Comparative Studies on the Nutritional Quality of Wheat and Oat Composite Flour Bread Enriched with Carrot and Ginger Powders

Ikechukwu, Ezekiel Emeka[1*], Joseph Egwu Inya[2], Ihuoma Joy Afor[3], Sunday Emmanuel Ukah[4], Chibuike Goodluck Nwovu[5] Adangozi Benita Nna-Johnson[6], Israel Inioluwa Ogunsola[7], Moses Oluwasegun Ogunyemi[8], Taoheed Gbadamosi[9], Nwadili Bernard Kachi[10], Adam Mustapha Uzaifa[11], Oko Dominic Ogbu[12], Chisom Stephen Okoro[13], Maigari Martha Adamu[14], Joshua Eniyoke Amuofu[15], Otung Jacob Akung[16], Folasade Ademilola[17], Chinenye Jacinta Ogbuaka[18], Omenihu Gladys[19]

[1,2,3,4]Science Laboratory Technology Department, Federal University of Technology Owerri, Imo State, Nigeria
[5,6,7] National Health Fellows, Sector Wide Approach Office, Federal Ministry of Health and Social Welfare
[8,9]Industrial Microbiology & Information Science Departments, University of Ibadan, Nigeria
[10]PJ Living Hospital and Maternity Nkwelle Ezunaka, Oyi L.G.A, Anambra State, Nigeria
[11] Biochemistry Department, Plateau State Polytechnic, Plateau State, Nigeria
[12,13]Mathematics Department, Alex Ekwueme Federal University Ndufu Alike Ikwo, Ebonyi State, Nigeria
[14,15]Educational Foundation, Abubakar Tafawa Balewa University Bauchi State, Nigeria
[16]Public Health Department, National Open University of Nigeria, Nigeria
[17]Animal Science Department, Obafemi Awolowo University, Ile-Ife, Nigeria
[18]Biotechnology Department, Ebonyi State University Abakaliki, Ebonyi State, Nigeria
[19]Department of Medical Laboratory Science, Rivers State University, Nigeria
*Corresponding Author Email: iykemanprojects@gmail.com

Abstract

The nutritional value of wheat and oat composite flour bread enhanced with powdered carrot and ginger was studied. The bread was produced at TastyBite Food's Bakery, Owerri West. The 5-point hedonic scale was used for sensory evaluation, and the AOAC rules were used for analysis. Data were analyzed using Duncan Multiple Range Test and one-way Analysis of Variance at a 95% confidence level using SPSS. The sensory quality of breads B, C, D, E did not differ statistically ($P>0.05$) from the control (A). Vitamin A, B_1, B_2, B_3, B_6, B_9, and E compositions of the breads containing carrot, oats and ginger were greater and differed statistically ($P<0.05$). The bulk density (0.68 to 0.47g/ml), foam stability (25.87 to 21.76%), and capacity (60.72 to 52.425%) of the loaves dropped as the amount of wheat flour (93.75 to 112g) increased ($P<0.05$). The swelling index (2.12g/g), gelatin temperature (73.64°C), oil (1.94%), and water absorption capacities (2.57%) were greater in B, C, D, and E than the control. As the amount of ginger, carrot, and wheat increased, the levels of calcium, sodium, magnesium, phosphorus, potassium, iron, and zinc increased among the enhanced breads. The same was observed for energy value, carbohydrate, moisture content, crude protein, fiber, fat, and ash contents when the raw materials for enhancement were adjusted. According to the data obtained, bread E produced the best result because it contained moderate amount of wheat flour (112.5g), ginger (2.5g), carrot slices (6.25g) and the fewest oats (12.5g). Dabino fruit can be used as sugar.

Keywords

Bread, Composites, Enhanced foods, Gelatin, Quality.

INTRODUCTION

Humans need food for survival. Food can be any nutrient-rich substance taken by humans or animals to keep life and growth [1]. Although food is location-dependent, the primary purpose remains general and cannot be negotiated, whatever the reason. However, what is perceived as food in one location may not be regarded in another location, but what is unarguable remains the biochemical and nutritional profile [2]. Characteristically, food must be tasty, certified to contain nutrients, and preferably non-allergic. No single food has all six classes of nutrients in equal proportion. Therefore, one food material can be used to enrich another to serve a particular purpose. Most times, one nutrient may be greater than the other in each food material. For example, the carbohydrate composition of wheat used in making bread was analyzed [3]; they found that it contained 80% of carbohydrates and other nutrients in smaller proportions [3].

Bread is a basic staple made historically from wheat flour, salt, and yeast, and it is widely consumed around the world [4]. Some bread we buy and eat every day is produced from a wide variety of grains such as soy flour, corn composites, barley extracts, millet ingredients and rice but wheat is still required for the proper leavening due to its gluten concentration [5]. There is higher demand for bread in Nigeria [5]. Consumers currently prefer healthier food to reduce their risk of food-associated illnesses. This is why buyers are very selective on the type of bread to get from the market. This has encouraged bread businesses and food research technologies, consequently increasing bread product diversity, quality, flavor, and accessibility. The sensory properties, mineral, vitamin, proximate and functional composition of any food product usually helps in its marketability. Food consumers bestow their judgment on the sensory attributes of food. Therefore, the nutritional quality of food sample defines the salability. Bread made with wheat is common but enhancing it with oat, ginger, gallic and carrot can make it richer and more nutritious because the additional substances can contribute greatly to the attractiveness and marketability [4].

Wheat belongs to one of the most diverse plant groups, specifically to the family of *Poaceae*. It is the principal cereal crops for most of the population of world. The commonest wheat has the botanical name of *Triticum aestivum* and can be regarded as polyploid in nature and domestically grown worldwide [6]. Wheat is grown in Northern and Western African countries, China and India. It is also grown in high quantities in some parts of Nigeria. Consequently, wheat is crop that can be harvested after one season or biennially. It is primarily grown for its grains. The plant has linearly arranged leaves with an erect smooth stem growing in two rows on both sides. A typical wheat stem has larger 'flag' leaves at the top. The botanists reported that the stem has individual spikelets, each with 3-9 florets on the stem. The seed known as the kernel which develops from the wheat fruit are formed within the spikelets [7]. From reports so far, bread flour can be obtained from hard wheat, often called hard spring wheat. Research has shown that it has protein value, between 10% and 13%, which makes it good for baking bread plus the presence of yeast it contributes. The wheat is white in colour when finely milled. The white flour is gotten from soft wheat, and this is why wheat is selling well in the labour market [8]. Low production of wheat can lower the production of bread because of its relevance in bread-making industries [9]. As it stands now, wheat remains the most sought raw material globally based on grain acreage and it is ranked second based on the total food production volume [10]. Wheat farming has been complicated by high temperature and unpredicted distribution of rainfall in Nigeria for the last few decades and this has affected its production greatly [11]. Some wheat flours used in Nigeria are imported to meet the demands despite the population, and this is why bread has been very expensive.

Oat on the other hand is one of the preferred food materials by people because it has a low glycemic index [12]. Assessment carried out by some authors suggested that oat contains about 4% beta-glucan, 7% fat contents, 14% protein and 60% of starchy compositions [12]. Research has shown that oat has high protein composition compared to other grains that have higher fatty and starchy contents. Another fascinating feature of oat has been observed in their high composition in fiber and soluble beta-glucans. Oat has high potassium content [12]. It also contains high phenolics contents among them include avenanthramides which are particular to oats. This biomolecule alone has attracted a lot of interest to oat and has tremendously increased the market value. Interestingly, if oat composite is added to wheat during bread making, the nutritional value can be enhanced. Taking food materials that do not quickly rise blood glucose can help prevent the occurrence of diabetes and they are encouraged by public health dieticians. However, since the glycemic index of oat is low, bread produced with it can be used by diabetic patients to promote their health conditions. This will also help to supply natural sugar to their system at a moderate index. Bread produced with oats can also be used as food to target teenagers that lack protein because it has a high protein content of up to 12–17%. Then, lack of gluten may make taking oats favorable for individuals with celiac disease [13].

Ginger (*Zingiber officinale roscoe*) is being used as a spice, supplement, and flavoring agent. In Igboland, it is traditionally used as a medicine due to its beneficial characteristics. It is characteristically pungent, aromatic, nutritious, and possesses high pharmacological activity [14] [15]. Those with metabolic syndrome have been encouraged to eat ginger and ginger extracts because of the numerous therapeutic effects. It has also been recommended for patients with diabetes. Ginger extracts when consumed in moderate quantity reduce cholesterol level and regulate lipid metabolism and control inflammation [14] [15]. Ginger rhizome contains many chemicals. It has an average of 3% fatty oil, 9% protein, 65% carbohydrates, 5.5% crude fiber, 8% ash, 10.5% water, and 2.5% volatile oil [16]. Since ginger has the following important nutritional profile, incorporating it into bread can also help to greatly add to the value, taste, and texture.

