124

Egypt. J. Chem. **Vol. 68**, No. 3. pp. 291 - 309 (2025)

Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

Influence of Partial Substitution of Wheat Flour with Chia Seeds Powder on Dough Rheology and Quality Attributes of Pan Bread

M.A.A. Zyada,[a] Alia M.A. Elgharably,[a] Eman E. Yousef,[a] M. A.M. Saleh[b]

[a]*Food Science Department, Faculty of Agricultural, Ain Shams University, Egypt*

[b]*Food Technology Research Institute, Agricultural Research Centre, Giza, Egypt*

Abstract

Pan Bread enriched with chia seed powder (CSP) is a kind of nutritional and functional bakery product. This research aims to evaluate the chemical, physical, rheological (Farinograph, Extensograph, Alveograph, tests) and sensory properties of Pan Bread made by replacing wheat flour with Chia Seed Powder in different percentages (2%, 4%, 6%, 8%, 10%, 12%, 15%). The results of the chemical composition revealed a gradual increase in the percentage of ash, protein, fat, and fiber also, a decrease in the percentage of moisture and carbohydrates with an increase in the percentage of replacement with CSP. The elements iron, calcium, and zinc recorded a gradual increase with an increase in the percentage of replacement with CSP compared to these elements in the control sample without CSP. Furthermore, there was a gradual decrease in the energy value by increasing the percentage of replacing wheat flour with chia seed powder from 2% to 15%. Regarding the farinograph, it was observed that; the ratios of replacement with CSP increased the absorption of water and stability time in the dough samples compared to the control dough. The extensibility of the dough also decreased significantly and the resistance to extension of the dough increased. The results of the physical properties of Pan Bread samples enriched with different percentages of CSP had a smaller specific volume (cm3)/g compared to the control sample. There was a gradual increase in the AWRC by increasing the proportion of wheat flour replaced by CSP in the range from 2% to 15%, which means that the addition of CSP increases the degree of freshness of the samples compared to the control. Sample without CSP. Additionally, overall acceptability of Pan Bread Samples It was shown that there were no significant differences at $p<0.05$ between the control sample and the samples with 6% and 8% CSP. However, Pan Bread samples were accepted for all sensory properties tested (Volume, Flavour, Texture, Crust color and Crumb color) up to 10% CSP replacement.

Keywords: Chia Seed Powder, Pan Bread, Rheological, Physical, Sensory Properties

1. Introduction

Wheat (Triticumaestivum) is one of the cereals used for bread making. However, breads made from wheat flour dough are considered nutritionally inadequate [1]. The partial replacement of wheat flour with non-wheat flour increases the nutritional quality and flavour of bakery products. In this context, blended flours based on wheat and other grains and non-cereal seeds (e.g., sunflower, amaranth, quinoa, lupine, chickpea, flaxseed, chia, hemp, teff) have become popular in baking technology and play several roles, such as improving the rheological properties of the dough and increasing the overall bread quality and nutritional value [2].

Bread is an essential product that contains almost all the components necessary to maintain human life and health: proteins, complex carbohydrates, calcium, iron, phosphorus, B vitamins, including thiamine, niacin and riboflavin, with a small amount of fat. In addition, bread is a convenient product for enrichment with vitamins, micronutrients and other healthy substances, which makes it possible to create an assortment that takes into account the needs of people suffering from diseases, living in ecologically unfavorable regions, of different ages and national taste preferences. Consumers prefer products that contain less fat and sugar. The market demand for healthy bakery products is increasing, while taste remains an important success factor Therefore, the guaranteed provision of all categories of the population with high-quality bread and bakery products is the main factor in the social stability of various countries (more than 140 million tons of bakery products are bought in the world) [3, 4]. Some bakery products can be prepared using chia seed flour with wheat flour to produce high-quality baked goods that are suitable for patients with high blood pressure, diabetes, and obesity [5]. Several studies have

*Corresponding author e-mail:mohamed_ahmed_ali@agr.asu.edu.eg.; (M.A.A. Zyada).
Received date 27 May 2024; revised date 27 June 2024; accepted date 24 July 2024
DOI: 10.21608/EJCHEM.2024.291981.9755
©2025 National Information and Documentation Center (NIDOC)

shown that chia seeds can be used for production of bread, and that it contributes to the technological quality and texture parameters, depending on the method of preparation or additive type (flour or seeds) [6, 7, 8].

Chia seeds (Salvia hispanicaL.) belong to the Lamiaceae family have been referred to as the “seeds of the 21st century” and “the new gold, super nutrients and superfoods” [9, 10]. There are about 900 species in various regions of the world [11]. Now that numerous studies have shown the remarkable nutritional properties of the chia seed, it is recommended for consumption because of its high oil, protein, antioxidants, minerals and dietary fiber contents [12, 13]. Moreover, it is rich in minerals such as iron, manganese, aluminum. Nitrogen and phosphorus, potassium, calcium and copper [14]. Chia seeds have a high health-promoting potential, exerting hypolipemic, hypoglycemic, antimicrobial, carotenoids and phenolic compounds, which can quench and scavenge free radicals and cation radicals. [15, 16, 17]. reported that because of the nutritional properties of chia, its consumption can promote proper intestinal functioning, decrease blood cholesterol and glucose levels and decrease the incidence of diseases related to metabolic syndrome, play a role in the proper functioning of vision, as well as in the prevention of cardiovascular diseases, cancer, and autoimmune and inflammatory diseases. In addition to being nutritionally important to good health.

The grain quality is important for the processing of these end products, particularly the protein content and the gluten strength. For this reason, the rheological characterization of wheat flour dough is essential in the bakery industry. Traditional dough testing instruments such as Extensograph, Farinograph, Alveograph, have become important tests to asses and predict the quality of the finished bakery products [16]. According to recent studies, the rheological, textural, and water characteristics of dough were analyzed using empirical instruments such as Farinograph and Extensograph.Farinograph was used to know about rheological characteristics and dough development behavior for flour samples of wheat [18]. Farinograph has shown dough mixing properties, whereas Extensograph shows dough tensile properties [19, 20]. The alveograph is a rheological tool for evaluating the performance of flours used for baked products. The energy value (W) of the alveograph reflects gluten strength, while tenacity (P), extensibility (L), and the balance between them (P/L) are important for assessing dough rheological properties [21].

The aim of the study was to evaluate bread doughs made by replacing wheat flour with different proportions of chia seed powder on rheological properties. Also, to evaluate the quality of Pan Bread manufactured by replacing wheat flour with different proportions of chia seed powder.

The aim of the study was to enrich Chia Seed Powder in different proportions with wheat flour and to study the rheological properties of the doughs and use it in the manufacture of Pan Bread to evaluate its chemical, physical and sensory quality.

2. MATERIALS AND METHODS

2.1. Raw materials:

Wheat flour with 72% extraction was obtained from Foodzymes International Company for Mills and Bakery Supplies in Cairo in the summer season, of 2023. Wheat flour was packed in polyethylene bags and stored at 4±1°C until use.

Chia seeds were obtained from the local market in Giza governorate, Egypt, during the summer season2023. Chia seedswere packed in polyethylene bags and stored at 4±1°C until use.

Baking Ingredients: Compressed yeast (stored frozen), sugar, corn oil, and salt were obtained from local marketing in Giza governorate, Egypt, during the summer seasonof 2023.

All chemicals used were standard analytical standards.

2.2. Preparation of chia seed powder:

The chia seeds were cleaned free of any impurities and then ground with a Moulinex grinder (French, model MC300132, 180 watts, capacity: 80 grams), then this powder was taken and finely ground to pass through a standard 40-mesh sieve, then it was packed in polyethylene bags and stored at 4°C until use. This method is consistent with [22], the method of grinding chia seeds in (Moulinex mill, AR11, China) to obtain whole chia powder.

2.3. Pan Bread preparation:

The straight dough method was applied to produce bread according to the method described in [23], which is summarized as follows: wheat flour (72% ext.) with chia flour in different proportions, in addition to salt (1 g/100 g), pressed yeast (1.5 g /100 g), sugar (1.5 g/100 g), corn oil (1.5 g/100 g), and the optimum amount of water as determined by farinograph data. Mix the ingredients well by hand for one minute, then mix the dough again in the mixer for about four minutes. Place the dough in a greased fermentation vessel, then cut, wrap, and place in the fermentation cabinet for 50 min. at a temperature of 37 ± 2°C and a relative humidity of 80-85%. The dough is then baked in an electric oven at 220 ± 8 °C for 15 min. After loaves of Pan Bread were separated from a metal bowl and allowed to cool at room temperature before sensory evaluation. The bread produced was weighed, the volume measured and after that, it was packaged and stored refrigerated at 4±1°C. (Table 1) Shows the ingredients used in manufacturing dough mixes for Pan Bread and the percentages of chia seed powder used in them as follows:

Table (1): Ingredients used in making Pan Bread dough mixes and percentages of replacement with Chia Seed Powder (CSP) (g/100g).

