

**UTILIZATION OF ORANGE FLESH SWEET POTATO AND CHICKPEA  
FLOUR TO IMPROVE THE NUTRIENT CONTENT OF WHEAT BASED  
BREAD**

**MSc. THESIS**

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**Utilization of Orange Flesh Sweet Potato and Chickpea Flour to  
Improve the Nutrient Content of Wheat Based Bread**

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As thesis research advisors, we hereby certify that we have read and evaluated this Thesis prepared, under our guidance, by Tewodros Sharew entitled with '**Utilization of Orange fleshed sweet potato and Chickpea Flour to Improve Nutritional Content of Bread**', we recommend that it be accepted as fulfilling the thesis requirement.

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## **DEDICATION**

I dedicate this Thesis to all members of my family and friends.

## **STATEMENT OF THE AUTHOR**

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## **BIOGRAPHICAL SKETCH**

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## **ACRONYMS AND ABBREVIATIONS**

AACC	American Association of Cereal Chemists
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
DZARC	Debre- Zeit Agricultural Research Center
FAO	Food and Agriculture Organization
GI	Glycemic Index
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
LSD	Least Significant Difference
OAC	Oil absorption Capacity
OFSP	Orange Flesh Sweet Potato
SAS	Statistical Analysis Software
VAD	Vitamin A Deficiency
WAC	Water Absorption Capacity
WHO	World Health Organization

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## **ABSTRACT**

*Bread is a worldwide staple food that is crucial for food security in Ethiopia. The country faces significant public health issues such as protein malnutrition and vitamin A deficiency. Nonetheless, there is a limitation of raw materials, wheat flour due to imported raw material. Therefore, it is essential to supplement wheat flour with locally available raw materials to improve the nutritional value of bread. Therefore, the study aims to investigate the possibility of blending chickpea and OFSP flour with wheat for preparation of bread. The experiment was conducted with two factors: flour blending ratio and bread baking temperature. A full factorial design was used to conduct the experiment and the analysis of the data was done using a statistical software package version 9.4. The flour blending ratio of wheat, chickpea and OFSP were 80:10:10, 70:15:15, 60:20:20, 50:20:30 respectively and control sample 100% wheat flour. The baking temperatures were 180, 200 and 220°C. The results of proximate composition of bread displayed that partial replacing wheat with chickpea and orange fleshed sweet potato increased the moisture content 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  $\beta$ - carotene 0 to 8.04  $\mu\text{g/g}$  of bread but reduced carbohydrate 57.66 to 51.81%, and energy 281.64 to 257.10 Kcal/100, due to wheat flour high source of carbohydrate and energy. On the contrary, loaf weight of bread was 123.28 to 131.29 g increased due to higher water absorption capacity of both chickpea and OFSP flour than wheat while loaf volume 359.17 to 205.83  $\text{cm}^3$  and specific volume of bread 2.91 to 1.58  $\text{cm}^3/\text{g}$  were reduced due to reduction of gluten content present in wheat flour. With the rise in the proportion of chickpea and OFSP flour, the sensory acceptability of composite bread recorded in a scale 7 point were decreased from 6.19 to 2.77 in color, from 5.78 to 2.62 in texture, from 5.70 to 2.44 in flavor and from 5.90 to 2.58 in overall acceptability of bread. In conclusion, blending wheat with both chickpea and OFSP flour in bread formulations is found to be promising to improve the nutritional quality, especially protein and beta carotene contents of bread. In addition, giving attention to those locally under-utilized raw materials*

**Keyword:** *beta carotene, chickpea, food security, OFSP, protein, , , proximate analysis,*

## 1. INTRODUCTION

### 1.1. Background

Bread is a global staple food that plays a vital role in food security. Over the past decades, the change in food habits has tremendously increased the demand for wheat-based foods, such as bread, in developing countries (Malavi *et al.*, 2022). Bread is one of the most ancient foods and commonly consumed in all its various forms by humanity (Wang and Jian, 2022). 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.

Cereals, particularly wheat, are ideal for bread preparation over other types of grains due to their high concentration of carbohydrates and energy at a low cost, as well as their unique rheological properties. Gluten proteins such as glutenin and gliadin are present in wheat bread and help to form the bread's structure. Wheat flour is the major basic ingredient in bakery products due to its important characteristics, and it is the main ingredient in most types of breads (Herrera and Gonzalez, 2021). In addition, bread can be also produced from other flours like maize, rye, barley, rice, legumes and sweet potatoes. The use of non-gluten flour is advantageous in bread making for developing countries as it promotes high-yielding native plant species, increases nutritional values and enhances domestic agriculture production (Dako, *et al.*, 2016).

Wheat is naturally a good source of proteins (8-12%), vitamins such as Vitamin E, minerals such as Iron, Zinc, and dietary fibers (Alrayyes, 2018). Wheat is a significant source of carbohydrates and protein, which is reasonably high as compared to other main cereals but rather low in protein quality for delivering necessary amino acid special lysine (Ewunetu *et al.*, 2023).

Chickpea (*Cicer arietinum L.*) is the world's third largest legume crop based on the cultivated area. In the presence of fiber, legumes prevent diabetes, cardiovascular disease, lower cholesterol level and help regulate blood pressure (Saget *et al.*, 2020). Legume seeds are an excellent source of protein (16-25% db), and rich in amino acids, including lysine (Tetrycz *et al.*, 2020). Grain legumes are important for protein, minerals, and vitamins in developing countries. They provide a rich source of vegetable protein for all, especially children, and can improve nutrition and economy

in these countries (Hadero and Nigusse, 2018). Chickpeas is already used as an ingredient in gluten-free bread and showed a lower glycemic response due to high source of fiber in chickpea and had a good sensory acceptability (Lima *et al.*, 2017).

Orange flesh sweet potato (*Ipomoea batatas* (L)) is a variety of sweet potato categorized by its orange- or yellow-colored tubers. Currently, it is strongly emerging as the most popular commonly cultivated and demanded variety, due to its unique properties for its rich in beta-carotene (86-90%) content. Beta carotene is a carotenoid plant pigment responsible for the yellow coloration. It is an important staple for the poor and less privileged considering its relative ease of cultivation, and poor utilization and numerous health benefits, for children and pregnant women (Thuy *et al.*, 2020). Roots and tubers are excellent sources of antioxidants, fiber, zinc, potassium, sodium, manganese, calcium, magnesium, iron, and vitamin C. Due to their nutritional benefits; sweet potatoes were chosen as one of the foods to be evaluated for extended space (Abebe and Dereje, 2018).

In order to promote food security in developing countries, the idea of lowering wheat imports by partially substituting it with local crops in food production widely practiced in developing countries dates back to the 1960s (Wang and Jian, 2022). In the developing world, vitamin A deficiency (VAD) is common in young children; an estimated 127 million children under the age of six are expected to be affected worldwide. The highest estimated prevalence rates of subclinical vitamin A insufficiency are found in Sub-Saharan Africa like Ethiopia. Vitamin A deficiency can impair growth, erode immunity, result in blinding, and raise mortality rates. Vitamin A deficiency continues to be a major public health problem in Ethiopia in spite of the various intervention measures since 1989. In Ethiopia, sweet potatoes with orange flesh are contain more  $\beta$ -carotenes, which are essential for preventing night blindness and vitamin A insufficiency (Zegeye *et al.*, 2015). Replacing other ingredients with sweet potato including OFSP significantly boosted the amount of  $\beta$ -carotene in processed food items (Abebe and Dereje, 2018).

In addition, chickpeas are the main source of protein, they are highly concentrated in other essential amino acids like lysine, phenylalanine, and leucine. However, a lack of sulfur-containing amino acids such as methionine and cysteine (they found in wheat). When wheat flour in combination with legumes to supply nearly all the essential amino acids needed for human growth and development. Chickpeas are widely consumed cereals, like wheat, when in combination with

wheat, to provide diets with a balanced protein intake (Dhillon *et al.*, 2022). They are also suitable for individuals who need a gluten-free diet. Chickpeas have a low-fat content, containing 2 – 6% fat, mostly made up of polyunsaturated fatty acids. As plant-based foods, grains have no cholesterol, but they do contain sterols. Plant sterols are recognized for their ability to lower cholesterol levels. Pulses such as chickpeas are a source of slowly digested carbohydrates or low glycemic index and are rich in insoluble and soluble fibers, resistant starch, and oligosaccharides (Abebe and Dereje, 2018).

Wheat is naturally a decent source of dietary fiber, proteins (8%-14%), vitamins, and minerals, however, some of these essential nutrients are substantially lost during milling of wheat flour specially proteins (lysine (the limiting amino acid in wheat)). To compensate for the loss of nutrients and fulfill the demand for healthier products (Herrera and Gonzalez, 2021). Blended bread with chickpea and orange-fleshed sweet potatoes presents an exciting and relevant alternative due to its potential nutritional and health benefits. Different studies have been made on wheat flour mixed with different legumes such as Mexican common bean, soybean, split bean, faba bean and lentils. In addition, bread is also prepared from sweet potatoes. However, bread made from wheat flour is less nutritious and commercially very expensive because it is imported raw material. Incorporation of OFSP and chickpea flours in wheat flour for the production of bread would increase both beta-carotene and protein content of developed bread, diversify the use of the crops and inspire farmers to produce local crops, which would increase their economic power. Limited literature is available on bread preparation with both chickpea and orange flesh sweet potato flour blends. This research also helps to enhance the nutritional quality of bread, by partial substitution of the wheat flour with locally available raw materials.

## **1.2. Objective**

### **1.2.1. General objective**

To investigate the quality bread by incorporating the wheat with orange flesh sweet potato, chickpea flours for improve nutritional product.

### 1.2.2. Specific objectives

- To study some selected engineering, functional and pasting properties of wheat, orange flesh sweet potato and chickpea flours and to determine their beta-carotene and proximate composition,
- Optimize the effect of blending ratio of orange flesh sweet potato, chickpea and wheat flours on the quality of composite bread product
- Optimize the effect of baking temperature on quality of composite bread product
- Assess the sensory acceptability of the composite bread product.

## 2. LITERATURE REVIEW

### 2.1. Overview of Bread Production

The study of bakery items has drawn a lot of interest due to their widespread use and attractiveness. Bread is one of the most well-known bakery items worldwide. Mostly in Europe, Africa, and the Middle East, it is a staple diet. Wheat or hard wheat is the most important consumed cereal grain, which is mostly used in production of different kinds of breads. In more than half the world's countries, bread supplies over half of the total caloric intake. Human beings have become masters of bread-making thousands of years ago. The oldest baker's oven in the world shows that bread was known in Babylon in 4000 B.C. Production of bread then spread throughout the world to Egypt, Greece, and all other countries (Alrayyes, 2018). History demonstrates that mixing bread with other sources has been going on since the Neolithic, when bread-making first began. It was known as "National Loaf" during the Second World War, and calcium carbonate was added to it to make up for the shortages of milk and cheese that were anticipated at the time (Goel *et al.*, 2021).

In developing countries like Ethiopia, bread production heavily depends on imported wheat; bread wheat is in fact a single most important primary food crop imported from abroad. Bread wheat import increased by an average of 6.6% over the past decade. For instance, in 2008 Ethiopia imported more than a million tons of bread wheat, which was equivalent to about 40 percent of the total domestic production and almost 250% of the marketed volume (Abboye, 2021).

### 2.2. Nutritional Composition of Wheat

Hard wheat consists of 12-18% protein and has characteristics such as brown peel, tough seed, and high-water absorbent. This kind of wheat consists of high protein, so it is suitable for making bread and produces good quality flour. In addition, soft wheat consists of a 7-12% low level of protein and has white and red color and soft seed. This kind of wheat is suitable for making cake, because the dough that is produced has a low absorbent level. The nutritional content comparison of durum wheat (semolina) and bread wheat flours contain the percentage of protein (12.70, 10.60); damaged starch (11.50, 8.50); carbohydrate (77.80, 82.00); amylose (27.00, 23.00); fat (1.00, 0.50) and dietary fiber (1.19, 0.91) respectively (Kassahun, 2020).

## 2.3. Orange Fleshed Sweet Potato

Orange fleshed sweet potato (*Ipomoea batatas* (L.) Lam.) is a persistent tuber and member of the Convolvulaceae family. It ranked fourth in tropical countries and the seventh-most significant food crop in the world food production after wheat, rice, maize, potato, barley, and cassava. Sweet potato roots come in a variety of colors including, white, purple and orange. Sweet potatoes are among the most significant and underutilized crops in the world. Although it is frequently used as a crop for subsistence, food security, or famine relief, its applications have become much more varied in emerging nations. Sweet potatoes grow well in a variety of climates and on less fertile soil, and their fast maturity time makes them a promising food source in poor countries with limited resources (Assefa *et al.*, 2020). Some OFSP varieties are found in nature, while others are the result of conventional breeding. Sweet potatoes, regardless of color, are low in protein quality and quantity (Olosunde *et al.*, 2020).



Figure 1. orange flesh sweet potato. Source: Kebero (2021)

### 2.3.1. Orange fleshed sweet potato production in Ethiopia

Sweet potatoes are a staple food in most countries, particularly those in tropical and subtropical sweet potato production in the world. In 115 countries, there were 112.8 million tons of sweet potatoes produced in 2017. China was the largest producer, followed by Nigeria, Tanzania, Indonesia, and Uganda (Neela and Fanta, 2019). After enset, sweet potato is Ethiopian second most important root crop. The main sweet potato producing areas in Ethiopia are the south nation nationalities and peoples, Oromia, Harighe, and Amhara regions (Abrham *et al.*, 2021). According to the Central Statistical Authority, sweet potato occupied about 53,499 hectares of land with a total annual production of 1.85 million tons during the main growing season only. Small-scale

farmers with limited land, labor and capital-grown sweet potato almost exclusively for household food security in the countries in the south, southwest and eastern regions of Ethiopia (Sora, 2021).

### 2.3.2. Orange fleshed sweet potato nutritional composition

Sweet potatoes can have white, cream, yellow, orange or purple flesh. Sweet potato flour is low in fat and cholesterol and contains dietary fiber that can naturally sweeten, color, and flavor processed foods. It can also be used as a source of energy and carbohydrates, starch, beta carotene (pro-vitamin A), minerals (Calcium, Phosphorus, Iron, and Potassium), vitamins (C, E, thiamin B1, riboflavin B2, pantothenic acid (vitamin B5) and pyridoxine (vitamin B6) and folic acid. The storage roots have a 25% to 30% carbohydrate content, with the remaining portion being made up of water (58-78%). The commercially popular type is the orange-fleshed sweet potato with low dry matter content (18–25%), high  $\beta$ -carotene level, sweet and moist-texture after cooking. The high quantities of beta-carotene in orange-fleshed sweet potatoes have increased demand and attention in recent years. The sweet potato with the orange flesh has a lot of promise to help with vitamin A deficiency (Kebero, 2021).

The orange flesh sweet potato contains 13000-16000 mg of beta-carotene and includes 100g OFSP in one's daily diet can help prevent VAD in children, pregnant women, and lactating mothers (Assefa *et al.*, 2020). Vitamin A Deficiency is common in underdeveloped nations, particularly Ethiopia and has serious repercussions for young children. Through the introduction of enhanced orange flesh sweet potato varieties in Ethiopia, there is a great potential for enhancing both yield and beta carotene content. Beta-carotene which the body utilizes to make vitamin A is abundant in the OFSP cultivar. OFSP is well accepted by young children and can treat Vitamin A Deficiency; OFSP cultivars are a cheap source of vitamin A for poor families in developing East Africa countries such as Ethiopia (Gezahegn, 2021). The importance of orange flesh sweet potatoes in health is attributed to their high nutritional content, which includes anti-carcinogenic and cardiovascular disease properties. Phenolic acid components in orange flesh sweet potatoes have antioxidant and free radical scavenging action as well as other health promoting properties (Neela and Fanta, 2019).

### 2.3.3. Processing of orange fleshed sweet potato in to flour

The orange-fleshed sweet potato tubers are sorted to separate the damaged ones, then cleaned and washed to eliminate any soil, filth, or foreign matter. To enable fast drying and milling operations,

the roots are peeled and sliced 0.5 mm thickness with a potato slicer. The sliced tubers are blanched at 65 °C for 10 minutes in a water bath to inactivate enzymes that may induce browning reaction and the Blanche tuber then, cooled in cold water and dried in the oven at 45°C until constant weight is obtained. The drying temperature (45 °C), is recommended for drying fresh orange flesh sweet potato tuber to obtain high quality flour in terms of lower moisture content and higher protein, vitamin C and beta-carotene. The dried samples are milled, sieved and packed in an airtight polyethylene bag (Nicanuru, 2016).