Carrot (*Daucus carota*) is a commonly eaten leafy food known for its high nutrient composition, health benefits and therapeutic characteristics [17]. The root is a perfect source of essential micro and macro-nutrients (minerals) and vitaminous materials (potassium, phosphorus, calcium, magnesium, vitamin A, vitamin C, etc. [18] [19]. Using carrots to enhance wheat flour while producing bread will boost the beta-carotene composition of the bread and give it a sweeter taste. In the body during certain metabolic processes, beta-carotene is converted into vitamin A (retinol). Studies have shown that the body needs vitamin A for good sight and eye health, for strong body immunity, healthy skin and mucous membranes [20]. Based on research, carrots have a high content of beta-carotene which the body readily converts to vitamin A for its healthy growth and nourishments [20].

The development of nutritionally optimized bread products with balanced micronutrient compositions, macronutrient fortification and acceptable sensory properties may contribute to improving dietary adequacy across diverse population groups, including individuals with specific health conditions. Combining wheat flour, oats, carrots, and ginger may provide better bread of higher quality than some conventional breads that are bought from the market [21] and reports might have proven that the taste could be better and more natural. It is in this light that the present study searched for possible means of partially replacing wheat flour with carrots, oat, and ginger composites during bread making to improve the sensory qualities, mineral, vitamin, functional and proximate compositions as well as comparing the enhanced breads to the control in order to suitably recommend the food for the population that may have special dietary needs.

MATERIALS AND METHODS

Materials: Wheat (*Triticum aestivum*) flour, Carrot (*Daucus* carota), oats flour (*Avena sativa*), ginger (*Zingiber officinale*), yeast, egg, butter, water and salt.

Apparatus: Oven, baking pans, bread baking bowl, measuring cups, dough scraper, roller, apron, hand glove, bench scraper, bread knife, electric blender and analytical weighing balance.

Collection of Materials: The materials were locally sourced from the sellers. Ginger rhizomes, carrots, wheat and oat flours were purchased from a Food Scientist selling food materials at Ihiagwa Market Owerri. Other materials for production of the bread were purchased from the same source and were transported to the bakery were the production of the bread was carried out.

Location of the Bread Production and Analysis: Production of bread was conducted at TastyBite Food's Limited Bakery, Eastman Junction along, Federal University of Technology, Owerri Back-gate, Owerri West Imo state while the proximate and nutritional composition analyses were done in the National Root Crops Research Institute, Michael Okpara University, Umudike, Abia State Nigeria. All analyses were done in accordance with the procedure provided by [21].

Processing of Ginger and Carrot in Powder and Slices and Collection of other Materials: Freshly purchased ginger rhizomes were dried and later blended with electric grinding machine into powder and kept in clean container. The freshly harvested carrots were sliced into smaller pieces with a clean cutter and kept in separate container. The oat and the wheat flour composites were in their powdered forms when they were purchased. Other ingredients used to produce the bread were prepared and preserved in clean container.

Formulations of the Ingredients

Table 1 below shows the ingredients for production of normal bread produced without enhancement and the formulations. The materials used were basic without additives.

Table 1. Formulation of the control (A)

Ingredients	Quantity
Wheat flour	250 g
Sugar	40 g
Salt	5 g
Butter	30 g
Dry yeast	4 g
Water	120 ml/120 g

Table 2 below shows the formulation of the breads enhanced with oat flour, ginger and carrot slices in varying proportions. Parts of the wheat flour were partially replaced with enhanced materials.

Table 2. Formulation of the ingredients used to produce the bread samples

Ingredients	Quantity			
	B (g)	C (g)	D (g)	E (g)
Wheat flour	93.75	100	106	112.5
Sugar	20	20	20	20
Salt	2	2	2	2
Butter	15	15	15	15
Dry yeast	2	2	2	2
Water	60	60	60	60
Oat flour	31.25	25	18.75	12.5
Ginger	0.65	1.25	1.8	2.5
Carrot slices	2.5	3.75	5	6.25

Key: B = First Bread, C = Second bread, D = Third bread E: Fourth bread

Production of the Whole Wheat Bread (Control): Production of the bread from the wheat composite adopted the standard method [22] and [23] with little modifications. Forty grams (40 g) of granulated sugar was placed in a container, and a little quantity of water was added to dissolve it. 15 g of butter was also placed on another container, stirred until a homogenous mixture was obtained. The sugar solution was poured into the bowl containing the homogenous butter and stirred continuously until a uniform mixture was obtained and allowed standing. 250 g of wheat flour was measured and poured into a mixing baking bowl, with the addition of 2 g/2 spoonfuls of salt and mixed. Two spoonful/2 g of dry yeast were also added to the mixture of wheat flour and salt. All the dry ingredients were thoroughly mixed until they were properly mixed. The mixture of butter and sugar was also added to the dry ingredients and stirred for 10-20 minutes to obtain mixed dough. The dough was placed on the bench scraper for kneading until the dough was smooth, elastic, and no longer sticky. After the kneading, it was placed on a bowl and covered with a waterproof to enable it rise allowing for 1.5-2 hrs. Re-kneading took place, and the dough was re-placed on bowl for a second rising (30-60 minutes). The risen dough was taken and placed inside baking pan and carefully placed in the oven and allowed for 180-240 ºC for 20-45 minutes. Afterward the bread was baked.

Production of the Bread Enhanced with Oat Flour, Ginger and Carrot: The same procedures above were repeated but the product contained oat flour, ginger and carrot adopting the specifications contained in the formulation on Table 2. The ratios of wheat flour, oat flour, ginger and carrot in the breads were varied as documented on the formulation above, keeping other ingredients constant for all the four breads produced.

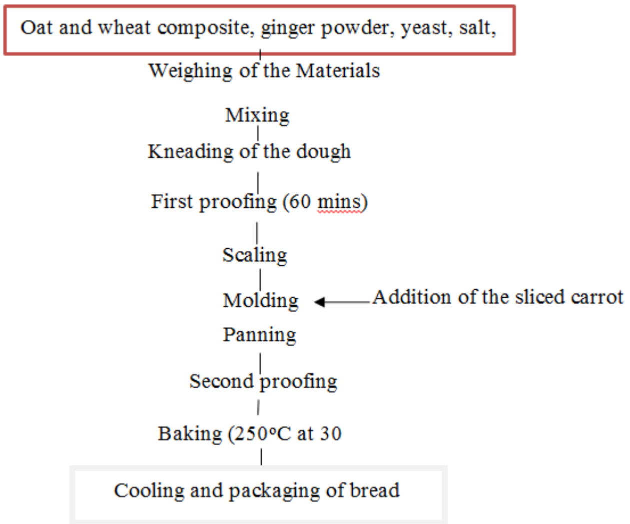

Figure 1. The Bread production process

Determination of Sensory Properties of the Bread: Sensory properties of the breads produced were determined using a questionnaire organized under 5-point Hedonic scale. Twenty (20) persons each were recruited from the departments of Food Science Technology, Science Laboratory Technology, Crop Science Technology, Public Health Technology and Biochemistry all in Federal University of Technology, Owerri for the test of sensory properties. Questionnaires validated by a specialist in Food Science Technology were given to the students to obtain their views on the texture, shape, flavour and taste of the breads produced.

Proximate Composition

Moisture Content: The clean container was dried and weighed (W_1) [24] when the moisture content of the bread sample was to be determined. The bread sample was placed on it and weighed too (W_2) using analytical weighing balance and was kept in the oven for 24 hrs., dried to constant weight maintaining the temperature of 115°C. After the oven drying, the weight of the test bread sample was determined. The moisture content of the sample was also determined by subtracting the final weight after oven drying from the initial weight of the container and the sample, W_2-W_3 = W_{moist} in grammes. The weight of the sample obtained was regarded as the moisture content and expressed as w/w % [21].

$$\text{Moisture content} = \frac{W2-W3}{W2} \times 100 \qquad (1)$$

Where W_2 = Sample's weight before oven drying, W_3 = Weight after oven drying.

