Egyptian Journal of Nutrition
Official journal of the Egyptian Nutrition Society
Print ISSN: 1687-1235
Online ISSN: : 2090-2514
Vol. 40 (3):26-45(2025).
DOI: 10.21608/ENJ.2025.416803.1137
https://ejn.journals.ekb.eg/

Nutritional, Physical, Chemical, and Sensory Evaluation of Pulse-Based Brownies as a Healthy Alternative to Wheat Flour

Wafaa Z. Elfeky[1*]:, Eman S. Mohamed[2]and Hanan A. Hussien[2]

1 Crops Technology Res. Department, Food Technology Research Institute, Agricultural Research Center, Egypt.

2 Bread and Pastries Res. Department, Food Technology Research Institute, Agricultural Research Center, Egypt.

[*]**Corresponding Author:** Wafaa Z. Elfeky

Email: wafaazakaria98@yahoo.com

ABSTRACT

This study developed nutritionally enhanced, gluten-free brownies by completely replacing wheat flour with red lentils, chickpeas, or faba beans. The nutritional, physicochemical, and sensory properties of these pulse-based formulations were evaluated. Pulses were soaked and crushed to create pastes that replaced wheat flour, eggs, dairy, and gluten, producing vegan brownies suitable for individuals with dietary restrictions or allergies. Incorporation of pulse paste increased protein content to 18.50–20.19%, crude fiber to 2.10–2.61%, and iron content to 4.23–5.62 mg/100 g, compared with the wheat flour control. Faba bean brownies recorded the highest protein (20.19%) and crude fiber (2.61%). Chickpea brownies exhibited the highest ash (1.86%), fat (13.82%), calcium (130.69 mg/100 g), zinc (2.10 mg/100 g), antioxidant activity (82.03%), and total phenolic content (869.0 mg GAE/100 g). Lentil brownies contained the highest flavonoid content (122.0 mg/100 g) and iron (5.62 mg/100 g). Texture analysis showed reduced hardness and chewiness, linked to higher moisture and crude fiber. Specific volume decreased significantly in all pulse-based brownies compared with the wheat brownies. Sensory evaluation indicated no significant difference in overall acceptability between lentil brownies and the wheat brownies; chickpea brownies achieved the highest score (8.75) and faba bean brownies the lowest (7.58). These results confirm pulses as nutritionally superior and sensorily acceptable wheat flour alternatives for gluten-free and vegan brownies, providing a scientific basis for functional bakery product development.

Keywords: Lentil, Chickpea, Faba bean, substitute brownies, Quality properties .

Received: 26-8-2025 ***Accepted:13-9-2025*** ***Published: Issue 3- 2025***

INTRODUCTION

The need for affordable functional food products has increased due to changing lifestyles and preserving good health **(Deepika et al., 2024)**. At the same time to improved awareness of healthy diets and viability, the numbers of pulse-based alternatives being introduced to the market have been increasing **(Onwezen et al., 2021)**. Beans, chickpeas, peas, lentils, and soybeans are among the edible seeds that belong to the leguminosae family. They offer a significant amount of energy, protein, dietary fiber, and micro-nutrients, according to the **FAO (2023)**. In particular, they are crucial for the prevention and management of chronic diseases like diabetes, cardiovascular disease and cancer **(Askari 2021)**. Additionally, the high lysine content of pulse proteins complements the amino acid composition of cereals, particularly in diets lacking in proteins **(Boye et al., 2010)**. Moreover, pulse powder are less digestible than cereal powder. According to **Guillon and Champ (2002)**, pulses are actually considered low-glycemic foods, and adding pulse flours to baked goods can lower their glycemic index.

Lentils (*Lens culinaris M.)* are grown in a variety of agroecological zones across the world . A good source of dietary fiber (31 %in red and pink lentils,11 % in green lentils), certain minerals, and a variety of bioactive compounds, lentils are high in protein (about 25 %) **(Dhull et al., 2022)**. Even though lentils have about (60%) carbohydrates, it's important to remember that these carbohydrates are somewhat slowly broken down in the intestine **(Sidhu et al., 2022)**.

Chickpea (*Cicer arietinum L.*) is the third most important pulse crop, which has high levels of protein and a low glycemic index , dietary fiber, vitamins, and vital minerals.The types of chickpea had protein content (23.33% to 30.95%), lipid (4.25% to 6.98%), and carbohydrate (54.60% to 60.40%) contents **(Gupta et al.2019)** . According to **USDA (2021)**, it is a notable source vitamins (folic acid, tocopherol, and niacin), minerals (potassium, phosphorus, magnesium, and calcium), bioactive compounds (phenolic acids, isoflavones, and saponins),unsaturated fatty acids (mainly linoleic and oleic acids), dietary fibers, and a higher proportion of nondigestible carbohydrates. Compared to other pulses, chickpeas have higher protein digestibility (76–78%) and better protein quality, it has eight essential amino acids **(Wang et al., 2021)**. Chickpeas have been shown to have positive effects on cardiovascular disease, cancer, and the reduction of blood pressure, cholesterol, and glucose levels **(Sharma et al., 2017)**. Chickpea protein has a digestibility range from 48% to 89.01% **(Rachwarosiak et al., 2015)**.

The broad bean, or faba bean (*Vicia faba*), has a protein content that high in lysine, complex carbohydrates, dietary fiber, secondary metabolites that are not nutrients, and bioactive compounds that have a number of health advantages **(Khazaei et al., 2019; Liu et al., 2022)**. According to **USDA (2021)**, faba beans have a high level of proteins (26.1%) , dietary fiber (25.0%) and carbohydrates (58.3%). Additionally a good source of minerals and other macro- and microelements **(Rahate et al. 2020)**.

The importance of pulses soaking process improved the nutrient bio-availability of pulses , protein digestibility and reduced the presence of anti-nutritional factors **(Patterson, Curran, and Der, 2017)** . pulses dehulling often removes anti-nutrients while improving nutritional quality. Dehulling process reduces crude fiber, dietary fiber, and tannin levels while increasing protein and fat contents in faba beans. However, phenolic content, and antioxidant activity may not be equally affected by dehulling **(Yu-Mi ,2023)** ,additionally dehulling process improve the

protein content and starch , little effect in ash content and significant decrease in tannin content in lentil **(Dhull et al., 2022)**.

Brownies are chocolate-flavored cakes that can be baked or steam-cooked using basic ingredients. It is typically eaten as dessert, and depending on personal preference, it can have a fudgy or cakey texture **(Selvakumaran et al., 2019),** There is no need for gluten to develop. Studies confirm that replacing some or all of the wheat flour in brownies with pulse-based alternatives can produce a healthier, nutrient-dense product. Pulses such as chickpea, lentil, and bean flour are high in protein and fiber, contributing to a more balanced nutritional profile. However, adjustments are often required to manage the physical and sensory changes that come with using pulse flours**.**

This study was conducted to prepare and evaluate pulse-based brownies made from lentils, chickpeas and faba beans paste that can offer a healthy food choice for all consumers categories

MATERIALS AND METHODS

Materials

Wheat flour of extraction rate 72% ,red split lentils, split faba beans and chickpea seeds , molasses , sunflower oil, vanilla essence, unsweetened cocoa powder, baking powder and baking soda were purchased from local market, Zagazig City, Al Sharqia Governorate. Chemicals used in this work were of analytical grade.

