University of Thi-Qar Journal of agricultural research

Thi-Qar Journal of agricultural research

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 363-373

https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

Partially substituting wheat bread with Psyllium husk flour: Nutritional, Textural, and Sensory Characteristics Study

Hiran Sarwar Karim

[1]Department of food science and quality control, University of Sulaimani-IRAQ

E-mail: hiran.sarwar@univsul.edu.iq

Abstract

This study aimed to investigate the impact on bread quality, texture parameters, nutritional qualities, and sensory aspects of partially replacing wheat flour with psyllium husk flour (PHF) at different levels of 5%, 10%, and 15%. The proximate analysis revealed that the amount of moisture, crude fiber and ash content considerably raised with increasing the psyllium husk flour (PHF) to (9.86%, 12.22% and 1.92) respectively, while the amount of protein decreased to 8.38% and fat content decreasing to 0.31%. According to The Farinograph parameters, water absorption (76.5% to 89.77%), development time heightened to (5.53 min), as well as stability decreased from (2.50 min) to (1.20 min) at addition of 15% PHF. Nutritionally, total phenol content (3.31 to 7.92 mg/100g), flavonoids (3.38 to 3.77 mg/100g), antioxidant activity (3.24 to 15.48 μM TE/100g), and minerals content like sodium (Na), calcium (Ca) and iron (Fe) showed significant increasing to (37.73mg/l, 42.88mg/l and 2.78mg/l) correspondingly at the level of 15% psyllium husk flour-enriched bread. Bread weight increased to (143.20gm) as 15% psyllium husk flour added. However, with increasing PHF levels, loaf volume and specific volume decreased from (350.37 to 148.02 cm³) (2.44 to 1.20 cm³/g) respectively, while hardness increased (827 N to 1817 N at 15% PHF) as indicated by texture analysis. Sensory evaluation showed significant declines in taste, texture, and overall acceptability at 15%. Vice versa at PHF ≤ 10%. The results show that a larger substitution level degrades technology. Hence, the PHF 10% content is a good balance between nutritional enrichment and sensory appeal.

Keyword: Bread, Psyllium husk, mineral, phenolic content

I. Introduction

Traditionally, bread is made by baking a mixture of flour (usually made from cereal grains) and liquid (usually water or milk). Fermentation agents like yeast or sourdough microbes are used to leaven the mixture, and occasionally salt, fats, or other ingredients are added to improve its flavor and texture. In terms of structure, it is defined as an elastic-plastic foam in which gas bubbles that were trapped during fermentation swell during baking to form a porous crumb structure within a crust [1]. Bread is usually known as an important source of carbohydrates in the food pyramid to ensure that a person can get enough nutrition that is needed by the body [2]. To produce healthy bread, bakers often reduce calories, fat, and sugar, while increasing fiber or water. Also, natural ingredients are seeking to substitute chemically produced ones [3]. One of the natural substitutes may be Psyllium.

Psyllium (Plantago ovata) is an annual herb originating from West Asia it is a source of natural and concentrated soluble fiber derived from the husks of blonde psyllium seed. The psyllium husk contains 6.83% fiber, 0.94% protein, 4.07% ash, and 84.98% total carbohydrates [4]. The molecular structure of the psyllium is 75% xylose, 23% arabinose, traces of other sugars, and around 35% non-reducing terminal residues, with both (1→4) and β-(1→3) glycosidic bonds in the

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 363-373
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

Xylan backbone, the polysaccharide is a highly branched acidic arabinoxylan [5]. The husk is the outermost skin of the seed which is removed by a mechanical process. The total recovery of husk is about 25 to 26% from the seed. The psyllium husk consists of 6.83% fiber, 0.94% protein, 4.07% ash, and 84.98% total carbohydrates [4]. The beneficial health effects of psyllium consumption have been widely studied and include the prevention of constipation, diarrhea, irritable bowel syndrome (IBS), inflammatory bowel disease-ulcerative colitis, colon cancer, diabetes, and hypercholesterolemia [6]. Psyllium has been used in the production of gluten-free breads as a gluten replacer [7] It was mentioned by [8], that studies on the use of psyllium in white bread are scarce, and there is no study on the use of psyllium as an improvement in whole meal bread. Hence, the current study investigates the substitute effect of wheat flour with different levels of psyllium husk (PHF%) in the bread.

