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Impact of Defatted Chia Seeds Flour Addition on Chemical, Rheological, and Sensorial Properties of Toast Bread

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ABSTRACT

This study presents functional healthier bakery products, by increasing nutritional quality and appropriate quantities of bioactive compounds such as protein, minerals, dietary fiber, and amino acids. Chia seeds have good nutritional and pharmaceutical properties, thus, fortification with chia seeds in toast bread could be beneficial in improving the final product. This study was carried out to examine the effect of partial substitution of wheat flour (WF) with defatted chia seed flour (DCSF) at levels of 5, 10, 15 and 20%. The rheology characteristics of dough, proximate compositions, and physical characteristics of the toast bread. Partial substitution of WF with DCSF significantly ($P \leq 0.05$) increased water absorption, arrival time, dough developing time and stability of dough. Meanwhile, the softening degree was reduced in all blends containing DCSF. Also, elasticity and energy were increased by the addition of DCSF. Toast bread supplemented with DCSF reduced the quality in terms of specific loaf volume, while weight was increased. DCSF up to 20% could partially replace WF in toast bread as it increases its nutritional value in terms of fiber, amino acids content and minerals with only a small depreciation in the bread quality. Sensory characteristics showed that toast bread incorporation of DCSF up to 20% was acceptable and gave a significant difference ($P \leq 0.05$) in parameters of taste, crumb texture, crumb grain, appearance, crust color, odor, and overall acceptability compared to the control.

Key words: Chia seeds, Toast bread, Rheology, Color.

1. INTRODUCTION

Bread is comprised principally of wheat flour, water, salt (sodium chloride), and baker's yeast. However, other constituents are added in small quantities to improve dough properties during processing and the quality of the final product (Matuda, 2004). Bakery products are extensively consumed and therefore demand their quality properties established. Particularly for pan bread, shape, texture, and color are essential for consumers. Shelf-life of bakery foods is principally limited by staling. Staling is a procedure of chemical and physical changes including, drying, moisture redistribution, starch retrogradation, increased firmness and fragility, as well as loss of flavor, and aroma flavor (Amigo *et al.*, 2016). Chia (*Salvia hispanica* L.) is an herbaceous plant that belongs to the order Lamiales, family Lamiaceae, and genus *Salvia* (Arctos Specimen Database, 2018). The *Salvia* genus is considered the most various in the family Lamiaceae. It contains of nearly 900 species widely distributed in numerous areas of the world, including Central America, Southern Africa, South America, South-East Asia, and North America (Takano, 2017).

The majority of this genus' seeds are grown in mountainous areas from temperate to subtropical climates (Capitani *et al.*, 2012). The chemical nutritional value of chia seeds may differ

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according to geographic location, climatic and soil conditions and nutrients, as well as the year of cultivation (Ayerza, 2009). For example, the composition of fatty acids differs according to the altitude of the plant, where, the higher and colder region, the higher the content of omega-3 unsaturated fatty acids (Ayerza and Coates, 2011). Over time, there has been an increase in chia consumption, given its health welfares related to chronic illnesses like cardiovascular illnesses, obesity, cancer, and diabetes mellitus (Ixtaina *et al.*, 2008, Vazquez-Ovando *et al.*, 2010, Poudyal *et al.*, 2013). These benefits result principally from the high concentrations of proteins, dietary fibers, essential fatty acids, minerals, carotenoids, vitamins, and antioxidants in chia seeds (Reyes-Caudillo *et al.*, 2008 and Ayerza and Coates, 2011). These days, the chia seed is eaten whole or added to other foods, like fruits, salads, and yogurts (Cahill, 2004 and Vuksan *et al.*, 2007), in preparations such as cakes, bread, beverages, and granola bars. Adding chia seeds to wheat bread increases its nutritional content, antioxidant activity, textural properties (higher moisture content and lower hardness), color, and sensory profiles with 3.7 points in global acceptability score (one to five) (Sayed-Ahmad *et al.*, 2018). The active components include Myricetin, Kaempferol, Quercetin, Caffeic acid, Omega-3, and Omega-6 (Capitani *et al.*, 2012) and Melo *et al.*, 2019). The concentrations of these active compounds may vary due to cultivation regions. Chia seed has high-fat content (30-33%), proteins (15-25%), dietary fiber (18-30%), carbohydrates (26-41%), vitamins, antioxidants, and minerals (Da Silva *et al.*, 2019). Chia seeds contain majorly polyunsaturated fatty acids (linoleic acids and α-linolenic acids) (Oyalo and Mburu 2021). Chia seed has 39% oil which contains 19% omega-6 and 68% omega-3 fatty acid (Vuksan *et al.*, 2017).