Methods

Preparation of pulses

The pulse seeds were cleaned from foreign matter, seeds and dust . The split lentils were washed well and soaked in tap water for 3-4 hours at room temperature and the water was changed about 2 times. After that water was decanted until usage. The split faba beans were washed well, covered with boiled water ,and let them soak for 12 hours at room temperature 25±2°C and the water changed 3 times .After that water was decanted until usage. Chickpea seeds were washed well, covered with boiled water ,and let them soak for 12 hours at room temperature and the water changed 3 times .After that water was decanted until usage and the chickpea hull was removed manually to get chickpeas split until usage.

Preparation of brownies

For the preparation of brownies, the method was carried out according to **Rashid et al.,(2021)** with some modification. Soaked pulses, sunflower oil, molasses, vanilla , baking powder , baking soda and cocoa powder were added to an electric mixer(Bosch 1000 w model mum58420 made in Slovenia) and mixed until well blended . Water was added to the mixture as required. Then, the mixture is consistently mixed and the batter is then poured into the mold. After that, samples were baked at 160°C for 30 minutes. Baked samples were left to cool for 1 h at room temperature,cut into cubes (3.5, 3.5, and 2 cm), and kept until analysis for physical and sensory properties (Figure 2). The rest of the brownies were stored in an airtight plastic container at -18°C until further chemical analysis.

Table 1: Formula of alternative gluten-free brownies

Ingredients (gm)	WBF	LBF	CHBF	FBF
Wheat flour	100	-	-	-
Soaked Lentil	-	100	-	-
Soaked Chickpea	-	-	100	
Soaked Faba bean	-	-	-	100
Cocoa powder	20	20	20	20
Sunflower Oil	15	15	15	15
molasses	65	65	65	65
Baking powder	3	3	3	3
Baking Soda	3	3	3	3
Vanilla essence	2	2	2	2

WBFl: Wheat brownies Formula , LB: lentil brownies Formula, CHB: chickpea brownies Formula and FB: faba bean brownies Formula.

Chemical analysis:

The moisture, crude protein ,fat, crude fiber and ash contents of soaked pulses and brownies were analyzed based on (**AOAC, 2019**). Total carbohydrates content was calculated by difference on dry weight basis according to the following formula (1):

$$\textit{Total carbohydrates}\ (\%) = 100 - (\textit{ash} + \textit{fat} + \textit{crude protein} + \textit{crude fiber}). \quad 1$$

Iron (Fe), zinc (Zn), and calcium (Ca) contents were measured using the Agilent Technologies Microwave Plasma Atomic Emission Spectrometer (Model: 4210-MP, AES, USA) (**AOAC, 2019**). were calculated according to (RDA, 1989) from formula (2) as follows:

$$\text{RDA}\ (\%) = \textit{Value of the nutrient in the brownies sample} \times 100\ /\ \textit{RDA for the same nutrient} \quad 2$$

Water holding capacity (WHC)

The water holding capacity (WHC) of the main raw materials were determined by weighing 1 g of sample (W1) in a pre-weighed tube (W2) and mixing it with 10 ml of H2O (**Hayta et al., 2002**). Then samples were allowed to stand for 30 min and centrifuged at 4000 xg for 20 min (Model Z 206 A, HERMLE Labrotechnik GmbH, Wehingen, Germany). Excess water from samples was decanted, allowed to drain, and reweighed (W3). The WHC were calculated as formula (3):

$$WHC\ (g/g) = (W3 - W2)\ /\ W1 \quad \mathbf{3}$$

Total Phenolic, Total Flavonoids Content and Antioxidant Activity as(DPPH)

Total phenolic content was evaluated according to the method of **Singh et al. (2002)** using Folin–Ciocalteu reagent . It was expressed as milligrams of gallic acid equivalents per 100-g dry weight . The total flavonoid content was determined using the method of **chang et al., (2002)** as milligrams of Quercetin equivalent per 100-g dry weight **.** The free radical scavenging activity was determined using the 2.2-diphenyl-2-picryl-hydrazyl (DPPH %) method according to **Fischer et al. (2013)**. The scavenging activity was calculated using the following equation(4):

$$DPPH\ radical\ scavenging\ activity\ (\%) = (A0 - B1)/A0 \times 100 \qquad 4$$

Where A0 and B1 are the absorbance (at 515 nm) of the control and the sample, respectively.

Sensory evaluation of brownies

Fifteen panelists were given four random samples from the midsection of the brownies The brownies were evaluated using a nine-point hedonic scale (1 = extremely disliked, 9 = extremely liked) for appearance, odor, color, texture, taste, mouthfeel, and overall acceptability , according to **Lyon *et al*., (1992)** with some modification.

Physical properties

Brownie's weight (g) was recorded after cooling using a digital balance. Brownie's volume (mm^3) was determined by using the alfalfa seed displacement method.

Specific volume of brownies was measured according to **(AACC, 2016)** as a ratio of a volume of produced brownies to its weight occupied after baking, using the following equation (5):

$$Specific\ volume = volume(mm^3)/Weight(gm) \qquad 5$$

Color Measurement

Brownies were evaluated for color using a colorimeter (CR-400, Konica Minolta Sensing Inc., Japan). The measuring head was placed in the center of each brownie cube. Color values were measured in triplicate and means were recorded as L^* = lightness (0 = black, 100 = white), a^* ($-a^*$ = greenness, $+a^*$ = redness) and b^* ($-b^*$ = blueness, $+b^*$ = yellowness).

Texture Profile Analysis (TPA)

Texture Profile Analysis of brownies in terms of hardness (N), adhesiveness (mJ), cohesiveness, springiness (mm), chewiness (mJ), gumminess (N), and resilience was measured using Brookfield Engineering Lab., Inc., Middleboro, MA. 02346-1031, USA according to **AACC (2010)**. Brownies were cooled and analyzed after 24 h of baking. Measurements were made for two cycle compressions , and the following test settings were used: Target =4.00 % Trigger load = 3.00 N - Test speed = 3.00 mm/s - Return Speed = 3 mm/s**.**

Measurement of Water Activity (a_w)

Lab Start-aw (Nevisian, Switzerland) equipment was used to measure the water activity of samples at 25±2°C (**Shahidi *et al*., 2008**).\

Statistical Analysis

The data was performed to one way analysis of variance (ANOVA) using computer software Costat statistical version 6.400. The experimental data were statistically analyzed for means and standard deviations at $p<0.05$ in triplicate using Duncan's multiple range tests, to assess differences between the sample means (**Steel *et al.*, 1997).**

RESULTS AND DISCUSSION

Legumes are high in minerals, fiber, and protein. A health benefits of their consumption have shown in the Several research studies.

Chemical Composition and water holding capacity of wheat flour and soaked pulses

The chemical composition of raw materials is represented in Table 2. pulses seeds are recognized for being a rich source of protein, as evidenced by their crude protein contents ranging from 23.21% to 25.22% (refer to Table 2). It is noteworthy that pulses have nearly double the protein content of wheat flour (10.67%), these results are in line with **Ruckmangathan et al. (2022)** who reported a similar crude protein content in faba bean and red lentil also **Rehab,(2022)** who reported similar crude protein content in chickpea Split . These findings spotlighted that the crude protein content of legumes varied by location, cultivar, and plant growth stage **(Wang and Daun, 2004)**.Additionally, the crude fiber and fat content of pulses is higher compared to wheat flour.

