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Effect of Storage Period and Packaging on the Shelf Life of Cereal Bran Incorporated Biscuits

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ABSTRACT

Both full fat and defatted cereal brans were blended with wheat flour at different levels to prepare nutritive biscuits. Product making, sensory and texture quality were assessed to find out the most appropriate level of bran incorporation. On the basis of quality (spread ratio and sensory by a panel of judges), 20% level was selected best. Acceptability of enriched biscuits was affected with progressive storage, however, the product remained in high acceptability range upto 3 months. Free fatty acids content of biscuits were within permissible limits after three months of storage except rice bran (full fat) biscuits. Packaging material had significant impact on biscuit quality. The biscuits were stored safely in both packaging material i.e., HDPE and laminate. Microbiological study depicted that microbial count was far below the permissible limits upto three months of storage of biscuits in HDPE and laminate at room temperature. Economics of enriched biscuits revealed that wheat bran enriched biscuits were economically profitable.

Key words: Cereal brans, packaging, storage, cost analysis, wheat flour

INTODUCTION

Bakery products are becoming increasingly popular in India due to their convenience, unique taste and easy availability at reasonable cost. Among bakery products, biscuits/cookies and crackers are the most popular and versatile snack foods and widely consumed to satisfy the occasional 'pangs' of hunger and are an integral part of the society.

There is an ever growing demand for high protein biscuits for therapeutic value (Agarwal, 1990). Protein calorie malnutrition is widely prevalent amongst the lower income population in India (Rajor *et al*., 1989). Townsend and Buchanan (1967) have developed high protein milk biscuits which had not only a long shelf-life but also facilitated easy transport, storage and distribution, thereby leading to its use as an emergency food at the time of natural disasters. The enrichment of protein in biscuits may be achieved through incorporation of protein rich ingredients (McWatters, 1978).

Cereal brans, the by-products obtained in large amounts in grain milling industry, considered as inedible material for humans, is mostly used as animal feed. However, brans are concentrated source of dietary fibre and other nutrients (proteins, B-vitamins and minerals). Rice bran is rich in protein, lipids, fibre, minerals (e.g., Mg, K, Fe, Mn) and B-vitamins. Rice bran is also an excellent source of choline and insitol (Hoffpauer *et al*., 2005). Rice bran contains hemi-cellulose which were shown to bind bile acids *in vitro* and *vivo* in rats (Kestin *et al*., 1990). Corn bran is high in TDF, low in calories (approximately 40 kcal/100 g). Corn bran exhibits water holding capacity of

approximately 2.4:1. The ability to retain water may increase the shelf-life of some products and also aids in calorie reduction (Burge and Duensing, 1989). Oat bran is considered good source of soluble fibre, the major portion of which is β-D glucan, a hemicellulose (Seibert, 1987). Plasma, total and low-density lipoprotein (LDL) concentrations were significantly lowered by oat bran. Total dietary fibre content of malted barley products ranges from 35-65% (primary insoluble fibre). Wheat bran increases the intestinal transit time, stool weight and stool frequency. Fecal bulking and improved regularity have been associated with wheat bran and other insoluble dietary fibres (Kahlon and Chow, 1997).

Today's consumer is becoming more concerned about the health benefits of reduced calories and consuming additional proteins and dietary fibre in the diet. Low calorie products rely on the addition of high bulking agent that have high moisture absorption resulting in reducing calories by one third. Diabetes, blood pressure and malnutrition are the major health problems of the majority of the Indian population and those suffering from them need high protein, high fibre and low calorie diet. Cereal brans are considered desirable for human consumption due to reported health benefits. Extensive research reviewed by Kahlon and Chow (1997) has shown that incorporating rice bran in the diet results in plasma and liver cholesterol reductions that lower the risk of cardiovascular disease. Therefore, biscuits can be identified as carrier for supplementation and source for additional dietary fibre, protein, vitamins and minerals.

Enrichment of cereal-based foods with oil seed protein has received considerable attention. There has been a trend to incorporate bran from various sources into cereal products such as high protein- fiber source (Hegazy and Ibrahim, 2009). Intake of high dietary fiber is associated with lower risk of coronary heart disease, colon cancers and bowel disorders (O'Connor *et al*., 2003). Supplementation of biscuits with rice bran which has been noted for its high dietary fiber, is advantageous (Alobo, 2007). Therefore, it is important to meet the consumers' wish for convenience and healthy foods in addition to potential utilization of milling industry by-products as fibre and nutrient source.