Ingredients (g)	Wheat flour without CSP (Control)	Wheat flour with 2% CSP	Wheat flour with 4% CSP	Wheat flour with 6% CSP	Wheat flour with 8% CSP	Wheat flour with 10 % CSP	Wheat flour with 12 % CSP	Wheat flour with 15 % CSP
Flour	200 g	196 g	192 g	188 g	184 g	180 g	176 g	170 g
Chia	0	4 g	8 g	12 g	16 g	20 g	24 g	30 g
Sugar	3 g	3 g	3 g	3 g	3 g	3 g	3 g	3 g
Salt	2 g	2 g	2 g	2 g	2 g	2 g	2 g	2 g
Yeast	3 g	3 g	3 g	3 g	3 g	3 g	3 g	3 g
Oil	3 g	3 g	3 g	3 g	3 g	3 g	3 g	3 g
Water(ml)	125	125	125	125	125	125	125	125

2.4. Approximate chemical analysis calorific value

The determination of moisture, crude protein, ash, crude fat, fiber minerals and gluten characteristics according to [24], while carbohydrate was calculated by difference. The caloric value of the Pan bread was calculated using the coefficients of atwater [25], based on the caloric coefficients corresponding to the protein, carbohydrate and lipid contents, according to Equation (1), as follows:

$$\text{Caloric (Kcal. 100 g-1)} = (\text{g of protein}*4) \pm (\text{g of fat}*9) \pm (\text{g of carbohydrates } *4). \quad (1)$$

2.5. Heavy Metals in Foods (ICP-MS)

Determination of Heavy Metals in Foods by inductively coupled plasma Mass spectrometry after high-pressure microwave digestion[26].

2.6. Estimating the falling number of wheat flour:

Falling number of wheat flour samples as indicator for α-amylose activity was determined using (falling number AB instrument type 1402, No. 539 Stockholm, Sweden) according to standard [24] methods 56-81.

2.7. Determination of gluten content in wheat flour

According to (AACC, 2000) wet and dry gluten were determined by using (Glutomatic 2200 instrument) as follows: 10g of flour sample is put into a glutomatic wash chamber equipped withan 88-micron polyester sieve. 4.8 ml of salt solution (2%) was added to the flour and mixed gently to form a dough for 20 sec, the washing process automatically started and continuous for 5 min, after that wet gluten is transferred to special-cased and centrifuge for 1 min, at 6000 rpm. The fraction passed through the case is weighted, while the fraction remaining on the other side of the case is collected and weighted as total wet gluten. Wet gluten was dried in Glutork (type 2020) at 150°C for 4 min, to determine as dry gluten as in the following equations:

$$\text{Wet gluten content (\%)} = \text{Wet gluten weight / sample weight x 100.} \quad (2)$$

Gluten index = [Remained gluten on cased (g) / Total gluten] x100. (3)

Dry gluten content (%) = Dry gluten weight / sample weight x 100. (4)

2.8. Rheological properties

2.8.1. Farinograph test of doughs

The farinograph (877563 Brabenderfarinograph Germany HZ 50) was used to study the hydration and mixing characteristics of the dough under investigation according to [23]. Three hundred grams of tested flour were placed in the bowel of the apparatus and sufficient water was added so that the consistency of the dough was such that the mixing curve was centred on the 500 Brabender unit (B.U.) line at the point of maximum development. Different parameters could be obtained from the farinograms as follows:

Water absorption (%): The amount of water required for the dough to have a consistency of 500 Brabender unit line.

Arrival time (min): The time in minutes required for the curve to reach the 500 B.U.line after the mixer had been started and the water was added.

Dough development time (min): It is the time in minutes from the first addition of water to the development of the dough's maximum consistency.

Dough stability (min): It is the time in minutes elapsing when the top of the curve interacts with the first 500 B.U. the line leaves that line.

Mixing tolerance index: It is the difference in the Brabender unit from the top of the curve at the peak to the top of the measured 5 min after the peak.

Weakening of dough (B.U.): It is the difference in Brabender units (B.U.) from the 500 B.U. line to the Centre of the curve measured after 12 min from the peak.

2.8.2 Extensograph test:

Extensograph test was carried out according to the method described in the [23] using an Extensograph type: 4821384 (Brabender Extensograph Germany HZ 50) to measure the following parameters:

A normal run of the farinograph was made to estimate the water absorption capacity of the flour. The dough was prepared from three hundred grams of flour and six grams of sodium chloride dissolved in the quantity of water (estimated by farinograph). The produced dough was mixed for one minute after which a sufficient salt solution was added to give a consistency of 500 Brabender line (in farinograph test), after 5 min of rest, mixing was resumed and continued until reached the full development time of the farinogram. The dough was removed from the mixer and cut into two portions, each 150 g. The dough was rounded in the extensograph rounder. The dough ball was then carefully cantered on the shaping unit and rolled into a cylindrical test piece; this was ten-clamped in a lightly greased dough holder. The tested piece was stored in a humidified chamber for 45 min from the shaping operation, the stretching hook was started and stopped when the test piece was broken; the dough was removed after the first test, reshaped, allowed a rest period of 45 min and then stretched again. By repeating such procedure, the dough was tested at 45, 90 and 135 min.

For evaluating the results of the extensograph test; the extensogram of the test period at 135 min was used to measure the following data.

Dough extensibility (E) (mm): The total length of the base of the extensograph curve measured in millimetres.

Dough resistance to extension (R) (B.U.):

The height of the extensograph curve measured in bar bender units 5 min from the start.

Proportional number (R/E): R/E is obtained by dividing the resistance to extension by the extensibility.

Dough energy (cm2): It is represented by the area in cm2out line the curve.

2.8.3. Alveograph characteristics:

Alveograph test was carried out in an Alveograph MA 82 (Chopin, Tripetteet Renaud, France) following the Approved Method 54-30A [24].The following Alveograph parameters were automatically recorded by a computer software program: the maximum over pressure (P) needed to blow the dough bubble, which is an index of resistance to extension (elasticity): the average abscissa (L) at bubble rupture, an index of dough extensibility, P/L indicating the ratio of elasticity to the extensibility of the dough and the deformation energy (W) an index of dough strength.

2.9. Determination of physical properties of Pan Bread:

The specific volume of pan bread was calculated according to the AACC method 10-05.01 [24] by dividing volume (cm3) by weight (g). The volume (cm3) of different types of produced pan bread was determined by TexVol Instruments AB Box 45, 260 40 Viken, Sweden.

2.10. Bread Freshness Test

The freshness of each packed sample was tested at room temperature during storage for 24 and 48 Hr. by alkaline water retention capacity (AWRC) according to the method of [27], as modified by [28] as follows:

Five grams of bread sample (placed into a dry plastic centrifuge tube of 50 ml capacity) and 25 ml $NaHCO_3$ solution (8.4 g sodium bicarbonate dissolved in 1 L of distilled water) were added. The tube was stoppedand shacken until all samples were wet, then the mixture was left for 20 min with shaking every 5 min. The contents were thencentrifuged at 2500 rpmfor 15 min. The supernatant was decanted and the precipitate was left for 10 min. at 45 angles (to get rid of free water). The gain in weight is expressed in percent. Loss of freshness (RD %) was calculated using the following equation:

$$\text{Loss of freshness (RD \%)} = \frac{\text{AWRC (zero time) - AWRC (n time)}}{\text{AWRC (zero time)}} \times 100 \qquad (5)$$

Where n= time of storage

2.11. Sensory evaluation of Pan Bread:

Sensory evaluation of the dairy bread produced (control and different mixtures) as described by [23] with little modification was conducted by ten faculty members in the Department of Food Science, Faculty of Agriculture, Ain Shams University. Pan Bread quality scores were calculated for smoothness (10), flavor (10), texture (10), crust color (10), crumb color (10), and overall acceptability (50). Scores: 9.0-10 Very Good (V.G.), 8.0-8.9 Good (G.), 7.0-7.9 Satisfactory (S.), less than 7.0 Questionable (Q).

2.12. Statistical analysis:

Data obtained from different tests were expressed as the Mean±SE and they were analyzed statistically using the one-way analysis of variance ANOVA followed by Duncan's test. In all cases $p<0.05$ was used as the criterion of statistical significance by the SAS program [29].

3. RESULTES AND DISCUSSIONS

3.1. Chemical composition of strong wheat flour and Chia Seed Powder.

The chemical composition of wheat flour72% extraction and Chia Seed Powder (CSP) is presented in (Table 2) Chia Seed Powder has a higher content of crude protein, fat ether extract, crude fiber and ash and a lower content of total carbohydrates than that of wheat flour 72% extraction.