Total Ash Content: The determination of total ash content was done by weighing 5g of the bread sample into dish that was ignited, cooled in a desiccator, and weighed after reaching room temperature. They were re-burnt into a muffle furnace at 550˚C for 6-7 hours and cooled in a desiccator at room temperature (28˚C) before weighing. The total ash content was then evaluated as the weight of the test and expressed in % w/w.

$$\%\text{ ash} = \frac{(Weight\ of\ empty\ dish+content\ after\ ashing)-(Weight\ of\ empty\ dish+sample)}{(weight\ of\ empty\ dish)-(weight\ of\ dish+content\ after\ ashing)} \times 100 \qquad (2)$$

The ash obtained was further used for the analysis of vitamins and the mineral compositions of the bread samples.

Determination of Crude Protein (Kjieldahl Method): A digestion device was filled with 2g of bread sample dissolved in fifteen ml of concentrated sulfuric acid. In a fume cupboard set at 410˚C for 45 minutes, Kjieldahl apparatus was introduced to start the digestion process. Once a clear solution was obtained, 76ml of distilled water was used to prevent it from hardening. After placing the tube in a distilling unit and adding fifty milliliters of forty percent sodium hydroxide to the solution, the digested distillate was placed in twenty-five milliliters of 40% boric acid for five minutes. The distillate was titrated against 0.47 molar hydrochloric acid until a grey tinge was developed. The titre value was determined in accordance with normal guidelines and was done once the first run was completed. The conversion factor multiplied by the total nitrogen yielded the percentage of nitrogen. The following mathematical expression was used to calculate it:

$$\text{Titre value} = \frac{Titre\ value\ \times 14.01 \times 047}{Weight\ of\ sample\ \times 100} \qquad (3)$$

Nitrogen's molecular weight = 14.0, conversion factor = 6.25, molarity of HCl = 0.47.

Crude Fat: After being weighed, ten (10 g) grams were added to a test tube. After adding 10 milliliters of conc. hydrochloric acid, the mixture was placed in a boiling water bath until the solids had dissolved and became brownish. After being removed and allowed to cool, it was moved into a separating funnel after which ten milliliters of ethanol and thirty milliliters of diethyl ether were added. The mixture was agitated and allowed to stand and separate [21]. After weighing a dry, clean conical flask, the ether layer was transferred inside. Following two sequential extractions using 25 milliliters of diethyl ether, the solvent was evaporated in a water bath. After cooling at 105˚C in the oven, the fat was weighed. For every bread sample, the process was repeated, and the percentage of fat was determined as follows:

$$\%\text{ ash} = \frac{(Weight\ of\ dried\ conical\ flask+content\ after\ drying)-(Weight\ of\ dried\ conical\ flask)}{Weight\ of\ the\ sample} \times 100 \qquad (4)$$

Crude Fibre: The standard guideline was used to calculate crude fiber. A six hundred milliliters beaker was filled with 2g of bread samples. Hot 1.25% sulfuric acid (200 ml) was added. After setting the beaker on the hot plates of the digesting system, it was boiled, refluxed, and filtered using

Whiteman GF/A paper. Distilled water was used to rinse the beaker under running tap and to get off the residue on the paper making the filtrate at pH 6.9-7.1. Heated 1.25% NaOH was transferred from the paper back into the beaker containing the filtrate. Both went through the processes again. The residue-containing paper was put into a crucible, dried overnight at 100˚C, cooled in a desiccator, and then weighed again (weight A). After six hours at 600˚C in a furnace, the sample was cooled in a desiccator and weighed again (weight B). The weight of crude fiber was indicated by the weight lost during cremation.

% crucible fibre = (weight A) – (weight B) × 100 (5)

Determination of Carbohydrate Content: The carbohydrate value was determined using the [17] technique. Each bread sample's carbohydrate content was evaluated using the following formula: Carbohydrate = 100 – (% moisture content + % ash + % protein + % fat).

Determination of Energy Value: The energy contents of the breads were calculated using Atwater factors 4, 4, and 9 for protein, carbohydrate, and fat, respectively [14][21].

Mineral Composition Determination

Mineral composition of samples was determined as the continuation of ash content composition. 2g of each bread sample (control and tested) were weighed into a clean ceramic crucible [21] [25]. For 4 hours, the crucible containing the bread samples was kept at 500˚C in a muffle furnace. The sample was carefully removed from the oven after it had cooled down. The ash sample was placed in a 50 ml centrifuge tube that had already been labeled, and five milliliters of distilled water were added to dissolve it. Again, the crucible was rinsed with five milliliters of aqua regia. This process was repeated until the total volume reached 20 milliliters. The material underwent five minutes of centrifugation at 10 rpm for 5 minutes after thorough mixing. To determine the minerals, the supernatant was placed in transparent vials. The absorbance at different wavelengths for each of the mineral elements mentioned below was measured using a Buck Scientific Model 670A Atomic Absorption Spectrophotometer (AAS).

Determination of Zinc: By employing the molybdate with hydroquinone as a reducing agent, the amount of zinc in the bread samples was ascertained [24]. A 50-milliliter graduated flask was filled with five milliliters (5 ml) of the test solution (bread ash solution). After that, 10 milliliters of the molybdate were introduced and diluted with water. For colour development, it was left to stand for half an hour. A blank was used to measure the absorbance at 660 nm. The absorbance and zinc content were connected to create a curve. The zinc concentration in the samples was established by plotting a standard curve.

$$\% \text{ Zinc} = \frac{\text{graph reading} \times \text{solution volume}}{100} \quad (6)$$

Determination of Iron: The quantity of iron was determined using phenanthroline [24] and according to the standard guidelines set by [21]. Five milliliters of digested bread samples were put in a 50-milliliter volumetric flask, gradually mixed with three milliliters of phenanthroline solution, two milliliters of hydrochloric acid, and one milliliter of hydroxylamine solution. After boiling the sample solution for two minutes, nine milliliters of ammonium acetate buffer solution were introduced and further diluted with 50 ml of water. The absorbance was measured at a wavelength of 510 nm while concentration of the sample was ascertained by drawing a calibration curve using the iron standard solution from there the quantity of Fe was known.

Determination of Potassium and Sodium: Flame photometer was used to measure the amount of potassium and sodium in the bread using established protocol [24]. First, standards for sodium and potassium were created. The instrument readout of the bread sample was calibrated using the standard solution. Highest concentration of the standards was aimed at when the meter reading was at 100% E (emission). On linear graph paper, the percentage E of each intermediate standard curve was plotted alongside the readings. The device was used to test the sample solution, and the readings (% E) were noted. According to the standard curve, the K and Na concentrations in the sample solution were found and expressed in Ppm 100 DF.

$$\% \text{ Potassium/Sodium} = \frac{\text{Ppm} \times 100 \times \text{DF}}{1\, million} \quad (7)$$

Determination of Calcium and Magnesium: The technique used by [9] was used to determine the amount of Ca and Mg contents in the bread samples. In a 250 ml conical flask, 25 milliliters of the digested bread samples were added, along with a pinch of Eriochrome Black-T-Indicator (EBT). 2 milliliters of 0.1N NaOH solution was then added, and the combination was titrated using 0.01M EDTA solution.

$$\text{Calcium/ Magnesium (mg/L)} = \frac{\text{Titre value} \times \text{Molarity of EDTA} \times \text{Equiv.wt of Calcium} \times 1000}{Volume\ of\ the\ sample\ used} \quad (8)$$

Determination of Phosphorus: Vanado-mohybdate (yellow) spectrometry, as reported by [24], was used to assess the content of the bread samples. Every sample was put into a test tube. Each tube's contents were combined with an equal volume of vanado-molybdate and allowed to stand at room temperature for 15 minutes before the absorbance was taken at 420 nm using a Jenway electronic spectrophotometer.

$$\text{Phosphorus} = \frac{100}{w} \times \frac{AU}{AS} \times C \times \frac{VF}{VA} \quad (9)$$

Where:

W stands for sample weight under analysis, AU for test sample absorbance, AS for standard solution absorbance, VF for total filtrate volume, VA for filtrate analyzed volume, and C for total extract volume.

Determination of Vitamins

Vitamin A: The spectrophotometric approach, as outlined by [26], was used to determine the sample's vitamin A level in the bread. A test tube with a tight stopper was used to measure out two milliliters (2 ml) of the bread sample solution, which was labelled I. The liquid in test tube 1 was mixed with 1 milliliter of a 1M KOH and 90% ethanol solutions and thoroughly agitated for a minute. After one-third hours of heating at 60 °C in a water bath, test tube 1 was cooled with cold water and two milliliters of xylene was added and agitated for a minute and spined for ten minutes at 1500 rpm. The supernatant (top layer) was moved into test tube II. The extract labelled I was examined by comparing its absorbance to xylene at a wavelength of 335 nm (A1). After 30 minutes of exposure to UV radiation, extract II was tested for absorbance and given the designation A2. By using the formula Cx = (A1 − A2) × 22.23, which was derived from the absorbance of the absorption coefficient of a 1% solution of retinol in xylene at 335 nm in a cuvette of 1 cm thickness, the concentration of vitamin A in the extract was verified.

