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# Enhancing Wheat Bread Nutrient Content with Orange Flesh Sweet Potato and Chickpea Flour

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***Abstract***

Bread is crucial for food security in Ethiopia, tackling protein malnutrition and vitamin A deficiency. To reduce reliance on imported wheat, supplementing wheat flour with local raw materials is essential. Therefore, this study aims to investigates blending ratio of chickpea and OFSP flour with wheat at different baking temperatures to prepare nutritionally enhanced and high-quality bread. The experiment was conducted in a full factorial design with two factors: flour blending ratio (80:10:10, 70:15:15, 60:20:20, 50:20:30 for wheat, chickpea, and OFSP respectively, and a control of 100% wheat flour) and baking temperatures (180°C, 200°C, and 220°C). The study analyzed the proximate composition of flour and bread, including moisture, ash, protein, fat, fiber, carbohydrates, and β-carotene, while also evaluating the bread's physical and organoleptic properties. Data analysis was conducted using SAS software package version 9.4. The proximate composition of bread showed that substituting wheat with chickpea and orange-fleshed sweet potato increased moisture (28.84 to 35.79%), protein (10.85 to 14.59%), fat (0.85 to 2.05%), fiber (1.49 to 1.84%), ash (0.93 to 2.06%), and β-carotene (0 to 8.04 µg/g of bread). However, it decreased carbohydrate (57.66 to 51.81%) and energy content (281.64 to 257.10 Kcal/100g), due to wheat flour high source of carbohydrate and energy. On the contrary, bread loaf weight increased (123.28 to 131.29 g) due to the superior water absorption capacity of chickpea and OFSP flours compared to wheat. However, loaf volume (359.17 to 205.83 $cm^3$) and specific volume (2.91 to 1.58 $cm^3/g$) decreased due to reduced gluten content in wheat flour. As the proportion of chickpea and OFSP flour increased, sensory acceptability ratings on a 7-point scale decreased: color (6.19 to 2.77), texture (5.78 to 2.62), flavor (5.70 to 2.44), and overall acceptability (5.90 to 2.58) of the bread. In conclusion, blending wheat with chickpea and OFSP flour in bread formulations enhances nutritional quality, especially protein and beta-carotene. Utilizing locally underutilized raw materials is a viable alternative for the growing population.

***Keywords:*** Beta carotene, Chickpea, Enhanced bread, Orange flesh sweet Potato, Proximate composition.

## 1. Introduction

Bread is one of the most ancient foods and commonly consumed in all its various forms by humanity [1]. Bread, a fundamental food across the globe, is vital for maintaining food security. The demand for wheat-based products such as bread has dramatically increased in developing countries due to shifts in food preferences over recent decades [2]. Bread is a food product formed from wheat flour, water, salt and yeasts by a series of processes of mixing, kneading, proofing, shaping and baking. Bread contains a good source of nutrients, such as macronutrients and micronutrients [3].

Wheat is ideal for bread due to its high carbohydrate content, energy, and unique rheological properties, all at a low cost. Gluten proteins in wheat form the bread's structure,

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making wheat flour essential in bakery products [4]. However, bread can also be made from other flours like maize, rye, barley, rice, legumes, and sweet potatoes. Using non-gluten flour is beneficial for developing countries as it promotes high-yielding native plants, increases nutritional values, and enhances domestic agriculture [5]. Wheat is a natural source of proteins (8-12%), vitamins like Vitamin E, minerals such as iron and zinc, and dietary fibers [6]. While wheat provides significant carbohydrates and protein compared to other cereals, its protein quality is lower in delivering essential amino acids like lysine [7].

Chickpea (*Cicer arietinum* L.), the world's third-largest legume crop, is rich in fiber, protein (16-25% db), and essential amino acids like lysine, phenylalanine, and leucine [8]. They help prevent diabetes, cardiovascular disease, lower cholesterol, and regulate blood pressure [9]. In developing countries, grain legumes provide crucial protein, minerals, and vitamins, enhancing nutrition and the economy [10]. Chickpeas, used in gluten-free bread, have a lower glycemic response due to high fiber content and good sensory acceptability [11]. Combining wheat flour with chickpeas offers a balanced protein intake, compensating for the lack of sulfur-containing amino acids like methionine and cysteine [12]. Orange flesh sweet potato (Ipomoea batatas (L)), with its orange- or yellow-colored tubers, is popular due to its high beta-carotene (86-90%) content, beneficial for children and pregnant women [13]. Roots and tubers, including sweet potatoes, are excellent sources of antioxidants, fiber, zinc, potassium, sodium, manganese, calcium, magnesium, iron, and vitamin C. Their nutritional benefits make sweet potatoes a candidate for extended space missions [14]. Orange-fleshed sweet potato (OFSP) is a biofortified cultivar rich in beta carotene, polyphenols, flavonoids, vitamin C, dietary fiber, and minerals. High-quality OFSP flour can replace wheat flour in the bakery industry, enhancing the nutritional and health benefits of baked products [15].