Similar to the use of 10% chia flour, which increased the amounts of protein, fat, and dietary fiber compared to white gluten-free bread, the use of 10% chia flour received an acceptability score of 8.1 on a scale of 10 cm (Sandri *et al.*, 2017). Also, the use of 30% chia seed flour (w/w) in a gluten-free noodle preparation increased the content of the antioxidant activity, fat, protein, and total phenolic compounds in comparison to the control. Also, the content of P, K, Ca, Mg, Zn, and Fe increased in noodles containing chia seed and there was a decrease in surface smoothness, chewiness score of raw, and cooked noodle samples, and appearance (Levent, 2017).

Chia seeds contain between 22-42% fiber (85% insoluble and 15% soluble), which depends on the area of growth and atmosphere (Sargi *et al.*, 2013).

Moreover, adding dietary fiber to toast bread improved the properties of the dough that is used in the preparation of toast bread and improved the quality of toast bread due to the ability of dietary fiber to absorb high amounts of water, which has the ability to increase the freshness of the toast and reduce the phenomenon of staling (El-Hadidy and El-Dreny, 2020). To our knowledge, this is the first research on use of DCSF as a functional food and as a high source of dietary fiber in toast bread preparation. Also, to estimate the impact of fortified wheat flour with the DCSF on chemical, and sensory parameters of toast bread and rheological properties of dough.

2. MATERIALS AND METHODS

2.1. Raw materials

Wheat flour (72%), was purchased from the North Cairo Flour Mills Company, Egypt (2022). Chia seeds (*Salvia hispanica* L.) were obtained from the Agricultural Research Center, Giza, Egypt. (2022). Active dry yeast (*Saccharomyces cerevisiae*) was obtained from the Egyptian Sugar and Integrated Industries Company (ESIIC), Chemicals Factory, El-Hawamdia City, Giza, Egypt. Shortening, salt (sodium chloride), and sugar (sucrose) were purchased from the local market, Egypt (2022).

2.2. Defatting of Chia Seeds

The oil was obtained from the chia seeds (*Salvia hispanica* L.) in a hydraulic press (MECAMAQ Model DEVF 80, Vila-Sana, Lleida, Spain) as described by Muñoz-Tebar *et al.* (2019). The defatted chia meal was grounded at 10,000 rpm for 3 min with a knife mill GRINDOMIX GM 200 (Retsch, Haan, Germany) and stored vacuum-packed in darkness at 4 °C until use.

2.3. Baking experiment

Experimental bread-preparing was done according to the method outlined by El-Hadidy (2020). The baking formula contains (14%) flour weight was; flour (295 g), salt (6 g), and fresh compressed yeast (5 g). The wheat flour was substituted by DCSF at levels of 5, 10, 15 and 20%. Flours (or flour mixtures) were stirred for 1 min in the farinograph bowl. After that, the other constituents (salt and yeast), were dissolved separately in water and then added. The quantity of water to be used was estimated by the farinograph absorption value. The dough was formerly mixed for five min, and placed in baking pans and fermented at 30°C and 80–90% relative humidity. Formerly the dough was re-mixed and was substituted for re-fermentation. The above 2 fermentation periods were 45 min in both cases. Baking for each 400 g dough piece was at 220°C for 45 min. Throughout baking, some water was vaporized in the oven to evade any extreme dryness of the bread crust.

2.4. Farinograph method

The dough mixing measurements of different wheat-DCSF flour mixtures were examined with the Brabender farinograph (Brabender, Duisburg, Germany) according to the constant flour weight process AACC (1983) and ICC (1992). Dough development time was determined as the time to the point of the curve immediately before the first sign of a decrease in consistency. The maximum consistency was defined as the consistency in B.U., measured at the development time and in the middle of the curve bend, while the dough stability was defined as the drop of the curve (B.U.) during the first 2 min after dough development time.

2.5. Extensograph method

Doughs from the farinograph properties were cut into two parts (150g each) and passed through the balling and molder unit of a Brabender extensograph (Brabender, Duisburg, Germany). After 45 min rest in the fermentation cabinet, the dough was stretched. After this first test, the balling and mounding operations were repeated and the doughs were tested again after a further 45 min resting time. The same procedure was repeated for a third time, following the official procedure AACC (1983) and ICC (1992). The results were expressed as the resistance to constant deformation after 50 mm stretching (R50); the extensibility (Ex) was described as the distance traveled by the recorder paper from the moment that the hook touches the test piece until the rupture of the test piece and the ratio between them (R50/Ex).

2.6. Proximate analysis of DCSF and toast bread blends on dry weight basis

Defatted chia seeds flour and toast bread blends were investigated for crude protein, ash, ether extract, and crude fiber according to the reported methods outlined by AOAC (2005).

Available carbohydrates were calculated by difference as follows:

Available carbohydrates = 100 – (protein + ash + fat + crude fiber)

2.7. Determination of soluble and insoluble dietary fiber

The soluble and insoluble dietary fibers were determined according to the method described by ASP *et al.* (1983).