Table 2: Chemical Composition of wheat flour and soaked pulses

Samples	Wheat flour (ext 72%)	Red Lentil	Chickpeas	Faba Beans
Moisture (%)	12.45^{d}±.07	57.51^{a}±0.05	48.82^{b}±0.08	46.14^{c}±0.11
Crude Protein%	10.67^{d}±0.13	23.21^{c}±0.11	23.72^{b}±0.17	25.22^{a}±0.15
Fat%	0.74^{d}±0.05	1.53^{c}±0.03	5.71^{a}±0.09	1.91^{b}±0.06
Ash%	0.53^{d}±0.09	1.92^{c}±0.06	3.42^{a}±0.03	2.32^{b}±0.08
Crude Fiber%	0.58^{c}±0.11	2.72^{b}±0.04	2.58^{b}±0.05	3.21^{a}±0.02
Total Carbohydrates(%)	87.48^{a}±0.19	70.62^{b}±0.10	64.57^{d}±0.16	67.34^{c}±0.13
WHC (g/g)	1.29^{d}±0.05	3.40^{c}±0.09	2.23^{b}±0.11	2.00^{a}±0.013

Data are presented as means ± SDM (n=3). Numbers in the same row followed by the same letter are not significantly different at $p<0.05$ level.

The ash content followed a similar pattern, with chickpeas having the highest content (3.42%) and wheat flour having the lowest (0.53%). These outcomes are consistent with the results of **El-Safy et al., (2013)**, who studied how legumes were affected by soaking and germination. As shown in Table 2, red lentil displayed the highest WHC at 3.40 g/g, followed by chickpea (2.23 g/g) and faba bean (2.00 g/g) .

Nutritional Properties of Brownies

Chemical and Mineral Content of Brownies

The proximate chemical composition of wheat flour brownies and pulse-based brownies are displayed in Table 3.

Table 3: Chemical Composition and Mineral Contents of produced Brownies

Composition	WB	LB	CHB	FB
Moisture (%)	17.00 ^{d} ±0.51	18.64 ^{a} ±0.09	18.00 ^{b} ±1.61	17.76 ^{c} ±0.08
Crude Protein (%)	8.90 ^{d}±0.43	18.50 ^{c} ±0.24	18.92 ^{b} ±0.20	20.19 ^{a} ±0.15
Fat (%)	11.98 ^{c} ±0.53	12.11 ^{b} ±0.24	13.82 ^{a} ±0.16	12.68 ^{b} ±0.04
Ash (%)	0.94 ^{d} ±0.02	1.11 ^{c} ±0.05	1.86 ^{a} ±0.05	1.39 ^{b} ±0.26
Crude Fiber (%)	0.45 ^{c} ±0.16	2.20 ^{b} ±0.14	2.10 ^{b} ±0.07	2.61 ^{a} ±0.21
Total Carbohydrates (%)	79.73 ^{a} ±0.14	66.08^{b} ±0.32	63.30 ^{c} ±0.10	63.13 ^{c} ±0.36
Energy (Kcal)	462.34^{a} ±0.62	447.31 ^{c}±1.00	453.26 ^{b} ±0.08	447.40 ^{c} ±0.11
Minerals(mg/100g)				
Ca	78.70^{d} ±0.03	118.99 ^{c} ±0.10	130.69 ^{a} ±0.05	126.86 ^{b} ±0.07
Fe	2.34 ^{c} ±0.05	5.62 ^{a} ±0.08	4.91 ^{b} ±0.03	4.23 ^{b} ±0.11
Zn	0.87 ^{c} ±0.10	1.58 ^{ab} ±0.07	2.10 ^{a} ±0.09	1.43 ^{b} ±0.05

Data are presented as means ± SDM (n=3). Numbers in the same row followed by the same letter are not significantly different at $p<0.05$ level.WB: Wheat brownies as control ,LB: lentil brownies, CHB: chickpea brownies and FB: faba bean brownies. Chemical composition was calculated as dry weight basis.

The addition of soaked pulses paste affected the moisture content of brownies, the moisture of brownies increased significantly , lentil brownies had the highest moisture content followed by chickpeas then faba beans (18.64, 18.00 and 17.76; respectively) compared with wheat brownies (17.00). The higher moisture contents of brownies with pulses may result from the added moisture from the soaked pulses, the findings agree with work by **Selvakumaran *et al.* (2019).**

In comparison to the control sample, brownies with pulses had higher contents of protein, fat, fiber and ash but lower content of carbohydrates than the wheat flour brownies. Incorporation of pulses led to protein-enriched brownies that contained significantly higher Amounts of protein compared to wheat brownies.

These results agree with data presented by **Levant and Bilgiçli, (2011)** and **Bravo-Núñez and Gómez, (2023)**. As for fat content, chickpea brownies had significantly higher content (13.82%), followed by faba bean (12.68 %) and finally lentil brownies (12.11 %) , all pulses brownies are significantly higher in fat content than control. Results agree with data presented by **Gularte et al., 2012** in their research on gluten-free cakes with different legume flours. Ash content follows the same trend with chickpea brownies having higher content (1.86%), followed by faba bean (1.39 %) and finally lentil (1.11 %) brownies. Results agree with these presented by **Ertaş, (2021)** in his study on improving the cake quality by using red kidney bean. While for fiber content, faba bean brownies has the highest fiber content (2.61 %), followed by lentil (2.20 %) and finally chickpea (2.10 %) brownies. But carbohydrate content, wheat brownies have the highest content (79.73%),while lentil have (66.08%)brownies followed by chickpea (63.30 %) and faba bean (63.13%) brownies . wheat brownies had higher energy (462.34 %)while Chickpea brownies had (453.26 %), but lentil and faba bean brownies had lower energy(447.31%. , 447.40% respectively) . Results are consistent with the findings by (**Gularte et al., 2012) .**

Data in Table 3 show that when comparing the produced samples, brownies with pulses had higher contents of calcium, iron and zinc, these results are in line with work by **Bassinello et al., (2020) and Fakhri-Aldeen et al., (2017).** And when comparing different brownies with pulses, the chickpea brownies had the highest levels of calcium and zinc (130.69 and 2.10 mg/100g). While lentil brownies had the highest content of iron (5.62 mg/100g).

Total Phenolic, Total Flavonoids Content and Antioxidant Activity of Pulse-based Brownies

Antioxidants are a positively regarded compounds that combats oxidation which in turn reduces the chemical reaction in our bodies that produces free radicals and plays a role in protection from heart disease and other illnesses. Antioxidants are highly valued substances that fight oxidation, which limits the chemical process in our bodies that generates free radicals and contributes to heart disease and other diseases.

Table 4. displays total phenolic , total flavonoids content and antioxidant activity, of pulses brownies. Chickpea and lentil brownies have the highest level of total phenols (869 and784 mg /100g) followed by faba bean brownies (615 mg /100g),these results are in line with **Saleh et al. (2019) and Labba et al. (2021)** . But lentil brownies have the highest content of Flavonoids (122.0 mg/100g), since lentils have a number of bioactive compounds, such as flavonoids, phenolics, tocopherols, carotenoids , phytic acid, saponins and phytosterol (**Zhang et al., 2018**). While faba bean brownies is the lowest content of flavonoids (40.0 mg/100g).

