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Exploring the functional and physiochemical properties of bread enriched with fermented cereals bran

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Abstract

Cereal bran has a wide application for the development of health tilting products as they are enriched with bioactive compounds and dietary fiber. Hence, the aim of the present study was to evaluate the effect of fermentation on the different constituents of brans isolated from major cereals (wheat, barley and oat). Purposely, the bran from aforementioned sources was separated, purified and subjected for fermentation by *Saccharomyces cerevisiae*. The obtained brans were analyzed for different physiochemical and bioactive components before and after fermentation. Furthermore, fermented bran was incorporated into bread samples to probe the impact on different functional and technological aspect of bread. The bread samples were analyzed for physiochemical, functional and sensory properties. The results of the study indicated that fermentation of brans has a significant (($P \leq 0.05$) effect on the different bioactive and nutritional components of the brans. The bioactive and nutritional components of all cereals brans increased after fermentation. Maximum antioxidant activity was recorded in barley bran followed by wheat and oat. The supplementation of bran in bread also affected the physiochemical and technological attributes of the bread. An increase in moisture, DF, protein and ash contents while a decrease in bread volume and gluten contents was noticed. Additionally, incorporation of bran increased phenolic and antioxidant activity of bread. The findings of the present study showed that there is a great potential use of fermented cereals bran in different bakery products.

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Introduction

One of the most crucial future problems is an ever-increasing population. There is dire need to make a strong food security strategy to feed this ever-increasing population. Currently, Food wastage and loss are the major hurdles in food insecurity (Searchinger *et al.*, 2019). The attention of the food scientist is being drawn towards the effective utilization of crops by-products. Now, it has become very much indispensable to study and analyze the useful by-products of different crops. Cereals are considered a major source of nutrition in subcontinents. The maximum portion of the energy in Asian countries is derived from different cereals. However, most of the cereals are deficient in important and essential nutrients. The demand for nutrient and antioxidant-rich food products is increasing around the globe (Jin *et al.*, 2018).

Although there is enough production of different cereals throughout the world, most of the product gets wasted or lost during different post-harvest activities. The major by-products of these cereals are bran that is being wasted or used as animal feed (Garcia-Herrero *et al.*, 2018).

The major by-products from cereals industry include the brans and germ separated during cereals processing. The bran of different cereals is rich source of different bioactive components. It has been investigated that that bran of cereals has therapeutic potential against different diseases (diabetes, cancer, obesity and bowel related issues). The role of bran as a prebiotic has been investigated by many scientists and found that it extraordinarily influences gut microflora (Duţă *et al.*, 2018).

Cereals bran comprises various bioactive compounds (DF particularly β-glucan, phenolic compounds, folates, minerals vitamins and some essential amino acids). The binding form of these bioactive components makes them unavailable for nutritional purpose. Fermentation is being considered as a potential bio-processing tool to improve the bioactivity of the aforementioned compounds (Katina *et al.*, 2007). The development of different bioprocess technologies has made feasibility for the use of different by-products in the production of functional foods. In this regard, fermentation has been gaining attention as a very reasonable choice to augment the storage stability, nutritional, technological and sensorial attributes of the various products supplemented with brans derived from cereals as by-products.

The increase in major nutritional components like vitamins, minerals, TPC and many other essential bioactive components has been reported by in different studies. Additionally, a decrease in the anti-nutritional components like phytic acid has also been reported (Yu and Tian, 2018).

Considering the importance of different cereal brands and their nutritional profile the present study was designed to evaluate the effect of fermentation on the bioactive components of different brands. Secondly, the objective was to elucidate the effect of brans supplementation on the different functional, technological and sensory attributes of the bread.

Materials and methods

Procurement of raw material

The required variety of cereals (wheat, barley and oat) was purchased from Wheat Research Institute, Ayub Agriculture Research Institute (AARI), and Faisalabad. Baker's yeast (*Saccharomyces cerevisiae)* was obtained from Food safety and Biotechnology laboratory of Government College University, Faisalabad. All Chemicals were procured with brand Sigma Aldrich Company Ltd.

Preparation and tempering of cereals Samples

Procured cereals were properly cleaned and tempering was carried according to method no. 26-95 AACC, 2000 to obtain the required moisture for milling of grains.