2.8. Determination of minerals content

Minerals were determined according to the procedures outlined by AOAC (2005).

2.9. Determination of amino acids

Amino acids of DCSF and all samples were estimated according to the method outlined by AOAC (2005).

2.10. Determination of tryptophan

The tryptophan content of samples was estimated calorimetrically according to the method described before by Miller (1967).

2.11. Computed protein efficiency ratio (C-PER)

C-PER was determined as described by Alsmeyer *et al.* (1974) equation as follows: C-PER = -0.4687+0.454(Leucine)-0.105(Tyrosine).

2.12. Biological value (BV)

Biological value was measured as described by Farag *et al.* (1996) according to the following equation: BV=49.9+10.53C-PER.

2.13. Sensory evaluation of toast bread

Sensory evaluation of toast bread was estimated by 20 panelists from the staff of Sakha Food Technology Research Laboratory., Agric. Res. Center, Egypt. Panelists were asked for sensory properties of toast bread crust color, taste, odor, crumb grain, appearance crumb, texture, and overall acceptability according to the method outlined by Kramer and Twigg (1974). Panelists estimated toast bread blends on a 9-point hedonic scale quality analysis

2.14. Color Measurements of toast bread

The crust and crumb color of the products was measured according to the method outlined by McGurie (1992) using a handheld Chroma meter (model CR-400, Konica Minolta, Japan).

2.15. Toast bread physical parameters

The average weight of theloaves was recorded after cooling the loaves for three hrs. The loaf volume was estimated by the rapeseed displacement method as outlined by AACC (1983). Specific volume (cm^3/g) was determined by dividing the volume of the loaf by its weight.

2.16. Statistical Analysis.

The data were statistically analyzed using SPSS (2000). One-way analysis of variance (ANOVA) was performed using SPSS software version 6.0 (SPSS Institute Inc., Cary, NC, USA).

A value of P ≤ 0.05 was considered statistically significant.

3. RESULTS AND DISCUSSIONS

3.1. Chemical composition of chia seeds, DCSF, and wheat flour (72%) on a dry weight basis.

The proximate chemical of raw materials, were presented in Table (1). Data revealed that chia seeds flour contained 4.80% ash, 25.00% crude protein, 32 % ether extract, 24% crude fiber, and 14.20 % available carbohydrates. Also, the caloric value was 451.92 kcal/100g. These results were similar to that obtained by Mohammed *et al.*, (2019). They reported that chia seeds flour contains 26.10% crude protein, 36.57% fat, 5.15% ash, 22.22% crude fiber, and 9.96% total carbohydrates. Additionally, the proximate composition of DCSF and wheat flour used for the preparation of bakery products (toast bread) is shown in Table (1). The obtained data revealed that the highest content of protein found in DCSF reached about 34.25%. While the lowest value was found in wheat flour (12%). Fat content were 32.0, 5 and 1.80% for CS, DCSF and wheat flour, respectively. DCSF had the highest arrival content of ash 6.58% followed by CS (4.80%) and finally wheat flour (0.55%). Fiber content was (32.88%, and 0.88%) for DCSF, and wheat flour, respectively. Wheat flour had the highest value of available carbohydrate content of 84.95%. and cs had the lowest value 14.20 followed by DCSF 21.29%. The results are in harmony with the work of EL-Derny and El-Hadidy (2018), which showed that wheat flour had 11.69% crude protein, 1.40% crude ether extract, 0.60% ash, 85.66% total carbohydrates, and 411.88 kcal/100g caloric value.

Moreover, El-Hadidy (2020) explained that wheat flour contains 11.81% crude protein, 0.45% ash, 0.84% crude fiber, and 86.13% carbohydrates. It was observed that there were significant differences at P<0.05 between chia seeds, DCSF, and wheat flour in the content of all chemical compositions.

Table (1): Chemical composition of chia seeds, DCSF and WF on dry weight basis.

Raw materials	Chia seeds (CS)	Defatted chia seeds (DCSF)	Wheat flour (72% ext.) (WF)
Moisture%	8.50[b] ±0.55	4.5[c] ±0.30	8.70[a] ±0.45
Crude protein%	25.00[b] ±1.00	34.25[a] ±0.90	12.00[c] ±0.60
Ether extract%	32.00[a] ±0.33	5.00[b] ±0.08	1.80[c] ±0.05
Ash%	4.80[b] ±0.35	6.58[a] ±0.30	0.55[c] ±0.03
Available Carbohydrates%	14.20[c] ±0.50	21.29[b] ±0.30	84.95[a] ±0.45
Crude Fiber%	24.00[b] ±0.60	32.88[a] ±0.45	0.80[c] ±0.01
Soluble fiber %	ND	2.85[a] ±0.05	0.33[b] ±0.02
Caloric value (kcal/100 g)	451.92[a] ±0.33	273.21[c] ±0.55	413.88[b] ±0.44

