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Wheat bread fortification by Lebanese sumac and cactus seeds: nutritional, antioxidant, and sensory properties

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Abstract

Bread is an indispensable staple food and a great source of complex carbohydrates, making it a potential product for fortification. The purpose of this study was to investigate the sensory, antioxidant, and nutritional properties of bread fortified with sumac (*Rhus coriaria*) and cactus (*Opuntia ficus-indica* L.) seed powder. Different levels (4, 6, and 8% w/w flour replacement) of the powdered seeds were used. Fortified bread samples were compared to control (unfortified) bread and evaluated for their moisture, nutritional composition (protein, fat, fiber, ash, carbohydrates, and energy value), sensory preference, total phenolic content (TPC), and antioxidant activity (2,2-diphenyl-1-picrylhydrazyl assay). The antioxidant capacity and TPC were significantly higher ($p<0.05$) for sumac- and cactus-fortified bread samples compared to the control. Nutritionally, fortification significantly increased fiber and fat content while decreasing carbohydrate content and energy value ($p<0.05$); protein content remained relatively stable. Sensory evaluation showed a preference for sumac-fortified bread, particularly at lower concentrations. Moisture content was significantly lower in fortified samples. This study demonstrates that fortification, particularly with 8% sumac, yielded favorable results concerning antioxidant activity, phenolic content, and sensory preference, alongside notable changes in nutritional composition.

Introduction

Diets that are healthy and nutritious have garnered significant consumer interest recently. Food is expected not only to satisfy fundamental nutritional requirements and hunger but also to improve consumer health (The Innovation of Steamed Bun, 2018). Improving resource efficiency and promoting sustainable lifestyles are essential global aims (United Nations, 2015). White wheat bread, a crucial staple food consumed worldwide, represents a significant portion of daily meals, with over 32 million tons consumed annually in the European market alone (Ngozi, 2014). While high in complex carbohydrates, it is typically low in dietary fiber and other essential micro- and macronutrients (Tolve *et al*., 2021).

In response to growing consumer demand for nutritious foods, manufacturers are increasingly focusing on products with high nutritional value (United Nations, 2015). Plant-derived phytonutrients, including polyphenols, flavonoids, carotenoids, and others, offer unique biological functions beneficial to human health (Gupta and Prakash, 2014). Bread presents an optimal vehicle for fortification, potentially reducing the need for supplements (Cardoso *et al*., 2019). Numerous studies have explored fortifying bread with various plant materials. For instance, adding fennel seeds improved phenolic content and antioxidant activity (Das *et al.*, 2013; Sayed-Ahmad *et al*., 2017), while cumin and caraway seeds increased moisture, nutritional value, and antioxidant properties (Sayed Ahmad *et al*., 2018). Grape seeds have been shown to boost mineral and fiber content (Peng *et al*., 2010; Oprea and Gaceu, 2020), and rice bran increased vitamin E and phenolic content, although higher substitution levels negatively impacted sensory qualities (Irakli *et al*., 2015).

This study focuses on fortifying whole wheat bread with seeds from two plants readily available in the Mediterranean region, particularly Lebanon: Sumac (*Rhus coriaria*) and Cactus pear (Op*untia ficus-indica* L.). The selection of these specific seeds is based on several factors relevant to the regional context.

Nutritional potential

Both seeds offer distinct nutritional profiles compared to wheat flour (approximately 10 g protein, 1.2 g fat, 2.3 g fiber per 100 g, as per label). *Rhus coriaria* seeds, based on literature, contain notable levels of fat (approximately 7.4%), fiber (approximately 14.6%), and ash (approximately 1.8%), along with phytochemicals like flavonoids and gallic acid (Rayne and Mazza, 2007; Sakhr and El Khatib, 2020). Opuntia ficus-indica seeds are rich in fiber (~18% or higher), protein (~10%), lipids (~10.5%), minerals, and possess significant phenolic content (~90 mg GAE/100g) (El Kossori *et al*., 1998; Al-Naqeb *et al*., 2021). This contrasts with common fortificants like isolated vitamins or minerals, aligning with strategies promoting whole food ingredients.

Availability and cost

Both plants are native or widely cultivated in the Mediterranean, suggesting local availability and potentially lower costs compared to imported fortificants. Sumac spice is relatively inexpensive (approximately 5 USD/100g), and seeds for both species are generally accessible, making them economically viable options (Sakhr and El Khatib, 2020).