The OFSP flour can be used in different food applications, either alone or blended with other food products for nutritional improvement (Mitiku and Teka, 2017). For children aged 3 to 4 years old, bread enriched with 30% OFSP flour can provide 83.3 and 74.2% of their daily vitamin A requirements, respectively. In comparison to local bread, the OFSP flour-enhanced bread typically provided pre-school children with a large quantity of the vitamin A they needed each day (Kidane *et al.*, 2013).

## **2.4. Chickpea Production in Ethiopia**

Pulses, such as the dry grains of peas, chickpeas, lentils, peas, beans, and lupines are classified as legumes and members of the family Leguminosae. Ancient societies in Asia, the Middle East, South America, and North Africa produced and used legumes. Chickpea is the second most important legume crop after faba beans. During the period 1999- 2008, it contributed roughly 16% of total pulse production. Chickpea output averaged around 173 thousand tons per year from 1999-2008 (Tolesa, 2014). There are two sorts of chickpeas in the world; Desi and Kabuli. Desi seeds are smaller, reddish brown-colored and have a thick seed coat, while Kabuli's seeds are larger cream-colored seeds with a thin seed coat (Joshi and Rao, 2016).

Chickpea, also known as shimbira in Amharic is a prominent pulse crop in Ethiopia along with faba bean, field pea, haricot bean, lentil and grass pea. Regarding its proportion of the overall area cultivated for pulses and its contribution to direct human consumption. Chickpea is one of the most important annual crops, a versatile crop that grows extensively throughout Ethiopia. Despite the fact that chickpeas are widely farmed in Ethiopia, the majority of the country's production occurs in the two regional states of Amhara and Oromia (Yegrem, 2021). Amhara and Oromia regions in Ethiopia cover more than 90% of the total chickpea area and produce 92% of the overall chickpea

production. North Shewa in the Amhara area is one of the major chickpeas producing zones accounting for 80% of the country's chickpea production and different chickpea varieties are released in different seasons (Tigabie *et al.*, 2020).

The national chickpea research program first established in 1972 at the Debre Zeit Agricultural Research Center to increase the production of chickpea. To date, 29 improved chickpea varieties, including 15 Kabuli types and 14 Desi types, have been created and released in Ethiopia by both the national (DZARC) and regional research programs (yegerem, 2021). Some of them are listed below in table 2.

Table 2. Chickpea varieties developed and released by DZARC and regional research programs (2011-2019).

Variety	Type	Origin	Year of release
Akuri	Kabuli	ICRISAT	2011
Kobo	Kabuli	ICRISAT	2012
Dalota	Desi	ICRISAT	2013
Teketay	Desi	ICRISAT	2013
Dimtu	Desi	ICRISAT	2016
Hora	Kabuli	ICARDA	2016
Dhera	Kabuli	ICARDA	2016
Koka	Kabuli	ICRISAT	2019
Geletu	Desi	ICRISAT	2019

Source: Yegerem, (2021).

#### 2.4.1. Consumption and nutritional benefit of chickpea

Chickpeas are the world's most popular pulse. They are high in protein, vitamins (riboflavin, folate, thiamin, and niacin), minerals (calcium, phosphorus, iron, magnesium, and potassium) (Tamrat *et al.*, 2018), and a high concentration of nutritionally important unsaturated fatty acids such as oleic acid (21.6%–22.2% in oil), linoleic acid (54.7%–56.2% in oil), and linoleic acid

(0.5%–0.9% in oil) (Herrera and Gonzalez, 2021). The insoluble and soluble dietary fiber, particularly resistant starch, is abundant in legumes and used to reduce abnormal sugar rises in the bloodstream after eating bean cereal-based composite flour foods (Zafar *et al.*, 2020).

Chickpeas are high in protein (18- 25 %, dry basis) and carbohydrate (50-60 %, dry basis), with starch (22-45 %, dry basis) (Osorio-Diaz *et al.*, 2008). Around the world, legumes are regarded as a great source of protein since they provide around three times more protein than cereal grains. In many Asian tropical and subtropical nations, it is a staple food crop. Mostly utilized as a food crop, chickpeas can take numerous forms. In Ethiopia, chickpea seeds are consumed in many dishes such as Eshete green seed, roasted ‘kolo’, Genfo (porridge), Kita (flat bread), flour ‘shiro’ or mixed with injera and bread, boiling ‘Nifro or mixed with vegetables, in other Africa countries consumed in roasted chickpea with pasta and macaroni (Ebisa *et al.*, 2018).

#### 2.4.2. Preparation and utilization of chickpea flour

Chickpea grains are sifted and steeped in distilled water to eliminate extraneous contaminants. To eliminate or diminish these anti-nutritional qualities and boost flavor, the grains are cooked for 1 hour at 100 °C in a double-jacketed kettle, drained, and then dried for 8 hours at 38–40 °C in an industrial air drier. To obtain fine flour, the two types of chickpeas (Kabuli and Dessi) milled into powder and sifted using a mesh stainless steel screen. The type of flour is vacuum packed into nylon bags for later use (Dandachy *et al.*, 2019). Chickpea flour is higher in protein (lysine) than wheat flour, and being gluten-free might be beneficial in the production of such a bread product (Wang *et al.*, 1999).

Wheat flour fortifications with legume flours have become extremely popular in recent years for nutritional purposes. Chickpea has been utilized in many food products such as bread, biscuit and pasta to boost their nutritional worth due to nutritional content (Handayani *et al.*, 2020). Study on bread made from Supplementing wheat with chickpea flour up to 10 - 20 % flour also was acceptable. Chickpea addition with more than 20 % significantly impaired the volume, internal structure and texture of the breads. The reason is that these factors are attributed primarily to the gluten fraction, which was weakened by the addition of chickpea protein. The bread had a strongly brown color, a hard crust, and was unacceptable to consumers (Mohhamed *et al.*, 2014).

## 2.5. Physical Properties of Flour

Physical properties affect their flow behavior and storage of Granular particles', thus it's important to take these into account when designing structures and facilities that will handle and store huge materials in a way that is appropriate, effective, and economical. These qualities have a critical role in determining the flow behavior of flour, enabling appropriate handling during the various stages of processing, shipping, and storage (Abdeta, 2022).

### 2.5.1. Particle size distribution

Reducing the size of grains is a crucial process for increasing the surface area to volume ratio of resulting flours. Milling and grinding create flour samples with a diverse mixture of particles. The properties of flour are significantly influenced by its particle size, which in turn impacts the quality of products made from that flour. The distribution of particle sizes gives a comprehensive description of a flour or powder. Sieving flour can create a sample with a consistent particle size distribution, leading to the production of products with improved functional properties (Bala *et al.*, 2020). Particle size is the most significant physical characteristic of powder. The physical qualities of products and/or the behavior of materials are intimately correlated with the distribution of particle sizes. Particle size and distribution have a significant impact on a food powder's bulk density, compressibility, and flow ability. The particle size of flour also affects the properties of dough, including its softening degree, water absorption, and ultimately the texture of the bread. Particle size distribution in food powders must be measured for quality assurance or system property description (Tesfaye, 2018).

### 2.5.2. Angle of repose

The angle of repose is the angle formed by a powder heap (piled on a level surface) and the horizontal. Higher angles are formed by more cohesive powders, whereas lower angles, to some extent, indicate more flow ability. Density measurement is crucial in particle technology for processing condition definitions, pneumatic and hydraulic powder and particle transport, and separation procedures. This magnitude, if determined under appropriate circumstances, can offer helpful information for the design of solid flow, conveyors, bin discharge, and storage structures. For bulk quality control, it's also commonly utilized in the food ingredient business.

The angle of repose is high for materials that are extremely fine and sticky (Abdeta, 2022). The angle of repose and flow characters of flour properties presented below in Table 2.2.

Table 3. The flow characters of flour

Angle of repose (°)	Flow characters
25-30	Excellent
31-35	Good
36-40	Fair
41-45	Passable
46-55	Poor
56-65	Very poor
>65	Much poor flow

Source: Tesfaye, (2018).

### 2.5.3. Bulk density and tapped density

The bulk density is a measure of the amount of packaging material in relation to its volume, which is crucial for storage, transportation, marketing, and the wet food processing industry. It also offers insights into a product's porosity, which can impact packaging selection and design (Dereje *et al.*, 2020). It provides details on a product's porosity and might affect the design and choice of packaging. Bulk density control is one of the main goals of many food processing procedures, particularly during spray drying and grinding. Indeed, depending on how it is applied in process calculations or product characterization, there are various forms of density that can be used, including real, material, particle, apparent, tapped, and bulk (Tesfaye, 2018). Tap density is the measurement of the bulk density of a powder or granular material when it is softly tapped or vibrated to achieve a uniform packing arrangement. This is a crucial factor in the production of flour as it impacts different aspects of flour quality and processing effectiveness (Deribe, 2023).

### 2.5.4. Starch pasting properties

The functional behavior of starch during heating and cooling is inferred from its pasting qualities. The resistance of a fluid or semi fluid to flow when a shear stress is applied is measured by viscosity. When starch is heated above the temperature at which gelatinization occurs, the starch granules absorb water, lose some of their crystalline structure, and become significantly viscous. This refers to this viscosity-development process as "starch pasting." These characteristics have an impact on product stability, consumer acceptability, and production dependability (Dereje *et al.*, 2020). Peak viscosity is the quick rise in viscosity that happens when sufficient granules swell. This happens at the time where swelling and polymer leaching are in equilibrium. The aggregation

of the amylose molecules in the mixture will cause the viscosity to rise to a final level when it is cooled (Tesfaye, 2018).

The minimal temperature needed to cook the flour is indicated by the pasting temperature. The material's capacity to produce a viscous paste is shown by its final viscosity, while its setback measures the starch's tendency to retrograde or interact after cooling cooked starch pastes. The starch with the lowest setback value has a lesser retrograde propensity. For food products like soups and sauces, where retrogradation causes viscosity loss and precipitation, the reduced propensities to retrograde are advantageous. Viscosity of breakdown is a measure of how easily the swollen granules can be broken down (Dereje *et al.*, 2020).

#### 2.5.4. Functional properties of flour

Functional qualities of flours are crucial when making products. The functional characteristics of flour, such as water and oil absorption capacity are crucial to ascertain because they can either make the flour useful for food development or have an impact on formulations, processing applications, food quality, and storage, changing the texture and sensory qualities of food products beyond meeting the minimum nutritional requirements. The characteristics of flour, such as its bulk density, viscosity, and water absorption capacity, indicate the functional qualities of the products that are generated (Dereje *et al.*, 2020).

Water absorption flour is ability to absorb water is primarily affected by the nature and quantity of its hydrophilic ingredients, with pH and protein composition also playing a role. When a product, like dough and pastes, is faced with water constraints, its water absorption characteristic indicates its capacity to bond with water (Neela and Fanta, 2019). Water and oil absorption capacity, which can range from 0.6 to 4.9g-1, is a useful indicator of a protein's ability to stop fluid leakage from the product during food processing or storage. It is defined as the amount of water and oil that can bond per unit of weight of protein material (Bekele, 2017).

## 2.5. Bread Making

The major ingredients of bread are wheat flour, water, yeast, and salt but other ingredients incorporated for different purposes based on the desired products. Water has functions in bread making and makes possible the formation of gluten. Only when flour proteins are hydrated, gluten is formed. Water controls the consistency of dough and assists in the control of dough temperatures and warming or cooling of dough can be regulated through the water. It dissolves salts; suspends

and distributes non-flour ingredients uniformly. Salt is hardened and without salt, the dough is wet and improves the texture of loaf by strengthening the dough, thus indirectly helping color, grain, and texture. The function of yeast in bread making is to lighten the dough, impart to it a characteristic aroma, and flavor (Kasahun, 2020). The characteristics of wheat bread as physical attributes of texture, color, and volume are among the most important parameters taken into account by the consumers (Goel *et al.*, 2021).

## **2.6. Factors Affect the Quality of Bread**

### **2.6.1. Wheat flour protein content and quality**

The genetic control of protein quality significantly affects a variety's potential for baking bread. The main protein component of wheat flour's qualities also has an impact on how well it bakes. Good amounts of total wheat protein are required to make bread, and while it has long been believed that a loaf's volume rises as protein content does, there have recently been some noteworthy exceptions in the case of particular kinds. The protein content is a key quality factor that determines the suitability of wheat for a particular type of product as it affects other factors including mixing tolerance, loaf volume, and water absorption capacity. Both protein quantity and quality are considered important in estimating the potential of flour for its end-use quality (Kasahun, 2020).

### **2.6.2. Gluten content and quality**

Gluten is an important constituent of wheat because it provides strength and texture to baked wheat products and makes it capable of forming many bakery products. Gluten is a plastic-elastic substance consisting of the proteins of gliadin and glutenin, obtained after washing out the starch from wheat flour dough (Kasahun, 2020). The gluten proteins are responsible in making dough viscoelasticity. Glutenin responsible for plasticity and gliadin proteins act as elasticity of the dough (Elsahookie *et al.*, 2021).

### **2.6.3. Wheat milling process**

Conventional milling reduces the nutritional content of flour and concentrates them in the milling residues. The milling process indicated that at a low extraction rate (68%), the protein, fat, fiber, ash, iron, zinc, phosphorous, and antioxidant contents of the samples significantly decreased by milling. The flour particle size, damaged starch, and protein quality and quantity have adverse

effects on the baked products (Kasahun, 2020). Most wheat is ground into flour, which can be used to create a variety of breads with various shapes, structures, and sensory properties. The grain's fibrous layers are eliminated during milling. About 45% of the protein in the grain is lost without the bran and germ, along with 80% of the fiber, 50–85% of the vitamins, 20–80% of the minerals, up to 99.8% of the phytochemicals (Plant-based bioactive compounds are produced by plants for their protection) and important amino acid losses (between 35 and 55%) also happen during refining (Rosell, 2011).

#### 2.6.4. Baking temperature and time

In bread preparation, baking is one of the processes that received an interest due to the application of heat in transforming dough into bread. Several reactions occur during baking that can change in rheological properties of the bread (Ibrahim *et al.*, 2020). The quality of baked products is affected by the time and temperature of the baking process. The baking temperature can affect the bread texture, surface color, protein denaturation, and evaporation of moisture from the crumb and crust. Varying the baking time and temperature the bread physical-chemical parameters and volatile compounds profile change significantly (Sabovics *et al.*, 2014).

#### 2.6.5. Wheat flour ash content

Ash is the residue that is left over after the food products' organic components have completely burned. The ability to classify flours is made possible by the estimate of ash concentration in grains. Flour ash can change the color of the final product, giving them a darker color. The wheat flour has ash contents ranging from 1.8% to 2.16% (Kasahun, 2020).

### 3. MATERIALS AND METHODS

#### 3.1. Experimental Location

The experiments were conducted at Haramaya University, Wolkite University and Addis Ababa Science and Technology University in the Food Process Laboratory. The experiments on the proximate analysis, color analysis, functional properties, particle size, angle of repose, dispersibility flour and physical property of bread were conducted at Wolkite University in the food laboratory. Vitamin A determination and sample preparation were conducted at Haramaya University at the Food Science and Postharvest Technology laboratory. The remaining baking bread samples, sensory analysis of products and pasting properties of flour were held at the Minister of Agriculture and Addis Ababa Science and Technology University respectively.

#### 3.2. 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 "Alamura" (Ukr/Eju-10) variety was collected from farmers of Asebe Tefferi they taken from Haramaya University Research Center. The OFSP tuber was selected due to high beta carotene content than the other purple and white sweet potato tubers.

The Chickpea "Koka" kabuli variety was obtained from Debrezeit Agricultural Research Center (DZARC). Koka variety grown at attitude of 1900, average annual rainfall 851mm, soil type is vertisols and it is newly released variety in 2019 in DZARC.

#### 3.3. Experimental plan

The experiment was conducted in full factorial design with two factors of three and four levels, i.e. baking temperature and blending ratio respectively. The baking temperature levels T1, T2, and T3 were 180, 200 and 220 °C and the blending ratios were B1 (10%, 10%, 80%), B2 (15%, 15%, 70%), B3 (20%, 20%, 60%), and B4 (20%, 30%, 50%) chickpea, OFSP, and wheat flour respectively with 100% wheat flour taken as a control. The blending contains different proportions of wheat, chickpea, and OFSP flour. Finally, each experiment was done in triplicates and flour formulation was listed below.

Table 3. Experimental Layout

Factor BR	Factor Baking Temperature		
	T1	T2	T3
C	CT1	CT2	CT3
B1	T1B1	T2B1	T3B1
B2	T1B2	T2B2	T3B2
B3	T1B3	T2B3	T3B3
B4	T1B4	T2B4	T3B4

**Where;** C = control sample (100% wheat flour),

B1 = 80% wheat, 10% chickpea, 10% OFSP

B2 = 70% wheat, 15% chickpea, 15% OFSP,

B3 = 60% wheat, 20% chickpea, 20% OFSP flours and

B4 = 50% wheat, 20% chickpea, 30% OFSP flours

T1, T2, and T3 (180, 200 and 220) (Ibrahim *et al.*, 2020) baking temperatures respectively.

