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Research article

Effects of blending ratios and baking temperature on physicochemical properties and sensory acceptability of biscuits prepared from pumpkin, common bean, and wheat composite flour

Abebe Desalegn Melese [a,*], Ebisa Olika Keyata [b]

[a] Department of Chemical Engineering, Faculty of Technology, Shambu Campus, Wollega University, Shambu Town, Ethiopia
[b] Department of Food and Nutritional Sciences, Faculty of Agriculture, Shambu Campus, Wollega University, Shambu Town, Ethiopia

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ABSTRACT

The utilization of vegetables with supplementation of cereals and pulses plays a vital role in improving protein-energy malnutrition and micronutrient deficiency. Therefore, the study aimed to develop biscuits from pumpkin, common bean, and wheat composite flour with better physicochemical properties and sensory acceptability. All quality parameters were evaluated by using an official standard procedure. The results showed a significant ($p < 0.05$) difference among products. The addition of pumpkin and common bean flour to composite biscuits significantly ($p < 0.05$) increased the protein (9.44–16.16%), fat (17.03–21.42%), ash (1.72–2.08%), and crude fibre (1.37–2.06%) contents. In addition, the biscuit's lightness decreased as the incorporation of pumpkin and common bean increased. However, the redness and yellowness of the sample increased. Sensory evaluation scores indicated that biscuits supplemented with 10% pumpkin, 15% common bean, and 75% wheat composite flour baked at 200 °C were more preferred than other formulated products. Therefore, substituting pumpkin powder with wheat-common bean flour significantly improved the nutritional content of the biscuit with desirable sensory acceptability. The findings also showed that the developed products are essential in improving dietary diversity and food insecurity among low-income families.

1. Introduction

In developing countries, particularly Ethiopia, progress in development and urbanization coupled with the population's fast rise has led to a highly increased interest in consuming wheat-based food products such as bread and biscuits (Reardon et al., 2021). However, the country's production capacity and the needs for wheat consumption contradict each other (Tadesse et al., 2018). To alleviate this gap, many researchers have tried to replace whole wheat with desirable composite flour produced from locally grown and available food and vegetables (Abdulwahab et al., 2018; Goranova et al., 2020).

Composite flour is a mixture of flour obtained from tubers, cereals, pulses, oil seeds, vegetables, and fruits to develop bakery, pastry and complementary food products (Hasmadi et al., 2020). Composite flour is important in a retaining hard currency that used for import wheat from abroad, promoting indigenous and underutilized crops, and providing nutritional enrichment of food products (Akinola et al., 2020). Mostly, in the bakery industry, the main ingredient adopted was wheat flour due to its appropriate and unique quality of gluten content that will impart to the dough the desired degree of plasticity, elasticity, and viscosity and a good source of calories and other nutrients, but its protein and mineral content were lower than in legumes (Dewettinck et al., 2008).

The bakery's products, particularly bread, cakes, and biscuits, were some of the most popular food products widely consumed and preferred among the community (Kumar, 2017). Among the indicated products, biscuit is one of the ready-to-eat snacks that were easily affordable, convenient, and consumed among all age groups in several countries (Adebowale et al., 2012). It was also highly nutritious, containing high protein, minerals, and energy-providing foods. Biscuit production was not only limited to the household level it was mainly produced at a large scale of production and distribution due to extended shelf life (Ayensu et al., 2019). Davidson's (2018) findings indicated that the biscuits' good eating quality characteristics make them more conducive to protein fortification and nutritional improvements, especially applicable in children's feeding programmes, for the elderly, and low-income groups.

* Corresponding author.
E-mail address: suabebe25@gmail.com (A.D. Melese).

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In order to overcome the problem of protein-energy malnutrition, the supplementation of wheat flour with legumes, especially common bean (Phaseolus vulgaris L.), is vital for supplementation of protein contents (Sarikamiş et al., 2009). Common bean contains 22.73% protein, 6.22% crude fibre, 1.42% fat, 61.75% carbohydrate, and 4.09% ash (Ketema et al., 2019). Despite their high nutritional value, common beans are a good source of antioxidants, vitamins, minerals, and bioactive compounds that are important for the prevention and regulation of chronic diseases such as obesity, diabetes, cancer, and coronary heart disease (Messina, 2014).

Besides common bean and wheat flour, supplementation of pumpkin (Cucurbita sp.) flour during product formulation can improve the nutritional and healthy benefits of the products (Mitiku and Berake, 2021). Pumpkin has high β-carotene content which is the major source of vitamin A and provides the yellow or orange colour (Mala et al., 2018), β-carotene is an important for preventing eye disorders, cancer, and skin diseases (Gul et al., 2015). Despite this potential, the consumption of pumpkins in Ethiopia was taken as a sign of poverty.

Traditionally, pumpkin pulp was processed and eaten in the form of boiled sauces, soup, and in baking industry as the main ingredient (Mala et al., 2018). The flavours, sweetness, acceptable dietary fibre, deep yellow and orange colour properties of pumpkin flour provide attractive characteristics for bakery products (Kulaitienė et al., 2014).

In Ethiopia, Yilma & Admassu (2019) developed biscuits from composite flour of cowpea and wheat flour, While Kumsa and Haile (2020) prepared them from wheat, moringa, and potato. However, there was limited information on the effects of blending ratios and baking temperature of biscuits formulated from wheat, common bean, and pumpkin to improve physicochemical properties and sensory acceptability. Given this, the study attempted to develop improved quality biscuits in terms of proximate composition, functional, physical, and sensory properties from a neglected vegetable (pumpkin flesh flour) with wheat flour and common bean supplementation.

2. Materials and methods

2.1. Experimental materials

The raw materials used for the formulation of biscuits were collected from different places. For example, wheat Liban variety, was collected from the Gitillo research center. The common bean of the Wajo variety was collected from the Bako agricultural research center, and fresh pumpkin was procured from local producers at the Shambu market. Biscuit ingredients such as sugar, salt, butter, margarine, baking powder, vanilla extract, and eggs were purchased from a supermarket in Shambu, Ethiopia.

2.2. Experimental design

General full factorial design (3^2**)** with three replications was used to determine the effects of two factors (three blending ratios and three baking temperatures) with a comparison of control samples, as indicated below. The composite flour formulation was conducted based on the recommendations indicated by Anitha et al. (2020) and Mitiku and Bereka (2021).

