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Effect of Different Stabilization Methods on Proximate and Mineral Composition of Wheat Bran

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***Abstract*:** Wheat bran, a byproduct of wheat milling industry which is commonly used for feeding animals has dense nutritional composition and potential application in human diet that have attracted market interest. However, its preservation for safe use is still challenging. Therefore, the objective of the present study was to identify the best stabilization method which would safely preserve the bran. For the stabilization of wheat bran different methods (microwave, hot air oven, roasting and chemical method) were used. The assessment of proximate and mineral characteristics of wheat bran depicted that the highest crude protein (15.56%), ash (6.31%) and crude fibre (12.52%) were observed in microwave stabilized wheat bran, while as the minimum protein (13.61%), ash (5.32%) and crude fibre (11.72%) content were in unstabilized wheat bran (control). During storage period, the mean moisture content increased from 7.19 to 7.88 per cent, while as crude protein, ash, crude fat and crude fibre decreased from 15.29 to 14.01 per cent, 5.87 to 5.58 per cent, 5.96 to 5.39 per cent and 12.58 to 11.81 per cent, respectively. Based on overall proximate and mineral composition and stability, microwave stabilized wheat bran was more effective than hot air oven, autoclave, roasting and chemical methods.

***Keywords*:** Stability, Inactivation, Nutritional, Fortification, Consumption

Wheat is the largest cereal grain crop of the world and the second largest in India, corresponding to annual production of approximately 109 million tons during the year 2021 (Anonymous 2022a). Wheat grain consists of three main parts-endosperm, germ, and bran. The bran fraction, which is generally produced as a milling by-product, constitutes about 13-19 per cent of total wheat grain weight (Laukova et al 2016) and has food (Curti et al 2013) and non-food applications (Apprich et al 2013). It is estimated that 796 thousand metric tonnes of wheat bran are produced annually (Anonymous 2019b). Wheat bran is the outer layer of wheat kernel, sub-divided into three distant layers, viz., testa, aleurone and pericarp**.** It contains about 53 per cent dietary fibre (cellulose, lignin, galactan, xylans, and fructans). It is also rich in bioactive components such as ferulic acid, alkylresorcinols, carotenoids, lignans, flavonoids, and sterols (Onipe et al 2015). Other components include vitamin B (thiamin, riboflavin, pyridoxine, and folate) and Vitamin E (Fardet 2010). Besides, it contains minerals iron, zinc, manganese, magnesium, and phosphorous (Brouns et al 2012). The pericarp is divided into inner and outerlayers, which comprises of phenolic acids in bound state and insoluble dietary fibre (Apprich et al 2013). These nutrition-rich components are often discarded during milling out of ignorance, organoleptic reasons, or rancidity problems. Knowingthe phytochemical constituents and pharmacological profile of bran is expected to give insight to their potential application in promotion of health. Wheat bran, the by product obtained in large amounts in wheat milling is considered as inedible material for humans and is mostly used as animal feed (Dar, 2011). Besides, these nutritional ingredients, wheat bran contains lipase. High lipase activity in bran leads to rapid deterioration of lipids by rancidification during storage and is the most common problem of raw bran (Ertas 2015). Once the bran is removed from the kernel, the lipid substrate and enzymes are brought together, and enzymatic hydrolysis proceeds rapidly. Since bran contains high fat content, rapid deterioration of crude fat by lipase immediately occurs, following the milling process and yields free fatty acids and glycerol. The fat hydrolysis causes the bran unsuitable for human consumption and lowers the oil yield (Patil et al 2016). The reaction between molecular oxygen and lipids results in oxidative rancidity that led to spoilage. The reaction occurs at the double bonds of unsaturated fatty acids and can be accelerated by free radicles, singlet oxygen, radiation, metal ions (iron, copper and cobalt), enzymes and light, containing a transition metal prosthetic group like lipoxygenase (Malekian et al 2000). Therefore, it necessitates inactivation of lipase and inhibition of the formation of free fatty acids immediately after milling process. During the storage, rancidification can reduce the nutritional value of food and cause some quality changes involving appearance, flavor, and texture. Lipid

hydrolysis in wheat bran may affect baking, nutritional and sensory properties (Ertas 2015). Therefore, stabilization of bran is important to inactivate lipases and peroxidases.

