Using lentils and faba beans as a substitute for wheat flour to enhance the nutritional value and improve the physical, chemical, and sensory properties of fermented Tarhana soup

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Using lentils and faba beans as a substitute for wheat flour to enhance the nutritional value and improve the physical, chemical, and sensory properties of fermented Tarhana soup

Abstract

Lentils and faba beans are among the most popular and widely used types of legumes in Egypt. Using them to enhance wheat flour tarhana is due to their high content of protein and nutrients and low fat. This study investigated the effects of substituting wheat flour (WF) with lentil powder (LP) and faba bean powder(FBP) on the nutritional, functional, and sensory properties of tarhana control (100% WF) and Samples with substitution ratios 25%, 50% and 75% of (LP and FBP). Proximate Composition Analysis of raw materials and tarhana with all treatments, Total Phenolic Content (TPC), Total Flavonoid Content (TFC), DPPH Radical Scavenging Activity, Physical Analysis, Functional Properties and sensory evaluation of tarhana and all treatments were determined. The results demonstrated that legume incorporation significantly enhanced the nutritional profile, with higher protein content (up to 37.24 g/100g) and increased dietary fiber (6.94 g/100g) in (25%WF+75%LP). Antioxidant activity and phenolic content also rose, particularly in 25%WF+75%FBP (1148.11 mg GAE/100g total phenolic content(TPC) and 73.05% DPPH scavenging activity), attributed to fermentation. Functional properties, such as foaming capacity (2.27 ml/ml) and emulsification activity (90.45%), were superior in faba bean blends, while water absorption increased with legume substitution. However, sensory evaluation revealed lower overall acceptability in legume-enriched blends (38.66–42.00 vs. 47.73 for control), with texture and flavor being key challenges. The 50% substitution level showed better result for sensory

Keywords: lentil powder, faba bean powder, Antioxidant activity, DPPH, Functional properties

Introduction

Tarhana, is a fermented soup. It has a dry form of yogurt-cereal mixture and forms a significant element of the diets of many people in several nations, including Turkey (**Celik *et al.*, 2005**). It is made by combining yogurt. wheat flour, and a variety of vegetables and spices (tomatoes, onions, salt, mint, and paprika) followed by fermentation **(Siyamoglu 1961; Maskan and Ibanoglu 2002).** It is a source of vitamin, protein and minerals (**Dağlıoğlu, 2000; Özdemir *et al.*, 2007).** This dough-like products have been discovered in a number of countries."Kishk" in Egypt, Syria, and Jordan, "trahana" in Greece, "turkhana" in Bulgaria, "kushuk" in Iraq and Iran, and "tarana" in Serbia are the terms used (**Yildirim and Ercan, 2004)**. It helps to build and strengthen bones and protects from a variety of ailments due to its content of lycopene, so it is beneficial for children and older **(İbanoğlu and İbanoğlu1999)** and (**Üçok *et al*. 2019**). Dry and soup are two sides of the tarhana cooking method **(Tamer *et al.*, 2007 and Kumral, 2015).** Because tarhana is a meal rich in protein, minerals and vitamins, it is considered a valuable source of food **(anÖzdemir *et al.*, 2007).** Tarhana is a meal richer in nutritional value when some other plants are used in its manufacture, such as some legumes and grains **(Bilgiçli and İbanoğlu 2007).**

The characteristics of traditional tarhana can be improved by replacing with legumes powder. One of the most popular legumes in Egypt, Lentils (*Lens culinaris Medik.*). Lentils vary in color from yellow to black, green, orange, and red **(Khazaei *et al.*, 2019).** Compared to other pulses, lentils contain higher protein, fibre, and iron content, as well as a surprisingly high vitamin B content, particularly folate (B_9), which has been found to exceed that of rice by two magnitudes **(Hall *et al.*, 2017).** Their high carbohydrate content is partially made up of prebiotics; moreover, their resistant starch content may lower the glycaemic index of meals **(Siva *et al.*, 2018 and Ferawati *et al.*, 2019).** Lentils, like other pulses, include bioactives such as saponins, phytates, tannins, and trypsin inhibitors **(Patterson et al., 2017).**

Faba bean (*Vicia faba* L.) is considered to be the third most significant feed grain legume which is the oldest crops in the world. Horse bean, fava bean and broad bean are also famous names given to it **(Mínguez and Rubiales 2021)**. Because of the bean's unique ability to thrive in all climatic conditions and its ability to adapt to a wide range of soil environments, it is considered the best crop. **(Singh *et al.*, 2013).** Faba beans are rich in proteins, lysine, carbs, vitamins, minerals, and many beneficial substances **(Dhull *et al.*, 2022).**

Grain legumes, such as beans and lentils, have favorable nutritional compositions for human consumption, being low in fat and high in protein, dietary fibers, iron, zinc and vitamins such as folate, riboflavin and thiamine **(Tiwari and Singh 2012)** Furthermore, grain legumes contain antioxidants and other bioactive compounds that can contribute to human health **(Ganesan and Xu 2017).** Although wheat is rich in calories, it is poor in some amino acids like lysine and threonine **(Bakke and Vickers 2007)** using combination of legumes and cereals cover all essential amino acids, similar to animal-based proteins. **The present study aimed to** Improve the nutritional, functional and technological value of tarhana (fermented soup) by using legume powder (lentils and faba beans) as an alternative to certain proportions of wheat flour.