Blending Ratios	Baking Temperature		
	T_1	T_2	T_3
B_1	B_1T_1	B_1T_2	B_1T_3
B_2	B_2T_1	B_2T_2	B_2T_3
B_3	B_3T_1	B_3T_2	B_3T_3
Control (C)	CT_1	CT_2	CT_3

Where: - **B1** is Blending ratio 1 (5% pumpkin flour, 10% common bean and 85% wheat flour), **B2** is Blending ratio 2 (10% pumpkin flour, 15% common bean and 75% wheat flour), **B3** is Blending ratio 3 (15% pumpkin flour, 20% common bean flour and 65% wheat flour), **C** is Control (100 % wheat flour). **T1** = 180 °C, **T2** = 200 °C, and **T3** = 220 °C.

2.3. Sample preparation

2.3.1. Preparation of wheat flour

The wheat flour was cleaned to remove dirt, stones and extraneous matter. The cleaned grain husk was removed and dried under a cabinet oven (Memmert, model 765, Germany) drier at 60 °C for 6 h before being milled (RRH-200, Zhejiang, China) to powder and sieved through a 500 μm sieve size to obtain fine homogenized flour. The flour was sealed in a polyethylene bag and stored at room temperature (Peter-Ikechukwu et al., 2020).

2.3.2. Preparation of common bean flour

Common beans were manually cleaned by handpicking the chaff and stones. The cleaned beans were washed with water to remove the adhering dirt. The common beans were soaked in water for about 10 min and pounded gently in a mortar to dehull, then dried under a cabinet oven at 60 °C for 6 h s and milled (RRH-200, Zhejiang, China) to the flour with aperture size of a 500 μm (Ketema et al., 2019).

2.3.3. Preparing pumpkin flour

The pumpkin flour was prepared following the method outlined by Kulaitienė et al. (2014). Ripe pumpkin fruits were washed initially with tap water, then distilled water, and dried carefully. After cleaning, the pumpkin fruits were peeled and cut with sharp knives, fibres and seeds were removed, the pulp was cut into pieces of 2–3 mm thick, and finally, each sample was dried at 60 °C in the laboratory cabinet drying oven (Memmert, model 765, Germany). After this process, the samples would be ground and sifted using a sieve to obtain the fine powder and kept in sealed containers at room temperature until the required tests were performed.

2.4. Biscuit preparation

The biscuit was prepared using the AACC (2000) method 10.50. The flours (200 g), butter (33 g) and salt (0.2 g) were mixed manually for 5 min to get creamy dough. The baking powder (2.0 g), fortified milk (15 mL), whole eggs (1.25 mL), sugar (1.25 g), and vanilla (1.0 g) were mixed thoroughly. 65 mL of water was gradually added using continuous mixing until a good texture and slightly firm dough was obtained. The dough was kneaded on a clean flat surface for 4 min. It would manually have rolled into sheets and cut into shapes using the stamp cutting method. The cut dough pieces were transferred into fluid fat grease pans and baked in an oven at temperatures of 180, 200 and 220 °C for 10 min, cooled and packed for further analysis.

2.5. Proximate composition analysis of biscuits

The moisture content of the samples was determined by the convective oven drying method (130 °C for 1 h) by taking about 3 g sample (dried sample powder) as described in the AOAC (2000) method 925.10. Crude protein content was determined by the micro- Kjeldahl method by taking about 1.0 g of the sample as described in AOAC (2000) Method, 920.87. The crude fat content was determined by taking about 1.5 g of the sample by the Soxhlet extraction method using petroleum ether as a solvent (AOAC, 2000, method, 920.39). The crude fibre content was determined following AOAC (2000) method 962.09 after sequential digestion with 1.25% H_2SO_4 and 28% KOH, screened through 75 microns, drying and ignition in a muffle furnace (Sx2-4-10, Zhejiang, China) to subtract ash from the crude fibre. The total ash content was determined gravimetrically after carbonization of about 2.0 g sample on a blue flame of Bunsen burner followed ignition of the sample at 550 °C until ashing complete (AOAC, 2000, method 923.03). The difference determined total carbohydrate content (TCC) (Onwuka, 2005).

2.6. Determination of functional properties of composite flours

2.6.1. Bulk density

Bulk density (BD) was determined according to the method stated by Gupta et al. (2015). About one gram of the powder sample was placed in 10 mL test tube by constantly tapping until there was no further change in Volume. The final bulk volume was recorded. Bulk density was then calculated as the weight of sample powder (g) divided by its final Volume (mL) using the following Eq. (1): -

$$Bulk\ density\ (g/ml) = \frac{weight\ of\ flour\ used}{Volume\ of\ the\ flour\ after\ tapping} \tag{1}$$

2.6.1.1. Water absorption capacity. Water Absorption Capacity (WAC) was determined by using the method of Adebowale et al. (2012). The 1-g sample was weighed and mixed for 30 s at room temperature with 10 mL distilled water. The flour suspension was allowed to stand for 30 min before centrifugation. The clear water was drained by keeping the micro centrifuge tube at an angle. The tube was weighed again, and the difference in weights obtained the weight of the supernatant before and after draining. Water-holding capacity was expressed as a gram of water held per gram of flour sample (Equation 2).

$$\text{Water absorption capacity (g/g)} = \frac{w3 - w2}{w1} \tag{2}$$

Where: - W3 is the weight of empty tube + the sample after centrifuged and decanted, W2 is the weight of empty tube + Sample before centrifuging, and W1 is the weight of a sample.

2.6.2. Oil absorption capacity

Oil absorption capacity (OAC) was determined using the method of Achy et al. (2017). About one gram of the sample (W0) was weighed into pre-weighed 15 mL centrifuge tubes and thoroughly mixed with 10 mL (V1) of refined pure groundnut oil using a vortex mixer. Samples are allowed to stand for 30 min. The sample-oil mixture was centrifuged with a centrifugal machine (Centurion Scientific Model: 1020D). Immediately after centrifugation, the supernatant was carefully poured into a 10 mL graduated cylinder, and the Volume was recorded (V2). Oil absorption capacity was calculated as follows (Equation 3): -

$$Oil\ Absorption\ capacity (ml/g) = \frac{\mathrm{V1 - V2}}{\mathrm{W0}} \tag{3}$$

Where: - V1 is the Volume of flour + Volume of oil, V2 is the Volume of centrifuged flour, and W0 is the weight of the sample.