To promote food security and combat malnutrition, the practice of lowering wheat imports by partially substituting it with local under-utilized crops in food production has been widely adopted in developing countries [1]. Vitamin A deficiency is one of the major public health problems in low and middle-income countries including Ethiopia. It impairs growth, weakens immunity, causes blindness, and increases mortality rates [16]. Sweet potatoes, especially orange-fleshed varieties, are rich in β-carotene, essential for preventing night blindness and vitamin A deficiency [17], and their inclusion in processed foods significantly boosts β-carotene content [14]. Wheat is a good source of dietary fiber, proteins (8-14%), vitamins, and minerals, but some nutrients are lost during milling, especially lysine. To address this, blending wheat flour with chickpea and orange-fleshed sweet potatoes can enhance nutritional value and health benefits [18]. Studies have explored mixing wheat flour with various legumes and sweet potatoes, but bread made solely from wheat is less nutritious and costly due to imported raw materials. Incorporating chickpea and orange-fleshed sweet potatoes flours in wheat bread increases beta-carotene and protein content, diversifies crop use, and boosts local farmers' economic power. Hence, the aim of this study was to develop and characterize bread prepared from a composite flour of wheat, chickpea, and orange-fleshed sweet potato. Additionally, the study evaluated the bread's physical properties, proximate composition, β-carotene content, and sensory acceptability.

## 2. Materials and method

### 2.1. Experimental Materials

Wheat flour (hard wheat) (15 kg) was obtained from the Mia macaroni and flour factory in Dire Dawa food complex. An orange-fleshed sweet potato called *Alamura* (Ukr/Eju-10) variety was collected from Haramaya University Research Center. This variety was selected due to high beta carotene content than the other purple and white sweet potato tubers. And *Koka* chickpea variety which is kabuli type was obtained from Debre Zeit Agricultural Research Center.

## 2.2. Sample Preparation

Orange-flesh sweet potato flour was prepared according to the method described by Kindeya *et al*. [19]. OFSP tuber was sorted, cleaned and washed before peeling, peeled, and washed with tap water. The Peeled OFSP roots were sliced with a slicer at a thickness of 0.5 mm and blanched in a water bath at 65°C for 10 minutes for preventing a browning reaction. The treated slices were dried for 8 hours at 60°C using a hot air oven (Figure 1). The dried OFSP slices were ground into flour using a laboratory miller and sieved with a 710-µm sieve scale. The flour was sealed in a polyethylene plastic bag and held in a cool, dark place until needed for the desired purpose. Whereas, the chickpea seeds were manually cleaned of all foreign matter, broken grains, and other impurities. Then, the cleaned seeds were washed in water until the outer parts of the seeds were free from dirt. The washed seeds were dried under sunlight for 24 hours [20]. The dry chickpeas were milled using a laboratory miller after the seed coat or husk was removed, and the flour was screened to pass through a 710- µm mesh screen. The flour was packed in an airtight plastic bag at room temperature for further use.

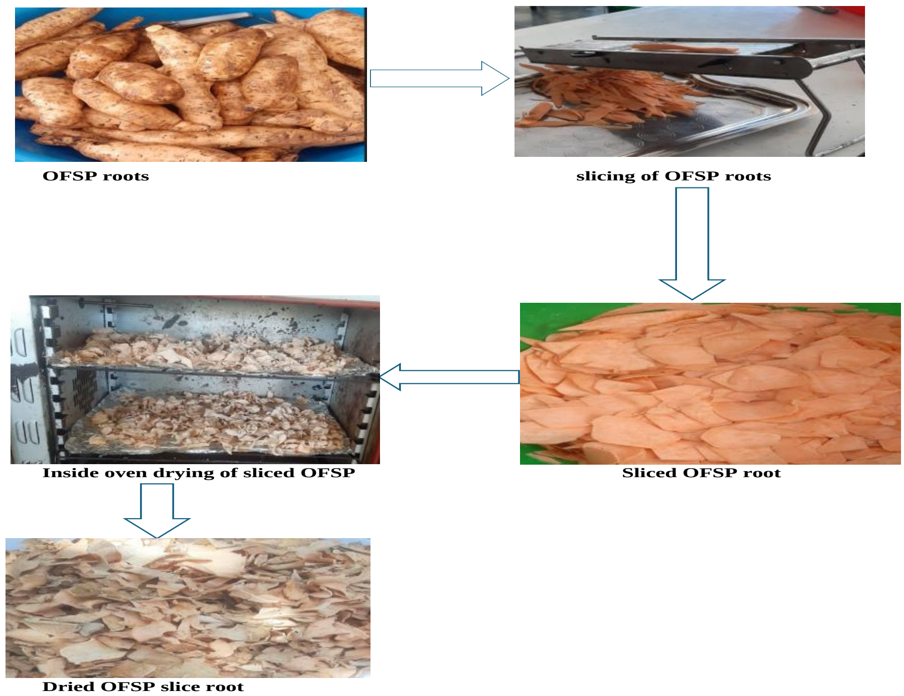


**Figure 1**. **-** OFSP preparation flow diagram

## 2.3. Development of composite flour and Bread

Composite flour was designed with a focus on essential factors influencing bread quality. The quantity was standardized through numerous preliminary trials experiments and reference to existing literature. Three different flours such as chickpea, OFSP, and wheat flour were mixed in blending ratios: C (0, 0,100), B1 (10, 10, 80), B2 (15, 15, 70), B3 (20, 20, 60), and B4 (20, 30, 50) %, respectively. Baking temperatures of 180°C, 200°C, and 220°C were applied uniformly for 35 minutes.