MATERIALS and METHODS

MATERIALS

Wheat flour (72% extraction), lentils and faba beans, full-fat yoghurt (Juhayna), tomato paste, chopped onions, paprika, mint, salt, and active dry yeast used in tarhana production were acquired at a local store in Fayoum, Egypt.

Methods

Preparing the tarhana dough

Tarhana was prepared according to **Özdemir et al. (2007)** with some modifications using 500g flour, 350g yoghurt, 40g tomato paste, 40g chopped onions, 10g paprika, 6g salt, and 2g mint. For 7 days' dough was incubated at 35°C in a glass jar and dried in an air convection oven at 55°C for 72 hours. The dried samples were ground and stored in jars made from at room temperature.

Determination of the proximate chemical composition of lentils, faba beans and tarhana samples

Dried and ground lentils, faba beans and tarhana samples analyzed for, crude fiber, protein, lipids, ash and moisture contents by the methods of the American Association of Cereal Chemists **AACC (1990)** and carbohydrate was calculated by difference.

Extraction

Each plant's dry powder (10.0 g) was extracted three times with Et-OH (96% v/v) at room temperature while stirring. **Dzoyem et al. (2014)** employed an aqueous suspension of the concentrated Et-OH extract that has been evaporated to dryness for all studies.

Determination of total phenolic

According to **Jayaprakasha *et al*. (2001)** Compounds, as gallic acid in tarhana and its treatment were measured

Total flavonoid content analysis

Total flavonoid (TFC) in each extract was evaluated using aluminum trichloride solution (AlCl3) and the colorimetric technique adopted by **Djeridane *et al*., (2006)**. An aliquot of the crude extract (500 µl) was combined with 500 µl of 2% AlCl3. The intensity of the pink hue was then measured at 420 nm using Shimadzu's UV-Vis (UV-1601, PC). After 15 minutes. Rutin was chosen as the standard. The results were represented as mg rutin equivalents per gram of dry weight.

DPPH radical scavenging activity

Tarhana and its treatments were extracted to calculate the free radical 1, 1-diphenyl-2- picrylhydrazyl. The solution's absorbance will be measured at 517nm against Ethanol described by **Aboelsoued *et al*. (2019).** The DPPH scavenging capacity will have calculated using the following equation

$$\text{Scavenging activity (\%)} = \frac{Ac - As}{Ac} \times 100$$

Where Ac and As are the absorbance's at 517nm of the control and treatments, respectively

The Physical analysis

- pH of tarhana

The pH of Tarhana dough and powder samples were determined using a standardized pH meter (HANNA, HI 9025) with buffer solutions of pH 4.0 and 7.0, following Adeleke and Odedeji's approach **(Adeleke and Odedeji 2010).**

-The Dough Fermentation

According to **Bilgicli (2009),** loss percent of tarhana treatments was determined

Colour measurements

Tarhana colour was assessed by spectrophotometer. Each treatment was replicated three times. The hunter colour parameters L*, a*, and b* according to **Granato and Masson (2010).**

Determination of functional properties

The water/oil absorption capacity (WAC & OAC)

Water and oil absorption were assessed in triplicates using the method given by **Sosulski and McCurdy (1987).**

Tarhana treatments' foaming capacity (FC)

The foaming capacity was evaluated by combining 10 g of tarhana powder with 25 mL of distilled water, then centrifuged at (4000 rpm for 20 min). The resulting supernatant was whipped at high speed for two minutes (Moulinex blender, France). The foam volume was measured after 10 seconds. The quantity of gas integrated per milliliter of solution was used to calculate foaming capacity. As time passed, foam stability (FS) was evaluated until half of the initial foam volume had disappeared. Foaming capacity (%) = A - B/B X 100.

Where A is volume after whipping (mL) and B is volume before whipping percentage. Foam stability = foam volume after time (t)/initial foam volume X 100.

Emulsification activity (EA)

Tarhana solution was centrifuged at 4000 rpm. The supernatants were then combined with equal proportions sunflower oil and homogenised in a waring mixer. A measuring cylinder was used to calculate the emulsified layer. The emulsification activity (%) was estimated by dividing the emulsified layer's height by the mixture's total height. It was estimated according to **Hayta *et al.*, (2002).**

Sensory properties

The sensory qualities of tarhana soup were investigated using **Hayta *et al.*, (2002).** Cook 10 grams of tarhana powder in 100 ml of vegetable broth over medium heat for 12 minutes. The samples were given in disposable cups at 50ºC and evaluated by 10 panel members. Tarhana soup samples were evaluated for taste, color, flavor, consistency, sourness, and overall acceptance .