2.6.3. Swelling power

Swelling power determinations were carried out in the temperature range of 60–90 °C using the method of Leach et al. (1959). About one gram of flour sample was accurately weighed and transferred into a clear dried test tube and weighed. About 15 mL of distilled water was added and mixed gently at low speed for 5 min. The slurry was heated in a thermostated water bath (HHS4 Laboratory Thermostatic Digital Water Bath, USA) at 75 °C for 30 min by mixing the suspension intermittently. The slurry was stirred gently during heating to prevent lumps forming in the flour. The test tube was cooled with its content rapidly to 20 °C. Then the cool paste was centrifuged, and immediately after centrifuging, the supernatant was decanted into a pre-weighed evaporating can and dried at 100 °C to constant weight approximately for 4 h. The weight of the sediment was taken and recorded as or swollen mass.

$$\text{Swelling power (\%)} = \frac{Weight\ of\ \text{Sediment}}{Sample\ weight - Weight\ of\ soluble} \tag{4}$$

2.6.4. Foaming capacity

The samples' foaming capacity (FC) was evaluated according to the method reported by Chandra et al. (2015). One gram of the sample was added to 50 mL of distilled water at 30 ± 2 °C in a 100-mL graduated cylinder. The suspension was mixed and shaken for 5 min to make the foam. The Volume of foam at 30 s after whipping was expressed as foam capacity using the following Eq. (5).

$$FC(\%) = \frac{\text{Volume of foam AW} - \text{Volume of foam BW}}{\text{Volume of foam BW}} \tag{5}$$

Where, FC is the foam capacity, AW is the after whipping, and BW is the before whipping.

2.6.5. Dispersibility

Dispersibility was determined using the method described by AACC (2000). Ten grams of the flour sample were weighed into a 100 mL measuring cylinder, and water was added to reach a volume of 100 mL. The set-up was stirred vigorously and allowed to stand for 3 h. The Volume of settled particles was recorded and subtracted from 100. The differences are reported as percentage dispersibility (Equation 6).

$$\text{\% Dispersibility} = 100 \text{ - Volume of settled particle} \tag{6}$$

2.7. Physical properties of biscuits

2.7.1. Analysis of surface colour

The colour values of the biscuits were measured in three different zones of the crust using a digital spectrophotometer Mini Scan EZ (Hunter Lab, USA), which was provided with the software. A chromameter was calibrated with the standard black and white colour. The results reported are averages of three measurements in each sample using CIELAB L*, a* and b* values (Palatnik et al., 2015). The whiteness index (WI) for each sample was calculated using the following Eq. (8) (Zhu et al., 2009).

$$\Delta E = ((L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2)^{½} \tag{7}$$

Where: L0 = 100, a0 = 0 and b0 = 0

$$WI = 100 - [(100 - L^*)^2 + a^{*2} + b^{*2}]^{½} \tag{8}$$

2.7.2. Spread ratio

Diameter and thickness were measured with a ruler at three different places in each biscuit, and the average was calculated for each. The averages of 6 biscuits were recorded for each batch. In order to determine the flour quality, the spread ratio (SR) was calculated using the following Eq. (9) (Chauhan et al., 2015).

$$Spread\ ratio = \frac{Diameter\ of\ Biscuits}{Height\ of\ Biscuits} \tag{9}$$

2.7.3. Specific volume

The biscuits' specific Volume (SV) was determined by the seed displacement method 2 h after baking (AACC, 2000). The specific Volume was calculated by dividing the Volume of the biscuits by their weight (Equation 10);

$$SV_{biscuit} = V_{biscuit} / W_{biscuit} \tag{10}$$

2.7.4. Textural profile analysis

The breaking force required of the biscuits was determined by a three-point bending test performed on a texture analyzer (TA.XT. plus 100C; Stable Micro Systems, Surrey, England) as designated by Morales-Polanco et al. (2017). Pre-test speed, test speed, post-test speed and distance were 1.0 mm s^{-1}, 2.0 mm s^{-1}, 10.0 mm s^{-1} and 6.0 mm, respectively. In this test, two beams at an identified distance support the product. A third beam was brought down to the product at a point equidistant from both support beams. With a blade (70 mm wide and 3 mm thick), a downward movement of the top beam was then exerted until the product broke. A texture analyzer with the 50 N load cells was used to measure the force needed for biscuits hardness analysis in compression mode. The maximum force required to break a single biscuit was recorded, and the average value of 6 biscuits for each batch was reported.

2.8. Sensory evaluation

The sensory evaluations of the prepared biscuits were conducted by using 30 semi trained panelists from Wollega University Food science and Nutrition staff and students. Before the test session, orientation was given to the panelists on the procedure of sensory evaluation. Then, coded products were given in a random order to the panelists for evaluation of sensory attributes such as color, taste, aroma, crispiness and overall acceptability were evaluated using a seven-point hedonic scale rated from 1 (extremely dislike) to 7 (extremely like) (Lawless and Heymann, 1999).

2.9. Statically analysis

The generated data were analyzed using the SAS version 9.1 software package (SAS Institute Inc., Cary, NC). Significant differences were determined at a probability level of 5%. Fisher's protected least significant difference (LSD) was used for mean comparison tests to identify significant differences among means. The results were expressed as mean ± standard deviation.

2.10. Ethical approval

The study was approved by the ethical review boards of the Faculty of Technology, Wollega University. All procedures involving human participants were under the ethical standards of the 1964 Helsinki declaration and its later amendments. Written informed consent was obtained from all study panellists.

3. Results and discussion

3.1. Functional properties of composite flour

The functional properties of formulated composite flours and their major components are presented in Table 1. Bulk density is an important parameter used to determine the development of different food products (Bello and Ekeh, 2014). The bulk density of composite flour investigated in this study was decreased from 0.84 to 0.60 g/mL with a decrease in the proportion of wheat flours and an increase in common bean and pumpkin flours in the blend (Table 1). The result was similar to Mitiku and Bereka (2021) who reported that increasing the pumpkin flour substitution to wheat flour, could reduce the bulk density of samples from 0.61 to 0.51 g/mL. The low bulk density values of composite flour were important for producing infant food products and saving packaging materials due to the massive number of particles that can stay together (Akinjide et al., 2017).