Chia seeds contained6.673±0.06 % moisture,20.714±0.08 % protein,29.608±0.07% ether extract,31.566±0.05% crude fiber,31.566±0.05 % ash, and 14.29% total carbohydrates. These results are parley with results of [30] as the result of the analysis of 13.4% moisture, 20-24% protein, 16-33% ether extract, 27-36% crude fiber, and 3.5-4.6% ash. These results agree with the results obtained by [31] where published that CSP contains 36.57% fat, 26.1% protein, 22.22% crude fiber, 9.96% and 5.15% ash. [32] reported that, the content of individual components of chia seeds depends on the variety as well as the environmental and growing conditions.

From the same table, we can observe, the results of the chemical composition of strong wheat flour samples showed that it contains 14.05% moisture, 12.30% protein, 1.01% ether extract, 0.512% crude fiber, 0.54% ash, and 85.63% total carbohydrates. The percentage of wet and dry gluten was 30.12% and 12.44%, respectively. The gluten index and fall number were 86% and 321 (sec) respectively. These results are almost consistent with the results reported by [33] where the analysis result was 13.4% moisture, 12.20% protein, 1.20% ether extract, 0.65% crude fiber, 0.57% ash, and 85.44% total. Carbohydrates.

These results are close to the results obtained by [34] they found, the crude protein, crude fat, ash, crude fiber and total carbohydrates of wheat flour extraction 72% were 11.81, 0.75, 0.45, 0.84 and 86.98%, respectively. The percentage of wet and dry gluten was 30.128±0.08 % and 12.443±0.05%, respectively.

The Gluten index and falling number were 86 % and 321±10.5 (sec), respectively. The chemical composition results of strong flour indicated that, the flour was suitablefor preparing good pan bread related to the percentage of protein and gluten.

Table (2): Chemical composition of Strong wheat flour (72%) and Chia seeds.

Components	Wheat flour (72%)	Chia seed
Moisture (%)	14.059±0.09^{a}	6.673±0.06^{b}
Ash* (%)	0.541±0.09^{b}	3.816±0.05^{a}
Protein * (%)	12.301±0.07^{b}	20.714±0.08^{a}
Ether extract* (%)	1.013±0.03^{b}	29.608±0.07^{a}
Crude fiber * (%)	0.512±0.04^{b}	31.566±0.05^{a}
Carbohydrates** (%)	85.633±0.03^{a}	14.296±0.01^{b}
Wet gluten content (%)	30.128±0.08	--
Dry gluten content (%)	12.443±0.05	--
Falling. No (sec)	321±10.5	--
Gluten index (%)	86	--

Note: Values aremeans standard deviations (n=3). Values in the same row with different letters differ significantly (P<0.05)
*on dry weight basis **Total carbohydrates (calculated by difference)

3.1.1. Mineral analysis

The results of the mineral analysis of strong wheat flour and chia seed powder (on a dry weight basis) were reviewed in (Table 3)We can notice that, there are statistically significant differences between the mineral elements found in wheat flour and chia seed powder, both in the analysis of macro minerals (calcium) and trace elements (iron& zinc), where calcium (Ca) recorded values of 25.632±0.05 and 562.932±0.07 (mg/100g) for strong wheat flour and chia seed powder (CSP), respectively. While iron (Fe) recorded values of 1.193±0.01 and 6.364±0.03 (mg/100g) for strong wheat flour and chia seed powder (CSP), respectively. Also, zinc (Zn) recorded values of 0.752±0.04and 4.232±0.05 (mg/100g) strong wheat flour and Chia seed powder (CSP), respectively. These results of chia seed powder are in agreement with [15, 35].

From the results in the same table,it can also be noted that CSP contained the highest value of calcium, Iron and Zinc, compared with strong wheat flour. Therefore, chia seeds are considered a source for fortifying bakery products with essential mineral elements.

Table (3): Minerals continent of strong wheat flour and chia seed Powder.

Mineral mg/100g	Strong wheat flour	Chia seed powder
Ca	25.632±0.05[b]	562.932±0.07[a]
Fe	1.193±0.01[b]	6.364±0.03[a]
Zn	0.752±0.04[b]	4.232±0.05[a]

Mean values ± standard error (n=3). Means of samples having different letter(s) within a column are significantly different (P<0.05).

3.2. Rheological properties of Pan bread dough samples.

The rheology of bread doughs gives us an idea of how they behave in different processes, and can also help us to predict some final characteristics of the breads [36]. On the other hand, the vegetal proteins modify the farinographic properties in a different way according to their type [37, 38].

3.2.1. Farinograph characteristics:

Farinograph test is animportant requirement of the industry and export markets. It measures the dough properties by measuring the resistance of dough against the mixing action of paddles (blades). It is generally used to determine water absorption required to make the dough, to evaluate the effects of ingredients on mixing properties and to check blending requirement for dough development, tolerance to mixing and dough consistency during production. In addition, farinograph was used to predict product texture characteristics [16].

The results in (Table 4 and Fig1) showed that; replacing wheat flour with different ratios of Chia Seed Powder led to a gradual increase in the percentage of water absorption compared withthe control sample. This result is completely consistent with [39] showed an increase in the water absorption percentage with an increase in the percentage of chia seed powder in the biscuit dough. These results are consistent with [40] mentioned that due to the increase in the percentage of fiber in the products resulting from the addition of chia, where the fiber increases the absorption of water; because it contains a group of hydroxyls, which are associated with the contents of the water.

Also, [41] a higher water absorption was observed in mixtures containing the biggest amount of Chia. [42] showed that adding fiber sources to wheat flour leads to increased water absorption of the dough formed, they attributed this to the high ability of fiber to absorb water.

The results in the same table also showed that; there was a gradual increase in the stability time (min)of the dough and a decrease in the degree ofWeakening(softness) of Dough (B. U) with an increase in the percentage of replacing wheat flour with Chia Seeds Powderat ratios (2% - 15%). These results are consistent with [43, 44, and 45].

There was a gradual decrease in the mixing tolerance index (B.U) by increasing the percentage of replacing wheat flour with CSP, it was reduced from 80 for the control to 40 for the dough containing 15% CSP.

However, it was found that Dough development time (min) (Peak time) was recorded at 2.5 min for the control dough and samples doughs which contained CSP ratios of 2%, 6% and 10% CSP, while it was recorded as 3 minutes for the other replacement ratios. These may be due to the difference in the behavior of the doughs inside the farinograph device, and it may also be due to the small difference between the CSP addition ratios.

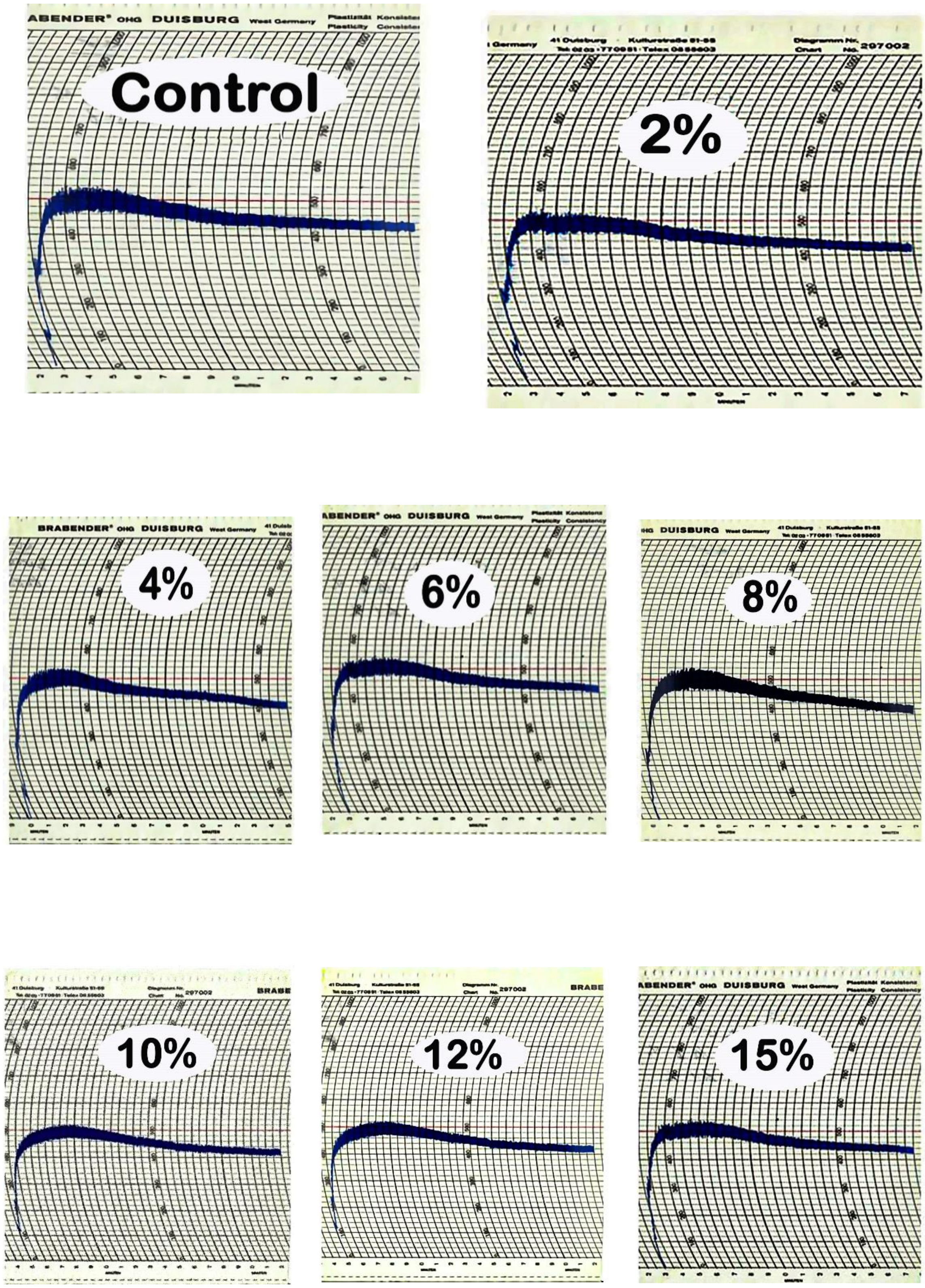

Fig. 1. Farinogram of wheat flour and inscription Chia Seed Powder doughs.

