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Comparative Analysis of Bread Properties Using Germinated and Un-Germinated Chickpea Flour

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Abstract
The aim of this study was to prepare and compare bread from refined wheat flour (RWF), germinated chickpea flour (GCF) and un-germinated chickpea flour (UGCF). The proximate composition of the flours was analyzed, and bread recipes were formulated using Design Expert software. Bread was prepared with varying proportions of refined wheat flour and UGCF. A (RWF: UGCF = 96.8:3.2), B (RWF: UGCF = 93.6:6.4), C (RWF: UGCF = 90.6:9.4), D (RWF: UGCF = 87.2:12.8), E (RWF: UGCF = 81.4:18.6), F (RWF: UGCF = 78.2:21.8), G (RWF: UGCF = 75:25), and H (RWF: UGCF = 100:0). The straight dough method was employed to prepare the bread. All variations showed significant differences ($p<0.05$) in loaf volume, weight, and specific volume compared to the control. Sensory evaluation was conducted for all eight formulations to assess acceptability, formulation D receiving the highest mean sensory scores across all attributes. The recipe for formulation D was subsequently used to prepare bread incorporating both RWF and GCF and found moisture content, crude protein, crude fat, crude fiber, ash, carbohydrate, iron, calcium, phytate and tannin were found as 42.63%, 14.95%, 6.98%, 1.01%, 0.84%, 773.75%, 2.73mg, 43.64mg, 153.97mg and 11.49mg

respectively. No significant differences (p>0.05) were found between bread made with GCF and UGCF regarding ash content, carbohydrate, iron, and calcium. Significant differences (p<0.05) were observed in moisture content, crude protein, fat, fiber, phytate, and tannin content between the two types of bread.
Keywords*:* Flour, Bread, Physical analysis, Sensory analysis

Introduction

Bread is a fundamental food consumed worldwide, offered in numerous sizes, shapes, textures, and forms, depending on regional and national traditions (Melini & Melini, 2018). It serves as a key staple in both industrialized and developing nations For decades, flour from both hard and soft wheat (*Triticum aestivum Desf*.) has been the primary ingredient in leavened bread due to its functional proteins (Abdelghafor et al., 2011). Wheat along with paddy and maize are the top dominant crops produced in Nepal (Dangal et al., 2021). Grain mixtures such as wheat, oats, barley, rye, millet, and corn, often mixed with milk or water are used to make the most basic breads. These ingredients are kneaded into dough, shaped, and commonly baked. Additional ingredients like sugar, salt, and eggs can be incorporated to improve the flavor, texture, or nutritional profile of the bread (Tiimub, 2013). It might be beneficial to move toward scientific development in order to enhance and diversify the traditional product (Chhetri et al., 2022).

Refined wheat bread is popular for its convenience despite of low nutritional value and has made celiac disease worse in those who are susceptible, even in developed nations. So, developed nations are looking into wheat bread substitutes (Tiimub, 2013). The need from consumers for healthier products has led to the development of breads high in dietary fiber and other bioactive/functional ingredients. Nepal's diverse agroecological, climatic, and soil conditions (Parajuli et al., 2022) are well-suited for the growth of many varieties of crops. For the purpose of improving the usage of underutilized crops and to enhance the nutritional status, food products can be created and consumed as functional foods (Karki et al., 2024).

Use of composite flour can be beneficial as it reduces import of wheat flour and can promotes the locally cultivated crops (Acharya et al., 2023). Protein from chickpeas (*Cicer arietinum* L.) is said to be of higher quality than that of other pulses. With the exception of sulfur-containing amino acids, which can be supplemented by including cereals in the daily diet, chickpeas contain sufficient levels of all the essential amino acids. Pulses contribute significant amount of calorie and protein. Among the various pulses, research findings have concluded chickpea have a higher protein bioavailability. The protein content in chickpea before and after dehulling significantly varies by (17-22%) and (25.3–28.9%) respectively (Jukanti et al., 2012). Digestibility of protein and bioavailability of chickpea seed was only 71.8 % and after cooking improved significantly to 83.5 % (Arab et al., 2010). Nutritiously significant unsaturated fatty acids, such as oleic and linoleic acids, are abundant in chickpeas. Chickpea seeds include mineral like Calcium, Magnesium, Phosphorus and most importantly potassium and cholesterol free (Jukanti et al., 2012). Important vitamins like riboflavin, niacin, thiamin, folate,