Statistical analysis

The current investigation's data was statistically analyzed using the computerized program SPSS software, version "20" for Windows, in accordance with **Snedecor and Cochran's (1980)** ANOVA method. The least significant difference (LSD) value was utilized to compute the significant difference between means. Data were presented as mean ± SD.

Results and discussion

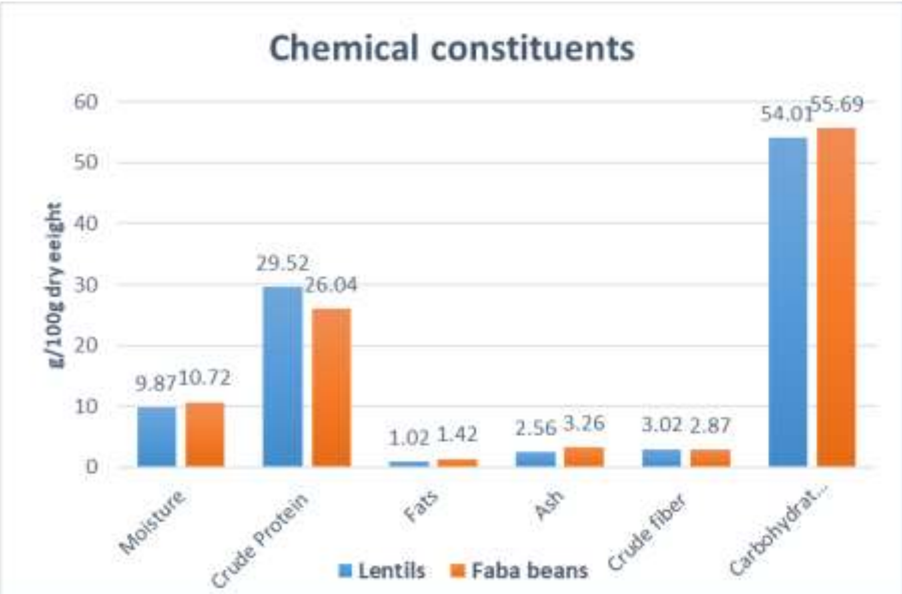


Fig. (1): Chemical composition of lentils and faba beans

Table (1): Chemical composition of fermented tarhana soup and different treatments

Samples	Chemical composition g/100g dry weight					
	Moisture	**Protein**	**Fiber**	**Ash**	**Fat**	**Carbohydrates**
Cont.	18.90±0.06[b]	11.10±0.35[g]	1.66±0.05[f]	2.90±0.02[b]	11.78±0.52[b]	53.66±0.7[b]
T1	13.97±0.09[d]	26.35±0.52[e]	4.34±0.1[c]	3.72±0.02[a]	8.53±0.93[d]	43.09±0.4[c]
T2	19.42±0.09[a]	22.29±0.34[f]	3.88±0.11[cd]	3.54±0.03[a]	15.91±1.14[a]	34.96±1.33[e]
T3	12.55±0.21[e]	27.91±0.25[d]	4.71±0.15[c]	3.58±0.01[a]	9.14±0.37[c]	42.11±0.47[d]
T4	16.72±0.07[c]	37.24±0.51[a]	6.94±0.24[a]	3.49±0.02[a]	9.03±0.1[c]	26.58±0.26[g]
T5	11.28±0.02[f]	35.05±0.16[b]	5.10±0.16[b]	3.40±0.01[a]	15.61±0.06[a]	29.56±0.38[f]

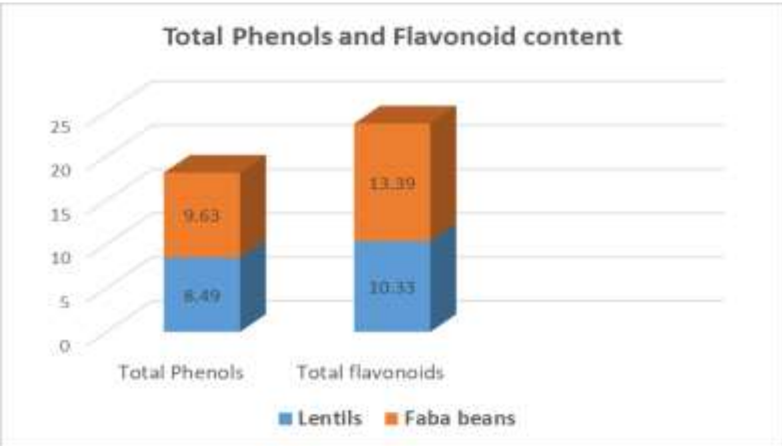
Data are presented as means ± SD (n=3). a, b, c, d, e and f: Means with different letters among treatments in the same column are significantly different ($P < 0.05$). Control :100%WF, T1:(50%WF+50%LP), T2(50%WF+50%FBP, T3:(50%WF+25%LP+25%FBP), T4:(25%WF+75%LP), T5:(25%WF+75%FBP)