Safety and cultural acceptance

Sumac spice (*R. coriaria* fruit powder) has a long history of safe culinary use in the region, implying high cultural acceptance. *Opuntia ficus-indica* fruits (prickly pears) are also traditionally consumed. While high-dose seed toxicology data may be limited, their presence in consumed fruits suggests a baseline safety profile, contrasting with novel ingredients requiring extensive evaluation (El Kossori *et al*., 1998; Rayne and Mazza, 2007). The *Rhus coriaria* variety used culinarily is generally recognized as safe in typical amounts.

While previous studies have explored *Rhus typhina* (staghorn sumac) powder as a preservative (Wang and Zhu, 2018) or investigated Opuntia seed oil (Al-Naqeb *et al*., 2021), research on fortifying bread specifically with *Rhus coriaria* or *Opuntia ficus-indica* seed powder is lacking. This study, therefore, aims to investigate the effects of incorporating different levels (4, 6, and 8% w/w flour replacement) of *Rhus coriaria* and *Opuntia ficus-indica* seed powders on the moisture content, nutritional composition (protein, fat, fiber, ash, carbohydrates, energy value), sensory preference, total phenolic content (TPC), and antioxidant activity [2,2-diphenyl-1-picrylhydrazyl (DPPH) assay] of whole wheat bread.

Materials and Methods

Bread making

Whole wheat flour (Crown Flour Mills Platinum, Crown Flour Mills, Beirut, Lebanon), salt, dry yeast, and active bakery components (Puratos, O-tentic Origin 4%, Puratos, Groot – Bijgaarden, Belgium) were all supplied from Al Forno Bakery Khalda, Lebanon. Dried sumac (*Rhus coriaria*) and cactus (*Opuntia ficus-indica*) seeds were obtained from a local market in the Bekaa region, Lebanon, and ground to a particle size of around 200 µm using a grinder (GM200 Retsch, Haan, Germany). To ascertain the effect of these powdered seeds on the quality of baguette bread, sumac and cactus powdered seeds were separately added to whole wheat bread at different concentrations.

The chemical composition of the sumac powder used was previously reported as approximately 2.6% protein, 7.4% fat, 14.6% fiber, and 1.8% ash content (Sakhr and El Khatib, 2020), and the cactus seeds powder as approximately 6.42% lipids and 3.2% ash (El-Mostafa *et al*., 2014). According to the wheat flour label, it contained 1.2 g of fat, 76 g of total carbohydrates, 10 g of protein, and 2.3 g of dietary fiber per 100 g.

Experimental recipes were obtained by replacing a portion of the whole wheat flour with 4, 6, and 8 g/100 g flour replaced (w/w) with sumac powder, obtaining SS4, SS6, and SS8 bread samples, respectively. The base recipe consisted of 320 g of packaged Crown Flour Mills flour, 210 mL of tap water, 3 g of salt, 15 g of sugar, and 3.5 g of dried brewer's yeast. The same recipe was used, replacing flour with 4, 6, and 8 g/100 g flour replaced (w/w) with cactus powdered seeds to obtain CS4, CS6, and CS8 bread samples, respectively. A control loaf (C) containing no added seeds was also prepared.

All ingredients were combined for 6 minutes on the lowest speed setting of a double-speed spiral dough mixer (Enshey Dough Bread Mixer, Golden Chef Machinery, Guangzhou, China). The dough samples were fermented in an electric baking proofer chamber for 30 minutes. The bread samples were then baked for 19 minutes at a temperature of 190±5°C in a rotating convection oven (Mechanical Control S/Steel electric oven, Golden Chef Machinery, Guangzhou, China). They were then cooled to room temperature (22±2°C) for 2 hours. Analyses (moisture, sensory, phenolic extraction) were conducted promptly after this cooling period on the fresh bread. Three separate doughs (*i.e.*, batch replicates) were created on the same day for each formulation. The moisture content of the bread is assessed by the mass loss of a 1 g sample of bread that has been oven-dried at 100°C until it reaches a constant mass. Triplicate measurements were conducted.

