Original Research Article||

Evaluation of Ethiopian Cassava Varieties for Quality of Cookies from Cassava-Chickpea Composite Flour

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Abstract

The use of cassava powder in bakery products, including cookies, is gaining attention in Ethiopia. However, cassava varieties grown in Ethiopia vary widely in their characteristics, which may influence their food applications that require investigation. This study aimed to evaluate the effects of cassava varieties and chickpea proportion on the quality of cookies from cassava-chickpea composite flour. The composite flour was prepared by blending powders from four cassava varieties (*Kello, Qulle, Hawassa-4, and Chichu*) with chickpea flour at 40%, 50%, and 60% composition. The findings indicated that the functional characteristics and physical properties of cookies were significantly affected by cassava varieties and chickpea proportion. Cookies formulated from Hawassa-4 cassava variety exhibited a high spread ratio. A cookie from 40% Hawassa-4 cassava and 60% chickpea was found to have better spread ratio and sensory qualities (taste, texture, flavor, and crispiness), high protein (12.85%) and fiber (5.90%) contents. Mineral analysis revealed the highest calcium content (75.90 mg/100 g) in cookies made with 40% Qulle, and the highest zinc content (2.23 mg/100 g) in those with 40% Kello. The phytate-to-calcium molar ratio (0.05–0.08) and phytate-to-zinc ratio (0.66–5.88) in all cassava-chickpea composite cookies were within acceptable limits, ensuring bioavailability of these minerals. However, the phytate-to-iron ratio exceeded the threshold of 1 in most formulations, highlighting potential challenges with iron absorption. These findings highlight the potential of cassava-chickpea composite cookies, particularly those made with 40% Hawassa-4 cassava, as a nutritionally valuable option to address protein-energy malnutrition in Ethiopia.

Key words: Cassava varieties, Chickpea proportion, Cookie, Physicochemical properties, Bioavailability of minerals

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INTRODUCTION

The utilization of locally available raw materials offers a strategic pathway to enhance food security and nutritional quality, particularly in developing countries such as Ethiopia (Owasa & Fall, 2024). This approach not only addresses immediate dietary needs but also promotes agricultural sustainability and resilience (Bozsik et al., 2022). Cookies, widely consumed across all age groups, are conventionally made from wheat flour (Ikuomola et al., 2017). However, increasing concerns over food insecurity and dietary-related health issues underscore the need for more nutritious and locally sourced alternatives. In response, this study investigates the potential of composite flours made from cassava (Manihot esculenta) and chickpea (Cicer arietinum) to develop wheat-free cookies. Beyond meeting the growing demand for gluten-free bakery products, this formulation aims to diversify food options while improving their nutritional value.

Several studies have investigated the use of cassava and chickpea flours in baked products. For instance, cassava-chickpea composite flours have been used in bread and cake formulations to enhance protein content and improve functional properties (Adebayo & Olatunde, 2020; Santos, *et al.,* 2018). Other studies have explored cassava-legume blends for snack production, revealing improved nutritional composition and acceptable sensory properties (Alamu, *et al.,* 2020; Maziya-Dixon et al., 2017). However, limited studies have specifically focused on the use of Ethiopian cassava varieties in combination with chickpea flour for cookie production. As such, this study lies in evaluating the effect of local cassava varieties and chickpea blending ratios on the quality attributes of gluten free cookies a product not yet thoroughly explored in this context.

Cassava is a root crop widely cultivated in the southern part of Ethiopia and plays an important role in local diets (Tadesse et al., 2013). The application of cassava flour is increasingly recognized in bakery products, including cookies (Bogale et al., 2022; Kebede et al., 2012). According to Senanayake *et al.* (2024), cassava powder holds significant potential as an alternative to wheat flour in baked goods due to its cost-effectiveness and local availability. Cassava powder was prepared following the method of Kebede et al. (2012) with slight modifications. The roots were peeled, sliced, sun-dried, and milled to produce cassava flour for use in the composite formulations. However, cassava varieties grown in Ethiopia exhibit distinct characteristics, influencing their suitability for various food products (Akonor *et al*., 2023). These varietal differences may affect the functional, nutritional, and sensory attributes of the final product, making it essential to evaluate their impact on cookie quality.

Chickpea, the second most important legume crop after faba beans in Ethiopia, plays a vital role in the country's agriculture and nutrition (Asfaw & Shiferaw, 2010). As a major pulse crop, it supports food security while providing a valuable source of protein (Fikre and Bekele, 2020). It plays a significant role in the country's agriculture, contributing to nutrition security and providing a valuable source of protein (Fikre and Bekele, 2020). Chickpea flour has been traditionally used in Ethiopian cuisine for dishes like *shiro* (a spiced stew), and it is also consumed as a roasted snack (Ashenafi et al., 2023). The high protein content of chickpea makes it an ideal complement to carbohydrate-rich root crops like cassava in composite flour formulations (Garske et al., 2023). Unlike traditional cookies made from wheat flour, this study explores the use of composite flours from cassava and chickpea to create wheat-free cookies, addressing the rising demand for gluten-free bakery products. Therefore, this study aims to evaluate the functional, physicochemical, and sensory properties of cookies made from composite flours of Ethiopian cassava varieties and chickpea.

MATERIALS AND METHODS

Materials

Four distinct varieties of cassava grown in Ethiopia, *Kello*, *Qulle*, *Hawassa-4*, and *Chichu*, were obtained from the Hawassa Agricultural Research Centre, Ethiopia. The cassava roots utilized were 18 months post-planting. Chickpea samples (Kabuli type, Arerti variety) were procured from the Debre Zeit Agricultural Research Centre. Other necessary ingredients for cookie preparation, including refined palm oil (Tena sunflower oil), granulated white sugar, table salt, and wheat flour (Eshet) were obtained from local supermarkets in Hawassa city, Ethiopia.

Preparation of Cassava Floor

Following the method of Kebede *et al.* (2012), cassava powder was prepared with a slight modification to the drying time, which was extended to 15 hours. Fresh cassava roots were peeled, washed, and sliced into approximately 3-5 cm thicknesses with a diameter of 10-15 mm. Then exposed to sunlight until it achieved a moisture content of 10–12%. The dried pieces were milled into flour and sieved through a 500 µm sieve and finally stored in polyethylene bags at 4°C until use.

