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Research Article

Effect of the Addition of Different Levels of Chard on the Dough Properties and Physicochemical and Sensory Characteristics of Pan Breads

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Background. Chard is a valuable vegetable and is considered a beneficial functional food. Fortification of bread with chard could increase the nutraceutical and functional food consumption. *Objective*. In this study, we performed a chemical analysis of chard and performed rheological analyses and sensory attribute evaluations of pan breads fortified with 5% and 10% chard powder. *Design*. The gross chemical composition of chard, some minerals, vitamin C, and total phenolic and flavonoid compounds were estimated. The rheological properties of doughs fortified with 5% and 10% chard powder and the chemical composition and sensory attributes of control, 5% chard and 10% chard pan bread samples were determined. *Results*. Chard contains carbohydrate, protein, and ash in addition to essential minerals and antioxidants such as vitamin C, phenols, and flavonoids. The chemical composition of 5% chard pan bread was significantly higher in ash and fiber, while the chemical composition of 10% chard pan bread was significantly higher in protein, ash, fiber, and moisture and significantly lower in fat, carbohydrate, and energy level than that of control pan breads. Compared with the control pan bread, the pan bread with increased chard powder content (10%) had significantly increased water absorption percentage, arrival time, dough development, elasticity, and proportional number ratio but significantly decreased stability time, softening degree, and extensibility. Pan bread fortified with 10% chard had the lowest specific volume among the tested breads. Sensory attribute evaluation further showed that increasing the amount of chard to 10% in the bread dough formulation produced lower overall acceptability scores. *Conclusions*. Pan bread containing 5% chard had better rheological scores and sensory attributes than the other formulations, in addition to good nutritional quality values.

1. Introduction

Breads have high nutritional value and are widely consumed worldwide; moreover, they feature different textures, shapes, toppings, and fillings. Bread is manufactured from whole wheat flour, baker's yeast, salt, and water [1]. In pan bread, also known as loaf bread or sliced bread, the dough is baked in a loaf pan, resulting in its characteristic form. Recently, consumers have become increasingly aware of the need to eat high-quality and nutritious foods. Functional foods, including functional breads, contain ingredients that offer numerous health benefits beyond essential nutrient requirements [2–4].

Vegetables have a relatively low caloric content and contain important antioxidants that provide additional health benefits [4–6]. The dietary fiber in vegetables is readily available, inexpensive, and present in large quantities and exhibits health benefits [7–10]. The consumption of fiber-rich bread is one approach to increasing fiber intake, but the appearance of whole grain bread may be unappealing to some consumers who prefer the softer texture and whiter color of conventional bread.

Notably, Swiss chard (*Beta vulgaris* subspecies *cycla*), which belongs to the family Chenopodiaceae, is an herbaceous, easy-to-grow plant that is cultivated all over the world and is available throughout the year at low cost. Its edible leaves are consumed raw in salads or cooked [11–13]. Moreover, Swiss chard is a glycophyte that contains carbohydrates, proteins, lipids, fibers, minerals, and essential vitamins and has functional therapeutic effects according to folk medicine. It is used as a treatment for many conditions, such as liver and kidney diseases, cancer, hematopoietic system stimulation, immune system dysfunction, and diabetes [14–16].

This study aimed to compare the chemical, physical, rheological, and sensory properties of pan breads supplemented with 5% and 10% chard with those of conventional pan bread to produce functional pan bread.

2. Materials and Methods

Commercial wheat flour (72% extract contains 13.2% moisture, 0.5% ash, 11.15% protein, and 10.62% gluten), sugar, salt, dry baker's yeast, and corn oil were purchased from the local market in Riyadh, Kingdom of Saudi Arabia. Chard (*Beta vulgaris* L) is a leafy green vegetable that was purchased from a grocery store and washed. The chard leaves were completely dried in a hot air oven (45°C) for 6 hours (Alto-Shaam, model: 500-TH/III Cook and Hold Oven with Deluxe Controls, country of origin: USA) and ground to a fine powder.

The chemical composition of the chard was evaluated to estimate the content of crude protein, crude fat, fiber, ash, and moisture according to the AOAC [17]. The total carbohydrates and energy were calculated by difference and energy conversion factors. Additionally, the calcium, iron, potassium, magnesium, and sodium levels were estimated by atomic absorption spectrophotometry according to the AOAC [17]. The levels of vitamin C and total phenolic and flavonoid compounds (mg/100 g dry basis) were determined in filtered 70% aqueous ethanol (1 : 10 w/v) extracts of chard according to the methods of Zheng and Wang [18].

Wheat flour was mixed with chard powder to produce individual mixtures containing 5 or 10% replacement levels. Three types of pan breads were prepared according to the straight dough methods reported by Trejo-González et al. [19], as shown in Table 1.