Milling of Cereals

The tempered grains were milled through Brabender Quadrumate Senior Mill (C.W. Brabender

Instruments, Inc.) available at wheat research Institute Ayub Agriculture Research Institute, Faisalabad to obtain different milling fractions i.e. break, reduction flour, bran and shorts.

Bran purification

Cereal bran of specific mesh size was separated from whole milled grains and washed with water to remove starch. Starch free pure bran was dried in sunlight and then grind.

Bran analysis

Characterization of non-fermented brans

Proximate composition: Cereals bran was evaluated for proximate composition i.e., moisture, ash, crude protein, crude fat & crude fibre according to their respective methods (AACC, 2000). The cereals bran was also analyzed for mineral profile.

Mineral Profile: The wet digestion of flour sample of each variety was done in di-acid mixture (3:1) of HNO_3:$HCLO_4$ at hot plate for 2 hours. The mineral content in the digested samples was estimated using Atomic Absorption Spectrophotometer (AA240 Varian K, Australia) on an acetylene air flame. The procedure described in AOAC (2006) was adopted to determine the mineral content in different samples.

Total Dietary Fiber (TDF): The samples were analyzed for total dietary fibre according to AACC (2000) method No. 32-05.

Total Phenolic Content: Total phenolic content of different cereals bran was estimated by the method described by (Singelton andRosi, 1965).

Total Flavonoid Content: Total flavonoid content of cereals bran was calculated with the method given by (Iqbal*et al.*, 2007) with minor changes.

Antioxidant potential: Scavenging activity (DPPH) of cereals bran was evaluated with the method described by (Yen and Chen, 1995) and reducing power (FRAP) was estimated by the protocol described by the (Benzie and strain, 1996).

Phytic acid content: Phytic acid content was determined according to Wheeler and Ferrell (1971).

Fermentation of cereals bran

Baker's yeast was obtained from Food safety and Biotechnology lab of the Institute of Home & Food Sciences. The obtained yeast (7.50g) was mixed with each cereals brans (wheat, oat and barley) separately in a large beaker and then, covered with aluminium foil. Fermentation was carried out as per experimental plan and previously reported by (Katina *et al.*, 2007). After fermentation the samples were taken for different analysis design. The cereals brans were freeze-dried for the analysis of different bioactive compounds.

Characterization of fermented bran

The fermented brans of cereals were analyzed for different characteristics followingabove-mentioned methods with slight modification.

Product development

Bread samples were prepared by supplementation of fermented cereal brans through its respective method mentioned in AACC (2000). The treatment plan is given in Table 1.

Statistical analysis

Data obtained from the study were statistically analyzed by Steel *et al.*, 1997. Statistix 8.1 software was used for this purpose.

Results and discussion

Proximate composition of fermented and non-fermented brans

The results regarding the proximate composition of the non-fermented and fermented brans are shown in Table 2. The results showed that wheat contains highest TDF compared to oat and barley bran.

Similarly, protein and ash contents in case of wheat were higher. An increase in nutritional content of the various brands was observed. The results of the present study are in accordance with results reported by (Manini *et al.*, 2014).

Table 1. Formulation of bread with the addition of different cereals bran.

Treatment	Description
Control	Bread without addition of any bran
WBB	Wheat bran bread containing 8% fermented bran
OBB	Oat bran bread containing 8% fermented bran
BBB	Barley bran bread containing 8% fermented bran

Table 2. Proximate composition of non-fermented cereals bran.

Parameters	wheat	oat	Barley
Moisture, %	9.45±0.47	7.69±0.38	6.5±0.32
Ash, %	5.95±0.29	2.81±0.14	3.1±0.15
Lipid, %	0.44±.02	1.00±.049	1.5±0.07
Protein	16.20±0.81	5.54±0.27	15.6±0.78
TDF	38.00±1.9	26.40±1.3	31±1.5

Total phenolic and flavonoid content

Total phenolic content of non-fermented wheat, oat and barley bran was 112, 96 and 103 mg GAE respectively while in the fermented wheat, oat and barley bran 180, 147 and 165 mg GAE (Fig. 1).