Preparation of Chicken Floor

The chickpea flour was prepared according to Olika *et al.* (2019). The seed was manually cleaned of all foreign matter, broken grains, and other impurities. The cleaned seed was soaked for 2 hours by immersing the seeds in water (Seed: water (1:3 V/V). The soaked seeds were then dried under sunlight for 10 hours. Milling was done to dhal the chickpea partially, then the dehulled whole grains were then cleaned. Then ground into flour and sieved through sieve a 500 µm sieve size. The resulting flour was packed into polyethylene plastic bags and stored at 4 °C until required for further processing.

Formulation of Composite Flour

The composite flour was prepared by blending cassava and chickpea flours at ratios of 40:60, 50:50, and 60:40 (cassava: chickpea) for each of the four cassava varieties. These blends were designated as C1, C2, and C3, respectively. A reference control (C0) containing 100% wheat flour was also prepared for comparison, as shown in Table 1. The cassava powder and chickpea flour were weighed separately with the aid of a digital electronic balance.

Table 1. Formulation of cookie from cassava-chickpea composite flour

Sample Code	Cassava powder (%)	Chickpea flour (%)	Wheat flour (%)
C1	40	60	0
C2	50	50	0
C3	60	40	0
C0	0	0	100

Determination of Functional Properties of Cassava-chickpea Composite Flour

Determination of Swelling Power of Composite Flour

The swelling power characteristics of the cassava-chickpea composite flour were investigated following the method outlined by Kusumayanti *et al.* (2015). The swelling power (g/g) was calculated by dividing the mass of the sediment (Wsd) by the original sample weight (Ws).

Swelling (g/g) = (Wsd/Ws dry basis) Eq1

where Wsd is dried sediment mass and Ws is original sample weight.

Determination of Water Holding Capacity (WHC) and Oil Holding Capacity (OHC)

The water and oil holding capacities of cassava-chickpea composite flours and wheat flour were determined following the method outlined in reference (Aremu *et al.,* 2007).

WAC or OAC(g/mL) = [((W3-W2))/(W1)] ………………………………………. Eq2

Where: W1 is weight of sample (db), W2 is weight of test tube, and W3 is weight of test tube and sediment.

Bulk Density

Bulk density of composite flour was determined according to Oladele and Aina (2007) method. About 50 g of composite flour was put in to a 100 mL measuring cylinder. The cylinder was tapped continuously until a constant volume was obtained. The bulk density was calculated as weight of the cassava-chickpea composite flour (g) divided by its volume (cm^3)

Cookie Preparation

The cookies were prepared as described by Jemziya and Mahendran (2015). The composite flour used for cookie preparation was based on cassava and chickpea flours, following the formulations described in section 2.3. Cookie dough was prepared by mixing 100 g of composite flour with 50 g of powdered sugar, 40 g of oil, 3 g of baking powder, and 0.8 g of salt. The dough was kneaded to a firm consistency, rolled out to a thickness of 5 mm, and cut into circular shapes (7.4 cm diameter) using a cookie cutter. The cookies were placed on a greased aluminum baking tray and baked in a pre-heated electric convection oven (UNOX XF043 model) at 200°C for 10 minutes. After baking, the cookies were cooled to room temperature and packed in polyethylene bag until sensory evaluation. A portion of the cookies was oven-dried at 40°C and ground into cookie powder for subsequent proximate and functional analysis.

Determination of Spread Ratio of Cookies

The cookies were selected randomly for physical analyses or spread ratios. The weight of the dough for each cookie should be consistent, 25 grams, 1 cm thickness in a baking tray, and cut into circles having 7.4 cm diameter. Baking conditions such as time, temperature, and tray placement were remaining constant, and cookies should cool for the same duration before measurement. The diameter and thickness were accurately measured by using a ruler, and the spread ratio was calculated by dividing the diameter by the thickness post-baking.

To determine the diameter of cookies, six samples were placed next to another, and the total diameter was measured accurately by using calipers. All of the cookies were rotated at an angle of 90°, and the new diameter was measured (for replication). The average of diameter was recorded. The thickness of the cookies was measured by four cookies stacking above the others and restacking four times. The average thickness was recorded. The spread ratio was calculated by dividing the diameter of cookies by the thickness of cookies (AACC, 2000).

Determination of Proximate Composition of Cookies

Moisture content

The moisture content of the cookie flour was determined according to the method of the Association of Official Analytical Chemists (AOAC, 2000). The moisture content of the cookies was calculated as follows:

$$MC\ (\%) = \left[\frac{W1-(W3-W2)}{W1}\right] \times 100$$ ……………………………………………… Eq3

Where: MC = moisture content, db), W1 = the weight of sample (g) before drying, W2 = the weight of the aluminum cup, and W3 = the weight of the aluminum cup plus the weight of the sample after drying.

Crude Fat

The fat content was determined using soxlet ether extraction techniques according to the standard expressed in AOAC (2000). method No. 920.39. The fat content was calculated using the formula. A five-gram sample was used for extraction.

Crud Fat (db) %= [[(W2-W1)/W] ∗100] ………………………………………. Eq 4

Where: W1 is weight of the extraction flask (g), W2 is weight of the extraction flask + the extracted crude fat (g), and W is weight of the sample (g).

Ash Content

The sample ash content was determined according to AOAC (2000). method 923.03 by taking about 3.0 g of sample after carbonization and ignition at 500 °C for 6 h in the muffle furnace (Model 2-525, J. M. Ney furnace, Yucaipa, USA).

Ash% = ((W3-W2)/W1) * 100 …………Eq 5

Where W1 is the weight of dried cookie flour before ashing, W3 is the weight of dried cookie flour after ashing with the weight of the crucible, and W2 is the weight of the crucible.

Crude Fiber

The acid and alkaline digestion procedure was used to assess the crude fiber content in accordance with the standard method in AOAC (2000). No. 962.09. About 1.5 g of the sample was used for the determination of crude fiber.

Crude fiber % (db) = [(W2-W3)/W1]∗100..Eq 6

Where: W1 is weight of samples (g); W2 is weight of crucible and residue after drying (g).

W3 is the weight of the crucible and ash after incarnations (g).

