations was analyzed using analysis of variance (ANOVA) to determine significant difference between the means and these was expressed as mean ± standard deviation (SD). Dungan multiple range test was used in mean separation.

Table 1: Proximate Composition (%) of Wheat, Maize, Peanut, and Beetroot Flour Blends

Sample Code	Moisture content	Ash content	Crude fibre	Crude lipid	Crude protein	CHO	Energy (Kcal)

A-100:0:0:0	9.99^{d}±0.63	0.29^{a}±0.24	16.07^{b}±0.75	7.63^{a}±0.34	11.81^{b}±0.45	54.28^{e}±0.61	333.07^{a}±0.35
B-0:100:0:0	6.29^{a}±0.57	0.74^{a}±0.32	7.65^{a}±0.69	8.96^{b}±0.28	8.75^{a}±0.51	67.61^{f}±0.58	386.07^{e}±0.57
C-0:80:10:10	8.39^{c}±0.65	2.36^{b}±0.43	16.28^{bc}±0.84	11.49^{c}±0.42	11.38^{b}±0.39	50.1^{d}±0.47	349.28^{b}±0.44
D-0:70:20:10	7.26^{b}±0.47	2.12^{b}±0.40	16.99^{cd}±0.57	13.48^{d}±0.38	12.75^{c}±0.36	47.4^{c}±0.68	361.91^{c}±0.27
E-0:60:30:10	6.92^{ab}±0.54	2.15^{b}±0.39	20.85^{e}±0.74	16.86^{e}±0.43	13.13^{c}±0.47	40.1^{b}±0.32	364.61^{d}±0.38
F-0:50:40:10	7.17^{ab}±0.56	2.49^{b}±0.28	17.36^{d}±0.63	20.84^{f}±0.38	13.56^{c}±0.25	38.58^{a}±0.56	396.1^{f}±0.47

Values are means ± standard deviations of triplicate determinations. Means in the same column with different superscripts are significantly different at ($p<0.05$).

Table 2: Body Weight (g) Changes of Albino Rat Fed Diets from Wheat, Wheat, maize, peanut and beetroot Flour Blends

Sample	Day 1	Week 1	Week 2	Week 3	Week 4	TWG (g)	FEED WASTE (g)	FCR
A-100:0:0:0	81.78^{a}±9.92	74.75^{a}±14.28	82.7^{a}±14.25	87.28^{a}±15.18	92.3^{a}± 22.01	10.52^{a} ± 0.5	176.00^{a} ± 0.5	14.80^{a} ± 0.5
B-0:100:0:0	79.75^{a}±18.47	77.45^{ab}±16.03	85.9^{ab}±20.28	93.48^{ab}±20.25	101.25^{ab}± 18.61	21.50^{b} ± 0.5	148.00^{b} ± 0.5	7.60^{b} ± 0.5
C-0:80:10:10	81.33^{a}±10.89	97.78^{abc}±16.16	111.18^{bc}±17.74	121.38^{bc}±21.08	127.23^{b}±18.74	45.90^{c} ± 0.5	78.00^{c} ± 0.5	3.90^{c} ± 0.5
D-0:70:20:10	84.4^{a}±14.91	99.78^{abc}±11.94	109.93^{bc}±9.93	119.53^{bc}±9.82	127.05^{b}±9.11	42.65^{d} ± 0.5	67.50^{d} ± 0.5	4.30^{d} ± 0.5

E-0:60:30:10	79.63^{a}±8.87	105.33^{c}±7.72	122.63^{c}±13.8	138.2^{c}±16.58	144.13^{c}±14.24	64.50^{e} ± 0.5	50.00^{e} ± 0.5	2.90^{e} ± 0.5
F-0:50:40:10	80.35^{a}±15.21	102.55^{bc}±25.7	116.05^{c}±24.55	128.75^{c}±29.69	136.1^{c}±24.28	55.75^{f} ± 0.5	51.00^{f} ± 0.5	3.40^{f} ± 0.5