Moreover, a significant increase in the total phenolic content was noted in the fermented brans. Thus, current findings clearly state that fermentation positively affects the phenolic content of cereals bran. Data showed that with increasing fermentation time and temperature up to a specific level, phenolic compounds increased the results are supported by the findings of (Katina *et al.,* 2007) who revealed that the fermentation is a key factor to enhance the level of total phenolics.

Table 3. Proximate composition fermented cereals bran.

Parameters	Wheat	Oat	Barley
Moisture	6.1±.28	5.3±0.22	3.9±0.16
Ash	4.1±0.18	1.4±0.05	2.2±0.11
Lipid	.74±0.03	1.9±0.09	2.7±0.1
Protein	21±1	9±0.4	18±0.87
TDF	48±2	29±1.3	37±1.5

Table 4. Mineral content of non-fermented cereals bran.

Minerals	Wheat amount (MG/100G)	Oat amount (MG/100G)	Barley amount (MG/100G)
Sodium	3±0.5	5±0.6	6.32±0.34
Potassium	250±6	306±7	451±9
Calcium	160±3	98±2	72±2
Magnesium	55±1	47±1	59.85±1.3

Total flavonoid content of cereals bran is shown in Fig. 2. The amount of total flavonoid content of non-fermented wheat, Barley and oat bran is 72, 81 and 67 mg Rutin equivalent and in fermented wheat, oat andbarley 108, 112 and 92 mg RE respectively. This study revealed that fermentation upsurged the flavonoid content of cereals bran compared to non-fermented bran.

Table 5. Mineral content of fermented cereals bran.

Minerals	Wheat Bran	Oat Bran	Barley Bran
Sodium	2±0.1	4±0.2	4.6±0.2
Potassium	199±3	276±5	320±3
Calcium	70±1	32±1	26±1
Magnesium	21±0.5	14±0.5	19±0.19

Table 6. Physical properties of Wheat, Oat and barley brans.

Bran type	WHCa g water/g solid	Loose density, g/ cm3	Packed density, g/cm3
Wheat bran	5.03±0.2	0.39±0.01	0.43±0.02
Oat bran	2.10±0.1	0.42±0.02	0.61±0.03
Barley	3.13±0.15	0.29±0.01	0.48±0.02

Antioxidant potential

DPPH free radical is widely used to determine the scavenging activity of bioactive compounds present in the foods. Results of the current study are depicted in the Fig. 3. DPPH radical scavenging activity of fermented brans possessed excellent antioxidant activity wheat bran (89 %) produced higher scavenging activity followed by barley bran (79%) and oat bran (74%). Moreover, in the non-fermented cereals bran scavenging activity was as follow wheat bran (52%), oat bran (40%) and barley bran (36%). The current study showed that gradual increase in the scavenging activity of fermented brans was due to yeast fermentation.

Table 7. Effect of cereals bran (Wheat, oat and barley) on dough development time.

Treatment	Dough development time(min)
Control	5.4±0.27
WBB	5.8±0.29
OBB	5.9±0.3
BBB	5.8±0.3

Table 8. Effect of cereals bran (Wheat, oat and barley) on porosity properties. Values are expressed as Mean ± standard deviation.

Treatment	Dough porosity (%)
Control	14.60±0.73
WBB	17.60±0.88
OBB	18.60±0.9
BBB	16.60±0.82

Reducing power (FRAP) of fermented cereals bran is shown in the Fig. 4 Cereals bran converted the fe3 to fe2 by donating electron. Reducing power is strongly associated with antioxidant activity. This study indicated that fermented Brans produced higher reducing power. The results of the reducing power are as follows wheat bran 18 Trolox eq., oat bran 14 Trolox eq. and barley bran 13.5 Trolox eq. Furthermore, non-fermented brans had lower ability to neutralize free radicals compared to fermented brans. The results of non-fermented brans were wheat bran 11 Trolox eq., oat bran 9 Trolox eq. and barley bran 7 Trolox eq. Greater reducing power indicates greaternumber of antioxidants which effectively quench and neutralize the free radicals.