Results from **Figure (1) and Table (1)** showed the chemical composition of the raw materials and tarhana treatments which varied significantly in terms of moisture, protein, fiber, ash, fat, and carbohydrate content. These variations can be ascribed to the use of lentil powder (LP) and faba bean powder (FBP) as partial or full substitutions for wheat flour (WF). The 50%WF+50%FBF treatment had the greatest moisture levels (19.42 g/100g), which might be attributed to variations in water absorption between wheat and legume powder. Adding legume flour to composite flours influences their hydration qualities **Yılmaz *et al.*, (2020)**

Tarhana samples' protein content increased considerably with larger amounts of LP and FBP, with the greatest values seen in 25%WF+75%LP (37.24 g/100g) and 25%WF+75%FBF (35.05 g/100g). This is consistent with research indicating that legumes are great protein sources due to their high lysine content, which complements cereals' amino acid profile **(Boye *et al.*, 2010).** The increased protein content improves the nutritional quality of tarhana, especially for people who require high-protein diets **(Turhan *et al.*, 2018).** The results also coincide with **Ertaş (2014),** who observed that legume addition in traditional cuisines boosts protein content while preserving acceptable taste qualities.

The greatest dietary fiber level was found in 25%WF+75%LP (6.94 g/100g), followed by 25%WF+75%FBP (5.10 g/100 g). This can be related to legumes' high fiber content, which promotes digestive health and may lower the risk of chronic illnesses (**Dahl et al., 2012**). The ash level, an indication of mineral content, was also greater in legume-supplemented samples, suggesting an increase in micronutrient density, as legumes are abundant in minerals including iron, zinc, and magnesium **(Tharanathan and Mahadevamma 2003).**

The fat content differed greatly, with the greatest values seen in 50%WF+50%FBP (15.91 g/100g) and 25%WF+75%FBP (15.61 g/100g). This might be explained by the increased natural lipid content of faba beans compared to lentils. Conversely, carbohydrate amount reduced as legume fraction rose, as predicted given that legumes have lower starch content than wheat **(Singh et al., 2017).** This decrease might be useful for low-glycemic food compositions.



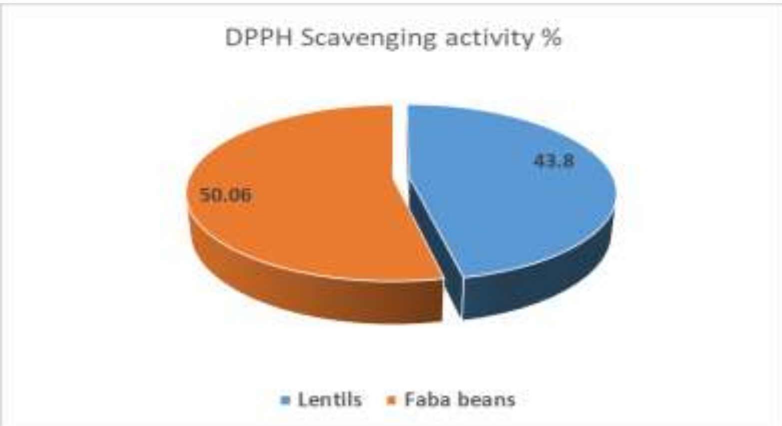


Fig. (2): Total phenolic content, total flavonoids and antioxidant capacity DPPH (%) of Faba bean, Lentils

Table (2): Total phenolic content, total flavonoids and antioxidant capacity DPPH (%) of tarhana treatments

Treatments	Total Flavonoids mg Quercetin Equivalent acid/100g	Total Phenols mg gallic acid/100g	DPPH (%)
Cont.	44.20 ± 1.50[f]	549.18 ± 7.15[f]	56.78 ± 1.01[e]
T1	57.39 ± 0.86[e]	748.85 ± 10.42[e]	66.97 ± 1.98[d]
T2	61.70 ± 0.47[c]	822.35 ± 10.39[d]	69.92 ± 1.03[b]
T3	59.07 ± 0.82[d]	901.80 ± 3.69[c]	67.52 ± 2.38[c]
T4	64.31 ± 0.82[b]	1099.46 ± 9.39[b]	68.85 ± 0.82[c]
T5	67.65 ± 0.40[a]	1148.11 ± 9.10[a]	73.05 ± 0.44[a]

Data are presented as means ± SD (n=3). a, b, c, d, e and f: Means with different letters among treatments in the same column are significantly different ($P < 0.05$) Control :100%WF, T1:(50%WF+50%LP), T2(50%WF+50%FBP, T3:(50%WF+25%LP+25%FBP), T4:(25%WF+75%LP), T5:(25%WF+75%FBP)