## 2.4. Bread Making Processes

The bread was prepared by using a straight dough method according to Luiz and Vanin [21]. All the ingredients (flour, salt, yeast, and warm water of 37±1°C) were mixed at the same time manually for 5 minutes, and kneading was done until a consistent dough was obtained. The resulting dough was left to rest for 20 minutes at room temperature (first proofing), then a 100-gram piece of dough was divided, rolled, and molded. Each piece of dough with control sample was placed in a metal pan and let ferment for 45 minutes at room temperature (final proofing), and then the baking process was carried out in an electrically heated oven at

180, 200, and 220°C [22], for 35 minutes constant time. After baking, loaves were separated from the metal pan and allowed to cool at room temperature before evaluation. The cooled loaves were dried at 60°C for 9 hours and milled into a fine powder using an electric grinder (High-Speed Sampling Machine Model FW100) until they passed through a 710 µm sieve mesh size. The ground sample flour was used for laboratory analyses.


**Figure 2** - Bread Prepared from Different Blending Ratios and Baking Temperatures

## 2.5. Proximate Compositions, β-carotene Flour and Bread

Proximate composition of flour and bread such as moisture, ash content, crude protein, crude fat, crude fiber, and carbohydrate content were analyzed using the AOAC [23].

**Moisture content**

The moisture content of each flour and product was determined. A clean crucible was dried, coated with flat aluminum dishes, and weighed as (W1) before transferring 5 g (W2) (sample mass with dish mass prior to drying) to the dish. After an overnight drying at 102°C, the dish was removed, and the sample was allowed to cool in desiccators. The dried sample's mass was determined to be W3. The sample's moisture content was determined using the following formula:

$$\text{Moisture content (\%MC)} = \frac{W2-W3}{W2-W1} \times 100 \qquad (1)$$

### 2.5.1. Crude protein

**Digestion**

Flour and bread samples of each 0.5 g were added in to Tecator tubes and 6 ml of acid mixture (5 parts of concentrated ortho-phosphoric acid and 95 parts of concentrated sulfuric acid) was added in to each tube, mixed, left-over night to allow enough reaction facilitating the digestion process and then 3.5 mL of 30% hydrogen peroxide was added step by step, resulting in a violent reaction. Following the cessation of violet reaction, the tubes were shaken and placed back to the rack. Catalyst mixture (ground 0.5 g of selenium metal with 100 g of potassium sulfate) of 3 g was added into each tube and allowed to stand for about 10 minutes before digestion. Following the attainment of digester temperature at 370 °C, the tubes were lowered into the digester. The digestion had been continued until a clear solution was obtained after 4 hours. The tubes in the rack were cooled in a fume hood. About 25 mL of deionized water was added and shaken to avoid precipitation of sulfate in the solution.

**Distillation and Titration**

The digested and diluted sample solution was distilled using 2% boric acid and 40% sodium hydroxide, and then the distillate was subjected to titration using 0.1N hydrochloric acid until a reddish color appeared.

$$\text{Nitrogen (\%)} = \frac{V\text{HCl} * N(HCl)}{Wo} \text{x14x100} \qquad (2)$$

$$\text{Crude protein content (\%)} = \text{N* } 6.25 \qquad (3)$$

The percentage of nitrogen is converted to the percentage of protein by using the appropriate conversion factor and correction factor for composite flour, which is 6.25.

Where: V: the volume of 0.1N HCl, N: normality of HCl (0.1N), Wo: sample weight on dry mass and 14: molecular weight of nitrogen.

### 2.5.2. Crude fat content

The fat content of flour and bread samples had been evaluated by using a semi-continuous solvent extraction method (Soxhlet method). The solvent had been built up in the extraction chamber for 5-10 minutes and completely surrounded the sample and then siphoned back to the boiling flask. The fat content was measured by weight loss of the sample or by weight of the fat removed. The materials used were the Soxhlet machine, the extraction thimble, the extraction chamber and the desiccators.

First the extraction thimble was cleaned, dried and weighed (W1). The extraction thimble covered primarily with fat free cotton containing the primarily weighed 2gm sample (W) was covered over again with a layer of fat free cotton. Then the thimble was put into the extraction chamber. The cleaned and dried extraction cylinder which was previously kept inside a desiccator was then taken out from the desiccators was put in the flask holder; 50ml ether was added in the extraction cylinder and was moved into the heating plank. The extraction continued for 4 hours at 55 ℃. Then after the extraction cylinder was disconnected and had been kept in the drying oven at 70 ℃ for 30 minutes and was again put into the desiccators to let it cool for 30 minutes. Finally, the extraction cylinder had been taken at once out of the desiccators and was weighed (W2). The crude fat content percent weight by weight was computed by the formula below:

$$\text{Crude fat (\%)} = \frac{W2-W1}{W}\ x\ 100 \qquad (4)$$

Where: W1= weight of the extraction flask in gram (g), W2= weight of the extraction flask and the dried crude fat in gram (g), W= weight of sample in gram (g).