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and the precursor β-carotene to vitamin A are all found in good amounts in chickpeas. The food products prepared with higher nutritional value adds flavor and value to our traditional foods while also potentially helping in the fight against protein-energy deficiency (Dahal et al., 2022). Similar to other legumes, chickpea seeds have anti-nutritional elements. Antinutritional factors (ANFs) in legumes can be reduced through soaking followed by germination (Jukanti et al., 2012; Pokharel et al., 2024). Incorporation of chickpea on bakery products could improve the nutritive value and protein content (Arab et al., 2010).

Research Objective

The objective of this work was to incorporate germinated chickpea flour and un-germinated chickpea flour in wheat flour to prepare bread.

Materials and Methods

Materials

Wheat flour, brown chickpea, hydrogenated vegetable ghee, activated dry baker's yeast (*Saccharomyces cerevisea*), pulverized table sugar and common salts were purchased from local market of Itahari, Nepal. All the required equipment and chemicals were provided in the laboratory of Nilgiri College, Itahari.

Methods

Preparation of flour from germinated and ungerminated chickpea

Flour prepared from germinated chickpea seeds followed a modified method of (Mittal et al., 2012). The chickpeas were cleaned, sorted, and soaked in potable water at room temperature overnight. After soaking, the chickpea grains were spread evenly on a plastic mat for germination, ensuring a uniform thickness of approximately 2–3 grains. A moist environment was maintained using a wet muslin cloth, with water sprinkled at 8-hour intervals. Germination was carried out for 48 hours, achieving a germination rate of 85–90%. The germinated chickpeas were dried using a cabinet dryer in three stages: initially at 50°C for 30 min, followed by 75°C for 20 min, and finally at 100°C until a constant moisture content of 13% was reached, taking approximately 1 h. The dried chickpeas were ground, and a 90-mesh sieve was used to obtain fine flour for bread-making. Flour from un-germinated chickpeas was prepared using the same process.

Experimental outline

The research aimed to optimize the inclusion of germinated chickpea in bread by preparing eight formulations, with UGCF concentrations ranging from 0% to 22.4%, in 3.2% intervals. The formulations were adjusted to ensure a total of 100 parts, with the remaining ingredients held constant, as shown in Table 1. The proportions of UGCF and refined wheat flour were balanced based on the flour blend to assess their impact on bread quality.

The bread was made up following the straight dough development process in which all ingredients (dry and liquid) are placed and dough is mixed to full development. The prepared samples were subjected to sensory analysis. Based on the sensory analysis, the formulation for un-germinated chickpea incorporated bread was optimized. The optimized bread recipe was

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used to prepare the bread incorporating GCF. The two bread samples prepared in this manner were then analyzed for their proximate composition.

Table 1: Recipe formulation for bread

Ingredients	Samples							
	A	B	C	D	E	F	G	H
Wheat flour (parts)	96.8	93.6	90.4	87.2	84	80.8	77.6	100
UGCF (parts)	3.2	6.4	9.6	12.8	16	19.2	22.4	0
Sugar (parts)	10	10	10	10	10	10	10	10
Salt (parts)	1	1	1	1	1	1	1	1
Yeast (parts)	3	3	3	3	3	3	3	3
Fat (parts)	3	3	3	3	3	3	3	3
Water (ml)	60	60	60	60	60	60	60	60

Source: (Mala et al., 2018)

Preparation of bread

All ingredients were prepared according to the formulation shown in Table 1. The bread was prepared with slight modifications according to the method outlined by Veluppllai et al., (2010). For dough preparation, refined wheat flour and chickpea flour were blended, followed by the addition of water, salt, yeast, and sugar. The mixture was kneaded by hand for 20 min and left to ferment for 45 min. After fermentation, the dough was knocked back, scaled, and divided, then proofed for 30 min. It was molded, placed in pans, and proofed for another hour. The dough was baked at 220°C for 30 min, then cooled, sliced, and packed in LDPE plastic. Thus prepared bread was used for sensory evaluation on following day.