Calculation of nutritional values

The nutritional values (protein, fat, carbohydrates, fiber) of the bread samples were calculated based on the recipe formulation and the nutritional information of the ingredients (wheat flour label, literature values for seed powders as cited in the *Bread making* section). Calculations followed EU Regulation 1169/2011 (European Parliament and Council, 2011). The energy value was calculated using the following conversion factors: 17 kJ/g (4 kcal/g) for protein, 37 kJ/g (9 kcal/g) for fat, 17 kJ/g (4 kcal/g) for carbohydrates, and 8 kJ/g (2 kcal/g) for fiber. Results are presented in Table 1, with energy values reported in kJ/100 g.

Bread sensory preference evaluation

The nutritional values (protein, fat, carbohydrates, fiber) of the bread samples were calculated based on the recipe formulation and the nutritional information of the ingredients (wheat flour label, literature values for seed powders as cited in the *Bread making* section). Calculations followed EU Regulation 1169/2011 (European Parliament and Council, 2011). The energy value was calculated using the following conversion factors: 17 kJ/g (4 kcal/g) for protein, 37 kJ/g (9 kcal/g) for fat, 17 kJ/g (4 kcal/g) for carbohydrates, and 8 kJ/g (2 kcal/g) for fiber. Results are presented in Table 1, with energy values reported in kJ/100 g.

Phenolic compounds analysis

Phenolic compounds extraction

Phenolic compounds were extracted from fresh bread samples based on methods adapted from established procedures for plant matrices (Naczk and Shahidi, 2004). Briefly, 1g of a fresh bread sample was extracted in an ultrasonic bath (WiseClean WUC-A06H, witeg Labortechnik GmbH, Wertheim, Germany) at 35 kHz for 10 minutes at 20°C using 10 mL of an ethanol/acetone/water (v/v/v=7/7/6) solution. The mixture was then centrifuged at 2500 rpm for 10 minutes (Neofuge 23R centrifuge). The supernatant was collected, and the remaining bread residue was re-extracted once more using the same procedure. The supernatants from both extractions were combined. Each sample was extracted in triplicate.

Total phenolic content

Folin-Ciocalteu analysis (Singleton *et al*., 1999) was used to evaluate the TPC of the bread extract. 0.5 mL of extract was combined with 2.5 mL of Folin-Ciocalteu reagent (diluted tenfold with water) and stirred for 3 minutes before adding 2 mL of sodium carbonate (Na_2CO_3) (75 g.L^{-1}). After another 30 minutes in the dark at room temperature, the mixture was tested for absorbance at 765 nm. The TPC values were determined using Gallic acid's calibration curve, and the results were represented in Gallic acid equivalents (GAE) 100 g^{-1} dry weight (DW) of the samples. Each extract was measured in triplicate.

Trolox equivalent antioxidant capacity determination

The 2,2-diphenyl-1-picrylhydrazyl (DPPH) technique (Farhan *et al.*, 2012) was used to determine the antioxidant activity of extracts. Fresh DPPH solution was produced by dissolving 4 mg DPPH in 100 ml methanol. Half a milliliter of extract was added to 3.5 ml of DPPH solution in a sample cavity. The mixture was then incubated at room temperature for 30 minutes in the dark. The absorbance at 517 nm was determined using an ultraviolet-visible spectrophotometer. Trolox mM equivalents (TE) 100 g^{-1} DW of the samples were used to calculate the radical scavenging activity. Each extract was measured in triplicate.

Statistical analysis

All experiments were conducted in triplicate, and the results are expressed as mean ± standard deviation (SD). The analyses were conducted using one-way analysis of variance followed by Tukey's post-hoc test for pairwise comparisons using appropriate statistical software (*e.g.*, SPSS, R). Differences were considered statistically significant at the $p<0.05$ level. Significance is indicated in tables and figures using superscript letters, where different letters denote statistically significant differences between means.

Results and Discussion

Figure 1 presents images of the fortified baguette bread samples. Figure 1A shows an overview of all samples, including the control (unfortified) bread and those fortified with cactus and sumac seeds. Figure 1B displays bread fortified with cactus seeds at 4%, 6%, and 8% levels, while Figure 1C shows bread fortified with sumac seeds at the same levels. Figure 1D provides a closer view of the bread crust appearance. Visually, the fortified bread samples exhibited an outside appearance (shape and color) similar to the control (unfortified) bread, making them difficult to differentiate without labels.