### 2.5.3. Ash content

The ash content was calculated using the prescribed procedure 923.03. A porcelain crucible that had been cleaned with distilled water and dried had previously spent 30 minutes at 550°C in a muffle furnace. The crucible was taken out of the furnace and allowed to cool for 30 minutes at room temperature by being placed in desiccators. This was followed by weighing the crucible to the nearest milligram (M1). Fresh 2.5 grams of sample were weighed to collect (M2) using the dried, cooled, and weighed crucible. Then, the sample was thoroughly charred in a fume hood by placing it on a hot plate and slowly increasing the temperature until smoking ceases. After the completion of charring, the samples were placed in a muffle furnace at 550°C for 5 hours. The ignition was continued by cooling for 1 hour and weighing until the ash was clean and white to the nearest milligram (M3).

$$\text{Total ash (\%)} = \frac{M3-M1}{M2-M1}\ x\ 100 \qquad (5)$$

Where: (M2-M1) is the weight of sample in gram (g) on dry basis; (M3-M1) is the weight of ash in gram (g).

### 2.5.4. Crude fiber content

**Digestion**

Bread and flour sample of 2 g (W1) was placed into a 600ml beaker; 200 mL of 1.25% sulphuric acid was added and boiled gently for

30 minutes while watch glass was placed over the mouth of the beaker. The level of the sample solution was kept constant by using hot distilled water during boiling. After exactly 30 minutes heating, 20 mL of 20% KOH was added and boiled gently for further 30 minutes with occasional stirring.

**Filtration**

The bottom of a sintered glass crucible was covered with a 10 mm sand layer and wet with distilled water. The solution was then poured into a sintered glass crucible, and filtered with the aid of a vacuum pump. The wall of the beaker was rinsed with hot distilled water several times. The washing will be transferred into the crucible and filtered.

**Washing**

The residue in the crucible was washed with hot distilled water and filtered twice. Again, the residue was washed with 1% H2SO4, filtered and again washed with hot distilled water, filtered and finally washed with 1% KOH, and filtered. At this level also, the residue was washed with hot distilled water, filtered and again washed with 1% H2SO4, and filtered. Finally, the residue was washed with water-free acetone.

**Drying and Combustion**

The crucible with the bread sample was dried in a drying oven for 2 hours at 130 ℃, cooled for 30 minutes in a desiccator and then weighed (W2). The crucible was then transferred into a muffle furnace, and heating was continued for 30 minutes at 550 ℃. The crucible was cooled in a desiccator and then the crucible was weighed with the content (W3). The crude fiber was determined by the formula below:

$$\text{Crude Fiber (\%)} = \frac{W2-W3}{W1}\, x\, 100 \qquad (5)$$

Where: W1: weight of the fresh sample, W2: weight of crucible with the sample after oven drying and W3: weight of the crucible with the sample after washing.

### 2.5.5. Utilizable carbohydrate

Utilizable total carbohydrate content of the samples content was determined by difference of:

Carbohydrate (%) = 100 - %Moisture + % Protein + %Fat + % Ash + % Fiber (7)

### 2.5.6. Gross energy

The gross energy content of raw and processed bread products was calculated as follows.

Gross energy (Kcal/100g) = (9x%crude fat) + (4x% crude protein) + (4x%carbohydrate) (8)

## 2.6. Determination of β-carotene

Using AACC [24] method, the beta carotene content OFSP flour and bread samples were determined, by using solvent extraction of the pigments and measuring color absorbance using a UV-Visible spectrophotometer at 470 nm. 8g sample flour was shifted to 125 mL glass stoppered flasks and a 40 mL reagent (normal ethanol saturated with water (1:5 alcohols to water)) was added. For one minute, the contents were carefully shaken for 5 min shaken, and then let to stand for 18 hours. The contents were again and filtered through What man no. 1 filter paper into test tubes. The mixture was filled into a standard cuvette and used to calibrate the spectrophotometer at 100% transmittance at 470 nm. The cuvettes were washed several times and filled with the sample extracts and the absorbance was read at 470 nm the carotenoid content was then calculated (μg/g) using the following equation [25].

$$\beta - \text{carotene}\left(\frac{\mu g}{g}\right) = \frac{A\ X\ V\ X\ 104}{A1\%\ X100\ X\ G} \qquad (9)$$

**Where:** A = absorbance, V = Total extract volume (ml), A1%= Total carotenoid extinction coefficient (2500) and G = weight (g) of sample flour.

## 2.7. Analysis of Physical Characteristics of the Bread

The baking qualities and characteristics of the bread were evaluated by measuring the loaf volume, loaf weight, specific loaf volume, and organoleptic properties. The loaf volume (VL) was determined using the seed displacement method with a slit modification, utilizing rapeseeds [26]. The loaf weight (W) was measured on a digital balance after allowing the bread to cool for one hour. The specific loaf volume (VS) was calculated using the following expression:

$$\text{Specific Loaf Volume } (cm^3/g) = \frac{WL}{W} \qquad (10)$$

### 2.8. Sensory evaluation of the bread

Sensory evaluation was conducted with 30 inexperienced panelists selected randomly from the Food Science and Nutrition staff at the Ethiopian Minister of Agriculture. Using a 7-point hedonic scale (7 = liked extremely, 1 = disliked extremely), panelists assessed the bread samples for flavor, texture, color, and overall acceptability. The evaluation was carried out in a controlled environment to prevent bias. Bread samples, wrapped in transparent polyethylene bags, were presented in small, sliced pieces with coded white papers. The raw scores were then statistically analyzed using the method described by Nwosu *et al*. [27].