Minerals content

The mineral content of non-fermented and fermented cereals bran was depicted in Table 4, 5. Barley bran contains higher concentration of sodium, potassium, calcium, magnesium, manganese and copper. For pearled grains, however, there is a decrease of those minerals due to the separation of the husk, which contains around 32% of the kernel total mineral content. Observations showed that potassium and magnesium are the maximum mineral element present in barley bran followed by oat and wheat bran. However, fermentation affected the mineral content of all the samples. Results of the mineral content after fermentation are shown in Table 4. The decline in mineral content might be due to the hydrolysis during fermentation.

Table 9. Effect of cereals brans (Wheat, oat and barley) on dough stickiness (N).

Treatment	Dough Stickiness (N)
Control	0.58±0.02
WBB	0.50±0.01
OBB	0.47±0.01
BBB	0.46±0.01

Table 10. Effect of cereals brans (Wheat, oat and barley) on dough fermentation time.

Treatments	Fermentation time (min)	Expansion rate (cm^3/min)	Bread specific volume (mL/g)
Control	65.9±2.5	1.3±0.07	3.6±0.18
WBB	66.3±2.6	1.5±007	3.5±0.17
OBB	67.4±2.6	1.4±0.07	3.5±0.17
BBB	66.6±2.6	1.5±0.07	3.4±0.17

WBB=Wheat bra bread, OBB= oat bran bread, BBB=barley bran bread and values are presented as mean ±standard deviation.

The results regarding the different physical properties of different brans are shown in Table 6. The data showed that wheat bran has maximum water holding capacity compared with the oat and wheat bran the results could be due to high TDF contents in the wheat bran.

The loose density was maximum in case of oat bran followed by wheat and barley. Oat bran showed highest packed density followed by wheat and barley brans.

Phytic acid content

The phytic acid content of different cereals bran is illustrated in Fig.5. In this assay, Phytic acid content of non-fermented cereals bran was significantly higher than fermented cereals bran. PAC was ranged from 600 to 720 in non-fermented cereals bran while it was ranged from 277 to 325 in the fermented cereals bran. Such decline in the phytic acid content indicates that fermentation hydrolyses the phytate content with the help of yeast induced phytase enzyme. However, there could be many reasons for phytic acid degradation as reported by (Zamudio *et al.*, 2001).

Dough development time

The results regarding the effect of various brans on dough development are shown in Table 7. It was noticed that the addition of the various cereals bran increased the dough development time as shown in the Table 7. The maximum dough development time was recorded for OBB followed by WBB, BBB and control. The increase in the TDF and other constituents could be one of the reasonsfor the different brans are shown in Table 7.