Since the flour quality and composition directly influence the quality of bread, it is preferable to aim to study the chemical composition of flour used for making a piece of bread before moving on to studying the effect of substitute wheat flour with different levels of PHF%. Therefore, this research work is divided into two parts; (1) an analysis of flour quality and (2) An investigation of the substitute effect of wheat flour with different levels of psyllium husk (PHF%) for baked products to make a psyllium husk supplemented bread (PHB) with good quality characteristics.

II. Materials and Methods

Materials

Psyllium husk was obtained from the herb market at Sulaimani city. A locally harvested wheat flour type (Baharan) with extraction rate (72%) and composition of 9.845 % moisture, 1.08 % fat 1.80% ash, and 13.3% protein content was used. The other raw materials of the recipe (dry milk, yeast, and salt) were bought from the local market. The psyllium husk was mixed with wheat flour in different percentages (5%, 10%, and 15%) to make psyllium husk bread (PHB).

Methods

Flour chemical composition analysis

For flour proximate analysis, the moisture content was determined by using an oven-dryer method [9]. Total fat was analyzed by a Soxhlet extraction apparatus (Soxtec 8000, FOSS, Hilleroed, Denmark) [10]. Total protein was determined by the Kjeldahl method [11], and ash by the incineration method [9], and dietary fiber by using the enzymatic method [12].

2.2.2 Total phenolic Content (TPC) and Antioxidant Activity

The total polyphenolic content (TPC) of the wheat flour with different level of psyllium husk flour was calculated by the Folin–Ciocalteu spectrophotometric method [15]. After 1 hour the absorbance at 765 nm was measured, using the UV-2401 PC spectrophotometer (Shimadzu, Kyoto, Japan). The results were stated as mg of gallic acid equivalents (GAE) per 100 g of dry bread. The ABTS and FRAP methods were applied in our studies as reported by [10]and [11]. The absorbance was measured at 734 nm and 593 nm using the UV-2401 PC spectrophotometer (Shimadzu, Kyoto, Japan). The results of anti-radical capacity and reducing power were expressed as Trolox equivalents in μmol per 100 g of dry sample (μM TE/100 g d.m.). Data were expressed as the mean value for three measurements.

University of Thi-Qar Journal of agricultural research

Thi-Qar Journal of agricultural research

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 363-373

https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

Total flavonoid content

The concentration of flavonoids in the flour blended with psyllium husk was determined by using a spectrophotometric method [16]. The analysis involved a test solution containing: 1 ml of 1 mg/ml methanolic extract solution and 1 ml of 2% AlCl3 solution dissolved in methanol The test solutions were incubated at room temperature for 1 hour. Later, the absorbance of each solution was measured using a spectrophotometer at a wavelength of maximum absorption (λmax) of 415 nm.

Determination of minerals

The mineral content of sodium (Na), calcium (Ca), and iron (Fe) were determined in the clear solution by inductively coupled plasma optical emission spectrometry (ICP-OES) (ICP-OES-9820 Plasma Atomic Emission Spectrometer; Shimadzu, Japan) [17]. Including a mini torch, part number (P/N) S211-81448. The optimum functioning parameters produced a maximum output of 1.6 kW at a frequency of 27 MHz; argon gas grade 5 was used for plasma, nebulizer, and auxiliary gas. The gas pressure was 450 ± 10 kPa, according to the gas purity. The flow values for plasma (coolant) gas, auxiliary gas, and carrier gas were set to 20, 1.5, and 1.5 L· min–1, respectively. All the analyses were carried out in three technical replicates.

Dough Quality Assessment:

Dough quality was performed using the Farinograph as stated by AACC Method: 54–21.02. Absorption was stated on a 14% moisture basis. The parameters determined by the farinograph on a 14% moisture basis were flour water absorption (FWA, percent on a 14% moisture basis), peak time (min), mixing stability (min), and mixing tolerance index (MTI; BU) [13].