### 2.9. Statistical Analysis

Data analysis was conducted using ANOVA with SAS software version 9.4. Differences at p<0.05 were compared using the least significance difference (LSD). Results are presented as mean values and standard deviation (mean ± standard deviation).

## 3. Results and discussions

### 3.1. Proximate Composition and Beta Carotene Content of Flour

The proximate composition of wheat, orange-fleshed sweet potato (OFSP), and chickpea flour is detailed in Table 1. Moisture contents were 10.67%, 7.47%, and 6.77% for wheat, chickpea, and OFSP flour, respectively, with previous studies reporting higher levels for wheat (12.7%) and chickpea (8.9%) [28]. Chickpea flour stands out with its higher crude protein content at 20.86% compared to wheat (9.67%) and OFSP flour (3.09%), emphasizing its role as an excellent protein source rich in essential amino acids like lysine, beneficial for managing type-2 diabetes. This finding is consistent with previous reports of chickpea protein content ranging from 19.3% [29] to 19-29 g/100 g [30]. In contrast, wheat flour's protein content aligns closely at 10.60% [31] while OFSP flour ranges between 1.91% and 5.83% [32]. Chickpea flour also exhibits a higher crude fat content (5.16%) compared to wheat (0.61%) and reported values by Hefnawy et al. [29] at 4.7%, with wheat lower than the value reported by Herrera and Gonzalez. [4] at 1.4%. Its high crude fiber content (5.82%) aligns with the reported range of 3.4-5.9% [33] whereas, the crude fiber content of wheat flour (0.56%) is lower than the 0.85% reported by David *et al*. [34] for refined wheat flour. Ash contents of 0.65%, 2.73%, and 2.81% for wheat, chickpea, and OFSP flour, respectively, are supported by previous studies [35,36].

Utilizable carbohydrate content varied significantly: wheat 77.82%, chickpea 60.96%, and OFSP 82.25%, with wheat exceeding the 72.73% reported by Ocheme *et al*. [37] chickpea ranging from 60-65 g/100 g [30-38] and OFSP at 82.51% [19]. Energy values were highest in chickpea flour (373.77 Kcal/100g), followed by wheat (355.49 Kcal/100g) and OFSP (350.96 Kcal/100g), critical in staple crops with OFSP ranging from 344.52 to 375.05 kcal/100g [32]. Orange-fleshed sweet potato flour's β-carotene content was notably highest at 14.49 µg/g [32] highlighting its role in fortifying products against Vitamin A deficiency in developing regions [1].

**Table 1.** The proximate composition and beta carotene-of wheat, chickpea and OFSP flour

| Material | Moisture (%) | Crude Protein (%) | Crude Fat (%) | Crude Fiber (%) | Ash (%) | Carbohydrates (%) | Energy (Kcal/100) | B-carotene (µg/100g) |
|---|---|---|---|---|---|---|---|---|
| Wheat | 10.67±0.55 | 9.67±0.30 | 0.61±0.02 | 0.56±0.06 | 0.65±0.04 | 77.82±0.20 | 355.49±2.02 | 0.00±0.00 |
| Chickpea | 7.47± 0.01 | 20.86±3.99 | 5.16±0.04 | 5.82±0.15 | 2.73±0.03 | 60.96±4.20 | 373.77±0.50 | 0.00± 0.00 |
| OFSP | 6.77± 0.40 | 3.09± 0.13 | 0.09±0.00 | 4.02±0.16 | 2.81±0.08 | 82.25±0.49 | 350.91±2.17 | 14.49±1.10 |
| CV (%) | 4.77 | 20.64 | 1.24 | 3.73 | 2.65 | 3.35 | 0.50 | 13.19 |
| LSD | 0.79 | 4.62 | 0.05 | 0.26 | 0.11 | 4.88 | 3.57 | 1.27 |

**Note:** All values are means of triplicates ± standard deviation. Means within the same column with different letters are significantly different (P< 0.05). CV= coefficient variation and LSD = least significant difference