A diet rich in whole-grain foods provides protection against some chronic diseases, including cardiovascular diseases, diabetes and many types of cancer. During milling, the bran and germ layers are removed and the remaining starchy endosperm which contains few antioxidant compounds is ground into flour to make various products. Whole-grain products, on the other hand, retain bran and germ which provide biologically active antioxidants that may act independently or synergistically with fibre to reduce the risk of a number of diseases (Decker *et al*., 2002). The role of dietary fibre in controlling chronic disorders like diverticulitis, bowel cancer, cardiovascular diseases, diabetes, constipation etc. has been well documented (Painter and Burkitt, 1975).

Now a days, consumers have been looking for food ingredients that are more natural and healthy. Trends in last few decades have shown emergence of health food category found in super markets. Baked products are considered as excellent vehicle for fortification, value addition and feeding at mass scale. Keeping in view the above factors the present study was designed to incorporate various brans viz., wheat, rice, corn, barley and oat brans for making biscuits and to conduct consumer evaluation and shelf life studies for the selected samples.

MATERIALS AND METHODS

Materials

Raw materials used in the investigation: Wheat flour, wheat bran and oat bran were purchased from local market. Corn bran was purchased from 'Sukhjeet Starch and Chemical Ltd., Phagwara, Punjab, India. Rice bran was purchased from A.P. Solvex Pvt. Ltd., Dhuri, Punjab,

India. Barley bran was prepared by Laboratory milling of barley in the Department of Food Science and Technology, Punjab Agricultural University, Ludhiana. The milling was done with Buhler Pneumatic Laboratory Mill (MLU-202, Buhler Bros, Inc, UZWIL, Switzerland).

Other raw materials used in investigation

Full fat bran: Different cereal brans collected/procured were kept in pearlpet jars for further processing.

Defatted bran: Defatting of cereal brans (wheat, rice, corn, barley, oat) was done by using the solvent hexane. Hexane was added to the brans (3:1) in glass containers and kept for 24 h, there after the solvent was removed through filtration and brans dried to remove the traces of solvent.

Drying: Both the full fat and defatted cereal brans were dried in oven at 50°C for 1 h.

Grinding: The grinding of dried cereal brans was done to a uniform particle size using cemotac mill having setting at No. 1.

Sieving: The ground material was sieved through 48 mesh size to obtain uniform particle size and stored in pearlpet jars for subsequent study.

Methods

Physico-chemical composition of raw materials: Physico-chemical characteristics of wheat flour, cereal brans (wheat, rice, corn, barley, oat) and biscuits were determined using AACC (2000) methods.

Moisture content: Weighted samples (2 g) were dried in a hot air oven at 130+1°C for 1 h and moisture content in percent was calculated from loss of weight (AACC, 2000).

Mircobiological analysis: Total plate counts were recorded as per APHA (1984) procedure using nutrient agar.

Free fatty acids: Standard AOAC procedure (Anonymous, 2001) was followed with slight modification. Weighed sample was taken in flask. Added 50 mL benzene and kept for 30 min for extraction of free fatty acids. Took 5 mL extract in flask, added 5 mL benzene, 10 mL alcohol, phenolphthalein as indicator and titrated against 0.02 N KOH till light pink color disappeared.

$$\%FFA=\frac{282\times 0.02\ N\ KOH\times mL\ of\ alkali\ used}{(\%\ oleic\ acid)\ 1000\times weight\ of\ sample\ taken}\times dilution\ factor\times 100$$

Shelf life studies

Equilibrium moisture content: Equilibrium moisture content was determined by using static method of ERH (Hall, 1970), where an acid (H_2SO_4) solution was used for maintaining the desired relative humidity.

Storage: Prepared biscuits were packed in HDPE (200 gauge) and aluminium laminates and kept under ambient conditions. Evaluated for shelf life by estimating moisture content, free fatty acids, microbiological quality, sensory evaluation and textural quality at the regular intervals of one month over the period of three months.

Mass consumer acceptability: On the basis of sensory score, easy availability, shelf stability and high production, the wheat bran biscuits were finally selected for Mass Consumer Acceptability. Samples were distributed randomly and acceptability score (excellent, very good, good, fair or poor) was judged (n = 100).