Bread moisture content

The moisture content of the bread samples is presented in Figure 2. The control (unfortified) sample had a moisture content of 33.5±1.3%. Fortification with both sumac and cactus seeds resulted in a statistically significant ($p<0.05$) reduction in moisture content compared to the control, with the effect being dose-dependent. Samples fortified with sumac seeds showed moisture contents ranging from 29.2±1.0% (SS4) down to 25.3±0.8% (SS8). Cactus seed fortification led to even lower moisture levels, ranging from 31.9±1.0% (CS4) down to 22.3±2.0% (CS8). This reduction is likely attributable to the increased fiber and protein content from the seeds (Table 1), which can bind water differently than wheat flour components and potentially influence starch-protein interactions and starch retrogradation during cooling and storage, leading to moisture redistribution (Baik and Chinachoti, 2000). While detailed shelf-life studies were not conducted, lower moisture content generally correlates with reduced microbial growth potential, potentially extending shelf life (Holley and Patel, 2005). Studies incorporating ingredients like Brewer's spent grain have linked increased fiber and protein to extended shelf life by restricting water accessibility (Sahin *et al*., 2021). The bread samples in this study were analyzed shortly after cooling (2 hours at 22±2°C), and further investigation would be needed to fully assess long-term storage effects.

Sensory preference evaluation

Sensory preference scores for the bread samples are presented in Figure 3. The control (unfortified) bread received a mean score of [insert control score ± SD from original data/figure]. Bread fortified with sumac seeds generally received higher scores, with SS8 achieving the highest score (4.7±0.5), which was statistically significantly preferred ($p<0.05$) over the control bread. Scores for SS4 (4.3±0.6) and SS6 (4.3±0.5) were also high, though their difference from the control might not have reached statistical significance (check original analysis results). Conversely, bread fortified with cactus seeds showed a clear trend of decreasing preference with increasing concentration. All cactus-fortified samples (CS4, CS6, CS8) were significantly less preferred ($p<0.05$) than the control bread, with CS8 receiving the lowest score (2.0±1.0).

These results suggest that sumac fortification, particularly up to 8%, is well-accepted and even preferred by consumers in this panel, potentially due to its contribution to flavor and aroma, possibly linked to essential oils present in *Rhus coriaria* (Morshedloo *et al*., 2018), similar to positive effects seen with fennel (Sayed-Ahmad *et al*., 2017). The dislike for cactus-fortified bread might be related to textural changes, such as increased hardness potentially caused by the high fiber content, as observed in studies with other high-fiber ingredients like black rice extract (Sui *et al*., 2016). It is important to note that this study focused on overall preference using a hedonic scale. More detailed sensory analysis evaluating specific attributes (texture, aroma, taste, appearance) and rheological measurements would be necessary to fully understand the impact of fortification on bread quality, but this was beyond the scope of the current study and could not be performed for this revision.

Calculated nutritional values

Table 1 presents the calculated nutritional content and energy values for the control (unfortified) and fortified bread samples, based on recipe formulation and ingredient data (see *Sensory preference evaluation* section). The control bread composition was calculated as: total carbohydrates 42.5 g/100g, protein 8.9 g/100g, fat 1.7 g/100g, and fiber 7.9 g/100g, with an energy value of approximately 991 kJ/100g (236.8 kcal/100g).

Fortification with both sumac (*Rhus coriaria*) and cactus (*Opuntia ficus-indica*) seed powders led to notable changes in the calculated nutritional profiles. As expected, increasing the fortification level generally resulted in a decrease in carbohydrate content compared to the control bread. For instance, at the 8% fortification level, carbohydrate content decreased to 39.5 g/100g for SS8 and 39.2 g/100g for CS8.

Conversely, fiber content increased with fortification, consistent with the high fiber content of the seed powders. Compared to the control (7.9 g/100g), fiber content increased progressively, reaching 9.3 g/100g for SS8 and a higher value of 10.4 g/100g for CS8. This aligns with findings from studies using other fiber-rich ingredients like grape pomace (Rocchetti *et al*., 2021).

Calculated protein content remained relatively stable for sumac-fortified bread (8.9 g/100 g across all levels, same as control), but showed a slight increase in cactus-fortified bread, reaching 9.1 g/100 g for CS8. Fat content also increased slightly with fortification, particularly for sumac, rising from 1.7 g/100 g in the control to 2.3 g/100g in SS8, while CS8 showed a smaller increase to 1.9 g/100 g.