Table 4: Total Phenolic, Total Flavonoids Content and Antioxidant Activity of Pulses Brownies

Samples	Total Phenolic (mg GAE/100g)	Flavonoids (mg QCE /100g)	Antioxidants as DPPH (%)
WB	$112^{c}\pm0.24$	$6.00^{d}\pm0.11$	$50.38^{d}\pm0.09$
LB	$784^{ab}\pm1.03$	$122.0^{a}\pm0.250$	$78.82^{b}\pm0.14$
CHB	$869^{a}\pm0.35$	$64.00^{b}\pm0.15$	$82.03^{a}\pm0.05$
FB	$615^{b}\pm0.13$	$40.00^{c}\pm0.05$	$60.08^{c}\pm0.10$

Data are presented as means ± SDM (n=10). Numbers in the same column followed by the same letter are not significantly different at p<0.05 level. WB: Wheat brownies as control ,LB: lentil brownies, CHB: chickpea brownies and FB: faba bean brownies.

It is also noticed that chickpea brownies is the highest content of antioxidant activity (82.03%) followed by lentil brownies (78.82%) and faba bean brownies is the lowest (60.08%) among pulses brownies. Chickpea contains high amounts of carotenoids, tocopherols, and polyphenols, including flavonoids, proanthocyanidins, hydroxybenzoic acids, and hydroxycinnamic acids (**Kaur,2021)**, as well as isoflavones. Polyphenolic compounds in faba beans, such as flavonoids and phenolic acids , also have antioxidant properties.

These components are important for health due to their antioxidant properties (**Siah,et al.,2014**). The antioxidant activity and total phenolic and total flavonoids content in the brownies also influenced by theobromine extracted from cocoa powder added to brownies.

Brownies Quality Assessment

Physical Properties

When incorporating pulses into brownies, several physical properties may be influenced compared to traditional brownies made with wheat flour.

The weight of the pulse -based brownies increased (21.18, 20.71 and 20.26g for lentil, chickpeas and faba bean brownies respectively) compared to wheat-based brownies which had a lower weight of (19.83g) only. Results align with those by **Shin et al., (2021)** who found that the weight of the brownie increased with the addition of whey protein .

The cake's volume is a consequence of results from the air incorporated in the batter. During baking process, protein denaturation , starch gelatinization and air bubbles expansion occur, and cake structure depends on the harmonization of these processes (**Yang and Foegeding 2010**). The volume of pulse-based brownies decreased (33.5, 33.0 and 29.3cm^3) for lentil, chickpeas and faba bean brownies respectively; compared with 35.50 cm^3 for wheat-based brownies. Results agree with work by **Shin et al., (2021)** who reported that as the whey protein amount increased, the total volume of the brownies decreased. The result observed with chickpeas align with **Gómez et al., (2008)**, who studied chickpea-wheat cake. Also, **de la Hera et al., (2012)** reported in their study of wheat-lentil composite flours cakes that adding lentil flour reduced cake volume.

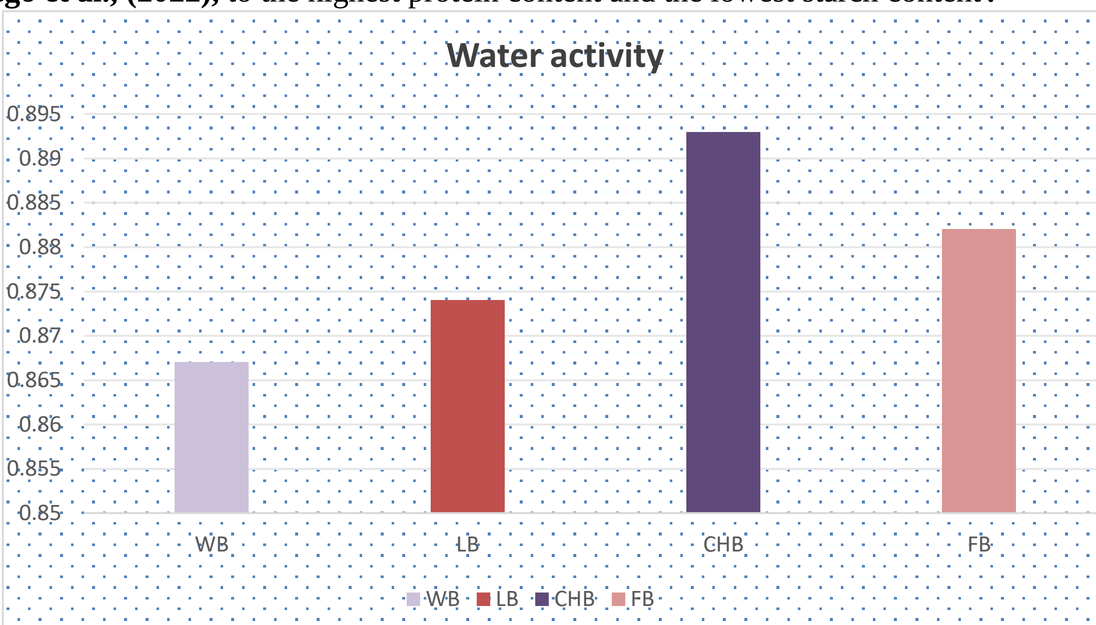
Table 5: Physical Properties of the Produced Brownies

Samples	Weight (gm)	Volume (mm$^{3)}$	Density (g/ mm^3)	Specific Volume (mm^3/g)
WB	19.83 ^{c}±0.11	35.50 ^{a}±0.20	0.56 ^{c}±0.06	1.79 ^{a}±0.05
LB	21.18 ^{a}±0.04	33.50 ^{b}±0.09	0.63 ^{b}±0.02	1.58 ^{b}±0.07
CHB	20.71 ^{b}±0.07	33.00 ^{b}±0.15	0.63 ^{b}±0.06	1.59 ^{b}±0.03
FB	20.26 ^{b}±0.14	29.30 ^{c}±0.11	0.69 ^{a}±0.03	1.45 ^{c}±0.06

Data are presented as means ± SD (n=3). Numbers in the same row followed by the same letter are not significantly different at p<0.05 level. WB: Wheat brownies as control ,LB: lentil brownies, CHB: chickpea brownies and FB: faba bean brownies.

The density of brownies with pulses may vary, due to the natural properties of legumes, resulting in a denser product, and this could be explained by the higher content of protein and fiber compared to wheat flour; the presence of these components can contribute to a denser brownie. **Minarro et al., (2012)** stated that proteins, especially when hydrated during baking, can form a network that affects the overall structure and density of the product. Soaked Pulses contain moisture, which can influence the density of brownies. Higher moisture content from the soaked pulses can contribute to a softer and potentially denser texture in the final baked product. To summarize, brownies with pulses may exhibit a denser texture compared to traditional brownies made with wheat flour due to the higher protein, fiber, moisture, and fat content of the pulses .

Overall, the specific volume of brownies decreased significantly with the addition of pulses paste compared with wheat flour brownies. Results in good agreement of work by **Shin et al., (2021)** who reported that as the whey protein amount increased, the specific volumes of the brownies decreased. Specific volume reduction with chickpea flour has also been attributed, by **Gallego et al., (2022),** to the highest protein content and the lowest starch content **.**



WB: Wheat brownies as control ,LB: lentil brownies, CHB: chickpea brownies and FB: faba bean brownies.