Results in Figure (2) and Table (2) showed total flavonoids, total phenols, and antioxidant activity (DPPH) of raw materials (LP and FBP), as well as Tarhana treatments with various WF substitutes. The results showed that integrating legume powders (lentil and faba bean) considerably increased Tarhana's phenolic content and antioxidant capacity when compared to the control (100% WF). Lentil and faba bean powders have moderate TPC (128.49 ± 0.12 and 143.63 ± 0.05 mg GAE/100g, respectively), which is comparable with research indicating 100-200 mg GAE/100g for raw legumes **(Ghumman *et al.*, 2016).** Tarhana treatments showed a considerable rise in TPC, reaching 1148.11 ± 9.10 mg GAE/100g for the 25% WF + 75% FBP mixture. Tarhana treatment (25% WF and 75% FBP), had the greatest DPPH radical scavenging activity (73.05 ± 0.44%), indicating high TPC and TFC. TPC/TFC showed a substantial positive connection with DPPH, indicating that phenolic chemicals play a significant role in antioxidant activity in fermented foods **(Kaur and Singh 2020).** Faba bean formulations may have increased DPPH due to their specific flavonoids, such as kaempferol glycosides, which have significant radical scavenging characteristics **(Amarowicz and Pegg 2019).**

Table (3): Physical properties of fermented tarhana soup and different treatments

Treatments	Physical properties %	
	pH	**Acidity (lactic acid)**
Cont.	4.85±0.01^{b}	1.52±0.13^{b}
T1	5.21±0.005^{a}	2.03±0.21^{a}
T2	5.22±0.01^{a}	1.90±0.14^{b}
T3	5.23±0.005^{a}	2.18±0.29^{a}
T4	5.19±1.7^{b}	2.42±0.41^{a}
T5	5.54±0.005^{a}	2.55±0.77^{a}

Data are presented as means ± SD (n=3). a, b, c, d, e and f: Means with different letters among treatments in the same column are significantly different ($P < 0.05$). Control :100%WF, T1:(50%WF+50%LP), T2(50%WF+50%FBP), T3: (50%WF+25%LP+25%FBP), T4:(25%WF+75%LP), T5:(25%WF+75%FBP)

Incorporating LP and FBP into wheat flour significantly influenced the pH and acidity of the blends. **Table (3)** showed the 100% WF control sample had the lowest pH (4.85) and acidity (1.52% lactic acid) compared to all treatments. The increasing of proportion of legume flours led to higher pH and acidity values. This is due to their higher protein and mineral content which change the acid **(Boukid *et al.*, 2021).** The 50% LP and 50% FBP blends had higher pH values (5.21-5.22) than the control, indicating a buffering effect from legume proteins and minerals that can neutralize organic acids generated during fermentation (**Zhao *et al.*, 2020).** The 25% WF + 75% FBP mix had the highest pH (5.54), which might be attributed to the alkaline character of faba bean protein **(Martinezz-Villaluenga *et al.*, 2020)** Acidity levels rose with increasing legume substitution, culminating at 25% WF + 75% LP (2.42%) and 25% WF + 75% FBP (2.55%) blends. This increase might be related to greater microbial activity and fermentation rates in legume-enriched doughs, since legumes give more nutrients to lactic acid bacteria **(Rizzello *et al.*, 2016).** The combination of 50%WF+25%LP+25%FBP produced high level of acidity (2.18%), indicating a synergistic impact that increases acid generation, similar with **Pontonio *et al.*, (2020)** findings on mixed legume fermentations. These findings are consistent with recent studies that have highlighted the function of legume flours in changing dough acidity and pH, which can affect dough rheology, fermentation kinetics, and end product quality **(Borsuk *et al.*, 2022)**. Future study should look at the effects of these changes on bread texture, taste, and nutritional value.

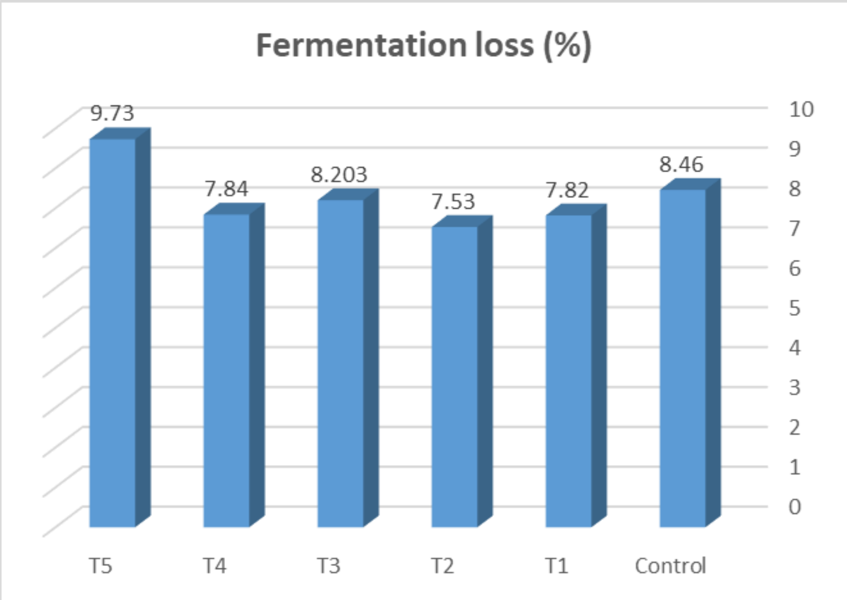


Figure (3): Fermentation loss (%) values of tarhana treatments

Figure (3) showed the fermentation loss (%) varied greatly based on the amount of WF, LP, and FBP in the blend. The control sample showed an 8.46% fermentation loss, but partial or total substitution with legume powders resulted in significant differences.