Table (4): Influence of replacement wheat flour with chia seed powder at different ratios on farinograph parameters.

Samples	Water absorption %	Dough development time (min)	Stability time (min)	Mixing tolerance index (B.U)	Weakening of Dough (B.U)
Wheat flour without CSP (Control)	59.2	2.5	4.0	80	110
Wheat flour with 2%CSP	59.3	2.5	4.0	80	100
Wheat flour with 4%CSP	59.5	3.0	5.0	60	90
Wheat flour with 6%CSP	59.8	2.5	5.0	60	80
Wheat flour with 8%CSP	60.3	3.0	5.0	50	80
Wheat flour with 10%CSP	61.0	2.5	5.0	60	80
Wheat flour with 12%CSP	61.2	3.0	5.0	60	70
Wheat flour with 15%CSP	61.8	3.0	5.5	40	60

Where: CSP means Chia seed powder, B.U = Brabender Unit.

3.2.2. Extensoghraph characteristics

Extensograph analysis gives information about the viscoelastic behavior of dough and measures dough extensibility and resistance to extension. A combination of good resistance and good extensibility results in desirable dough properties [40, 46].

Dough resistance to extension in B.U. is the most important index for dough's ability to retain gas this equipment provides a measurement of the extensibility and elasticity of the dough. The results in (Table 5 and Fig. 2) showed that adding chia seed powder to wheat flour in different proportions (2%, 4%, 6% ,8%,12% and 15%) led to a gradual increase in Resistancetoextension (B.U) (Elasticity)and a decrease in Extensibility(mm). These results are nearly in agreement with the results reported by [43].

Addition of Chia Seeds Powder to wheat flour increased energy(cm3) from 100,108,109,112.114, 121,122 and 123 for strong wheat flour dough (control) and doughs samples containing 2%, 4%, 6%, 10%, 12% and 15% Chia Seeds Powder, respectively. These results are nearly in agreement with the results reported by [47].

The results recorded an incremental increase in the Proportional number with increasing percentages of CSP in the dough samples studied compared to control sample dough.

Proportional number values were 2.73,3.23,3.23, 3.18, 3.07,3.03, 3.48 and3.42 for wheat strong flour and containing 2%, 4%, 6%, 10%, 12% and 15% Chia Seeds Powder, respectively. [48] revealed that, the control dough sample (without the addition of gum Arabic (GA) has a significantly lower extensibility than the samples of dough with the additions of GA and also that with the increasing amount of GA the extensibility is gradually increasing.

Dough resistance to extension in B.U. is the most important index for dough's ability to retain gas. The addition of GA to flour samples showed markedly increasing resistance to extension than the control samples (without the addition of GA) and also with the increasing amount of GA the resistance to extension is gradually increasing.

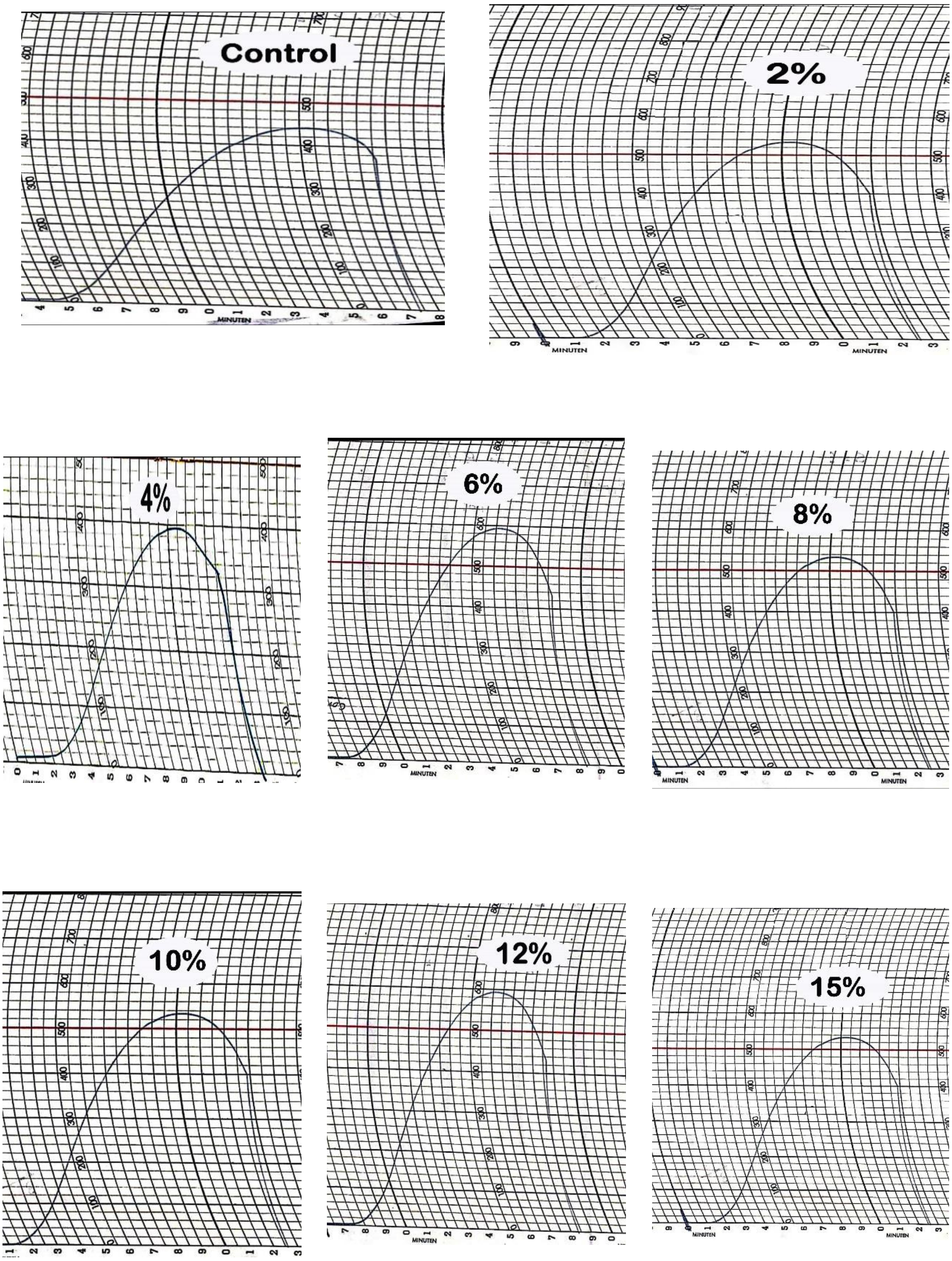

Fig. 2.Extensogram explains the effect of adding Chia Seed powder at different proportions on doughs

Table (5): Influence of replacement wheat flour with chia seed powder at different ratios on Extensoghraph parameters.

Samples	Resistant to extension (R)(B.U)	Extensibility (E) (mm)	Proportional number (R\E)	Energy (cm2)
Wheat flour without CSP(Control)	410	150	2.73	100
Wheat flour with 2% CSP	420	130	3.23	108
Wheat flour with 4% CSP	420	135	3.23	109
Wheat flour with 6% CSP	430	135	3.18	112
Wheat flour with 8% CSP	430	140	3.07	114
Wheat flour with 10% CSP	440	145	3.03	121
Wheat flour with 12% CSP	470	135	3.48	122
Wheat flour with 15% CSP	480	140	3.42	123

3.2.3. Alveograph.

The alveograph is a rheological tool for evaluating the performance of flours used for baked products. The energy value (W) of the alveograph reflects gluten strength, while tenacity (P), extensibility (L), and the balance between them (P/L) are important for assessing dough rheological properties [21]. The dough P value is the resistance of the dough [49]. The dough L value represents extensibility and the P/L ratio is the balance between dough strength and extensibility [50].