Proximate analysis raw materials and products

All chemical analyses were performed in triplicate. The moisture, crude protein, crude fat, total ash and crude fiber contents of samples were determined as per described by Ranganna, (1986). Carbohydrate content was determined by difference in value Sherma et al., (2024):

Total Carbohydrate = 100 – (fat + protein + ash + moisture + crude fiber) %

Gluten content

The gluten content of the flours was assessed using the hand washing technique as per Ranganna, (1986). A 25 g flour sample was weighed and mixed with water to form a dough ball, which was then submerged in water for an hour to aid starch removal. The starch was manually washed away, and its removal was verified using an iodine test. The starch-free dough was pressed to remove excess moisture and weighed. It was then dried in an oven at 100 °C for 24 h and reweighed. The gluten percentage was calculated from the recorded weights.

$$\text{Wheat gluten (\%)} = \frac{\text{Weight of gluten}}{\text{Weight of sample}} \times 100$$

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Physical parameter analysis of the bread

Volume of bread

Weight of bread was determined by weighing balance and volume of bread was determined by rapeseed displacement method as mentioned in (Rahman et al., 2015).

Specific loaf volume

Specific loaf volume of the bread specific loaf volume of bread is defined as the ratio of the volume of bread to the weight of bread. The specific loaf volume of bread was determined as suggested in Al-Saleh & Brennan, (2012).

$$Specific\ loaf\ volume\ =\ volume\ of\ bread /\ weight\ of\ bread.$$

Mineral and anti-nutritional content of wheat flour and bread

Calcium content

Calcium content was determined by precipitation method (KC & Rai, 2012).

Iron content analysis

The iron content of the sample was analyzed by converting all iron into its ferric form using oxidizing agents like hydrogen peroxide (H_2O_2) or potassium persulfate ($K_2S_2O_8$). The solution was then treated with potassium thiocyanate (KSCN) to form red ferric thiocyanate, which was measured calorimetrically at a wavelength of 480 nm (KC & Rai, 2012).

Phytate content

The sample weighing 0.2 g was placed in a 250 ml conical flask. It was soaked in 100 ml of 20% concentrated HCl for 3 h, the sample was then filtered. 50 ml of the filtrate was placedin a 250 ml beaker and 100 ml distilled water was added to the sample. Then, 10 ml of 0.3% ammonium thiocyanate solution was added as indicator and titrated with standard iron (III) chloride solution which contained 0.00195 g iron per 1 ml (Emmanuel & Deborah, 2018).

$$\text{Phytic acid (\%)} = \frac{\text{titer value}\times 0.00195\times 1.19}{2}\times 100$$

Tannin content

Tannin content was determined by the method adopted by Rajan et al., (2011). Detection of the blue color produced by tannin-like substances reducing Folin-Ciocalteu reagent in alkaline condition for colorimetric estimation of tannins. 0.1 ml of ethanolic extract was taken and 0.5 ml of Folin-Ciocalteu reagent was added in it. After that 1 ml of 0.5% Na_2CO_3 was added in it and then 10 ml of volume was made up with distilled water. Within 30 min of the process, the absorbance at 755 nm was measured in comparison to the reagent blank. Tannic acid concentrations of 20, 40, 60, 80, and 100 µL/ml were used to create the standard curve. The sum Tannic acid (g TE/g extract) was used to express the tannins in the extracts.