Means with different letter in the same row are significantly different at LSD at ($p \leq 0.05$).
- Each value was an average of three determinations ± standard deviation.
CS= Chia seeds WF =Wheat flour (72%ext.)
DCSF Defatted chia seeds flour ND = NOT Determined

3.2. Amino acids profile of defatted chia seed flour and toast bread supplemented with defatted chia seeds.

The amino acid composition (g amino acids / 100g protein) was presented in Table 2 of DCSF and all prepared toast bread. The obtained results showed that the overall essential amino acid contents of toast bread formula produced by supplementing DCSF (5, 10, 15, and 20 % of DCSF) were significantly (p≤0.05) higher than that of wheat flour toast bread. On the contrary, the control sample showed higher total non-essential amino acids when compared to formulas prepared from DCSF-toast bread. Table (2) displays the calculated protein efficiency ratio (C-

Table (2): Amino acids profile of defatted chia seed flour and toast bread supplemented with defatted chia seeds (g/100g of protein).

Amino acids	DCSF	Control	B5	B10	B15	B20	FAO／WHO／ UNU (g/100g)
Essential amino acids (EAA)							
Lysine	6.30	3.10	3.26	3.42	3.58	3.74	5.80
Isoleucine	4.55	4.20	4.22	4.24	4.25	4.27	2.80
Leucine	6.30	4.60	4.69	4.77	4.86	4.94	6.60
Phenylalanine	5.90	5.00	5.05	5.09	5.14	5.18	6.30
Tyrosine	2.70	1.95	2.04	2.07	2.11	2.14	
Histidine	4.70	4.00	4.04	4.07	4.12	4.14	1.90
Valine	5.34	4.70	4.77	4.79	4.80	4.83	3.50
Threonine	4.10	2.50	2.61	2.66	2.74	2.82	3.40
Methionine	3.20	1.20	1.30	1.40	1.50	1.60	2.20
Tryptophan	1.37	1.20	1.21	1.22	1.23	1.23	1.00
Total(EAA)	44.47	32.45	33.19	33.73	34.33	34.89	
Non- essential amino acids (NEAA)							
Aspartic acid	90.00	5.00	5.2	5.40	5.6	5.8	
Glutamic acid	18.00	33.00	32.25	31.50	30.75	30.00	
Proline	0.75	12.00	11.44	10.88	10.31	9.75	
Alanine	6.30	4.70	4.77	4.86	4.97	5.02	
Arginine	8.49	3.40	3.65	3.91	4.16	4.42	
Serine	6.30	5.90	5.93	5.94	5.96	5.98	
Glycine	4.90	2.90	3.01	3.10	3.21	3.30	
Total(NEAA)	53.74	66.90	66.25	65.59	64.96	64.27	
C-PER	2.11	1.41	1.45	1.48	1.52	1.55	
BV	72.10	64.81	65.14	65.49	65.87	66.22	

DCSF* Defatted chia seed flour. Control= 100% Wheat flour,
B5 = 95%Wheat flour + %5 DCSF, B10 = 90%
Wheat flour + 10% DCSF, B15 = 85% Wheat flour + 15%DCSF, B20 80% Wheat flour + 20%
DCSF EAA: Essential amino acids. NEAA: Nonessential amino acids
C-PER = Computed protein efficiency ratio. BV = Biological value

PER) and biological value (BV) of DCSF and all prepared toast bread. The C-PER and BV were higher in toast bread prepared from DCSF at different supplemented ratios than in the control sample. The results are in harmony with the work of El-Hadidy (2020) who explained that the chemical composition of toast bread prepared from wheat flour contains some essential amino acids, which form such a mixture in this study.

3.3. Chemical composition and mineral contents of DCSF and blends of toast bread (mg/ 100g on a dry weight basis)

Table (3) shows the mean value contents of crude protein, fat, ash, crude fiber, and carbohydrates of the prepared toast bread supplemented with 5, 10, 15, and 20% of DCSF. Crude protein, crude fiber, fat, and ash were significantly increased ($p \leq 0.05$) in toast bread enriched with DCSF compared with control. while there was a decrease in available carbohydrates, and caloric values. This is due to the high amount of crude protein, crude fiber, fat, and ash in DCSF compared to WF. This indicates that DCSF could be an alternative source of dietary fiber and crude protein in toast bread processing. This study was near to the results obtained by Boriy *et al.* (2021) who cleared that pan bread prepared from chia seeds powder increased in protein, ash, crude fiber, and ether extract compared to control pan bread made from wheat flour.

Table (3): Chemical composition and mineral contents of defatted chia seeds and blends of toast bread (mg / 100g) on a dry weight basis.