Vitamin E: High Performance Layer Chromatography was used to quantify Vitamin E [26]. Methanol was the only eluent utilized in the Agilent Eclipse XDB-C19 column used for the quantification. Vitamin E was detected by UV light at a wavelength of 290 nm. Isocratic elution and solvent flow rate maintenance at 1.0 ml/min served as the foundation for the vitamin E separation process. By comparing the retention periods to those of genuine standards, vitamin E was identified [22].

Vitamin B_1: The amount of vitamin B_1 was ascertained using a method described by [27]. Before filtration, one gram of the bread sample was weighed into a conical flask, dissolved with 100 milliliters of deionized water, thoroughly agitated, heated for five minutes, and allowed to cool. A spectrophotometer was used to measure the absorbance after the filtrate was transferred into a cuvette and the corresponding wavelength (261 nm) was determined.

$$\text{Concentration (mg \%)} = \frac{A \times D.F \times Volume\ of\ Cuvette}{E} \qquad (10)$$

Where A = absorbance
E = extinction coefficient = 25 for B_1
DF = dilution factor

Vitamin B_2: Quantification of Vitamin B_2 also adopted the method used by [27]. Here 1g of ash bread sample was put into a conical flask and was dissolved with one hundred milliliters of distilled water, agitated properly and heated for 5 minutes, allowed to cool before filtering. The filtrate was transferred into a 1 cm thick cuvette and their respective wavelength for the vitamin was set and used to read the absorbance using spectrophotometer (Vitamin B_2 = 242 nm).

$$\text{Concentration (mg \%)} = \frac{A \times D.F \times Volume\ of\ Cuvette}{E} \qquad (11)$$

Where A = absorbance
E = extinction coefficient = 25 for B_2
DF = dilution factor

Vitamin B_3: 25 mg of the bread sample was dissolved in 250 ml of deionized water. And the determination of vitamin B_3 was evaluated using the formula above adopting the same method used by [28].

$$\text{Concentration (mg \%)} = \frac{A \times D.F \times Volume\ of\ Cuvette}{E} \qquad (12)$$

Where A = absorbance
E = extinction coefficient = 25 for B_3
DF = dilution factor.

Vitamin B_6: Quantification of vitamin B_6 adopted the method described by [29]. The bread samples were initially ground to fine powder using mortar and pestle. The finely ground (mortar and pestle) pellet was dissolved in solvent of 10% ethanol and distilled water. Less than 10% (v/v) ethanol presents in the mixture were injected into the HPLC. The remaining volume was composed of acetic acid up to 0.696 molar, 77% distilled water (v/v), and 19% ethanol (v/v) as the eluent solvent. Next, appropriate-sized volumetric flask was filled with a determined quantity of fine powder. 90% distilled water and 10% ethanol (v/v) were used to dissolve the substance. The samples were filtered using Whatman filter paper, and the filtrate was then exposed to the HPLC method to determine the amount of vitamin B_6. The analysis was completed within a day.

Vitamin B_9: Vitamin B_9 was determined in the bread sample by adopting spectrophotometric method also used by [30]. 1.50 ml of 100 microgram per ml of the sample was poured into 10 ml volumetric flask; 2.5 ml of 0.6%, 2-Naphthoquine-4-Sulphonate was also introduced to the buffer solution of strong alkaline solution (NaOH / $NaHCO_3$). The sample prepared was made up to a volume by buffer solution, and the resulting solution was measured at 436 nm against reagent blank treated similarly.

Determination of Functional Compositions

Bulk Density: The bulk density was quantified following the method described by [31]. 10g of the powdered bread sample was weighed into a measuring cylinder containing 25 milliliters of water and gently tapped continuously on a laboratory table to eliminate spaces between the flour particles until a constant volume was obtained. The experiment was done in triplicate, and the mean values were taken.

$$\text{Bulk Density (g/ml)} = \frac{Weight}{Volume\ of\ sample\ after\ tapping} \qquad (13)$$

Water Absorption Capacity: With minor adjustments, the approach employed by [32] was applied to quantify the water absorption capacity. Each sample's Ig was distributed into a centrifuge tube that had been weighed. The sample was well mixed with ten milliliters of distilled water. After an hour of standing, the mixture was re-centrifuged for 30 minutes at 3500 rpm. The tube was inverted over absorbent paper to drain dry after the extra water that had not been absorbed was decanted. The difference was used to calculate the weight of water absorbed. The experiment was conducted twice, and the average results were recorded.

$$WAC = \frac{W2-W1}{W3} \times 100 \qquad (14)$$

W_1 = weight of sample, W_2 = weight of empty tube + sample used, W_3 = weight of empty tube + sample + water absorbed.

Oil Absorption Capacity: This was done using the procedure outlined by [32]. In a weighed centrifuge tube, 10 milliliters of oil were combined with one gram (1g) of each bread sample. After letting the mixture stand for an hour, the mixture was centrifuged for 30 minutes at 3500 rpm using a

Spectra Scientific centrifuge. The surplus oil was then decanted, the tube was inverted over absorbance paper to dry, and the OAC was calculated. The mean values were obtained after the experiment was conducted in triplicate.

$$OAC = \frac{W3-W2}{W1} \times 100 \quad (15)$$

W_1= weight of sample, W_2=weight of empty tube + sample used, W_3=weight of empty tube + sample + water absorbed.

Emulsion Capacity: The technique outlined by [31] was used to ascertain the emulsion capacity. In a calibrated centrifuge tube, 1g of each powdered sample was combined with ten milliliters of distilled water and ten milliliters of soybean oil. For five minutes, the emulsion was centrifuged at 2000 x g. Emulsion capacity was determined as a percentage by dividing the height of the emulsion layer by the overall height of the mixture.

Foam Capacity: The approach of [31] was applied. For five minutes at room temperature, 1g of each sample was combined with 50ml of distilled water in a blender to create foam. After the mixture was swiftly but carefully moved to the measuring cylinder, the foam volume was initially measured and recorded after 30 seconds. After that, it was recorded every 15 minutes for an hour. The experiment was conducted in duplicate, and the following formula was used to determine the foam capacity based on the volume of foam after the first thirty seconds:

$$FC = \frac{V3-Vb}{vb} \times 100 \quad (16)$$

Where

V_a= volume after blending, V_b= volume before blending.

Swelling Index: The technique outlined by [31] was used to ascertain the swelling index. Each sample was filled to the 10ml mark in a graduated cylinder that held 100 milliliters. A total of 50 milliliters were obtained by adding the distilled water. The graded cylinder was inverted, and its top was securely covered and mixed. After two minutes, the suspension was turned back over and allowed to stand for eight minutes. After the eighth minute, the sample's volume was measured.

Gelatinization Temperature: Differential scanning calorimetry (DSC) thermograms were used to measure the onset, peak, and completion temperatures of gelatinization using the technique described by [33] [34].

Analysis of Data

The data was entered correctly using MS Excel 2016 and analyzed using the Statistical Package for the Social Sciences (SPSS) 2022 version with one-way Analysis of Variance (ANOVA). The Duncan Multiple Range Test was used for comparison at a 95% confidence level. The data was displayed in a table as mean ± standard deviation (M±SD).

RESULTS

Assessment of Sensory Quality of the Bread

The sensory qualities of the breads produced from the raw materials are presented in Table 3. The colour of the control, B and E were statistically dissimilar ($P<0.05$) while C and D were same statistically. There was a statistical relationship between the texture of breads B, D and E which differ from A and C. Also, the flavour and taste of breads A, D and E were statistically alike ($P<0.05$) and differ ($P>0.05$) greatly from bread B and C that are statistically the same. The overall sensory quality of breads A, C, D and E are the same statistically and differ from B. The overall acceptability rate of bread B can be attributed to the greater quantity of oat flour (31.25g) found. Overall analysis showed that the sensory qualities of the breads differed statistically.