Figure 1:water activity of the Produced Brownies

Water activity (a_w) of brownies is shown in Fig. 1. Water activity is an important indicator to determine the shelf life of food product. The a_w values of all the samples were found to be around 0.9, which means that all brownies had a high percentage of free water for microbial growth, leading to a low-stability product. The value of a_w of pulses-based brownies increased (0.874, 0.893 and 0.882 for lentil, chickpeas and faba bean brownies respectively) compared to wheat-based brownies which had a lower a_w of (0.867).Results agree with work by **(Mota et al., 2020)** who reported that the water activity of lupine enriched cookies is significantly higher than control.

Color Attributes of Raw Materials and the Produced Brownies

Table 6 displays the impact of adding pulses to brownies on their color. Using pulses influenced all color parameters. Specifically, the L* value, representing lightness, significantly decreased. Wheat brownies exhibited higher L* values, indicating a lighter color compared to all other samples. The inclusion of pulses paste deepened the brownies' color, resulting in a darker appearance. This outcome aligns with findings from **Selvakumaran et al., (2019)**, who observed lower L* values in brownies substituted with orange sweet potato. **Jeddou et al., (2017)** suggested that this effect could be attributed to notable non-enzymatic browning when wheat flour is replaced with ingredients containing fiber and differing sugar compositions.

Table 6: Color Attributes of Raw Materials and the Produced Brownies

Samples	L*	a*	b*
Wheat	93.82 ^{a} ±0.03	0.81^{c} ±0.05	8.88 ^{d} ±0.07
Lentil	62.60 ^{c} ±0.06	0.98 ^{a} ±0.02	11.39 ^{c} ±0.01
Chickpeas	64.90 ^{b} ±0.04	0.89 ^{b} ±0.07	17.10 ^{a} ±0.03
Faba bean	61.48 ^{d} ±1.88	0.84 ^{c} ±1.73	12.93 ^{b} ±2.89
Brownies			
WB	24.54 $^{\mathbf{a}}$ ±0.05	4.76 $^{\mathbf{d}}$ ±0.05	4.75 $^{\mathbf{c}}$ ±0.06
LB	22.24 $^{\mathbf{c}}$ ±0.04	7.24 $^{\mathbf{a}}$ ±0.03	4.36 $^{\mathbf{d}}$ ±0.03
CHB	23.13 $^{\mathbf{b}}$ ±0.03	6.04 $^{\mathbf{b}}$ ±0.02	6.43 $^{\mathbf{a}}$ ±0.05
FB	20.53 $^{\mathbf{d}}$ ±0.02	5.34 $^{\mathbf{c}}$ ±0.01	5.95 $^{\mathbf{b}}$ ±0.04

L* = lightness (0 = black, 100 = white), a* (-a* = greenness, +a* = redness) and b* (-b* = blueness, +b* = yellowness). Data are presented as means ± SD (n=3). Numbers in the same column followed by the same letter are not significantly different at p<0.05 level.WB: Wheat brownies as control ,LB: lentil brownies, CHB: chickpea brownies and FB: faba bean brownies.

Using of pulses instead of wheat flour in brownies showed a significant increase in (a*) and (b*) values of brownies, compared to the control, the b* value, reflecting carotenoid levels and yellow color with the addition of pulses .

Foophow et al., (2020) noted that brownies made with brown rice flour exhibited comparable darkness to those made with wheat flour (control), they attributed this to similar levels of cocoa powder in the formulation and uniform non-enzymatic browning reactions (including Maillard reaction and caramelization) across all brownie types. **Purlis, (2010)** explained that browning in bakery products is influenced by ingredients, particularly amino acids, proteins, sugars, and leavening agents, along with operating conditions such as temperature and water activity.

It's important to recognize that the specific color effects described may vary depending on the recipe, the type and quantity of pulses used, and other ingredients in the brownie batter. Additionally, these effects are typically more noticeable in lighter-colored brownies than in darker chocolate varieties, where differences in color may be less apparent.

Texture Profile Analysis

Table 7 presents the textural properties of brownies containing wheat flour, lentil, chickpea, and faba bean paste. The inclusion of soaked pulses resulted in a significant reduction in hardness, resilience, cohesiveness, springiness, gumminess, and chewiness of the brownies.

Table 7: Texture Profile Analysis of the Produced Brownies

Samples	Hardness	Adhesiveness	Resilience	Cohesiveness	Springiness	Gumminess	Chewiness
WB	31.61[a]±0.15	0.15[b]±0.09	0.52[a]±0.02	0.82[a]±0.05	3.14[a]±0.03	26.62[a]±0.10	83.60[a]±0.15
LB	30.49[ab]±0.12	0.35[b]±0.10	0.15[b]±0.01	0.41[b]±0.02	1.88[b]±0.07	14.00[b]±0.05	26.35[b]±0.45
CHB	25.36[b]±0.07	3.65[a]±0.15	0.08[d]±0.02	0.39[b]±0.07	1.62[c]±0.18	6.62[c]±0.03	10.90[b]±0.30
FB	28.10[b]±0.18	2.55[ab]±0.11	0.12[c]±0.03	0.34[b]±0.01	1.80[bc]±0.08	11.33[bc]±0.1	20.30[b]±0.40

Data are presented as means ± SDM (n=3). Numbers in the same column followed by the same letter are not significantly different at $p<0.05$ level. WB: Wheat brownies as control ,LB: lentil brownies, CHB: chickpea brownies and FB: faba bean brownies.

The findings align with **Selvakumaran et al., (2019)**, who noted a significant reduction in hardness, adhesiveness, gumminess, cohesiveness, and chewiness of brownies with the incorporation of up to 50% orange sweet potato puree. **Alvarez et al., (2017)** suggested that lower hardness, springiness, cohesiveness, and chewiness compared to the control could be attributed to differences in protein concentrations among the ingredients. In comparison to brownies made with chickpea flour, the texture was found to be slightly superior to control brownies made with wheat flour.

Selvakumaran et al., (2019) also reported that increased water content in brownies following the addition of soaked pulses could be a major factor influencing textural changes. Although increased fiber typically correlates with increased hardness, the elevated moisture content resulting from the addition of soaked pulses may counteract the effect of increased fiber (as shown in Table 2), leading to reduced hardness. **de la Hera et al., (2012)** reported in their study on wheat-lentil composite flours cakes that adding lentil flour to the formula reduced cohesiveness and springiness.

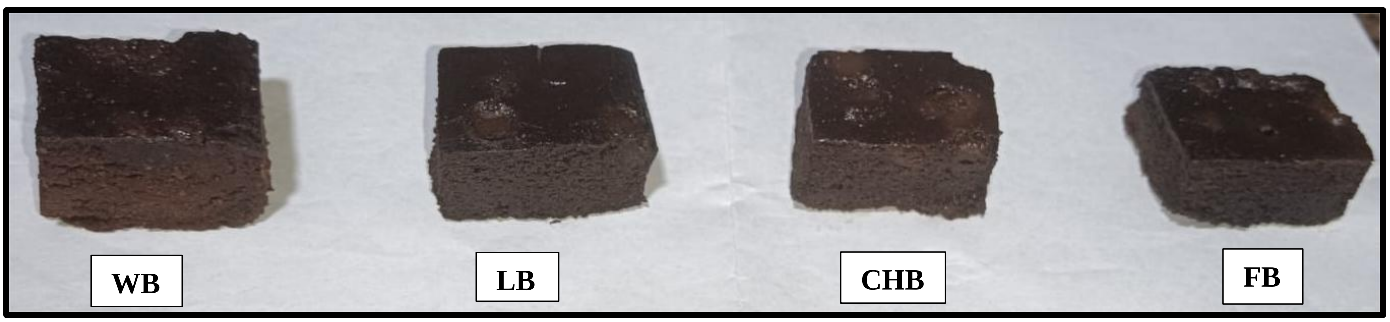
Sensory acceptability scores

The sensory acceptability scores for brownies are displayed in Table 8. The panelists rated all sensory attributes for both wheat flour brownies and pulses brownies.