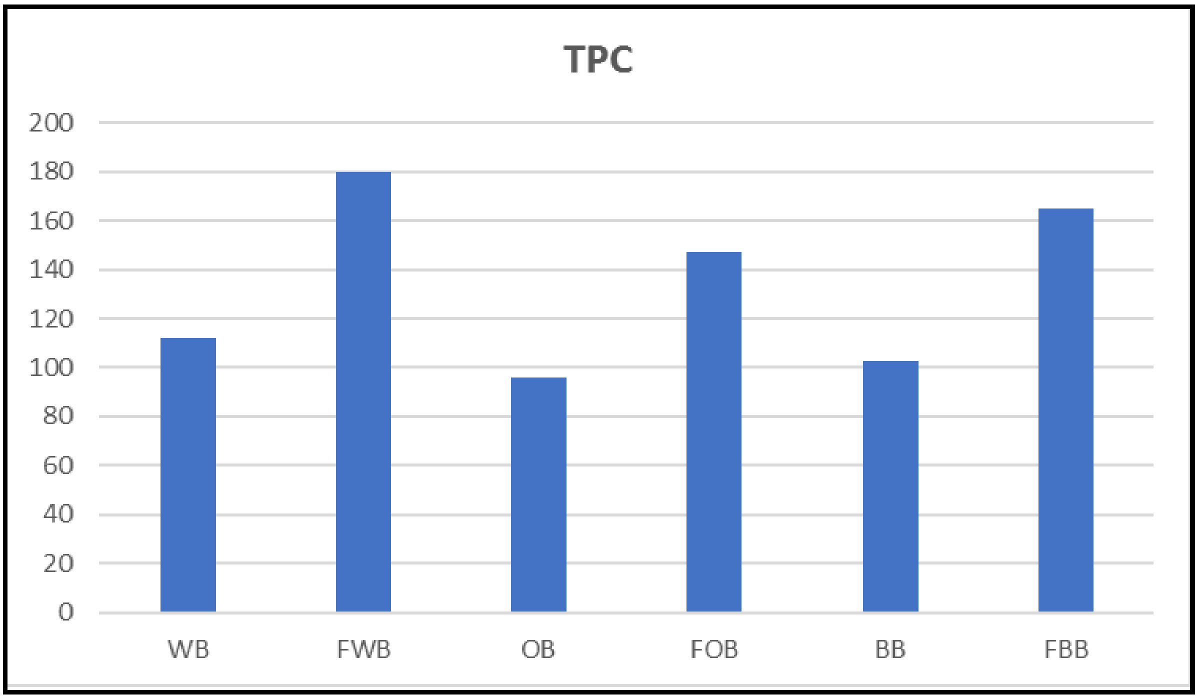

Fig. 1. Total phenolic content of fermented and non-fermented cereals bran.

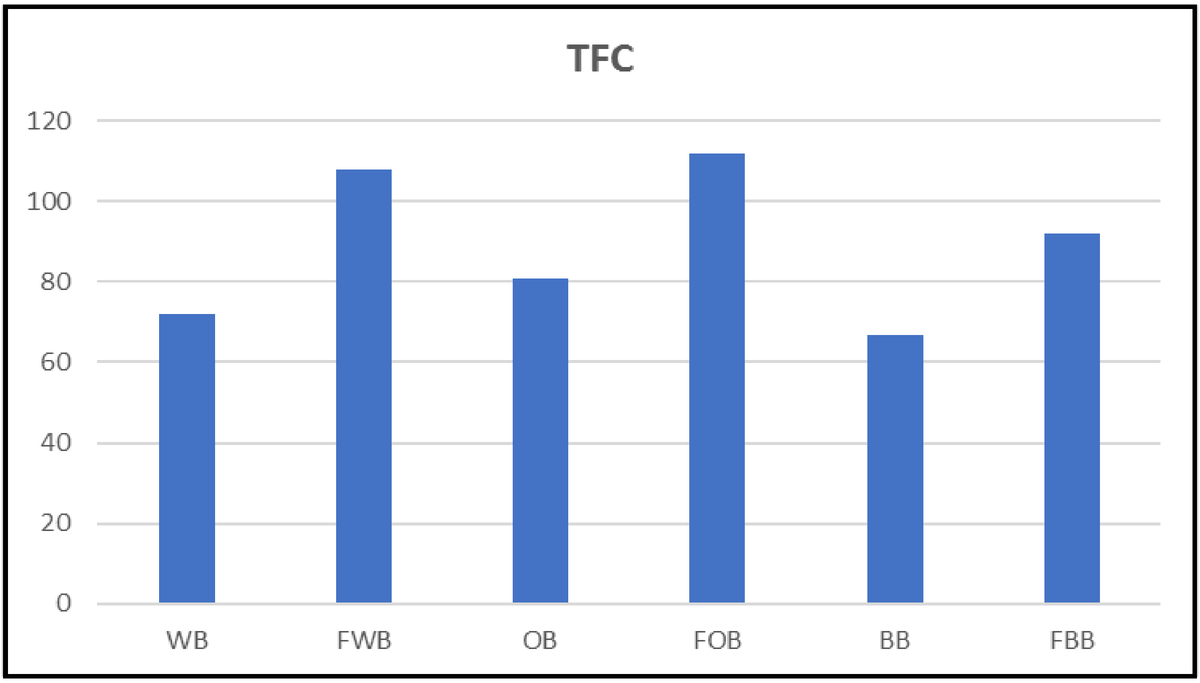

Fig. 2. Total Flavonoid content of fermented and non-fermented cereals bran.

The data showed that wheat high dough development time.

Porosity properties

The results regarding the effect of various cereals bran on porosity properties are shown in Table 8. The highest porosity was observed in case of the bread containing the oat bran (18.60) followed by WBB (17.60), BBB (16.60) and control (14.60) bread. It might be due to the particle size which affected the porosity properties of bread.