Table 3. Sensory quality of different bread samples

Sample code	Colour	Texture	Flavour	Taste	Overall Acceptability
A	8.10 ± 0.68^a	6.95 ± 0.77^b	7.40 ± 1.13^b	7.45 ± 0.84^b	7.60 ± 1.00^b
B	8.45 ± 1.13^a	7.10 ± 1.13^a	8.15 ± 0.93^a	8.30 ± 0.96^a	8.45 ± 1.04^a
C	7.40 ± 1.40^b	6.15 ± 0.96^c	6.55 ± 1.21^c	6.20 ± 1.07^c	7.15 ± 0.89^b
D	7.65 ± 1.07^b	7.20 ± 1.25^a	7.15 ± 1.36^b	7.10 ± 1.04^b	7.95 ± 0.84^b
E	8.00 ± 1.24^a	7.25 ± 1.01^a	7.85 ± 2.01^b	7.75 ± 1.78^b	7.80 ± 1.65^b
LSD	0.1628	0.18033	0.24883	0.31349	0.19047

Key: A= Control, B = First Bread, C = Second bread, D = Third bread, E: Fourth bread. Data are presented as $\bar{x}$±SD of duplicate values. Mean values with different letter within a column are significantly different ($p<0.05$). LSD= least significant difference.

Assessment of Vitamins Composition of the Bread

Table 4 displays the outcome of the vitamin compositions of the breads made. As the amounts of wheat flour, ginger, and carrot rose significantly above control, so did the amounts of vitamins A, B_1, B_2, B_3, B_6, B_9, and E components of B, C, D, and E. There was no significant difference ($P > 0.05$) between the Vitamin, B_2 and E composition of bread D, E and the control A but B and C differed statistically ($P<0.05$) from the rest. In the same vein, there is no statistical difference ($P > 0.05$) between the control (bread A) and the vitamin B_1, B_3 composition of bread E. Also, the vitamin B_1 and B_2 composition of bread B did not differ statistically ($P>0.05$) from the control (bread A). Obviously, bread C differs statistically from control in all the vitamin compositions.

Table 4. Vitamin Composition of the bread

Sample	Vit. A (µg/100g)	Vit. B1 (mg/100g)	Vit. B2 (mg/100g)	Vit. B3 (mg/100g)	Vit. B6 (mg/100g)	Vit. B9 (µg/100g)	Vit. E (mg/100g)
A	0.26±0.010[a]	0.365±0.005[a]	0.235±0.005[a]	3.26±0.01[a]	0.285±0.005[a]	24.125±0.015[a]	0.715±0.005[a]
B	0.355±0.005[b]	0.415±0.005[a]	0.365±0.005[a]	4.035±0.015[b]	0.36±0.01[b]	30.76±0.0200[b]	1.03±0.0100[b]
C	0.435±0.015[c]	0.475±0.015[b]	0.47±0.0100[b]	4.605±0.005[c]	0.5±0.00[c]	34.615±0.005[c]	1.175±0.015[c]
D	0.585±0.005[b]	0.61±0.01[c]	0.585±0.005[a]	5.255±0.015[b]	0.675±0.005[a]	39.605±0.005[c]	1.475±0.005[a]
E	0.715±0.005[b]	0.775±0.005[a]	0.675±0.005[a]	6.58±0.01[a]	0.775±0.015[d]	47.02±0.01[d]	1.725±0.005[a]
LSD	0.072608539	0.066296305	0.069690745	0.504231296	0.082527571	3.474621	0.156603959

Key: A= Control, B = First Bread, C = Second bread, D = Third bread E: Fourth bread. Data are presented as x̄±SD of the duplicate values. Means with different letter within a column are significantly different ($P<0.05$). LSD= least significant difference

Assessment of the Functional Composition of the Bread

Table 5 above shows the result of the functional compositions of the breads produced and analyzed. The result showed that bulk density (0.68 to 0.47 g/ml), foam stability (25.87 to 21.76 %) and foam capacity (60.72 to 52.425 %) of the breads decreased as the wheat flour increased (93.75 g-112.5 g). The bulk density, foam stability and foam capacity of the breads B, C, D and E statistically ($P<0.05$) differed from the control (bread A) apart from FC and FS of bread C. The water absorption capacity, oil absorption capacity, Swelling Index and Gelatin temperature of the breads B, C, D and E increased as the wheat flour increased, and they are all greater than the control. Apart from the bread B, these parameters differ statistically ($P < 0.05$) from the control.

Table 5. Functional composition of the breads

Sample	BD (g/ml)	WAC (%)	OAC (%)	FC (%)	FS (%)	SI (g/g)	GT (ºC)
A	0.68±0.010[a]	2.125±0.015[a]	1.43±0.01[a]	25.87±0.01[a]	60.72±0.01[a]	1.625±0.015[a]	63.43±0.02[a]
B	0.645±0.005[b]	2.245±0.015[a]	1.575±0.005[b]	25.025±0.015[b]	59.115±0.015[b]	1.785±0.005[b]	64.09±0.070[b]
C	0.605±0.005[b]	2.31±0.01[b]	1.725±0.015[c]	24.12±0.01[a]	57.57±0.01[a]	1.87±0.01[c]	66.295±0.025[c]
D	0.555±0.005[b]	2.385±0.005[c]	1.87±0.01[a]	23.275±0.005[c]	55.115±0.015[b]	1.975±0.005[b]	69.75±0.060[d]
E	0.47±0.010[c]	2.57±0.01[b]	1.935±0.015[c]	21.76±0.01[a]	52.425±0.015[b]	2.12±0.01[c]	73.64±0.040[e]
LSD	0.032845091	0.066401807	0.08319375	0.635756243	1.31331291	0.075007	1.701642971

Key: A= Control, B = First Bread, C = Second bread, D = Third bread E: Fourth bread. B.D = Bulk Density, WAC= Water absorption capacity, OAC = Oil absorption capacity, FC: Foam Capacity, FS = Foam stability SI = Swelling Index, GT = Gelation Temperature. Data are presented as mean±SD of duplicate determinations. Means with different letter within a column are significantly different ($p<0.05$). LSD= least significant difference.

Assessment of the Mineral Composition of the Bread

The finding **Table 6** shows that the mineral content of the breads B, C, D and E are all greater than the control due to increased quantity of the carrot and ginger. Interestingly, mineral composition tends to increase as the quantity of carrot and ginger increased. The potassium composition of breads varies statistically ($P<0.05$). The Iron content of breads C and D did not differ statistically ($P>0.05$) from the control. The calcium content of bread C, sodium composition of bread E and the magnesium content of bread do not differ from the control statistically ($P>0.05$). All the mineral compositions of Bread B ($P< 0.05$) differed significantly the control.

Table 6. Mineral Composition of the breads

Sample	Ca(mg/100g)	Na(mg/100g)	Mg(mg/100g)	P(mg/100g)	K(mg/100g)	Fe(mg/100g)	Zn(mg/100g)
A	19.62±0.015[a]	4.62±0.01[a]	21.78±0.005[a]	71.02±0.005[a]	82.54±0.01[a]	1.88±0.005[a]	1.62±0.015[a]
B	27.48±0.005[b]	4.95±0.005[b]	24.03±0.01[b]	90.64±0.02[b]	102.53±0.515[b]	2.43±0.015[b]	2.28±0.005[b]
C	29.73±0.015[a]	5.13±0.005[b]	31.38±0.01[b]	100.41±0.02[b]	122.66±0.02[c]	2.87±0.005[a]	2.82±0.01[c]
D	32.02±0.01[c]	5.42±0.015[c]	38.82±0.005[a]	127.12±0.01[c]	147.55±0.035[d]	3.26±0.005[a]	3.03±0.015[d]
E	35.42±0.005[b]	5.72±0.01[a]	44.75±0.025[c]	153.74±0.015[d]	169.82±0.01[e]	3.83±0.015[b]	3.33±0.015[d]
LSD	2.375356142	0.169408382	3.884909677	12.93445495	13.90044748	0.299741	0.27038639

Key: A= Control, B = First Bread, C = Second bread, D = Third bread E: Fourth bread. Ca = Calcium, Na = Sodium, Mg = Magnesium, P = Phosphorus, K = Potassium, Fe = Iron, and Zn = Zinc. Data are presented as x̄±SD of duplicate determinations. Means with different letter within a column are significantly different ($p<0.05$). LSD= least significant difference.

Assessment of the Proximate Contents of the Bread

The Carbohydrate content and energy value of the breads decreased as the oat content takes some percentages of the wheat flour and composition all differed significantly (P<0.05). The moisture, crude protein, fibre, fat and ash contents increased significantly with increased wheat, ginger and carrot percentage. All the compositions of the parameters mentioned were greater than the control (Bread A). From Table 7 above, bread E significantly differs from the control in all the parameters analyzed.

