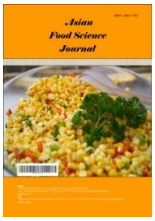

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Preparation and Evaluation of Pan Bread from Chia Seeds Powder as Substitute Wheat Flour

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Authors' contributions

This work was carried out in collaboration among all authors. Author EGB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors EAY and EAAAR managed the analyses of the study author EGB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

As part of this functional food covenant, the world is searching for new healthy food products with ample quantities of bioactive components such as fibre, mineral elements, essential amino acids, and phenols. Since CHIA seeds powder has both nutritious and pharmaceutical properties, integrating it into pan bread may be beneficial to human health. The sensorial parameters of pan bread enriched with CSP, amino acids composition, and proximate compositions of the pan bread were investigated in this study by partially replacing wheat flour (WF) with CHIA seeds powder (CSP) at levels of 3 percent, 6 percent, 9 percent, and 12 percent. The addition of CSP to pan bread improved the mineral content of the bread. With only a minor depreciation in bread quality, CSP could partially replace WF 72 percent extraction in pan bread, increasing its nutritional value in terms of fibre, essential amino acids, and minerals. Sensorial evaluation revealed that pan bread supplemented with up to 12% CSP was acceptable to the panelists, with notable differences in crumb texture, appearance, crust color, crumb grain, taste, odor, and overall acceptability as compared to pan bread control. When compared to pan bread without CSP, the CSP mixture increased the mineral content, essential amino acid content, and nutritional properties.

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Keywords: Chia; seeds; pan bread; amino acids; minerals.

1. INTRODUCTION

Functional foods have been a source of controversy in the food and nutrition industry for years. When designing functional bakery foods, it's critical to create a product that has physiological effectiveness as well as market acceptance in terms of appearance, taste, and texture [1]. Bread is a staple food made from wheat flour, salt, and yeast that is eaten all over the world [2]. Consumers tends to consume healthy foods to prevent infectious illnesses. Because of this, production and investigators are working to optimize the technology of bread making to enhancevariety, quality and taste[3].

Spices and herbs, which are natural antioxidants and antimicrobials, have a lot of potential as functional ingredients in bread. Wheat bread has been studied for its ability as a natural antioxidant source.

Food protection is achieved when all people have access to sufficient, secure, and nutritious food that meets their nutritional needs and allows them to live an active and balanced life that benefits their social, physical, and economic well-being. Climate change, rising global population, rising food prices, and environmental stresses all have a serious but somewhat uncertain impact on food safety[4].

Salvia hispanica, or chia seeds, is an annual herbaceous herb native to Guatemala and northern southern Mexico. There are nine hundred species in the genus Chia. The name chia comes from the Latin word 'salvere,' which means 'to heal.' Chia seeds are a well-known medicinal and culinary plant [5].

The chia plant produces a significant number of dry fruits, which are widely referred to as seeds. Chia seeds are small, dark or white seeds that were eaten along with main diets including amaranth, beans, and corn in pre-Columbian times, and were one of the essential diets in the food of a number of Central American civilizations, including the Aztec and Mayan peoples.[6]

Lemaitre, et al. [7] stated the influence of CSF supplementation on blood pressure. Data showed that by lowering blood glucose levels, blood became less susceptible to coagulation, resulting in lower levels of internal inflammation. The average systolic blood pressure dropped by 6mmHg.

Comba, et al. [8] outlined CSF oil was suggested for the treatment of inflammatory issues such as redness, swelling, and discomfort, which may lead to serious complications. Chia seeds and their oil, which contain PUFA, prostaglandins, and eicosanoids, were used to treat and prevent these health problems because they contain PUFA, prostaglandins, and eicosanoids, which cause less inflammation by reducing COX-2 induction.

Divyapriya et al. [9] Using the disc diffusion process, researchers investigated the antibacterial effects of CSF extract against all of the major periodontal pathogens. Similarly, both the ethanolic and aqueous extracts of CSF demonstrated antibacterial activity in the micro dilutionassay.