The linear statistical model for (wheat-OFSP-chickpea proportion and baking temperature) looks like:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ij} \quad 1$$

Where: Y is the response,  $\mu$  is the constant,  $\alpha_i$  is the effect of *i*th level of OFSP and chickpea proportion factor (*i*- 1,2,3,4, 5),  $\beta_j$  is the effect of *j*th level baking temperature factor (*j*- 1,2,3),  $(\alpha\beta)_{ij}$  interaction between OFSP and chickpea proportion and baking temperature,  $\epsilon_{ij}$  is the random error.

### 3.4. Raw Material Preparation

#### 3.4.1. Preparation of orange-flesh sweet potato flour

The method described by Kindya *et al.* (2021) was used to make OFSP flour. Sorted OFSP tubers were 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. The dried OFSP slices were ground into flour using a laboratory miller and

sieved with a 710- $\mu\text{m}$  sieve scale. The flour was sealed in a polyethylene plastic bag and held in a cool, dark place until needed for the desired purpose.

#### 3.4.2. Preparation of chickpea flour

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 (Yohannes, 2014). 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- $\mu\text{m}$  mesh screen. The flour was packed in an airtight plastic bag at room temperature for further use.

### 3.5. Bread Making Processes

The bread was produced by using a straight dough method according to AACC (2000). All the ingredients (flour, salt, yeast, and warm water of  $37 \pm 1$  °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 (Ibrahim *et al.*, 2020), 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  $\mu\text{m}$  sieve mesh size. The ground sample flour was used for laboratory analyses.

### 3.6. Determination of Some Selected Engineering Properties of Flour

#### 3.6.1. Particle size distribution

Particle size distribution indicates how readily the material segregates in the various components of the system, or simply, the distribution of particles in the powder sample. The particle size distribution of all three flour types was determined using sieve analysis techniques as described by Deribe, (2020). Different sieves with varying aperture sizes (2, 1, 0.5, 0.25, 0.1, 0.075, <0.075 mm) were arranged on top of each other, with the one having the biggest aperture on the topmost

level and arranged in decreasing order. The sieves were fastened into a rigid position using a fastening screw after a standard quantity of the flour sample (50g) was placed inside the topmost sieves. The sieves were shaken for 10 minutes, after which the quantity of flour on each sieve was collected, weighed, and the weight percentage calculated as follows:

$$\% \text{ Retained} = \frac{W_{sieve}}{W_{total}} \times 100 \quad (1)$$

Where:  $W_{sieve}$  - the weight of aggregate in the sieve

$W_{total}$  - the weight of the total aggregate.

### 3.6.2. Angle of repose

The angle of repose is the angle formed by the horizontal base of a pile of flour and the inclined surface of a cone-like pile of flour. A cylinder of 10 cm diameter and 15 cm height was placed vertically over a plain surface and was filled into the top by the flour samples. Tapping during filling was done to obtain uniform packing and minimize the wall effect, if any. The cylinder tube was slowly lifted off the surface, and the flour was slid down, forming a cone-shaped heap. The height of the peak of the heap above the surface and the diameter of the heap at its base were measured, and the angle of repose ( $\Phi$ ) calculated by the following relations (Melese *et al.*, 2021).

$$\text{Angle of Repose } (\Phi^\circ) = \tan^{-1} \left( \frac{2h}{r} \right) \quad (2)$$

Where:  $\Phi$  = angle of repose ( $^\circ$ )

h = height of the heap (mm)

r = radius of the base of the heap (mm).

### 3.6.3. Bulk and tapped density of flours

The bulk density of bread product gives an idea of the required space to store the product and shows the overall expansion and changes in cell structure, including the development of pores and voids. To determine the bulk density of the flour, 2 g of each sample was transferred into a 10 mL graduated cylinder, and its volume was recorded. Bulk density was calculated by dividing the mass by volume (g/m<sup>3</sup>). The tapped density was determined after tapping the measuring cylinder with a known volume of sample 20 times while the flour sample was in the graduated cylinder. The

tapped density was calculated by dividing the mass by the volume of the sample after the taps (Sisman *et al.*, 2022).

$$\text{Bulk density } (\rho_b) = \frac{M}{V_b} \quad (3)$$

$$\text{Tapped density } (\rho_t) = \frac{M}{V_t} \quad (4)$$

Where: M is mass of flour and  $V_b$  and  $V_t$  are volumes of bulk and tapped flour respectively.

#### 3.6.4. Color of the flours

The color of the flour was measured in accordance with the CIE  $L^*a^*b^*$  color space system based on the tristimulus value. The lightness (L), redness (+Ve a), greenness (-Ve a), yellowness (+Ve b), blueness (-Ve b), and magnitude of total color difference (DE) values were measured by placing the samples on the port of the color reader using a colorimeter. A positive value of  $a^*$  indicates the magnitude of the reddish component, while its negative value shows that of the greenish component. A positive value for  $b^*$  shows a yellowish component, while a negative value indicates a bluish component. The  $L^*$ ,  $a^*$ , and  $b^*$  values were recorded according to (Deribe, 2023).

$$\text{Hue angle} = \tan^{-1} \left( \frac{b^*}{a^*} \right) \quad (7)$$

$$\text{Chroma} = \sqrt{(a^*)^2 + (b^*)^2} \quad (8)$$

Where:

Hue angle = Color perceived by the naked eye and the color measure in degree

Chroma = Chromaticity coordinate which is perpendicular to the distance from lightness

### 3.7. Pasting properties of flours

The pasting profile of flour was determined using a Rapid Visco-Analyzer (model no. 4500 Perten instrument, Australia). A sample of 3.5 g of flour (14% moisture basis) was mixed with 25 ml of distilled water to make a flour suspension in the sample-holding cup to determine the viscosity using a rapid visco-analyzer. A 13-minute heating and cooling cycle was used in which the sample was held at 50°C for 1 minute, heated from 50°C to 95°C in 3.5 minutes, held at 95°C for 3 minutes, cooled to 50°C in 3.5 minutes, and then held for 2 minutes at 50°C. Determining all

pasting properties such as peak viscosity (CP), trough viscosity (CP), break down viscosity (CP), final viscosity (CP), set-back viscosity (CP), and pasting temperature (°C) were determined using the software thermocline for Windows version 3 (Deka and Sit, 2016).

### **3.8. Proximate Compositions, $\beta$ -carotene Flours and Bread**

#### **3.8.1. Proximate composition of flour and bread**

The standard method of the American Association of Cereal Chemists (AOAC, 2000; the official method 925.10) was used for the determination of moisture, ash content, crude protein, crude fat, crude fiber, and carbohydrate content.

#### **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:

$$\text{Moisture content (MC)} = \frac{W2 - W3}{W2 - W1} \times 100 \quad (9)$$

#### **Crude protein**

#### **Digestion**

Fresh samples (in triplicate) 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.

$$\text{Nitrogen (\%)} = \frac{V_{\text{HCl}} * N(\text{HCl})}{W_o} * 14 * 100 \quad (10)$$

$$\text{Crude protein content (\%)} = N * 6.25 \quad (11)$$

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.

### **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 °C. Then after the extraction cylinder was disconnected and had been kept in the drying oven at 70 °C 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:

$$\text{Crude fat (\%)} = \frac{W_2 - W_1}{W} \times 100 \quad (12)$$

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)

### **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).

$$\text{Total ash (in \% weight by weight)} = \frac{M_3 - M_1}{M_2 - M_1} \times 100 \quad (13)$$

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

(M3-M1) is the weight of ash in gram (g).

## **Crude fiber content**

### **Digestion**

Fresh sample of 2 g (W1) flour 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% H<sub>2</sub>SO<sub>4</sub>, 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% H<sub>2</sub>SO<sub>4</sub>, and filtered. Finally, the residue was washed with water-free acetone.

### **Drying and Combustion**

The crucible with the flour sample was dried in a drying oven for 2 hours at 130 °C, 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 °C. 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:

$$\text{Crude Fiber (\%)} = \frac{W_2 - W_3}{W_1} \times 100 \quad (14)$$

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.

### Utilizable carbohydrate

The formula indicated below was used to determine the carbohydrate content of the samples. Total carbohydrate content of the samples content was determined by difference of:

$$\text{Carbohydrate (\%)} = 100 - (\% \text{Moisture} + \% \text{Protein} + \% \text{Fat} + \% \text{Ash} + \% \text{Fiber})$$

### Gross energy

Gross energy was calculated according to Deribe, (2020). The gross energy content of raw and processed bread products was calculated as follows.

$$\text{Gross energy (Kcal/100g)} = (9 \times \% \text{crude fat}) + (4 \times \% \text{crude protein}) + (4 \times \% \text{carbohydrate})$$

### Determination of $\beta$ -carotene

Using AACC, (2000) method, the beta carotene content OFSP flour samples was 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 ( $\mu\text{g/g}$ ) using the following equation (kukric *et al.*, 2012).

$$\beta - \text{carotene} \left( \frac{\mu\text{g}}{\text{g}} \right) = \frac{A \times V \times 104}{A1\% \times 100 \times G} \quad (15)$$

Where:

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

### 3.9. Determination of functional properties of flour

#### Dispersibility of flour

Disperse ability of chickpea and OFSP flour were determined using the method described by AACC (2000). Ten grams of the flour sample was weighed into a 100 mL measuring cylinder. Distilled water was added to a volume of 100 ml. The sample was stirred vigorously and allowed to settle for three hours. The volume of settled particles was recorded and subtracted from 100. The difference was reported as percentage dispersibility.

$$\% \text{ of Dispersibility} = 100 - \text{volume of settled particle} \quad (16)$$

#### Water absorption capacity

Water absorption capacity was determined using the procedure described by Chikpah *et al.*, (2020). Flour (2 g) was measured into a clean pre-weighed 15 mL centrifuge tube and the weight of the tube with the sample was measured (W1). Distilled water (10 mL) was added to the tube and then vortexed for 1 min and kept at room temperature (25 °C) for 30 min followed by centrifugation at 4000 rpm for 30 min. The supernatant gently poured into a beaker and freed excess water drained by inverting the tubes on filter paper. The final weight of the centrifuge tube containing the sample after draining water was measured (W2) and WAC were expressed as grams of water absorbed per gram of flour as shown below;

$$\text{WAC (\%)} = \frac{(W2-W1)}{\text{Initial sample weight(g)}} \times 100 \quad (17)$$

Where: W1 is the weight of the tube with the sample

W2 is the weight of the centrifuge tube containing the sample after draining water

#### Oil absorption capacity (OAC)

The method used by Deribe, (2020) for the determination of oil absorption capacity of the flours. One gram of flour (W1) was transferred into a clean empty centrifuge tube with known weight (W2) and 10 mL of soybean oil was added. The mixture was vortexed for 30 s, kept at room temperature (25 °C) for 30 min and centrifuged for 30 min at 4000 rpm. Unabsorbed oil was carefully drained, after which the weight of the tube plus the sample was measured (W3) and OAC were calculated using the following formula;

$$\text{OAC} = \frac{W_3 - (W_1 + W_2)}{W_1} \times 100 \quad (18)$$

Where: W1 is the weight of the sample,  
 W2 is the weight of empty centrifuge tube and  
 W3 is the weight of the tube and the sample

### Swelling power and water solubility index

The swelling power of flour was determined according to AOAC (2000) method number 46.13.01. It involved weighing 3 gm of flour sample was added into a 25 ml centrifuge tube and 10 ml of distilled water was added and mixed gently. The slurry was heated in a water bath at a temperature of 80°C for 30 minutes. During heating, the slurry was stirred gently to prevent clumping of the flour. On completion of 30 minutes, the tube containing the paste was centrifuged at 300 rpm for 10 minutes. The supernatant was decanted immediately after centrifuging. The weight of the sediment was taken and recorded.

$$\text{SP} = \frac{\text{Weight of sediment}}{\text{Weight of sample}} \times 100 \quad (19)$$

Where: SP- is swelling power in %

The water solubility index was determined using a method described by Wondimu and Gebremariam (2010). The crucible was dried in the oven at 105°C for 20 minutes and allowed to cool in desiccators, after cooling, the crucible was weighed. One gram of flour sample was weighed into the test tube and 10 ml of distilled water was added and stirred gently with a stirring rod for 30 minutes. The supernatant was decanted into crucibles and dried in the oven at 105°C for 12 hours until the supernatant was dried off the crucible. Water solubility index were calculated as shown below:

$$\text{WSL} (\%) = \frac{\text{Weight of dry supernatant}}{\text{Weight of sample}} \times 100 \quad (20)$$

Where: WSL- is water solubility index in percent

### 3.10. Analysis of Physical Characteristics of the Bread

The bread characteristics or baking qualities were evaluated by measuring the loaf volume, the loaf weight, the loaf specific volume, and the organoleptic properties of the breads.

#### 3.9.1. Loaf weight, loaf volume and specific volume of bread

The loaf volume (VL) was measured by using seed displacement method (Dako *et al.*, 2016) with slit modification using chickpea instead of barley seed. Loaf weight (W) of bread was measured after cooling for one hour on digital balance. Specific loaf volume (VS) was calculated in the following expression:

$$\text{Specific Loaf Volume}(cm^3 / g) = \frac{VL}{W} \quad (21)$$

#### 3.9.2. Sensory evaluation of the bread samples

Sensory evaluation was carried out using 30 judges to assess the organoleptic attributes of the bread samples. The organoleptic attributes assessed were flavor, texture, color, and the overall acceptability. The panelists were selected randomly from the staff Minister of Agriculture at Addis Ababa. They were made to carry out the organoleptic assessment under controlled environment to avoid biased results. The bread samples wrapped with transparent polyethylene bags were presented in small sliced and coded identical white papers. The panelists were instructed to rate the breads based on a 7-point hedonic scale ranging from 7 = liked extremely to 1=disliked extremely. The raw scores were assembled and statistically analyzed using the method described by Nwosu, *et al.*, 2014.

### 3.11. Statistical Analysis

The data analysis was done using statistical methods. Collected data were subjected to analysis of variance (ANOVA) using SAS statistical software 9.4 version. Statistical differences in samples were tested at  $P < 0.05$  and the differences between means were compared using the least significance difference (LSD). The average values and standard deviation (average  $\pm$  standard deviation) to present the results.

## 4. RESULTS AND DISCUSSIONS

The proximate composition, beta carotene content, functional properties, particle size distribution of flour, color property, pasting property of flours were investigated. sensory evaluation and physical properties of bread products as influenced by flour proportion and baking temperature and the discussions associated with them are presented in the following sections.

### 4.1. Proximate Composition and Energy content of Flour

#### 4.1.1. Moisture content

The proximate composition of wheat, chickpea and OFSP flour used in this study are presented in Table 4.1. The moisture content was found of wheat 10.67%, chickpea 7.47% and OFSP 6.77% flour. Man *et al.* (2015) had reported that the moisture content of wheat and chickpea flour were 12.7%, and 8.9% respectively, which are higher with the results of this study. Kaur, and Singh, (2005) reported, the moisture content of chickpea varieties flour was ranged from 6.64-8.90%, which is inlined with the present study. Ewunetu *et al* (2023) also reported that the moisture content of wheat flour was 10%, which is close with the result of this study. The moisture content of OFSP flour reported in this study was in agreement with the various drying techniques for OFSP converted into flour to the moisture content of <11% (Neela and Fanta, 2019). The low moisture content is very important for flour to maintain long shelf life and prevent microbial activity.