Economics of high protein biscuits: Cost calculations were made only comparing the cost of raw materials, other things being equal and described in Rs kg^{-1} of biscuits.

Statistical analysis: The data collected in duplicate on different characteristics were analysed by completely randomized design. The Critical Difference (CD) was used as the test for significance (Singh *et al*., 1998). All results expressed at 14% moisture basis unless otherwise stated.

RESULTS AND DISCUSSION

Free fatty acid: The packaging material and storage period tangibly affected free fatty acid content of biscuits containing full fat cereal brans (Table 1).

The mean free fatty acid value (2.70%) was found to be significantly higher for rice bran fortified biscuits, whereas lowest mean values were obtained for oat bran biscuits (0.41%). Significant variations were observed in free fatty acid contents of different cereal bran added biscuits.

Packaging also manifested a conspicuous effect on the free fatty acid content of biscuits. The free fatty acid content was higher in the product packed in HDPE pouches, than the laminate pouches as evident from table values.

Kaur (2005) reported that formation of free fatty acids was higher in case of cookies stored in LDPE as compared to these stored in alumunium laminates and this could have been because of the fact that alumunium laminates protect biscuits against light, as light acts as catalyst for oxidation.

Table 1: Effect cereal brans (full fat), packaging materials and storage period on free fatty acid content (%) of biscuits

	High density polyethylene						Laminate						
Storage period (months)	Control	Wheat bran	Rice bran	Corn bran	Barley bran	Oat bran	Control	Wheat bran	Rice bran	Corn bran	Barley bran	Oat bran	Storage mean
0	0.39	0.50	2.50	0.60	0.50	0.36	0.39	0.50	2.50	0.60	0.50	0.36	0.81^{a}
1	0.48	0.61	2.67	0.70	0.56	0.39	0.41	0.59	2.58	0.64	0.53	0.38	0.88^{b}
2	0.50	0.69	2.89	0.74	0.60	0.42	0.49	0.65	2.70	0.72	0.59	0.40	0.95^{c}
3	0.58	0.73	2.92	0.80	0.63	0.50	0.53	0.70	2.80	0.78	0.63	0.47	1.01^{d}
Packaging mean	0.93^{b}						0.89^{a}						
Treatment mean control 0.47^{b}		Wheat bran 0.62^{d}		Rice bran 2.70^{f}		Corn bran 0.70^{e}		Barley bran 0.57^{c}		Oat bran 0.41^{a}			
CD (p≤0.05)													
Packaging (P)		0.009		Treatment (T) 0.01		Storage (S) 0.01		P×T		0.01			
P×S		0.02		T×S		0.03		P×T×S		0.04			

Mean values having same superscript do not vary significantly from each other, NS: Non significant

Apart from cereal brans and packaging, storage also demonstrated venerable effect on the free fatty acid contents of biscuits. There was a subsequent increase in the free fatty acid content of biscuits with storage. At 0 period the average free fatty acid content recorded for biscuits was 0.81%. It was found to increase considerably every month with mean value 1.01% after 3 months of storage.

Singh *et al.* (2000) studied that free fatty acid content of soy-fortified biscuits and reported its increase with storage period. The increase in FFA content of soy biscuits was due to greater increase in their moisture content which promoted fat hydrolysis during storage.

Moisture content: Table 2 represents the effect of cereal brans (full fat), packaging and storage on the moisture content of biscuits.

Different cereal brans had significant effect on the moisture content of biscuits. Identical values for moisture content (3.33) were observed in wheat bran and barely bran biscuits. Among the cereal bran biscuits, minimum values for moisture were observed in oat bran biscuits (3.14%) as compared to control biscuits which had 3.22% moisture.

Packaging was found to have a non significant effect on the moisture content. HDPE packed biscuits had 3.27% moisture, whereas laminate had 3.24% moisture. Rao *et al.* (1995) reported that biscuits packed in metallised polyester or biaxally oriented polypropylene had higher moisture content than those packed in paper-aluminium foil polyethylene laminate pouches. Biscuits packed in laminate pouches absorbed lesser moisture during storage which might have been due to the impervious nature of aluminium foil in the laminate to air and water vapour.