MATERIAL AND METHODS

Stabilization of wheat bran: The study was carried out in Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu using wheat bran purchased from Amar flour mills, Gangyal, Jammu. The sample was exposed to different five stabilization methods, viz., hot air oven, microwave, roasting, autoclave, and chemical while one was kept as such. Stabilized wheat bran samples were stored for a period of 3 months (Table 1).

Analysis of proximate composition: The crude protein, crude fat, ash, crude fibre and moisture, were determined according to AOAC (2005). After ashing of samples, calcium, phosphorous and magnesium content was determined according to AOAC method. For determination of minerals, ashing was done followed by digestion using solution of perchloric acid and nitric acid at ratio of 1:4, followed by cooling. Solution was filtered using Whatman filter paper 42, and volume of each sample was made to 25 ml using distilled water. Total dietary fibre and phytic acid was determined according to AOAC (2005) and Sadasivam and Manickam (2008), respectively.

Table 1. Experimental conditions for thermal treatments

Stabilization method	Sample code	Operating conditions
Control	Raw	None
Microwave	MW	2450 MHz for 3 minutes
Hot air oven	HAO	120℃for 20 minutes
Autoclave	AC	121℃ at 15 psi
Roasting	RO	190℃ for 20 minutes
Chemical	CH	Ethanol (5ml/100g WB)

Statistical analysis: The results obtained were statistically analyzed at 5 per cent level of significance using completely randomized design and through analysis of variance (ANOVA) using software OPSTAT.

RESULTS AND DISCUSSION

Proximate Components

Crude protein: Stabilization of wheat bran resulted in an increase in crude protein content in comparison to control (Table 2). Mean crude protein content of 15.56% was in MW stabilized wheat bran, which was significantly higher than other methods and is in agreement with Fahmida et al (2015). The short exposure times and uniform heating associated with microwave heating might be responsible for lesser deterioration of proteins in contrast to other stabilization methods (Sun et al 2019). Roasted samples had significantly less crude protein than hot air oven and autoclave treated samples. During roasting, the high temperatures employed might be responsible for protein denaturation and subsequent protein loss in comparison to autoclave and hot air oven, which have better retention of crude protein content (Arumuganathan et al 2010). The crude protein content of chemical treated wheat bran samples was lower than thermal treated wheat bran samples but higher than control, which was consistent with Bagchi et al (2014) and Younas et al (2011) in rice bran. The reason behind this increase might be due to reduction in the activity of enzymes involved in degradation of proteins (Gopinger et al 2015).

Ash: All stabilization methods resulted in a significant increase in ash content (Table 3). An increase in ash content after thermal processing might be attributed to non-volatile nature of minerals, which do not get destroyed on heating (Mahirah et al 2018). On considering the effect of stabilization methods on ash content, the highest ash content was observed in microwave stabilized wheat bran. Similar results

Table 2. Effect of stabilization methods and storage period on crude protein (%) of wheat bran

Stabilization method	Storage days				Mean
	0	30	60	90	
Control	14.25	13.79	13.43	12.97	13.61
MW	16.15	15.75	15.51	14.85	15.56
HAO	15.90	15.34	14.93	14.54	15.17
AC	15.58	15.18	14.60	14.37	14.93
RO	15.42	15.05	14.47	14.23	14.79
CH	14.45	14.07	13.52	13.14	13.78
Mean (Storage)	15.29	14.86	14.41	14.01	

CD (p=0.05)
Stabilization method (SB) 0.07
Storage (S) 0.05
SB x S 0.14

were reported by Siswanti et al (2019) in rice bran. This increase in ash content may be due to decrease in moisture content (Chauhan et al 2015).

Crude fat: The stabilization methods resulted in an increase in crude fat content of wheat bran (Table 4), which could be attributed to denaturation of proteins that results in formation of complex structures, leading to lesser exposure of hydrophobic domains (Lee et al 2019). The microwave stabilization method retained higher amount of mean crude fat content (6.87%) when compared to other stabilization methods like results of Fahmida et al (2019) and Siswanti et al (2019) reporting better retention of fat content in microwave than roasting, hot air oven, and autoclave. This increase in crude fat content might be attributed to opening of bonds within short period of time due to disturbance in fat complex and protein or fat and carbohydrates (Siswanti et al 2019). The hot air oven stabilized wheat bran, in contrast to roasted wheat bran, depicted a higher mean crude fat content of 6.30% coinciding with the results reported by El-Hady (2013) in rice bran. The higher mean crude fat content of chemical treated wheat bran (5.44%) than control (3.72%) might be due to better extractability of oil by solvents (El-Hady, 2013). Premkumari et al (2012also observed increase in fat content of alcohol treated rice bran.