According to the report, CSF contains 34 to 40% dietary fibre and is equal to 100% of the daily fibre recommendations for adults. The defatted CSF contains 40% crude dietary fibre, of which 5–10% was soluble dietary fibre, and forms part of the mucilage, which helps to control diabetes, slow digestion, and prevent cardiovascular disease [10]. CSF accelerated intestinal movement due to a high amount of insoluble dietary fibre, which increased faecal mass and provided satiety, preventing obesity and colon cancer in humans, according to studies[11].

CSF products have strong water-binding capability, oil-holding capacity, emulsion and viscosity operation, and can be easily extracted for use as a thickener, emulsifier, and stabilizer in frozenfoods [12].

CSF containing omega-3 fatty acids plays an essential role in preventing plaque and clot formation in the arteries, as well as preventing cardiovascular disease. It is advantageous to the proper functioning of the intestine as a rich source of dietary fibre and provides more highly nutritive proteinsthantraditionalcrops [13].

CSF is an excellent food because it is high in crude protein, crude dietary fibre, essential fatty acids, antioxidants, and vitamins, as well as valuable minerals like manganese, phosphorus, sodium, potassium, and calcium. CSF had a higher crude protein content than other commonly consumed cereals. such as corn, wheat, oat, rice, amaranth and barley along with

essential aminoacid profile [14].

The antimicrobial activity of CS owing to its ether extract composition (30%), which includes

50-57% linolenic acid and 17-26% linoleic acids [15].

Referred to because of its high dietary fibre content, CS gum was used in both food and industry. It serves not only as a physiological mechanism for its beneficial effect on human wellbeing, but also as a technical function that is heavily dependent on hydration properties. Chia gum has been used in the food industry to improve the physical properties of products. such as absorption capacity and water-holding, swelling, solubility, gelling and viscosity [16].

The use of CS in bread products was limited to a maximum of 5%. Aside from bread, chia seeds or their fat is used in cereals, breakfast, cookies, bars, chips, cake, fruit juices, and yoghurt in numerous countries around the world [17].

Chia mucilage could be used in the food industry because of its excellent thickening and stabilizing properties. CS mucilage has exposed greater emulsion stability than commercially available guar gum and gelatin. Thus, it can use in ice cream, bakery products, powdered beverages, yogurt, and sauces [18].

CSF is used purposes as addition and as a component in cereal bars, pasta, bread, biscuits and snacks, among others that contain their use even in cake preparations in several nations such as, the United States, Argentina, Mexico, Chile, Japan, New Zealand Australia and Canada.

Owing to their mucilage properties, CS are widely used in food processing in the form of soluble dietary fibre. Chia mucilage has been used to mixtures to prepare coatings and films with enhanced properties [19].

2. MATERIALS AND METHODS

2.1 Materials

Wheat flour and chia seeds were collected from the Agriculture Research Center in Giza, Egypt. Other ingredients for pan bread, such as instant active dry yeast, salt (sodium chloride), egg, and shortening, were purchased from the Kafrelsheikh region's local market., Egypt. All of the chemicals and solvents were used in this investigation were analytical grade and Sigma Company.

2.2 Methods

2.2.1 Pan bread processing

In pan bread preparation, the straight dough

method was made according to the method defined by El-Hadidy [20]. The control of pan bread was (300 g of WF and other materials), also four recipes 1, 2, 3 and 4 comprise (291 g WF+ 9 g CSP), (282 g WF+ 18 CSP) (273g WF +27g CSP) and (264 g WF +36 g PSP), respectively.

Pan bread preparation is presented in Table 1.

2.3 Chemical Analysis

According to the methods of AOAC, [21] CSF and pan bread mixtures were analyzed for ash, crude ether extract, crude protein, and crude fiber**.** The available carbohydrates were calculated by difference.

%The available carbohydrates = 100 – (ether extract + crude fiber + protein + ash)

The calorie value was determined in accordance with FAO [22] Atwater method.

The calorie value (kcal/100g) = (percent carbohydrate × 4.1) + (percent protein×4.1) + (percent fat× 9.1).

2.4 Fatty Acids Composition

Fatty acids composition of CHIA seeds oil was estimated according to the method outlined by [23].