Crude Protein

The protein content was determined following the Kjeldhl method in accordance with the standard method in AOAC (2000). About 1 g of samples were used for crude protein determination. The borate ion was titrated with a standardized 0.1N hydrochloric acid solution using Kjeldahl analyzer distillation until a light pink color was observed.

Nitrogen% = [(Vs-Vb)/10W]∗NHCl*14.01g….Eqn (7)

Where: Vs is volume of HCl consumed during titration of sample (mL), Vb is volume of HCl consumed during titration of blank (mL), N is normality of HCl used (0.1), W is weight of sample (g), 14 is molecular weight of nitrogen

The percent of nitrogen was converted to the protein percentage as follows:

Crude protein % = %N* F ………… Eq (8)

Where: the conversion factor is 6.25

Determination Mineral Analysis (Calcium, Zinc, and Iron) of Cookies

The mineral contents of the cookie product were determined by the procedure of AOAC (2005). The extracted minerals Fe, Ca, and Zn were analyzed by atomic absorption spectrophotometer after removal of organic material by dry ashing. The residue was dissolved in dilute acid. The solution was sprayed into the flame of the atomic absorption spectrophotometer (Buck. Scientific model 210GP, UAS), and the absorption of the metal to be analyzed was measured at a specific wavelength. The stock standard solutions of minerals (Ca, Fe, and Zn) were diluted with 0.3 N HCl to concentrations that fall within the working range (0.0-00.6, mg/kg for calcium analysis; 0.0-00.6, mg/kg for zinc analysis; 0.0- 18.0 mg/kg for iron analysis).

Mineral determination: The minerals were obtained from dried ash. The ash was wetted completely with 5 mL of 6N HCl and dried on a low-temperature hot plate. A 7 mL of 3N HCl was added to the dried ash and heated on the hot plate until the solution just boiled. The ash solution was cooled to room temperature in open air in a hood and filtered through a filter paper (What Man No. 1) into a 50-mL graduated flask. A 5 mL of 3 N HCl was added into each crucible dish and heated until the solution just boiled, cooled, and filtered into the flask. The crucible dishes were again washed three times with deionized water; the washings were filtered into the flask. A 2.5 mL of 10% lanthanum chloride solution was added into each graduated flask. Then the solution was cooled and diluted to the mark (50 mL) with deionized water. A blank was prepared by taking the same procedure as the sample.

$$\text{Mineral content (\%)} = ([(a-b) \times V])/W \times 100 \quad \text{………………………………Eq (9)}$$

Where: W = weight (g) of samples; V = volume (mL) of extract; a = concentration (μg/mL) of sample solution; b = concentration (μg/mL) of blank solution.

Determination of Anti-nutrient Analysis Contents of Cookies

HCN Contents Determination of Cookie Products

The quantification of hydrogen cyanide (HCN) levels in cookie products was conducted using Konzo Kits Protocol B2, following the methodology outlined by Bradbury *et al.* (1999). To initiate the process, a 100 mg of the sample was carefully weighed and placed on top of a buffer/enzyme paper disc, identifiable by a black spot, within a flat-bottomed plastic bottle. Next, 1.0 mL of distilled water was gently added with a plastic pipette and then thoroughly mixed. A yellow indicator paper attached to a plastic strip was introduced into the bottle, which was then sealed with a screw-capped lid to facilitate reaction. For each sample, subsequent analysis involved the careful removal of the plastic backing sheet from the indicator paper. The indicator paper was then transferred to a test tube, into which 5.0 mL of distilled water was added. The test tube was allowed to stand at room temperature for approximately 30 minutes, with occasional gentle stirring to ensure uniform distribution. The solution's absorbance was measured at 510 nm using a spectrophotometer.

The total cyanide content, expressed in parts per million (ppm), was calculated using the formula: total cyanide content (ppm) = 396 × absorbance. To ensure the reliability of the results, both positive and negative controls were included for each experimental set. The negative control involved the preparation of a solution without the inclusion of any sample, while the positive control utilized A buffer/enzyme paper disc, with a known cyanide concentration (approximately 10 ppm on a pink standard paper), to ensure accuracy and consistency in detection.

Condensed Tannins

Condensed tannin was analyzed by vanillin-HCI method of Price *et al*. (1978). The Vanilli-HCI reagent was prepared by mixing equal volume of 8% concentrated HCI in methanol and 1% Vanilli in methanol. The solution of the reagent was mixed just before use. A 0.2 g of the ground sample was placed in small conical flask. Then 10 ml of 1% concentrated HCI in methanol was added. The conical flask was capped and continuously shaken for 20 min and the content then is centrifuged at

2500 rpm for 5 minutes. About 1 ml of the supernatant was pipette in to a test tube containing 5ml of Vanillin-HCI reagent. Absorbance at 450 nm was read on spectrophotometer after 20 minutes' incubation at 30°C. A blank sample was also analyzed and its absorbance was subtracted from sample absorbance. A standard curve was prepared for catechin (0-1.2 mg/ml). Tannins content was expressed as catechin equivalent as follows:

Tannin (%) = (c×10×100)/Sw……….. Eq (10)

Where: C = concentration corresponding to the optical density, 10 = Volume of the extract (ml), Sw = Sample weight (mg)*2.10* 2.7.1 Condensed tannins

Phytate

The phytate content of the samples was determined by following the procedure mentioned by Vaintraub and Lapteva (1988). The 0.4 g of the dried sample were extracted with 10 milliliters of 0.2N HCl for one hour at ambient temperature. The mixture was then centrifuged at 3000 rpm for 30 minutes. The clear supernatant was collected for phytate estimation. To 3 milliliters of the supernatant, 2 milliliters of Wade reagent were added. The solution was then homogenized and centrifuged again at 3000 rpm for 10 minutes. The absorbance of the solution was measured at 500 nm using a UV-Vis spectrophotometer. The phytate concentration was calculated by comparing the absorbance of the sample with that of a blank, which consisted of 3 milliliters of 0.2N HCl and 2 milliliters of Wade reagent. The amount of phytic acid was determined using a phytic acid standard curve, and the results were expressed as phytic acid in µg/ml of fresh weight.