The dough was mixed by using an electric mixer for 4 min, allowed to rise for 30 min, kneaded for 5 min, and allowed to rise for another 30 min (Sammic, Planetary Mixer, model: BM-5, Dough Mixer- 5L, country of origin: Spain). The dough was then divided, kneaded again for 5 min, rounded, and molded. Next, it was placed in baking pans and allowed to rise for 60 min at 30°C (TEFAL, Baking Pans, model: TRI-89605, material: aluminum-non stick, country of origin: China).

The rheological properties of the dough were estimated by using farinograph and extensograph techniques as reported in AACC [20] by Brabender farinograph and extensograph apparatuses, respectively. The farinograph tests included analysis of the water absorption percentage (water required to produce dough), arrival time to reach maximum consistency (in minutes), dough development time to reach maximum consistency (in minutes), dough stability time (among of time that the dough remains at 500 Brabender units, BU), and softness degree (consistency of 500 BU). The extensograph tests included analysis of the elasticity, extensibility, proportional number ratio (P. N), and energy. Loaves were baked for 10 min at 250°C. The pan bread samples were allowed to cool on racks for approximately 2 hr before evaluation.

The weight and volume of the tested types of pan breads were measured by the rape seed displacement method [21] and used to calculate the specific loaf volume. The chemical compositions of the control, 5% chard, and 10% chard pan bread samples were determined according to the methods of the AOAC [22].

Forty panelists were recruited for the sensory evaluation. The panelists were asked to score the bread samples based on the following sensory attributes: taste, aroma, crust color, crumb color, chewiness, appearance, and overall acceptability.

All the analyses were performed in triplicate. Analysis of variance (ANOVA) was used for statistical analysis. Tukey test was performed to compare means, and $p < 0.05$ indicated a significant difference.

3. Results and Discussion

The chemical composition analysis of chard showed high contents of carbohydrates, protein, ash, and fiber, in descending order, with low moisture and fat levels. The energy content of chard reached 259.67 ± 6.22 kcal, as illustrated in Table 2. These results confirmed the nutritional value of chard, showing why it is so commonly used in many dishes [23, 24]. The obtained results were in agreement with those of Sacan and Yanardag [25], Colonna et al. [26], and Mzoughi et al. [4]. The differences in chemical compositions are related to the soil composition and the use of organic amendments [27].

Table 3 shows that chard leaves contain high levels of sodium, magnesium, calcium, iron, and potassium and considerably high levels of total phenols, total flavonoids, and vitamin C. These results were confirmed by many authors; for example, Anthony et al. [28] reported significant levels of vitamins (A and C) and minerals (calcium, iron, and phosphorus) in the leaves and stalks of chard. Additionally, Donald and George [11], Pyo et al. [29], and Ivanović et al. [24] reported that fresh chard leaves contain many nutrients and exhibit antioxidant activity due to the presence of flavonoids and phenolics. Flavonoid derivatives include flavonols, flavones, anthocyanidins, catechins, flavanones, and isoflavones, while phenolic acids include myricitrin, p-coumaric acid, and rosmarinic acid. The high levels of vitamin C, total phenols, and total flavonoids in chard demonstrated its antioxidant, antitumor, anti-inflammatory, antiacetylcholinesterase, antidiabetic, and hepatoprotective effects [30–33].

Table 4 shows that compared with the control pan breads, the 5% chard pan breads showed nonsignificant increases in protein and moisture levels, nonsignificant decreases in fat, carbohydrate, and energy levels, and significant increases in ash and fiber levels. As shown in the same table, compared with the control pan breads, the 10%

Table 1: Recipe of pan bread samples.

Pan breads	Wheat flour (g)	Yeast (g)	Sugar (g)	Salt (g)	Corn oil (g)	Chard powder (g)
Control	100	2.2	6	0.5	1	—
5% chard	95	2.2	6	0.5	1	5
10% chard	90	2.2	6	0.5	1	10

Table 2: Gross chemical composition of chard (dry weight basis).

Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	Carbohydrate (%)	Moisture (%)	Energy (kcal)
24.85 ± 2.66	1.95 ± 0.21	12.19 ± 2.41	19.22 ± 2.17	35.68 ± 5.45	6.11 ± 1.32	259.67 ± 6.22

Data are expressed as mean values ± standard deviations.

Table 3: Some minerals, vitamin C, total phenols, and total flavonoids of chard (dry weight basis).