Dough stickiness

The results regarding the effect of cereals brans (wheat, oat and barley) on dough stickiness (N) are shown in Table 9. The addition of various brans decreased the dough stickiness in all type of bread.Overall a decrease in stickiness of all type of bread formulation was noticed. The maximum stickiness was shown by the control followed by WBB, OBB and BBB. The addition of various brans increased water holding capacity that ultimately causes a decrease in stickiness.

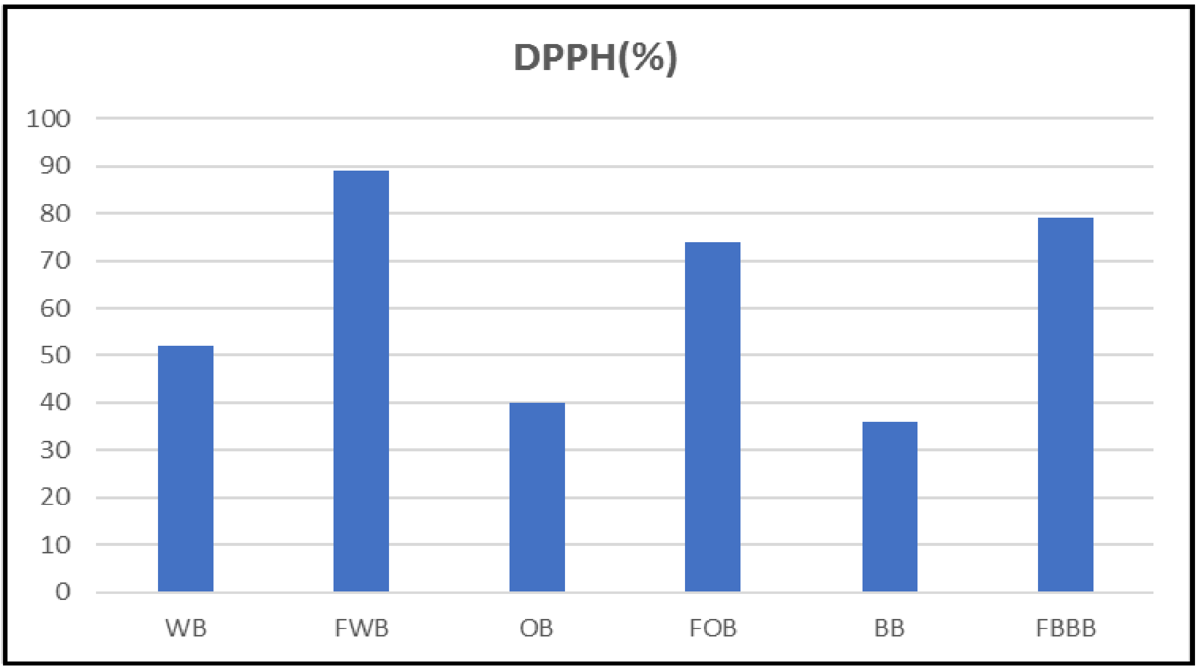

Fig. 3. Scavenging activity of fermented and non-fermented cereals bran.