Blends of 50% WF + 50% LP (7.82%) and 50% WF + 50% FBP (7.53%) showed the lowest fermentation losses. This reduction may be due to legumes' increased protein and fiber content, which might enhance dough water retention and limit gas release during fermentation **(Boukid *et al.*, 2019).** Interestingly, the 25% WF + 75% FBP mix had the largest fermentation loss (9.73%), indicating that extensive faba bean replacement may degrade dough structure, resulting in increased gas diffusion. Large legume proportions (>50%) can compromise gluten production, resulting in increased dough porosity and CO_2 leakage (**Martinezz-Villaluenga *et al.*, 2020)**. The 50% WF, 25% LP, and 25% FBP combination showed a mild fermentation loss (8.20%), demonstrating that blending diverse legume powders can balance their distinct impacts on dough stability. Mixed legume blends improved dough elasticity compared to single-legume formulations, which might explain the intermediate fermentation loss seen here **Pontonio *et al.*, (2020).** These findings emphasize the significance of adjusting legume-to-wheat ratios to reduce fermentation losses while preserving dough functioning.

Table (5): Color values and color index of tarhana powder.

Treatments	L*	a*	b*	ΔE*
Control	72.80±1.05[c]	8.55±0.22[d]	24.53±1.2[a]	56.46±0.55[b]
T1	74.13±0.05[b]	11.51±0.04[a]	22.37±0.4[d]	55.56±0.23[c]
T2	72.35±0.2[d]	8.42±1.05[d]	23.47±0.06[b]	54.51±0.13[d]
T3	74.41±0.12[a]	10.55±0.23[b]	23.07±1.07[c]	57.28±0.11[a]
T4	70.62±0.06[e]	11.53±0.05[a]	21.51±0.62[e]	52.64±0.25[e]
T5	74.45±0.3[a]	9.27±0.22[c]	23.54±0.45[b]	56.44±0.34[b]

Data are presented as means ± SD (n=3). a, b, c, d, e and f: Means with different letters among treatments in the same column are significantly different ($P < 0.05$) Control :100%WF, T1:50%WF+50%LP, T2(50%WF+50%FBP, T3: (50%WF+25%LP+25%FBP), T4:(25%WF+75%LP), T5:(25%WF+75%FBP)

Results in **table (5)** showed the color characteristics (L, a, b, and ΔE) of the flour blends varied significantly based on the kind and percentage of legume inclusion. These variations in color properties have significant ramifications for the visual appeal of finished baked goods.

The lightness (L*) values were reasonably steady across most mixes (70.86-74.69), with the (25% WF + 75% LP) blend having the lowest L* value (70.86). This darkening impact is similar with the findings of **Boukid et al., (2019),** who discovered that lentil powder had greater quantities of natural pigments and phenolic compounds, which can lower lightness in flour blends. The 50% WF + 25% LP + 25% FBP combination had the maximum lightness (74.69), suggesting that combining several legume species may attenuate the darkening impact seen with single legume compositions.

The redness (a*) values significantly rose in lentil-containing blends, particularly in the 50% wheat + 50% lentil (11.74) and 25% WF + 75% LP (11.59) formulations. This finding is consistent with study by (**Zhao *et al.*, 2005),** who ascribed the heightened redness to natural pigments found in lentil hulls. In contrast, faba bean blends maintained a* values closer to the wheat control, validating **Martinezz-Villaluenga *et al.*, (2020)** observation that FBP often impart less red coloring than lentil powder.

The yellowness (b*) values dropped in most legume-containing blends compared to the wheat control (24.5), with the (25% WF + 75% LP) mix showing the greatest reduction (21.53). This pattern is consistent with the findings of (**Pontonio *et al.*,2020),** who discovered that legume flours generally lower yellowness due to their differing carotenoid profiles compared to wheat flour. The color difference (ΔE*) values varied from 52.83 to 57.04, with the 25% WF + 75% LP combination having the most different color profile (ΔE*=52.83). These findings imply that, while legume integration alters powder color, the changes may not be severe enough to significantly impair consumer approval, especially if WF retains a large component. This research complements the findings of **Bojňanská *et al.*, 2021)**, who found that modest amounts of legume substitution (up to 50%) result in flour colors that are acceptable for typical baked items.