Blends	Control	B5	B10	B15	B20	
Crude protein%	11.03[e] ±0.02	12.03[d] ±0.07	13.05[c] ±0.05	14.04[b] ±0.04	15.09[a] ±0.09	
Fat%	4.40[d] ±0.05	4.55[c] ±0.04	4.78[b] ±0.01	4.85[b] ±0.02	5.00[a] ±0.03	
Ash%	0.51[e] ±0.01	0.81[d] ±0.05	1.06[c] ±0.04	1.34[b] ±0.03	1.61[a] ±0.05	
Crude fiber%	0.74[e] ±0.03	2.21[d] ±0.01	3.68[c] ±0.03	5.14[b] ±0.04	6.62[a] ±0.05	
Available Carbohydrates%	83.32[a] ±0.04	80.40[b] ±0.05	77.43[c] ±0.45	74.60[d] ±0.55	71.68[e] ±0.65	
Caloric value (kcal/100g)	426.88[a] ±0.45	420.37[b] ±0.65	414.47[c] ±0.75	407.68[d] ±0.85	401.26[e] ±0.35	
Mineral (mg/ 100g)						**DCSF**
Ca (mg/ 100g)	17.50e ±0.45	48.63[d] ±1.02	80.57[c] ±1.50	112.44[b] ±2.53	145.00[a] ±1.83	660 ±5.34
P (mg/100g	141.00[e] ±1.55	176.95[d] ±1.33	214.50[c] ±1.70	252.58[b] ±1.95	290.00[a] ±4.00	900.20 ±11.92
Na (mg/ 100g)	5.10[e] ±0.10	6.73[d] ±0.10	7.74[c] ±0.04	8.70[b] ±0.20	9.70[a] ±0.12	25.5 ±1.30
K (mg/ 100g)	120.50[e] ±01.40	150.19[d] ±2.78	182.25[c] ±2.60	213.50[b] ±3.50	246.00[a] ±2.50	750 ±14.80
Mg (mg/ 100 g)	105.00[e] ±0.54	120.50[d] ±2.50	137.50[c] ±1.95	154.74[b] ±1.90	172.00[a] ±2.50	450.00 ±10.50
Zn (mg/ 100g)	4.00[e] ±0.03	4.14[d] ±0.05	4.30[c] ±0.05	4.50[b] ±0.04	4.70[a] ±0.14	7.50 ±0.057
Mn (mg/ 100g)	0.90[e] ±.03	0.96[d] ±0.05	1.04[c] ±0.02	1.12[b] ±0.01	1.20[a] ±0.02	2.50 ±0.04
Fe (mg/ 100g)	1.80[d] ±0.20	2.33[e] ±0.19	2.92[c] ±0.14	3.50[b] ±0.17	4.10[a] ±0.05	13.50 ±0.50

-Means with different letter in the same row are significantly different at LSD at *($p \leq 0.05$)*.
- Each value was an average of three determinations ± standard deviation.
Control= !00% Wheat flour,
B5 = 95%Wheat flour + %5 DCSF, B10 = 90% Wheat flour + 10% DCSF, B15 = 85%Wheat flour + 15%DCSF, B20 80% Wheat flour + 20% DCSF.

Table 3. shows the content of macro and micro mineral elements in the control sample and toast bread supplemented with DCSF. DCSF showed a good source of minerals reaching about 660, 900.20, 25.50, 750, 450, 7.50, 2.50, and 13.50 mg/100g for Ca, P, Na, K, Mg, Zn, Mn, and Fe, respectively. In comparison to control, toast bread supplemented with DCSF has a higher content of P, Ca, Na, K, Mg, Fe, Zn, and Mn. The DCSF contains more essential mineral elements than an individual's everyday requirements. Calcium, phosphorus, sodium, potassium, magnesium, zinc, manganese, and iron Fe have contained in chia seed. The results are in harmony with the work of Mohammed *et al.* (2019).

3.4 Rheological parameters of toast dough

The farinograph and extensograph characteristics of wheat flour, and its blends with defatted chia seeds flour are presented in Table (4). From the obtained data, it could be observed that the water absorption of strong wheat flour gradually increased as the level of substitution with defatted chia seeds flour increased. The increase in water absorption of the wheat flour dough is perhaps due to the higher fiber contents of DCSF flour than wheat flour. These results are in harmony with Abd El-Moniem and Yassen (1993). They showed that the addition of fiber sources to wheat flour caused an increment in water absorption of the formed dough. This may be due to fibers' higher water hydration capacity (Chen *et al.,* 1988). Dough development time is the time from the addition of water to the time the dough reaches the point of greatest torque. During this mixing phase, the water hydrates the flour constituents and the dough is developed. The farinograph data showed that the addition of defatted chia seeds flour increased dough development time. This may be due to the delay in the hydration and development of gluten caused by the presence of the above-mentioned plant sources. Dough stability time is an important index for the dough strength based on the quantity and quality of dough gluten. It could be noticed that the stability time of the control sample was 8.00 min, which increased by adding DCSF to wheat flour reached about 9.5, 10.5, 11.5, and 12.0 min for B5, B10, B15, and B20, respectively.