2.5 Determination of Minerals

Minerals including calcium, potassium, phosphorus, magnesium, zinc, iron and manganese have been measured in ash solution according to the US EPA [24] using ICP-OES Agilent 5100 VDV

2.6 Determination of Amino Acids

Amino acids were analyzed according to the method described in AOAC, [21].

2.7 Computed Protein Efficiency Ratio (C-PER)

C-PER was calculated as described by [25] following the equation: C-PER = 0.684+0.456(Leucine)-0.047(proline).

Table 1. Pan bread formulation

Constituents	Control	Formula(1)	Formula(2)	Formula(3)	Formula (4)
WF (g)	100	97	94	91	88
CSF (g)	0	3	6	9	12
Salt (g)	2	2	2	2	2
Yeast (g)	1.5	1.5	1.5	1.5	1.5
Sugar (g)	2	2	2	2	2
shortening (g)	3	3	3	3	3

CSF = Chia seeds flour
WF = wheat flour 72% extraction

2.8 Computed Biological Value(BV)

Biological value was calculated as described by [26] according following equation: Computed Biological Value (BV) =49.9+10.53C-PER.

2.9 Sensorial Properties of Pan Bread Enriched with CSF

Twenty-five panelists from the staff of Sakha food Technology Research Laboratory., Agric. Res. Center. Egypt. were asked for sensory evaluation of pan bread appearance, volume, crumb texture, crumb grain, crust color, taste, odor and overall acceptability according to the method described by [27]. Panelists evaluated pan bread formulas on a 10-point hedonic scale.

2.10 Statistical Analysis

Statistical analysis was done using SPSS software (version 15) and Duncan's multiple range tests were used for mean comparison.

3. RESULTS AND DISCUSSION

3.1 Chemical Composition of Wheat and CHIA Flour

The chemical composition of wheat flour72% extraction and CSP is presented in Table 1. CSP has higher content of crude protein, crude fat, crude fibre and ash and lower content of total carbohydrates than that of wheat flour 72% extraction. These values agreed with those reported by [20] Stated that the crude protein, crude fat, ash, crude fibre and total carbohydrates of wheat flour 72% extraction were 11.81, 0.75, 0.45, 0.84 and 86.98%, respectively [28]. studied that CSP contain 36.57% lipid, 26.1% protein, 22.22% crude fibre 9.96% nitrogen- free extract and 5.15% ash.

3.2 Fatty Acids in CHIA Seed Flour (g / 100 g on a dry weight basis)

α-linolenic acid (α LA) was at the highest level concerning the fatty acids profile in CSP Table 3. followed by linoleic acid (LA), oleic acid and palmitic acid. Meanwhile, the quantity of unsaturated fatty acids was almost nine times than that of saturated fatty acids where the ratio of -3 fatty acids and -6 fatty acids was 3.26. These values agreed with those reported by [28] revealed that the fatty acid in chia seed flour was 7.15% palmitic ,6.35% oleic,16.77% linoleic and 64.56% α-linolenic, respectively.

3.3 Chemical Composition of Pan Bread

Data are given in Table 4. explain the gross chemical composition of CHIA-wheat pan bread in comparison with the wheat pan bread control. CHIA-wheat bread was higher in protein, ether extract, ash, crude fibre and caloric value. On the contrary. Available carbohydrates were lower than wheat pan bread. These values agreed with those reported by [29]. The breads with the addition of CSP were characterized by a significantly higher values of these components in comparison with the control sample.

A high content of crude protein, ash, and crude fibre in CSP contributed to an increase of the content of these components in the bread. Thus, the addition of CSP to bread had a positive influence on the nutritious values of the produce.

3.4 Amino Acids Profile of CSF and Pan Bread Enriched with CSP (g/100g of protein)

The amino acid composition (amino acid / 100 protein) was shown in Table 5. of CSP, Pan bread made from WF 72 percent extraction or

various CSP levels pan bread. The obtained results showed that the overall critical amino acid content of pan bread recipes (3 percent CSP, 6 percent CSP, 9 percent CSP, and 12 percent CSP) was significantly higher than that of wheat flour pan bread (72 percent extraction). On the contrary, when compared to a control made with wheat flour 72 percent extraction, total non-essential amino acids were lower in recipes made with CSP-pan bread. Table 5 shows the calculated protein efficiency ratio C- PER and biological value BV of CSP, pan bread made from WF, and pan bread made from CSF. The (C-PER and BV) were higher in recipes prepared with (3 percent, 6 percent, 10%, and 12 percent CSP) than in recipes prepared with control WF, as shown in this Table.