Bread Making

Psyllium husk bread (PHB) was prepared according to the straight dough method with some modifications [14]. All the ingredients were calculated on a g/100 g flour basis. The formulation consisted of: 100 g wheat flour, 2g instant active dry yeast, 1.0 g salt, 4.0 g sugar,4.0g dry milk,2.0g shortening, and water (added according to the farinograph test). Psyllium husk (PS) was incorporated by substituting WF at levels of 0%, 5%, 10%, and 15% (w/w). All ingredients were placed in a mixing bowl and mixed for 6 min at 28 ± 2.0℃.

The formulated dough was manually rounded with 20 times folding, followed by a bulk dough fermentation period for 10 min. The prepared dough was placed in lightly greased a baking pan and was proved for 80 min in a cabinet at 30 ± 0.5 °C and 85% relative humidity. Then baked in an electrical oven at 225 °C for 20 min. Subsequently, the baked bread was cooled at room temperature (25 ± 2.0 °C) for 60 min and then packed in polyethylene bags, before the measuremen

Physical Evaluation of Bread

Loaves were weighed in grams after two hours from of baking and the volume in (ml) of each loaf was determined using the seed displacement method. The specific loaf volume (S.L.V) and loaf weight were calculated [18].

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 363-373

https://jam.utq.edu.iq/index.php/main   *https://doi.org/10.54174/utjagr.v13i1.323*

Texture analysis

The bread samples, after baking, were cooled to room temperature of 22 ± 1 °C. at the center of all slices, the hardness, cohesiveness, and springiness of loaf bread were measured, and bread samples were cut into square-shaped pieces (5 × 2.5 cm) using a slicer. Then, bread crumbs were compressed twice to 50% of their original size using a stainless steel cylinder. The average ± standard deviation of these values has been reported for loaf bread samples [19].

Sensory analysis

Loaf bread sensory evaluation for crust and crumb color, aroma, taste, appearance, texture, and overall acceptability were assessed by semi-trained panelists. Ten-point hedonic scale was used, grading from one (immensely dislike) to ten (extremely like) [20].

Statical analysis

Statistical data analysis with the XLSTAT program for window applied Duncan's test at a significance level of $P \geq 0.05$ was used to the comparisons of the mean. The collected data were obtained in triplicates.