### 3.2. Effect of blending ratio and baking temperature on proximate composition of bread

The proximate composition of the bread, including ash, moisture, fat, fiber, protein, carbohydrates, β-carotene, and energy content, was analyzed and is presented in detail in Table 2. The moisture content of wheat flour substituted with chickpea and orange-fleshed sweet potato (OFSP) in the bread varied based on the blending ratio and baking temperature, as indicated in the same table. The control sample of wheat flour bread exhibited a moisture content of 2.84%, whereas composite flour breads showed significantly (p<0.05) higher values ranging from 29.43% to 35.79%. The highest moisture content (35.79%) was observed in B4 (20% chickpea, 30% OFSP, 50% wheat). These findings align with Malavi *et al.* [39], who reported similar trends in wheat and OFSP puree breads, suggesting that moisture content increases with higher proportions of chickpea and OFSP flour. This can be attributed to the high water-binding capacity of sweet potato starch and weak intermolecular forces, which enhance moisture retention in baked bread. Furthermore, baking temperature significantly (p<0.05) decreased bread moisture content, as higher temperatures lead to increased moisture evaporation during baking. The crude protein content data in Table 2 also showed significant (p<0.05) effects of blending ratios and baking temperature. The highest protein content (14.59%) was in B4, whereas the control had the lowest (10.85%). Increasing chickpea flour proportion increased protein content, aligning with Sidhu *et al.* [40], who reported similar findings for wheat blended with chickpea flour. Baking temperature significantly (p<0.05) reduced protein content from 13.86% to 11.33% as temperatures rose from 180°C to 220°C, consistent with Patel et al. [41] observations on protein denaturation at high baking temperatures. Regarding crude fat content, Table 2 indicated significant (p<0.05) differences due to blending ratio, with B4 (50% wheat, 20% chickpea, 30% OFSP) having the highest (2.05%) and control (100% wheat) the lowest (0.85%). Baking temperature also had a significant (p<0.05) impact, with fat content decreasing from 1.67% to 1.45% as temperature increased from 180°C to 220°C due to increased fat evaporation during baking.

**Table 2**. Effect of blending ratio and baking temperature on proximate composition of bread product

| Blending | MC (wb %) | Protein (%) | Fat (%) | Fiber (%) | Ash (%) | CHO (%) | Energy (Kcal/100) | Beta carotene (μg/g) |
|---|---|---|---|---|---|---|---|---|
| C | 28.84±0.65$^{e}$ | 10.85±0.39$^{c}$ | 0.85±0.16$^{c}$ | 1.49±0.00$^{d}$ | 0.93±0.03$^{e}$ | 57.66±0.91$^{a}$ | 281.64±3.21$^{a}$ | 0.00±0.00$^{c}$ |
| B1 | 29.43±0.67$^{d}$ | 11.22±0.68$^{c}$ | 1.60±0.18$^{b}$ | 1.54±0.12$^{c}$ | 1.41±0.0$^{d}$ | 56.98±0.96$^{b}$ | 282.45±3.11$^{a}$ | 7.36±0.67$^{b}$ |
| B2 | 31.43±1.21$^{c}$ | 12.05±1.46$^{b}$ | 1.69±0.20$^{b}$ | 1.54±0.12$^{c}$ | 1.88±0.02$^{c}$ | 52.63±1.80$^{c}$ | 269.07±4.86$^{b}$ | 7.29±0.60$^{b}$ |
| B3 | 34.52±1.06$^{b}$ | 14.29±1.35$^{a}$ | 1.68±0.53$^{b}$ | 1.59±0.00$^{b}$ | 1.95±0.0$^{b}$ | 49.64±0.73$^{e}$ | 257.10±6.21$^{d}$ | 7.39±0.62$^{b}$ |
| B4 | 35.79 ±0.73$^{a}$ | 14.59±2.05$^{a}$ | 2.05±0.07$^{a}$ | 1.84±0.00$^{a}$ | 2.06±0.06$^{a}$ | 51.81±1.76$^{d}$ | 267.04±6.63$^{c}$ | 8.04±1.32$^{a}$ |
| LSD | 0.39 | 0.38 | 0.10 | 0.04 | 0.03 | 0.39 | 1.03 | 0.42 |
| Temp | | | | | | | | |
| T1 | 32.90±2.88$^{a}$ | 13.86±2.31$^{a}$ | 1.45±0.52$^{b}$ | 1.41±0.42$^{a}$ | 1.65±0.44$^{a}$ | 52.39±3.33$^{c}$ | 266.05±12.21$^{c}$ | 6.21±3.31$^{a}$ |
| T2 | 31.88±2.81$^{b}$ | 12.61±1.69$^{b}$ | 1.61±0.51$^{a}$ | 1.44±0.29$^{a}$ | 1.65±0.45$^{a}$ | 53.73±3.26$^{b}$ | 272.11±8.43$^{b}$ | 6.00±3.21$^{ab}$ |
| T3 | 31.22±2.96$^{c}$ | 11.33±1.08$^{c}$ | 1.67±0.40$^{a}$ | 1.44±0.34$^{a}$ | 1.64±0.43$^{a}$ | 55.11±3.14$^{a}$ | 276.22±9.42$^{a}$ | 5.83±3.10$^{b}$ |
| LSD | 0.30 | 0.30 | 0.08 | 0.03 | 0.02 | 0.30 | 0.80 | 0.32 |
| CV (%) | 1.26 | 3.17 | 6.46 | 2.79 | 1.59 | 1.15 | 0.64 | 7.23 |

**Note:** Values are means ± SD and values in the same column with different superscript letters are significantly different from each other (P < 0.05). C = Control (100% wheat), B1= 80% wheat, 10% chickpea and 10% OFSP flour, B2 = 70% wheat, 15% chickpea and 15% OFSP flour, B3 = 60% wheat, 20% chickpea and 20% OFSP flour, B4 = 50% wheat, 20% and 30% OFSP flour. T1 = 180 °C, T2 = 200 °C, T3 = 220 °C

Blending ratio significantly ($p<0.05$) affected crude fiber content, with B4 showing the highest (1.84%) compared to the control (1.49%). Chickpea and OFSP flours' higher fiber content contributed to this increase, unaffected by baking temperature. Ash content of breads varied significantly ($p<0.05$) with blending ratio, increasing from 0.93% in the control to 2.06% in B4, reflecting higher ash content in chickpea and OFSP flours. Baking temperature had no effect on ash content.