Crude fibre: The different stabilization methods had a significant impact on the crude fibre content of wheat bran (Table 5). This might be attributed to the formation of protein-fibre complex (Nyangena et al 2020). Crude fibre content followed the order of microwave >roasting>hot air oven >autoclave>chemical>control. Fahmida et al (2019) reported higher crude fibre content in microwave stabilized rice bran than the samples subjected to roasting, steaming, and autoclave. Higher crude fibre content in microwave stabilized wheat bran in contrast to other methods might be due to increased susceptibility of lignocellulose substances to enzymatic activity in response to microwaves .The hot air oven retained higher crude fibre content as compared to autoclave and chemical stabilization, which might be due to

Table 3. Ash content (%) of wheat bran stabilized by different methods

Stabilization method	Storage days				Mean
	0	30	60	90	
Control	5.50	5.44	5.30	5.20	5.32
MW	6.45	6.37	6.27	6.18	6.31
HAO	5.87	5.79	5.68	5.59	5.73
AC	5.83	5.66	5.61	5.53	5.66
RO	5.98	5.90	5.83	5.75	5.87
CH	5.60	5.50	5.46	5.37	5.46
Mean (Storage)	5.87	5.78	5.68	5.58	

CD (p=0.05)
Stabilization method (SB) 0.05
Storage (S) 0.04
SB x S Non significant (NS)

Table 4. Effect of storage period and stabilization methods on crude fat content of wheat bran(%)

Stabilization method	Storage days				Mean
	0	30	60	90	
Control	4.00	3.83	3.64	3.39	3.72
MW	7.00	6.92	6.83	6.74	6.87
HAO	6.71	6.29	6.17	6.03	6.30
AC	5.91	5.72	5.51	5.32	5.61
RO	6.39	6.17	5.94	5.65	6.04
CH	5.72	5.50	5.35	5.19	5.44
Mean (Storage)	5.96	5.74	5.57	5.39	

CD (p=0.05)
Stabilization method (SB) 0.06
Storage (S) 0.04
SB x S 0.10

greater cellular disruption leading to greater susceptibility to enzymatic activity, thereby increasing the crude fibre content (Hameed 2016).

Moisture content: All the stabilization methods reflected a decrease in moisture content (Table 6). Reduction in moisture content due to stabilization methods might be due to the fact that moisture, being a bipolar molecule, gets heated up and subsequently evaporated from the bran samples (Patil et al 2016). Initially, the highest moisture content of 8.95 per cent was found in control, followed by chemical method depicting the moisture content of 7.35 per cent. Premkumari et al (2012) also reported lesser moisture content in ethanol treated rice bran than control, hence supporting our findings. The mean moisture content of 5.90 per cent was observed in roasting lower than the microwave (7.33%) and autoclave (8.56%). Fahmida et al (2019) also observed similar results in rice bran. The difference in moisture content of stabilized wheat bran samples might be due to different temperature conditions used (Filho et al 2016). The moisture content follows the order of control>autoclave>chemical> microwave>hot air oven>roasting, which is consistent with the findings of Thanonkaew et al (2012) in rice bran. Higher moisture content in microwave than in roasting might be due to the fact that during microwave heating, the air adjacent to the food product is cold and water vaporizing from products gets condensed on contact with cold air (Chandrasekaran et al 2013). The lower moisture content in the microwave compared to autoclave could be attributed to the microwave's high intensity heating (Chauhan et al 2015).