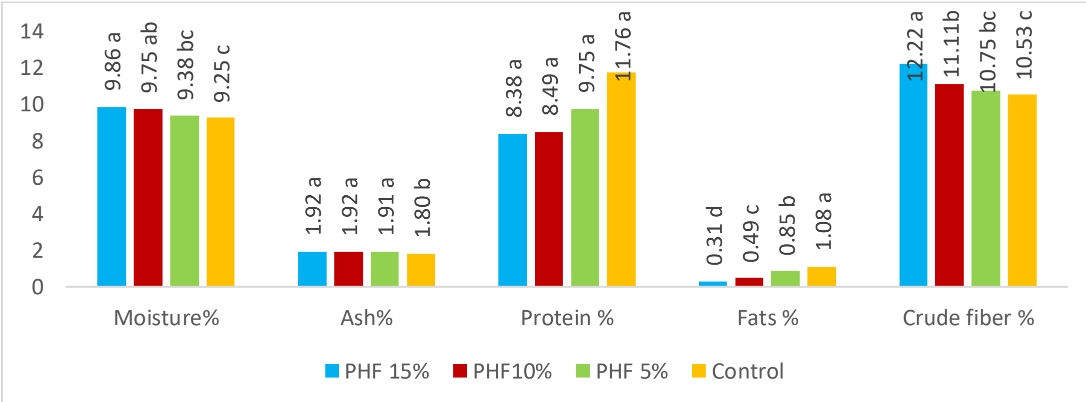
III. Results and Discussion

Flour chemical composition analysis

The chemical composition of wheat flours with different levels of PHF content (5,10,15%), was illustrated in (Figure 1). The moisture, fiber and ash percentage were increased from 9.25% to 9.86% for the former, from 10.53% to 12.20% fiber content and 1.80% to 1.92% in bread with increasing the PHF%. Vice Versa with protein and fat. Due to the higher moisture level of the flours, all components are diluted, resulting in lower protein amounts. The higher moisture content results from both the higher percentage of water in psyllium formulations and the high-water absorption capacity of psyllium, which minimizes water loss during baking and storage. This was proven by the absence of differences in water loss during baking, indicating that the excess water in the formulation, compared to the control, was retained in the bread. The higher fiber content results are due to Psyllium composition which is a mixture of polysaccharides, pentoses, hexoses, and uronic acids. Seed preparations contain approximately 47% soluble fiber by weight and husk preparations generally consist of 67-71% soluble fiber and approximately 85% total fiber by weight [21]. It was stated by [22] those biscuits prepared from psyllium seeds flour at different levels (0, 5, 10, and 20% of PSF) increased crude fat, crude fiber, and ash. Whereas, available carbohydrates and caloric value are reduced.

Standard consumption of fiber is an important issue to prevent many types of diseases through a standard balanced diet [23]. It is a good practice to modified the bread with PHF%, since the modification of wheat flour with different level of PHF% significantly increased the level of fiber. The positive role of dietary fiber as a prebiotic component is due to its effect in the reduction of chronic diseases such as cardiovascular disease, specific types of cancer, and constipation [24]. Hence, it is important to enrich various foods with a variety of dietary fibers.

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 363-373
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

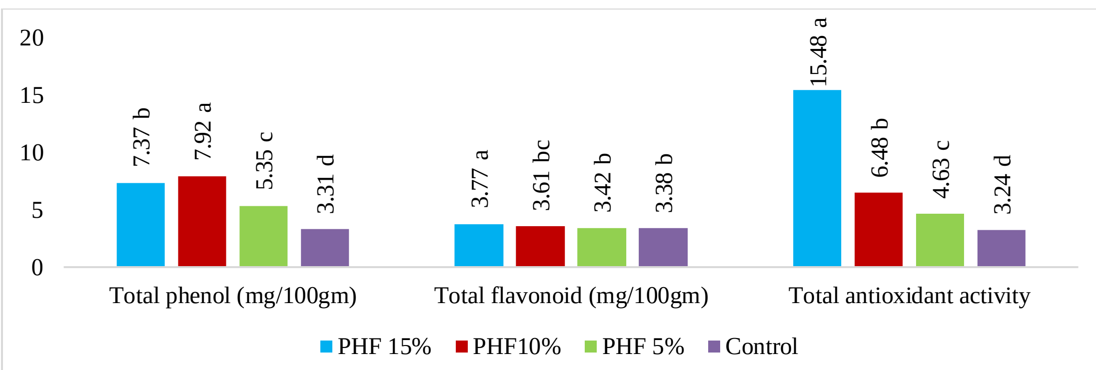


Values with the same superscripts did not differ significantly in a column (P=0.05).

Figure1. The approximate compositions of wheat flour replaced with different levels of PHF%

. Determination of total phenol, flavonoid, and antioxidant activity

The effect of modification of wheat flour with different levels of PHF% on the total phenol, flavonoid, and antioxidant activity was illustrated in (Figure 2) As compared to the control, the total phenol content increased significantly from 3.31 mg/100gm to 7.37 mg/100 in the modified wheat flour with 15% PHF, this could be due to Soluble commonly (arabinoxylans), insoluble polysaccharide (cellulose, lignin, and hemicellulose) as well as tannins, flavonoids, and phenols are the parts of the entire psyllium crop, arabinoxylan, psyllium, and husk seeds [26].