3.5 Mineral Contents of CS P and Blends of Pan Bread (mg / 100 g on Dry Weight Basis)

Table 4. displays the content of major and minor mineral elements in control CSP-free pan bread and pan bread enriched with CSP to varying degrees. In comparison to control, pan bread enriched with CSP has a higher content of phosphorus (P), calcium (Ca), sodium (Na), potassium (K), magnesium (Mg), iron (Fe), zinc (Zn), and manganese (Mn).

Table 2. Chemical composition of raw materials (g/100 g on a dry weight

Raw materials	WF 72% extraction	CSP
Crude protein %	11.71 ±0.12	24.00 ±0.55
Crude ether extract %	1. 50 ±0.08	38.00 ±0.60
Ash %	0.55 ±0.04	5.70 ±0.19
Total carbohydrates %	86.24 ±0.30	32.3 ±0.80
Available carbohydrates %	85.34±0.98	9.30±0.22
Crude fiber %	0.90 ±0.04	23.00 ±0.54
Caloric value (kcal/100g)	401.70±1.79	475.20±1.78

Means with different letter in the same column are significantly different at LSD at ($p \leq 0.05$).
- Each value was an average of three determinations ± standard deviation.
-CSF CHIA seed flour.*

Table 3. Fatty acids in CHIA seed powder (g/100g on a dry weight basis)

Fatty acids	Chia seeds oil (g / 100g oil)
Saturated fatty acids	
Plamitic acid	8.00
Monosaturated fatty acids	
Oleic acid C18:1 **9**	9.53
Polyunsaturated fatty acids	
Linoleic acid C18:2 **6**	19.37
Linolenic acid C18:3 **3**	62.50

K, Na, Ca, Mg, P, Fe, Mn, and Zn concentrations in CSP were 809, 11.5, 650, 496, 890, 14.50, 2.270, and 8.50 mg/100g, respectively. The CSP contains more essential mineral elements than an individual's everyday requirements. K, Mg, Na, Ca, P, Zn, Mn, and Fe were contained in chia seed powder according to [28].

3.6 The Na / K Ratio of CSF and Prepared Pan Bread Enriched with CSF

The Na/K Ratio of CSF and Prepared pan bread enriched with CSF at different extent were shown in Fig 1. The Na/K ratio of CSF, control, 3%, 6%, 9% and 12% of pan bread enriched with CSF were 0.014,0.038,0.028 ,0.026,0.025 and 0.023, respectively. The Na/K ratio of control has highly in comparative with pan bread enriched with CSF. The Na/K ratio was less than one with decreasing the levels of substitution (3%, 6%, 9% and 12%) of CSF-pan bread. These results agree with [30]. The Na/K ratio of less than one has been shown to be of great significance for high blood pressure in the body.

3.7 Sensorial Parameters of Pan Bread

Table 7. displays the effects of sensory characteristics such as appearance, volume, crumb texture, crumb grain, crust color, taste, odor and overall acceptability. It could be noted that appearance, volume, crumb texture, crumb grain, crust color, taste, odor and overall acceptability of all the recipes were insignificant reduced. pan bread produced by partial replacement of WF with CSP at different ratio 3, 6, 9 and 12 % characterized with good sensorial properties.

The addition of CSP produced darkening of the pan bread crumb, but it was generally not undesirably estimated by the panelists. The slightly lower notes for crumb color were tested for only 12 percent CSP recipe compared to control pan bread. In conclusion, the general desirability of the pan bread scores were given, which shows that the addition of CSP up to 12 per cent did not affect the acceptance of the final product. These results agreed with those described by [29].