Table 7. Proximate composition

Sample	MC (%)	CP (%)	CF (%)	FAT (%)	ASH (%)	CHO (%)	EV (Kcal)
A	26.165±0.025^{a}	9.72±0.01^{a}	1.68±0.01^{a}	2.08±0.005^{a}	0.88±0.01^{a}	59.48±0.00^{a}	295.48±0.005^{a}
B	27.055±0.025^{a}	10.48±0.005^{b}	2.24±0.01^{a}	4.02±0.005^{a}	1.15±0.01^{a}	55.07±0.005^{b}	298.30±0.045^{b}
C	27.745±0.035^{b}	10.92±0.01^{a}	2.88±0.005^{b}	4.85±0.01^{b}	1.63±0.005^{b}	51.99±0.015^{c}	295.27±0.190^{c}
D	28.13±0.02^{c}	11.63±0.005^{b}	3.17±0.010^{a}	5.42±0.005^{a}	1.98±0.015^{c}	48.19±1.470^{d}	293.48±0.4250^{d}
E	28.89±0.070^{d}	12.46±0.005^{b}	3.58±0.005^{b}	5.97±0.01^{b}	2.31±0.005^{b}	46.81±0.085^{e}	290.77±0.230^{e}
LSD	0.415799471	0.421183096	0.30194039	0.60700840	0.23407691	2.062555	1.110290

Key: A= Control, B = First Bread, C = Second bread, D = Third bread E: Fourth bread. MC = Moisture content, CP = Crude Protein, CF = Crude Fibre, FAT = Fat content, ASH = Ash content, CHO = Carbohydrate content, EV = Energy value. Data are presented as $\bar{x}$±SD of duplicate determinations. Means with different letter within a column are significantly different (p<0.05). LSD= least significant difference

DISCUSSION

The sensory quality of the bread produced is directly related to raw materials used in its production. The sensory qualities of the breads presented in Table 3 showed that the colour of the control (A), bread B and E were statistically similar (P<0.05) while C and D were also the same statistically. There was a statistical relationship between the texture of breads B, D and E which differed from A and C. Also, the flavour and taste of breads A, D and E were statistically alike (P<0.05) but differ (P>0.05) greatly from bread B and C that were statistically the same. The overall sensory quality of breads A, C, D and E were the same statistically but varied from that of B. The overall acceptability rate of B can be attributed to the greater quantity of oat flour (31.25g) found. The sensory qualities of the breads studied in this research were consistent with the reports of [34] and [35] who recorded that there was not much difference between bread produced from the normal bread composition and enhanced breads especially those produced from oat flours.

The vitamin contents of the breads produced increased by the addition of ginger and carrot when compared to the control. As the ginger and carrot compositions of the breads (B, C, D and E) increased from 0.65 g to 2.5 g and 2.5 g to 6.25 g respectively, the vitamin A (0.355 µg/100g – 0.715 µg/100g), vitamin B_1 (0.415 mg/100 g-0.775 mg/100g), vitamin B_2 (0.365 mg/100 g-0.675 mg/100g), vitamin B_3 (4.035 mg/100g - 6.58 mg/100g), vitamin B_6 (0.36 mg/100g-0.775 mg/100g), vitamin B_9 (30.76µg/100g-47.02 µg/100g) and vitamin E (1.03 mg/100g-1.725 mg/100g) increased above the control despite the reduction of the oat content of the bread. Carrot and ginger have been reported to contain vitamins [14] [15] [17] [20]. They are also possible contribution of the vitamin composition from oat and wheat flours. It was observed that part of the wheat flour was substituted with oat flour to enhance the composition. From possible evidence and as presented in Table 4, the combination of wheat and the oat alongside the carrot and ginger contributed to the significant increase of mineral composition. This is why the mean values of the enhanced breads differed (P<0.05) from the control significantly. The findings of this study are similar with the reports of [36] [37] [38] and [39], who used carrot, ginger and oat to enhance some food products and later found out that the vitamin content was increased. Aside from being added to bread, ginger, oats, and carrots are noteworthy for maintaining a healthy diet. They are a good source of vitamins because they contain sufficient amounts of vitamin A, which is crucial for healthy skin, eyesight, and the immune system; vitamin E, a potent antioxidant that shields cells from damage caused by free radicals [36]; and vitamin B complexes, which are necessary for the production of energy, the immune system, and the health of the nervous system [19].

The result of the functional compositions of the loaves that were produced is contained in Table 4, and results indicated that when the amount of wheat flour (93.75 g-112.5 g), ginger (0.65 g to 2.5 g), and carrot (2.5 g to 6.25 g) were increased, the breads' bulk density (0.68 to 0.47 g/ml), foam stability (25.87 to 21.76%), and foam capacity (60.72 to 52.425%) dropped. Apart from bread C, the bulk density, foam stability, and foam capacity of B, C, D, and E were statistically different from the control (bread A). As the amount of wheat flour was increased, the swelling index of, C, D, and E, gelatin temperature (63.43 °C–73.64 °C), oil absorption capacity (1.575%–1.935%), and water absorption capacity (2.245%–2.57%) also increased and were all higher than the control. Interestingly, bread B had all its parameters differing statistically (P<0.05) from the control. The drop in the bulk density of the bread was because of replacing some portion of the total wheat components with oat flour. A crucial factor in process development and the production of solid dosages of bread in the baking industry is bulk density. It is employed in figuring out how much powder can fit into a container, like a blender or a tablet press or capsule filler's hopper. Additionally, it is employed to calculate how much powder can fit within a capsule [33]. In the same vein, foam stability and capacity can be reduced when there is increased fat content. As seen in the findings of this study, the presence of oat flour in the bread, which is the main factor that increased the crude fat (4.02% - 5.97%) contents, contributed to the reduction and stabilization of the foam. This is not in corroboration with the result of some authors [31], who observed that the combination of sprouted/fermented pigeon pea flour and wheat flour increased foam stability and capacity. Furthermore, the addition of oat flour, ginger, and carrot contributed to the increased swelling index, water and oil absorption capacities, and all differed statistically ($P<0.05$) from the control, and this is perfectly in corroboration with the report of [31].

The higher mineral compositions of breads B, C, D, and E can all be attributed to the combination of wheat, oats, ginger, and carrots. The findings of the mineral composition presented in Table 5 demonstrated that the higher amounts of carrot and ginger in breads B, C, D, and E resulted in a higher mineral content than the control. It is interesting to note that as the amount of carrot and ginger increases, the mineral content tends to rise. There is statistical variation in the potassium content of breads ($P<0.05$). There was no significant difference ($P>0.05$) in the iron content of breads C and D compared to the control. Also, there was no significant difference between the calcium content of bread C, the sodium composition of bread E, and the magnesium content of bread and the control ($P>0.05$). All of bread B's mineral compositions were significantly different from the control ($P<0.05$). The result of this study is consistent with the reports of [6] [39] [28] and [40]. Interestingly, calcium is important for the strengthening of bone and hardness of teeth; sodium and potassium increase metabolic reaction by promoting the electron transport chain; phosphorus contributes to the formation of amino acids and repair of worn-out tissue, while magnesium enhances biological functions such as DNA and RNA stability, cell proliferation, and glucose, lipid, and protein metabolism [28] [40]. This implies that the consumption of bread enriched with ginger, carrot, and oats can contribute to promoting healthy nutrition.

From the findings, all the moisture content (27.055% - 28.89%), crude protein (10.48% - 12.46%), crude fiber (2.24% - 3.58%), fat content (4.02% - 5.97%), and ash content (1.15% - 2.31%) of breads B, increased when D increased compared to the control, while the carbohydrate (55.07% - 46.81%) and energy value (298.30 Kcal - 290.77 Kcal) decreased below the control (295.48 Kcal), apart from bread B. From the compositions of the breads, the parameters were greater than the control (Bread A), and bread E significantly differed from the control in all the parameters analyzed. The bread's energy value and carbohydrate content decreased as the oat content took some percentages of the wheat flour, and their compositions all differed significantly ($P<0.05$). The moisture, crude protein, fiber, fat, and ash contents increased significantly with an increase in the percentage of wheat, ginger, and carrot. There are possibilities that the oat content, which took part of the wheat, reduced that energy value apart from bread B, which had increased oat composites. Furthermore, as the oat composite decreased, the carbohydrate content of the bread tended to decrease, proving that the oat has higher energy content than the wheat composite. This agrees with the assertion of [34], who recorded lower protein and carbohydrate content when part of the wheat composite was replaced with oats. On the other hand, the fiber, fat, and moisture contents recorded by [34] were increased, which perfectly agrees with the findings of this study. Also, the impressive increase in the protein, moisture, crude fat, and fiber contents found in the enhanced breads may be attributed to the ginger, carrot, and oat added to them, and the improvement as observed in the parameters corroborated with the reports of [41] [42] [43] [44] [45], who recorded impressive proximate composition when they garnished food materials with oat, carrot, and ginger.