Blending wheat with chickpea and OFSP reduced carbohydrate content significantly ($p<0.05$), with the control at 57.66% and B3 (20% chickpea, 20% OFSP, 60% wheat) at 49.64%. Baking temperature also significantly ($p<0.05$) reduced carbohydrate content as temperature increased. Energy content showed significant ($p<0.05$) differences due to blending ratios and baking temperature, with the control and B1 having the highest values (281.43 and 282.45 Kcal/100g, respectively).Energy content decreased with higher proportions of chickpea and OFSP and increased baking temperature. Beta carotene content significantly ($p<0.05$) increased with higher proportions of OFSP flour due to its higher provitamin A content. Baking temperature significantly ($p<0.05$) decreased beta carotene content due to heat sensitivity, aligning with findings by Tiruneh *et al.* [42] on carotenoid degradation during baking and processing.

### 3.3. Blending ratio and baking temperature effects on physical property of bread

The physical properties of bread were evaluated, focusing on loaf volume, loaf weight, and specific volume (Table 3). Loaf weight varied significantly ($p<0.05$) across samples, with B4 (20% chickpea, 30% OFSP, 50% wheat) recording the highest weight (131.29 g) and the control (100% wheat flour) the lowest (123.28 g). Increased proportions of chickpea and OFSP flour generally resulted in higher loaf weights due to their superior water absorption capacity compared to wheat flour [26-28]. Baking temperature also had a significant impact ($p<0.05$) on loaf weight, decreasing from 131.07 g at lower temperatures to 124.27 g at higher temperatures, aligning with findings by Shittu *et al*. [43]. Loaf volume, a critical indicator of bread quality, showed a decrease as chickpea and OFSP flour proportions increased. The control sample exhibited the highest volume (359.17 $cm^3$), while B4 had the lowest (205.83 $cm^3$), indicating reduced gluten formation and gas retention with higher non-wheat flour content [28,44].

**Table 3.** Effect of blending ratio and baking temperature on physical property of bread

| Ratios | Loaf weight (g) | Loaf volume ($cm^3$) | Specific volume ($cm^3$/g) |
|---|---|---|---|
| C | $123.28 \pm 1.30^{e}$ | $359.17 \pm 14.09^{a}$ | $2.91 \pm 0.11^{a}$ |
| B1 | $123.45 \pm 3.24^{d}$ | $323.33 \pm 16.63^{b}$ | $2.62 \pm 0.19^{b}$ |
| B2 | $127.37 \pm 3.40^{c}$ | $251.67 \pm 7.60^{c}$ | $1.98 \pm 0.05^{c}$ |
| B3 | $129.94 \pm 7.64^{b}$ | $246.67 \pm 5.73^{d}$ | $1.90 \pm 0.12^{d}$ |
| B4 | $131.29 \pm 5.03^{a}$ | $205.83 \pm 23.95^{e}$ | $1.58 \pm 0.21^{e}$ |
| LSD | 0.01 | 2.49 | 0.02 |
| Temperature | | | |
| T1 | $131.47 \pm 4.98^{a}$ | $268.00 \pm 60.29^{c}$ | $2.06 \pm 0.53^{c}$ |
| T2 | $124.66 \pm 3.95^{b}$ | $291.00 \pm 59.17^{a}$ | $2.34 \pm 0.51^{a}$ |
| T3 | $124.27 \pm 4.95^{c}$ | $273.00 \pm 56.40^{b}$ | $2.19 \pm 0.52^{b}$ |
| LSD | 0.01 | 1.93 | 0.02 |
| CV (%) | 0.01 | 0.93 | 0.91 |

**Note:** Values are means ± SD and values in the same column with different superscript letters are significantly different from each other ($P < 0.05$). C = Control (100% wheat flour), B1 = 80% wheat, 10% chickpea flour and 10% OFSP flour, B2 = 70% wheat, chickpea 15% and 15% OFSP flour, B3 = 60% wheat, chickpea 20% and 20% OFSP flour, B4 = 50% wheat, chickpea 20% and 30% OFSP flour. T1 = 180°C, T2 = 200 °C, T3 = 220 °C.

Baking temperature significantly influenced ($p<0.05$) loaf volume, with higher temperatures yielding greater volumes, such as 291 cm³ at 200°C, attributed to improved dough development and gas retention.