Storage was found to have a noteworthy effect on the moisture content of biscuits. The mean percent moisture of biscuits at the beginning of storage was 2.23% which increased significantly to 4.09% as the storage period approaches three months. The above observations indicated that moisture was absorbed during three months of storage by the biscuits. The gain in moisture content might be due to hygroscopic nature of dried product, storage environment (temperature, relative humidity) as well as the nature of packaging material. This outcome is well supported with the observations of Robertson (1993). Leelavathi and Rao (1993) stated that higher moisture pick up of biscuits containing bran during storage could be due to greater hygroscopicity of wheat bran. The interaction of packaging and storage time was found to be significant ($p \leq 0.05$) for the moisture content.

Table 2: Effect of cereal brans (full fat), packaging materials and storage period on moisture content (%) of biscuits

	High density polyethylene						Laminate						
Storage period (months)	Control	Wheat bran	Rice bran	Corn bran	Barley bran	Oat bran	Control	Wheat bran	Rice bran	Corn bran	Barley bran	Oat bran	Storage mean
0	2.00	2.10	2.60	2.13	2.60	2.00	2.00	2.10	2.60	2.13	2.60	2.00	2.23[a]
1	2.85	3.20	3.30	2.90	3.00	2.70	2.74	3.15	3.25	3.33	2.95	2.64	3.00[b]
2	3.91	3.98	3.59	3.50	3.71	3.70	3.80	3.91	3.51	3.43	3.70	3.62	3.70[ab]
3	4.28	4.15	3.77	4.23	4.05	4.26	4.20	4.09	3.73	4.19	4.00	4.20	4.09[d]
Packaging mean			3.27						3.24				
Treatment mean control 3.22[b]		Wheat bran 3.33[c]		Rice bran 3.29[c]		Corn bran 3.23[b]		Barley bran 3.33[c]		Oat bran 3.14[a]			
CD ($p \leq 0.05$)													
Packaging (P)		NS		Treatment (T) 0.05		Storage (S) 0.07		P×T		NS			
P×S		NS		T×S		0.14		P×T×S		NS			

Mean values having same superscript do not vary significantly from each other, NS: Non significant

Table 3: Effect of cereal brans (full fat), packaging materials and storage period on the microbial quality (cfu/g) of biscuits

Storage period (months)	High density polyethylene: Control	Wheat bran	Rice bran	Corn bran	Barley bran	Oat bran	Laminate: Control	Wheat bran	Rice bran	Corn bran	Barley bran	Oat bran	Storage mean
0	0	0	0	0	0	0	0	0	0	0	0	0	0^{a}
1	1.25×10^{2}	1.75×10^{2}	3.00×10^{2}	1.30×10^{2}	0.75×10^{2}	1.50×10^{2}	1.25×10^{2}	2.85×10^{2}	4.00×10^{2}	1.75×10^{2}	1.20×10^{2}	2.90×10^{2}	$1.98^{ab}\times10^{2}$
2	5.55×10^{2}	2.00×10^{2}	4.10×10^{2}	3.55×10^{2}	3.40×10^{2}	1.85×10^{2}	5.05×10^{2}	3.45×10^{2}	4.90×10^{2}	3.05×10^{2}	4.00×10^{2}	4.50×10^{2}	$3.73^{b}\times10^{2}$
3	60.50×10^{2}	76.00×10^{2}	79.00×10^{2}	82.50×10^{2}	75.00×10^{2}	25.00×10^{2}	47.50×10^{2}	73.00×10^{2}	78.50×10^{2}	68.00×10^{2}	56.00×10^{2}	52.50×10^{2}	$62.92^{c}\times10^{2}$
Packaging mean			17.87×10^{2}						17.26×10^{2}				

Treatment mean control $15.26^{b}\times10^{2}$ Wheat bran $19.76^{c}\times10^{2}$ Rice bran $21.68^{c}\times10^{2}$ Corn bran $20.01^{c}\times10^{2}$ Barley bran $17.54^{b}\times10^{2}$ Oat bran $11.15^{a}\times10^{2}$

CD (p≤0.05)

Packaging (P)	NS	Treatment (T)	Storage (S)	P×T	NS
		1.98×10^{2}	2.43×10^{2}		
P×S	3.44×10^{2}	T×S	4.87×10^{2}	P×T×S	6.88×10^{2}

Mean values having same superscript do not vary significantly from each other, NS: Non significant

Microbial quality: The data presented in Table 3 reveals, how the packaging material and storage period influenced the microbial quality of full fat cereal bran biscuits.