Sensory Evaluation

Sensory evaluation was performed by 9 points hedonic scoring test (9 = like extremely, 1= dislike extremely) for color, texture, crumb, flavor, and overall acceptability measures. For sensory evaluation, the hedonic rating method was used as described by Ranganna, (1986). The panelist members consisted of faculties and students of Nilgiri College. Panelists were encouraged to rinse their mouths with warm water to cleanse their palates following each

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sensory evaluation. A sensory analysis was conducted on the next day that the bread were made.

Statistical Analysis

All the data obtained was analyzed by using IBM SPSS Statistice (version 25). Means were compared by Tukey's honestly significant difference (HSD) test at 5% level of significance to determine whether the sample were significantly different from each other. Microsoft- Excel 2016 was employed for the general calculations and tabulation.

Results and Discussion

Proximate composition of RWF, UGCF and GCF

The protein, moisture, fat, total ash, crude fiber, carbohydrate, and gluten content of RWF, UGCF, and GCF are all displayed in Table 2. The moisture content in wheat flour was recorded at 12.3%, slightly lower than the 12.92% reported by Dangal et al., (2021). The crude fat content was 1.67%, marginally higher than Dangal et al., (2021) (1.09%). Total ash was 0.54%, slightly below the 0.78% reported by Sangroula et al., (2024). Protein content was 13.88%, slightly exceeding Sangroula et al. (2024) (13.27%). Crude fiber was 0.29%, lower than Pokharel et al., (2023) (0.4%), while gluten content was 9.8%, nearly identical to Sangroula et al., (2024) (9.11%).

Moisture content of these flours were significantly different ($p<0.05$) with each other. The rise in moisture content in GCF than other two flour may be due to low amount of dry matter. The moisture content of flour has a significant impact on its quality. Flour storability is determined by moisture content. Increase in the levels of moisture stimulate microbiological activity, leading to product degradation in storage. Moisture content more than 14% is unacceptable (Bhatt & Gupta, 2015).

Table 2: Proximate composition of wheat and chickpea flour (germinated and un-germinated) per 100 g.

Parameter	RWF	UGCF	GCF
Moisture (% wb)	12.3 ± 0.17^a	10.38 ± 0.11^b	10.44 ± 0.14^b
Protein (% db)	13.88 ± 0.06^a	21.04 ± 0.07^b	22.34 ± 0.04^b
Fat ((db)	1.67 ± 0.11^a	5.36 ± 0.31^b	6.22 ± 0.18^c
Total ash (db)	0.541 ± 0.25^a	3.15 ± 0.25^b	2.95 ± 0.17^b
Crude fiber (db)	0.293 ± 0.37^a	6.81 ± 0.11^b	5.95 ± 0.144^c
Carbohydrate (db)	75.24 ± 0.61^a	64.10 ± 0.14^b	63.74 ± 0.76^b
Gluten (%)	9.8	0	0

Values are the means of triplicates ± standard deviation. Mean values within each row followed different letters are statistically significantly ($p< 0.05$) different.

Protein content was found higher in GCF compared to UGCF and RWF but no significant different ($p>0.05$) between germinated and un-germinated flour. The increase in protein content showed nutritional advantage on the GCF. The rise in protein value with germination may be attributed to net synthesis of enzyme protein by germinated seeds which might have resulted

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in the production of certain amino acids during protein formation (Marero et al., 1988). In addition, the utilization of seed components and the breakdown of protein into simple peptides during the germination phase were the primary causes of this rise (El-Adawy, 2002).

Fat content were significantly different ($p<0.05$) among flours. Fat content of UGCF was found to be higher than GCF. The activity of lipolytic enzymes increases during germination and hydrolyzes fat components into fatty acids and glycerol, may be the cause of this decrease in fat content. Similar result was found by Chinma et al., (2009).