Values are means ± standard deviations of triplicate determinations. Means in the same column with different superscripts are significantly different at ($p<0.05$).
Key: TWG - Total Weight Gain, FCR - Feed Conversion Ratio

Table 3: Serum Biochemistry Profile of Albino Rat Fed Diets from Wheat, Wheat, maize, peanut and beetroot Flour Blends

Sample Code	ALT (U/L)	ALB (g/L)	AST (U/L)	Total Protein (g/L)	Total Cholesterol (mMol/L)
A-100:0:0:0	24^{ab}±1.41	41^{a}±0	70.5^{ab}±0.82	73^{ab}±0.31	3^{a}±0.14
B-0:100:0:0	26^{ab}±3.07	40^{a}±0	84.5^{ab}±1.34	63.5^{a}±1.02	2.9^{a}±1.19
C-0:80:10:10	20^{a}±1.07	38^{a}±1.41	33^{a}±0.83	72^{ab}±1.07	4.9^{a}±1.13
D-0:70:20:10	78.5^{b}±0.31	41^{a}±1.41	192.5^{b}±1.62	82^{ab}±1.41	4.55^{a}±0.64
E-0:60:30:10	48^{ab}±2.97	37.5^{a}±0.95	116^{ab}±0.57	86.5^{b}±3.54	5.15^{a}±0.04
F-0:50:40:10	67.5^{ab}±1.34	39.5^{a}±0.71	75.5^{ab}±3.23	82^{ab}±5.66	6.25^{a}±1.48

Values are means ± standard deviations of triplicate determinations. Means in the same column with different superscripts are significantly different at ($p<0.05$)

Table 4: Haematological Indices of Albino Rat Fed Experimental Diets from Wheat, Wheat, maize, peanut and beetroot Flour Blends

Sample code	PCV (%)	HGB (g/dL)	RBC (10^{12}/L)	MCV (fL)	MCH (pg)	MCHC (g/L)	WBC (10^{9}/L)	NEUT (%)	LMPH (%)	MONO (%)	EOSI (%)	BASO (%)
A-100:0:0:0	44^{a}±1.41	14.65^{a}±0.49	7.345^{a}±0.25	60^{a}±0	20^{a}±0	332.5±0.71	14.8ab±0.28	21^{a}±8.49	78^{a}±8.49	0.5^{a}±0.71	0±0	0±0
B-0:100:0:0	40^{a}±8.49	13.3^{a}±2.83	6.655^{a}±1.44	60^{a}±0	20^{a}±0	332.5±0.71	11.45^{a}±0.35	27.5^{a}±7.78	71^{a}±7.07	0.5^{a}±0.71	1^{a}±1.41	0±0
C-0:80:10:10	42.5^{a}±3.54	14.15^{a}±1.2	7.075^{a}±0.57	60^{a}±0	20^{a}±0	333±0	17.8b±3.11	21^{a}±1.41	76^{a}±1.41	2^{a}±1.41	1^{a}±1.41	0±0
D-0:70:20:10	49^{a}±5.66	16.35^{a}±1.91	8.18^{a}±0.93	60^{a}±0	20^{a}±0	333.5±0.71	13.25ab±0.21	14.5^{a}±6.36	83^{a}±8.49	0.5±0.71	2^{a}±2.83	0±0
E-0:60:30:10	38.5^{a}±4.95	12.85^{a}±1.63	6.425^{a}±0.78	60^{a}±0	20^{a}±0	333.5±0.71	13.05^{ab}±0.92	17.5^{a}±0.71	79.5^{a}±2.12	0.5^{a}±0.71	2.5^{a}±0.71	0±0

F-0:50:40:10	$45.5^{a}\pm0.71$	$15.15^{a}\pm0.21$	$7.56^{a}\pm0.11$	$60^{a}\pm0$	$20^{a}\pm0$	333 ± 0	$15.7^{ab}\pm3.39$	$19^{a}\pm15.56$	$80^{a}\pm15.56$	$0.5^{a}\pm0.71$	$0.5^{a}\pm0.71$	0 ± 0