The replacement of wheat flour, which contains gluten, is a major technological challenge because gluten is an essential structure-building protein in flour, responsible for the elastic and extensible properties needed to produce good quality bread [51].

In this study, chia seed powder was added at different ratios to wheat flour. The effect of this addition was examined using an Alveograph, and the results obtained are shown in (Table 6 and Fig. 3). The obtained results indicated that, the wheat flour dough was affected by gradually adding different proportions of chia seed powder, led to an increase in the resistance values P(mm), while the values of elasticity L(mm) decreased. On the other hand, in the same coefficients, the values of the ratio (P/L) increased.

Moreover, the results presented in the same Table showed that the addition of chia seed at, 2%,4%, 6%,10% ,12% and 15% to wheat-strong flour led to an increase (P) to133,132,142,149,150,155,155 and 168, respectively. On the contrary, a decrease in elasticity (L) values was observed to (90, 82, 83, 83,73,75,74 and 71 for wheat strong flour with levels of chia seed.

The results were completely consistent with [52] they found that, the addition of quinoa flour to wheat flour increased, P increased and L decreased.

Table (6): Effect of replacement wheat flour with chia seed powder at different ratios on Alveograph parameters.

Samples	Resistance P (mm)	Elasticity L (mm)	(P/L) Ratio
Wheat flour without CSP(Control)	133	90	1.48
Wheat flour with 2%CSP	132	82	1.61
Wheat flour with 4%CSP	142	83	1.71
Wheat flour with 6%CSP	149	83	1.80
Wheat flour with 8%CSP	150	73	2.05
Wheat flour with 10%CSP	155	75	2.07
Wheat flour with 12%CSP	155	74	2.09
Wheat flour with 15%CSP	168	71	2.37

3.3 Chemical composition of Pan Bread fortified with different ratios of Chia Seeds Powder.

Pan Bread fortified with different ratios of Chia Seeds Powder and wheat flour was chemically analyzed, obtained results were summarized in (Table 8). Tabulated results revealed that Pan Bread fortified with different ratios of Chia Seeds Powder (CSP) 2%, 4%, 6%, 8%, 10%,12% and15%could be considered as a good source of ash, protein, Ether extract and crude fiber compared with these compounds in control sample without CSP, while the control Pan Bread sample recorded the highest percentage of moisture and carbohydrates. From the same table, the results in each row had significant differences at P<0.05. In general, from the same results, we note that there is a gradual increase in the percentage of ash, protein, fat, and fiber, and a decrease in the percentage of moisture and carbohydrates in the pan bread samples as the percentage of replacement with chia seed powder increases. These results completely agreed with the results indicated by previous studies [5,32,43].

Results of some essential minerals including Calcium (Ca), Iron (Fe) and Zinc (Zn), were observed in the same table. Calcium Iron and Zinc of Pan Bread fortified with different ratios of Chia Seeds Powder recorded the highest values compared with these compounds in the control sample without CSP. The results we obtained were confirmed by both [43,5] who published that the higher the level of chia, the more mineral elements in the bread.

Finally, it was found that there was a gradual decrease in the energy value by increasing the percentage of replacing wheat flour with chia seed powder from 2% to 15%. This can be explained, according to the results, by a decrease in the carbohydrate content of the bowl bread samples compared to the control sample.

Table (7): Chemical composition of Pan Bread fortified with different ratios of Chia Seeds Powder.

Components	Wheat flour without CSP(Control)	Wheat flour with 2% CSP	Wheat flour with 4% CSP	Wheat flour with 6% CSP	Wheat flour with 8%CSP	Wheat flour with 10%CSP	Wheat flour with 12% CSP	Wheat flour with 15% CSP
Moisture (%)	33.341±0.13[a]	33.303±0.02[a]	33.184±0.03[b]	32.809±0.02[c]	32.469±0.02[d]	31.815±0.01[e]	31.348±0.02[f]	30.744±0.02[g]
Ash* (%)	1.836±0.01[f]	1.888±0.02[e]	1.964±0.02[d]	2.014±0.03[d]	2.099±0.01[c]	2.143±0.02[c]	2.230±0.01[b]	2.337±0.01[a]
Protein * (%)	12.400±0.01[h]	12.443±0.03[g]	12.681±0.02[f]	12.800±0.05[e]	12.980±0.03[d]	13.188±0.03[c]	13.380±0.05[b]	13.658±0.04[a]
Ether extract*(%)	2.304±0.01[h]	2.353±0.02[g]	2.811±0.04[f]	3.269±0.04[e]	3.757±0.01[d]	4.147±0.02[c]	4.515±0.03[b]	5.127±0.02[a]
Crude Fiber extract * (%)	1.837±0.11[h]	2.349±0.05[g]	3.022±0.04[f]	3.604±0.01[e]	4.123±0.02[d]	4.800±0.03[c]	5.607±0.01[b]	6.390±0.02[a]
Carbohydrates** (%)	81.623±0.04[a]	80.967±0.02[b]	79.522±0.01[c]	78.313±0.01[d]	77.041±0.02[e]	75.722±0.03[f]	74.268±0.01[g]	72.488±0.02[h]
Ca	24.767±0.01[h]	33.879±0.08[g]	46.356±0.12[f]	55.982±0.04[e]	66.403±0.02[d]	80.013±0.03[c]	91.235±0.01[b]	106.98±0.04[a]
Fe	0.579±0.01[h]	0.620±0.05[g]	0.759±0.04[f]	0.899±0.01[e]	0.951±0.01[d]	1.122±0.03[c]	1.271±0.04[b]	1.392±0.02[a]
Zn	0.686±0.05[g]	0.700±0.04[g]	0.815±0.02[f]	0.890±0.01[e]	0.954±0.02[d]	1.034±0.03[c]	1.149±0.02[b]	1.215±0.01[a]
Energy value	396.828	394.817	394.111	393.873	393.897	392.963	391.227	390.727

Mean values ± standard error (n=3). The means of samples having a different letter(s) within a column are significantly different (P<0.05). * On dry weight basis**Total carbohydrates (calculated by difference)