Similarly, the specific volume of bread decreased with higher chickpea and OFSP flour proportions. The control sample had the highest specific volume (2.91 cm³/g), whereas B4 had the lowest (1.58 cm³/g), highlighting reduced gluten content and gas retention with increased non-wheat flour addition [44]. Baking temperature also had a significant effect on specific volume, with higher values observed at elevated temperatures, such as 2.34 cm³/g at 200°C, reflecting enhanced dough development and gas retention.

### 3.4. Sensory Evaluation of Bread Products

A seven-point hedonic scale was used to assess bread acceptability based on sensory attributes including color, texture, flavor, and overall liking, as detailed in Table 4. Blended breads combining wheat with varying proportions of chickpea and OFSP flours showed significant ($p<0.05$) differences in color acceptability. The highest score (6.62) was observed for the control sample (100% wheat flour), while the lowest (2.77) was for B4 (50% wheat, 20% chickpea, 30% OFSP), indicating moderate dislike.

Texture acceptability did not vary significantly ($p>0.05$) with blending ratio but tended to decrease as chickpea and OFSP flour proportions increased.

**Table 4**. Effect of blending ratio and baking temperature on sensory of bread.

| Blending Ratio | Parameters | | | |
|---|---|---|---|---|
| | **Color** | **Texture** | **Flavor** | **Overall acceptability** |
| C | 6.62± 0.27$^{a}$ | 6.39± 0.36$^{a}$ | 6.49± 0.34$^{a}$ | 6.56± 0.31$^{a}$ |
| B1 | 5.90± 0.32$^{b}$ | 5.63± 0.36$^{b}$ | 5.53± 0.25$^{b}$ | 5.74± 0.30$^{b}$ |
| B2 | 6.19± 0.43$^{ab}$ | 5.78± 0.41$^{b}$ | 5.70± 0.38$^{b}$ | 5.90± 0.42$^{b}$ |
| B3 | 4.64± 0.63$^{c}$ | 4.36± 0.71$^{c}$ | 4.23± 0.59$^{c}$ | 4.39± 0.63c |
| B4 | 2.77± 1.12$^{d}$ | 2.62± 0.96$^{d}$ | 2.44± 0.93$^{d}$ | 2.58± 0.98$^{d}$ |
| LSD | 0.6116 | 0.6092 | 0.567 | 0.5896 |
| Temp | | | | |
| T1 | 5.43± 1.45$^{a}$ | 5.12± 1.37$^{a}$ | 4.91± 1.52$^{a}$ | 5.13± 1.45$^{a}$ |
| T2 | 5.34± 1.46$^{ab}$ | 4.91± 1.44$^{a}$ | 5.00± 1.46$^{a}$ | 5.14± 1.49$^{a}$ |
| T3 | 4.91± 1.73$^{b}$ | 4.83± 1.69$^{a}$ | 4.73± 1.68$^{a}$ | 4.83± 1.73$^{a}$ |
| LSD | 0.47 | 0.47 | 0.44 | 0.46 |
| CV (%) | 12.16 | 12.77 | 12.07 | 12.17 |

**Note:** Values are means ± SD and values in the same column with different superscript letters are significantly different from each other ($P < 0.05$). C = Control (100% wheat), B1 = 80% wheat, 10% chickpea and 10% OFSP flour, B2 = 70% wheat, 15% chickpea and 15% OFSP flour, B3 = 60% wheat, 20% chickpea and 20% OFSP flour, B4 = 50% wheat, 20% chickpea and 30%OFSP flour. T1 = 180ºC, T2 = 200ºC, T3 = 220ºC, Temp = Baking temperature

Flavor acceptability differed significantly ($p<0.05$) among blends, with the control sample receiving the highest score (6.49) and B4 the lowest (2.44). Overall acceptability scores were significantly different ($p<0.05$) across blends, with B2 (70% wheat, 15% chickpea, 15% OFSP) scoring the highest (5.90) and B4 the lowest (2.58). Baking temperature showed no significant ($p>0.05$) effect on most sensory attributes of the bread.

## 4. Conclusion

The study revealed that a composite of wheat, chickpea, and OFSP flour yields bread of acceptable quality. The experiments were carried out to determine the proximate composition, beta carotene, and selected physical properties of the developed bread. Bread made from orange-fleshed sweet potatoes and chickpeas is rich in beta carotene and proteins, addressing vitamin A deficiencies and anemia. The resulting bread exhibited increased moisture, protein, fat, ash, fiber, and beta carotene, all beneficial for health. Various chickpea-OFSP-wheat flour ratios were tested for bread quality. The 70:15:15 wheat, chickpea, and OFSP composite flour bread, baked at 200°C, was preferred for its nutritional quality and sensory acceptability. Higher chickpea and OFSP ratios (20% and 30%) improved nutrition but resulted in cracked bread with lower sensory acceptability at higher baking temperatures. Overall, blending 70% wheat, 15% chickpea, and 15% OFSP flour produces high-quality bread. This ratio is recommended for small- and large-scale bakery industries due to its high nutritional value and good sensory acceptability.

## Conflict of interest

No potential conflict of interest was reported by the author(s).

### Author contributions

**Tewodros Sharew** conceived and designed the study, drafted the primary manuscript, and conducted the research. **Deribe Mengistu** contributed significantly by writing, editing, and structuring the manuscript to ensure clarity and coherence.

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