Table 4. The chemical composition of pan bread (g／100g on a dry weight basis)

Blends	Crude protein %	Ether extract %	Ash %	Crude fiber %	Available carbohydrates %	Caloric value (kcal/100g)
Control	10.74^{e} ±0.02	4.38^{e} ±0.01	0.51^{e} ±0.01	0.83^{e} ±0.03	83.54^{a} ±0.35	416.54^{e} ±0.55
3% CSP	11.08^{d} ±0.03	5.39^{d} ±0.06	0.64^{d} ±0.02	1.43^{d} ±0.02	81.46^{b} ±0.53	418.67^{d} ±0.40
6% CSP	11.42^{c} ±0.03	6.39^{c} ±0.06	0.79^{c} ±0.03	2.05^{c} ±0.05	79.35^{c} ±0.30	420.59^{c} ±0.75
9% CSP	11.76^{b} ±0.04	7.39^{b} ±0.05	0.97^{b} ±0.02	2.65^{b} ±0.06	77.23^{d} ±0.25	422.47^{b} ±0.65
12%CSP	12.09^{a} ±0.05	8.39^{a} ±0.07	1.06^{a} ±0.04	3.26^{a} ±0.04	75.20e ±0.33	424.67^{a} ±0.95

Means with different letter in the same column are significantly different at LSD at ($p \leq 0.05$).
- Each value was an average of three determinations ± standard deviation.
-CSP CHIA seed power*

Table 6. Mineral contents of CSF and blends of pan bread (mg / 100 g on a dry weight basis)

Mineral	K (mg/ 100g)	Na (mg/ 100g)	Ca (mg/ 100g)	Mg (mg/ 100g)	P (mg100 g)	Fe (mg/ 100g)	Mn (mg/ 100g)	Zn (mg/ 100g)
CSP	809 ±13.80	11.5 ±1.30	650 ±3.34	496.00 ±12.50	890.00 ±10.22	14.50 ±0.54	2.70 ±0.05	8.50 ±0.07
Control	115.74 ±01.60	4.37 ±0.15	16.20 ±0.55	98.15 ±0.64	138.00 ±1.25	1.66 ±0.05	0.79 ±.03	4.17 ±0.06
3% CSP	157.19 ±2.88	4.40 ±0.20	33.77 ±1.03	108.31 ±2.50	138.50 ±1.33	2.02 ±0.12	0.84 ±0.05	4.28 ±0.15
6% CSP	175.25 ±2.70	4.60 ±0.05	51.34 ±1.50	119.81 ±1.65	158.24 ±1.60	2.37 ±0.13	0.89 ±0.02	4.39 ±0.07
9% CSP	193.80 ±3.20	4.80 ±0.23	68.92 ±2.33	130.65 ±1.50	179.50 ±1.55	2.73 ±0.16	0.94 ±0.01	4.42 ±0.06
12% CSP	212.11 ±2.80	5.00 ±0.16	86.48 ±1.03	141.48 ±2.30	200.75 ±4.90	3.08 ±0.05	0.99 ±0.02	4.61 ±0.16

-Means with different letter in the same column are significantly different at LSD at ($p \leq 0.05$).
- Each value was an average of three determinations ± standard deviation.
-CSF CHIA seed flour*

Table 5. Amino acids profile of CSP and pan bread enriched with CS P (g/100g of protein)

Amino acids	CHIA seeds powder	Control of pan bread	3%CHIA Seed powder	6%CHIA Seed powder	9%CHIA Seed powder	12%CHIA Seed powder	FAO/WHO /UNU (g/100g)
Essential amino acids							
Lysine	5.50	3.00	3.07	3.15	3.22	3.30	5.80
Isoleucine	3.65	4.30	4.36	4.26	4.24	4.22	2.80
Leucine	6.70	4.50	4.56	4.63	4.69	4.76	6.60
phenylalanine	5.00	5.50	5.48	5.47	5.45	5.44	6.30
Tyrosine	2.80	1.85	1.84	1.89	1.93	1.95	
Histidine	3.70	4.25	4.23	4.21	4.19	4.18	1.90
Valine	4.74	4.50	4.50	4.51	4.52	4.53	3.50
Threonine	4.30	2.30	2.36	2.42	2.48	2.54	3.40
Methionine	3.00	1.10	1.15	1.21	1.27	1.32	2.20
Tryptophan	1.27	1.15	1.15	1.16	1.15	1.16	1.00
Total(EAA)	40.66	32.45	32.70	32.91	33.14	33.40	
Non- essential amino acids							
Aspartic acid	10.00	5.00	5.12	5.24	5.36	5.48	
Glutamic acid	20.00	32.00	31.58	31.16	30.42	30.01	
Proline	0.45	13.00	12.62	12.24	11.87	11.49	
Alanine	5.30	3.70	3.73	3.89	3.83	3.88	
Arginine	10.94	2.40	2.64	2.90	3.16	3.42	
Serine	6.00	6.90	6.87	6.84	6.81	6.79	