Table 1 depicts the water absorption capacity values of wheat, common bean, pumpkin and their composite flours. Common bean and pumpkin replacements in wheat flour could significantly ($p < 0.05$) decrease WAC from 2.15 -1.88% in composite flours. The decrease in WAC during supplementation of the high amount of common bean may be due to the rise in protein and reduction of carbohydrate contents in the composite flour. The findings agreed with the result reported by Ohizua et al. (2017). The WAC of control samples was similar to the findings of Melese et al. (2021) (wheat powder, 1.84 g/g), Alves et al. (2019) (common bean flour, 154.88–188.87%) and Mitiku and Bereka (2021) (pumpkin, 0.81 g/g). The high water absorption capacity (WAC) may be used to produce bakery products such as bread, biscuits, etc (Bello and Ekeh, 2014; Eriksson et al., 2014).

Oil absorption capacity (OAC) determines the capability of food material to absorb oil for the development of biscuits. The OAC content in the formulation increased from 1.09 to 3.29% with an increase in common bean and pumpkin flour ratios and decreased with a rise in wheat flour in the blend (Table 1). The increment of OAC content in composite flour was due to the high protein contents of the common bean and pumpkin flour investigated in this study. This might be due to the presence of protein exposing more non-polar amino acids to the fat and enhancing hydrophobicity; as a result of this, flour absorbs more oil (Oluwamukomi et al., 2011). The high OAC could improve the texture and provide suitable flavour and mouthfeel to food products (Appiah et al., 2011).

Swelling power measures, the granules' absorption index after heating and determines the capacity of starch molecules to hold water via hydrogen bonding, which is related to amino acid and starch concentration (Iwe et al., 2016). The swelling power of wheat flour was significantly ($p < 0.05$) influenced by blending ratios, as indicated in Table 1. Supplementation of pumpkin and common bean to wheat flour-based formulation decreases the swelling power of composite flour from 10.28 to 7.43%. The variation in swelling power of the flour may be due to the amylose to amylopectin ratio and amylose/amylopectin properties in terms of molecular distribution, degree and length of branching, and conformation (Hoover, 2001). The high swelling power of wheat flours was mainly due to higher amylopectin contents (Kusumayanti et al., 2015).

Foaming capacity is important to determine the ability of the flour to foam, which depends on the presence of the flexible protein molecules (Asif et al., 2014). The values for foaming capacity increased from 7.18 to 9.24%, with increments of common bean ratios in the formulations. The

Table 1. Functional properties of composite flour.

Treatments	Bulk Density (g/mL)	Water Absorption Capacity (g/g)	Oil Absorption Capacity (mL/g)	Swelling Power (%)	Foaming Capacity (%)	Dispersibility (%)
Wheat	0.84 ± 0.05^{a}	2.33 ± 0.09^{a}	1.09 ± 0.11^{d}	10.28 ± 0.35^{a}	5.99 ± 0.30^{e}	75.78 ± 0.05^{a}
Common bean	0.71 ± 0.03^{b}	1.81 ± 0.33^{b}	1.87 ± 0.49^{b}	9.46 ± 0.41^{b}	16.64 ± 1.07^{a}	73.91 ± 0.27^{bc}
Pumpkin	0.60 ± 0.04^{c}	1.38 ± 0.28^{c}	3.29 ± 0.63^{a}	7.43 ± 0.37^{c}	11.48 ± 0.79^{b}	73.05 ± 0.65^{c}
B1	0.83 ± 0.02^{a}	2.15 ± 0.06^{a}	1.33 ± 0.10^{cd}	10.06 ± 0.05^{ab}	7.18 ± 0.34^{d}	74.51 ± 1.04^{b}
B2	0.79 ± 0.01^{a}	1.91 ± 0.09^{b}	1.76 ± 0.10^{bc}	9.92 ± 0.78^{ab}	8.43 ± 0.10^{c}	73.52 ± 0.37^{c}
B3	0.72 ± 0.07^{b}	1.88 ± 0.10^{b}	2.05 ± 0.06^{b}	9.49 ± 0.41^{b}	9.24 ± 0.34^{c}	73.25 ± 0.45^{c}
LSD	0.07	0.38	0.45	0.73	1.06	0.90
CV	5.45	10.93	11.04	4.30	5.94	2.67

Results are means ± SD and values in the similar column with different superscript letters are significantly ($p < 0.05$) different from each other.
Note; - B_1 = 5% pumpkin flour, 10% common bean and 85% wheat flour B_2 = 10% pumpkin flour, 15% common bean and 75% wheat flour, B_3 = 15% pumpkin flour, 20% common bean and 65% wheat flour. LSD = Least significance difference, CV = Coefficient variation, SD = standard deviation.

high foaming capacity of common bean flour was due to high protein content that may cause a lowering of the surface tension at the water-air interface (Kaushal et al., 2012). The found results are comparable with the findings of Ohizua et al. (2017) (2.01%–12.88%), indicating that foaming capacity increased as the substitution of Pigeon pea flour increased in unripe banana and sweet potato composite flour.

The dispersibility of the composite flour and major ingredients are indicated in Table 1. The result showed a significant ($p < 0.05$) variation in the dispersibility of the flour during supplementation of wheat flour with common bean and pumpkin flour. The results depicted that as the proportion ratios of wheat flour increased in the formulation, the dispersibility value increased from 73.25 to 74.51%. The high dispersibility value indicates that they will reconstitute easily to fine consistent dough or pudding during mixing (Ohizua et al., 2017). Similarly, results were reported by Ekunseitan et al. (2017) as the substitution of mushroom flour increased the dispersibility of wheat, mushroom and cassava flour decreased from 72.00% to 62.17%.