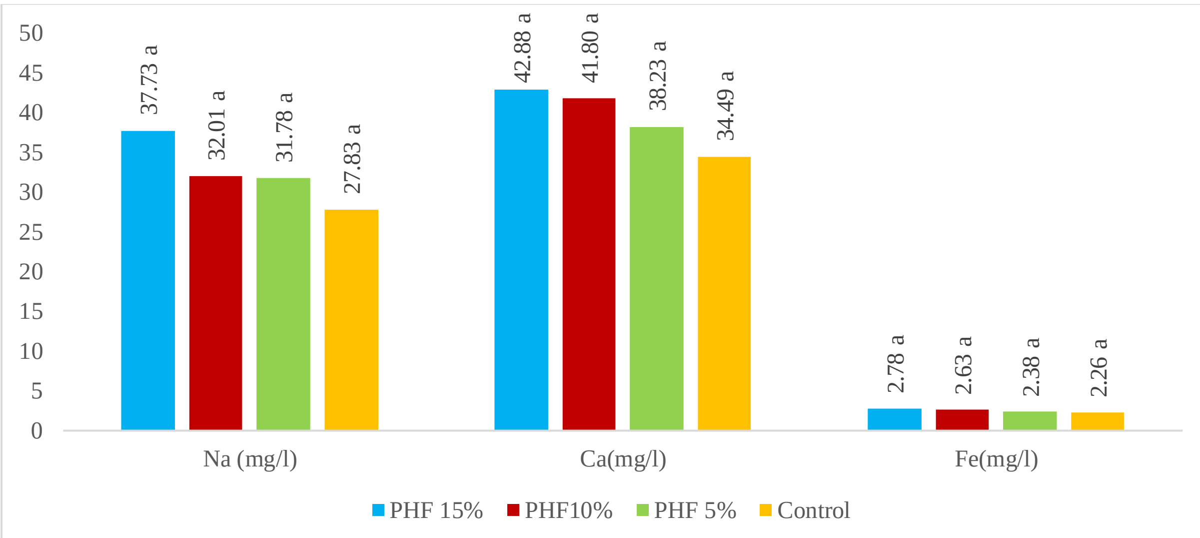
PHF – Psyllium husk flour. Mean values with the same superscripts did not differ significantly in a column (P=0.05).
Figure 2. The total phenolic, flavonoid, and Antioxidant Activity of modified wheat flour with different levels of PHF%.

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 363-373

https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

Minerals content

The increasing PHF% in the wheat flour particularly increased minerals levels of Na, Ca, and Fe to (37.73, 42.88, and 2.78 mg/l) respectively as compared to the control as shown in figure3. This result is in agreement with [27], as they mentioned that the most abundant mineral in the Psyllium husks powder was potassium, followed by calcium. Also, it was found by [28]that psyllium seeds contain Na, Ca, K, Fe, Mn, and Zn were 331, 1440, 7380, 183, 12.2, and 27.4 mg ⁄ kg, respectively.



Mean values with the same superscripts did not differ significantly in a column (P=0.05).

Figure 3. The mineral contents of modified wheat flour with different levels of PHF%.

3.5. Bread Quality

Brabender farinograph parameters have been effectively used as a sensitive tool for the investigation of the characterization of bread dough properties; especially for the modifications caused by fiber at the period of mixing and developing of bread dough [25]. Data in (table 1) shows the rheological characterize using the farinograph apparatus for four formulas using wheat flour as control and modified wheat flour with (5,10,15%) PHF. The results show that adding PHF to wheat flour will increase water absorption from 76.50% in the control to 89.77% in the modified wheat flour with PHF15% as well as the development time increased from 4.53 min to 5.53 min. However, the mixing tolerance index (B.U) was decreased significantly with increasing PHF to 15%. This could be due to the high capacity of water absorption of psyllium husk because of the molecular structure of Psyllium Seed, 75% xylose, 23% arabinose, traces of other sugar, and nearly 35% of non-reducing terminal remains [5].

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 363-373
https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

Table 1. The farinograph characteristics of modified wheat flour with different levels of PHF%.

Flour	Water absorption (basis on 14%)	Development time(min)	Stability (min)	Mixing Tolerance Index (BU)
PHF 15%	89.77 ^{a}	5.53 ^{a}	1.20 ^{b}	120.33 ^{c}
PHF10%	88.13 ^{a}	5.04 ^{b}	2.03 ^{a}	128.00 ^{a}
PHF 5%	84.57 ^{b}	4.23 ^{c}	2.13 ^{a}	141.33 ^{b}
Control	76.50 ^{c}	4.53 ^{c}	2.50 ^{a}	120.00 ^{c}
Standard deviation	1.01	0.26	0.30	2.81

Mean values with the same superscripts did not differ significantly in a column (P=0.05).