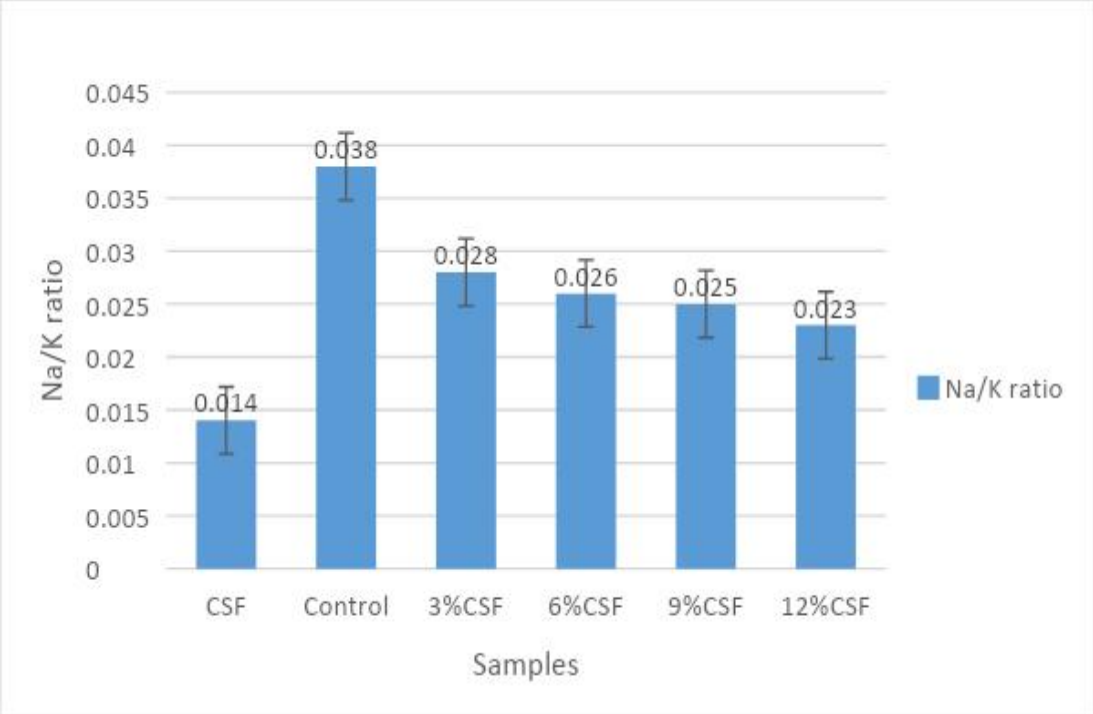

Fig 1. The Na / K ratio of CSF and prepared pan bread enriched with CSF

Table 7. Sensorial properties of pan bread fortified with CSP

Blends	Appearance 10	Volume 10	Crumb texture 10	Crumb Grain 10	Crust color 10	Taste 10	Odor 10	Overall Acceptability 10
Control	9.70^{a} ±0.25	9.40^{a} ±0.22	9.60^{a} ±0.32	9.40^{a} ±0.46	9.53^{a} ±0.23	9.40^{a} ±0.22	9.66^{a} ±0.32	9.43^{a} ±0.50
3% CSP	9.10^{b} ±0.48	8.80^{b} ±0.50	9.07^{b} ±0.59	8.73^{b} ±0.44	8.53^{b} ±0.50	8.60^{b} ±0.50	8.83^{b} ±0.15	8.73^{b} ±0.20
6% CSP	8.63^{c} ±0.41	8.20^{c} ±0.28	8.33^{c} ±0.86	8.07^{b} ±0.40	7.96^{c} ±0.59	8.00^{c} ±0.40	8.17^{c} ±0.27	8.2^{c} ±0.36
9%CSP	8.17^{d} ±0.42	7.50^{d} ±0.69	7.67^{d} ±0.50	7.43^{c} ±1.11	7.36^{d} ±1.70	7.20^{d} ±0.27	7.27^{d} ±0.60	7.63^{d} ±1.77
12%CSP	7.17^{e} ±0.29	6.30^{e} ±0.55	7.10^{e} ±0.32	6.66^{e} ±0.15	6.33^{e} ±0.62	6.30^{e} ±0.52	6.43^{e} ±0.32	7.10^{e} ±0.42