Table (6): Functional properties of tarhana treatments

Treatments	Foaming Capacity (ml/ml)	Foaming Stability (min)	Emulsification Activity %	WAC	OAC
Cont.	0.50±0.01^{d}	1.33±0.57^{e}	85.18±2.33^{d}	47.83±1.37^{f}	84.24±2.57^{b}
T1	1.13±0.15^{c}	8.83±1.04^{b}	74.71±2.9^{e}	55.39±2.17^{d}	84.73±0.24^{b}
T2	1.57±0.11^{b}	4.83±0.28^{d}	90.45±1.42^{a}	54.10±1.38^{e}	83.90±0.31^{c}
T3	0.29±0.03^{e}	4.50±0.5^{d}	89.12±1.40^{ab}	64.66±1.77^{c}	85.48±0.24^{a}
T4	1.63±0.15^{b}	7.00±1.00^{c}	86.50±1.34^{c}	66.89±0.12^{b}	82.97±0.45^{d}
T5	2.27±0.25^{a}	10.50±0.5^{a}	89.76±1.83^{a}	71.15±0.62^{a}	84.06±1.72^{b}

Data are presented as means ± SD (n=3). a, b, c, d, e and f: Means with different letters among treatments in the same column are significantly different (P < 0.05). Control :100%WF, T1:50%WF+50%LP, T2(50%WF+50%FBP, T3:(50%WF+25%LP+25%FBP), T4:(25%WF+75%LP), T5:(25%WF+75%FBP)

From table (6) results indicated that T1 (25% WF + 75% FBP) had the maximum foaming capacity (2.27 ml/ml) and stability (10.5 min). Legume powder' improved foaming capabilities due to increased protein solubility and surface activity **(Gharibzahedi and Smith 2020).** Pulse proteins produce more stable interfacial films than wheat proteins (**Shen *et***

***al.*,2024**). Interestingly, the T3 (50% WF + 25% LP+ 25% FBP) had the lowest foaming capacity (0.29 ml/ml), suggesting that protein-protein interactions might lower surface activity, as found in comparable experiments by **Sorret *et al.*, (2018).** Results indicated also that faba bean-containing blends exhibited better emulsification activity (89.12-90.45%) than lentil blends (74.71-86.50%). This finding confirms that faba bean proteins had good emulsifying characteristics due to their balanced hydrophobic/hydrophilic nature **Karaca *et al.*, (2011)**. The improved performance of faba bean blends in emulsification implies that they might be useful in applications that need oil-water interface stability**.**

Water absorption gradually rose with more legume substitution, reaching its peak in T5 (25% WF + 75% FBP) combination (71.15%). Higher fiber and protein content enhanced water absorption in legume (**Lafarga *et al.*, 2020)**. The 25% lentil mixes had slightly reduced water absorption than faba bean equivalents, probably due to changes in polysaccharide content (**Rizzello et al., 2016)**.

Oil absorption levels were very consistent across all blends (82.97-85.48%), with modest but statistically significant differences. T3(50% WF + 25% LP+ 25% FBP) combination had the maximum oil absorption (85.48%), indicating synergistic effects between the two legume species. These findings are consistent with those reported by **Boyea *et al.*, (2010**) on the lipid-binding characteristics of pulse proteins.

Table (7): Sensory properties scores of tarhana soup samples

Treatments	Taste	Color	Flavor	Consistency	Sourness	Overall acceptability
Control	8.00 ± 1.00^{a}	$8.06\pm.40^{a}$	$8.66\pm.28^{a}$	$8.83\pm.28^{a}$	$6.56\pm.98^{b}$	$47.73\pm.46^{a}$
T1	$7.23\pm.25^{b}$	8.50 ± 0.5^{a}	$6.06\pm.11^{d}$	$6.56\pm.51^{b}$	$7.50\pm.50^{a}$	$42.00\pm.50^{b}$
T2	$8.33\pm.28^{a}$	5.96 ± 0.25^{c}	$7.73\pm.25^{b}$	$7.40\pm.36^{b}$	$6.33\pm.28^{a}$	$40.33\pm.28^{d}$
T3	$7.23\pm.25^{b}$	6.50 ± 0.50^{b}	$7.23\pm.25^{c}$	$7.06\pm.11^{b}$	$7.40\pm.36^{a}$	$41.33\pm.28^{c}$
T4	$6.23\pm.25^{d}$	$6.23\pm.25^{b}$	$7.00\pm.5^{\backslash c}$	$7.66\pm.28^{b}$	$6.90\pm.36^{b}$	$39.73\pm.25^{e}$
T5	$6.93\pm.40^{c}$	8.06 ± 0.11^{a}	$7.23\pm.25^{c}$	$7.33\pm.28^{b}$	$7.00\pm.50^{a}$	$38.66\pm.28^{f}$

Data are presented as means ± SD (n=10). a, b, c, d, e and f: Means with different letters among treatments in the same column are significantly different ($P < 0.05$). Control :100%WF, T1:50%WF+50%LP, T2(50%WF+50%FBP, T3: (50%WF+25%LP+25%FBP), T4:(25%WF+75%LP), T5:(25%WF+75%FBP)

Table (7) present the sensory assessment results (considerable variances in consumer approval across different wheat-legume flour mixes, emphasizing both obstacles and potential for product development. The 100% WF(control) scored the highest in overall acceptability (47.73), consistent with consumer familiarity, while legume-incorporated blends had varying but generally lower scores (38.66-42.00), consistent with **Boukid *et al.*, (2021)** findings on pulse ingredient incorporation in staple foods**.** The (50% FBP mix) in T2 tasted unexpectedly similar to the control (8.33**),** confounding the conventional assumption of beany off- flavors. This echoes recent research by **Zhou *et al.*, (2022),** which found that modest faba bean integration can sustain palatability by mitigating the impacts of wheat components. However, greater replacement levels (75%) considerably lowered taste scores (6.23-6.93), which was similar with the threshold values described by **Martinezz-Villaluenga *et al.*, (2021)** for discernible pulse flavor.