Table 8: Sensory acceptability scores of Brownies

Samples	Appearance	Odor	Color	Texture	Taste	Mouthfeel	Overall Acceptability
WB	8.75 [a] ±0.40	8.70[a] ±0.140	8.83[a] ±0.42	8.58[a] ±0.51	8.75[a] ±0.27	8.83[a] ±0.25	8.37 [ab] ±0.43
LB	8.50 [ab] ±0.44	8.67[a] ±0.42	8.42 [a] ±0.81	8.33[ab] ±0.80	8.00[b] ±0.51	8.00[bc] ±0.84	8.00 [b] ±0.98
CHB	8.33 [ab] ±0.81	8.42[ab] ±0.66	8.33 [a] ±0.51	8.00 [b] ±0.49	8.73 [a] ±0.48	8.41[ab] ±0.49	8.75 [a] ±0.64
FB	7.75 [b] ±0.75	7.48 [b] ±0.82	8.00 [a] ±0.89	7.50 [c] ±0.80	7.33 [c] ±0.92	7.67 [c] ±0.54	7.50 [c] ±0.46

Data are presented as means ± SDM (n=10). Numbers in the same column followed by the same letter are not significantly different at p<0.05 level. WB: Wheat brownies as control ,LB: lentil brownies, CHB: chickpea brownies and FB: faba bean brownies.



WB: Wheat brownies as control ,LB: lentil brownies, CHB: chickpea brownies and FB: faba bean brownies

Figure2: A Photograph of the produced brownies

The appearance ratings for the brownies indicated that wheat flour brownies received the highest score (8.75), followed by lentil and chickpea brownies with slightly lower scores (8.50 and 8.33), and faba bean brownies with the lowest score (7.75). Regarding odor, there were no significant differences between wheat flour brownies and lentil brownies, while faba bean brownies scored the lowest (7.48). The data from Table 8 show that there were no significant differences in color between wheat flour brownies and those with pulses . As for texture, there was a slight but significant difference between wheat flour brownies (8.58) and lentil brownies (8.33), while faba bean brownies scored the lowest (7.50). In terms of taste, wheat flour brownies and chickpea brownies showed no significant difference (8.75 and 8.73), while lentil brownies scored slightly lower (8.00) and faba bean brownies scored the lowest (7.33). The Mouthfeel exhibited a significant difference between wheat flour brownies and those with pulses. Overall acceptability chickpea brownies scoring the highest (8.75) and faba bean brownies scoring the lowest (7.58), while wheat flour brownies and lentil brownies, showed a slight difference between them. These findings are consistent with the research conducted by **Large, 2021.**

Daily intake of some nutrients in pulse-based brownies .

The daily intakes of protein,energy, calcium, iron, and zinc were calculated for aged young Males and females(14-18 years) , adult Males and females (31-50 years)based on the proximate chemical composition (Table 3) for the control and pulse-based brownies (Table 9).Results showed that control brownies covered 17.12; 14.67; 6.05; 21.27 and finally 9.67% of the RDA for young males (14-18 years) in protein, energy, Ca, Fe and Zn, and they also cover 19.35; 19.52; 6.05; 15.6 and 9.67%of the RDA for young females (14-18years) in these nutrients, respectively. Besides, they also covered 15.08; 17.45; 7.87; 29.25 and 7.91% of the RDA for adult males (31-50 years) of these nutrients, respectively. Moreover, they also covered 17.8; 18.49; 7.87; 13 and 10.88% of the RDA for adult females (31-50years) in these nutrients, respectively.Regarding lentil brownies,results showed that each 100 g of lentil brownies provide 35.58; 14.19; 9.15; 51.09; and 17.56% of the RDA for young males in protein, energy, Ca, Fe and Zn,and they cover 40.22; 18.89; 9.15; 37.47 and 17.56%of the RDA for young females in these nutrients, respectively. Moreover, they also covered 31.36; 16.88; 11.90; 70.25; and 14.36% of the RDA for adult males of these nutrients, respectively. Additionally, they also covered 37.0; 17.89; 11.90 ; 31.22and 19.75% of the RDA for adult females of these nutrients, respectively. Regarding RDA for chickpea brownies,it covered 36.38; 14.38; 10.05; 44.64 and 23.33% of the RDA for young males in protein, energy, Ca, Fe and Zn,and they cover 41.13; 19.14; 10.05; 32.73and 23.33%of the RDA for young females in these nutrients respectively. Moreover, for adult males they provide 32.07, 17.10, 13.07, 61.38 and 19.09% of the RDA in these nutrients, respectively. Similarly, they covered 37.84; 18.13; 13.07; 27.28and 26.25% of the RDA for adult females of these nutrients, respectively.Regarding RDA for faba bean brownies, data showed that they covered 38.83; 14.19; 9.76; 38.45and 15.89% of the RDA for young male in protein, energy, Ca, Fe and Zn and they cover 43.89; 18.89; 9.76; 28.20and 15.89%of the RDA for females in these nutrients ,respectively. Additionally, for adults males they also covered 34.22; 16.88; 12.69; 52.88 and 13% of the RDA of these nutrients, respectively. For females they covered 40.38; 17.90; 12.69; 23.5 and 17.88% of the RDA of these nutrients, respectively.

Table 9: Nutritional characteristics of some nutrient provided from 100g of the Produced Brownies for young males and females (14-18 y), adult males and females (31-50 y).

			RDA from 100g pulse-based brownies samples (%)			
Age group	**Nutrients**	**RDA***	**WB**	**LB**	**CHB**	**FB**
Males (14-18years)	Protein(g)	52	17.12	35.58	36.38	38.83
	Energy (K cal)	3152	14.67	14.19	14.38	14.19
	Ca (mg)	1300	6.05	9.15	10.05	9.76
	Fe (mg)	11	21.27	51.09	44.64	38.45
	Zn (mg)	9	9.67	17.56	23.33	15.89
Females (14-18years)	Protein(g)	46	19.35	40.22	41.13	43.89
	Energy (K cal)	2368	19.52	18.89	19.14	18.89
	Ca (mg)	1300	6.05	9.15	10.05	9.76
	Fe (mg)	15	15.6	37.47	32.73	28.20
	Zn (mg)	9	9.67	17.56	23.33	15.89
Males (31-50 years)	Protein(g)	59	15.08	31.36	32.07	34.22
	Energy (K cal)	2650	17.45	16.88	17.10	16.88
	Ca (mg)	1000	7.87	11.90	13.07	12.69
	Fe (mg)	8	29.25	70.25	61.38	52.88
	Zn (mg)	11	7.91	14.36	19.09	13
Females (31-50 years)	Protein(g)	50	17.8	37	37.84	40.38
	Energy (K cal)	2500	18.49	17.89	18.13	17.90
	Ca (mg)	1000	7.87	11.90	13.07	12.69
	Fe (mg)	18	13	31.22	27.28	23.5
	Zn (mg)	8	10.88	19.75	26.25	17.88