#### 4.1.2. Crude protein

The chickpea flour showed higher crude protein content (20.86%) than wheat (9.67%) and OFSP flour (3.09%) (Table 4.1). The data presented here shows chickpea flour to be plenty of source of proteins (20.86%) with higher amounts of essential amino acids (lysine) which are low in cereals. Chickpea is an excellent

Table 4.1. The proximate composition and beta carotene-of wheat, chickpea and OFSP flour

<b>Material</b>	MC (%)	CP (%)	CF (%)	CFb (%)	Ash (%)	CHO (%)	Energy (Kcal/100)	B-carotene (µg/100g)
<b>Wheat</b>	10.67±0.55 <sup>a</sup>	9.67±0.30 <sup>b</sup>	0.61±0.02 <sup>b</sup>	0.56±0.06 <sup>c</sup>	0.65±0.04 <sup>b</sup>	77.82±0.20 <sup>b</sup>	355.49±2.02 <sup>b</sup>	0.00±0.00 <sup>b</sup>
<b>Chickpea</b>	7.47± 0.01 <sup>b</sup>	20.86±3.99 <sup>a</sup>	5.16±0.04 <sup>a</sup>	5.82±0.15 <sup>a</sup>	2.73±0.03 <sup>a</sup>	60.96±4.20 <sup>c</sup>	373.77±0.50 <sup>a</sup>	0.00± 0.00 <sup>b</sup>
<b>OFSP</b>	6.77± 0.40 <sup>b</sup>	3.09± 0.13 <sup>c</sup>	0.09±0.00 <sup>c</sup>	4.02±0.16 <sup>b</sup>	2.81±0.08 <sup>a</sup>	82.25±0.49 <sup>a</sup>	350.91±2.17 <sup>c</sup>	14.49±1.10 <sup>a</sup>
<b>CV (%)</b>	4.77	20.64	1.24	3.73	2.65	3.35	0.50	13.19
<b>LSD</b>	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). CHO = utilizable carbohydrate, MC=moisture content, CP= crude protein, CF= crude fat, CFb=crude fiber, CV= coefficient variation and LSD = least significant difference among treatments.

source of protein than wheat and OFSP flour and lower in carbohydrates than wheat flour, making it a good option for people with type-2 diabetes. The crude protein content for chickpea flour reported by Hefnawy *et al.* (2012) was (19.3%) lower than the present study. Raza *et al.* (2019) reported crude protein content of chickpea between (19-29 g/100 g), which supports the result of this study. Chickpeas are known to have higher proteins than cereals. Kasahun, (2020) reported the crude protein content of wheat flour to be 10.60% which supports the finding of this study. The study reported by Neela and Fanta, (2019) on the protein content of orange-fleshed sweet potato flour was ranged between 1.91 and 5.83%, which is agreed with this study.

#### 4.1.3. Crude fat content

The higher value (5.16%) was recorded for chickpea flour (Table 4.1). The crude fat content of chickpea flour reported by Hefnawy *et al.* (2012) was 4.7% which is lower than the finding of this study. The crude fat content of wheat flour obtained in this study was 0.61% which is lower than 1.4% reported by Herrera and Gonzalez, (2021). Neela and Fanta, (2019) reported the crude fat content of orange-fleshed sweet potato of <1% which agreed with the result of this study. Texture and flavor of food products may be influenced by fat content.

#### 4.1.4. Crude fiber content

The high value (5.82%) crude fiber content was recorded for chickpea flour as shown in Table 4.1. On the other hand, a crude fiber content of 0.56% was determined for the wheat flour, which was higher than the range 0.175-0.35% reported by Deribe, (2021). The crude fiber content of orange-fleshed sweet potato flour recorded for this study is higher than 3.68% reported by Chikpah *et al.* (2023). The crude fiber content of chickpea flour obtained from this study agreed with the range of 3.4-5.9% reported by Dida and Urga, (2018). Dietary fiber is a structural component of plants (soluble and insoluble fiber). Soluble fiber can dissolve in liquids and quickly break down by bacteria in the colon. They are frequently allied to preventing heart disease by reducing blood glucose and cholesterol levels (Deribe, 2020).

#### 4.1.5. Ash content

Ash is either the term for the inorganic material that is left over after food has burned or completely oxidized. The amount of minerals in a food is represented by its ash content. Ashing is the initial step in preparing a food sample for a certain basic analysis (Deribe, 2021). The analysis showed

that the ash contents are 0.65, 2.73 and 2.81% for wheat, chickpea and OFSP flour, respectively. The result for wheat is in close agreement with the result reported as (0.87%) by Chikpah *et al.* (2023). Neela and Fanta, (2019) reported, the ash values for OFSP flour were ranged from 1.17% to 4.33%, which agreed with the current study. The study reported by Rachwa-Rosiak *et al.* (2015), the total ash content for chickpea flour were ranged from 3.2–2.8% which is inlined the current study. Kaur and Singh, (2005) also reported the ash content of different chickpea variety flour ranged from 2.72-2.88%, which supports the present study.

#### 4.1.6. Utilizable carbohydrate content

The utilizable carbohydrate content of the wheat, chickpea and orange fleshed sweet potato flour scores were 77.82, 60.96 and 82.25% respectively, as shown in Table 4.1. The utilizable carbohydrate content recorded for wheat flour in this study was higher than the 72.73 % reported by Ocheme *et al.* (2018). The total carbohydrate content for chickpea flour reported by Raza *et al.* (2019) and Hamdani *et al.*, (2020) were ranged range 60-65 g/100 g and 61.0 g/100g respectively, which support the result of this study. Kindeya *et al.* (2021) reported that the utilized carbohydrate content of orange- fleshed sweet potato flour was 82.51%, which corroborates the finding of the current study.

#### 4.1.7. Energy

Table 4.1 presents the energy contents of the wheat, chickpea and orange- fleshed sweet potato flours. The higher total energy value (373.77 Kcal/100) was recorded for chickpea flour, whereas lower values of 355.49 Kcal/100 for the wheat and 350.96 Kcal/100g for orange- fleshed sweet potato flour were recorded. Energy is a very important property of the staple crops. The energy content for OFSP flour fell in the range 344.52–375.05 kcal/100 g which was reported by Neela and Fanta, (2019).

#### 4.1.8. Beta carotene content

Beta-carotene is the most prevalent provitamin A carotenoid found in food and nutritional supplements. Orange fleshed sweet potato is a richer source of beta carotene content than wheat and chickpea flour. Orange fleshed sweet potato plays a crucial role on fortified bread products enhancing nutritional quality and combating Vitamin A deficiency. Data indicated that beta carotene content of orange fleshed -fleshed sweet potato flour was 14.49  $\mu\text{g/g}$  (Table 4.1). Neela and Fanta, (2019), reported beta carotene content of orange fleshed sweet potato flour which ranged between 1-15  $\mu\text{g/g}$  on a dry basis which corroborates the finding of the present study. Sweet

potato flours, especially those with orange flesh, contain high levels of  $\beta$ -carotene, which is the most crucial provitamin A carotenoid. They have been utilized as a hopeful approach to combat vitamin A deficiency in developing worlds (Wang and Jian, 2022).

## 4.2 Functional Properties of Flour

### 4.2.1. Water absorption capacity of flour

Water absorption capacity refers to the ability of flour to absorb water under conditions where water is limiting and it is useful for assessing flour ability to take up water and swelling to increase food uniformity. Chickpea flour exhibited higher water absorption capacity (2.21 g/g) than the 0.82 and 1.53 g/g of wheat and orange-fleshed sweet potato flours, respectively. This is due to more hydrophilic constituents, like polysaccharides, and it is possible that the proteins found naturally in chickpea flours contributed to this ability (Kaur and Singh, 2005).

On the other hand, chickpea flour and orange-fleshed sweet potato flour contain less gluten and more fiber, which allows them to absorb more water compared to wheat flour. The water absorption capacity of chickpea flour in this study is the same as (2.21 g/g) the result obtained from the study reported by Solanke *et al.* (2021). The water absorption capacity of orange-fleshed sweet potato flour of this study was lower than the 1.56 g/g reported by Chikpah *et al.* (2020).

### 4.2.2. Oil absorption capacity

Oil absorption capacity of flour refers to the amount of oil that can be absorbed or physical entrapment of oils. Oil absorption capacity is useful in food formulation where oil-holding capacity is needed for bakery products to enhance mouth sensation, texture and retain flavors of the final product (Dereje *et al.*, 2020). The oil absorption capacity of chickpea and orange-fleshed sweet potato flours were 1.03 and 1.05 g/g, respectively. The record for the chickpea flour was much higher than the 0.77 g/g reported by Badia-Olmos *et al.* (2023). The oil absorption capacity of orange-fleshed sweet potato flour in this study agreed with the 0.94-1.06 g/g reported by Dereje *et al.* (2020).

### 4.2.3. Swelling power

Swelling power refers to the ability of a flour to absorb water and increase in volume and it is an important property in determining the gelatinization and viscosity of starches (Dereje *et al.*, 2020).

Onabanjo *et al.* (2020) reported swelling power of wheat flour of 5.82 g/g which was higher than the records in this study. According to a study by Jagannadham *et al.*, (2015), the swelling power of chickpea flour ranged from 1.75-9.54g/g, which is in line with the results of this study. The swelling power of orange fleshed sweet potato flour was 7.47 g/g and is comparable to the records 5.7-23.5 g/g reported by Dereje *et al.* (2020) as obtained from different sweet potato varieties.

#### 4.2.4. Water solubility index

Water solubility index measures the portion of flour components that can dissolve in water. Wheat flour has a lower water solubility index due to gluten structure than chickpea and orange-fleshed sweet potato flours. The water solubility index of chickpea (25.41%) was higher than the 11.45 and 5.56% of the OFSP and wheat flours as presented in Table 4.2. The water solubility index of the chickpea flour was lower than the 26.75% recorded for similar flour by Solanke *et al.*, (2021) which could be attributed to various reasons including variety, soil type of growing area and agronomic practices conducted during cultivation. The solubility of OFSP flour (11.45%) was in line with the finding of Gitanjali and Lakhawat, (2019) who reported water solubility values which ranged from 8.56 to 19.97% in for flours extracted from different varieties of sweet potato. The variation in water solubility of OFSP flours can be due to the different processing method of flour production.

#### 4.2.5. Dispersibility

The dispersibility of flour refers to the ability of flour to evenly disperse with a liquid medium such as water or another liquid medium. Dispersibility is a key parameter for determining how well flour will rehydrate with water without forming swellings. In this report, OFSP flour had higher dispersibility than wheat and chickpea flour. The dispersibility 75% of OFSP flour reported by Eke-Ejiofor *et al.*, (2021) was similar to the finding in the current study. The dispersibility value for wheat flour reported by Melese *et al.* (2021) was 73%, which is higher than the record in this study. In another study, Kindeya *et al.* (2020) reported 65% dispersibility of haricot bean flour, which is higher than the present study for chickpea flour. Generally, higher dispersibility indicates stronger reconstitution property, and used to make a fine dough consistency during mixing.

#### 4.2.6. Bulk and tapped densities

The particle size of the flour has an impact on the bulk and tapped density, which is crucial for determining packaging needs, material handling, and use in the wet processing food industry. The

bulk density of wheat, chickpea and OFSP recorded were 0.67, 0.5 and 0.74 g/mL, respectively, in Table 4.2. In this study, the bulk density of wheat flour was lower than the 0.70 g/mL recorded by Ocheme *et al.*, (2018). Bulk density of OFSP flour in this study was agreed with the 0.74 g/mL reported by Tiruneh *et al.* (2018). In a similar study, reported by Mulugeta and Solomon, (2022), the bulk density of taro flour (0.74 g/mL) was the same as obtained for OFSP flour in this study. The high bulk density is essential for use in food preparation (liquid, semi solids or solids) and low-density flour would be beneficial for preparing weaning foods (Solanke *et al.* 2021). Bulk density (0.74 g/mL) of wheat flour reported by Kindeya *et al* (2021) was higher than the 0.67 g/mL recorded in this study. The bulk density of chickpea flour reported by Hasmadi *et al.*, (2020) ranged from 0.536 to 0.571 g/mL, which supports this study.

Orange-fleshed sweet potato has a higher bulk (0.74 g/mL) and tapped density (0.87 mL/g) compared to chickpea (0.77 mL/g) and wheat (0.84 mL/g) flour due to its higher starch content. The higher bulk and tapped density are due to the small particle size and high density of sweet potato flour, which results in a higher packing requirement. According to the study by Amankwah *et al.* (2022) the tapped density of wheat flour was 0.74 mL/g, which is lower than the present study.

Table 4.2. Functional properties of wheat, chickpea and OFSP flour

<b>Material</b>	<b>WAC (g/g)</b>	<b>OAC (g/g)</b>	<b>SP (g/g)</b>	<b>WSI (%)</b>	<b>DS (%)</b>	<b>BD (g/mL)</b>	<b>TD (mL/g)</b>	<b>AR</b>
Wheat	0.82± 0.01 <sup>c</sup>	1.23± 0.07 <sup>a</sup>	4.41± 0.17 <sup>b</sup>	5.56± 0.06 <sup>c</sup>	69.50± 0.50 <sup>b</sup>	0.67± 0.00 <sup>b</sup>	0.84± 0.01 <sup>b</sup>	45.13± 1.28 <sup>a</sup>
Chickpea	2.21± 0.02 <sup>a</sup>	1.03 ± 0.06 <sup>b</sup>	4.15± 0.41 <sup>b</sup>	25.41±0.52 <sup>a</sup>	52.17± 0.76 <sup>c</sup>	0.54± 0.00 <sup>c</sup>	0.77 ± 0.00 <sup>c</sup>	42.48± 0.61 <sup>b</sup>
OFSP	1.53± 0.01 <sup>b</sup>	1.05± 0.02 <sup>ab</sup>	7.47±0.06 <sup>a</sup>	11.45±0.11 <sup>b</sup>	75.00± 0.50 <sup>a</sup>	0.74± 0.00 <sup>a</sup>	0.87 ± 0.01 <sup>a</sup>	40.41± 0.22 <sup>c</sup>
CV (%)	0.85	8.35	4.81	2.19	0.92	0.28	0.84	1.94
LSD	0.03	0.18	0.51	0.62	1.20	0.004	0.01	1.66

**Note:** All values are means of triplicate ± standard deviation. Means within the same column with different letters are significantly different ( $P \leq 0.05$ ). WAC= water absorption capacity, OAC= oil absorption capacity, SP= swelling power, WSI= water solubility index, DS= disperisability, BD= bulk density, TD= true density, AR= angle of repose, CV=coefficient variation and LSD=least significant difference among treatments.

#### 4.2.7. Angle of repose

The angle of repose indicates the flow ability and cohesiveness of the flour. Highest angles of repose were recorded for wheat (45.13°), chickpea (42.48°), and OFSP (40.41°). The wheat flour was found in the range of passable to flowing (can easily flowing), chickpea in the range of passable, and OFSP in the range of fair flowing ability based on the angle of repose flow characters (Al-Hashemi *et al.*, 2018). Materials having higher moisture content have a higher angle of repose. The lower the angle of repose is the more free flowing of the powder (Deribe, 2021).

### 4.3. Some Selected Engineering Properties of Flour

#### 4.3.1. Particle size distribution

The flour's particle size distribution demonstrates the various ranges of particle sizes that are present in a sample of flour. In the current study calculation of the weight percentage of millimeter-sized flour particles was done using the sieve analysis techniques. The size distribution of the flour's particles determines whether the flour is fine or coarse. The highest percent of wheat flour retained on the sieve was 50.00 on sieve size of 0.1 mm and the lowest was 0.61% on sieve size of <0.075. For chickpea flour the highest value was 50.03% on sieve size 0.5mm and the lowest value was 0.21% on sieve size 2 mm. Similarly, for orange-fleshed sweet potato, the highest was 37.04% of sieve size <0.075 mm and lowest value was 0.00% of sieve size 2 and 1 mm, as presented in Table 7.

Materials exhibit greater cohesive behavior because the particle surface area per unit mass increases with decreasing particle size, which shows having more points of contact. The protein, maltose, and ash contents of specific flours are correlated with their particle size. In addition, as the particle size is reduced, the ash content increases due to the large particle having a lower surface area, and the greater particle size has an advantage. Larger particles flow more smoothly than fine or smaller particles and smaller particles with a lot of surface area have a stronger attraction to one another and are more likely to stick together and resist flow. As the size of small particles increases with increase the surface area to volume ratio due to this there is strong attraction among them which results friction of particulates induces resistant to flow (Deribe, 2020).

Table 7. Particle size distribution (%) of wheat, chickpea and OFSP flour

Materials	Particle size (mm)						
	2	1	0.5	0.25	0.1	0.075	<0.075
<b>Wheat</b>	0.67±0.23 <sup>a</sup>	0.72± 0.51 <sup>ab</sup>	0.82±0.01 <sup>c</sup>	35.55±0.00 <sup>a</sup>	50.00±0.01 <sup>a</sup>	11.46±1.34 <sup>b</sup>	0.61±0.14 <sup>c</sup>
<b>Chickpea</b>	0.22±0.23 <sup>b</sup>	1.12± 0.39 <sup>a</sup>	50.03±0.01 <sup>a</sup>	27.00±0.00 <sup>b</sup>	19.41± 2.16 <sup>b</sup>	1.30± 0.28 <sup>c</sup>	0.92±0.02 <sup>b</sup>
<b>OFSP</b>	0.00±0.00 <sup>b</sup>	0.00± 0.00 <sup>b</sup>	23.53±1.29 <sup>b</sup>	13.53±0.00 <sup>c</sup>	18.62± 0.00 <sup>b</sup>	20.21±0.00 <sup>a</sup>	37.04±0.00 <sup>a</sup>
<b>CV (%)</b>	62.72	60.4	3.01	0.00	4.25	7.17	0.64
<b>LSD</b>	0.37	0.74	1.51	0.00	2.49	1.58	0.17

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

#### 4.3.2. Color of flour

Color is an essential quality attribute of food products as it affects consumer acceptability. Particularly, flour color is vital to note because it affects the crumb color of the product (Alviola and Monterde, 2018).