Calcium (ppm)	Iron (ppm)	Potassium (ppm)	Magnesium (ppm)	Sodium (ppm)	Vitamin C (ppm)	Total phenols (mg/100 g)	Total flavonoids (mg/100 g)
4551.21 ± 42.14	411.55 ± 39.36	3220.51 ± 30.71	6987.11 ± 56.11	7549.30 ± 66.22	122.33 ± 13.17	887.33 ± 65.91	455.61 ± 37.22

Data are expressed as mean values ± standard deviations.

Table 4: Chemical composition in the control, 5% chard, and 10% chard pan breads.

Pan breads	Protein (g/100)	Fat (g/100)	Ash (g/100)	Fiber (g/100)	Carbohydrate (g/100)	Moisture (g/100)	Energy (kcal)
Control	11.66 ± 1.45b	2.11 ± 0.22a	0.88 ± 0.11c	0.25 ± 0.010c	72.22 ± 6.77a	12.88 ± 1.05b	354.5120.11a
5% chard	12.51 ± 1.66ab	1.95 ± 0.17ab	1.02 ± 0.10ab	3.22 ± 0.41b	67.85 ± 5.22ab	13.45 ± 1.31ab	338.99 ± 19.24ab
10% chard	13.35 ± 1.49a	1.80 ± 0.15b	1.19 ± 0.11a	6.19 ± 1.22a	63.16 ± 4.66bc	14.31 ± 1.67a	322.24 ± 17.55bc

Mean values ± standard deviations in each column with different letters (a, b, c, and d) are significantly different ($P < 0.05$).

chard pan breads showed significant increases in protein, ash, fiber, and moisture levels and significant decreases in fat, carbohydrate, and energy levels. The levels of all measured nutrients in the 10% chard bread were significantly different from those in the control pan bread. These results may be due to the relatively high contents of protein, ash, and fiber in chard powder. The lower carbohydrate content in the 10% chard pan bread than in the control bread was related to the increased moisture content. These results agree with those obtained by Chantaro et al. [34]. Additionally, Hager et al. [35] illustrated a similar trend in which the moisture content increased and the specific volume decreased following the addition of β-glucan to bread; this observation was explained by Ishida and Steel [36], who reported that fiber absorbs additional water during the mixing stage and results in high water retention capacity. The addition of chard to pan breads could increase the intake of fiber, flavonoids, β-carotene, vitamins, and minerals such as calcium and magnesium [37].

The effect of pan bread fortification with 5% and 10% chard powder on the rheological properties of dough is summarized in Table 5. Compared with the control pan bread dough, the 5% chard pan bread dough presented significant increases in water absorption percentage, arrival time, elasticity, and P.N values and significant decreases in dough development and energy level. Compared with the control pan breads, the 10% chard pan bread showed significantly increased water absorption %, arrival time, dough development, elasticity, and P.N values, while the stability time, softening degree, and extensibility were significantly decreased in 5% chard pan bread.

The fortification of wheat flour with 5 and 10% chard leaf powder increases water absorption and is directly related to the high fiber content of chard. Gluten is an important protein for dough development and exhibits special structural shaping features. Dough development time is the time required to develop the gluten network and reflects an increase in the dough consistency. Gluten network formation is affected by mechanical disturbances and water availability as a result of supplementation with either soluble or insoluble fiber [38–40]. In our study, the dough development time significantly increased and dough stability significantly decreased with increasing chard levels. These results are consistent with the study of Ashoush and Gadallah [41], who reported that dough development time increased because of the interaction of fiber with gluten, which hinders protein hydration. These results were also in agreement with Sullivan et al. [42], Skendi et al. [43], and Ktenioudaki and Gallagher [44], who reported that optimum dough development requires additional water and increased mixing time. The addition of β-glucan to the flour weakens the gluten network by disturbing the intermolecular associations of gluten proteins formed in dough. Additionally, Salmenkallio-Marttila et al. [45] and Monthe et al. [46] stated that bran or fiber weakened the structure of bread by lowering the volume and elasticity of the crumb.

The fortification of bread with 5% chard and 10% chard affected the physical properties of the resulting pan breads. Increasing the percentage of fortification significantly lowered the weight and volume, as shown in Table 6. No significant differences in weight or specific volume were observed between the control bread and 5% chard pan bread.

Table 5: Rheological properties of chard pan bread dough.