3.2. Proximate composition of wheat, common bean and pumpkin composite flour biscuit

Moisture content of food is an indicative of the dry matter in that food. The low moisture content values ensure long shelf life stability in dried products. In this study, the moisture content of biscuits formulated from wheat, common bean and pumpkin ranged from 3.84 to 6.28%, as indicated in Table 2. The moisture value recorded in this study was with the safe moisture content that has no adverse impact on the shelf life of the developed products (Adebowale et al., 2012). The control biscuits showed a significantly ($p < 0.05$) lowest moisture value than the composite biscuits sample. Besides this, the high-temperature baked biscuits sample rated low moisture value. This may be because a high baking temperature reduces sample moisture content. Correspondingly, replacing wheat flour with legumes increases moisture content from 4.05 to 5.92% (Chinma et al., 2011), and pumpkin flour increases bread's moisture content from 11.07 to 13.19 (Mitiku and Bereka, 2021).

Protein-rich products are vital to overcoming protein-energy malnutrition (Mathewson et al., 2021). The protein content observed in this study was significantly ($p < 0.05$) affected by the blending ratio, baking temperature and their interaction, as indicated in Table 2. According to this result, control biscuit samples had lower protein values than composite samples. Incorporating legumes in bakery products could enrich the protein content and improve the amino acid balance of composite products (Abdulwahab et al., 2018; Bojňanská et al., 2021). The results were in line with the findings of Mala et al. (2018), who described that the protein content increased with an increase in the ratio of pumpkin flour. However, increasing the baking temperature could denature the protein content of the samples (Desalegn and Kibr, 2021). The findings showed that supplementation of common bean and pumpkin flour enhances the product with an improved protein content that reduces protein deficiency in the community (Buzigi et al., 2020).

Ash indicates the total mineral content of food (Bassey et al., 2013). The ash content of the biscuit samples ranged from 1.72% to 2.08% (Table 2). The values observed in this study depicted that the total ash content of the composite biscuits increased with an increased substitution level of pumpkin and common bean flour. A similar result was reported by Imran et al. (2013); the incorporation of pumpkin flour in composite bread increases the ash content of products.

The blending ratio and baking temperature significantly ($p < 0.05$) increase the fibre content in the developed biscuits compared to the control samples as indicated in Table 2. The fibre contents ranged from 1.37 to 2.00%. The increments might be due to gelatinization and retrogradation of the starch during heat treatment. Lewu et al. (2010) showed that the baking temperature could also modify the native starch into non-degradable polysaccharides that raise the fibre content. The findings suggested that improving food fibre in the developed composite products plays a significant role in preventing constipation, hemorrhoids, and diverticular disease by softening and increasing the stool size (Aune et al., 2020). Egbuonu and Nzewi (2016) also confirmed that food fibre is also essential to minimize blood cholesterol and glucose, aids digestion, and protects the body against colon cancer, diabetes, and cardiovascular illnesses. The fibre content (1.37–2.06%) recorded in this study was similar to the findings of Mitiku and Bereka (2021) (1.18–1.54%) reported for composite bread produced from wheat, soybean and pumpkin flour.

Fats are the highest caloric content compared to protein and carbohydrates (Mathewson et al., 2021). The fat content in the formulation was increased from 17.71 to 21.42% with an increase in common bean and pumpkin flour ratios and decreased due to baking temperature from 220 to 180 °C (Table 2). The result also indicated significant improvements in fat contents in the developed composite biscuit compared to the control samples. Similar trends were reported by Mitiku and Bereka (2021); the fat content (16.31–18.74%) increased as the pumpkin and soybean substitution levels increased during the preparation of composite bread. The increases in fat content were due to the high-fat content of common bean flour (0.84%–2.86%) (Ketema et al., 2019) and pumpkin flour (3.60%) (Saeleaw and Schleining, 2011) than wheat flour (0.9–1.1) (Reddy, 2004).

The composite biscuit samples were significantly ($p < 0.05$) lower in the total carbohydrate than the control sample. This could be due to the

Table 2. Proximate composition of biscuit samples.

Treatments	Moisture (%)	Protein (%)	Ash (%)	Fiber (%)	Fat (%)	Carbohydrate (%)
CT_1	4.54 ± 0.51^{cd}	9.44 ± 0.83^{e}	1.72 ± 0.02^{f}	1.37 ± 0.06^{e}	17.03 ± 0.72^{f}	67.25 ± 1.01^{a}
CT_2	4.70 ± 0.11^{bcd}	10.26 ± 0.27^{e}	1.77 ± 0.05^{ef}	1.37 ± 0.02^{e}	17.64 ± 0.28^{ef}	66.47 ± 0.66^{a}
CT_3	3.84 ± 0.39^{d}	9.65 ± 0.68^{e}	1.85 ± 0.03^{cde}	1.56 ± 0.13^{de}	17.62 ± 0.96^{f}	66.17 ± 1.09^{a}
B_1T_1	5.24 ± 0.77^{bc}	13.26 ± 0.30^{cd}	1.95 ± 0.02^{b}	1.60 ± 0.13^{d}	19.25 ± 0.40^{cd}	60.28 ± 1.40^{c}
B_1T_2	4.39 ± 0.21^{cd}	12.48 ± 0.37^{d}	1.82 ± 0.01^{de}	1.63 ± 0.11^{d}	18.82 ± 0.90^{de}	62.48 ± 0.75^{b}
B_1T_3	4.41 ± 0.67^{cd}	12.59 ± 1.04^{d}	1.87 ± 0.04^{bcde}	1.72 ± 0.04^{cd}	17.71 ± 0.61^{ef}	63.40 ± 1.91^{b}
B_2T_1	4.77 ± 0.43^{bcd}	16.16 ± 1.09^{a}	1.85 ± 0.03^{cde}	1.95 ± 0.07^{ab}	20.72 ± 0.66^{ab}	56.49 ± 0.70^{ef}
B_2T_2	5.06 ± 0.31^{bc}	14.37 ± 1.03^{bc}	1.86 ± 0.04^{bcde}	2.00 ± 0.10^{ab}	20.40 ± 0.78^{abc}	58.30 ± 2.07^{cde}
B_2T_3	5.60 ± 0.11^{ab}	13.53 ± 0.89^{cd}	1.93 ± 0.07^{bc}	1.95 ± 0.15^{ab}	20.79 ± 0.95^{ab}	58.14 ± 1.11^{de}
B_3T_1	6.28 ± 0.67^{a}	15.89 ± 0.43^{a}	1.89 ± 0.06^{bcd}	1.83 ± 0.02^{bc}	21.42 ± 0.48^{a}	54.51 ± 0.67^{f}
B_3T_2	4.97 ± 0.77^{bc}	14.96 ± 0.82^{ab}	1.95 ± 0.02^{b}	1.92 ± 0.01^{abc}	21.15 ± 0.62^{a}	56.95 ± 1.45^{e}
B_3T_3	4.90 ± 0.79^{bc}	13.30 ± 0.46^{cd}	2.08 ± 0.13^{a}	2.06 ± 0.06^{a}	19.64 ± 0.54^{bcd}	59.07 ± 0.69^{cd}
LSD	0.95	1.26	0.09	0.19	1.19	2.02
CV	4.07	5.73	3.05	6.68	3.64	1.96