The color values of wheat, chickpea and orange-fleshed sweet potato flour are presented in Table 4.3. The highest L\* the value was 96.39 for wheat flour and the lowest value was 89.62 for chickpea flour. According to the study by sidhu *et al.* (2023) reported the L\* the values for white wheat and chickpea flour were 66.3 and 60.8 respectively, which is higher than the present study. According to the study by Islam *et al.* (2020) the L\* the value for OFSP flour was 90.54 reported, which is the closest value with the present study. Chickpea flour had the lowest L\* value (89.62), which means that it was the darkest flour as compared to wheat OFSP flours. Wheat flour has a lighter color due to naturally occurring carotenoid pigments than chickpea and orange sweet potato flour because it contains less pigments such as carotenoids and anthocyanin that are responsible for the color of chickpea and OFSP flours.

The a\* value represents the red or green color (positive value represents for red and negative value indicates for green). The a\* the value of wheat, chickpea and OFSP flour were -1.85, 3.43 and 1.21 calculated respectively. The a\* values for 12 varieties of Ghanaian sweet potatoes were ranged between (-2.52 to 1.22), which agreed with this study. The a\* the values for both wheat and sweet potato flour were 1.78 and 1.95 as reported by Alviola and Monterde, (2018), which are higher values than with the present study.

The b\* the values for wheat, chickpea and OFSP flour were significantly ( $p < 0.05$ ) different among all treatments as shown in Table 4.3. The b\* value for wheat, chickpea and OFSP flour were 6.86, 11.78 and 13.03 scored respectively. The highest b\* value was recorded for OFSP flour and lowest value was for wheat flour. According to the study of Alviola and Monterde, (2018) the b\* value of wheat flour was 7 which is higher than that reported in this study. According to the report of Chikpah *et al.* (2023) the b\* value of OFSP flour was 35 which is much higher than the current study. The b value chickpea flour reported by Fenn *et al.* (2010) was 19, which is higher value than this finding.

The chromaticity coordinates, or chroma, is the perpendicular distance from the lightness. The recorded values of chroma of wheat, chickpea and OFSP flours were 7.11, 12.27 and 13.09 respectively. The chroma value for three chickpea varieties reported by Deribe, (2023) ranged from 22.06-25.01, which is a higher value than present study.

The hue angle of wheat, chickpea and OFSP flour were 74.96, 73.77 and 84.70° recorded in Table 4.3. The highest hue angle recorded for OFSP flour was 84.70 and lowest was 73.77 for chickpea flour. The hue angle for desi and kabuli chickpea flour reported by Ravi and Harte, (2009) were 87.56 and 86.07°h reported respectively, which are higher value than to this study. Azzahra *et al.* (2019) reported that the hue angle of OFSP flour was 80.75 °h, which is lower value than this study.

Table 4.3. Color values of wheat, chickpea and OFSP flour

Material	L*	a*	b*	Hue angle (h°)	Chroma
Wheat	96.39± 0.04 <sup>a</sup>	-1.85± 0.29 <sup>c</sup>	6.86± 0.15 <sup>c</sup>	74.96±1.94 <sup>c</sup>	7.11± 0.21 <sup>c</sup>
Chickpea	89.62±0.18 <sup>c</sup>	3.43±0.09 <sup>a</sup>	11.78±0.21 <sup>b</sup>	73.77±0.19 <sup>b</sup>	12.27±0.22 <sup>b</sup>
OFSP	92.75± 0.03 <sup>b</sup>	1.21± 0.12 <sup>b</sup>	13.03± 0.31 <sup>a</sup>	84.70±0.62 <sup>a</sup>	13.09±0.30 <sup>a</sup>
CV (%)	0.12	19.91	2.19	4.24	2.28
LSD	0.22	0.37	0.46	2.36	0.49

**Note:** All values are means of triplicates ± standard deviation. Means within the same column with different letters are significantly different ( $P < 0.05$ ). Where, L\* = white (+) and black (-), a\* =red (+) and green (-), and b\* = yellow (+) and blue (-)

#### 4.4. Pasting properties of flour

Pasting properties are characteristic of the intensity of changes that occur during starch alteration (Mulugeta and Solomon, 2020). The alterations that occur in food because of applying heat while water is present is pasting properties of the food. These changes have an impact on the food product's final texture, digestion, and usability (Ocheme *et al.*, 2018).

**Pasting temperature:** Pasting temperature is the lowest temperature at which the viscosity begins to raise (Belay *et al.*, 2020). The pasting characteristic of the wheat, chickpea and orange -fleshed sweet potato flour are shown in Table 5. The pasting temperatures for wheat, chickpea and OFSP

flours were 87.47, 78.25 and 75.05°C, respectively. Ocheme *et al.*, (2018) reported that the pasting temperature of wheat flour was 88.03°C, which was close to the result in this study. Higher pasting temperature value indicates a greater ability to prevent starch granules from swelling and breaking (Dhillon *et al.*, 2022). Pasting temperature of chickpea starch was 72.35°C found by (Jagannadham, and Parimalavalli, 2015), which is lower value than the present study. The study by Aguilar and Vélez-Ruíz, (2016) reported the pasting temperature of raw chickpea variety flour which ranged between 74.6-85.9°C, which agreed with the result of this study. According to the study by George *et al.*, (2021), the gelatinization temperature for different varieties of sweet potato flour ranged from 55.50 -75.50°C, which agreed with this study. A higher amylose content could be the cause of the lower pasting temperature value (Hashimoto *et al.*, 2020).

**Peak viscosity:** peak viscosity indicated by the maximum viscosity that can be attained when making starch paste and measure of the starch granule's ability to bind water (Mulugeta and Solomon, 2021). In this study, the peak viscosity of wheat, chickpea and OFSP flour were 2453.33 1270.67 and 1428.67 cp, respectively. The peak viscosity of wheat flour reported by Julianti *et al.* (2015) was 2433 cp, which is almost similar value with this study. According to the report by Dereje *et al.*, (2020) the peak viscosity of sweet potato flour for different varieties ranged from 826 to 3039 Cp, which is in agreement with this study. The peak viscosity of chickpea starch reported by Jagannadham and Parimalavalli, (2015) was 4453 cp, much higher than the present study. The peak viscosity of desi chickpea flour reported by Dhillon *et al.*, (2022), was 732.27 cp, which is much lower value than peak viscosity of chickpea flour from this study, due to different factors such as variety, environmental and soil fertility effect.

**Trough viscosity:** The trough viscosity (hos paste viscosity) is an indicator of the ability of paste to withstand high temperature conditions (Dhillon *et al.*, 2022). Trough viscosity of wheat, chickpea and OFSP flour were 1048, 937.17 and 1046 cp respectively. The report by Jan *et al.*, (2022), on trough viscosity of wheat flour was 1254 cp, which is higher than recorded in this study. According to the finding of Dreje *et al.* (2020) the trough viscosity of sweet potato variety ranged from 826- 3039 cp, which is in agreement with the current study. The trough viscosity of sweet potato flour reported by Julianti *et al.* (2015) was 1002 cp, which is close to the value of the present study. The trough viscosity of chickpea (Desi variety) flour value was 617.73 cp, reported by Dhillon *et al.*, (2022), which is lower than to this study the difference in trough viscosity is may

be due to chickpea variety. High trough viscosity values could be an indication of excellent eating quality and minimal cooking losses (Dereje *et al.*, 2020).

**Breakdown viscosity:** breakdown viscosity is a metric that indicates how much the viscosity decreases during heating and assessing the level of starch stability during heating and shearing is crucial in starch water systems. The breakdown viscosity of wheat, chickpea and OFSP flour were 1405.33, 333.97 and 383.33 cp respectively, as presented in Table 4.4. According to the report of Julianti *et al.* (2015) the breakdown viscosity of wheat and sweet potato flour were 1151 and 829 cp, respectively, of which the value of wheat flour was lower and that of sweet potato was higher than the present study. Kaur and Singh, (2006) reported breakdown viscosity of different chickpea flour that ranged between 71-269 cp, which was lower than in this study. In a study reported by Dhillon *et al.* (2022) the breakdown viscosity of chickpea (Kabuli variety) flour was 113.27 cp which is lower than the present study, the difference may be due to chickpea variety. Lower breakdown viscosity of chickpea flour indicates its paste stability of the flour and decrease in the rate of rupturing of starch granules. The higher breakdown viscosity OFSP flour indicates lower ability of the sample to withstand heating during cooking.

**Final viscosity:** The ability of a substance to produce a viscous paste is indicated by its final viscosity (cold paste viscosity, and this ability correlates with the viscosity of foods during consuming food. The final viscosity of wheat, chickpea and OFSP flour were 2908.33, 1520 and 1847.97 cp respectively, are presented in Table 5. The aggregation of amylose indicates a high final viscosity and low value indicates the resistance of the paste to shear stress during stirring (Dereje *et al.*, 2020). The final viscosity of wheat flour reported by Jan *et al.* (2022) was 2199 cp, which is lower value than this study. According to the report of Kaur and Singh, (2006) the final viscosity of different chickpea flour were in the range from 1515-2704 cp, which is higher value than the present study. The study by Julianti *et al.* (2015) the final viscosity of sweet potato was 1565 cp, which is lower value than the current study.

**Setback viscosity:** The setback viscosity indicates the tendency of the starch paste to dehydrate or retrograde after cooling. Setback viscosity of wheat, chickpea and OFSP flour were 1859.83 cp, 584 cp and 802.30 cp, respectively. In comparison, to other flour, chickpea exhibited lower setback viscosity indicating its lower tendency to retrograde and higher setback viscosity of wheat flour indicates a reasonable amount of retrogradation of granules during cooling (Dereje *et al.* 2020).

According to the study reported by Julianti *et al.* (2015), setback viscosity of both wheat and sweet potato flour were 1131 cp and 563 cp respectively, which are lower value than the current study. According to the report of Dereje *et al.* (2020) the setback viscosity of different varieties of sweet potato ranged between 62- 865 cp, which is in agreement with this study. The setback viscosity of chickpea flour reported by Dhillon *et al.* (2022) was 287.37 cp, which is lower value than the present study. In general, chickpea flour has lower viscosity and lower swelling power than wheat and OFSP flour due to the difference in size and shape of starch granules.

Peak time: is a measure of how long it takes for each type of flour to attain its maximum viscosity. The peak time for wheat, chickpea and OFSP flour were 5.80, 6.27 and 4.97 min scored for this study. The peak time of chickpea flour reported by Maurya *et al.* (2023) was 6.20, which is a higher value than in this study. Chickpea flour has a higher pasting time than wheat and orange-fleshed sweet potato flour due to its higher protein content and lower starch content. The protein in chickpea flour forms a stronger network during cooking, resulting in a longer pasting time.

According to the report of Jan *et al.*, (2022) the peak time of wheat flour was 5.93 min, which is almost similar to this study. Peak time for sweet potato flour was found in the range from 3.3 to 9.76 minutes (Dereje *et al.*, 2020), which supports the current study. The longest peak time was 6.27 min recorded for chickpea flour and the shortest was 4.97 min of the OFSP flour. This is due to gluten free flours requiring more energy and a longer cooking time to form a paste. In addition, they are more resistant towards swelling and higher protein flours in general need more time to reach their peak viscosity (Alviola and Monterde, 2018). In addition, the high starch content shortens the pasting time and long peak time is not suitable in baking industries because it related to requirement of long dough development time and high energy input (Dereje *et al.* 2020).

Table 4.4. Pasting properties of wheat, chickpea and OFSP flour

Materials	PT(°C)	PV(CP)	TV (CP)	BDV(CP)	FV(CP)	SBV(CP)	Pt(min)
Wheat	87.47± 0.57 <sup>a</sup>	2453.33± 1.53 <sup>a</sup>	1048± 1.00 <sup>a</sup>	1405.33± 0.58 <sup>a</sup>	2908.33± 0.58 <sup>a</sup>	1859.83± 0.76 <sup>a</sup>	5.80± 0.01 <sup>b</sup>
Chickpea	78.25± 0.01 <sup>b</sup>	1270.67± 0.58 <sup>c</sup>	937.17± 0.29 <sup>c</sup>	333.97± 0.06 <sup>c</sup>	1520.93± 0.12 <sup>c</sup>	584± 0.00 <sup>c</sup>	6.27± 0.01 <sup>a</sup>
OFSP	75.05± 0.01 <sup>c</sup>	1428.67± 0.58 <sup>b</sup>	1046± 0.00 <sup>b</sup>	383.33± 0.58 <sup>b</sup>	1847.97± 0.06 <sup>b</sup>	802.30± 0.52 <sup>b</sup>	4.97± 0.06 <sup>c</sup>
CV (%)	0.41	0.06	0.06	0.07	0.02	0.05	0.59
LSD	0.66	2.00	1.20	0.94	0.68	1.07	0.07

**Note:** Values are means ± standard deviation of three determinations. Means in the same row with different superscript are significantly different ( $p < .05$ ). PT= pasting temperature, PV= peak viscosity, TV= trough viscosity, BDV= breakdown viscosity, FV= final viscosity, SBV= setback viscosity and Pt= pasting time.

## 4.5. Main Effects of Blending Ratio and Baking Temperature on the Loaf weight, Loaf Volume and Specific Volume of Bread

Physical properties of bread include loaf volume, loaf weight and specific volume. These physical properties are influenced by various factors such as the type of flour used, and the baking temperature of bread products.

### 4.5.1. The Loaf Weight of Bread

Table 4.5 represents the loaf weight of bread samples based on this result there is significant ( $p < 0.05$ ) difference among all products. The highest loaf weight was (131.29 g) scored for B4 (20% chickpea, 30% OFSP and 70% wheat) flour and the lowest (123.28 g) was for the control (100% wheat flour). Based on the result from the table as the ratio of chickpea and OFSP flour increased, the loaf weight increased.

Dako *et al.* (2016) reported an increase in loaf weight of bread samples with increased sweet potato flour. This is due to higher water absorption capacity of sweet potato flour than that of wheat flour. According to the study by Man *et al.* (2015) reported preparation of bread from wheat and chickpea flour, as the ratio of chickpea flour increased with increased loaf weight of bread. The increase in bread weight was found significant ( $p < 0.05$ ). In comparison to wheat flour, chickpea flour has a higher fiber and protein content, which causes a higher water absorption in the finished product and an increase in weight.

Baking temperature had an effect on loaf weight of sample bread with significant ( $p < 0.05$ ) differences among treatments. As baking temperature increased the loaf weight decreased from 131.07-124.27 g. According to the study by Shittu *et al.* (2007) higher baking temperature and longer baking time caused reduction of loaf weight.

### 4.5.2. The Loaf Volume of Bread Samples

Loaf volume, a crucial aspect of bread quality, shows how much gas the dough can hold. The loaf volume data of bread in Table 4.5 below, showed that the loaf volume of bread decreased as both chickpea and OFSP flour increased. The highest loaf volume was recorded for control sample (359.17 cm<sup>3</sup>) and the lowest (205.83 cm<sup>3</sup>) was for B4 at the ratio of 20%, chickpea and 30% OFSP flour proportion. As the ratios of other ingredients increase the quantity of the gluten reduces thus

decrease in formation of bubbles to trap the CO<sub>2</sub> gas reducing the volume. Kure *et al.* (2021) observed that bread made from wheat and OFSP flour blends, as the ratio of OFSP flour to the bread increased, decreased the loaf volume due to the lowering gluten content of wheat flour and the reduction in loaf volume and specific volume of bread when non-wheat flour was blended in with wheat flour. Man *et al.* (2015) the primary result of adding fiber to bakery goods is a reduction in their volume. Chickpea flour is higher in fiber and protein content than wheat and OFSP flour. Loaf volume is influenced by quality and quantity of protein in the flour. Baking temperature had an effect on loaf volume of bread samples. The highest loaf volume was at T2 (291cm<sup>3</sup>), which was related to dough development and gas retention of bread. The lowest value was 268 cm<sup>3</sup> at baking temperature of T1 (180°C). As baking temperature increased with increased loaf volume of bread.

#### 4.5.3. Specific Volume of Bread

The specific volume of bread is a good indicator of its gluten content; other ingredients like starch and fiber also play a role. The specific volume of the bread decreased as the substitution of both chickpea and orange-fleshed sweet potato flour increased. The highest value was 2.91 cm<sup>3</sup>/g of the control sample (100% wheat flour) and lowest value (1.58 cm<sup>3</sup>/g) was of B4 (20% chickpea and 30% OFSP).