The total plate count on nutrient agar medium was found nil for fresh biscuits before storage of different cereal bran biscuits under ambient conditions. Oat bran biscuits had least bacterial count (11.15×10^{2} cfu g^{-1}) whereas rice bran biscuits had maximum bacterial count (21.68×10^{2} cfu g^{-1}).

Packaging material had non-significant effect on the microbial quality of biscuits, however, growth was observed more in biscuits packed in HDPE than the laminate packed biscuits. Storage period showed significant effect on the microbial quality of biscuits. The count increased from 1.98×10^{2} cfu g^{-1} to 62.92×10^{2} cfu g^{-1} after three months of storage. The increase in microbial load as the storage period lengthened might have been due to a corresponding increase in moisture content during storage.

Microbiological studies indicated that the cereal bran biscuits packaged in HDPE and laminates and placed at room temperature upto 3 months had better stability as the microbial load remained within the permissible limits. According to Indian standards, total bacterial count/g should not be more than 50,000 in high protein biscuits.

Free fatty acids: Free fatty acid content of biscuits prepared from defatted cereal brans as influenced by packaging material and storage period is given in Table 4.

Significant variations were noticed in free fatty acids content of different cereal bran biscuits. The biscuits prepared from corn bran had higher values for free fatty acids (0.57%) followed by biscuit containing rice bran (0.51%). Whereas, wheat bran biscuis had lowest content of free fatty acids (0.39%). Free fatty acids content of barley and oat brans biscuits were similar (0.44%).

Packaging material had significant effect on free fatty acids content of biscuits. HDPE packed biscuits showed significantly higher values for the mean free fatty acids content of biscuits (0.48%), while biscuits packed in laminate pouches were less in free fatty acids content (0.46%). This might be attributed to the protective effect of foil laminate. Statistically significant variation for free fatty acid content of biscuits was noticed upto 3 months of storage period where, the mean values were 0.39 (0 month) and 0.55 (after 3 month). Noteworthy increase in percent free fatty acids content was recorded with the lengthening of storage period. Kaur (2005) stated that free fatty acid was

Table 4: Effect of cereal brans (defatted), packaging materials and storage period on free fatty acid content (%) of biscuit

	High density polyethylene						Laminate						
Storage period (months)	Control	Wheat bran	Rice bran	Corn bran	Barley bran	Oat bran	Control	Wheat bran	Rice bran	Corn bran	Barley bran	Oat bran	Storage mean
0	0.39	0.31	0.42	0.47	0.36	0.39	0.39	0.31	0.42	0.47	0.36	0.39	0.39[a]
1	0.48	0.39	0.49	0.55	0.42	0.44	0.41	0.35	0.46	0.53	0.40	0.42	0.45[b]
2	0.50	0.42	0.55	0.64	0.47	0.46	0.49	0.40	0.52	0.59	0.46	0.45	0.50[c]
3	0.58	0.50	0.62	0.68	0.51	0.47	0.53	0.46	0.59	0.66	0.50	0.46	0.55[d]
Packaging mean			0.48[b]						0.46[a]				
Treatment mean control 0.47[c]		Wheat bran 0.39[a]		Rice bran 0.51[d]			Corn bran 0.57[e]			Barley bran 0.44[b]		Oat bran 0.44[b]	
CD (p≤0.05)													
Packaging (P)		0.05		Treatment (T) 0.007			Storage (S) 0.009			P×T		0.01	
P×S		NS		T×S			0.01			P×T×S		NS	

Mean values having same superscript do not vary significantly from each other, NS: Non significant

Table 5: Effect of cereal brans (defatted), packaging materials and storage period on moisture content (%)of biscuits