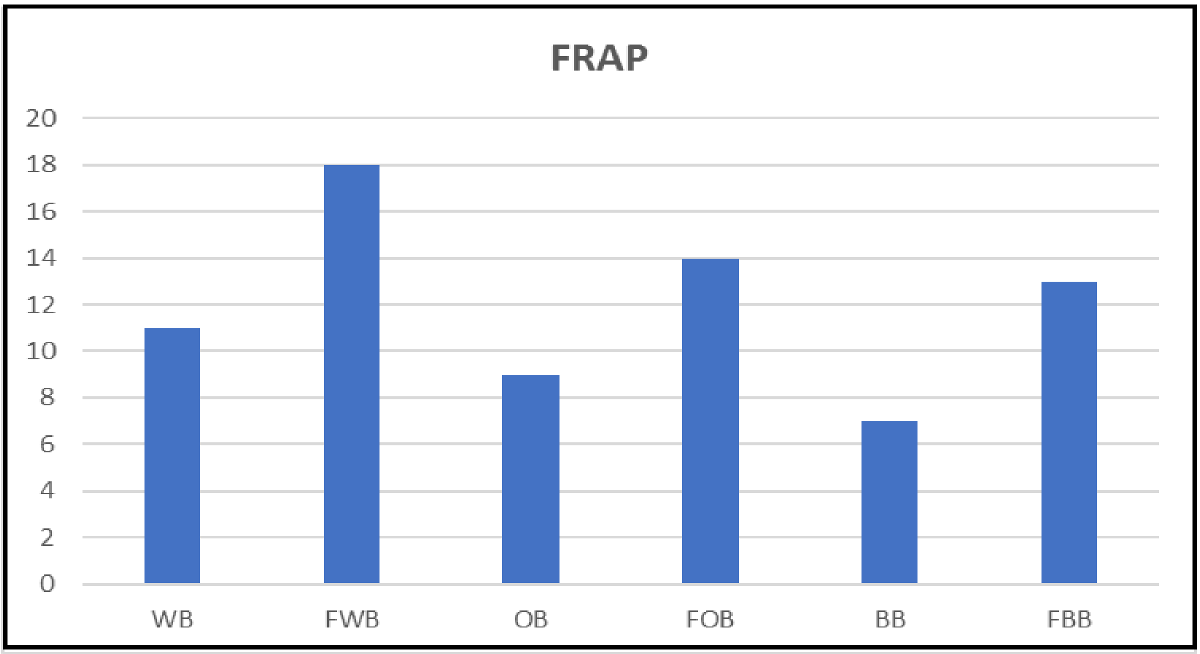

Fig. 4. Reducing power of fermented and non-fermented cereals bran.

Dough fermentation time and bread quality

The results regarding the Effect of cereals brans (wheat, oat and barley) on dough fermentation time (minutes) and bread quality is shown in Table 10. The results indicated that the addition of the various brans increased fermentation time as compared to control. Likewise, in case bread specific volume overall a decrease in bread volume (mg/g) was noticed. The maximum expansion rate was shown by the WBB and BBB followed by OBB and control. The addition of various brans content in bread formulation decreases the bread volume while increased the fermentation time and expansion rate of the bread.

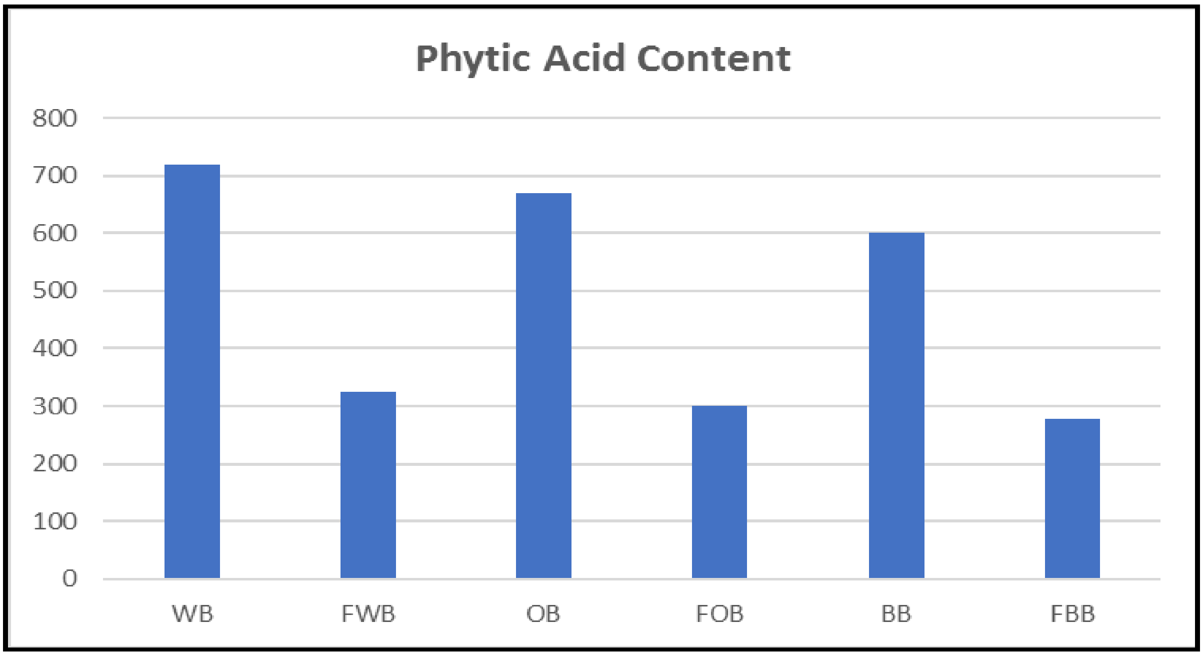

Fig. 5. Phytic acid content of fermented and non-fermented cereals bran.