The carbohydrate of refined wheat flour was in agreement with the studies of Rani & Singh, (2018) who found 74.21% and in un-germinated and germinated chickpea flour were obtained higher with the finding made by El-Adawy, (2002). Carbohydrate content of GCF was lower than UGCF and RWF. There was no significant effect ($p>0.05$) between GCF and UGCF. During the stages of germination, alpha amylase activity increases and causes the breakdown of complex carbohydrates into simpler and absorbable sugars are utilized by growing seedlings. However, moisture and carbohydrate contents were detected to be considerably lower. Chickpea flours appeared to be of higher nutritional value compared to RWF in terms of proteins, fat, ash, and fibers. These findings were in line with those reported by Hefnawy et al., (2012). Between the two types of chickpea flour, proteins, fat, and total carbohydrates appeared to be similar. However, ash content was significantly lower ($p<0.05$) in germinated compared to the ungerminated GCF.

Crude fibers was modestly, but significantly ($p<0.05$) increased in GCF compared to UGCF. It appears that germination of chickpea ultimately increased the fiber content of the flour. Fibers are the edible parts of pulses that are resistant to digestion and absorption in the human small intestine, with complete or partial fermentation in the large intestine. Fibers are of high importance since they have beneficial physiological effects, including laxation, blood glucose, and cholesterol attenuation (Tosh & Yada, 2010). The mechanism behind fibers increase is still unclear, and is thought to be due to Maillard reactions or to the presence of different amounts of fiber-associated resistant starch or protein–fiber complexes (Pedrosa et al., 2015; Vasishtha & Srivastava, 2013).

As for the compositions of chickpea flours, they appear to be comparable with others except for ash. The ash content appears to be significantly lower in GCF compared to UGCF (Arab et al., 2010).

Mineral content of RWF, UGCF and GCF

The mineral content of refined wheat flour, germinated and ungerminated chickpea flour are presented in Table 3.

Table 3: Mineral content of refined wheat flour and chickpea flour (germinated and un-germinated) per 100 g.

Parameter	RWF	UGCF	GCF
Iron (mg)	2.32 ± 0.14^a	6.25 ± 0.1^b	5.58 ± 0.01^c
Calcium (mg)	29.62 ± 0.37^a	141.12 ± 0.34^a	139.22 ± 0.41^b

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Values are the means of triplicates ± standard deviation. Mean values within each row followed different letters are statistically significantly ($p < 0.05$) different.

In this study, iron and calcium were detected as 2.32 mg and 29.62 mg per 100 g. Iron and Calcium content of germinated chickpea flour showed significant decrease than un-germinated chickpea flour. Similar pattern of results were observed by El-Adawy, (2002) who found calcium 176mg in raw chickpea and 166mg per 100g in germinated chickpea. Lee and Karunanithy (1990) stated that the loss of calcium content associated due to its binding with protein leading to the formation phytate-cation-protein compound. Iron content were found lowered in germinated than un-germinated chickpea which closely agreed with finding made by Lee & Karunanithy, (1990) in germinated beans.

Anti-nutritional content of RWF, UGCF and GCF

Table 4 lists the antinutritional properties of refined wheat flour, germinated chickpea flour, and un-germinated chickpea flour.

Table 4: Anti-nutritional of refined wheat and chickpea flour (germinated and un-germinated) per 100 g.

Parameter	RWF	UGCF	GCF
Phytate (mg)	167 ± 0.17^a	90.23 ± 0.35^a	65.23 ± 0.41^b
Tannin (mg)	6.5 ± 0.37^a	169.77 ± 0.41^b	45.61 ± 0.37^c

Values are the means of triplicates ± standard deviation. Mean values within each row followed different letters are statistically significantly ($p < 0.05$) different.

Phytate and tannin content of GCF was significantly reduced ($p<0.05$) compared to un-germinated and refined wheat flour. In this study phytate of RWF was 1.67mg/g which was lower than values obtained by other researcher. Febles et al., (2002) reported 3.0mg/g in factory produced RWF. These could result from the leaching of soluble tannin molecules during soaking and a rise in endogenous phytase enzyme activity, which was then further decreased following germination (Desalegn, 2015). Tannins are naturally generated polyphenols that block enzymes and form compounds with proteins to limit the digestion of proteins. However, cereal tannins and phenols also function as good sources of antioxidants and are necessary for metabolic disorders, aging, and overall wellness (Rani & Singh, 2018).