	High density polyethylene						Laminate						
Storage period (months)	Control	Wheat bran	Rice bran	Corn bran	Barley bran	Oat bran	Control	Wheat bran	Rice bran	Corn bran	Barley bran	Oat bran	Storage mean
0	2.00	2.70	2.40	2.30	1.90	1.50	2.00	2.70	2.40	2.30	1.90	1.50	2.13[a]
1	2.85	3.65	3.29	3.49	2.66	2.55	2.74	3.56	3.20	3.45	2.57	2.48	3.04[b]
2	3.91	4.01	4.00	3.69	3.29	3.21	3.80	3.90	3.88	3.58	3.09	2.98	3.61[c]
3	4.28	4.28	4.23	4.19	3.89	3.65	4.20	4.19	3.98	4.00	3.78	3.50	4.01[d]
Packaging mean			3.24[b]						3.15[a]				
Treatment mean control 3.22[c]		Wheat bran 3.62[f]		Rice bran 3.42[e]			Corn bran 3.37[d]			Barley bran 2.88[b]		Oat bran 2.67[a]	
CD (p≤0.05)													
Packaging (P)		0.005		Treatment (T) 0.008			Storage (S) 0.01			P×T		0.01	
P×S		0.01		T×S			0.02			P×T×S		0.02	

Mean values having same superscript do not vary significantly from each other, NS: Non significant

higher in case of "atta" stored in LDPE as compared to According to ISI specifications (IS:7487) the acidity of fat as 1.5% (maximum) for high protein biscuits. FFA content of all biscuits were within the range except rice bran biscuits (2.70%).

In the present investigation, statistical analysis revealed a significant interaction ($p<0.05$) between cereal brans, packaging and storage for free fatty acid content of biscuits (Table 5).

Moisture content: Table 5 delineate the effect of cereal brans (defatted), packaging and storage on the moisture content of biscuits. Different cereal brans were found to have a definite effect on the moisture content of biscuits. The mean moisture content in wheat bran biscuits (3.62%) was found to be higher than other cereal bran biscuits. Oat bran biscuits had lowest value of moisture (2.67%). Control biscuits contained 3.22% moisture content. However, packaging remarkably affected the moisture content of biscuits. The mean moisture (3.24%) recorded for HDPE packed product was significantly higher (3.15%) than that observed for laminate packed biscuits. Storage of biscuits (packed in either packaging material) prominently affected the mean moisture of the same. The mean value of moisture was recorded to be 2.13% for the fresh biscuits. Therefore, the mean moisture increased significantly to 3.04, 3.61 and 4.01% after 1, 2 and 3 months of storage,

respectively. Higher moisture uptake in the polyethylene pouches might be due to their permeability to moisture and air. Paine (1969) had also mentioned that aluminium foil had less water vapour transmission rate as compared to polyethylene. The interaction between packaging, cereal brans and storage period had significant effect ($p \leq 0.05$).

Microbial quality: Table 6 depicts the microbial quality of defatted cereal bran biscuits stored in different packaging materials.

Microbial count was varied significantly among the cereal bran biscuits. Rice bran biscuits found to have higher count (20.52×10^2 cfu g^{-1}), whereas corn bran biscuit had least count (11.35×10^2 cfu g^{-1}). Packaging material had significant effect on microbial count of biscuits. HDPE packed biscuits had maximum count (16.96×10^2 cfu g^{-1}) than laminate packed biscuits (15.68×10^2 cfu g^{-1}).

Significant variation was observed in the microbial count during the storage period. The total plate count on nutrient agar medium was detected in different cereal bran biscuits after one month of storage. The count was observed in range 2.20×10^2 to 59.54×10^2 cfu g^{-1}. Microbial count of defatted cereal bran biscuits remained within the permissible limits.

The interactions between packaging and cereal brans, as well as cereal brans and storage were significant but the interaction between packaging and storage was non-significant.

Mass consumer acceptability: Biscuits containing 20% wheat bran were selected for mass consumer acceptability. Fifty one percent consumers rated the product as excellent whereas 39 and 10% rated it as very good and good, respectively. Therefore, it is evident from data that the biscuits can be enriched with cereal brans, produced abundantly in the state through milling of grains.

Economics of high protein biscuits: Economics calculations of prepared biscuits are presented in Table 7a and b. The cost of wheat flour biscuits prepared in the laboratory was Rs. 45.41 kg^{-1}. Among the different cereal bran biscuits wheat bran biscuits had lesser cost i.e. Rs. 42.51 kg^{-1}, whereas oat bran biscuits had higher cost Rs. 43.22 kg^{-1}. The cost of cereal bran biscuits ranged from Rs. 42.51 to 43.22 kg^{-1}. The cost of cereal bran biscuits were lower because the cost of cereal

Table 6: Effect of cereal brans (defatted), packaging materials and storage period on the microbial quality (cfu/g) of biscuits