Pan breads	Farinograph					Extensograph			
	Water absorption (%)	Arrival time (min)	Dough development (min)	Stability time (min)	Softening degree (BU)	Elasticity (BU)	Extensibility (mm)	P.N	Energy (kcal)
Control	58.22 ± 3.17c	0.50 ± 0.03c	4.30 ± 0.56b	7.3 ± 0.80a	90 ± 5.61a	125 ± 2.17c	96 ± 6.21a	1.35 ± 0.12c	23 ± 2.11a
5% chard	72.11 ± 4.21b	1.3 ± 0.11b	1.75 ± 0.22c	6.5 ± 0.71ab	85 ± 4.21ab	300 ± 5.14b	65 ± 5.4b	4.91 ± 0.11b	15 ± 0.40b
10% chard	83.66 ± 5.11a	5.5 ± 0.48a	7.3 ± 0.42a	5.8 ± 0.50bc	70 ± 3.11c	320 ± 4.91a	50 ± 3.77c	6.3 ± 0.35a	24 ± 2.5a

Mean values ± standard deviations in each column with different letters (a, b, c, and d) are significantly different ($P < 0.05$).

Table 6: Physical properties of pan breads fortified with 5% chard and 10% chard compared with those of the control pan bread.

Pan breads	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)
Control	92.55 ± 5.66a	242.44 ± 25.14a	2.61 ± 0.44a
5% chard	98.66 ± 7.33ab	180.77 ± 11.12b	2.02 ± 0.30ab
10% chard	83.11 ± 6.81b	135.75 ± 9.41c	1.63 ± 0.22c

Mean values ± standard deviations in each column with different letters (a, b, c, and d) are significantly different ($P < 0.05$).

Table 7: Sensory evaluation of pan breads fortified with varying levels of chard.

Pan breads	Taste	Aroma	Crust color	Crumb color	Chewability	Appearance	Overall acceptability
Control	18.77 ± 1.11a	18.55 ± 1.43a	14.55 ± 0.75a	14.45 ± 0.67a	14.25 ± 0.62a	14.35 ± 1.02a	94.92 ± 6.77a
5% chard	16.11 ± 0.96b	15.96 ± 0.80b	12.11 ± 0.54b	12.55 ± 0.35b	12.44 ± 0.51b	11.88 ± 0.45b	81.05 ± 6.41b
10% chard	14.55 ± 0.55c	13.95 ± 0.60c	10.22 ± 0.41c	11.08 ± 0.33c	11.02 ± 0.42c	10.55 ± 0.26bc	71.37 ± 5.71c

Mean values ± standard deviations in each column with different letters (a, b, c, and d) are significantly different ($P < 0.05$).

Pan bread fortified with 10% chard had the lowest specific volume as a result of its comparatively decreased weight and volume. Loaf volume is one of the most important characteristics used to assess bread quality, as it quantitatively represents baking performance [47]. The obtained results were in accordance with previous studies on bread fortified with bran reported by Gómez et al., which showed that bran prevents dough extension and leads to low-strength dough [48]. Compared to control bread, the higher fiber content from flaxseed in bread decreased the technological quality of bread, leading to, in particular, decreased specific volume [49, 50]. Furthermore, the 10% substitution of wheat flour with an inulin and white oat fiber mixture resulted in a decrease in specific volume and an increase in hardness [51].

The taste, aroma, crust color, crumb color, chewiness, and appearance influence the overall acceptability of breads. In summary, the addition of chard to pan breads improved the sensory scores given by the panelists, as shown in Table 7. Increasing the amount of chard to 10% in the bread dough formulation produced lower overall acceptability scores. Moreover, the pan bread with 5% chard had a higher sensory evaluation score than the pan bread with 10% chard. The addition of chard to the pan bread formulation produced crust and crumb color changes that were scored significantly lower than the control bread. The sensory values of the 5 and 10% chard pan breads tended to decrease with increasing chard content. Our results agreed with previous studies by Koca and Anil [52], who reported that increasing levels of flaxseed flour to bread darkened the crust color. Similar results were obtained by Alpaslan and Hayta [53] and Osuna et al. [54] for breads containing flaxseed, soy, and corn. The obtained sensory results were related to the effect of the original color of chard added to the wheat flour. Furthermore, Miś et al. [55] reported that the addition of fiber may be a reason for the undesirable effects on the final bread quality.

4. Conclusions

It is concluded that pan breads fortified with chard powder have good nutritional quality and contain many essential micronutrients and functional ingredients. Sensory evaluation showed that pan bread containing 5% chard had better rheological values and sensory attribute scores than the other formulations.

4.1. Recommendation. From the obtained results, it is recommended to fortify pan bread with 5% chard to increase the nutritional value. Further studies are required to investigate the dough rheological properties and nutritional quality of different bakery products supplemented with chard, and biological studies on the use of these products as prophylactics for different diseases are also needed.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Additional Points

Functional foods contain ingredients that offer numerous health benefits beyond essential nutritional requirements. Swiss chard has nutritional and functional therapeutic effects according to folk medicine. Pan bread with 5% chard had better rheological and sensory evaluation values than pan bread with 10% chard.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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