Regarding energy value, fortification led to a slight decrease compared to the control bread (approximately 991 kJ/100 g). At the 8% level, the calculated energy value was approximately 975 kJ/100g for SS8 and 971 kJ/100 g for CS8. This reduction is primarily due to the lower carbohydrate content and the specific energy conversion factors used for fiber.

Overall, these calculations indicate that fortifying whole wheat bread with sumac or cactus seed powder, particularly at higher levels, can shift the macronutrient profile towards higher fiber and slightly lower carbohydrate and energy content, making it a potentially healthier alternative in terms of these specific nutrients compared to conventional whole wheat bread.

Total phenolic content

TPC of the bread extracts, determined using the Folin-Ciocalteu method, is presented in Figure 4, as mg GAE per 100 g DW. The control (unfortified) bread had a baseline TPC value of 30±0.05.

Fortification with both sumac (*Rhus coriaria*) and cactus (*Opuntia ficus-indica*) seed powders resulted in a statistically significant ($p<0.05$) increase in TPC compared to the control bread, and this increase was dose-dependent. For sumac-fortified bread, TPC values increased from 33±2.2 mg GAE/100 g DW for SS4 to 95.5±7.1 mg GAE/100 g DW for SS6, reaching 197.0±36.6 mg GAE/100 g DW for SS8. This represents an approximate six-fold increase at the highest fortification level compared to the control.

Similarly, cactus seed fortification significantly boosted TPC, with values rising from 58.9±4.9 mg GAE/100g DW for CS4 to 75.5±5.3 mg GAE/100g DW for CS6, and reaching 209.8±12.3 mg GAE/100g DW for CS8. This corresponds to roughly a seven-fold increase compared to the control at the 8% level. These increases are substantial and highlight the contribution of phenolic compounds from the seed powders, aligning with literature reporting high phenolic content in both sumac and cactus seeds (Kosar *et al*., 2007; Ammar *et al*., 2015; Sakhr and El Khatib, 2020; Al-Naqeb *et al*., 2021).

The observed TPC increases are comparable to, though slightly different from, studies using other fortifying agents like grape pomace, where increases depend heavily on the source material and concentration (Tolve *et al*., 2021). The addition of phytochemical-rich ingredients like these seed powders is a known strategy to enhance the phenolic content of staple foods like bread, counteracting losses during milling and potentially increasing the intake of beneficial antioxidants (Sivam *et al*., 2011; Skendi *et al*., 2019).

Antioxidant capacity (trolox equivalent antioxidant capacity)

The antioxidant capacity of the bread extracts was assessed using the DPPH radical scavenging assay and expressed as TEAC in mM trolox equivalents (TE) per 100 g DW. The results are presented in Figure 5.

The control (unfortified) bread exhibited a baseline TEAC value of 3.2±0.04 mM TE/100 g DW. Similar to the TPC results, fortification with both sumac (*Rhus coriaria*) and cactus (*Opuntia ficus-indica*) seed powders led to statistically significant ($p<0.05$) increases in antioxidant capacity compared to the control, with a clear dose-dependent effect.

Sumac fortification resulted in higher TEAC values compared to cactus fortification at equivalent levels. For sumac-fortified bread, TEAC values increased significantly ($p<0.05$) from the control to 5.1±0.2 mM TE/100 g DW for SS4, remained similar at 5.1±0.3 mM TE/100 g DW for SS6, and reached 5.3±0.1 mM TE/100 g DW for SS8. This represents an approximate 1.7-fold increase at the highest fortification level compared to the control.

Cactus seed fortification also significantly ($p<0.05$) increased TEAC values, rising from 3.4±0.2 mM TE/100 g DW for CS4, to 3.5±0.3 mM TE/100 g DW for CS6, and reaching 4.1±0.3 mM TE/100 g DW for CS8. This corresponds to an approximate 1.3-fold increase compared to the control at the 8% level.