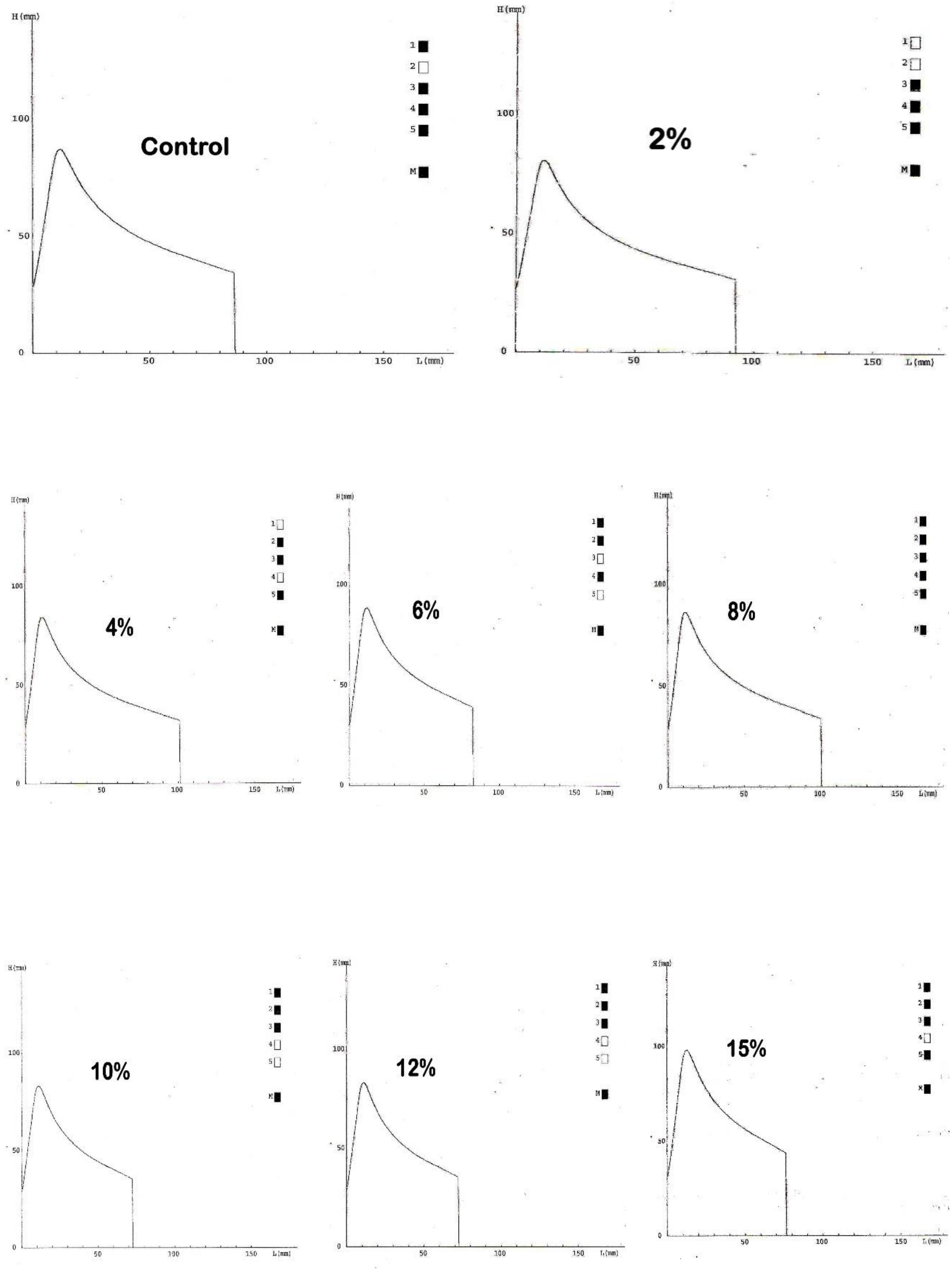

Fig.3. Explains the effect of adding Chia Seed powder at different proportions on resistance P (mm) and Elasticity L (mm) of doughs.

3.4. Physical properties of bread made from wheat flour replaced with different proportions of chia seed powder

The effect of replacement wheat flour with chia seed powder at different ratios on the physical properties of pan bread is presented in (Table 8) Statistical analysis of the results confirmed that there were significant differences p <0.05) between all samples. Pan Bread enriched with chia seed powder had a smaller Volume (cm3) than the control sample Pan Bread at all replacement ratios. The additionof chia seed reduced the volume of Pan Bared loaves from 1696.6 to 1570.1(cm3). These results are roughly consistent with those reported by [53].

The Pan Bread samples enriched with different ratios of chia seed powder had a significantly smaller specific volume(cm3/g) compared to the control sample. We can explain this by reducing wheat flour gluten with chia seeds, which are devoid of this protein, which is responsible for the disruption of the starch and gluten matrix and decreased carbon dioxide retention during fermentation, which leads to a decrease in the volume of Pan Bread samples. These results are completely consistent with, [12] they reported that; the incorporation of chia flour by 10% reduces the specific volume of bread flour. Also, results are consistent with, [54] he found that; there is a decrease in the specific volume as the percentage of chia increases, as the specific volume is derived from the ratio of cake volume to weight.

Table (8): Effect of replacement wheat flour with Chia Seed Powder at different ratios on physical properties of Pan Bread.

Samples	Weight(g)	Volume (cm3)	SP.V(cm3 / g)
Control	258.5±0.11^{h}	1696.6±0.05^{a}	6.563±0.09^{a}
Wheat flour with 2%CSP	261.5±0.06^{g}	1683.8±0.18^{b}	6.439±0.03^{b}
Wheat flour with 4%CSP	264.0±0.29^{f}	1674.1±0.02^{c}	6.341±0.18^{c}
Wheat flour with 6%CSP	268.0±0.02^{e}	1663.9±0.09^{d}	6.208±0.05^{d}
Wheat flour with 8%CSP	271.5±0.21^{d}	1647.0±0.05^{e}	6.066±0.16^{e}
Wheat flour with 10%CSP	275.0±0.03^{c}	1624.1±0.16^{f}	5.905±0.09^{f}
Wheat flour with 12%CSP	279.0±0.19^{b}	1590.5±0.07^{g}	5.700±0.04^{g}
Wheat flour with 15%CSP	285.5±0.08^{a}	1570.1±0.021^{h}	5.499±0.02^{h}

Mean values ± standard error (n=3). The means of samples having different letter(s) within a column are significantly different (P<0.05). CSP= Chia Seed Powder

3.5. Affecting of addition of Chia Seeds Powder at different ratios to Pan Bread on alkaline water retention capacity (AWRC).

Alkaline water retention capacity (AWRC) is a simple and quick test to follow the staling of bread. Higher values of AWRC mean higher freshness of [55].

The changes in Alkaline Water Retention Capacity (AWRC) of Pan Bread samples prepared by replacement wheat flour with different levels of CSP and stored at room temperature (25±1°C.) for 0, 1, 2 and 5 days. The results in (Table 9) indicated that the alkaline water retention capacity (AWRC) of all Pan Bread samples decreased by increasing in storage period. Furthermore, there was a gradual increase in the percentages of AWRC by increasing the percentage of replacing wheat flour with chia seed powder in the range from 2% to 15%, which means that adding CSP increases the degree of freshness of the samples compared to the control sample without CSP and thus reduces the loss in the pan bread.

On the other hand, it can be noted that there was a loss in freshness (RD%) in all samples of pan bread, whether the control sample without CSP or the samples containing different percentages of CSP with increasing storage period at a temperature of 25±1°C.

Table (9): Alkaline water retention capacity (AWRC %) of stored pan bread at 25±1°C.

Samples	Zero time	1 day AWRC	RD %	2day AWRC	RD %	3day AWRC %	RD %	4day AWRC	RD %	5day AWRC	RD %
Control	270.2	229.1	15.21	200.7	25.72	189.1	30.03	144.0	47.14	136. 9	49.34
Wheat flour with 2%CSP	276.7	250.4	9.5	239.0	13.62	235	15.07	200.9	27.39	187.1	32.38
Wheat flour with 4%CSP	278.8	254.7	8.64	243.2	12.76	236.6	15.13	204.7	26.57	188.1	32.53
Wheat flour with 6%CSP	279.3	255.3	8.59	244.5	12.45	237.1	15.10	206. 6	26.02	191.5	31.43
Wheat flour with 8%CSP	280.5	257. 8	8.09	247.4	11.80	241.4	13.93	208.7	25.59	193.5	31.01
Wheat flour with 10%CSP	282.4	258.2	8.56	248.7	11.93	243.3	13.84	210.8	25.35	194.2	31.23
Wheat flour with 12%CSP	285.4	259.7	9.00	249.4	12.61	243.3	14.75	214.2	24.94	199.3	30.16
Wheat flour with 15%CSP	287.6	263.2	8.48	253.3	11.92	247.3	14.01	215. 9	24.93	202.1	29.72

Where: AWRC =Alkaline Water Retention Capacity RD% =Loss of freshness

3.6. Sensory evaluation for un-enriched and enriched pan bread with different levels of chia seeds:

Sensory evaluation was done for Pan Bread samples enriched with different levels of chia seeds in terms of (Volume, Flavor, Texture, Crust color, Crumb color, and overall acceptability) as shown in (Table 10 and Fig. 4). From the results of the sensory evaluation of the Pan Bread samples, we note the following:

There were significant differences $p<0.05$ within one characteristic, such as volume, flavor, etc. Additionally, there was acceptance of all the Pan Bread samples that were evaluated for all characteristics except for the size and flavor characteristics at 12% and 15% also and the texture recipe at 15% replacement with CSP.

The results also showed that there was a gradual decrease in the volume of Pan Bread loaf as the percentage of replacing wheat flour with chia seed powder increased compared to control samples. This may be due to the dilution of the gluten network, which led to a decrease in its gas retention.

There were no significant differences at $p<0.05$ between the control sample and the Pan Bread samples, up to a 10% replacement rate with CSP, in the characteristics of flavor and texture

All Pan Bread samples were accepted sensory-wise in terms of the color crust, and there were no significant differences in the samples up to a 6% replacement rate compared to the control. The sample with a 15% replacement rate recorded the lowest score of 7.1.

All samples were accepted as sensory when evaluating Crumb color. There were no significant differences at $p<0.05$ between the Pan Bread samples at the replacement rate of 2% to 10%, but there were significant differences at $p<0.05$ between all samples compared to the control sample.

Overall acceptability of the Pan Bread samples, there were no significant differences between the control sample and the samples with 6% and 8% CSP.However, bread samples were accepted for all sensory properties tested up to 10% CSP replacement.

Table (10): Sensory evaluation of Pan Bread samplesenriched with different percentages of Chia Seeds Powder (CSP) versus control sample without chia seeds powder.