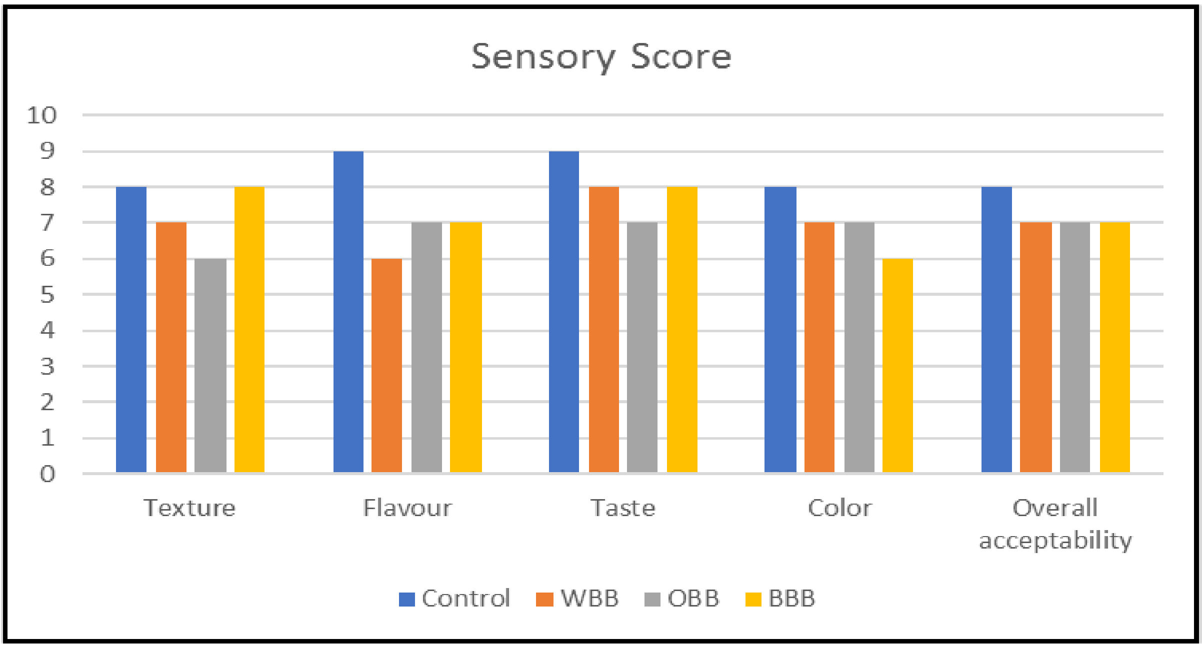

Fig. 6. Sensory scores of bread.

Sensory profiling of bread

Addition of different cereals brans in bread formulation is shown in Fig 7.The sensory parameters which were studied include texture, flavour and taste, colour and overall acceptability. t is revealed from the results that quality score decreased with increasing incorporation of fermented all cereals after a particular level). An increase in Colour of the crumb was observed in case of the bread containing the various brans. Few members of the sensory panellist noticed a stronger pungent flavour, this could be due to bitter phenolic and flavonoid compounds that were liberated from the cell wall of various brans. In short, the bread with fermented brans was nutritionally superior but other attributes were affected as compared to control bread.

Conclusion

The fermentation of various bran with yeast effectively improved the nutritional and bioactive components of the bran. Fermentation increased the bioactive components by the degradation of bounded components. The incorporation of fermented brans in bread directly affected the functional, technological and sensory properties of bread. The physicochemical and functional properties of wheat and oat bran along with their anti-nutrient contents, these must be utilized to contest malnourishment and food insecurities issues.

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