The higher antioxidant capacity observed in the fortified breads is directly linked to the increased phenolic content contributed by the seed powders, as shown in the TPC results (*Total phenolic content* section). The stronger effect observed with sumac aligns with literature suggesting higher antioxidant activity in sumac compared to cactus seeds (Kosar *et al*., 2007; Ammar *et al*., 2015). Enhancing the antioxidant potential of staple foods like bread through fortification with phytochemical-rich ingredients is a valuable strategy, as processing (like milling) often reduces the natural antioxidant content of grains (Skendi *et al*., 2019). These results confirm that sumac and cactus seed powders can effectively boost the antioxidant capacity of whole wheat bread.

Conclusions

This study investigated the effects of fortifying whole wheat baguette bread with powdered seeds from sumac (*Rhus coriaria*) and cactus (*Opuntia ficus-indica*) at levels of 4%, 6%, and 8% (w/w flour replacement). The results demonstrated that fortification significantly enhanced the nutritional profile and antioxidant properties of the bread compared to the unfortified control.

Specifically, fortification led to a statistically significant increase in calculated dietary fiber content, particularly with cactus seeds, and a corresponding decrease in carbohydrate content and calculated energy value. TPC and antioxidant capacity (measured by DPPH assay) were significantly boosted by both seed types in a dose-dependent manner, with sumac seeds generally showing a stronger effect on antioxidant capacity. These findings highlight the potential of using these readily available Mediterranean seed by-products to improve the nutritional value of staple foods like bread.

However, sensory analysis indicated a strong preference for sumac-fortified bread, especially at the 8% level, while cactus-fortified bread was significantly less preferred than the control. This suggests potential challenges for consumer acceptance of cactus seed fortification related to taste or texture, possibly linked to its higher fiber content. Furthermore, fortification led to a decrease in bread moisture content, which might influence texture and shelf life, although detailed rheological and storage studies were not conducted.

While both *Rhus coriaria* and *Opuntia ficus-indica* seeds are traditionally consumed and generally considered safe, further investigation into potential anti-nutritional factors or optimal processing methods could be beneficial, especially for cactus seeds, to improve sensory acceptance. Limitations of this study include the reliance on calculated nutritional values and the lack of detailed rheological, textural, and shelf-life analyses. Future research should focus on these aspects, including objective texture measurements, detailed sensory profiling, storage studies to assess shelf-life implications (microbial growth, staling), and potentially exploring methods to mitigate the negative sensory impact of cactus seed fortification, such as using different processing techniques or combining it with other ingredients.

In conclusion, fortifying whole wheat bread with sumac and cactus seed powders, particularly sumac, offers a promising approach to enhance its fiber and antioxidant content. However, sensory acceptability, especially for cactus seeds, remains a key factor to address in future development.

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Figure 1. A) Cactus, sumac, and control bread; B) bread fortified with cactus seeds; C) bread fortified with sumac seeds; D) bread crust. SS4, 4% sumac seed; SS6, 6% sumac seed; SS8, 8% sumac seed; CS4, 4% cactus seed; CS6, 6% cactus seed; CS8, 8% cactus powder.

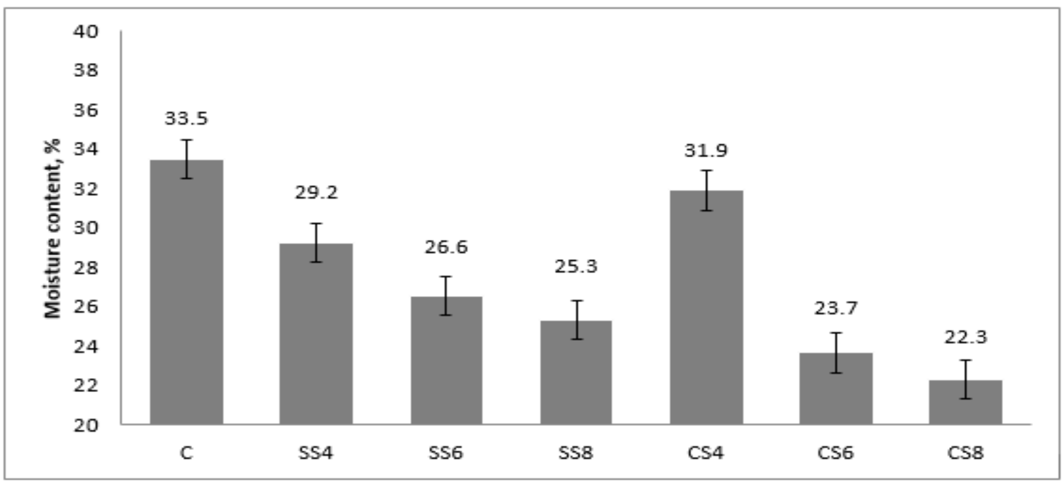

Figure 2. The moisture content of sumac and cactus powder seeds-fortified bread. C, control; SS4, 4% sumac seed; SS6, 6% sumac seed; SS8, 8% sumac seed; CS4, 4% cactus seed; CS6, 6% cactus seed; CS8, 8% cactus powder. Values are expressed by mean ± standard deviation of the three samples.