-Means with a different letter in the same column are significantly different at LSD at ($p \leq 0.05$).
- Each value was an average of ten determinations ± standard deviation.
-CSP CHIA seed powder*

4. CONCLUSION

Based on the overall results, it can be concluded that partially substituting chia seeds flour for wheat flour improved the nutritional value by a large amount. CHIA seed powder is used in pan bread recipes; With only a minor depreciation in pan bread consistency, increase its nutritional value. Sensory properties revealed that the bread supplemented with up to 12% CHIA seeds was acceptable and had a noticeable difference in crumb texture, appearance, crust color, crumb grain, taste, odor, and overall acceptability as compared to the control. Regardless to this, it could prepare some bakery products using chia seeds flour and wheat flour with high quality that are suitable for high blood pressure or obese patients.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Siro I, Kapolna E, Ka´polna B, Andrea Lugasi A. Functional food. Product development, marketing and consumer acceptance—A review. Appetite. 2008; 51:456-467.
2. Fan L, Zhang S, Yu L, Ma L. Evaluation of antioxidant property and quality of breads containing Auricularia auricula polysaccharide flour. Food Chemistry. 2006; 101:1158-1163.
3. Hathorn CS, Biswas MA, Gichuhi PN, Bovell Benjamin AC. Comparison of chemical, physical, micro-structural, and microbial properties of breads supple mented with sweet potato flour and high-gluten dough enhancers. LWT - Food Science and Technology. 2008;41:803-815.
4. Gibson M. Food security-a commentary: what is it and why is it so complicated. Foods. 2012;1(1):18-27.
DOI: 10.3390/foods1010018.
5. Dweck AC. The folklore cosmetic use of various salvia spices. In: kitzios SE (edition) sage the genus salvia. Handbook Academic Publishers. Amsterdam. 2005;1-25.
6. Segura Campos MR, Ciau Solis N, Rosado Rubio G, Chel Guerrero L, Betancur Ancona D. Chemical and functional properties of chia seed. International Journal of Food Science and Nutrition. 2014;11(3):1-5.
7. Lemaitre RN, King IB, Mozaffarian D, Kuller LH, Tracy RP, Siscovick DS. n−3 Polyunsaturated fatty acids, fatal ischemic heart disease, and nonfatal myocardial infarction in older adults: The Cardiovascular Health Study. The