Storage period (months)	High density polyethylene: Control	Wheat bran	Rice bran	Corn bran	Barley bran	Oat bran	Laminate: Control	Wheat bran	Rice bran	Corn bran	Barley bran	Oat bran	Storage mean
0	0	0	0	0	0	0	0	0	0	0	0	0	0^{a}
1	1.25×10^2	2.00×10^2	1.50×10^2	1.30×10^2	3.50×10^2	3.0×10^2	1.25×10^2	1.85×10^2	1.50×10^2	2.75×10^2	3.20×10^2	3.40×10^2	$2.20^{ab} \times 10^2$
2	5.55×10^2	2.00×10^2	4.35×10^2	3.55×10^2	3.50×10^2	3.50×10^2	5.05×10^2	2.45×10^2	2.35×10^2	2.75×10^2	3.40×10^2	4.50×10^2	$3.55^{b} \times 10^2$
3	60.50×10^2	76×10^2	78.50×10^2	40.50×10^2	58.00×10^2	59.00×10^2	47.50×10^2	74.00×10^2	76.00×10^2	40.00×10^2	51.00×10^2	52.50×10^2	$59.54^{c} \times 10^2$
Packaging mean			$16.96^{b} \times 10^2$						$15.68^{a} \times 10^2$				

Treatment mean control $15.26^{b} \times 10^2$ Wheat bran $19.76^{c} \times 10^2$ Rice bran $20.52^{c} \times 10^2$ Corn bran $11.35^{a} \times 10^2$ Barley bran $15.31^{b} \times 10^2$ Oat bran $15.73^{b} \times 10^2$

CD ($p \leq 0.05$)

Packaging (P)	0.87×10^2	Treatment (T)	Storage (S)	P×T	1.75×10^2
		1.23×10^2	1.51×10^2		
P×S	NS	T×S	3.03×10^2	P×T×S	NS

Mean values having same superscript do not vary significantly from each other, NS: Non significant

Table 7a: Cost calculations of wheat flour biscuits

Ingredients	Quantity	Rate (Rs/Kg)	Total cost (Rs)
Wheat flour	1 Kg	20.00	20.00
Sugar	450 g	25.00	11.25
Shortening	500 g	60.00	30.00
Baking powder	3 g	180.00	0.54
Eggs	60 g	2.00*	4.00
Liquid glucose	20 g	100.00	2.00
Salt	5 g	9.25	0.05
Skim milk powder	20 g	150.00	3.00
Vanilla essence	5 ml	20.00**	5.00
Ammonium bicarbonate	4 g	257.00	1.03
Sodium bicarbonate	2 g	167.00	0.33
Water	Optimum (5 mL)	-	-
Total	2.07 kg	-	77.20 R

*Rate of eggs-@ 2/- per egg, **Rate of vanilla essence-@ 20/-per 20 mL pack

Table 7b: Cost comparison of wheat flour and cereal bran biscuits

	Actual weight of prepared biscuits (kg)	Rate (Rs kg^{-1}) cereal brans	Total cost (Rs)	Cost (Rs kg^{-1}) biscuits
Wheat flour biscuits	1.70	-	77.20	45.41
Wheat flour+20% wheat bran biscuits	1.75	6.00	74.40	42.51
Wheat flour+20% rice bran biscuits	1.73	7.00	74.60	43.12
Wheat flour+20% corn bran biscuits	1.75	6.50	74.50	42.57
Wheat flour+20% barley bran biscuits	1.72	4.00	74.00	43.02
Wheat flour+20% oat bran biscuits	1.74	10.00	75.20	43.22

brans is lower than wheat flour. The cost of wheat flour Rs. 20 kg^{-1}, whereas cost of cereal brans ranged between Rs. 6 to 10 kg^{-1}. There was not much variation in cost of wheat bran and corn bran biscuits. So the use of cereal brans in the preparation of biscuits is economical.

CONCLUSION

Based on these results and observations, it can be concluded that cereal brans (full fat and defatted) i.e., wheat, rice, corn, barley and oat brans as a source of dietary fibre and protein can be added without adversely affecting the physiochemical and sensory quality of biscuits. These types of baked products can go a long way in supplying the required quantities of dietary fibre and protein to various segments of our population and also results in profitable utilization of byproducts of milling industry.

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