Concerning the extensograph characteristics, the results presented in the same table show that the elasticity (resistance to extension) of WF dough was increased as a result of increasing substitution levels with DCSF, it was 280, 470, 540, and 680 B.U. for B5, B10, B15, and B20, respectively, in comparing with 120 B.U. for WF dough. According to Bojňanska *et al.* (2013) revealed that the process of dough formation from the initial water addition to flour up to forming of compact dough with desired qualities (consistency, resistance to deformation, stability) goes through different phases during which fluidity, firmness, and elasticity gradually change. The dough development time depends on the amount and quality of gluten, flour granules and degree of milling and dough stability indicates the time interval during which dough maintains maximal consistency, and the high dough stability is considered of good quality from the point of view of further baking use (Skendi *et al.,* 2009 and Bojňanska *et al.,* 2013).

3.5.1. Sensory Evaluation of toast bread

The sensory evaluation is considered to be a valuable tool in solving problems involving food acceptability. It is useful in product improvement, quality maintenance, and more important in new product development (Kramer and Twigg, 1974). The sensory evaluation of toast bread samples is shown in Table (5). From sensory evaluation, it could be observed that there were significant differences ($p \leq 0.05$) in taste, appearance, crumb texture, crumb grain, odor, crust color and overall acceptability for all samples (Table 5). The addition of DCSF significantly increased ($p \leq 0.05$) the taste, crumb texture, crumb grain, and odor compared to the control sample. On the other hand, the addition of DCSF to WF significantly decreased ($p \leq 0.05$) the appearance, crust color, and overall acceptability compared to the control sample. From the observation data in Table (5), it could be concluded that the best addition level to obtain a high overall acceptability score was B10.

3.5.2. Color Measurements of toast bread

Color is one of the most important quality characteristics of toast bread. Color measurements of toast bread are shown in Table (5). Data indicated that supplementation with DCSF significantly decreased ($p \leq 0.05$) the lightness (L) values of crust color toast bread. Control recorded the highest value (50.33), while B20 showed the lowest (41.00). The redness (a) values increased significantly in B20 compared with the control. Regarding yellowness (b) values, supplementation with DCSF significantly increased ($p \leq 0.05$) the yellowness of crust color, whereas sample B20 recorded the maximal b value (24.0). In contrast, the sample control recorded the minimal b value (16.0). Color measurements of crumb color are shown in Table (5). Data indicated that supplementation with DCSF significantly decreased ($p \leq 0.05$) the lightness (L) values of crumb color toast bread. Control recorded the highest value (68.00), while B20 had the lowest (42.00). The redness (a) values increased significantly ($p \leq 0.05$) in B20 (7.10) compared with the control (1.17).

These results are in agreement with Romankiewicz *et al.* (2017) who showed that adding chia seeds to wheat flour at extents 2, 4, 6, and 8% increased the lightness (L) values of crumb color bread. Throughout the baking procedure, the temperature in the crumb of toast bread does not reach 100°C, while in the crust of toast bread it is above 100 °C. Mailard's reaction that impacts the color of the bread took place only in the crust of bread **(**Steffolani *et al.,* 2014).

The color of the bread crumb mainly depends on comprise of raw materials used. The color of chia seeds can vary from dark grey to light cream (Ixtaina *et al.,* 2008). Chia seeds are rich in phenolic compounds like caffeic acid, ferulic acid, 7-hydroxycoumarin, p-coumaric acid, quercetin, quercetin-3- glucoside, kaempferol, and catechol, which besides their antioxidant properties affect the color of the bread (Iglesias-Puig, and Haros, 2013).

Table (4): Effect of substituted wheat flour with different proportion of defatted chia seeds on the rheological characteristics of toast dough

Farinograph parameters					
Samples	**Water Absorption (%)**	**Arrival time (min)**	**Dough development (min)**	**Stability (min)**	**Degree of softening (B.U.)**
Control	61.80	1.0	2.0	8.0	70
B5	66.00	1.5	2.0	9.5	60
B10	69.20	2.0	2.5	10.5	50
B15	74.10	2.0	3.0	11.5	40
B20	76.20	3.0	4.5	12.0	30
Extensograph parameters					
Control	**Elasticity (B.U.)**	**Extensibility (mm)**	**Proportional number**	**Energy (cm^2)**	
Control	120	115	1.04	24	
B5	280	95	2.95	55	
B10	470	80	5.88	68	
B15	540	40	13.5	70	
B20	680	30	15.33	73	