Phytic acid in µg/g = ($(A_s - A_b)$-Intercept)/ Slope x W ……………………………Eq (11)

Where A_s= sample absorbance, A_b= blank absorbance, W= weight of sample

A stock solution was prepared by dissolving 0.1814 grams of phytic acid in 100 milliliters of 0.2N HCl. A series of standard solutions containing 4-40 µg/ml phytic acid in 0.2N HCl were prepared from this stock solution. Three milliliters of each standard solution were pipetted into 15 milliliter centrifuge tubes, with 3 milliliters of 0.2N HCl used as a zero-level blank. To each tube, 2 milliliters of Wade reagent were added, and the solutions were mixed on a vortex mixer for 5 seconds. The mixtures were then centrifuged at 3000 rpm for 10 minutes, and the absorbance of the supernatant was measured at 500 nm using 0.2N HCl to zero the spectrophotometer. A calibration curve (absorbance vs. concentration) was plotted using Excel, and the slope and intercept were determined from this curve.

Sensory Analysis

A hedonic sensory evaluation was conducted to assess the consumer acceptability of the cookie samples. Sensory evaluation was conducted on formulations using the Hawassa-4 cassava variety at 40%, 50%, and 60% chickpea composition. This variety demonstrated superior physical (spread ratio) and functional properties (WHC and OHC). In addition, selecting a single high-performing variety like Hawassa-4 allowed us to reduce the number of samples for sensory evaluation while still ensuring the reliability and relevance of the results. The evaluation was carried out by a panel of 50 semi-trained members drawn from the College of Agriculture, Hawassa University. Panelists were selected based on their regular consumption of cookies and their willingness to participate, ensuring they had sufficient familiarity with the product to provide informed evaluations.
The sensory test employed a nine-point hedonic scale, a standard method in consumer preference studies due to its simplicity and effectiveness in capturing degrees of liking (Addo-Preko *et al.*, 2023). The scale ranged from 1 = "dislike extremely" to 9 = "like extremely," allowing panelists to express a wide range of preferences for each sensory attribute.

Samples were served three hours after baking to ensure consistency in temperature and texture. Each cookie was presented in a randomized order on plates coded with three-digit numbers to minimize bias. The formulations tested during the sensory evaluation were prepared as described in Section 2.3 and baked following the procedure outlined in Section 2.5. A cookie made from 100% wheat flour was included as the control sample for comparative purposes.

Data Analysis
Data were analyzed using one-way analysis of variance (ANOVA) in JMP Pro 14 software to determine the significance of factors at a 95% confidence level. Sensory evaluation scores from the hedonic scale were used to calculate the mean sensory scores for each sample. Differences among means were separated using Tukey's Honest Significant Difference (HSD) test. For graphical representation, data were imported and visualized using Microsoft Excel. Results were expressed as mean values ± standard deviation.

RESULTS AND DISCUSSION

Functional Properties of Cassava-Chickpea Composite Flour

The functional properties of the cassava-chickpea composite flour are presented in Table 2. The bulk density ranged from 0.405 g/cm³ to 0.505 g/cm³, with the highest recorded in the 40% *Chichu* formulation. The lowest bulk density (0.405 g/cm³) was observed for 60% *Chichu*. Bulk density affects the compactness of the dough. Higher chickpea content led to increased bulk density, indicating a potential for denser cookie dough. This aligns with findings by Apotiola and Fashakin (2013), who observed similar trends with soybean-cassava blends. This indicates that heavier weight (high bulk density) might have an impact on the final texture and chewiness of cookies.

WHC was highest in 40% Kello (2.98 g/mL) and lowest in 60% Qulle (2.56 g/mL). WHC of control sample (2.92) is resembles to the WHC of formulation with higher chick pea proportion (Table 2). Higher WHC is associated with higher protein content, as proteins have strong water-binding capabilities (Makinde & Adebile, 2018). Moisture retention is essential for achieving softer cookies, as reported by Aljobair (2022). Therefore, the enhanced WHC observed in chickpea-containing blends could improve the texture and freshness of cookies, aligning with consumer preferences for soft, moist products (Aljobair, 2022).

For oil holding capacity (OHC), 40% Qulle formulation scored the highest (2.12 g/mL) and the lowest OHC was seen in 60% Kello (1.82 g/g). OHC of control sample (2.05) is resembles to the OHC of formulation with higher chick pea proportion (Table 2). The oil holding capacity in cookie making is important as it contributes to flavor retention, mouth feel, and a richer texture (Aremu *et al*., 2007). As chickpea content increased, OHC also tended to increase, a trend consistent with findings by Akubor and Ukwuru (2003) in cassava-soybean composite flour. Flours with higher OHC are advantageous in cookie formulations because they help in flavor delivery and create a more indulgent eating experience, potentially boosting consumer appeal.

The swelling power of the control sample (100% wheat flour) was the highest (7.3), resulting in a more expanded and airy texture compared to all cassava-chickpea blends. This indicates that cassava-chickpea blends may produce denser, less aerated cookies due to the lower swelling capacity of cassava starch compared to wheat starch. Swelling power indicates the ability of starch molecules to retain water through hydrogen bonding, which influences the final cookie volume, structure, and lightness (Dat, 2018). These differences might impact sensory attributes such as crumb structure, crispiness, and visual appeal.

Table 2. Functional properties of composite flour blends of cassava and chickpea at different ratios

Variety-Composition	Bulk Density	WHC (mL/g)	OHC (mL/g)	Swelling power (mL/g)
40% Chichu	0.505±0.5 ^{a}	2.97±0.71^{a}	2.04±0.51^{cd}	3.42 ±0.30^{h}
50% Chichu	0.455±0.11^{cd}	2.73±0.41^{bc}	2.005±0.61^{de}	4.02 ±0.5^{fg}
60% Chichu	0.405±0.01^{e}	2.58±0.61^{ef}	1.95±0.21^{fg}	4.56±0.40^{d}
40% Hawassa-4	0.505±0.21^{a}	2.94±0.06^{a}	2.09±0.41^{ab}	4.32±0.52^{e}
50% Hawassa-4	0.49±0.30^{ab}	2.795±0.31^{b}	2.01 ±0.61^{ce}	4.98±0.80^{c}
60% Hawassa-4	0.485±0.31^{ab}	2.72 ±0.27^{bd}	1.985±0.41^{ef}	5.53±0.72^{b}
40% Kello	0.475±0.31^{bc}	2.98±0.5 ^{a}	2.04±0.50^{cd}	3.83±0.38^{g}
50% Kello	0.455±0.21^{cd}	2.65 ±0.41^{cf}	1.975 ±0.31^{eg}	4.05±0.50^{f}
60% Kello	0.445±0.4 ^{d}	2.6 ±0.34$^{d\ f}$	1.82^{h}±0.21	4.62±0.41^{d}
40% Qulle	0.495±0.07^{ab}	2.69 ±0.21^{be}	2.12±0.21^{a}	2.93±0.61^{i}
50% Qulle	0.475±0.41^{bc}	2.61 ±0.11^{df}	2.0±0.3^{de}	3.45±0.31^{h}
60% Qulle	0.455±0.21^{cd}	2.56±0.6^{f}	1.93±0.21^{g}	3.88±0.26^{fg}
Control	0.495±0.31^{ab}	2.92±0.81^{a}	2.05±0.32^{bc}	7.3 ±0.14^{a}