Available carbohydrates: Stabilization methods resulted in a significant decrease in available carbohydrates of treated wheat bran samples as compared to control which might be attributed to an increase in crude protein, crude fat, and ash content (Nyangena et al 2020). Carbohydrate content of control sample was 67.91 percent which is in the range (60-75 %) given by Javed et al (2012). The available

Table 5. Crude fibre content of wheat bran as affected by stabilization methods and storage period (%)

Stabilization method	Storage days				Mean
	0	30	60	90	
Control	12.46	11.75	11.46	11.20	11.72
MW	12.79	12.62	12.44	12.25	12.52
HAO	12.59	12.42	12.21	11.89	12.28
AC	12.52	12.39	12.13	11.79	12.20
RO	12.65	12.49	12.28	12.10	12.38
CH	12.49	12.03	11.79	11.63	11.98
Mean (Storage)	12.58	12.28	12.05	11.81	
CD (p=0.05)					
Stabilization method (SB)	0.03				
Storage (S)	0.02				
SB x S	0.06				

Table 6. Effect of stabilization methods and storage period on moisture (%) of wheat bran

Stabilization method	Storage days				Mean
	0	30	60	90	
Control	8.95	9.20	9.50	9.95	9.40
MW	6.95	7.28	7.43	7.67	7.33
HAO	5.95	6.20	6.37	6.65	6.29
AC	8.25	8.43	8.67	8.90	8.56
RO	5.67	5.76	5.95	6.20	5.90
CH	7.35	7.50	7.69	7.92	7.62
Mean (Storage)	7.19	7.40	7.60	7.88	
CD (p=0.05)					
Stabilization method (SB)	0.06				
Storage (S)	0.04				
SB x S	0.11				

carbohydrates followed the order as control>chemical >roasting>hotairoven>autoclave>microwave (Table 7). Siswanti et al (2019) also reported lesser carbohydrate content in microwave stabilized wheat bran than ones subjected to hot air oven and autoclave. In comparison to autoclave stabilized wheat bran, roasted wheat bran samples exhibited higher available carbohydrate content. This is consistent with the findings of Fahmida et al (2019) where higher carbohydrate in rice bran samples stabilized by roasting. Available carbohydrate content of wheat bran samples stabilized by roasting exhibited higher carbohydrate content than those stabilized by hot air oven and microwave, which was quite consistent with the findings of El-Hady (2013) in stabilized rice bran. Available carbohydrate content of chemical treated wheat bran was higher than autoclave and control.

Phytic acid: Phytic acid content of fresh wheat bran was 39.69 mg per g, which is comparable with the results reported by Kaur et al (2011a). All the stabilization methods resulted in a significant decrease in phytic acid content (Table 8). The reason behind this decline might be due to heat liable nature of phytic acid (Kaur et al 2011b). Ertas (2016) also reported similar decrease in phytic acid content of wheat bran stabilized with microwave, hot air oven and autoclave. Laukova et al (2020) also reported the maximum reduction in phytic acid content of microwave stabilized wheat bran than hot air oven, similar to the present study. Roasting of wheat bran resulted in significantly higher reduction in phytic acid content of wheat bran than autoclave. The findings for chemical treated wheat bran is supported by Zhonget al (2015).

Minerals: Wheat bran is a good source of minerals which are present in varied amounts. Minerals found in higher amounts are phosphorous and magnesium. Stabilization of wheat bran resulted in a significant increase in the calcium, phosphorous, and magnesium content (Table 9). Faria et al (2012) also reported increase in mineral content of stabilized

Table 7. Effect of stabilization methods and storage period on available carbohydrates (%) of wheat bran

Stabilization method	Storage days				Mean
	0	30	60	90	
Control	67.30	67.74	68.13	68.49	67.91
MW	63.45	63.68	63.96	64.56	63.91
HAO	65.57	66.38	66.85	67.19	66.50
AC	64.43	65.01	65.61	65.88	65.23
RO	66.54	67.12	67.81	68.17	67.41
CH	66.88	67.43	67.98	68.38	67.67
Mean (Storage)	65.60	66.23	66.72	67.11	

CD (p=0.05)
Stabilization method (SB) 0.04
Storage (S) 0.03
SB x S 0.08

Table 8. Effect of stabilization methods and storage period on phytic acid (mg/g) of wheatbran

Stabilization method	Storage days				Mean
	0	30	60	90	
Control	39.69	37.27	35.42	33.31	36.42
MW	16.45	14.12	12.67	10.95	13.55
HAO	18.92	16.78	14.49	11.59	15.44
AC	19.47	17.86	15.84	13.34	16.62
RO	18.72	16.31	14.23	11.29	15.13
CH	21.78	19.22	17.45	15.47	18.48
Mean (Storage)	22.50	20.26	18.35	15.99	

CD (p=0.05)
Stabilization method (SB) 0.03
Storage (S) 0.03
SB x S 0.06

rice bran. Increase in the mineral content of wheat bran due to stabilization methods might be attributed to reduction in anti-nutritional factors, which are inhibitors of mineral absorption, thereby increasing the mineral extractability and bioavailability (Nkundabombi et al 2016). Ertas (2016) observed that microwave stabilized wheat bran samples had significantly higher mineral content than hot air oven and autoclave samples.