The lower specific loaf volume of the breads could be responsible for their higher loaf weights. This is because of reduction in the amount of gluten content as addition of chickpea and OFSP flour occurs. Gluten in wheat flour acts as a binding agent, creating a network that traps gasses produced during fermentation, leading to bread expansion. When flours lack gluten, it results in reduced gas retention and a decrease in specific volume of the bread (Kure *et al.*, 2021). Baking temperature influenced specific volume of bread products. The highest specific volume, which was 2.34 cm<sup>3</sup>/g, was scored at 200 °C, and lowest value was 2.06 cm<sup>3</sup>/g at baking temperature of 180°C which was due to dough development and gas retention of the bread sample.

Table 4.5. Effect of blending ratio and baking temperature on loaf weight, loaf volume and specific volume of bread

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

#### 4.6. Interaction Effect of Blending Ratio and Baking Temperature on Loaf Weight, Loaf Volume and Specific Volume of Bread

##### 4.6.1. Loaf weight of bread

Loaf weight of bread samples had significant ( $p < 0.05$ ) differences due to treatments of blending ratio and baking temperature. The highest loaf weight (137.17 g) was recorded for B4T1 (20% chickpea, 30% OFSP and 50% wheat at 180°C) and the lowest values (119.86 g) was for B3T2 (20% chickpea, 20% OFSP and 60% wheat at 200°C). As the substitution of both chickpea-OFSP flour was increased and the loaf weight was increased.

##### 4.6.2. Loaf volume of bread

The loaf volume of bread showed significant ( $p < 0.05$ ) differences as displayed in Table 4.6, due to the interaction effect of baking temperature and blending ratio. The loaf volume values were highest for the control samples staying between 347.5 and 377.5 cm<sup>3</sup> and the values decreased as

the blending ratios of the wheat decreased the lowest being for breads with only 50% wheat. For any blending ratio of OFSP and chickpea flours the loaf volume of bread was highest for baking temperature of 200 °C. These results were in agreement with results reported by Chikpah *et al.* (2023), in which loaf volume increased as the baking temperature rose from 150 to 180°C. This is due to an increase in CO<sub>2</sub> gas expansion in the dough and to increase in the heating at the early stage of baking. However, at higher baking temperatures ( $\geq 180$  °C) the loaf volume reduced significantly. This was due to occurrence of starch gelatinization at higher baking temperatures that have the potential of reducing dough extensibility and causing rupture of gas cell membranes and finally decreasing the volume of the baked bread. A similar trend was observed in the current findings that the loaf volume values reduced at the 220°C. In this case the volume reduction happened at a temperature higher than that occurred in Chikpah *et al.* (2023) studies because of the blends of chickpea and OFSP flours.

#### 4.6.3. Specific volume of bread

The specific volume of bread varied significantly ( $p < 0.05$ ) as shown in Table 4.6 due to interaction of blending proportion and baking temperature, but some of the interaction did not show significant difference. The highest specific volume was 3.06 cm<sup>3</sup>/g scored for CT2 (control sample at 200°C) as compared to the 1.64 of B4T3 (20% chickpea and 30% OFSP substitution at 220°C). The study by Shittu *et al.* (2007) reported bread from cassava with substitution with wheat flour. The higher temperature and longer baking time increased both loaf volume and specific volume of bread due to rises in gas retention in loaf.

Table 4.6. The interaction effect of blending ratio and baking temperature on loaf weight, loaf volume and specific volume of bread

Code	Loaf weight	Loaf volume	Specific volume
CT1	124.76± 0.00 <sup>i</sup>	352.50± 2.50 <sup>b</sup>	2.83± 0.02 <sup>b</sup>
CT2	123.33± 0.00 <sup>k</sup>	377.50± 2.50 <sup>a</sup>	3.06± 0.02 <sup>a</sup>
CT3	121.76± 0.00 <sup>m</sup>	347.50± 2.50 <sup>c</sup>	2.85± 0.02 <sup>b</sup>
B1T1	127.49± 0.00 <sup>f</sup>	302.50± 2.50 <sup>f</sup>	2.37± 0.02 <sup>e</sup>
B1T2	122.75± 0.01 <sup>l</sup>	340.00± 0.00 <sup>d</sup>	2.77± 0.00 <sup>c</sup>
B1T3	120.12± 0.00 <sup>n</sup>	327.50± 2.50 <sup>e</sup>	2.73± 0.02 <sup>d</sup>
B2T1	131.73± 0.00 <sup>d</sup>	255.00± 5.00 <sup>g</sup>	1.94± 0.04 <sup>g</sup>
B2T2	126.24± 0.00 <sup>h</sup>	257.50± 2.50 <sup>g</sup>	2.04± 0.02 <sup>f</sup>
B2T3	124.13± 0.06 <sup>j</sup>	242.50± 2.50 <sup>j</sup>	1.95± 0.02 <sup>g</sup>
B3T1	136.18± 0.00 <sup>b</sup>	252.50± 2.50 <sup>h</sup>	1.85± 0.02 <sup>h</sup>
B3T2	119.86± 0.00 <sup>o</sup>	247.50± 2.50 <sup>i</sup>	2.06± 0.02 <sup>f</sup>
B3T3	133.78± 0.00 <sup>c</sup>	240.00± 0.00 <sup>j</sup>	1.79± 0.00 <sup>i</sup>
B4T1	137.17± 0.00 <sup>a</sup>	177.50± 2.50 <sup>m</sup>	1.31± 0.02 <sup>k</sup>
B4T2	131.13± 0.00 <sup>e</sup>	232.50± 2.50 <sup>k</sup>	1.77± 0.02 <sup>i</sup>
B4T3	126.57± 0.00 <sup>g</sup>	207.50± 2.50 <sup>l</sup>	1.64± 0.02 <sup>j</sup>
LSD	0.03	4.31	0.03

Values are means ± SD and values in the same column with different superscript letters are significantly different from each other ( $p < 0.05$ ).

#### 4.7. Main Effects of Factors, Blending Ratio and Baking Temperature, on Proximate Composition and Nutrient Content of chickpea-OFSP Bread

##### 4.7.1. Moisture content

The moisture content of bread substitute of wheat flour with chickpea and OFSP was influenced by both blending ratio and baking temperature as presented in Table 4.7. The control sample of the wheat flour bread had a moisture content of 2.84 and the composite flour breads exhibited significantly ( $p < 0.05$ ) higher values of 29.43, 31.43, 34.52 and 35.79%. The highest moisture content was (35.79%) scored for B4 (20% chickpea, 30% OFSP and 50% wheat). Based on these results the moisture content of bread product increased as both chickpea and OFSP flour proportion increased. This result was in agreement with the study by Malavi *et al.* (2022), who indicated that the moisture content of bread from wheat and OFSP puree increased as the ratio of OFSP flour increased. This is due to the fact that sweet potato starch has a high-water binding capacity and weak molecular forces between the starch granules, sweet potato bread has a high moisture content. Molecular surfaces are available for binding water during the gelatinization of starch which leads to a higher moisture content that is retained in baked bread. The baking temperature significantly

( $p < 0.05$ ) affected the moisture of bread products. As the baking temperature increased the moisture, the content of bread decreased. This may be due to the high evaporation of moisture at high baking temperature.

#### 4.7.2. Crude protein content of bread

Crude protein content result of bread is given in the same Table 4.7, showing the significant ( $P < 0.05$ ) effects of blending ratios and baking temperature. The highest crude protein content values were 14.59% of B4 (20% chickpea, 30% OFSP and 50% wheat) and whereas the lowest value was 10.85% recorded for control (100% wheat flour). As the ratio of chickpea flour increased with increased the protein content of bread. This is due to the fact that chickpea had higher crude protein content than wheat flour. The study by Sidhu *et al.* (2023) reported, bread from wheat blending with chickpea flour at proportions of (20, 30 and 40% chickpea flour ratio) when combined with wheat flour. The protein content of bread increased with the increased in the ratio of chickpea flour. Therefore, the addition of chickpea flour to bread will greatly improve the protein content in bread. The effect of baking temperature was significantly ( $P < 0.05$ ) high among all treatments. The protein content of the breads decreased from 13.86 to 11.33% as the baking temperature increased from 180 to 220°C. The study reported by Patel *et al.* (2020) showed reduction of total protein content of bread during at high baking temperature at above 200 °C, there is denaturation proteins of bread.

#### 4.7.3. Beta carotene content of bread

The beta carotene content of blended bread is displayed in Table 4.7 indicating significant ( $P < 0.05$ ) differences due to blending ratios and baking temperature. The control sample of 100% wheat flour had no beta carotene. As the ratio of OFSP flour blend increased it increased the beta carotene content of the bread. This is due to the fact that OFSP flour contains a better amount of provitamin or beta carotene content than wheat and chickpea flours.

The addition of OFSP flour improves the nutritional aspect and alleviates vitamin A deficiency. The highest value 8.04  $\mu\text{g/g}$  was recorded for B4 (20% chickpea, 30% OFSP and 50% wheat flour) and the rest of the values of the composite flour breads ranged from 7.29 to 7.39  $\mu\text{g/g}$  with no statistical difference among them. Baking temperature had a significant ( $p < 0.05$ ) impact on beta carotene content of bread. As baking temperature increased beta carotene content decreased.

Cooking, processing and baking have degrading effect on beta carotene content because carotenoids are highly sensitive to heat (Tiruneh *et al.*, 2021)

Table 4.7. 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 ( $\mu\text{g/g}$ )
C	28.84 $\pm$ 0.65 <sup>c</sup>	10.85 $\pm$ 0.39 <sup>c</sup>	0.85 $\pm$ 0.16 <sup>c</sup>	1.49 $\pm$ 0.00 <sup>d</sup>	0.93 $\pm$ 0.03 <sup>e</sup>	57.66 $\pm$ 0.91 <sup>a</sup>	281.64 $\pm$ 3.21 <sup>a</sup>	0.00 $\pm$ 0.00 <sup>c</sup>
B1	29.43 $\pm$ 0.67 <sup>d</sup>	11.22 $\pm$ 0.68 <sup>c</sup>	1.60 $\pm$ 0.18 <sup>b</sup>	1.54 $\pm$ 0.12 <sup>c</sup>	1.41 $\pm$ 0.0 <sup>d</sup>	56.98 $\pm$ 0.96 <sup>b</sup>	282.45 $\pm$ 3.11 <sup>a</sup>	7.36 $\pm$ 0.67 <sup>b</sup>
B2	31.43 $\pm$ 1.21 <sup>c</sup>	12.05 $\pm$ 1.46 <sup>b</sup>	1.69 $\pm$ 0.20 <sup>b</sup>	1.54 $\pm$ 0.12 <sup>c</sup>	1.88 $\pm$ 0.02 <sup>c</sup>	52.63 $\pm$ 1.80 <sup>c</sup>	269.07 $\pm$ 4.86 <sup>b</sup>	7.29 $\pm$ 0.60 <sup>b</sup>
B3	34.52 $\pm$ 1.06 <sup>b</sup>	14.29 $\pm$ 1.35 <sup>a</sup>	1.68 $\pm$ 0.53 <sup>b</sup>	1.59 $\pm$ 0.00 <sup>b</sup>	1.95 $\pm$ 0.0 <sup>b</sup>	49.64 $\pm$ 0.73 <sup>e</sup>	257.10 $\pm$ 6.21 <sup>d</sup>	7.39 $\pm$ 0.62 <sup>b</sup>
B4	35.79 $\pm$ 0.73 <sup>a</sup>	14.59 $\pm$ 2.05 <sup>a</sup>	2.05 $\pm$ 0.07 <sup>a</sup>	1.84 $\pm$ 0.00 <sup>a</sup>	2.06 $\pm$ 0.06 <sup>a</sup>	51.81 $\pm$ 1.76 <sup>d</sup>	267.04 $\pm$ 6.63 <sup>c</sup>	8.04 $\pm$ 1.32 <sup>a</sup>
LSD	0.39	0.38	0.10	0.04	0.03	0.39	1.03	0.42
Temp								
T1	32.90 $\pm$ 2.88 <sup>a</sup>	13.86 $\pm$ 2.31 <sup>a</sup>	1.45 $\pm$ 0.52 <sup>b</sup>	1.41 $\pm$ 0.42 <sup>a</sup>	1.65 $\pm$ 0.44 <sup>a</sup>	52.39 $\pm$ 3.33 <sup>c</sup>	266.05 $\pm$ 12.21 <sup>c</sup>	6.21 $\pm$ 3.31 <sup>a</sup>
T2	31.88 $\pm$ 2.81 <sup>b</sup>	12.61 $\pm$ 1.69 <sup>b</sup>	1.61 $\pm$ 0.51 <sup>a</sup>	1.44 $\pm$ 0.29 <sup>a</sup>	1.65 $\pm$ 0.45 <sup>a</sup>	53.73 $\pm$ 3.26 <sup>b</sup>	272.11 $\pm$ 8.43 <sup>b</sup>	6.00 $\pm$ 3.21 <sup>ab</sup>
T3	31.22 $\pm$ 2.96 <sup>c</sup>	11.33 $\pm$ 1.08 <sup>c</sup>	1.67 $\pm$ 0.40 <sup>a</sup>	1.44 $\pm$ 0.34 <sup>a</sup>	1.64 $\pm$ 0.43 <sup>a</sup>	55.11 $\pm$ 3.14 <sup>a</sup>	276.22 $\pm$ 9.42 <sup>a</sup>	5.83 $\pm$ 3.10 <sup>b</sup>
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  $\pm$  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

#### 4.7.4. Crude fat content of bread

The data of crude fat content of bread presented in Table 4.7 showed significant ( $p < 0.05$ ) differences due to blending ratio. The highest value (2.05%) was of the B4 bread (50% wheat, 20% and 30% OFSP flour). The fat content of breads of the other composite flours had no statistical differences ( $p > 0.05$ ) among them with values ranging from 1.60-1.69%, but are significantly higher than that of the control sample (100% wheat flour) which was the lowest of all (0.85%). The baking temperature had a significant ( $p < 0.05$ ) impact on the value of crude fat content of bread. The values were 1.45, 1.61 and 1.67% for baking temperatures of 180, 200 and 220°C. High baking temperature causes more fat to be lost during baking due to evaporation.

#### 4.7.5. Crude fiber content of bread

The data of the crude fiber content of breads are displayed in Table 4.7. Blending ratio had a significant ( $p < 0.05$ ) effect on the crude fiber content of bread products. The control sample had the lowest value of 1.49% crude fiber while the blended products had records of 1.54, 1.59 and 1.84% the highest of which was of B4 (50% wheat, 20% and 30% OFSP flour). As both chickpea and OFSP flour are increased the crude fiber content of bread increases and this can be explained by high fiber contents of the substituted chickpea and OFSP flour. On the other hand, baking temperature had no impact on the value of crude fiber content.

#### 4.7.6. Total ash content of bread

Blending ratio exhibited significant ( $p < 0.05$ ) difference on ash content of breads with chickpea and OFSP substitutes for wheat flour as shown in Table 4.7. The value of ash content ranged between 0.93-2.06 percent. The ash content of blended bread increased consistently with the addition of more chickpea and OFSP flours with significant ( $p < 0.05$ ) differences among the values. The highest value 2.06% was of B4 (20% chickpea, 30% OFSP and 50% wheat flour) and lowest value was 0.93% of the control (100% wheat flour). This happened because both chickpea and orange fleshed sweet potato flours had higher ash content than wheat flour as shown in Table 4.1. The baking temperature had no effect on the ash content of bread samples.

#### 4.7.7. Utilizable carbohydrate content of bread

Blending wheat with both chickpea and OFSP flour resulted in bread was significantly ( $p < 0.05$ ) lower carbohydrate content than the control sample (Table 12). The highest carbohydrate content was 57.66% of the control sample and the lowest is 49.64% for B3 (20% chickpea, 20% OFSP and 60% wheat).

This result was in line with the work of Amal (2015) who reported on carbohydrate content of bread from wheat with sweet potato flour. As the ratio of sweet potato flour increased the carbohydrate content of blended bread products decreased. In a similar study reported by Yaseen *et al.* (2009) in making bread from blends of wheat and okara flour, as the ratio of okara flour was raised the content of utilizable carbohydrate was reduced because okara had lower carbohydrate content than wheat flour. Baking temperature had a significant ( $p < 0.05$ ) effect on utilizable carbohydrate as shown in Table 12. The carbohydrate of the breads decreased as the baking temperature increased.

#### 4.7.8. Energy content of bread

Blending ratio exhibited significant ( $p < 0.05$ ) differences in energy content of the breads with the control (100% wheat) and those of B1 (80% wheat, 10% chickpea and 10% OFSP flour) having the highest values of 281.43 and 282.45 Kcal/100g with no statistical difference between them (Table 4.10). The next higher value was 269.07 Kcal/100g of sample B2 (70% wheat, 15% chickpea and 15% OFSP) whereas the lowest was 257.10 Kcal/100 g of sample B3 (60% wheat, 20% chickpea and 20% OFSP). Increase in blending ratio of chickpea and OFSP flour into the composite flour a decrease the energy content of bread follows. Baking temperature had a significant ( $p < 0.05$ ) effect on the energy content of composite bread. As baking temperature increased from 180-220°C the energy content of the bread increased.