Physical evaluation of bread

The effect of loaf bread modification with different levels of PHB% on weight (g), volume (cm^3), and specific volume (cm^3/g) are shown in (Table 2). Such a table presented the negative effect of increasing PHF% on the bread's volume and specific volume as compared to control loaf bread. Otherwise, the weight increased from 140.53 g in the control to 143.20 g in the modified wheat flour with 15% PHF. The present results are in agreement with [29]. As they found that the volume of the bread reduced as the amount of Psyllium seed flour increased, because of interactions among dietary fiber components, gluten, and water.

Table 2. The weight, volume, and volume-specific loaf of modified wheat flour with different levels of PHF%.

Flour	Weight (g)	Volume(cm^3)	S.V.L(cm^3/g)
PHF 15%	143.20 ^{a}	148.02 ^{a}	1.20 ^{d}
PHF10%	143.81 ^{a}	178.20 ^{b}	1.24 ^{c}
PHF 5%	141.13 ^{b}	191.10 ^{c}	1.36 ^{b}
Control	140.53 ^{b}	350.37 ^{d}	2.44 ^{a}
Standard deviation	0.42	1.45	0.17

Mean values with the same superscripts did not differ significantly in a column (P=0.05).

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 363-373
https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

Texture analysis

The variations in surface profile investigation parameters (i.e., hardness, cohesiveness, and springiness) in bread are given in (Table 3). The results propose that as hardness increases, the value for cohesiveness also tends to increase with non-significant differences in Springiness value. This result was in agreement with [30].

Table 3. Texture Profile Analysis of modified wheat flour with different levels of PHF%.

Flour	Hardness N	Cohesiveness	Springiness mm
PHF 15%	1817.00 ^{a}	0.90 ^{a}	4.81 ^{a}
PHF10%	1527.10 ^{b}	0.90 ^{a}	4.80 ^{a}
PHF 5%	1045.47 ^{c}	0.88 ^{a}	4.80 ^{a}
Control	827.00 ^{d}	0.79 ^{b}	4.71 ^{a}
Standard deviation	4.55	0.03	0.14

Mean values with the same superscripts did not differ significantly in a column (P=0.05).

Sensory Evaluation

Sensory evaluation of bread with different amounts of PHF% is given in (Table 4). Aroma and appearance attributes showed non-significant differences as compared to the control. However, taste and texture scores decreased as the level of PHF% addition increased to 15%. In this study, the crust color of the bread containing 15% PHF had the lowest score as compared with other treatments. Similar results were correct for the bread's appearance, texture, and overall acceptability. Nevertheless, all the modified loaves of bread with 5, 10, and 15% PHF gave the volunteers satisfaction. Consequently, consumers would readily accept levels less than 15% psyllium husk addition in bread. The previous results exposed that sensorial evaluation, at 5, 10 and 15% of the Psyllium seed flour addition to the pan bread the quality parameters of the pan bread significantly deteriorated at 15% portion of wheat flour, the color deteriorated.

Table 4. Sensory evolution of wheat flour with different levels of psyllium husk flour

Sensory variable	Control	5% PHF	10% PHF	15% PHF
Crust Color	8.2 ^{a}	7.8 ^{b}	7.8 ^{b}	7.4 ^{c}
Aroma(odor)	7.5 ^{a}	7.5 ^{a}	7.0 ^{a}	7.0 ^{a}
Taste	8.2 ^{a}	7.2 ^{b}	6.4 ^{c}	6.2 ^{d}
Appearance	7.6 ^{a}	7.2 ^{a}	7.0 ^{a}	7. 0 ^{a}
Texture	7.8 ^{a}	7.0 $^{a\ b}$	6.4 ^{b}	6.0 ^{b}
Overall acceptability	7.8 ^{a}	7.5 ^{b}	6.8 ^{a}	6.8 ^{c}

Mean values with the same superscripts do not differ significantly in a column (P=0.05).