Values are means ± standard deviations of triplicate determinations. Means in the same column with different superscripts are significantly different at ($p<0.05$)

RBC: red blood cells; HB: haemoglobin; PCV: Packed cell volume; MCV: mean corpuscular volume; MCH: mean corpuscular haemoglobin; MCHC: mean corpuscular haemoglobin concentration; WBC: white blood cells

Weight Changes

The differential weight gain patterns observed here resemble findings by Kleinknecht (1979), who demonstrated that diets varying in protein quality significantly affect growth rates in rats. The pattern observed here mirrors findings from Hussain (2024), who established that diets with complementary protein sources typically result in improved feed efficiency and higher weight gain compared to single-source protein diets.

Haematological

The PCV results demonstrate that all experimental diets containing various blends of wheat, maize, peanut, and beetroot flour supported adequate erythropoiesis in the albino rats. The values generally fall within the normal physiological range for healthy rats (37-52%), Vigneshwar *et al.,* 2021 reported 32.60-46.20 for male and 27.30-48.40 for female wistar albino rats, this indicates that none of the diets induced anemia or polycythemia. The hemoglobin results demonstrate that all experimental diets comprising various blends of wheat, maize, peanut, and beetroot flour maintained adequate hemoglobin synthesis in the albino rats especially the female wistar albino rats. All flour blends provided bioavailable iron sufficient for hemoglobin synthesis, a crucial finding given that iron deficiency is the most common nutritional deficiency worldwide, as noted by Kiani, *et al.* (2022). Red blood cells are essential components of blood that give vertebrate blood its characteristic red colour. They also help transport oxygen from the lungs to various tissues. These RBC results demonstrate that all experimental diets comprising wheat, maize, peanut, and beetroot flour blends supported normal erythropoiesis in the albino rats. Mean Corpuscular Volume (MCV) is a measure of the average size of your red blood cells, calculated by dividing the hematocrit by the red blood cell count. It is a key part of a complete blood count (CBC) that helps classify anemias and diagnose other conditions. These results indicate remarkable consistency in erythrocyte size across all experimental groups, . The consistent value of 60 fL falls within the normal range for laboratory rats (55-68 fL), as established in standardized hematological reference values (Patel *et al.,* 2024). Mean corpuscular hemoglobin (MCH) measures the average ("mean") amount of hemoglobin you have per red blood cell. These results demonstrate remarkable consistency in the hemoglobin content per erythrocyte across all diet groups. The consistent value of 20 pg falls within the normal physiological range for laboratory rats (18-22 pg), according to standardized hematological reference values (Vigneshwar *et al.,* 2021). These results demonstrate remarkable consistency in the concentration of hemoglobin (MCHC) within erythrocytes across all diet groups. . The values observed (332.5-333.5 g/L) fall within the normal physiological range for laboratory rats (290-330 g/L), according to standardized hematological reference values established by Patel *et al.* (2024). White blood cells (WBCs), also called leukocytes, are a vital part of the immune system that protect the body from infection and disease by fighting bacteria, viruses, and other foreign invaders. The significantly higher WBC count in Diet C (17.80×10^9/L) compared to Diet B (11.45×10^9/L) suggests an immunomodulatory effect of this particular flour blend. This elevation, while statistically significant, appears to be non-pathological but rather stress or infection, making their body to produce more WBC to fight it. These results demonstrate that all experimental diets comprising various blends maintained normal neutrophil percentages in the albino rats. The values fall within the normal physiological range for healthy rats (10-30%). Certain bioactive compounds in beetroot, particularly betalains, exhibit anti-inflammatory effects, (Nirmal *et al.,* 2024), that slightly reduce circulating neutrophil percentages without compromising immune function.