### 4.8. Sensory Evaluation of Bread Products

#### 4.8.1. Main effect of blending ratio and baking temperature on sensory acceptability of bread

A seven-point hedonic scale was used to estimate the acceptability of bread in sensory attributes. The results of sensory evaluation such as color, texture, flavor and overall acceptability of bread were judged by panelists as shown in Table 4.8.

Blended bread of wheat, chickpea and OFSP flour proportions of (80% wheat, 10% chickpea and 10% OFSP), (70% wheat, 15% chickpea and 15% OFSP), (60% wheat, 20% chickpea and 20% OFSP) and 50% wheat, 20% chickpea and 30% OFSP flour) had significant ( $p < 0.05$ ) differences among them in color acceptability of bread. The highest value was 6.62 for control sample (100%

wheat flour) which is moderately liked (6) and lowest value was 2.77 for B4 (50% wheat, 20% chickpea and 30% OFSP flour) which is moderately disliked (2). Of the blended products the highest result was 6.19 for B2 (70% wheat, 15% chickpea and 15% OFSP flour). This showed both control and blending at (70% wheat, 15% chickpea and 15% OFSP) composite bread samples were more favored by panelists. Baking temperature had a significant ( $p < 0.05$ ) effect on sensory acceptability of color of bread samples. The highest score was 5.43 for T1 (180 °C) and lowest value was 4.91 at T3 (220 °C). The sensory panelists liked the color of the bread samples baked at temperatures of 180 and 200°C.

Regarding the acceptability of texture of bread were not significant ( $p < 0.05$ ) differences, due to blending ratio. The highest score was 6.39 for the control sample and lowest value was 2.62 for B4 sample bread. As the ratio of both chickpea and OFSP flour increased and the scores for texture decreased. Of the composite breads both B1 and B2 exhibited scores lower than the control but higher than breads of higher proportions of chickpea and OFSP. Baking temperature had no significant ( $p > 0.05$ ) effect on sensory acceptability of texture of bread.

The acceptability score for the flavor of bread showed differences due to blending ratio. The highest score (6.49) in a scale of 7 points was of the control sample followed by 5.53 and 5.70 of samples of B1 and B2 blends with no statistical difference ( $p > 0.05$ ) between them. Samples of B4 blends had the lowest score (2.44) with some level of disliking. Sensory panelists liked the flavor of bread samples with less chickpea and OFSP flour. Baking temperature had no significant ( $p > 0.05$ ) effect on flavor sensor acceptability of bread.

In overall acceptability of bread produced by blending both chickpea and OFSP flour with wheat flour the data showed significant were not ( $p < 0.05$ ) differences due to blending ratio. Apart from the control sample, the highest result was 5.90 for B2, which is moderately liked and lowest value was 2.58 for B4, which is moderately disliked. Panelists liked bread samples made from composite flours of about 10% chickpea and OFSP flour. The higher the blending ratios of the chickpea and OFSP flours the less the overall acceptability of the breads. Baking temperature had no significant ( $p < 0.05$ ) effect on almost all sensory acceptability of the breads.

Table 4.9. Effect of blending ratio and baking temperature on color acceptability of bread product (chickpea-OFSP)

Blending Ratio	Parameters			
	Color	Texture	Flavor	Overall Acceptability
C	6.62± 0.27 <sup>a</sup>	6.39± 0.36 <sup>a</sup>	6.49± 0.34 <sup>a</sup>	6.56± 0.31 <sup>a</sup>
B1	5.90± 0.32 <sup>b</sup>	5.63± 0.36 <sup>b</sup>	5.53± 0.25 <sup>b</sup>	5.74± 0.30 <sup>b</sup>
B2	6.19± 0.43 <sup>ab</sup>	5.78± 0.41 <sup>b</sup>	5.70± 0.38 <sup>b</sup>	5.90± 0.42 <sup>b</sup>
B3	4.64± 0.63 <sup>c</sup>	4.36± 0.71 <sup>c</sup>	4.23± 0.59 <sup>c</sup>	4.39± 0.63 <sup>c</sup>
B4	2.77± 1.12 <sup>d</sup>	2.62± 0.96 <sup>d</sup>	2.44± 0.93 <sup>d</sup>	2.58± 0.98 <sup>d</sup>
LSD	0.6116	0.6092	0.567	0.5896
Temp				
T1	5.43± 1.45 <sup>a</sup>	5.12± 1.37 <sup>a</sup>	4.91± 1.52 <sup>a</sup>	5.13± 1.45 <sup>a</sup>
T2	5.34± 1.46 <sup>ab</sup>	4.91± 1.44 <sup>a</sup>	5.00± 1.46 <sup>a</sup>	5.14± 1.49 <sup>a</sup>
T3	4.91± 1.73 <sup>b</sup>	4.83± 1.69 <sup>a</sup>	4.73± 1.68 <sup>a</sup>	4.83± 1.73 <sup>a</sup>
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 = 180°C, T2 = 200°C, T3 = 220°C, Temp = Baking temperature

#### 4.8.2. The interaction effect of blending ratio and baking temperature on sensory acceptability of chickpea-OFSP bread

The interaction between blending ratio and baking temperature showed significant ( $p > 0.05$ ) difference on color scores (Table 4.10). The highest values (5.83 to 6.37) belonged to samples with combinations of 100 and 80% wheat with baking temperatures of 180 and 200°C. The lowest score (1.97) was for a sample with a combination of B4T3. Texture wise interactions of nearly all combinations, except those with blends of B3 and B4 exhibited statistically highest values whereas combinations of B4T2 and B4T3 resulted in the least scores. Similar trends prevailed in both flavor and overall acceptability scores.

Table 4.10. The interaction effects of blending ratios and baking temperature on sensory quality of bread product

Code	Color	Texture	Flavor	Over all acceptability
CT1	6.80± 0.17 <sup>a</sup>	6.53± 0.21 <sup>a</sup>	6.73± 0.15 <sup>a</sup>	6.68± 0.20 <sup>a</sup>
CT2	6.70± 0.00 <sup>ab</sup>	6.27± 0.25 <sup>a</sup>	6.40± 0.26 <sup>ab</sup>	6.60± 0.10 <sup>a</sup>
CT3	6.37± 0.32 <sup>ab</sup>	6.37± 0.59 <sup>a</sup>	6.33± 0.47 <sup>ab</sup>	6.40± 0.53 <sup>ab</sup>
B1T1	5.83± 0.40 <sup>cab</sup>	5.50± 0.44 <sup>ab</sup>	5.30± 0.26 <sup>c</sup>	5.57± 0.40 <sup>cb</sup>
B1T2	6.13± 0.25 <sup>ab</sup>	5.53± 0.42 <sup>ab</sup>	5.70± 0.20 <sup>cb</sup>	5.87± 0.23 <sup>ab</sup>
B1T3	5.73± 0.21 <sup>cb</sup>	5.87± 0.15 <sup>a</sup>	5.60± 0.10 <sup>cb</sup>	5.80± 0.26 <sup>ab</sup>
B2T1	6.37± 0.60 <sup>ab</sup>	5.83± 0.49 <sup>a</sup>	5.60± 0.53 <sup>cb</sup>	5.87± 0.64 <sup>ab</sup>
B2T2	6.20± 0.26 <sup>ab</sup>	5.87± 0.47 <sup>a</sup>	5.87± 0.35 <sup>cab</sup>	6.05± 0.36 <sup>ab</sup>
B2T3	6.00± 0.44 <sup>ab</sup>	5.63± 0.38 <sup>ab</sup>	5.63± 0.35 <sup>cb</sup>	5.77± 0.34 <sup>ab</sup>
B3T1	4.83± 0.65 <sup>cd</sup>	4.60± 0.82 <sup>cb</sup>	4.30± 0.62 <sup>d</sup>	4.56± 0.70 <sup>cd</sup>
B3T2	4.63± 0.76 <sup>d</sup>	4.17± 0.90 <sup>cd</sup>	4.30± 0.79 <sup>d</sup>	4.34± 0.80 <sup>d</sup>
B3T3	4.47± 0.71 <sup>d</sup>	4.30± 0.60 <sup>c</sup>	4.10± 0.56 <sup>d</sup>	4.26± 0.62 <sup>d</sup>
B4T1	3.30± 1.42 <sup>e</sup>	3.13± 1.27 <sup>ed</sup>	2.63± 1.10 <sup>e</sup>	2.98± 1.25 <sup>f</sup>
B4T2	3.03± 0.86 <sup>e</sup>	2.73± 0.74 <sup>ef</sup>	2.73± 0.90 <sup>e</sup>	2.83± 0.79 <sup>ef</sup>
B4T3	1.97± 0.87 <sup>f</sup>	2.00± 0.75 <sup>f</sup>	1.97± 0.95 <sup>e</sup>	1.93± 0.81 <sup>f</sup>
LSD	1.06	1.06	0.98	1.02

**Note:** Values are means ± SD and values in the same column with different superscript letters are significantly different from each other (P < 0.05).

## 5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### 5.1. Summary

The present study was on utilization of both chickpea and orange fleshed sweet potato blended with wheat flour to improve the nutrient content of bread products. Chickpea is one of the most important annual crops, a versatile crop that grows extensively throughout Ethiopia. They are high in protein, vitamins (riboflavin, folate, thiamin, and niacin), minerals (calcium, phosphorus, iron, magnesium, and potassium). In addition, the OFSP is a good source of the basic nutrients and different vitamins, and contains high beta-carotene. The use of both chickpea and OFSP flour blended with wheat flour on the bread production could significantly reduce imported wheat flour and improve the nutritional content as well as increase utilization of both chickpea and OFSP in various aspects.

Bread prepared from chickpea and OFSP blended with wheat flour at different ratios of B1(80% wheat, 10% chickpea and 10% OFSP), B2(70% wheat, 15% chickpea and 15% OFSP), B3(60% wheat, 20% chickpea and 20% OFSP flour), B4(50% wheat, 20% chickpea and 30% OFSP flour) and 100% wheat flour taken as control sample and baked at different baking temperature of 180, 200 and 220°C were considered. Then, the developed product was tested by using a factorial experiment of 4x3 design excluding control samples.

The proximate composition of flour and bread samples such as moisture, protein, fiber, ash, carbohydrate, energy and beta carotene content were determined. The chemical composition of wheat flour including moisture 10.67%, protein 9.67%, fiber 0.56%, ash 0.65%, CHO 77.82%, energy 355.49 Kcal/100 and fat 0.61% were determined. The proximate composition of chickpea flour includes protein 20.86%, moisture 7.47%, fat 5.16%, fiber 5.82%, ash 2.73%, CHO 60.96% and energy 373.77 Kcal/100. In similar, chemical composition of OFSP flour were: moisture 6.77%, protein 3.06%, fat 0.09%, fiber 4.02%, ash 2.81%, CHO 82.25%, energy 350.91 Kcal/100 and beta carotene content 14µg/g. The functional property, pasting property, color and particle size of wheat, chickpea and OFSP flours showed significant ( $p < 0.05$ ) difference among them.

Blending ratio was found to have a prominent influence on the product properties. As the blending ratio of both chickpea and OFSP flour increased, moisture content, protein, fat, fiber, ash, beta

carotene content and loaf weight of bread were significantly increased. But, carbohydrate, energy, loaf volume and specific volume of developed product were significantly decreased.

Baking temperature had an effect on moisture content, protein, carbohydrate contentment, energy, loaf weight, loaf volume and specific volume of bread. But, had no effect on fat, fiber, ash content and sensory acceptability of improved bread products. The specific weight of bread varied significantly among all products. The addition of both chickpea-OFSP flour ratios affects the loaf volume of all bread products significantly ( $p < 0.05$ ). The specific volume of all bread products varied significantly at ( $p < 0.05$ ). As the blending ratio of both chickpea and OFSP flour increased the loaf volume and specific volume of bread decreased. This is due to the gluten content of wheat flour being reduced due the addition of non-gluten content of chickpea and OFSP flours.

The loaf weight of bread showed a significant ( $p < 0.05$ ) difference on interaction between two factors among all products including control sample. The loaf weight ranges from 137.17-119.86 g where the highest and lowest loaf weight of bread at proportion of 137.17 g B4T1 @ 180 °C (50% wheat, 20% chickpea and 30% OFSP) and 119.86 g B3T2 @ 200°C (60% wheat, 20% chickpea and 20% OFSP) of flour proportions. The highest value for loaf volume score was 377.50 cm<sup>3</sup> OF 100% wheat flour @ 200°C and lowest value was 177.50 cm<sup>3</sup> at B4T1 (50% wheat, 20% chickpea and 30% OFSP) flour recorded. The specific volume ranges between 3.06-1.31 cm<sup>3</sup>/g the highest CT2 (100% wheat) @ 200°C and lowest at B4T1 (50% wheat, 20% chickpea and 30% OFSP) flour @ 180°C. There is no significant ( $p < 0.05$ ) difference in the interaction effect of both loaf volume and specific volume of bread products. The addition of both chickpea and OFSP flour to wheat flour reduced the color acceptability score of bread products. The color score ranged from 2.77-6.62, with significant ( $p < 0.05$ ) difference among them. The baking temperature had an effect on color acceptability of chickpea-OFSP bread. There was a significant difference in texture characteristics of bread due to the blending ratio excluding baking temperature. The highest score was 6.39 for control and lowest value 2.62 for B4 bread sample. There was a significant difference ( $p < 0.05$ ) for both flavor and overall acceptability of bread due to blending ratio. Blending ratio had no effect on flavor and overall acceptability of bread products.

## 5.2. Conclusions

The study demonstrated that a composite of wheat, chickpea, and OFSP flour can provide bread of acceptable quality. The bread produced from a combination of orange-fleshed sweet potatoes and chickpeas was rich in beta carotene and proteins. This can be used to address deficiencies in vitamin A and anemia. The bread sample produced has increased moisture, protein, fat, ash, fiber, beta carotene of bread products, which are all desirable for good health and wellbeing. All the chickpea- OFSP- wheat flour ratios were tested for bread quality. Among all bread samples with 70: 15:15 wheat, chickpea and OFSP composite flour bread baked at 200 °C was selected based on nutritional quality and sensory acceptability than the remaining developed bread products. Composite bread proportion with 20 and 30% both chickpea- OFSP flour to wheat resulted in increased nutrition but as baking temperature increased, the bread samples were cracked or broken and lower acceptability in terms of sensory attributes than control sample. Generally, good quality bread can be produced by blending of chickpea and OFSP with wheat flour at ratio of 70% wheat, 15% chickpea and 15% OFSP flour.

## 5.3. Recommendations

The following are recommended for future studies.

- Determination of physical and chemical properties composite flour.
- Optimum operating condition to get the best blending ratio and baking temperature for bread production.
- Study the effect of different chickpea-orange flesh sweet potato varieties on nutritional quality and sensory acceptability of bread.
- Study the anti-nutritional and mineral content of chickpea and OFSP flour

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## 7. APPENDICES

### Appendix 7.1. Sensory evaluation sheet

Panelist Name \_\_\_\_\_ Date: \_\_\_\_\_ Age: \_\_\_\_\_ Sex: \_\_\_\_\_

Please read the description and definition part of the attribute of terms before ranking the products.

Description for ranking for seven hedonic scale

1. Dislike very much
2. Dislike moderately
3. Dislike slightly
4. Neither like nor dislike
5. Like slightly
6. Like moderately
7. Like very much

Table 1. Sensory analysis format for bread

No	Sample code	color	Texture	Flavor	Over all acceptability
1					
2					
3					
4					
5					
6					
7					

## Appendix 7.2. ANOVA Tables

Table 15. ANOVA of moisture content of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr > F
Model	2	25.96421400	12.98210700	82.74	<.0001
Error	6	0.94139600	0.15689933		
Corrected Total	8	26.90561000			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 16. ANOVA of protein content of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr > F
Model	2	484.1197737	242.0598869	45.23	0.0002
Error	6	32.1096297	5.3516049	516.2294034	
Corrected Total	8				

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 17. ANOVA of fat content of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr > F
Model	2	46.79256867	23.3962843	39933.0	<.0001
Error	6	0.00351533	0.00058589		
Corrected Total	8	46.79608400			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$ .