Results are means ± SD and values in the similar column with different superscript letters are significantly ($p < 0.05$) different from each other.
Note; - B_1 = 5% pumpkin flour, 10% common bean and 85% wheat flour B_2 = 10% pumpkin flour, 15% common bean and 75% wheat flour, B_3 = 15% pumpkin flour, 20% common bean and 65% wheat flour. LSD = Least significance difference, CV = Coefficient variation, SD = standard deviation.

Table 3. Color values of biscuit samples.

Treat ments	L*	a*	b*	ΔE	W
CT_1	68.27 ± 0.18^{a}	12.31 ± 1.26^{g}	24.18 ± 0.43^{f}	42.34 ± 0.47^{f}	71.39 ± 0.51^{a}
CT_2	64.60 ± 2.18^{b}	12.38 ± 0.84^{fg}	25.56 ± 0.32^{e}	45.41 ± 1.55^{e}	70.97 ± 0.71^{ab}
CT_3	60.36 ± 1.15^{cd}	15.24 ± 2.24^{bcd}	26.78 ± 0.66^{e}	50.25 ± 0.51^{d}	68.48 ± 0.72^{cd}
B_1T_1	64.46 ± 1.71^{b}	13.39 ± 1.22^{defg}	26.66 ± 0.72^{e}	46.42 ± 1.42^{e}	69.55 ± 0.15^{bc}
B_1T_2	62.41 ± 2.17^{bc}	15.86 ± 0.62^{bc}	28.68 ± 0.68^{d}	49.89 ± 1.24^{d}	66.65 ± 0.85^{ef}
B_1T_3	61.37 ± 1.94^{cd}	15.85 ± 1.95^{bc}	30.12 ± 1.26^{bcd}	51.53 ± 1.59^{cd}	65.34 ± 0.26^{fg}
B_2T_1	61.01 ± 0.63^{cd}	14.75 ± 0.86^{bcde}	28.68 ± 0.84^{d}	50.60 ± 0.96^{d}	67.14 ± 0.81^{de}
B_2T_2	58.75 ± 0.31^{def}	16.11 ± 0.48^{bc}	29.47 ± 0.91^{cd}	53.19 ± 0.53^{bc}	65.79 ± 0.56^{ef}
B_2T_3	58.90 ± 0.40^{de}	16.65 ± 1.05^{b}	31.25 ± 2.38^{b}	52.27 ± 1.91^{c}	64.00 ± 2.48^{g}
B_3T_1	56.21 ± 3.12^{ef}	13.13 ± 0.61^{efg}	29.41 ± 1.07^{cd}	54.36 ± 1.01^{b}	67.11 ± 1.08^{de}
B_3T_2	57.13 ± 1.63^{ef}	14.40 ± 1.31^{cdef}	30.52 ± 0.96^{bc}	54.58 ± 1.46^{b}	65.60 ± 1.22^{f}
B_3T_3	56.12 ± 1.08^{f}	19.01 ± 0.91^{a}	33.82 ± 0.42^{a}	58.61 ± 2.16^{a}	60.63 ± 0.43^{h}
LSD	1.63	2.02	1.67	2.29	1.44
CV	2.72	8.28	3.59	2.64	3.56

Results are means ± SD and values in the similar column with different superscript letters are significantly ($p < 0.05$) different from each other.
Note; - B_1 = 5% pumpkin flour, 10% common bean and 85% wheat flour B_2 = 10% pumpkin flour, 15% common bean and 75% wheat flour, B_3 = 15% pumpkin flour, 20% common bean and 65% wheat flour. LSD = Least significance difference, CV = Coefficient variation, SD = standard deviation.

low carbohydrate content in the pumpkin and common bean flour. The results obtained in this study were comparable to the findings of Mala et al. (2018) and George et al. (2020), who reported that replacement of pumpkin in composite flour reduces the carbohydrate content. Similarly, legumes incorporation can also reduce the carbohydrate content of the composite products (Oluwamukomi et al., 2011; Idowu, 2014).

3.3. Physical properties of developed biscuit

3.3.1. Color values

Colour is an essential physical characteristic that enhances the product to be a good quality and acceptable behind consumers. The colour values of biscuits such as L*, a*, b*, ΔE and whiteness index are indicated in Table 3. The L* value (5 6.12 to 68.27) recorded in this study was similar to values reported by Melese et al. (2021) (62.51–65.06). The lightness value was decreased as the incorporation of pumpkin, and common bean flour was increased. Mala et al. (2018) also confirmed that L* values were decreased when the proportion ratio of pumpkin flour increased in wheat flour. Besides this, the L* value of the biscuit significantly ($p < 0.05$) decreased as the baking temperature increased. The lightness colour changes may be due to a higher degree of Millard reaction, which is the interaction between a protein with sugar and caramelization, which occur when carbohydrates are exposed to high temperatures (Quintas et al., 2007).

The a* value indicates the red/green value of the sample, which ranged from 12.31 to 19.01 (Table 3). According to this study, baking temperature exhibited a kind of domination over blending ratio. Among the sample similarly incorporated with pumpkin and common bean flour, the biscuit baked at high temperature enhances the highest redness value.