-DCSF* Defatted chia seed flour.
Control= !00% Wheat flour,
B5 = 95%Wheat flour + %5 DCSF, B10 = 90% Wheat flour + 10% DCSF, B15 = 85% Wheat flour + 15%DCSF, B20 80% Wheat flour + 20% DCSF

3.5.3. Bread Crumb Texture

The texture profile analysis characteristics were presented in Table (5). The hardness of the bread crumb is a measurement that is most often estimated in bread texture studies. It is described as the maximum force that was logged during the first crumb kneading (Armero and Collar, 1997). The hardness of the wheat toast bread crumb without additives amounted to 22.86N. For B5, B10, B15, and B20 samples a slight but significant reduction ($p \leq 0.05$) of this parameter were observed to the level of 14.36 N. DCSF addition weakens the gluten matrix and causes the weakening of the crumb cell structure, thus, the prepared toast bread had a lower volume. The lower volume of toast bread usually causes an increase in crumb hardness. On the contrary, the decrease in force required to compress the toast bread slice was observed for B5, B10, B15, and B20 crumb samples, which means that crumb hardness was decreased. This may be caused by the chemical comprised of chia seed and particularly gum and fat constituent which probably caused a decrease in bread hardness. The results were of similar comprise to chia seed enriched with wheat flour (Marpalle *et al.*, 2014). The springiness of the bread crumb ranged from 5.45 to 7.37, while the cohesiveness of the bread crumb ranged from 0.65 to 0.77.

The bread's springiness is a characteristic that indicates how well the crumb reverts to its original shape after compression.

The cohesiveness parameter is estimated on the basis of work done during the compression of the crumb during the first and second kneading (Armero and Collar, 1997 and Marpalle *et al.*, 2014). DCSF addition had no significant impact on these parameters.

The gumminess of the control sample was 17.66 N. The bread with chia seed addition had fewer gummy crumbs than the control sample. The gumminess is estimated by the force required to fragment the product (Armero and Collar,1997). The raise of bread crumb gumminess is received unfavorably by consumers (Dziki *et al.*, 2011).

Table (5): Characteristics of obtained toast breads.

Samples	Control	B5	B10	B15	B20
Sensory evaluation					
Taste	9.00[a] ±0.00	8.50[ab] ±0.50	8.00[b] ±0.50	7.80[b] ±0.20	7.00[c] ±0.50
Appearance	8.80[a] ±0.20	8.00[b] ±0.30	7.50[c] ±0.15	7.00[d] ±0.10	6.50[e] ±0.20
Crumb texture	8.50[a] ±0.10	8.00[b] ±0.20	7.50[c] ±0.10	7.00[d] ±0.30	7.00[d] ±0.20
Crumb grain	8.50[a] ±0.20	8.30[ab] ±0.30	8.00[bc] ±0.20	7.80[bd] ±0.30	7.50[d] ±0.50
Odor	9.00[a] ±0.00	8.50[b] ±0.10	8.50[b] ±0.30	8.00[c] ±0.20	8.00[c] ±0.20
Crust color	9.00[a] ±0.00	8.50[b] ±0.20	8.00[c] ±0.15	7.50[c] ±0.30	7.00[d] ±0.40
Overall acceptability	9.00[a] ±0.00	8.50[b] ±0.30	8.00[c] ±0.40	8.00[c] ±0.20	7.00[d] ±0.30
Crust color					
L	50.33[a] ±0.50	49.00[a] ±1.00	45.00[b] ±0.50	42.00[c] ±1.00	41.00[c] ±0.50
a	8.50[d] ±0.45	11.00[c] ±0.50	13.50[b] ±0.35	14.00[ab] ±0.50	15.00[a] ±0.55
b	16.00[e] ±0.55	18.00[d] ±0.55	20.00[c] ±0.55	22.00[b] ±0.55	24.00[a] ±0.55
Crumb color					
L	68.00[a] ±0.45	55.00[b] ±0.30	50.00[c] ±0.33	45.00[d] ±0.25	42.00[e] ±0.35
a	1.17[e] ±0.01	2.60[d] ±0.02	3.80[c] ±0.01	5.6[b] ±0.05	7.10[a] ±0.03
b	3.80[e] ±0.01	4.90[d] ±0.05	6.80[c] ±0.09	10.40[b] ±0.07	12.00[a] ±0.50
TAP					
Hardness N	22.86[a]	20.08[b]	18.01[c]	14.75[d]	14.36[e]
Cohesiveness	0.69[b]	0.67[c]	0.77[a]	0.67[c]	0.65[d]
Springiness mm	7.37[a]	5.45[d]	6.19[b]	5.45[d]	5.65[c]
Gumminess N	17.66[a]	11.35[c]	15.06[b]	11.04[d]	10.21[e]
Chewiness mJ	104.70[a]	60.30[b]	55.30[e]	60.20[b]	57.70[c]
Physical parameters of toast bread					
Volume (Cm^3)	1600[a] ±6.45	1400[b] ±8.33	1300[c] ±6.20	1250[d] ±6.30	1080[e] ±5.30
Weight (g)	462[e] ±03.40	470[d] ±5.20	481[c] ±2.70	491[b] ±4.55	500[a] ±2.55
Specific volume (cm^3/g)	3.46[a] ±0.03	2.98[b] ±0.02	2.70[c] ±0.07	2.54[d] ±0.09	2.16[e] ±0.03