Where WHC = water holding capacity, OHC = oil holding capacity, 40% = 40% cassava + 60% chickpea, 50% = 50% cassava + 50% chickpea, and 60% = 60% cassava + 40% chickpea, Values are mean ±SD. Each value with the same column followed by different letters is significantly different, and the same letters are not significantly different at the level of 0.05.

Spread Ratio of Cookies from Cassava-Chickpea Composite Flour

The spread ratio is a key measurement of how much a cookie spreads or flattens out during baking. The highest spread ratio (5.74) was recorded for cookies made from the 40% Hawassa-4 formulations (Figure 1). The lowest spread ratio (4) was recorded for cookies made from 60% Chichu formulation. A higher spread ratio often results in thinner, crisper cookies, which some consumers prefer for their crunchiness (Boz, 2019; Thorat and Lande, 2017). Cookies from Hawassa-4 variety ranged from 4.80 – 5.74, falls nearly within the ideal range of 5–6, supporting both crispness and structural integrity (Ashwath and Sudha, 2021). The addition of chickpea to cassava flour resulted in a significant ($p < 0.05$) increase in the spread ratio of the cookies from cassava-chickpea composite flour. A similar finding was observed by Leticia *et al.* (2022), who reported that the spread ratio of cookies from cassava-mung bean composite flour increased with the higher the proportion of mung bean flour (Akubor & Ukwuru, 2003). The higher the spared ratio, the reduced hardness, and subsequently the taste preference level increased (Leticia *et al.,* 2022).

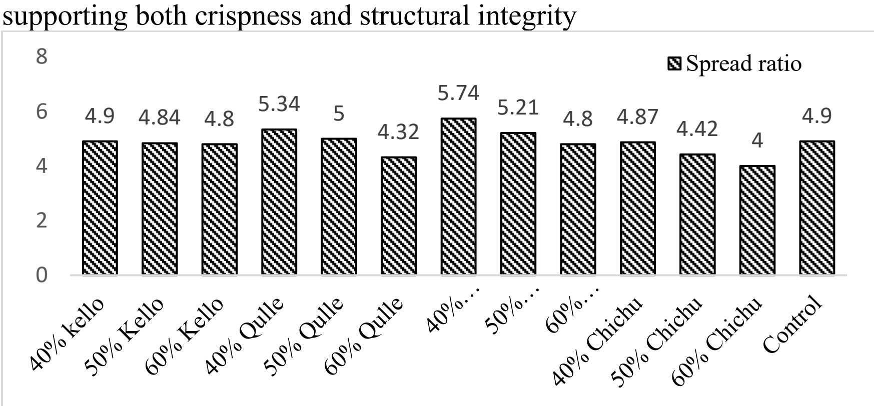

Figure 1. Spread ratio record of cookies from chickpea-cassava composite flour

Where 40% = 40% cassava + 60% chickpea, 50% = 50% cassava + 50% chickpea and 60% = 60% cassava + 40% chickpea

Proximate Composition of Cookies Made from Cassava-Chickpea Composite Flour

The proximate composition of cookies made from cassava-chickpea composite flour, as shown in Table 3, highlights significant variations in moisture, ash, fat, fiber, and protein content across different varieties and compositions. The variation in proximate composition influences cookie texture, flavor, and nutritional profile. The highest moisture content (4.95%) was observed in 40% Chichu, while the lowest moisture level (3.40%) was observed for 60% Hawassa-4. The higher moisture content of the cookie was seen in the cookie from higher chickpea flour, which might be because of the higher fiber content in chickpea. A similar finding was observed by Leticia *et al*. (2022), who reported that higher moisture was observed for cookies from high fiber content. Fiber types such as cellulose have hydrophilic properties (Célino *et al.,* 2014). The moisture content of the cookies was less than 10% to reduce the chances of spoilage by microorganisms and consequently guarantee good storage stability (Ayo *et al*., 2007). Ash content was highest (4.19%) in 40% Hawassa-4 while the lowest ash content (2.05%) was scored for the control sample (100% wheat flour). The varying ash content levels across cassava-chickpea formulations imply differences in mineral content, which can impact the nutritional profile. Ash content is an indication of the mineral content of the product (Czaja *et al.,* 2020). Fat content was higher (25.3%) for 40% Chichu, while the control sample had the lowest (19.95%) fat content. Fat content in cookies contributes to a richer mouth feel and potentially more flavorful cookies (Ikuomola *et al.,* 2017).

Fiber content varied across samples, with 40% Hawassa-4 containing the highest fiber levels (5.90%) while the 60% Qulle sample was found to have the lowest fiber content (4.01%). The presence of high fiber in food products is essential owing to its ability to facilitate bowel movement (peristalsis), bulk addition to food, and prevention of many gastrointestinal diseases (Satinder *et al.,* 2011). Protein content was highest in 40% Hawassa-4 (12.85%) whereas lower protein content (7.54%) was observed in 60% Chichu formulation. Previous findings confirm that addition of legumes could enhance the protein content of cookies (Apotiola and Fashakin, 2013; Adekunle and Mary, 2014). Overall, these proximate composition differences come primarily due to the difference in cassava-chickpea proportion among products of cookies. As chickpea is a good source of protein, fat, fiber, and ash content Yegrem *et al*. (2022) found that it enhances the nutritional profile of cookies made from cassava.