CONCLUSION AND RECOMMENDATIONS

The present study discovered that adding carrot, ginger, and oats to bread modified fiber, moisture, protein, fat, and ash contents while simultaneously moderating the calorie load and carbohydrate compositions. In terms of functional qualities, the enhancement of the bread with carrot, ginger, and oat outperformed wheat flour in terms of gelatin temperature, swelling capacity, watery, and oil absorption capacities, reducing bulk density, and foam capacity and stability. Moreover, the bread enhanced with oat, ginger, and carrot contained more vitamin A, B_1, B_2, B_3, B_6, B_9, and E than the normal wheat bread. The bread also contained more Ca, Na, K, Mg, P, Fe, and Zn than the bread normally formed from wheat flour. Organoleptic features of the bread showed that the taste of the bread became less sugary, more aromatic, and more flavorful. Physical observation of the bread enhanced with oats, ginger, and carrot showed that the bulk density of the bread reduced as fewer oats were added and the bread became rougher after baking. These results validated the use of inexpensive by-products, such as ginger and carrot slices, as a practical functional supplement to improve the nutritional content of foods with less gluten. The use of 6.25 g of carrot, 2.5 g of ginger, 12.5 g of oat, and 112.5 g of wheat in the bread production showed the most satisfactory method and gave the highest nutritional quality among other combinations. Based on the insightful discoveries of this report, the following recommendations are imperative:

i. The quantity of oat composite added to the bread during production can be increased while reducing the quantity of wheat flour.
ii. Other food composites such as cabbage, sweet potato, spinach, radish etc. can be combined with wheat flour to enhance bread quality.

iii. Addition of natural sugar source such as dabino fruit is also recommended instead of using synthetic sugar.

Acknowledgments

We sincerely thank Dr. Olawuni of FST Department FUTO who contributed to shaping the topic, Mr. O. J. Obinna who contributed to the Lab work and Nancy C. Akagha of FUTO ICT Library who assisted in checking the level of plagiarism.

Authors' Contributions

IEE, JEI, IJA, and SEU coined the topic and initiated the experimental design of the study. JEI, SEU, and CGN collected and aggregated the data. CGN, ABN, IIO, MOO, IEE, TG and SEU gathered the materials, produced the bread and assisted in all laboratory analyses. IEE, NBK, ODO, CSO, JEA, MMA, FA, AMU, OJA, CJO and OG carried out data entry, analyses and wrote the manuscript. All authors read, proofread and approved of the final manuscript before submission for publication.

Ethics Approval

Ethical approval was obtained from the Food Standard Ethical Committee, School of Engineering and Engineering Technology (SEET) of Federal University of Technology Owerri Imo State. All methods were performed in accordance with the relevant guidelines and regulations.

Consent for Publication

Not applicable

Availability of Data and Materials

All data generated or analyzed during the study are included here and are available from the corresponding author on request.

Competing Interests

There are no competing interests.

Funding

This study did not receive any grant or financial support from anyone or organization.

REFERENCES

[1] FAO, 2020, Profiles and relevant WTO negotiating issues, Food and Agricultural Organizations. Agricultural commodities 2009. Retrieved from http://www.fao.org/docrep/006/y4343e/y4343e02.htm# on December 17, 2021.

[2] Borghini, A., and Piras, N., (2019). Food and Foods. Toward a Definition. *Rivista Italiana di Filosofia del Linguaggio* (*RIFL*), 1(3):384-392. doi: 10.4396/SFL2019ES06.

[3] Shewry, P.R., and Hey, S.J. (2015). The contribution of wheat to human diet and health. *Food Energy Security*, 4(3), 178-202. doi: 10.1002/fes3.64.

[4] You, Y., Zhang, F., Han, J., Liu, R., Li, B., and Ding Z., 2021, Breakfast preferences and consumption location among children at a median age of 7 in Shenzhen: Implications for managing overweight and obesity. *Appetite*, 156 (7):104851. doi: 10.1016/j.appet.2020.104851.

[5] Issa-Zacharia, A., and Julian, P.M., 2023, Production of ginger-flavored bread from wheat-soy composite flour. *International Journal of Agriculture and Food Science*, 5(2), 61-68. https://doi.org/10.33545/2664844X.2023.v5.i2a.149.

[6] Khalid, A., Hameed, A., and Tahir, M.F., 2023, Wheat quality: A review on chemical composition, nutritional attributes, grain anatomy, types, classification, and function of seed storage proteins in bread making quality. *Front Nutrition*, 1053196. doi: 10.3389/fnut.2023.1053196.

[7] Manthey, F.A., 2016, Starch: Sources and Processing. *Encyclopedia of Food and Health*, 2(3), 160-164. doi: 10.1007/s13197-018-3085-2.

[8] Cappelli, A., and Cini, E., 2021, Challenges and Opportunities in Wheat Flour, Pasta, Bread, and Bakery Product Production Chains: A Systematic Review of Innovations and Improvement Strategies to Increase Sustainability, Productivity, and Product Quality. *Sustainability*, 13(2608), 1-17. https://doi.org/10.3390/su13052608.

[9] Dambazau, S. A., Jayasree, K. M., and Tajuddeen, A., 2021, Contemporary issues of wheat production in Nigeria: A review. *International Journal of Agricultural Economics and Rural Development*, 11(1):1-11.

[10] Shahbandeh, M., 2021, Wheat-Statistics and Facts. Available https://www.statista.com/topics/1668/wheat/. Accessed on Mar 23, 2021.

[11] Haruna, S. A., Adejumo, B. A., Chukwu, O., and Okolo, C. A., 2017, Getting out of the Nigerian "Wheat Trap": A multi-disciplinary approach. *International Journal of Engineering Research and Technology*. *6*(2):23-32. doi: 10.5937/PoljTeh2401001L.

[12] Zhang, K., Dong, R., Hu, X., Ren, C. and Li, Y., 2021, Oat-Based Foods: Chemical Constituents, Glycemic Index, and the Effect of Processing. *Foods*, 10(6), 1304. doi: 10.3390/foods10061304 .

[13] Tan, S.Y., Siow, P.C., Peh, E., and Henry, C.J., 2018, Influence of rice, pea and oat proteins in attenuating glycemic response of sugar-sweetened beverages. *European Journal of Nutrition*, 57, 2795–2803. doi: 10.1007/s00394-017-1547-3.

[14] Alkurd, R., Takruri, H., Muwalla, M., and Arafa, T., 2020, The Nutritional Value, Energy and Nutrient Contents and Claims of Marketed Multi-grain Breads. *Journal of Food and Nutrition Research*, 8(10):600-605. doi: 10.12691/jfnr-8-10-9.

[15] Alsherbiny, M.A., Abd-Elsalam, W.H., El Badawy, S.A, Taher, E., Fares, M. & Torres A (2019). Ameliorative and protective effects of ginger and its main constituents against natural, chemical and radiation-induced toxicities: a comprehensive review. *Food Chemistry of Toxicology*, *123*, 72–97. doi: 10.1016/j.fct.2018.10.048 .

[16] Kiyama, R., 2020, Nutritional implications of ginger: chemistry, biological activities and signaling pathways. *Journal of Nutritional Biochemistry*, 86(108486):1-15. doi: 10.1016/j.jnutbio.2020.108486 .

[17] Anozie, C.C., Njoku, E.A., Eze, E.I., .Eze, F.O., Baiyeri, K.P., Zoubek, T., and Bartoš, P., 2024, Assessment of Mineral and Vitamin Contents of Carrot (*Daucus carota* L.) as Influenced by Poultry Manure, Variety and Tillage. *Tropical Journal of Natural Product Research*, 8(2), 6305-6310. doi: 10.26538/tjnpr/v8i2.31.

[18] Koley, T.K., Nishad, J., Kaur, C., Su, Y., Sethi, S., Saha, S., Sen., S. and Bhatt, B.P., 2020, Effect of High-pressure Micro fluidization on Nutritional Quality of Carrot (*Daucus carota*

L.) juice. *Journal of food Science and Technology*, 2(57), 2159-68. doi: 10.1007/s13197-020-04251-6.

[19] Lijja, T. (2023). Exploring the benefits and functions of vitamins and proteins in the human body. *Clinical Nutrition and Hospital Dietics*. 43(1), 1-2. doi: 10.12873/0211-6057.23.01.197.