The tannin activity during germination may have contributed to the greater decrease of tannin. These findings are in good agreement with those published by El-Adawy, (2002) for sprouted chickpea.

Physical properties of bread

Physical properties of bread such as loaf volume, weight and specific loaf volume are presented in the Table 5.

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Table 5: Physical analysis of Control and UGCF incorporated bread

Samples	Loaf volume (cm^3)	Weight (g)	Specific loaf volume (cm^3/g)
A	325.98±0.08^{a}	155.44±1.12^{a}	2.10 ± 0.069^{a}
B	319.13±0.53^{b}	153.36±1.85^{a}	2.08±0.004^{b}
C	309.36±0.61^{ab}	151.66±1.76^{b}	2.04±0.031^{a}
D	299.98±0.73^{c}	147.94±1.23^{ab}	2.03±0.034^{ab}
E	295.67±0.89^{bc}	146.20±1.32^{c}	2.02±0.017^{c}
F	292.67±0.31^{d}	145.35±1.70^{d}	2.01±0.016^{c}
G	283.56±0.29^{d}	142.56±1.34^{d}	1.99±0.046^{d}
H (control)	348.78±6.69^{e}	165.25±1.49^{e}	2.39±0.027^{e}

*Values are the means of triplicates measurement ± standard deviation. Mean values within each column followed different letters are statistically significantly ($p<0.05$) different.

Weight of loaf is based on the amount of dough used, moisture and carbon dioxide release out during baking (Menon et al., 2015). The weight of bread decreased significantly (165.25±1.49 to 142.56±1.34 g) with increasing replacing RWF with GCF. The decrease in loaf weight could be attributed to decrease in moisture content and increase in fat content chickpea flour. This might be due to the lower water absorption of composite flours compared to controls (Hefnawy et al., 2012). This result is similar to the study of Dabels et al., (2016).

The loaf volume of bread made incorporating the GCF decreased significantly (348.78±6.69 to 283.56±0.29) compared with bread made from the 100% RWF on increasing replacing RFW with GCF. It was found that on increasing the percentage of substitute flour had a detrimental impact on bread volume. The result obtained was similar to the finding reported by Menon et al., (2015), who found higher volume to the bread made from RWF and lower to higher percentage of incorporation of chickpea flour. It is known that fibers induce the gluten in RWF to dilute and deterioration of gluten network, as a result the volume of bread reduces. Similar result was obtained by Dabels et al., (2016) in similar work.

Several studies have shown that reducing the amount of gluten in bread dough formulation by diluting it with non-RWF decreased the volume and specific volume of bread (Indrani et al., 2010). In addition, to it was anticipated that adding chickpea flour would reduce the specific volume of bread because it would dilute the gluten-forming proteins, which are only found in RWF (Brites et al., 2022).

Sensory quality attributes of bread

Eight UGCF bread samples were prepared by altering the UGCF formulation. Table 6 displays the mean scores and significant differences for color, flavor, texture, crumb, and overall acceptance.

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Color of breads

The statistical analysis showed that there was a significant effect (p<0.05) of chickpea flour variation on color at 5% level of significance. The mean sensory score for color of sample D was found to be 7.7, which was significantly similar to control sample H that was found to be 7.6. Statistical analysis showed that the partial substitution of UGCF on RWF had significant effect (p<0.05) on the color. The effect of higher amount of incorporation of the chickpea flour may be the cause of slightly darker color that are observed in the case of other samples which could be the cause of lower acceptance due to color. The darker color is be due to Maillard reaction between reducing sugar and protein (Dhingra & Jood, 2002). In this case, an increase in protein content, especially the higher lysine, from chickpea flour probably caused the darker crust color.