Table 3. Proximate composition of cookies prepared from cassava-chickpea composite flours at varying formulation levels

Variety and composition	Moisture%	Ash%	Fat%	Fiber%	Protein%
40% Chichu	4.95±0.21[a]	3.29±0.10[de]	23.95±0.21[abc]	5.07 ±0.21[ad]	10.38±0.33[b]
50% Chichu	4.20±0.14[ab]	2.86±0.11[f]	23.15 ±0.14[bd]	4.51 ±0. 2[bd]	10.69±2.14[ab]
60% Chichu	4.34±0.37[ab]	2.78±0.13[f]	22.2±0.35[cd]	4.11±0.13 [cd]	7.54±0.14[c]
40% Hawassa-4	4.60±0.11[ab]	4.19±0.06[a]	23.60 ±0.14[bd]	5.90±0.08[a]	12.85±0.07[a]
50% Hawassa-4	4.12±0.12[ab]	4.02±0.08[ab]	23.1 ±0.07[bd]	5.69±0.05[ab]	9.08±0.06[bc]
60% Hawassa-4	3.40±0.14[b]	3.78±0.09[bc]	26.70±0.28[g]	5.13 ±0.62[ad]	7.35±0.16[c]
40% Kello	4.56±0.77[ab]	3.29±0.42[de]	25.3±0.35[a]	5.17 ±0.06[ad]	10.64±0.01[ab]
50% Kello	4.20±0.28[ab]	3.02±0.13[ef]	33.10±0.28[ab]	4.68 ±0.06[ad]	9.21±0.04[bc]
60% Kello	4.86±0.22[a]	2.99±0.07[ef]	24.25±0.07[ab]	4.32±0.15[cd]	7.72±0.07[c]
40% Qulle	4.05±0.35[ab]	3.80±0.01[bc]	24.2 ± 0.28[abc]	5.42 ±0.14[ac]	10.78±0.15[ab]
50% Qulle	4.80±0.71[ab]	3.28±0.04[de]	23.1 ±0.07[bd]	5.12 ±0.13[ad]	9.23±0.13[bc]
60% Qulle	4.50±0.14[ab]	3.45±0.07[cd]	22.20 ±0.28[bd]	4.01±1.00[d]	7.66±0.23[c]
Control	4.25±0.07[ab]	2.05±0.08[g]	19.95±0.78[e]	0.89±0.03[e]	7.30±0.28[c]

Where, Chichu, Hawassa-4, Kello and Qulle are cassava varieties. 40% = 40% cassava variety+ 60% chickpea, 50% = 50% cassava variety + 50% chickpea and 60% = 60% cassava variety+ 40% chickpea. Values are mean ±SD. Each value with the same column followed by different letters are significantly different and same letters is not significantly different at level of 0.05

Mineral and Anti-Nutrient Composition of Cookie from Cassava-Chickpea Composite Flour

The mineral and anti-nutrient composition of cookies made from cassava-chickpea composite flour varied notably among different varieties and compositions (Table 4). The cookies from cassava-chickpea composite flour demonstrated an enhanced mineral profile, particularly in calcium, zinc, and iron, compared to the control, indicating their potential to serve as a nutrient-dense snack. Calcium content was highest (76.90 mg/100g) in the cookie from 40% Qulle formulation. The lowest calcium content was recorded for 60% Qulle formulation. In contrast, the control cookie (100% wheat) exhibited the lowest calcium content at 14.00 mg/100 g, indicating a lower mineral density compared to the composite flour cookies. Calcium (Ca) is an important bone-related micro element in human nutrition (Ciosek *et al.,* 2021). Zinc levels were highest in 40% Kello (2.23 mg/100g), 50% Qulle (2.21 mg/100g), and the control (2.25 mg/100g) formulations. The lowest zinc level (1.19 mg/100 g) was observed in 60% Chichu formulation. Adequate zinc in cookies supports immunity and growth, especially where zinc deficiency is common. Iron content was highest 4.20 mg/100g in 50% Qulle formulation, whereas 60% Chichu had the lowest iron content (1.80 mg/100g). Phytate content was highest (92 mg/100 g) in 40% Hawassa-4 and lowest in the control cookie (15 mg/100 g). Phytic acid is the primary storage compound of phosphorus in cereals, legumes, nuts, and oilseeds (Lott et al., 2009). The tannins reduced the availability of minerals, proteins, and starch (Barros et al., 2012). However, tannins have antioxidant properties beneficial in small amounts, although higher concentrations may reduce iron absorption. Overall, the enhanced mineral profile, particularly in calcium, zinc, and iron was observed for cookies from cassava-chickpea than the control sample. Therefore, cookies from cassava-chickpea can be considered as nutrient-dense alternative to traditional wheat cookies. The highest HCN content (4.35 mg/100 g) was recorded for the 60% Qulle formulation. The lowest HCN content (1.82 mg/100 g) was recorded for the 40% Chichu formulation. The tolerable limit for HCN in cassava products varies by regulatory guidelines but is generally recommended to be below 10 mg/100 g in ready-to-eat products, according to FAO (1998). The values in this table suggest that while all samples fall below the 10 mg/100 g limit.

Table 4. Mineral and anti-nutrient content of Cookie from Cassava-chickpea Composite Flour