[20] Ebadi, M., Mohammadi, M., Pezeshki, A., and Jafari, S.M., 2023, Health Benefits of Beta-Carotene. *Handbook of Food Bioactive Ingredients*, 22(115):12-67. doi: 10.1007/978-3-030-81404-5_51-1.

[21] AOAC., 2015, Official Methods of Analysis. Association of Official Analytical Chemists. 18th Edition, AOAC, Arlington, 806-814.

[22] Onoja, U.S., Dibua U. M. E, Eze, J.I., and Odo, G.E., 2011, Physico-Chemical Properties, Energy, Mineral, Vitamin and Sensory Evaluation of Wheat-Based Bread Supplemented with Legume, Root, tuber and Plantain flour. *Global Journal of Pure and Applied Sciences*, 17(3):319-327. www.globaljournalseries.com.

[23] Turfani, V., Narducci, V., Durazzo, A., Galli, V., and Carcea, M., 2017, Technological, nutritional and functional properties of wheat bread enriched with lentil or carob flours. *Food Science and Technology (Lwt.)*, 78, 361-366. https://doi.org/10.1016/j.lwt.2016.12.030.

[24] Verem, T.B., Dooshima, I.B., Ojoutu, E.M., Owolabi. O.O. and Onigbajumo., 2021, Proximate, Chemical and Functional Properties of Wheat, Soy and Moringa Leaf Composite Flours. *Scientific Research Publishing*, 12, 18-38. doi: 10.4236/as.2021.121003.

[25] Izundu, I. A., Chukwuma O. M., Adimonyemma, N. R., Akachukwu, E. E. and Iroka, C. F., 2016, Effects of Ripening Acceleration Methods on the Proximate, Biochemical and Mineral Compositions of *Musa paradisiaca* (Plantain). *Ewemen Journal of Herbal Chemistry & Pharmacology Research*, 2(1), 26-33. http://ewemen.com/category/ejhcpr/.

[26] Oteng, P., Otchere, J.K., Adusei, S., Mensah, R. Q. and Tei-Mensah, E., 2020, Vitamin Analysis, Trace Elements Contents and Their Extractabilities in *Tetrapleura tetraptera. Journal of Chemistry*, 1(1), 1-8. doi: 10.1155/2020/1608341.

[27] Uzoekwe, N.M., Ukhun, M.E., and Ejidike, P., 2021, Proximate Analysis, Vitamins, Moisture Content and Mineral Elements Determination in Leaves of *Solanum erianthum* and *Glyphaea brevis*. *Journal of Chemical Society of Nigeria*, 46(1):149. doi: https://doi.org/10.46602/jcsn.v46i1.566.

[28] Iqbal, M. J., Shams, N. and Fatima, K., 2022, Nutritional Quality of Wheat. *IntechOpen*. 12(1):12-16. doi: 10.5772/intechopen.104659.

[29] Bartzatt, R., Gajmer, P., Cassandra Nguyen, M. H., and My-Hanh Tran, A., 2016, Detection and Assay of Vitamin B6 (Pyridoxine Hydrochloride) Utilizing Isocratic High Performance Liquid Chromatography. *Journal of Scientific Research and Reports*, 12(3), 1–12. doi: 10.9734/JSRR/2016/28991.

[30] Al-Alraji, R.R.,Mashkour, M.S., and Al-Mulla, E.A.J., 2017, Spectrophotometric Determination of Vitamin Folic Acid B_9 in Some Drugs Using 1, 2-Naphthoquine-4-Sulphonate (NQS). *Nano Biomedical Engineering*, 9(3), 208-213. https://doi.org/10.5101/nbe.v9i3.p208-213.

[31] Arukwe, D. C., 2021, Proximate composition, functional and pasting properties of wheat flour supplemented with combined processed pigeon pea flour. *International Journal of Food Science and Nutrition*, 6(4), 59-64. doi: 10.1002/fsn3.670.

[32] Adebowale, Y.A., Adeyemi, and A.Oshodi, A. A. 2005, Functional and physico-chemical properties of flours of six mucuna species. *African Biotechnology*, 4(12), 1461-1468. http://www.academicjournals.org/AJB.

[33] Coral, D.F., Pineda-Gomez, P., Rosales-Rivera, A., and Rodriguez-Garcia, M., 2009, Determination of the Gelatinization Temperature of Starch Presented in Maize Flours. *Journal of Physics*, 167(012057):1-6. doi: 10.1088/1742-6596/167/1/012057.

[34] Zaki, H. M., Elshawaf, A.M., El-Makhzangy, A. and Hussein, A. M. S., 2018, Chemical, Rheological and Sensory Properties of Wheat-Oat Flour Composite Cakes and Biscuits. *Journal of Production & Development*, 23(2), 287- 306.

[35] Amjad, A., Sohaib, A., Nawaz, H., Javed, M. S., Shah, M., Shah, F.U.H., Tariq, M.R., Sajid, M.W., Khan, A. A, Bilal, M., Usman, H., Ahmad, M., and Ahmad, T.M., 2022, Assessment of rheological and quality characteristics of bread made by the addition of ginger powder in wheat flour. *Food Science and Technology*, 42, 47820. https://doi.org/10.1590/fst.47820.

[36] Varshney, K., and Mishra, K., 2022, An Analysis of Health Benefits of Carrot. *International Journal of Innovative Research in Engineering & Management (IJIREM)*, 9(1):211-214. https://doi.org/10.55524/ijirem.2022.9.1.40.

[37] Ibeabuchi, C. G., Patrick-Iwuanyanwu, K.C., Eugene, N. Oyeike, E.N., and Akaninwor, J.O., 2023. Proximate Analysis, Vitamins, and Mineral Compositions of *Zingiber officinale*, *Ocimum gratissimum* and their Herbal Blend. *IPS Journal of Nutrition and Food Science*, *2*(2):27-32. https://doi.org/10.54117/ijnfs.v2i2.27.

[38] Prasad, R.V., Dhital, S., Williamson, G. & Barber, E., 2024, Nutrient Composition, Physical Characteristics and Sensory Quality of Spinach-Enriched Wheat Bread. *Foods*,13 (15):2401. https://doi.org/10.3390/foods13152401.

[39] Alemayehu, G.F., Forsido, S.F., Tola, Y.B., Teshager, M.A., Assegie, A.A., and Amare, E., 2021, Proximate, mineral and anti-nutrient compositions of oat grains (*Avena sativa*) cultivated in Ethiopia: implications for nutrition and mineral bioavailability. *Heliyon*, 7(8):7722. doi: 10.1016/j.heliyon.2021.e07722 .

[40] Purewal, S.S., Verma, P., Kaur, P., Sandhu, K.S., Singh, R.S., Kaur, A. and Salar, R.K., 2023, A comparative study on proximate composition, mineral profile, bioactive compounds and antioxidant properties in diverse carrot (*Daucus carota* L.) flour. *Biocatalysis and Agricultural Biotechnology*, 48, 102640. doi: 10.1016/j.bcab.2023.102640.

[41] Youssef, M. K. E. 1., Nassar, A.G., EL–Fishawy, F. A. & Mostafa, M. A. (2016). Assessment of Proximate Chemical Composition and Nutritional Status of Wheat Biscuits Fortified with Oat Powder. *Assiut Journal of Agricultural Science*,47(5):83-94. https://www.aun.edu.eg/faculty-agriculture.

[42] Agu, C.S., Igwe, J.E., Amanze, N.N., and Oduma, O. 2016, Effect of Oven Drying on Proximate Composition of Ginger. *American Journal of Engineering Research* (AJER), *5*(8):58-61. www.ajer.org.

[43] Abubakar, U.S., Tajo. S.M., Joseph, M., Yusuf, K.M., Abdu, G.T., Jamila, G.A., Fatima, S.S. and Saidu, S.R., 2019, Comparative Study of the Proximate, Mineral and Phytochemical Composition of *Zingiber officinale* (Zingiberaceae) Cultivated in Kano and Kaduna States, Nigeria. *Specialty Journal of Chemistry*, 4(3), 1-6. www.sciarena.com.

[44] Kudake D., Pawar V., Muley A.B., Parate A.R.V. & Talib I.M. (2017). Enrichment of wheat flour noodles with oat flour: effect on physical, nutritional, antioxidant and sensory properties. *International Journal Current Microbiology of Applied Science*, 6(12), 204–213. https://doi.org/10.20546/ijcmas.2017.612.026.

[45] Syed, S.J., Gadhe, K.S., and Katke, S.D., 2020, Studies on physical, chemical and mineral evaluation of oats (*Avena sativa*). *Journal of Pharmacognosy and Phytochemistry,* 9(5), 79-52. www.phytojournal.com.