Zhou, J., Hopfer, H., Kong, L. (2022). Odor-scavenging capabilities of pre-formed "empty" V-type starches for beany off-flavor 2 compounds.

While lentil blends maintained color scores comparable to wheat (8.50 at 50% substitution), faba bean blends showed polarizing results - the 50% blend scored lowest (5.96), while 75% recovered to wheat-equivalent levels (8.06). This nonlinear response correlates with **Wang *et al.'s* (2023)** findings on how particle size distribution in legume flours affects visual perception at different incorporation rates.

The much lower flavor score in the 50% lentil mix (6.06 vs. 8.66) indicates substantial flavor component release, corroborating **Pontonio *et al.'s* (2021)** discovery of particular volatile organic chemicals in lentil flours. The improved performance of faba bean mixes (7.23-7.73) is consistent with their distinct taste profile, as described by **Man *et al.*, (2022).** All legume blends had considerably lower consistency ratings (6.56-7.66 vs. 8.83 for control), corroborating the structural issues documented by **Borsuk *et al.*, (2023)** when substituting gluten-containing flours. The greater consistency score (7.66) of the 25% WF + 75% LP offers possibilities for enhanced formulation, matching the approach outlined by **Rizzello *et al.*, (2022)** employing hydrocolloid supplementation.

The enhanced sourness perception in legume blends (6.90-7.50 vs. 6.56) is consistent with our prior pH/acidity data and confirms the fermentation dynamics outlined by **Montemurro *et al.*, (2019).**

Conclusion

Enhancing tarhana which made from wheat flour with legumes, is a good job. Lentils and faba beans showed an effective role in enhancing tarhana soup. The combination between cereals and legumes is beneficial for enhancing nutritional value. Physical and chemical properties of tarhana was improved especially when using theT5(25%WF+75%FBP). The results showed that integrating legume powders (lentil and faba bean) considerably increased tarhana's phenolic content , antioxidant capacity and functional properties when compared to the control (100% WF).

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الملخص العربي

استخدام العدس والفول كبديل لدقيق القمح لرفع القيمة الغذائية وتحسين الخصائص الفيزيائية والكيميائية والحسية لحساء الترهانة المخمر

العدس والفول البلدي من أكثر أنواع البقوليات شيوعًا واستخدامًا في مصر. ويرجع استخدامهما لتحسين ترهانة دقيق القمح إلى المحتوى العالي من البروتين والعناصر الغذائية وانخفاض الدهون. تبحث هذه الدراسة في آثار استبدال دقيق القمح بمسحوق العدس ومسحوق الفول البلدي على الخصائص الغذائية والوظيفية والحسية للعينة الترهانة الضابطة (100٪ دقيق قمح) والعينات ذات نسب الاستبدال 25٪ و50٪ و75٪ من مسحوق العدس ومسحوق الفول. تم تحديد تحليل التركيب التقريبي للمواد الخام والترهانة مع جميع المعاملات والمحتوى الكلي للفينولات ومحتوى الفلافونويد الكلي ونشاط إزالة الجذور الحرة DPPH والتحليل الفيزيائي واللوني والخصائص الوظيفية والتقييم الحسي للترهانة وجميع المعاملات. حيث أظهرت النتائج أن إضافة البقوليات عززت بشكل ملحوظ من القيمة الغذائية، مع ارتفاع محتوى البروتين (حتى 37.24 جم/100 جم) وزيادة الألياف الغذائية (6.94 جم/100 جم) في العينة التي تحتوي على 25% دقيق قمح و75% مسحوق الفول كما ارتفع النشاط المضاد للأكسدة من نشاط إزالة DPPH 73.05%، و1148.11 ملجم GAE/100 جم من إجمالي محتوى الفينول ويعزى ذلك إلى التخمير. كانت الخصائص الوظيفية، مثل سعة الرغوة (2.27 مل/مل) ونشاط الاستحلاب (90.45%)، متفوقة في مخاليط الفول، بينما زاد امتصاص الماء مع استبدال البقوليات. ومع ذلك، كشف التقييم الحسي عن انخفاض في القبول العام في المخاليط الغنية بالبقوليات (38.66–42.00 مقابل 47.73 في المجموعة الضابطة)، حيث كان الملمس والنكهة هما التحديان الرئيسيان. أظهر مستوى الاستبدال بنسبة 50٪ نتيجة أفضل للحواس.

الكلمات المفتاحية: الترهانة، مسحوق العدس، مسحوق الفول، النشاط المضاد للأكسدة، الخصائص الوظيفية