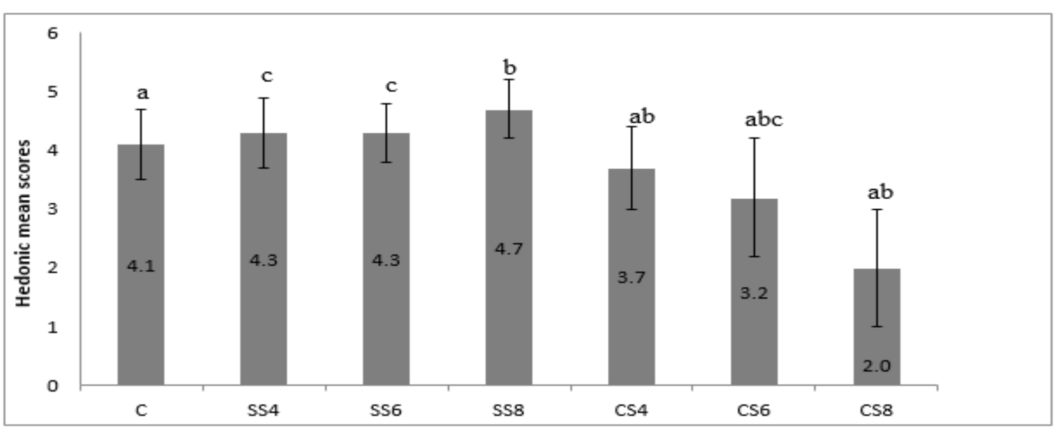

Figure 3. The mean preference values for baguette bread samples enriched with sumac and cactus seed powder. C, control; SS4, 4% sumac seed; SS6, 6% sumac seed; SS8, 8% sumac seed; CS4, 4% cactus seed; CS6, 6% cactus seed; CS8, 8% cactus seed. Columns in each bar chart with the same subscript letters are not significantly different (p>0.05).

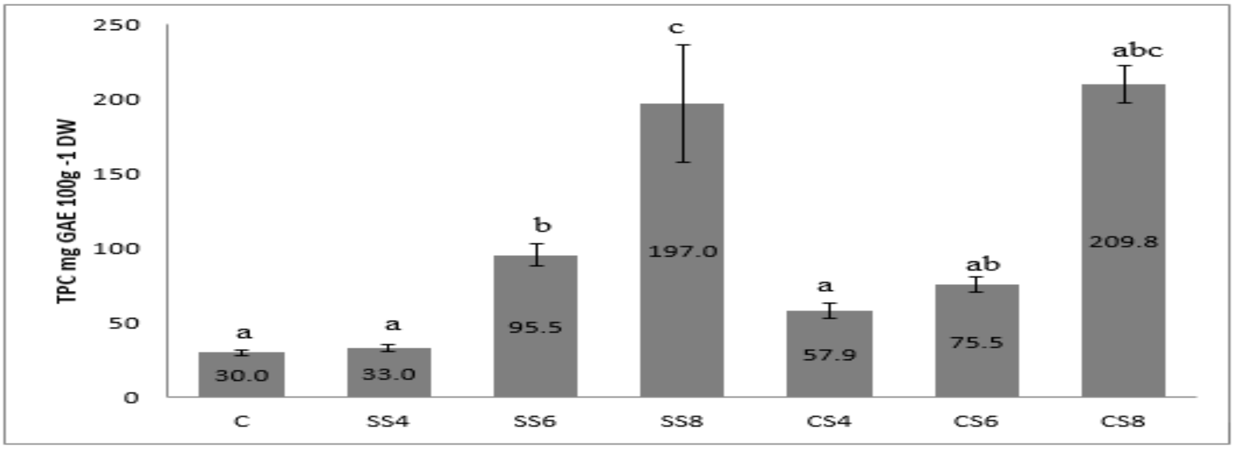

Figure 4. Total phenolic content of bread enriched with sumac and cactus powder seeds [reported as mg gallic acid equivalent (GAE) 100 g-1 dry weight (DW)]. C, control; SS4, 4% sumac seed; SS6, 6% sumac seed; SS8, 8% of sumac seed; CS4, 4% of cactus seed; CS6, 6% of cactus seed; CS8, 8% of cactus seed. Columns in each bar chart with the same subscript letters are not significantly different (p>0.05).