Samples	Volume (10)	Flavor(10)	Texture (10)	Crust color(10)	Crumb color(10)	Overall acceptability (50)
Wheat flour without CSP (control)	9.5 ± 0.28^{a}	9.5 ± 0.28^{a}	9.1 ± 0.16^{a}	9.6 ± 0.16^{a}	9.8 ± 0.16^{a}	48.3 ± 0.33^{a}
Wheat flour with 2% CSP	8.8 ± 0.16^{a}	8.6 ± 0.44^{a}	8.3 ± 0.16^{a}	9.5 ± 0.28^{a}	9.1 ± 0.16^{b}	43.5 ± 0.20^{b}
Wheat flour with 4% CSP	8.8 ± 0.16^{a}	9.0 ± 0.50^{a}	8.5 ± 0.28^{a}	9.6 ± 0.16^{a}	9.1 ± 0.16^{b}	41.7 ± 0.44^{c}
Wheat flour with 6% CSP	8.1 ± 0.16^{b}	8.5 ± 0.28^{a}	8.5 ± 0.28^{a}	9.3 ± 0.16^{a}	8.6 ± 0.16^{b}	44.6 ± 0.22^{ab}
Wheat flour with 8% CSP	8.1 ± 0.44^{b}	8.6 ± 0.16^{a}	8.5 ± 0.28^{a}	8.6 ± 0.16^{b}	8.5 ± 0.28^{b}	45.0 ± 0.18^{ab}
Wheat flour with 10% CSP	8.1 ± 0.16^{b}	8.5 ± 0.28^{a}	8.8 ± 0.16^{a}	9.0 ± 0.28^{ab}	8.5 ± 0.28^{b}	40.5 ± 0.11^{d}
Wheat flour with 12% CSP	6.8 ± 0.16^{c}	7.0 ± 0.28^{b}	7.6 ± 0.16^{b}	7.8 ± 0.16^{c}	7.6 ± 0.16^{c}	39.5 ± 0.29^{e}
Wheat flour with 15% CSP	6.3 ± 016^{c}	6.3 ± 0.44^{b}	6.6 ± 0.16^{c}	7.1 ± 0.16^{d}	7.1 ± 016^{c}	37.5 ± 0.14^{f}

Mean values ± standard error (n=10). Means of samples having the same letter(s) within a column are not significantly different ($p<0.05$). CSP= Chia Seed Powder.

(Fig. 4) shows the clearest picture of the pan bread obtained as a result of replacing wheat flour with chia seed powder in different proportions and cross-section in loaves of bread versus the control sample without CSP.

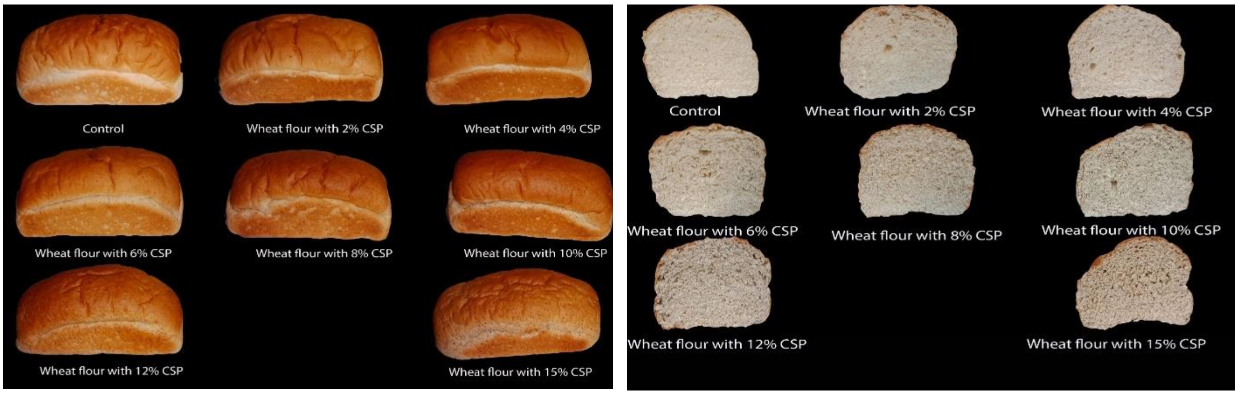

Fig.4. Pan Bread samples enriched by different percentages of chia seeds powder versusthe control sample without chia seeds powder.

4. Conclusion

Based on the aforementioned results, it can be concluded that the Partial Substitution of wheat flour with chia seed powder improved the nutritional value and quality of the Pan Bread.Mineral elements (iron, calcium, and zinc) experienced a gradual increase with increasing replacement ratio with CSP compared to these elements in the control sample without CSP. It was found that all added CSP improved the protein content and functional properties of the control wheat flour. Furthermore,adding chia seed powder increased the freshness period of the bread compared to the control sample without CSP, and this is beneficial in reducing bread waste.Therefore, some functional bakery products can be prepared using chia seed powder with high quality, organoleptic properties and nutritional value.

5. REFERENCES

[1] Sabanis D &Tzia C (2009). Effect of rice, corn and soy flour addition on characteristics of bread produced from different wheat cultivars. Food and Bioprocess Technology 2(1): 68-79 doi.org/10.1007/s11947-007-0037-7.

[2] Švec I &Hrušková M (2015). The Mix lab parameters of composite wheat/hemp flour and their relation to quality features. *LWT-Food Science and Technology* 60(1): 623-629. doi.org/10.1016/j.lwt.2014.07.034

[3] Samuilenko, T. D., Gurinova, T.A., Akulich, A.V., Tomashov, V.A. (2021). Comprehensive assessment of the quality of unsweetened flour snacks of the "Natural product" category // Bulletin of the Belarusian State University of Food and Chemical Technologie, No.2, pp. 40–48.

[4] Mickiewicz, B., &Britchenko, I. (2022). Main trends and development forecast of bread and bakery products market. VUZF REVIEW 7(3):113-123.

[5] Boriy, G. E., Yousef, E. A., &AbdRabou, E. A. (2021). Preparation and Evaluation of Pan Bread from Chia Seeds Powder as Substitute Wheat Flour. Asian Food Science Journal, 20 (5), 1-10.

[6] Romankiewicz, D., Hassoon, W. H., Cacak-Pietrzak, G., Sobczyk, M., Wirkowska-Wojdyła, M., Ceglińska, A., &Dziki, D. (2017). The effect of chia seeds (Salviahispanica L.) Addition on Quality and Nutritional Value of Wheat Bread. *Journal of Food Quality*, *1*, 1–7.

[7] Hrušková, M.,andŠvec, I. (2015). Chemical, rheological and bread characteristics of wheat flour influenced by different forms of chia (*Salviahispanica*L.). Emirates Journal of Food and Agriculture, 27(12), 872–877.

[8] Miranda-Ramos, K.; Millán-Linares, M.C.; Haros, C.M. (2020). Effect of chia as breadmaking ingredient on nutritional quality, mineral availability, and glycemic index of bread. Foods, 9, 663.

[9] Dinçoğlu, A. H., &Yeşildemir, Ö. (2019).A renewable source as a functional food: Chia seed. *Current nutrition & food science*, *15*(4), 327-337

[10] Suri S., Passi S.J., Goyat J (2016). Chia seed (*Salviahispanica*L.)—A new age functional food. In: 4th International Conference on Recent Innovations in Science Engineering and Management pp. 286-299.

[11] Takano, A. (2017): Taxonomic study on Japanese Salvia (Lamiaceae): Phylogenetic position of S. akiensis, and polyphyletic nature of S. lutescens var. intermedia. Phyto Keys (80): 87-104.

[12] Ahmed, I. B. H., Hannachi, A., and Haros, C. M. (2020). Combined effect of chia flour and soy lecithin incorporation on nutritional and technological quality of fresh bread and during staling. *Foods*, *9*(4), 446.

[13] Falco, B.; Amato, M.; Lanzotti, V. (2017). Chia seeds products: An overview. Phytochem. Rev., 16, 745–760.

[14] Ali, M. N.; Yeap, S.K.; Ho, W.Y.; Beh, B.K.; Tan, S.W., and Tan, S.G. (2012): The promising future of chia (*Salviahispanica L.*) J Biomed Biotechnol: 171956.

[15] Kulczyński, B.; Kobus-Cisowska, B.; Taczanowski, M.; Kmiecik, D. and Gramza-Michałowska, A.(2019) The Chemical Composition and Nutritional Value of Chia Seeds—Current State of Knowledge. Nutrients, 11, 1242.

[16] Saraswathi, R., & Hameed, R. S. (2018).Farinographas a rheological tool to predict the quality characteristics for blend of wheat with pulse flour. *Int J AdvAgricSciTechnol*, *5*(8), 146-153.

[17] Kulczyński, B.; Grdeń, M.; Kobus-Cisowska, J.; Taczanowski, M.; Kmiecik, D. and Gramza-Michałowska, A. (2017).Nasiona chia. *Przem. Spoż.*,*4*, 42–45.

[18] Siddique, B., Wang, A., Wu, L., & Ahmad, I. (2024). Effect of Millet flour addition on dough rheology, chapati quality, and moisture distribution. Food and Humanity, 2, 100249.