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 363-373

https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

IV. Conclusion

The modification of wheat flour with PHF% significantly enhanced the quantities of dietary fiber, total phenols, total flavonoids, and mineral elements, alongside enhanced antioxidant activity. Such results indicate that it is appropriate for meeting certain dietary needs, especially for people looking for functional meals. Adding PHF% to baked goods may help lower the incidence of colon cancer, regulate body weight better, and prevent weight-related diseases like obesity and mineral shortages. Moreover, the increasing PHF% in the wheat flour incorporation significantly increased dough water absorption and development time while reducing the mixing tolerance index. Sensory evaluation indicated that crust color, taste, texture, and overall acceptability were significantly influenced by psyllium addition (5–15% substitution levels), though aroma and appearance remained unaffected. All psyllium-enriched samples achieved sensory scores ≥7 (on a standard hedonic scale), confirming consumer acceptability across tested formulations.

V. References:

[1] B. Caballero, P. Finglas, and F. Toldrá, *Encyclopedia of food and health*. Academic Press, 2015.

[2] A. S. Sivam, D. Sun-Waterhouse, S. Quek, and C. O. Perera, 'Properties of bread dough with added fiber polysaccharides and phenolic antioxidants: A review', *J Food Sci*, vol. 75, no. 8, pp. R163–R174, 2010.

[3] D. M. El-Sheikh, 'Rheological characteristics of Arabic Gum suspension and Plantago seeds mucilage.', 2014.

[4] A. Verma and R. Mogra, 'Psyllium (Plantago ovata) husk: a wonder food for good health', *International Journal of Science and Research*, vol. 4, no. 9, pp. 1581–1585, 2013.

[5] M. H. Fischer, N. Yu, G. R. Gray, J. Ralph, L. Anderson, and J. A. Marlett, 'The gel-forming polysaccharide of psyllium husk (Plantago ovata Forsk)', *Carbohydr Res*, vol. 339, no. 11, pp. 2009–2017, 2004.

[6] E. A. N. Franco, A. Sanches-Silva, R. Ribeiro-Santos, and N. R. de Melo, 'Psyllium (Plantago ovata Forsk): From evidence of health benefits to its food application', *Trends Food Sci Technol*, vol. 96, pp. 166–175, 2020, doi: https://doi.org/10.1016/j.tifs.2019.12.006.

[7] M. Belorio, G. Marcondes, and M. Gómez, 'Influence of psyllium versus xanthan gum in starch properties', *Food Hydrocoll*, vol. 105, p. 105843, 2020, doi: https://doi.org/10.1016/j.foodhyd.2020.105843.

[8] M. G. Farbo, C. Fadda, S. Marceddu, P. Conte, A. Del Caro, and A. Piga, 'Improving the quality of dough obtained with old durum wheat using hydrocolloids', *Food Hydrocoll*, vol. 101, p. 105467, 2020, doi: https://doi.org/10.1016/j.foodhyd.2019.105467.

[9] AACC. International Method 08–01.01: Ash–Basic method', 1999, *St. Paul, MN*.

[10] J.-M. Shin *et al.*, 'Comparison of different methods to quantify fat classes in bakery products', *Food Chem*, vol. 136, no. 2, pp. 703–709, 2013.

[11] A. Sameen, A. Niaz, and F. M. Anjum, 'Chemical composition of three wheat (Triticum aestivum L.) varieties as affected by NPK doses', *Int. J. Agri. Biol*, vol. 4, no. 4, pp. 537–539, 2002.

[12] K. J. Cranker, K. M. Phillips, M. C. R. V Gonzales, and K. K. Stewart, 'Fine tuning a bile-enzymatic-gravimetric total dietary fiber method', *J AOAC Int*, vol. 80, no. 1, pp. 89–94, 1997.

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 363-373

https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

[13] B. V McCleary, N. Sloane, A. Draga, and I. Lazewska, 'Measurement of total dietary fiber using AOAC Method 2009.01 (AACC International Approved Method 32-45.01): evaluation and updates', *Cereal Chem*, vol. 90, no. 4, pp. 396–414, 2013.

[14] D. Ćurić, J. Đugum, and I. Bauman, 'The influence of fungal α-amylase supplementation on amylolytic activity and baking quality of flour', *Int J Food Sci Technol*, vol. 37, no. 6, pp. 673–680, 2002.