Variety-Composition	Ca mg/100g	Zn mg/100g	Fe mg/100g	Phytate mg/100g	Tannin mg/100g	HCN mg/100g
40% Chichu	75.90 ± 1.84^{a}	1.63 ± 0.06^{bc}	3.30 ± 0.14^{abc}	77.5 ± 0.09^{ab}	0.05 ± 0.02^{a}	1.82 ± 0.26^{c}
50% Chichu	61.00 ± 0.28^{bc}	1.40 ± 0.12^{bc}	1.95 ± 0.21^{d}	$70\pm0.08^{a-c}$	0.07 ± 04^{a}	2.37 ± 0.54^{bc}
60% Chichu	54.65 ± 0.64^{de}	1.19 ± 0.09^{c}	1.80 ± 0.14^{d}	61 ± 0.06^{bc}	0.08 ± 05^{a}	$3.08\pm0.60^{a-c}$
40% Hawassa-4	76.65 ± 0.64^{a}	1.55 ± 0.14^{bc}	3.60 ± 0.42^{ab}	92 ± 0.04^{a}	0.06 ± 02^{a}	2.12 ± 0.40^{bc}
50% Hawassa-4	61.55 ± 0.21^{b}	1.40 ± 0.07^{bc}	$2.35\pm0.35^{b-d}$	80 ± 0.06^{ab}	0.08 ± 0.01^{a}	$2.84\pm0.58^{a-c}$
60% Hawassa-4	57.15 ± 0.92^{cd}	1.23 ± 0.08^{c}	$2.30\pm0.28^{b-d}$	$72\pm0.06^{a-c}$	0.09 ± 0.01^{a}	3.76 ± 0.48^{ab}
40% Kello	73.90 ± 0.42^{a}	2.23 ± 0.17^{a}	$2.60\pm0.28^{b-d}$	$70.5\pm0.08^{a-c}$	0.07 ± 0.01^{a}	3.76 ± 0.49^{ab}
50% Kello	63.0 ± 0.99^{b}	1.53 ± 0.14^{bc}	$2.52\pm0.40^{b-d}$	61 ± 0.04^{bc}	0.08 ± 0.01^{a}	$2.93\pm0.45^{a-c}$
60% Kello	51.95 ± 2.05^{ef}	1.89 ± 0.07^{ab}	2.25 ± 0.21^{cd}	56.5 ± 0.09^{bc}	0.11 ± 0.01^{a}	3.76 ± 0.49^{ab}
40% Qulle	76.9 ± 0.57^{a}	1.78 ± 0.06^{ab}	3.95 ± 0.78^{a}	63.5 ± 0.06^{bc}	0.18 ± 0.43^{a}	2.30 ± 0.42^{bc}
50% Qulle	59.7 ± 0.85^{bc}	2.21 ± 0.28^{a}	4.20 ± 0.14^{a}	56 ± 0.08^{bc}	0.09 ± 0.01^{a}	$2.44\pm0.45^{a-c}$
60% Qulle	48.50 ± 0.57^{f}	1.56 ± 0.08^{bc}	1.90 ± 0.14^{d}	49.5 ± 0.05^{c}	0.12 ± 0.01^{a}	4.35 ± 0.50^{a}
Control	14.0 ± 0.99^{g}	2.25 ± 0.21^{a}	$3.55\pm0.21^{a-c}$	14.5 ± 0.01^{d}	0.01 ± 03^{a}	______

Table 5 showed the molar ratios of phytate to minerals (Ca, Zn, and Fe) in cookies made with various cassava-chickpea formulations and a control made of 100% wheat flour. The chelating properties of phytic acid released during food processing or in the gut also bind minerals and make them unavailable as nutritional factors. Understanding these molar ratios is important because high phytate-to-mineral ratios can inhibit the absorption of these essential minerals in the body. Across the different formulations, the phytate-to-calcium ratio ranges from 0.05054 (40% Qulle) to 0.07964 (50% Hawassa-4). Generally, a phytate/Ca molar ratio above 0.17 is considered inhibitory to calcium absorption (Ulrich *et al.,* 2007), so these values suggest minimal interference with calcium absorption. The phytate-to-zinc ratio shows significant variation, with the lowest (0.6604) in the control sample and the highest (5.87973) in 40% *Hawassa-4* formulation. Ratios above 10 are known to inhibit zinc absorption (Gharib *et al.,* 2006), so while these values are relatively low, they are within a tolerable range. The phytate-to-iron ratio ranges from 0.35755 (control) to 2.99429 (50% Chichu). Ratios above 1 are generally considered to impair iron absorption (Ulrich et al., 2007). Formulations from cassava-chickpea have values exceeding this threshold, suggesting possible challenges for iron bioavailability, especially in the Chichu and Hawassa-4 samples.

Table 5. Molar ratio of Phytate-mineral ratio of cookies from cassava –chickpea composite flour

Formulation of Cookies	Molar ratio phytate/Ca	Molar ratio phytate/Zn	Molar ratio phytate/Fe	Molar ratio phytate/Ca
40% Chichu	0.06241	4.74032	2.00014	0.06241
50% Chichu	0.06869	4.88227	2.99429	0.06869
60% Chichu	0.06785	3.18037	2.86772	0.06785
40% Hawassa-4	0.07294	5.87973	2.16254	0.07294
50% Hawassa-4	0.07964	5.66061	2.88072	0.07964
60% Hawassa-4	0.07657	5.79867	2.64901	0.07657
40% Kello	0.05834	3.15395	2.31081	0.05834
50% Kello	0.05880	3.94948	2.04837	0.05880
60% Kello	0.06669	2.98754	2.14374	0.06669
40% Qulle	0.05054	3.56173	1.37108	0.05054
50% Qulle	0.05696	2.51013	1.12828	0.05696
60% Qulle	0.06261	3.17502	2.22687	0.06261
Control	0.06506	0.66040	0.35755	0.06506

Where 40% = 40% cassava + 60% Chickpea, 50% = 50% cassava + 50% Chickpea and 60% = 60% cassava + 40% Chickpea

Sensory Acceptance of Cookies from Cassava-Chickpea Composite Flour

Table 6 shows the sensory acceptance scores for cookies made from cassava-chickpea composite flour at 40%, 50%, and 60% cassava proportion and 100% wheat (control). The 50% blend had the highest color score (7.77), while the control had the lowest color acceptance (5.08). Sensory evaluation was conducted solely on formulations using the Hawassa-4 cassava variety: chick pea proportions such as 40:60, 50:50, and 60:40. This is due to as this variety demonstrated superior physical (spread ration) and functional properties (WHC and OHC). The above figure suggests that 50% blend is the most visually appealing among the formulations. The chickpea-incorporated cookies had a golden-brown color, which is widely accepted as desirable for cookies (Ikuomola *et al.,* 2017). The golden-brown color of chickpea-enriched cookies is likely due to Maillard browning, which occurs during baking when reducing sugars react with proteins (Ikuomola *et al*., 2017). This desirable color was most pronounced in the 50% cassava blend (score = 7.77), surpassing the control (7.08).