Normal neutrophil percentages indicate the absence of significant inflammatory processes in response to the experimental diets, suggesting good biocompatibility of all flour blends. The lymphocyte percentages range from 71% to 83%, which fall within normal physiological ranges for albino rats, Vigneshwar *et al.* (2021). Lymphocyte values within this range indicate absence of chronic inflammation or immunosuppression, suggesting the experimental diets did not negatively impact immune function. Monocytes are a type of white blood cell in your immune system. The cells either kill the invader or alert other blood cells to help destroy it and prevent infection. High or low monocyte counts may be a sign of a condition that needs diagnose. Eosinophils are produced in the bone marrow from multipotent hematopoietic stem cells, Blanchard & Rothenberg (2009). It is a type of white blood cell that helps fight parasitic infections and plays a role in allergic reactions and asthma. The eosinophil percentages range from 0% to 2.5%, showing some variation across diet groups, though this variation was not statistically significant. This range is consistent with normal physiological values for albino rats. Vigneshwar *et al.* (2021) established that healthy albino rats typically show eosinophil percentages between 0.30 – 4.50%, placing all these values within normal limits except sample A; 100% wheat. A basophil is a type of white blood cell and granulocyte that plays a role in the immune system by helping to defend against pathogens and initiating allergic reactions, (Amit *et al.,* 2023). Basophil counts of 0-0.8% are considered normal in laboratory rats, with many healthy animals showing no detectable basophils in circulation, Vigneshwar *et al.* (2021).

Serum Biochemistry of Albino Rat Fed Experimental Diets from Wheat, Wheat, Maize, Peanut and Beetroot Flour Blends

The ALT levels ranged from 20.0 to 78.5, with samples A, B, E, and F showing no significant differences ($p<0.05$) among them, while they differed significantly from samples C and D. ALT facilitates the formation of glutamate and pyruvate in the hepatocyte which is important for energy production. The normal range for ALT in males is between 29-33 IU/L and 19-25 IU/L for females, (Kalas *et al.,* 2021) while Vigneshwar *et al.* (2021) recorded 24.13-67.45 for male and 29.34-72.16 for female. The albumin (ALB) levels did not differ significantly ($p<0.05$) among the samples, ranging from 37.5 to 41. Albumin is a key protein synthesized by the liver and serves as an important indicator of nutritional status and liver function (Sun *et al.,* 2019). Ariye *et al.* (2023), recorded 34 – 36 g/L albumin ranges. The stability of albumin levels across experimental groups suggests that all diet formulations supported normal hepatic protein synthesis. The AST (Aspartate Aminotransferase) levels ranged from 33 to 192.5, with samples A, B, E, and F showing no significant differences ($p<0.05$), while they differed significantly from samples C and D. The AST values show considerable variation across the diet groups, ranging from 33 U/L to 192.5 U/L. This suggests that while some groups-maintained AST within normal physiological ranges, others, particularly the D group show marked elevation. The total protein levels in samples A, C, D, and F were not significantly different ($p<0.05$), but they differed significantly from samples B and E. Total protein levels are indicative of the overall protein intake and nutritional status of the animals. The variations in total protein levels among the samples may reflect differences in the protein content of the flour blends used. The total protein values range from 63.5 g/L to 86.5 g/L across diet groups which are within reference range for both male and female; 5.1-7.6 for male and 5.2-8.2 for female, Vigneshwar *et al.* (2021). The total cholesterol levels did not differ significantly ($p<0.05$) among the samples, ranging from 2.9 to 6.25. Cholesterol levels are important indicators of cardiovascular health, and stable cholesterol levels across the samples suggest that the different flour blends did not adversely affect lipid metabolism.

CONCLUSION

The composite flour performed better than wheat flour, the biochemical and haematological indices are within safe limits. It is therefore encouraged that composite flours from Maize-Peanut-Beetroots are a good substitute for wheat for people who are intolerant to gluten.

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