[15] R. L. Prior, X. Wu, and K. Schaich, 'Standardized methods for the determination of antioxidant capacity and phenolics in foods and dietary supplements', *J Agric Food Chem*, vol. 53, no. 10, pp. 4290–4302, 2005.

[16] C. Quettier-Deleu *et al.*, 'Phenolic compounds and antioxidant activities of buckwheat (Fagopyrum esculentum Moench) hulls and flour', *J Ethnopharmacol*, vol. 72, no. 1–2, pp. 35–42, 2000.

[17] A. O. AC, 'Association of official analytical chemists', *Official methods of analysis of AOAC International*, 1990.

[18] D. Alkandari, H. Sarfraz, and J. S. Sidhu, 'Development of a functional food (pan bread) using amla fruit powder', *J Food Sci Technol*, vol. 56, pp. 2287–2295, 2019.

[19] S. N. Al-Hooti *et al.*, 'Developing functional foods using red palm olein: objective color and instrumental texture', *Int J Food Prop*, vol. 7, no. 1, pp. 15–25, 2004.

[20] M. Tóth, T. Kaszab, and A. Meretei, 'Texture profile analysis and sensory evaluation of commercially available gluten-free bread samples', *European Food Research and Technology*, vol. 248, no. 6, pp. 1447–1455, 2022.

[21] R. Ahmadi, A. Kalbasi-Ashtari, A. Oromiehie, M.-S. Yarmand, and F. Jahandideh, 'Development and characterization of a novel biodegradable edible film obtained from psyllium seed (Plantago ovata Forsk)', *J Food Eng*, vol. 109, no. 4, pp. 745–751, 2012.

[22] M. Krystyjan, D. Gumul, A. Korus, J. Korus, and M. Sikora, 'Physicochemical properties and sensory acceptance of biscuits fortified with Plantago psyllium flour', *Emir J Food Agric*, vol. 30, no. 9, pp. 758–763, 2018.

[23] C. M. Rosell, E. Santos, and C. Collar, 'Physico-chemical properties of commercial fibres from different sources: A comparative approach', *Food Research International*, vol. 42, no. 1, pp. 176–184, 2009.

[24] S. Beikzadeh, S. H. Peighambardoust, M. Beikzadeh, M. A. Javar-Abadi, and A. Homayouni-Rad, 'Effect of Psyllium Husk on Physical, Nutritional, Sensory, and Staling Properties of Dietary Prebiotic Sponge Cake.', *Czech Journal of Food Sciences*, vol. 34, no. 6, 2016.

[25] P. Koletta, M. Irakli, M. Papageorgiou, and A. Skendi, 'Physicochemical and technological properties of highly enriched wheat breads with wholegrain non wheat flours', *J Cereal Sci*, vol. 60, no. 3, pp. 561–568, 2014.

[26] A. M. Bernstein, B. Titgemeier, K. Kirkpatrick, M. Golubic, and M. F. Roizen, 'Major cereal grain fibers and psyllium in relation to cardiovascular health', *Nutrients*, vol. 5, no. 5, pp. 1471–1487, 2013.

[27] Q. Guo, S. W. Cui, Q. Wang, and J. C. Young, 'Fractionation and physicochemical characterization of psyllium gum', *Carbohydr Polym*, vol. 73, no. 1, pp. 35–43, 2008.

[28] A. Ziemichód, M. Wójcik, and R. Różyło, 'Seeds of Plantago psyllium and Plantago ovata: Mineral composition, grinding, and use for gluten-free bread as substitutes for hydrocolloids', *J Food Process Eng*, vol. 42, no. 1, p. e12931, 2019.

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 363-373

https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

[29] S. Man, A. Paucean, S. Muste, A. Pop, and E. A. Muresan, 'Influence of psyllium husk (Plantago ovata) on bread quality', *Bulletin Of University Of Agricultural Sciences And Veterinary Medicine Cluj-Napoca-Food Science And Technology*, vol. 74, no. 1, pp. 33–34, 2017.

[30] K. R. Elbassiony, 'Using amaranth and Psyllium for production of bread and evaluate of properties', *Food Technology Research Journal*, vol. 4, no. 1, pp. 35–48, 2024.