The b* value represents the samples' yellow (a positive value) or blue (negative value) colour. In this work, the composite biscuits had significantly ($p < 0.05$) higher b* values than the control samples. The increase in the yellowness of biscuits was attributed to the high content of the pumpkin flour's enzymatic activity and beta-carotene pigment (Uscanga et al., 2019). This study was in line with the findings of See et al. (2007), who stated that the redness and yellowness increased as pumpkin flour was incorporated into wheat-based composite flour. In addition, the baking temperatures of biscuits could also significantly ($p < 0.05$) increase the yellowness value of samples. The findings highlighted that the entire biscuit samples had positive b* values, showing a strong predominance of the yellow colouration over the blue colour.

The degree of colour difference (ΔE) (42.34–58.61) value of the biscuit was significantly ($p < 0.05$) affected by the blending ratio and baking temperature (Table 3). The results indicated that the control sample and low-temperature baked products had low colour differences value. The sample's whiteness index (WI) shows the degree of whiteness that specifies the extent of discolouration during the drying process (Hsu et al., 2003). The WI of biscuits ranged from 60.63-to 71.39, as shown in Table 3. The control samples had the highest whiteness index value compared to composite biscuit samples, and the low-temperature baked product was observed with a high whiteness index value.

3.4. Physical properties of biscuits

The blending ratio and baking temperature have a significant ($p < 0.05$) effect on the spread ratio, specific volume and hardness of biscuits, as indicated in Table 4. The spread ratio of biscuits is an actual physical property with a value ranging from 6.26 to 9.62. According to this study, the control sample exhibited a significantly ($p < 0.05$) lower spread ratio compared to composite biscuits. The result found in this study was comparable with the findings of Abdulwahab et al. (2018). They reported

Table 4. Physical properties of biscuit flour.

Treatments	Spread Ratio	Specific Volume (cm^3/g)	Hardness (N)
CT1	6.26 ± 0.16^{h}	2.70 ± 0.21^{a}	10.68 ± 1.27^{bcd}
CT2	6.50 ± 0.21^{g}	2.25 ± 0.04^{b}	11.39 ± 1.01^{bc}
CT3	6.66 ± 0.60^{g}	1.94 ± 0.07^{def}	13.25 ± 0.31^{a}
B1T1	7.22 ± 0.16^{f}	2.15 ± 0.11^{bc}	10.08 ± 0.86^{d}
B1T2	7.47 ± 0.20^{e}	2.02 ± 0.80^{cd}	10.18 ± 0.21^{d}
B1T3	7.51 ± 1.06^{e}	1.94 ± 1.09^{def}	11.76 ± 1.11^{b}
B2T1	8.11 ± 0.96^{d}	1.97 ± 0.01^{cde}	9.66 ± 1.27^{de}
B2T2	8.21 ± 1.03^{d}	1.88 ± 0.16^{defg}	9.95 ± 0.79^{de}
B2T3	8.56 ± 0.06^{c}	1.79 ± 0.11^{fgh}	9.91 ± 0.54^{de}
B3T1	8.92 ± 0.25^{b}	1.80 ± 0.08^{efgh}	8.90 ± 0.71^{e}
B3T2	9.49 ± 1.16^{a}	1.72 ± 0.05^{gh}	10.59 ± 1.21^{cd}
B3T3	9.62 ± 0.46^{a}	1.63 ± 0.08^{h}	10.06 ± 0.43^{d}
LCD	0.21	0.18	1.12
CV	1.64	5.45	6.31

Results are means ± SD and values in the similar column with different superscript letters are significantly ($p < 0.05$) different from each other.
Note; - B_1 = 5% pumpkin flour, 10% common bean and 85% wheat flour B_2 = 10% pumpkin flour, 15% common bean and 75% wheat flour, B_3 = 15% pumpkin flour, 20% common bean and 65% wheat flour. LSD = Least significance difference, CV = Coefficient variation, SD = standard deviation.

Table 5. Sensory properties of biscuits.

Trt	Colour	Taste	Aroma	Crispness	Over all acceptability
CT1	5.30 ± 0.83^{bcde}	5.70 ± 0.74^{a}	6.03 ± 0.76^{a}	5.53 ± 0.97^{bcde}	5.56 ± 0.99^{cde}
CT2	6.30 ± 0.53^{a}	5.46 ± 0.77^{abc}	5.63 ± 0.88^{abc}	5.43 ± 1.01^{cdef}	6.26 ± 0.65^{a}
CT3	4.96 ± 1.03^{defg}	5.16 ± 0.91^{bcd}	5.13 ± 0.81^{def}	4.10 ± 1.18^{h}	5.30 ± 0.95^{def}
B1T1	5.46 ± 1.13^{bc}	5.66 ± 0.75^{a}	5.83 ± 1.01^{ab}	5.80 ± 0.71^{abc}	5.21 ± 1.06^{ef}
B1T2	5.70 ± 0.71^{b}	5.43 ± 0.81^{abc}	5.30 ± 0.98^{cde}	4.93 ± 1.03f^{g}	6.16 ± 0.69^{ab}
B1T3	4.90 ± 0.95^{efg}	4.90 ± 1.15^{de}	4.93 ± 1.17^{ef}	4.80 ± 1.18^{g}	5.20 ± 0.69 ^{ef}
B2T1	5.43 ± 0.77^{bcd}	5.23 ± 1.16^{abcd}	5.80 ± 0.81^{ab}	6.00 ± 0.78^{ab}	5.73 ± 0.54^{c}
B2T2	6.46 ± 0.68^{a}	5.63 ± 1.09^{ab}	4.93 ± 0.94^{ef}	6.23 ± 0.98^{a}	6.56 ± 0.73^{a}
B2T3	5.10 ± 1.09^{cdef}	5.00 ± 1.01^{cde}	4.70 ± 0.98^{f}	5.16 ± 0.67^{defg}	5.46 ± 0.87^{cde}
B3T1	5.33 ± 1.11^{bcde}	4.80 ± 0.84^{de}	5.56 ± 0.93^{bcd}	5.63 ± 0.81 ^{bcd}	5.20 ± 0.55^{cd}
B3T2	4.76 ± 1.13^{fg}	4.60 ± 0.81^{e}	5.06 ± 1.01^{ef}	5.33 ± 1.44^{cdef}	5.83 ± 1.03^{bc}
B3T3	4.50 ± 1.10^{g}	4.53 ± 1.30^{e}	4.70 ± 0.98^{f}	5.06 ± 1.23 ^{efg}	5.01 ± 0.99^{f}
LSD	0.48	0.48	0.45	0.50	0.41
CV	17.92	18.27	17.06	18.50	14.50

Results are means ± SD and values in the similar column with different superscript letters are significantly ($p < 0.05$) different from each other.
Note; - B_1 = 5% pumpkin flour, 10% common bean and 85% wheat flour B_2 = 10% pumpkin flour, 15% common bean and 75% wheat flour, B_3 = 15% pumpkin flour, 20% common bean and 65% wheat flour. LSD = Least significance difference, CV = Coefficient variation, SD = standard deviation.

that increasing the incorporation of Bambara nut flour and cowpea flour could enhance a higher spread ratio than whole wheat flour biscuit. Kirssel (1979) indicated that biscuits containing a higher spread ratio are the most desirable product.