American Journal of Clinical Nutrition. 2003;77(1):319-325.
8. Comba A, Maestri DM, Berra MA, Garcia CP, Das U, Eynard AR. Effect of n-3 and ω-9 fatty acid rich oils on lipoxygenases and cyclooxygenases enzymes and on the growth of an adenocarcinoma mammary model. Lipids Health Disease. 2010;9(4): 112-115.
9. Divyapriya GK, Veeresh DJ, Puja Y. Evaluation of Antibacterial efficacy of chia (*Salvia hispanica*) seeds extract against porphyro monas gingivalis, fuso bacterium nucleatum and aggregate bacter action mycetemcomitansan *in-vitro* study. International Journal of Ayurveda and Pharma Research. 2016;4(4):22-26.
10. Mohid AN, Yeap SK, Wan YH, Boon KB, Sheau WT, Soon GT. The Promising Future of Chia, Salvia hispanica L. Journal of Biomedicine and Biotechnology. 2013;1-9.
11. Yuan JYF. The effects of functional fiber on postprandial glycemia, energy intake, satiety, palatability and gastrointestinal wellbeing: A randomized crossover trial. Nutrition journal. 2014;13(76).
12. Ixtaina VY, Nolasco SM, Tomás MC. Physical properties of chia (Salvia hispanica L.) seeds. Original Research Article. Industrial Crop and Products. 2008;28:286-293.
13. Reyes Caudillo E, Tecante A, Valdivia López MA. Dietary fibre content and antioxidant activity of phenolic compounds. present in Mexican chia (*Salvia hispanica* L.) seeds. Food Chemistry. 2008;107(2): 656-663.
14. Weber CW, Gentry HS, Kohlhepp EA, Mc Crohan PR. The nutritional and chemical evaluation of chia seeds. Ecology of Food and Nutrition. 1991;26:119-125.
15. Ayerza R, Coates W. Dietary levels of chia: influence on yolk cholesterol, lipid content and fatty acid composition for two strains of hens. Poultry Science. 2000; 79(5):724-739.
16. Capitani MI, Ixtaina V, Nolasco MYS, Tomas MC. Microstructure, chemical composition and mucilage exudation of chia (*Salvia hispanica* L.) nutlets from Argentina. Journal of Science and Food Agriculture. 93:3856-3862.
DOI: https://doi.org/10.1002/jsfa.6327.
17. Borneo R, Aguirre A, Le´on AE. Chia (Salvia hispanica L) gel can be used as egg or oil replacer in cake formulations. Journal of the American Dietetic Association. 2010; 110(6):946-949.
18. Chavan VR, Gadhe KS, Dipak S, Hingade ST. Studies on extraction and utilization of chia seed gel in ice cream as a stabilizer. Journal of Pharmacognosy and Phytochemistry. 2017;6(5):1367-1370.
19. Munoz Loreto A, Cobos A, Diaz O, Aguilera JM. Chia seed (Salvia hispanica): An ancient grain and a new functional food. Food Review International. 2012;29(4):394-408.
20. El Hadidy GS. Preparation and Evaluation of Pan Bread Made with Wheat Flour and Psyllium Seeds for Obese Patients. European Journal of Nutrition & Food Safety. 2020;12(8):1-13.
21. AOAC. Official methods of analysis of the association of official analytical chemists.18th Edition, Washington DC; 2005.
22. FAO. Food energy. Methods of analysis and conversion factors. Food and Nutrition Paper 77. Report of a technical workshop, Rome; 2002.
ISSN: 0254-4725.
23. Radwan SS. Coupling of two dimension thin layer chromatography with gas chromatography for the quantitative analysis of lipids classes and their constituent fatty acids. J. Chrom. Sci., 1978;16:538-542.
24. US EPA Method. Determination of metals and trace elements in water and wastes by inductively coupled plasma atomic emission s; 2007.
25. Alsmeyer RH, Cuningham AE, Happich ML. Equations predict PER from amino acid analysis. Food Techno.1974;28(7):34-40.
26. Farag SA, El-Shirbeeny A, Nassef AE. Physicochemical studies for preparing quickcooking rice by using gamma irradiation. Annals of Agric Sci., Moshtohor, 1996;34:641-652.
27. Matz SA. Bakery technology and engineering. The AVI Pub. Co., Westport, Connecticut; 1972.pectrometry. Revision 4.4. Cincinnati; 1994.
28. Mohammed OBR, Abd El-Razek AM, Bekhet MHH, Moharram YG. Evaluation of Egyptian Chia (*Salvia hispanica* L.) Seeds, Oil and Mucilage as Novel Food Ingredients, Egypt. J. Food. Sci. 2019; 47(1):11-26.
29. Romankiewicz D, Hassoon WH, Cacak Pietrzak G, Sobczyk M, Wirkowska

WojdyBa M, CegliNska A, et al. The Effect of Chia Seeds (Salvia hispanica L.) addition on quality and nutritional value of wheat bread. Journal of Food Quality. 2017;1-7.

30. Aremu MO, Olaofe O, Akintayo TE. Comparative study on the chemical and amino acid composition of Some Nigerian Under-Utilized Legume Flours. Pakistan Journal of Nutrition. 2006;5:34-38.

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