Total dietary fibre: The total dietary fibre content of wheat bran increased significantly across all the stabilization methods (Table 10). This increase in total dietary fibre content due to stabilization might be attributed to either aggregation of proteins or formation of protein fibre complexes that remains resistant to protease treatment during determination of fibre content of sample, or it is believed that thermal processing made a small amount of the starch less available to enzymes that might cause increase in total dietary fibre. On assessing the mean total dietary fibre content of stabilized wheat bran, microwave stabilized wheat bran reflected higher total dietary fibre content and chemical treated wheat bran reflected lower total dietary fibre in contrast to other stabilization methods that are similar to findings of Premkumari et al (2012). The results for higher total dietary fibre content in microwave than autoclave has been confirmed by Dong et al (2019).

Color: Color is an important characteristic for determining the consumer acceptance of any product. The color is measured in three coordinates: L^*, a^* and b^*. The L^*, a^* and b^* values for freshly milled wheat bran were recorded as 58.50, 3.65 and 15.75, respectively, which were similar to the results reported by Sharma et al (2014) in wheat bran. Stabilization methods resulted in a decreased L^* value and increased a^* and b^* values (Table 11). The decrease in L^* value due to stabilization might be due to the fact that heat treatment causes the maillard reaction between sugar and protein content of bran by generation of certain browning products

Table 9. Effect of stabilization methods and storage period on mineral content (mg/100 g) of wheat bran

SB		0	30	60	90	Mean
Control	Ca	542.21	542.17	542.10	541.95	542.11
	P	641.10	641.03	640.95	640.89	640.99
	Mg	333.90	333.82	333.70	333.56	333.74
MW	Ca	547.45	547.41	547.37	547.29	547.38
	P	645.32	645.28	645.23	645.18	645.25
	Mg	340.47	340.41	340.33	340.23	340.36
HAO	Ca	545.74	545.69	545.63	545.58	545.66
	P	643.67	643.61	643.58	643.53	643.60
	Mg	338.70	338.62	338.50	338.35	338.54
AC	Ca	543.79	543.74	543.68	543.63	543.71
	P	642.56	642.51	642.47	642.41	642.49
	Mg	336.52	336.47	336.36	336.20	336.39
RO	Ca	546.74	546.70	546.64	546.58	546.66
	P	644.34	644.29	644.25	644.18	644.26
	Mg	339.28	339.21	339.12	339.00	339.15
CH	Ca	542.43	542.39	542.34	542.28	542.36
	P	642.21	642.17	642.09	642.00	642.12
	Mg	334.45	334.36	334.24	334.06	334.28
Mean	Ca	544.72	544.68	544.63	544.55	
	P	643.20	643.15	643.09	643.03	
	Mg	337.22	337.14	337.04	336.90	
CD (p=0.05)		Stabilization method (SB)	Storage (S)	SB x S		
	Ca	0.06	0.05	NS		
	P	0.07	0.05	NS		
	Mg	0.05	0.04	NS		

(Kim et al2014). An increase in b* value in treated wheat bran than untreated bran might be due to lesser rate of lipid oxidation reactions in stabilized bran, since lipid degradation is directly proportional to carotenoid degradation (Jia et al 2007). Our findings are supported by Kaur et al (2011b) in cereal brans. Gopinger et al (2015) reported similar results while studying the whole rice stabilization using short chain organic acid mixture. Thanonkaew et al (2012) also reported

Table 10. Effect of stabilization methods and storage period total dietary fibre (%) of wheat bran

Stabilization method	Storage days				Mean
	0	30	60	90	
Control	44.50	41.72	37.70	32.95	39.22
MW	50.23	48.15	45.86	42.76	46.75
HAO	46.90	44.65	42.13	38.78	43.12
AC	46.45	44.10	41.15	38.02	42.43
RO	48.70	46.52	44.10	40.85	45.04
CH	45.10	42.35	38.50	34.38	40.08
Mean (Storage)	46.98	44.58	41.57	37.96	