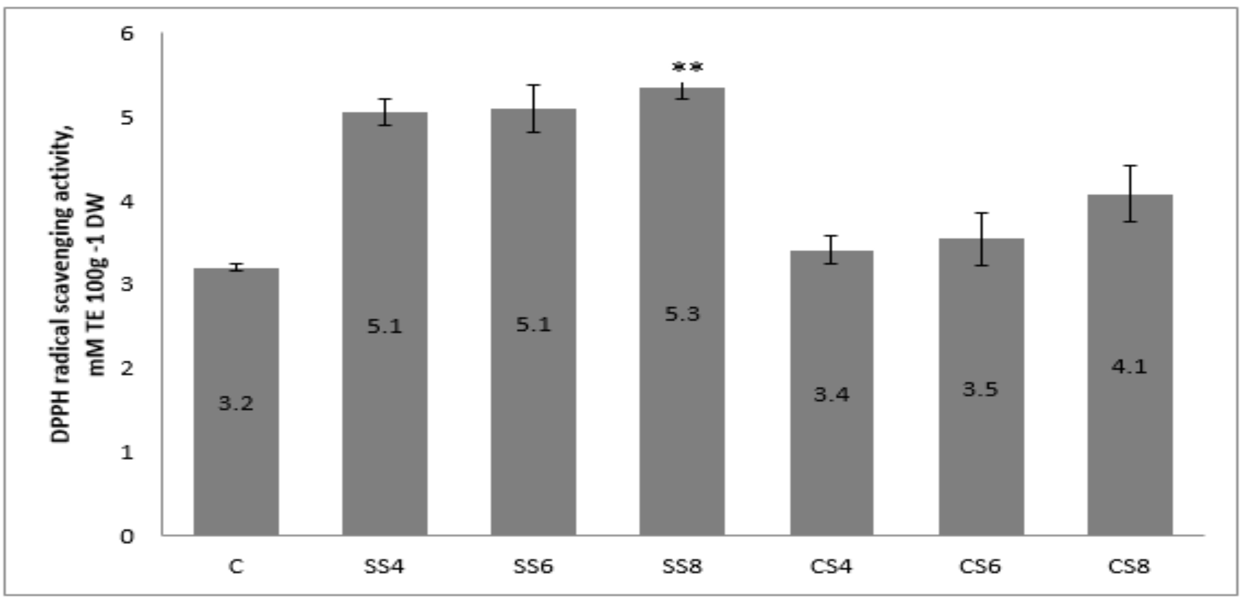

Figure 5. Trolox equivalent (TE) antioxidant activity of bread enriched with sumac and cactus powder seeds [TE expressed as mM TE 100 g-1 dry weight (DW)]. C, control; SS4, 4% sumac seed; SS6, 6% sumac seed; SS8, 8% sumac seed; CS4, 4% cactus seed; CS6, 6% cactus seed; CS8, 8% cactus seed. **Significant difference to concerning the control (p<0.05).

Table 1. Nutritional values and energy content of fortified bread samples compared to the control.

Bread Samples	Nutrients (g/100 g)				Energy Values (KJ/100 g)
	Carbohydrates	Protein	Fat	Fiber	
C	42.5	8.9	1.7	7.9	236.8=990.7KJ
SS4	41.0	8.9	2.0	8.6	234.8=982.4KJ
SS6	40.3	8.9	2.2	8.9	234.5=981.1KJ
SS8	39.5	8.9	2.3	9.3	232.9=972.4KJ
CS4	40.9	9.0	1.8	9.2	234.1=979.4KJ
CS6	40.1	9.1	1.9	9.8	233.4=976.5KJ
CS8	39.2	9.1	2.0	10.4	232.0=970.6KJ