[19] Xiong, L., Zhang, B., Niu, M., & Zhao, S. (2017). Protein polymerization and water mobility in whole-wheat dough influenced by bran particle size distribution. LWT - Food Science and Technology, 82, 396–403. https://doi.org/10.1016/j. lwt.2017.04.064

[20] Yang, Y., Guan, E., Zhang, T., Li, M., & Bian, K. (2019). Influence of water addition methods on water mobility characterization and rheological properties of wheat flour dough. Journal of Cereal Science, 89. https://doi.org/10.1016/j. jcs.2019.102791

[21] Li, Y.F., Wu, Y., Hernandez-Espinosa, N., Pe˜ na, R.J., (2013). Heat and drought stress on durum wheat: responses of genotypes, yield, and quality parameters. J. Cereal. Sci. 57, 398–404. https://doi.org/10.1016/j.jcs.2013.01.005.

[22] Mihafu, F. D.; Kiage, B. N.; Kimang'a, A. N. and Okoth, J. K. (2020): Effect of chia seeds (Salviahispanica) on postprandial glycaemia, body weight and hematological parameters in rats fed a high fat and fructose diet. International Journal of Biological and Chemical Sciences, 14(5): 1752-1762.

[23] A.A.C.C. (2002).Approved Method of American Association of Cereal Chemists, published by American Association of Cereal Chemists, Ins. St. Paul, Minnesota, USA.

[24] AACC (2000) Approved Methods of the AACC. 10th Edition, American Association of Cereal Chemists, St. Paul.

[25] Watt, B. and Merrill, A.L. (1963). *Composition of foods: raw, processed, prepared*. Washington, DC: Consumer and Food Economics Research Division / Agricultural Research Service, 198 (Agriculture Handbook, 8), 1963.

[26]Food additives and contaminants, June 2003,vol. 20, No. 6, P. 543 – 552

[27] Yamazaki, W.T. (1953).An alkaline water retention capacity test for the evaluation of cookie baking potentialities of soft winter wheat flours. *Cereal Chemistry,* 30, 242-246.

[28] Kitterman, J. S. and Rubenthaler, G. L. (1971). Assessing the quality of early generation wheat selection with the micro AWRC test. *Cereal Science Today,* 16, 313-316, 328.

[29] SAS, (2003): SAS/ Stat Users Guide: Statistics, System for Windows, version 4.10 (release 8.01 TS level 01M0), SAS Inst., Inc. Cary, North Carolina, USA.

[30] Carrillo W, Cardenas M, Carpio C, Morales D, Álvarez M, Silva M (2018). Content of nutrients component and fatty acids in chia seeds (*Salviahispanica*L.) cultivated in Ecuador. Asian Journal of Pharmaceutical and Clinical Research 11(2):1-4.

[31] Mohammed OBR, Abd El-Razek AM, Bekhet MHH, Moharram YG. (2019): Evaluation of Egyptian Chia (*Salviahispanica*L.) Seeds, Oil and Mucilage as Novel Food Ingredients, Egypt. J. Food. Sci.; 47(1):11-26.

[32] Ibrahim, F. Y.; Abdel-Haleem, A. H. M. and Abosalem, K. I. (2019). Influence of incorporating chia seeds on the quality characteristics of pan bread. Journal of Food and Dairy Sciences, 10(5), 159-163.

[33] Rizk, I. R. S., Rasmy, N. M., &Mahdy, S. M. (2019). Effectofreplacing wheat flour with oat and barley flour on the functional, rheological and sensory properties of Tarhana.*Arab Universities Journal of Agricultural Sciences*, *27*(1), 445-465

[34] El Hadidy, G.S. (2020): Preparation and Evaluation of Pan Bread Made with Wheat Flour and Psyllium Seeds for Obese Patients. European Journal of Nutrition & Food Safety. 12(8):1-13

[35] Jin, F., Nieman, D. C., Sha, W., Xie, G., Qiu, Y., & Jia, W. (2012). Supplementation of milled chia seeds increases plasma ALA and EPA in postmenopausal women. *Plant foods for human nutrition*, *67*, 105-110.

[36] Sluimer, P.(2005). Principles of Breadmaking. In Functionality of Raw Materials and Process Steps; AACC: St Paul.MN, USA, 2005.

[37] Liu, X.; Li, T.; Liu, B.Y.; Zhao, H.F.; Zhou, F.; Zhang, B.L.(2016).An external addition of soy protein isolate hydrolysate to sourdough as a new strategy to improve the quality of chinese steamed bread. J. Food Qual.2016, 39, 3–12

[38] Perez-Carrillo, E.; Chew-Guevara, A.A.; Heredia-Olea, E.; Chuck-Hernandez, C.; Serna-Saldivar, S.O. (2015).Evaluation of the functionality of five different soybean proteins in hot-press wheat flour tortillas. Cereal Chem.2015, 92, 98–104.

[39] Heba, M. M. Hassan; Alia, M.A. Elgharably; Ashoush, I.S.; Abd-El-Khalek, M H.; and SafaaA.A. Salem (2023). Rheological, Physical Properties and Sensory Evaluation of Biscuits Enriched with Chia Seed Powder. Egyptian Journal of Nutrition, Vol. 38 No. (2): 32-50.

[40] Rosell, C. M., Rojas, J. A., & Barber, C. B. (2001). Influence of hydrocolloids on dough rheology and bread quality. Food Hydrocolloids, 15(1), 75-81.

[41] Segura-Campos, M. R., Ciau-Solís, N., Rosado-Rubio, G., Chel-Guerrero, L., & Betancur-Ancona, D. (2014). Physicochemical characterization of chia (Salvia hispanica) seed oil from Yucatán, México. *Agricultural Sciences*, *5*(03), 220.

[42] Chen, H.; Rubenthaler G. L. and Schamus E. C. (1988). Effect of apple fiber and cellulose on the physical properties of wheat flour. J. Food Sci. 53 (1): 304-306.

[43] Nassef, S. L., El-Hadidy, G. S., and Abdelsattar, A. S. (2022). Impact of defatted chia seeds flour addition on chemical, rheological, and sensorial properties of toast bread. *Egyptian Journal of Agricultural Sciences*, *73*(4), 55-66.

[44] Khan, M. A.; Ameer, K.; Shakoor, S.; Ashraf, M. R.; Butt, M.; Khalid, M. S. and Rafeh, M. (2022). Development and characterization of wheat rusks supplemented with Chia (Salviahispanica L.) flour with respect to physicochemical, rheological and sensory characteristics. Food Science and Technology, 42, e53921.

[45] Guiotto, E. N.; Tomás, M. C. and Haros, C. M. (2020). Development of highly nutritional breads with by-products of chia (Salviahispanica L.) seeds. Foods, 9(6), 819.

[46] Zalatica, K., Jolana, K. and Michaela J.. (2012). Influence of carrot pomace powder on the rheological characteristics of wheat flour dough on wheat rolls quality. Acta Sci. pol. Technol .Aliment. 11(4) , 381-387 .

[47] Aly, A.; Abd El-Sabor, R. and Sadeek, R. (2021).IncorporationQuinoaand Chia Flour with Wheat Flour to Enhance the Nutritional Value and Improve the Sensory Properties of Pasta. Journal of the College of Specific Education for Educational and Specific Studies *6*(18), 1-37.

[48] Elhassaneen, Y. A.; Elhady, Y. A. A. and Mohamed, N. H. (2014). The use of gum arabic from acacia tree (Acaciasenegal), a food additive to improve the nutritional and rheological properties of wheat flour dough. Life Science Journal, 11(4), 385-393.

[49] Hibbs, A.N., Posner, E.S., 2011. Wheat: the raw material. In: Hibbs, A.N., Posner, E.S. (Eds.), Wheat Flour Milling. AACC International, St. Paul, Minnesota, USA, pp. 1–46.

[50] Carson, G.R., Edwards, N.M., 2009. Criteria of wheat and flour quality. In: Khan, K., Shewry, P.R. (Eds.), Wheat: Chemistry and Technology, fourth ed. AACC International, St. Paul, Minnesota, pp. 97–118.

[51] Gallagher, E., Gormley, T. R., & Arendt, E. K. (2003). Crust and crumb characteristics of gluten free breads. *Journal of food engineering*, *56*(2-3), 153-161.

[52] Coţovanu, I., Ungureanu-Iuga, M., &Mironeasa, S. (2021). Investigation of quinoa seeds fractions and their application in wheat bread production. *Plants*, *10*(10), 2150.

[53] Mandala, I.; Karabela, D.; Kostaropoulos, A. (2007): Physical properties of breads containing hydrocolloids stored at low temperature. I. E ect of chilling. Food Hydrocol. 21, 1397–1406.

[54] Aljobair, M. O. (2022). Effect of chia seed as egg replacer on quality, nutritional value, and sensory acceptability of sponge cake. Journal of Food Quality, Journal of Food Quality Volume 2022, Article ID 9673074, 11 pages https://doi.org/10.1155/2022/9673074

[55] Giannone, V.; Lauro, M. R.; Spina, A.; Pasqualone, A.; Auditore, L.; Puglisi, I and Puglisi, G. (2016).A novel α-amylase-lipase formulation as anti-staling agent in durum wheat bread. LWT-Food Science and Technology, 65: 381-389.