*Table 18. ANOVA of fiber content of wheat, chickpea and OFSP flour*

Source	DF	SS	MS	F Value	Pr > F
Model	2	42.73812956	21.36906478	1278.57	<.0001
Error	6	0.10027933	0.01671322		
Corrected Total	8	42.83840889			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

*Table 19. ANOVA of ash content of flour*

Source	DF	SS	MS	F Value	Pr > F
Model	2	8.93929867	4.46964933	1492.09	<.0001
Error	6	0.01797333	0.00299556		
Corrected Total	8	8.95727200			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

*Table 20. ANOVA of COOH content of wheat, chickpea and OFSP flour*

Source	DF	SS	MS	F Value	Pr > F
Model	2	1061.656261	530.828131	88.97	<.0001
Error	6	35.798842	5.966474		
Corrected Total	8	1097.455104			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 21. ANOVA of Energy content of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr > F
Model	2	376.3962976	188.198148	58.82	0.0001
Error	6	19.1980993	3.1996832		
Corrected Total	8	395.5943969			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 22. ANOVA of beta carotene content of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr>F
Model	2	419.7463380	209.8731690	517.24	<.0001
Error	6	2.4345140	0.4057523		
Corrected Total	8	422.1808520			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 23. ANOVA of WAC of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr > F
Model	2	2.91372467	1.45686233	8799.84	<.0001
Error	6	0.00099333	0.00016556		
Corrected Total	8	2.91471800			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 24. ANOVA of OAC of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr > F
Model	2	0.06794822	0.03397411	4.00	0.0788
Error	6	0.05097600	0.00849600		
Corrected Total	8	0.11892422			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 25. ANOVA of SP of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr > F
Model	2	20.48286489	10.24143244	155.49	<.0001
Error	6	0.39520400	0.06586733		
Corrected Total	8	20.87806889			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 26. ANOVA of WSI of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr > F
Model	2	623.2174376	311.608718	3242.62	<.0001
			8		
Error	6	0.5765873	0.0960979		
Corrected Total	8	623.7940249			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 27. ANOVA of Dispersibility of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr > F
Model	2	852.0555556	426.027777	1179.77	<.0001
Error	6	2.1666667	0.3611111		
Corrected Total	8	854.2222222			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 28. ANOVA of Bulk density of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr > F
Model	2	0.05727800	0.02863900	8591.70	<.0001
Error	6	0.00002000	0.00000333		
Corrected Total	8	0.05729800			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 29. ANOVA of True density of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr > F
Model	2	0.01503022	0.00751511	154.07	<.0001
Error	6	0.00029267	0.00004878		
Corrected Total	8	0.01532289			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 30. ANOVA of AR of wheat, chickpea and OFSP flour

Source	DF	SS	MS	F Value	Pr > F
Model	2	33.59524067	16.7976203	24.50	0.0013
Error	6	4.11446733	0.68574456		
Corrected Total	8	37.70970800			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 31. ANOVA of particle size distribution 2mm

Source	DF	SS	MS	F Value	Pr > F
Model	2	0.50992267	0.25496133	861.68	<.0001
Error	6	0.00177533	0.00029589		
Corrected Total	8	0.51169800			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 32. ANOVA of particle size distribution 1mm

Source	DF	SS	MS	F Value	Pr > F
Model	2	2.99587356	1.49793678	853.47	<.0001
Error	6	0.01053067	0.00175511		
Corrected Total	8	3.00640422			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 33. ANOVA of particle size distribution 0.5 mm

Source	DF	SS	MS	F Value	Pr > F
Model	2	14769.07932	7384.53966	8870.61	<.0001
Error	6	4.99483	0.83247		
Corrected Total	8	14774.07415			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 34. ANOVA of particle size distribution 0.25 mm

Source	DF	SS	MS	F Value	Pr > F
Model	2	3448.443280	1724.22164	59.24	0.0001
Error	6	174.632538	29.105423		
Corrected Total	8	3623.075818			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 35. ANOVA of particle size distribution 0.1 mm

Source	DF	SS	MS	F Value	Pr > F
Model	2	12445.23222	6222.61611	139.49	<.0001
Error	6	267.65530	44.60922		
Corrected Total	8	12712.88752			

Table 36. ANOVA of particle size distribution 0.075 mm

Source	DF	SS	MS	F Value	Pr > F
Model	2	213.4969696	106.7484848	136.08	<.0001
Error	6	4.7066320	0.7844387		
Corrected Total	8	218.2036016			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 37. ANOVA of particle size distribution &lt; 0.075 mm

Source	DF	SS	MS	F Value	Pr > F
Model	2	18161.71969	9080.85984	3232.47	<.0001
Error	6	16.85556	2.80926		
Corrected Total	8	18178.57525			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 38. ANOVA of pasting temperature (PT)

Source	DF	SS	MS	F Value	Pr > F
Model	2	249.5449556	124.772477	1134.98	<.0001
Error	6	0.6596000	0.1099333		
Corrected Total	8	250.2045556			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

Table 39. ANOVA of Peak viscosity (PV)

Source	DF	SS	MS	F Value	Pr > F
Model	2	2473606.222	1236803.11	1236803	<.0001
Error	6	6.000	1.000		
Corrected Total	8	2473612.222			

Table 40. ANOVA of Trough viscosity (TV)

Source	DF	SS	MS	F Value	Pr > F
Model	2	24132.72222	12066.3611	33414.5	<.0001
Error	6	2.16667	0.36111		
Corrected Total	8	24134.88889			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

*Table 41. ANOVA of Breakdown viscosity (BV)*

Source	DF	SS	MS	F Value	Pr > F
Model	2	2194747.602	1097373.80	4913614	<.0001
Error	6	1.340	0.223		
Corrected Total	8	2194748.942			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

*Table 42. ANOVA of Setback viscosity (SV)*

Source	DF	SS	MS	F Value	Pr > F
Model	2	2793782.336	1396891.16	4910946	<.0001
Error	6	1.707	0.284		
Corrected Total	8	2793784.042			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

*Table 43. ANOVA of Pasting Time*

Source	DF	SS	MS	F Value	Pr > F
Model	2	2.59980000	1.29990000	1146.97	<.0001
Error	6	0.00680000	0.00113333		
Corrected Total	8	2.60660000			

*Table 44.* ANOVA of Final viscosity

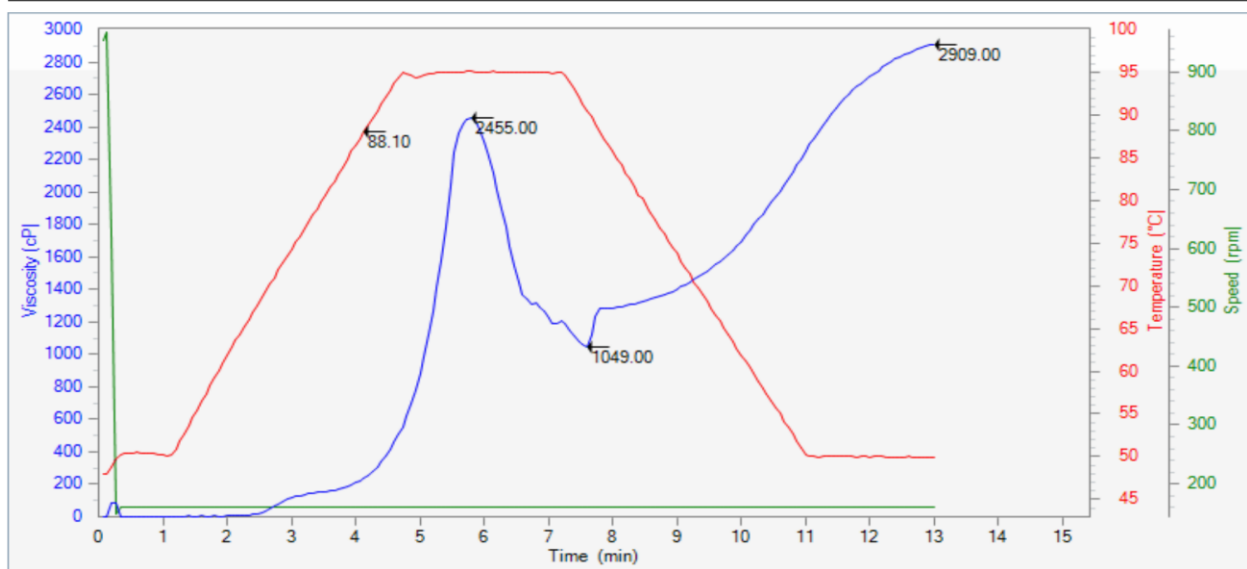
Source	DF	SS	MS	F Value	Pr > F
Model	2	3156207.029	1578103.51	1.353E7	<.0001
Error	6	0.700	0.117		
Corrected Total	8	3156207.729			

**Where:** DF= degree of freedom, SS= sum of square, MS= mean square and a significant was at  $p < 0.05$

### Appendix 7.3. Figures

**Test Results**

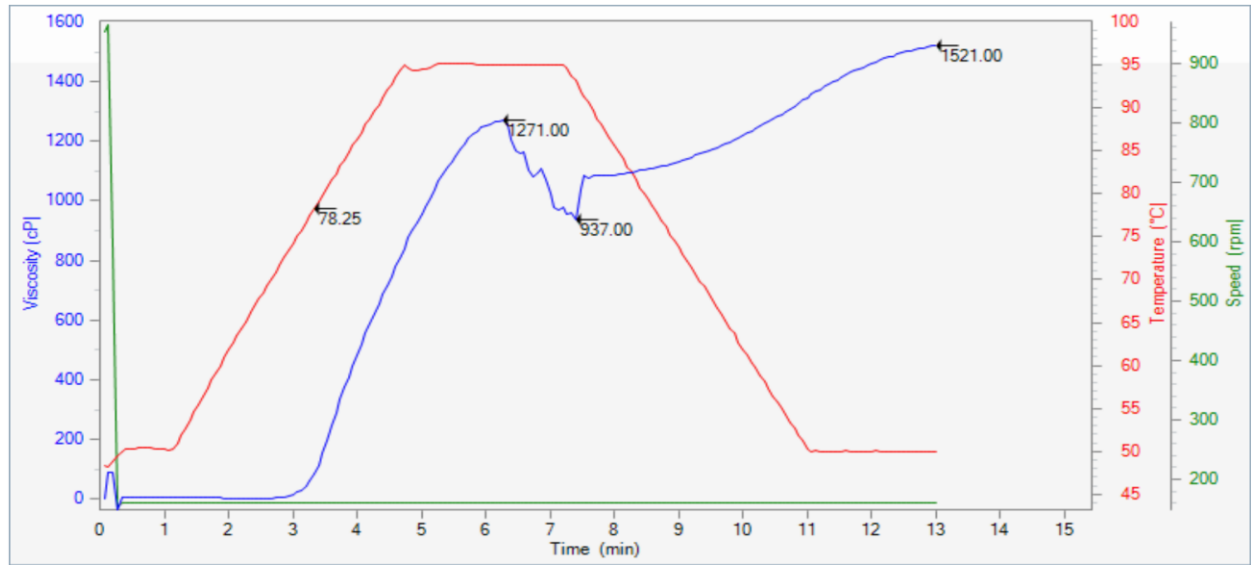
Test	Peak 1	Trough 1	Breakdown	Final Visc	Setback	Pasting Temp
03 wheat1	2455.00	1049.00	1406.00	2909.00	1860.00	88.10
Test	Peak Time					
03 wheat1	5.80					



Appendix Figure 1: Pasting property of wheat flour

**Test Results**

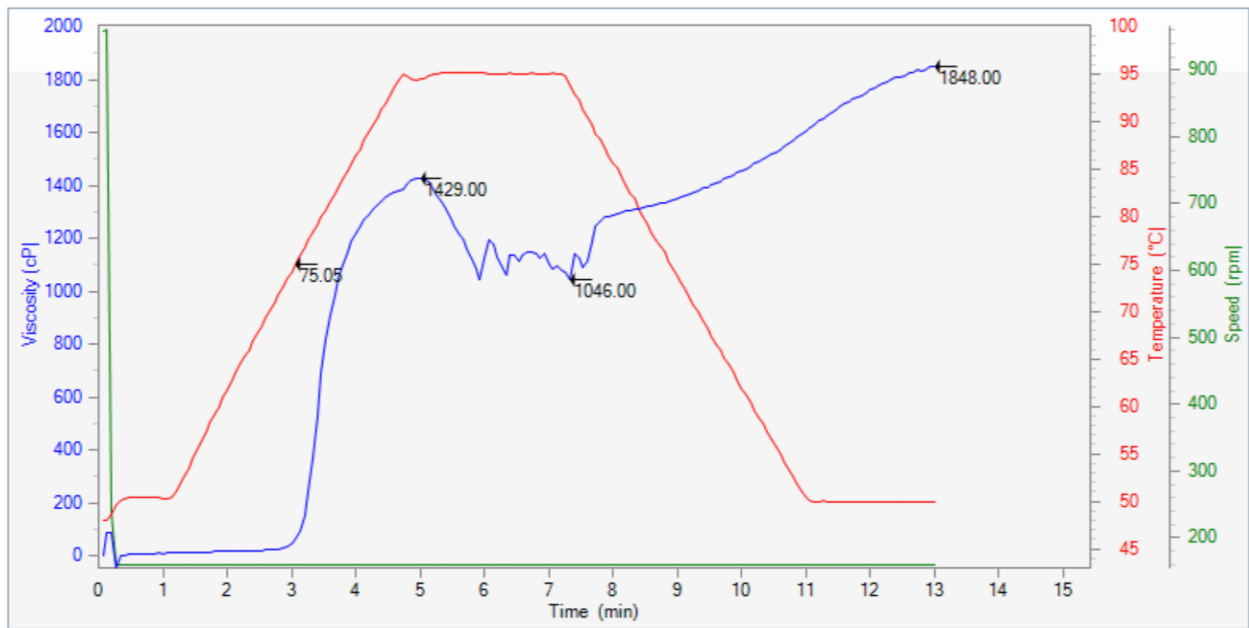
Test	Peak 1	Trough 1	Breakdown	Final Visc	Setback	Pasting Temp
04 cheak pea1	1271.00	937.00	334.00	1521.00	584.00	78.25
Test	Peak Time					
04 cheak pea1	6.27					



Appendix Figure 2: Pasting property of chickpea flour

**Test Results**

Test	Peak 1	Trough 1	Breakdown	Final Visc	Setback	Pasting Temp
05 orange potato	1429.00	1046.00	383.00	1848.00	802.00	75.05
Test	Peak Time					
05 orange potato	5.00					



Appendix Figure 3: Pasting property of OFSP flour

Appendix 7.4. Photos



OFSP roots



slicing of OFSP roots



Sliced OFSP root



inside oven drying of sliced OFSP



*Dried OFSP slice root*



*raw chickpea (koka variety)*



*Control 100% wheat flour bread*



*BI@180 °C*



*BI@200 °C*



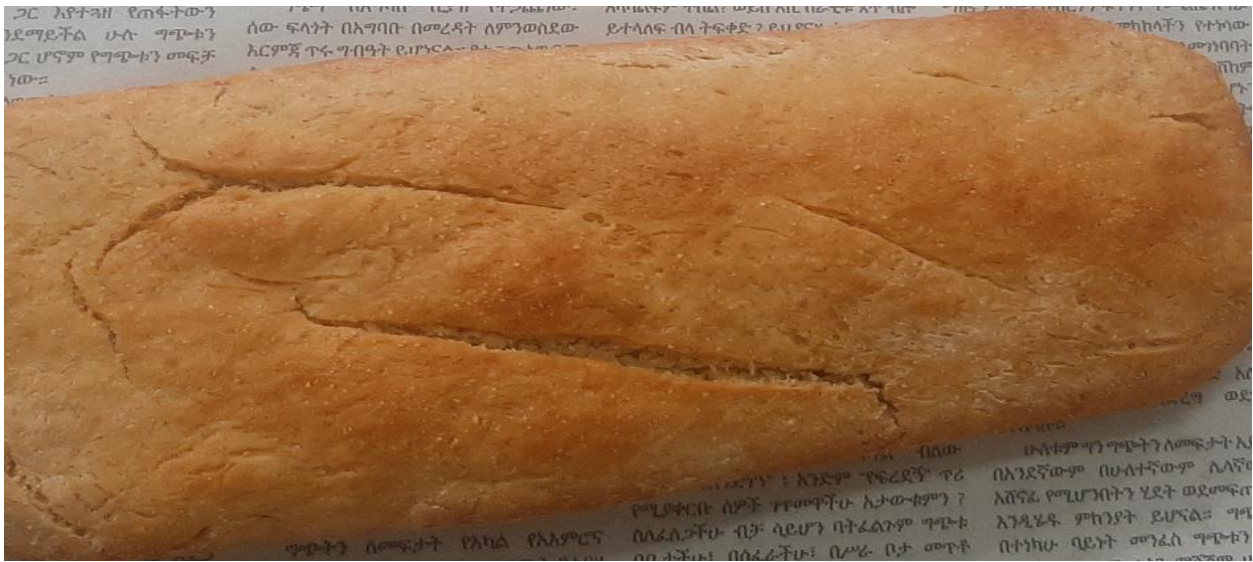
*B2@ 180 °C*



*B2@ 200 °C*



*B3@ 180°C*



*B3@ 200 °C*



*B3@ 220 °C*