WB: Wheat brownies as control ,LB: lentil brownies, CHB: chickpea brownies and FB: faba bean brownies.
RDA (%) = Value of nutrient in the sample of brownies × 100 / RDA for the same nutrient based on Table 3 result

CONCLUSION

Growing consumer demand exists for extremely nutrient-dense, healthful products , producing alternative brownies with out wheat flour . In response to this demand, we indicated that replacing wheat flour with pulses (lentil, chickpea, and faba bean) in brownies preparation introduces unique quality properties that can enhance texture, flavor, and nutritional profile. Besides, brownies made from pulses had higher nutritional value of the samples including high level of protein, fiber, minerals and bio-active compounds with lower content of carbohydrates compared with wheat brownies. Chickpea brownies emerged as the most nutritionally balanced, with optimal antioxidant activity and sensory acceptance. The findings highlight the potential of pulses as valuable ingredients for developing nutritious, gluten-free baked products that cater to specific dietary needs. Future research directions should explore processing optimizations to further improve textural characteristics and expand the application to other pulse types and bakery products.

REFERENCES

AACC. (2010). Approved methods of Analysis 11th edition, Methods 10-15D, and 44-15. St-, Plau. MN.

AACC. (2016). Approved methods of the American Association of Cereal Chemists, 11th ed. Methods 55-50.01. The Association, St. Paul, MN, US.

Alvarez, M. D., Herranz, B., Jiménez, M. J., and Canet, W. (2017). End-product quality characteristics and consumer response of chickpea flour-based gluten-free muffins containing corn starch and egg white. Journal of Texture Studies, 48(6), 550–561.

AOAC. (2019). Official Methods of Analysis of Association of Official Analytical Chemists international. Latimer, G. (Ed.), 21th ed., Association of Official Analytical Chemists, Washington, DC, USA.

Askari M, Daneshzad E, Jafari A, Bellissimo N and Azadbakht L (2021). Association of nut and legume consumption with Framingham 10-year risk of general cardiovascular disease in older adult men. a cross-sectional study. Clin Nutr ESPEN. 42:373–80.

Bassinello, P. Z., Bento, J. A. C., Gomes, L. D. O. F., Caliari, M., and Oomah, B. D. (2020). Nutritional value of gluten-free rice and bean based cake mix. *Ciência Rural*, *50*, e20190653.

Boye, J.; Zare, F. and Pletch, A. (2010). Pulse proteins: Processing, characterization, functional properties and applications in food and feed. Food Research International, 43(2), 414-431.

Bravo-Núñez, Á. and Gómez, M. (2023). Enrichment of cakes and cookies with pulse flours. A review. Food Reviews International, 39(5), 2895-2913.

Chang CC, Yang MH, Wen HM, et al.,(2002) . Estimation of total flavonoid content in propolis by two complementary colorimetric methods. J. Food Drug Anal ;10:178e82.

de la Hera, E., Ruiz-París, E., Oliete, B., and Gómez, M. (2012). Studies of the quality of cakes made with wheat-lentil composite flours. LWT, 49(1), 48-54.

Deepika Kathuriaa, Hamidb, Prasad Chavanb , Amit K. Jaiswal c,d, Abhimanyu Thakure , and Anju K. Dhimane(2024). A Comprehensive Review on Sprouted Seeds Bioactives, the Impact of Novel Processing Techniques and Health Benefits Food Reviews International, 40, (1) 370-398.

Dhull S. B., Joyce Kinabo and Mark A.Uebersax (2022). Nutrient profile and effect of processing methods on the composition and functional properties of lentils (Lens culinaris Medik): A review.Legume Science,5:e156.

El-Safy, F., Salem, R. and YY, E. M. (2013). The impact of soaking and germination on chemical composition, carbohydrate fractions, digestibility, anti-nutritional factors and minerals content of some legumes and cereals grain seeds. Alexandria Science Exchange Journal, 34(October-December), 499-513.

Ertaş, N. (2021). Improving the cake quality by using red kidney bean applied different traditional processing methods. Journal of Food Processing and Preservation, 45(6), e15527.

Fakhri-Aldeen, F., Slman, W. J., and Abas, W. F. (2017). Fortification of some food products (cake) for the preschool aged children. Int. J. Sci. Res, 6, 1642-647.

Fischer, S., Wilckensa, R., Jara, J., and Arandac, M. (2013). Variation in antioxidant capacity of quinoa (Chenopodium quinoa Will) subjected to drought stress. Industrial Crops and Products, 46, 341–349.

Food and Agriculture Organization of the United Nations (FAO) 2023. Crops statistics concepts, definitions and classifications. Accessed May 12, 2023

Foophow, T., Phoohinkong, W., Lertkowit, P., and Ketkoom, N. (2020). Fortification of iron in brownies with Sinlek brown rice flour. Songklanakarin Journal of Science and Technology, 42(5).

Gallego, C., Belorio, M., Guerra-Oliveira, P., and Gómez, M. (2022). Effects of adding chickpea and chestnut flours to layer cakes.International Journal of Food Science and Technology, 57(8), 4840-4846.

Gómez, M., Oliete, B., Rosell, C. M., Pando, V., and Fernández, E. (2008). Studies on cake quality made of wheat–chickpea flour blends. Food Science and Technology, 41, 1701–1709.

Guillon, F. and Champ, M. J. (2002). Carbohydrate fractions of legumes uses in human nutrition and potential for health. British Journal of Nutrition, 88(S3), 293-306.

Gularte, M. A., Gómez, M., and Rosell, C. M. (2012). Impact of legume flours on quality and in vitro digestibility of starch and protein from gluten-free cakes. Food and Bioprocess Technology, 5, 3142-3150.

Gupta, S., Liu, C. and Sathe, S.K. (2019). Food Quality of a Chickpea-Based High Protein Snack. Journal of Food Science, 84, 1621-1630.

Hayta, M.; Alpaslan, M. and Baysar, A. (2002). Effect of drying methods on functional properties of tarhana: a wheat flour-yoghurt mixture. J. Food Sci., 67(2): 740-744.

Jeddou, K.B., Bouaziz, F., Zouari-Ellouzi, S., Chaari, F., Ellouz-Chaabouni, S., Ellouz-Ghorbel, R. and Nouri-Ellouz, O., (2017). Improvement of texture and sensory properties of cakes by addition of potato peel powder with high level of dietary fiber and protein. Food chemistry, 217, pp.668-677.

Kaur, R.; Prasad, K. (2021). Technological, processing and nutritional aspects of chickpea (*Cicer arietinum*)-A review. Trends Food Sci. Tech., 109, 448–463.

Khazaei, H., Purves, R. W., Hughes, J., Link, W., O'Sullivan, D. M., Schulman, A. H., Björnsdotter, E., Geu-Flores, F., Nadzieja, M., Andersen, S. U., Stougaard, J., Vandenberg, A., and Stoddard, F. L. (2019). Eliminating vicine and convicine, the main anti-nutritional factors restricting faba bean usage. Trends Food Sci. Tech., 91, 549–556.