Table 6: Mean sensory score of bread incorporated with UGCF

Sample	Color	Flavor	Texture	Crumb	Overall Acceptability
A	7.4 ± 0.36^a	6.5 ± 0.43^a	7.1 ± 0.64^a	6.6 ± 0.26^a	6.8 ± 0.47^a
B	7.1 ± 0.4^b	6.6 ± 0.23^a	6.7 ± 0.62^b	6.6 ± 0.42^a	6.7 ± 0.53^b
C	7.0 ± 0.33^a	6.4 ± 0.53^a	6.5 ± 0.26^c	6.5 ± 0.47^b	6.9 ± 0.13^c
D	7.7 ± 0.21^c	7.3 ± 0.22^b	7.1 ± 0.42^a	7.5 ± 0.23^c	7.4 ± 0.23^d
E	6.5 ± 0.51^b	6.2 ± 0.51^d	6.6 ± 0.47^c	6.1 ± 0.53^d	6.1 ± 0.53^e
F	6.2 ± 0.41^d	6.1 ± 0.41^d	6.4 ± 0.53^e	6 ± 0.33^e	5.9 ± 0.33^f
G	6.1 ± 0.22^d	5.9 ± 0.22^e	6.1 ± 0.13^b	5.7 ± 0.21^f	5.9 ± 0.41^g
H	7.6 ± 0.33^c	7.2 ± 0.27^b	7.2 ± 0.33^a	7.3 ± 0.17^g	7.2 ± 0.36^h

*Values are the means of triplicates measurement ± standard deviation. Mean values within each column followed different letters are statistically significant different (p < 0.05) different.

Flavor of breads

The statistical analysis showed that the partial substitution chickpea flour on RWF had significant effect (p< 0.05) on the flavor of the different bread formulation. Product D got 7.3, the highest score which was significantly different from other formulation but similar to control sample H that scored 7.2. From this, it was found that as the amount of chickpea flour increases the acceptability on flavor of product but flavor was found in decreasing order after further incorporation of chickpea flour increased, whcih could be due to beany flavor of chickpea. As the level of substitution of UGCF increases the product had a

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significant beany flavor which could be the causes of poor acceptance by the panelist and gave low rank (Dabels et al., 2016).

Texture of breads

The statistical analysis showed that there was no significant effect (p>0.05) of chickpea flour variation on texture was found in product A, D and H. The texture of sample H scored the highest mean value 7.2 among all the samples formulated by incorporating UGCF. Which may be due to its higher gluten content, which provides good texture to different RWF based products (Benayad et al., 2021). With increase in proportion of chickpea flour, the level of protein also increases that results in lower dough hydration and less consistency of dough resulting crumbly bread as observed by Manohar & Rao, (1999).

Crumb of breads

The statistical analysis showed that there was a significant effect (p<0.05) of chickpea flour variation on crumb. The product D scored 7.5 was significantly different with other product whereas scored was found close to control product H which scored 7.3. Use of excessive non glutinous flour gives poor crumb characteristics and decreases acceptability. The increased crumb firmness value show adverse effect of on the addition of GCF and similar result on the multigrain bread performed by (Indrani et al., (2010).

Overall acceptability of breads

Effect of chickpea flour incorporation on overall acceptability of breads showed that there was a significant effect (p<0.05) of chickpea flour variation on overall acceptance at 5% level of significance The mean sensory score on overall acceptance of products were significantly different (p<0.05). On increasing the level of substitution of chickpea flour overall acceptance decreases and similar result was reported by Yaver & Bilgiçli, (2018). The highest overall acceptability scores were obtained using 5% of significance in both breads

The statistical analysis means sensory score in terms of color, flavor, texture and overall acceptance of product D using 87.2% RWF and 12.8% UGCF got highest mean sensory score than other bread formulation.

Selection of best product

Thus, from statistical and sensorial analysis, the best product (D) was found to be composite bread containing 12.8% UGCF and 87.2% RWF and same proportion of GCF incorporated bread was prepared.