The specific volume values for control biscuits (1.94–2.70 cm^3/g) exhibited significantly ($p < 0.05$) higher as compared to the lower values for composite biscuits (1.63–1.80 cm^3/g) (Table 4). The lower volume of composite biscuit flour samples was due to the lower gluten content, which creates gas retention in the dough. Ostermann et al. (2017) also reported that increasing the incorporation of okara induces cookies with the lowest specific volume.

Hardness is a mechanical property that indicates the force needed to break a biscuit in the mouth, which is an essential characteristic for product acceptance. The measured breaking strength with the lower value indicates the higher crispness property, but the high result indicates the rigidity structure of biscuits (Leiva et al., 2018). The breaking strength of biscuit ranged from 8.90 to 13.25N, as shown in Table 4. The incorporation of common bean and pumpkin flour significantly ($p < 0.05$) reduces the breaking strength compared to the sample made from whole wheat flour. This may be attributed to the lower gluten content of composite flour as the wheat was reduced.

Similarly, the cowpea-wheat composite biscuit had a lower hardness value than the control wheat flour prepared biscuit (Yilma and Admassu, 2019). Contrary to this study, Kulkarni and Joshi (2013) reported that increasing the incorporation of pumpkin flour in a wheat-pumpkin biscuit sample requires a high amount of breaking force than that of a whole wheat biscuit sample. Besides blending ratio, increasing the baking temperature application could also bring a high hardness of biscuits. This was maybe the more amount of water removed from the biscuits during baking.

3.5. *Sensory evaluation of wheat, common bean and pumpkin composite flour biscuit*

The mean sensory scores for formulated biscuits and control samples evaluated by semi-trained panellists are indicated in Table 5. Colour is an essential criterion in deciding the initial acceptability of the baked products. The colour score of formulated biscuits increased from 4.50 to 6.46 with increased wheat flour and decreased common bean and pumpkin flour ratios. In addition to this, biscuit samples baked at 200 °C recorded the highest colour score. In addition to this, more addition of common beans and pumpkin reduce the colour preference of consumers. However, regarding nutritional point views, increasing the levels of common bean enhance protein contents in the developed products (Ubbor and Akobundu, 2009).

The mean score for a taste of formulated biscuit and control samples ranged from 4.53 to 5.66 and 5.16 to 5.70, respectively (Table 5). The findings showed that the highest taste score was observed for the control flour biscuit baked at the lowest baking temperature compared to the composite sample baked at a high temperature. The taste score decreases as the incorporation of common bean and pumpkin flour increases. This might be due to bean flavours generated from common beans (Okoye and Okaka, 2009) and bitterness nature of pumpkin flour (Kulkarni and Joshi, 2013).

The results of the sensory aroma scores from 4.70 to 6.03 are presented in Table 5. Due to the blending ratio and baking temperature, there was a significant ($p < 0.05$) difference in the aroma of biscuits. However, the interaction between the blending ratio and the baking temperature could not result in a significant difference. Incorporating common bean and pumpkin flour into whole-wheat biscuits resulted in reduced aroma scores.

Crispness is a force required to break biscuit structure rather than deforms when chewed with the human mouth teeth (Chauvin et al., 2008). The sensory analysts provided the highest crispness score for 75% wheat flour, 15% common bean and 10% pumpkin flour prepared biscuit in the blend, which was baked at 200 °C. However, the score decreased as the supplementation of composite flour increased (Table 5). The foundation of the result indicated a significantly ($p < 0.05$) higher crispness score for the control than for composite samples. Although, more supplementation of pumpkin and common bean flour significantly reduces the crispness score of the sample.

The sensory score of overall acceptability of the developed biscuits and control sample was evaluated by panellists ranging from 5.01 to 6.56 and 5.30 to 6.26, respectively (Table 5). The recorded results indicate that biscuit developed from B2T2 (75% wheat flour, 15% common bean and 10% pumpkin flour) and baked at 200 °C was the most preferred and liked significantly by panelists as compared to the formulated and control samples. Although the overall acceptability score for the entire biscuit was above five that indicates an acceptable standard (Meilgaard et al., 2007). The findings highlighted that the overall acceptability score of the developed biscuits decreased with an increase in the proportion of common bean and pumpkin flour in biscuit formulation. A similar study reported that increasing the incorporation of pumpkin in wheat flour induces a decrease in the overall acceptability score of biscuits (Usha et al., 2010; Kulkarni and Joshi, 2013).

4. Conclusion

In this study, biscuits made from wheat flour, common bean and pumpkin flour baked at 180, 200 and 220 °C, and control samples practiced in the local communities were evaluated for physicochemical composition and sensory acceptability. The findings indicated that supplementing pumpkin and common bean with wheat flour significantly enhances crude protein and fat contents, which plays a vital role in solving protein-energy malnutrition in the country. Besides this, increased pumpkin and common bean flour in the formulation could provide better physical and functional properties. The sensory acceptability results showed that biscuits formulated at 75% wheat flour, 15% common bean and 10% pumpkin flour) and baked at 200 °C significantly ($p < 0.05$) preferred in terms of all sensory attributes compared to control and other formulated products. The findings suggested that the products developed from locally available raw materials and unexploited vegetables were essential to reduce hard currency for wheat importation, improve dietary diversity and enrich nutritional contents.

Declaration

Author contribution statement

Abebe Daselegn Melesse, Ebisa Olika Keyata: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

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