CD (p=0.05)	
Stabilization method (SB)	0.06
Storage (S)	0.04
SB x S	0.11

Table 11. Effect of stabilization methods and storage period on L*, a*, and b* value of wheat bran

SB		0	30	60	90	Mean
Control	L*	58.50	56.25	54.76	52.29	55.45
	a*	3.65	3.71	3.89	4.10	3.84
	b*	15.75	16.10	16.53	16.76	16.28
MW	L*	56.65	54.86	51.79	48.28	52.89
	a*	4.16	4.29	4.43	4.58	4.36
	b*	16.91	17.19	17.34	17.65	17.27
HAO	L*	50.25	48.75	42.10	39.87	45.24
	a*	4.49	4.68	4.85	5.01	4.76
	b*	17.36	17.62	17.89	18.03	17.72
AC	L*	53.20	50.46	46.47	43.87	48.50
	a*	4.37	4.57	4.76	4.89	4.65
	b*	17.12	17.28	17.51	17.82	17.43
RO	L*	42.84	39.28	35.40	31.96	38.87
	a*	4.93	5.29	5.44	5.70	5.34
	b*	17.78	17.96	18.29	18.47	18.12
CH	L*	47.50	44.57	40.78	36.14	42.25
	a*	4.72	4.96	5.21	5.47	5.09
	b*	17.54	17.79	17.96	18.25	17.88
Mean	L*	51.16	49.03	45.22	42.07	
	a*	4.39	4.58	4.76	4.96	
	b*	17.10	17.32	17.58	17.83	

CD (p=0.05)	Stabilization Method (SB)	Storage (S)	SB x S
L*	0.06	0.04	0.09
a*	0.07	0.04	0.11
b*	0.06	0.04	0.15

decrease in L* value and increase in a* value by microwave heating during stabilization of rice bran.

Storage studies: On accessing the storage mean vales, a significant reduction was recorded in crude protein, crude fat, ash, crude fibre, total dietary fibre, phytic acid while moisture and available carbohydrates increased. With increase in storage period, increase in moisture content might be attributed to hygroscopic nature of wheat bran and storage environmental conditions (Nagi et al 2012). Decrease in crude protein content with increase in storage period might be attributed to gain in moisture, resulting in hydrolysis of peptide bonds with the help of protease enzyme, that cause splitting of protein molecules (Kumar and Thakur 2017)**.** During the 90 days of storage, ash content decreased from initial level of 5.87 to 5.58%. Interaction with other food components like protein and carbohydrates during storage might be responsible for decrease in ash content (Akhter et al 2005). The decrease in crude fat content during storage might be attributed to increase in moisture content that influences the activity of endogenous enzyme lipase and lipoxygenase to a great extent, which splits fat into fatty acids and glycerol (Akhter et al 2005). With the increase in storage period, crude fiber and total dietary fibre decreased significantly, which might be attributed to degradation of structural polysaccharides and also dietary fibre becomes less recognizable due to breakage of weak bonds between polysaccharide chains and glycosidic linkages (Sharon and Usha, 2006). Phytic acid content decreased with the increase in storage period from 22.50 to 15.99 mg per g. This decrease in phytic acid content with the increase in storage period might be attributed to increased metabolic activity, inactivation of phytase and membrane degradation.

Storage studies of stabilized wheat bran revealed a significant decrease in L* value from an initial mean level of 51.16 to 42.07 while a* and b* values increased from 4.39 to 4.96 and 17.10 to 17.83, respectively, during 90 days of storage. This might be due to lipid oxidation and Maillard reaction that results in decrease in lightness of bran and an increase in yellowness and redness during storage (Park et al 2012). Similar results for color value were reported by Kim et al (2014) who reported decrease in L* value and an increase in a* and b* value in rice bran during storage.

CONCLUSION*:*

The stabilization of wheat bran resulted in increase in proximate constituents viz., crude protein, fat and ash and decrease in moisture and carbohydrates. Furthermore, increase was observed in total dietary fibre, calcium, phosphorous and magnesium and decrease in phytic acid content. All the stabilization methods resulted in increase in proximate composition, but Microwave stabilization method was most effective in increasing crude protein, fat, ash, minerals, total dietary fibre without affecting the physical appearance of wheat bran.

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