Nutritional profile of UGCF and GCF incorporated bread

Table 7 provides the nutritional profile of bread made with 12.8% GCF and 12.8% UGCF (best product, sample D), while keeping the other ingredients constant. Moisture content of UFCF and GCF incorporated bread was 40.3% and 42.63 %. Germination caused significant increase in the moisture content of chickpea flour which may be attributed to the water absorbed during germination. The results are in agreement with Mubarak, (2005) who also reported an increase in the moisture content of chickpea during germination. The in vitro protein digestibility (IVPD) values was not affected among breads made with germinated flour compared with bread made with raw chickpea flour. The improvement in digestibility might result from the

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denaturation of protein, destruction of the trypsin inhibitor or reduction of tannins and phytic acid in GCF. Processing can improve the digestibility of proteins by destroying protease inhibitors and opening the protein structure through denaturation (Hsu et al., 1977).
A significant increase in fat content was observed in GCF than UGCF un-germinated flour used due to which the bread prepared from GCF had higher fat content when constant fat was used as shortening. It may be due to the activity of lipases enzyme which breaks down the triglycerides and produces compounds like free fatty acids and glycerol (Perveen et al., 2024) and also related due to the use of fat as energy during the germination process (Mittal et al., 2012).

Table 7: Nutritional profile of germinated and UGCF incorporated bread.

Nutritional profile	UGCF incorporated bread (Sample D, 12.85% UGCF:87.2%)	GCF incorporated bread (12.85% GCF:87.2 RWF)
Moisture content (%wb)	40.3±0.2[a]	42.63±0.15[b]
Crude protein (%db)	14.79±0.05[a]	14.95±0.09[b]
Crude fat (%db)	5.14±0.23[a]	6.98±0.45[b]
Crude fiber (%db)	1.12±0.26[a]	1.01±0.07[b]
Ash (%db)	0.87±0.16[a]	0.84±0.09[a]
Carbohydrate (%db)	73.80±0.43[a]	73.75±0.28[a]
Iron (mg)	2.82 ± 0.17^{a}	2.73 ± 0.24^{a}
Calcium (mg)	43.88 ± 0.33^{a}	43.64 ± 0.16^{a}
Phytate (mg)	157.13 ± 0.34^{a}	153.97 ± 0.44^{b}
Tannin (mg)	27.39 ± 0.56^{a}	11.49 ± 0.34^{b}

*Values are the means of triplicates measurement ± standard deviation. Mean values within each row followed different letters are statistically significantly ($p<0.05$) different.

A slight decrease in ash was observed in bread made with GCF compared to that made with UGCF, probably caused by leaching of minerals during soaking and germination (Baik & Han, 2012; Mittal et al., 2012). Significant increase in the crude fiber content in GCF incorporated bread was mainly due to the use of seed components and degradation of protein to simple peptides during the germination process.
Carbohydrate content of chickpeas decreased from 73.80% to 73.75 % during germination. The reduction in carbohydrate content may be attributed to utilization of carbohydrates as the source of energy by the developing embryo during germination (Chinma et al., 2009).
There was decrease in iron and calcium content in germinated chickpea flour incorporated bread. This decrease in mineral content may be attributed to leaching of minerals into soaking medium (Okorie et al., 2013).
The phytate and tannin in bread made by incorporating GCF was 157.13 mg and 27.39 mg and 153.97 mg and 11.49 mg per 100g in bread made incorporating UGCF and GCF respectively. These could result from the leaching of soluble tannin molecules during soaking and a rise in endogenous phytase enzyme activity, which was then further decreased following germination (Desalegn, 2015). The tannin activity during germination may have contributed to the greater

decrease of tannin. These results align well with the findings reported by El-Adawy, (2002) for sprouted chickpeas.

Conclusion

Bread prepared using a 12.8: 87.2 ratio of ungerminated chickpea flour to refined wheat flour showed good sensory qualities compared to wheat flour bread. GCF bread is considered superior to UGCF based on its nutritional profile, as it demonstrated higher crude protein and crude fat content, along with a significant reduction in antinutritional factors, while both UGCF and GCF bread showed similar levels of crude fiber, ash, carbohydrate, iron, and calcium content. Further studies could explore the use of barley, millet, soybean, and other grains for preparation and analysis to enhance the nutritional profile and properties of bread.

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Conflict Of Interests

None

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