-Means with different letter in the same row are significantly different at LSD at ($p \leq 0.05$).
- Each value was an average of three determinations ± standard deviation.
Control= !00% Wheat flour,
B5 = 95%Wheat flour + %5 DCSF, B10 = 90% Wheat flour + 10% DCSF, B15 = 85%Wheat flour + 15%DCSF, B20 80% Wheat flour + 20% DCSF.

3.5.4. Physical properties of fortified toast bread

The influence of toast bread supplemented with DCSF on weight (g), volume (cm^3) and specific volume (cm^3/g) are presented in Table (5). From the results, it is revealed that toast bread enriched with DCSF had lower values in volume and specific volume in comparison with control toast bread. On the contrary, weight increased with increasing DCSF ratio. These results are in agreement with Romankiewicz *et al*. (2017) who explained that bread enriched with chia seed had lower values in volume and specific volume compared to control toast bread, this could be due to the interactions among dietary fiber components, gluten, and water.

Conclusions

The findings of the present study could be concluded that the produced bakery products were rich in crude protein, ash, crude fiber, and ether extract with a low caloric value. These products were a rich source of essential amino acids, and minerals especially phosphorous, calcium, potassium, magnesium, and iron. It could be concluded that the partial substitution of wheat flour with DCSF improved the rheological properties of the dough to a different extent. The inclusion of DCSF in the toast bread formula; increased its nutritional value, with only a small depreciation in toast bread quality. The sensorial properties of prepared toast bread from DCSF were nearly similar to products prepared using WF. The sensory properties showed that the addition of DCSF up to 20% had no significant influence on bread quality. Organoleptic characteristics presented that the loaf supplemented up to 20% DCSF was suitable and has a significant difference with control in terms of crumb texture, appearance, crumb grain, crust color, overall acceptability odor, and taste.

Authors agreement

The authors have read and agreed to the published version of the manuscript.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

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تأثير إضافة دقيق بذور الشيا المنزوعة الدهن على الخصائص الكيميائية والريولوجية والحسية لخبز التوست

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ملخص

فى هذه الدراسة تم انتاج منتجات مخابز وظيفية أكثر صحة، من خلال زيادة القيمة الغذائية والمركبات النشطة بيولوجيًا مثل البروتين والمعادن والألياف الغذائية والأحماض الأمينية. تتمتع بذور الشيا بخصائص غذائية وصيدلانية جيدة، لذا فإن التدعيم ببذور الشيا في خبز التوست قد يكون مفيدًا في تحسين المنتج النهائي. أجريت هذه الدراسة باستبدال جزئي لدقيق القمح بدقيق بذور الشيا منزوع الدهن بمستويات 5،10،15 ، و 20٪ ودراسة الخصائص الانسيابية والخصائص الفيزيائية للعجين لخبز التوست. أدى الاستبدال الجزئي لدقيق القمح بدقيق بذور الشيا المنزوعة الدهن بشكل معنوي ($P\leq0.05$) إلى زيادة امتصاص الماء، ووقت الوصول، وقت نمو العجين، وثبات العجين. وفي نفس الوقت، تم تقليل درجة التليين في جميع الخلطات التي تحتوي على دقيق بذور الشيا غيرمنزوعة الدهن. أيضا، تمت زيادة المرونة والطاقة عن طريق إضافة دقيق بذور الشيا المنزوعة الدهن. أدى خبز التوست المضاف إليه دقيق بذور الشيا المنزوعة الدهن إلى انخفاض الجودة من حيث حجم الرغيف المحدد بينما زاد الوزن. يمكن أن يحل دقيق بذور الشيا المنزوعة الدهن حتى 20٪ جزئيًا محل دقيق القمح في خبز التوست؛ يزيد من قيمته الغذائية من حيث محتوى الألياف والأحماض الأمينية والمعادن مع انخفاض بسيط في جودة الخبز. أظهرت الخصائص الحسية أن دمج الخبز التوست لدقيق بذور الشيا المنزوعة الدهن حتى 20٪ كان مقبولاً وأعطى فرقاً معنوياً ($P\leq0.05$) في معاملات التذوق وقوام البابة والتحبب والمظهر ولون القشرة والرائحة والقبول العام مقارنةً بالكنترول.