The control sample (7.08) and the 40% cassava-chickpea formulation (6.77) scored highest in taste score. The 50% and 60% cassava formulations received lower taste scores. The decrease in taste score for higher cassava levels may be due to the earthy flavor of cassava. This finding is consistent with Akubor & Ukwuru (2003).

The 40% cassava- 60% chickpea formulation scored the highest (7.15) in favorable profile. The 60% cassava blend had the lowest flavor score (5.17). The 40% cassava formulation is closest to control sample in consumer preferences in terms of flavor, which might be highlighting the potential of formulation for cookies making.

The 40% cassava blend achieved a texture score of 7.92, close to the control (8.00). This result could be attributed to the flour's higher spread ratio, water-holding capacity (WHC), and oil-holding capacity (OHC), which improve moisture retention and contribute to the familiar mouth feel of traditional cookies (Makinde & Adebile, 2018).

The control sample, prepared from 100% wheat flour which is the standard and most commonly used ingredient in conventional cookie production was included as a baseline to benchmark the sensory quality of the composite flour formulations. It received the highest score for crispiness (7.33), indicating it was the most preferred in terms of crisp texture. This highlights the familiarity and acceptability of wheat-based cookies among consumers and provides a reference point to evaluate the performance of cassava-chickpea blends, which are being explored as alternative, locally available, and gluten-free options.

Cookies from 40% Hawassa-4 formulation had recorded highest in crispiness (7.21) while cookies from 60% cassava formulation had the lowest crispiness score (6.27). The crispiness of cookies from control sample was higher than that of cassava-chickpea composite cookies. This can be attributed to a lower swelling capacity of cassava-chickpea composite flour than wheat starch, leading to a denser, less crispy texture aligned with the finding by Adekunle & Mary (2014).

The 40% cassava blend had an overall acceptance score of 7.21, slightly lower than the control (7.67) but still within a favorable range (Figure 2). This indicates that cookies made with 40% cassava and 60% chickpea can be a viable alternative to wheat-based cookies, especially for consumers seeking gluten-free or alternative baked products. Therefore, 40% Hawassa-4 cassava and 60% chickpea blend stands out for its balance in taste, flavor, texture, test, and overall acceptance, making it a suitable alternative to wheat flour cookies.

Table 6. Sensory Evaluation Results for Cookies Made from Cassava-Chickpea Composite Flour

Formulation	Color	Taste	Flavor	Texture	Crispiness	Overall acceptance
40% Hawassa-4	6.38±1.71[b]	6.77±0.98[a]	7.15±1.24[a]	8.00±0.79[a]	7.31±1.39[a]	7.21±0.94[ab]
50% Hawassa-4	7.77±0.90[a]	5.31±1.65[b]	6.48±1.00[b]	5.92±2.08[c]	6.69±1.34[ab]	7.15±1.04[ab]
60% Hawassa-4	7.40±1.16[a]	5.67±0.86[b]	5.17±1.08[c]	6.83±1.34[b]	6.27±0.87[b]	7.00±0.92[b]
Control	5.08±1.46[c]	7.08±1.87[a]	7.00±1.17[ab]	7.92±0.96[a]	7.33±1.81[a]	7.67±1.51[a]

Where 40% = 40% cassava + 60% Chickpea, 50% = 50% cassava + 50% Chickpea and 60% = 60% cassava + 40% Chickpea, Values are mean ±SD. Each value with the same column followed by different letters are significantly different and same letters is not significantly different at level of 0.05

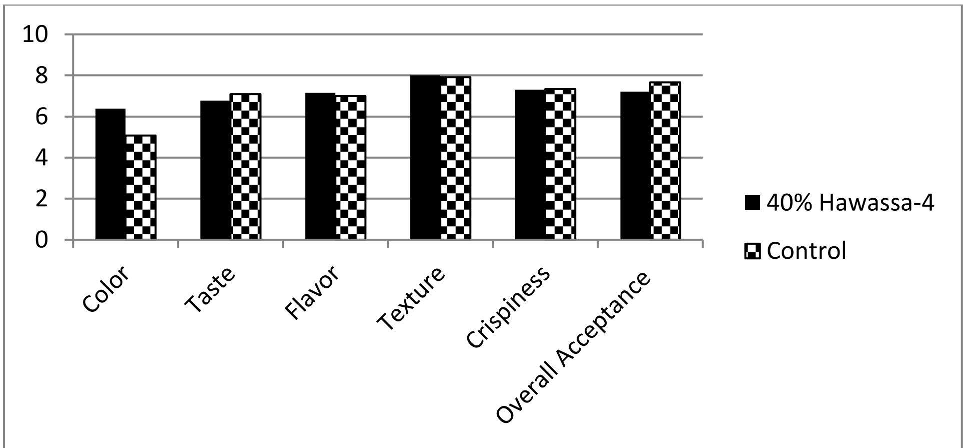

Figure 2. Sensory evaluation result of the 40% Hawassa-4 formulation and control sample

CONCLUSIONS

The results of this study indicated that the functional characteristics and physical properties of cookies were significantly influenced by both cassava variety and chickpea proportion. Among the different formulations, the 40% cassava-60% chickpea blend using the Hawassa-4 variety emerged as the optimal formulation. These cookies achieved the highest spread ratio and exhibited desirable sensory qualities, particularly in terms of texture, flavor, crispiness, taste, and overall acceptance, which are crucial for consumer acceptance. In addition to this the cassava-chick pea cookies had good protein, fiber and micro nutrient content than the control sample. This study shows the commercial potential of using local crops like cassava and chickpea to produce nutritious, acceptable cookies, supporting import substitution, value addition, and economic growth in producing regions. By leveraging locally available raw materials, the approach also offers a sustainable alternative to wheat-based products, with potential to influence both industrial practices and consumer choices in areas where cassava and chickpeas are abundant.

By promoting the use of locally available cassava and chickpea flours in cookie production, this study contributes to the development of sustainable food systems and supports Ethiopia's efforts toward improved food security and reduced reliance on imported wheat. Future research should focus on optimizing processing parameters such as baking temperature and time to further enhance product quality. It is also recommended to test cassava-chickpea flour blends in other baked goods, such as breads, muffins, or cakes, to assess their broader applicability.

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CONFLICTS OF INTEREST

Authors declare that they have no conflict of interest regarding the publication of this paper.

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