Labba, I.-C. M., Frøkiær, H., and Sandberg, A.-S. (2021). Nutritional and antinutritional composition of fava bean (Vicia faba L., var. minor) cultivars. Food Research International, 140, 110038.

Large, Madeline (2021). Effects of Chickpea Flour Replacement on Physical and Sensory Characteristics of Brownies. Williams Honors College, Honors Research Projects. 1450

Levent, H. and Bilgiçli, N. (**2011).** Enrichment of gluten-free cakes with lupin (Lupinus albus L.) or buckwheat (Fagopyrum esculentum M.) flours. International Journal of Food Sciences and Nutrition, 62(7), 725-728.

Liu, C., Pei, R., and Heinonen, M. (2022). Faba bean protein: A promising plant-based emulsifier for improving physical and oxidative stabilities of oil-in-water emulsions. Food Chemistry, 369, 130879. https://doi. org/10.1016/j.foodchem.2021.130879

Lyon D.H., Francombe M.A. and Hasdell T.A. (1992). Guidelines for sensory analysis in food product development and quality control. Chapman and Hall, London, UK.

inarro B., Albanell E., Aguilar N., Guamis B. and Capellas M. (2012). Effect of legume flours on baking characteristics of gluten-free bread. J. Cereal Sci., 56(2):476–81.

Mota, J., Lima, A., B. Ferreira, R. and Raymundo, A. (2020). Lupin seed protein extract can efficiently enrich the physical properties of cookies prepared with alternative flours. Foods, 9(8), 1064.

Onwezen M.C., Bouwman E.P., Reinders M.J., et al.,(2021) .A systematic review on consumer acceptance of alternative proteins: pulses, algae, insects, plantbased meat alternatives, and cultured meat. Appetite. ; 159: 105058. PubMed Abstract | Publisher Full Text

Patterson, C. A., Curran, J., and Der, T. (2017). Effect of Processing on Antinutrient Compounds in Pulses. Cereal Chemistry, 94(1), 2–10.

Purlis, E. (2010). Browning development in bakery products. Journal of Food Engineering, 99(3), 239-249.

Rachwarosiak, D., Nebesny, E. and Budryn, G. (2015). Chickpeas composition, nutritional value, health benefits, application to bread and snacks: a review. Critical Reviews in Food Science and Nutrition, 55, 1137-1145.

Rahate, K. A., Madhumita, M., and Prabhakar, P. K. (2020). Nutritional composition, anti-nutritional factors, pre-treatments-cum-processing impact and food formulation potential of faba bean (*Vicia faba* L.): A comprehensive review. LWT - Food Science and Technology, 138, 110796.

Rashid Raza,Sania Yousuf, Misbah Khalid, Minal Naveed, Muqita Ghaznavi and Wajiha Temuri (2021). Production of nutraceutical chocolate brownies by incorporation of Magnifera Indica leaves extract. Journal of Reseash Science, 28-29(1-4), 25-35.

Rehab Mohamed Ibrahim (2022).Utilization of Chickpea Split (*Cicer arietinum L.*) in Preparing Some Gluten-Free Casein-Free Food Products for Autism Children.Food and Nutrition Sciences, 13, 284-315.

RDA., 1989. Recommended Dietary Allowances 10th Ed National Academy Press Washington, D.C. UAS.302 p.

Ruckmangathan, S., Ganapathyswamy, H., Sundararajan, A., Thiyagamoorthy, U., Green, R., and Subramani, T. (2022). Physico-chemical, structural, and functional properties of protein concentrate from selected pulses: A comparative study. Journal of food processing and preservation, 46(12), e17169.

Saleh, H. M., Hassan, A. A., Mansour, E. H., Fahmy, H. A., and El-Bedawey, A. E.-F. A. (2019). Melatonin, phenolics content and antioxidant activity of germinated selected legumes and their fractions. Journal of the Saudi Society of Agricultural Sciences, 18(3), 294-301.

Selvakumaran, L., Shukri, R., Ramli, N. S., Dek, M. S. P., and Ibadullah, W. Z. W. (2019). Orange sweet potato (*Ipomoea batatas*) puree improved physicochemical properties and sensory acceptance of brownies. Journal of the Saudi Society of Agricultural Sciences, 18(3), 332-336.

Shahidi, F., Sedaghat, N., Farhoosh, R. and Mousa-vi-Nik, H. (2008). Shelf-life determination of saffron stigma: Water activity and temperature studies. World Applied Sci. J., 5(2):132-136.

Sharma, C., Singh, B., Hussain, S.Z. and Sharma, S. (2017). Investigation of Process and Product Parameters for Physicochemical Properties of Rice and Mung Bean (*Vigna radiata*) Flour Based Extruded Snacks. Journal of Food Science and Technology, 54, 1711-1720.

Shin, J. H., Chae, M. J., and Han, J. A. (2021). Physical and sensory characteristics of brownies containing whey powder. Korean Journal of Food Science and Technology, 53(3), 321-328.

Siah, S., Wood, J. A., Agboola, S., Konczak, I., and Blanchard, C. L. (2014). Effects of soaking, boiling and autoclaving on the phenolic contents and antioxidant activities of faba beans (*Vicia faba* L.) differing in seed coat colours. Food Chemistry, 142, 461–468.

Sidhu, J. S., Zafar, T., Benyathiar, P., and Nasir, M. (2022). Production, processing, and nutritional profile of chickpeas and lentils. In Dry beans and pulses: Production, processing, and nutrition (2nd ed., pp. 383–407).

Singh, R. P., Murthy, K. N. C., and Jayaprakasha, G. K. (2002). Studies on antioxidant activity of pomegranate (Punica granatum) peel and seed extracts using in vitro models. Journal of Agricultural and Food Chemistry, 50, 81–86.

Steel, R.G.D.; Torrie, J.H. and Dicky, D.A. (1997). Principles and Procedures of Statistics: A Biometrical Approach. 3rd Edition, McGraw Hill, Inc. Book Co., New York, 352-358

USDA (US Dept of Agriculture). (2021). Food Data Central (Nutrient Database).

Wang, J., Li, Y., Li, A., Liu, R.H., Gao, X., Li, D., Kou, X. and Xue, Z., (2021). Nutritional constituent and health benefits of chickpea (*Cicer arietinum* L.): A review. Food Research International, 150, 110790.

Wang, N., and Daun, J. K. (2004). Effect of variety and crude protein content on nutrients and certain anti-nutrients in field peas (*Pisum sativum*). Journal of the Science of Food and Agriculture, 84(9), 1021-1029.

Yang, X., and Foegeding, E. A. (2010). Effects of sucrose on egg white protein and whey protein isolate foams: factors determining properties of wet and dry foams (cakes). Food Hydrocolloids, 24, 227–238.

Yu-Mi Choi , Hyemyeong Yoon ,Myoung-Jae Shin , Sukyeung Lee , Jungyoon Yi , Young-ah Jeon ,Xiaohan Wang and Kebede Taye Desta (2023). Nutrient Levels, Bioactive Metabolite Contents, and Antioxidant Capacities of Faba Beans as Affected by Dehulling. Foods , 12, 4063.

Zhang, B., Peng, H., Deng, Z., and Tsao, R. (2018). Phytochemicals of lentil(Lens culinaris) and their antioxidant and anti-inflammatory effects. Journal of Food Bioactives, 1, 93–103.