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Analysis of Ingredients, Functionality, Formulation Optimization and Shelf Life Evaluation of High Fiber Bread

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ABSTRACT

The aim of this study was to analyze the ingredients, develop high fiber bread and evaluate its shelf life. Bread and baked products are the most important sources of dietary fiber in the total food consumption. The role of dietary fiber in controlling chronic disorders like diverticulitis, bowel cancer, cardiovascular diseases, diabetes, constipation etc has been well known. Chemical composition and functional properties of oat fiber and psyllium husk were studied by following standard AOAC methods and these were incorporated at levels of 0, 1, 2, 3, 4 and 5% in wheat flour on percentage weight basis for preparation of bread according to standard AACC methods. Best levels were selected on the basis of bread making and organoleptic properties. Oat fiber at 5% and Psyllium husk at 3% levels were selected. These breads were evaluated for visual examination of mold growth under refrigerated and ambient temperature conditions. Shelf life of these breads was found to be 5 days at room temperature.

Key words: Fiber, functional properties, mold growth, shelf life, chemical composition, diabetes

INTRODUCTION

India is a developing country with large segment of population depending on wheat and rice as staple foods which provide calories and protein. Grain has been a main contributor to human nutrition throughout the ages. Other cereal foods used to compute the average per capita consumption play only a minor-part in the total intake of dietary fiber; bread and baked products are the most important sources of dietary fiber in the total food consumption (Hans *et al*., 1986). The role of dietary fiber in controlling chronic disorders like diverticulitis, bowel cancer, cardiovascular diseases, diabetes, constipation etc. has been well documented (Painter and Burkitt, 1975). The dietary fiber content of baked goods may be increased by adding various plant components rich in dietary fiber, i.e., psyllium husk, oat fiber or wheat bran. Krishnan *et al*. (1986) carried out work on substitution of white wheat flour with 10 to 15% level of commercial oat bran to determine effect on dough properties and bread quality. Protein and dietary fibre analysis were conducted along with these assays to determine the efficacy of supplementation. The inclusion of bromate in the formula improved loaf volume, grain and texture of oat breads. A taste panel preferred 15% bran bread than 10% bran bread. Ahluwalia *et al*. (1995) studied that isabgol (Psyllium husk) at 3.0% level, lead to a non significant decrease in specific volumes of cake and bread and spread ratio of cookies. However, texture and grain structure of cake and bread were found to improve. They concluded that by supplementing atta and maida with isabgol upto 3.0%

level, cake, bread and cookies could be produced without affecting their acceptability. Singh *et al.* (2008) prepared protein concentrates from chick pea and found that they have potential use in food formulations owing to their good emulsifying/foaming and water/oil binding capacities. Kamaljit *et al.* (2010) studied that pea flour could be incorporated in bread and cookies upto 5.0% to improve the protein and fibre content without affecting the sensory quality. Charles (2005) found that use of dietary fibers alter food structure, texture and viscosity and hence the rate of starch degradation during digestion. Research illustrated an association between the rate of carbohydrate degradation during digestion and regulation of postprandial blood sugar and insulin levels. Sidsel *et al.* (2009) conducted a sensory profile of wheat and whole wheat pan bread to characterize sensory changes during a three week storage period. Results showed that storage time had a significant effect on aroma and flavor of both bread types. Burton and Manninen (1982) found that fiber made of psyllium husk improved bowl function and faecal output confirming its value as a non-irritant, harmless, bulk forming laxative. Yadav *et al.* (2010) prepared traditional Indian unleavened bread (chapati) by incorporating wheat bran and oat bran into whole wheat flour and recommended to incorporate 5.5 g wheat bran and 9.7 g oat bran per 100 g flour for making optimally acceptable fiber rich chapaties. The present study was conducted by incorporating oat fibre and psyllium husk at levels of 0, 1, 2, 3, 4 and 5% in wheat flour on percentage weight basis for preparation of bread. The major objectives of this study were:

- To study the physico-chemical composition and functional properties of wheat flour, oat fiber and psyllium husk
- To optimize the levels of oat fiber and psyllium husk on the basis of bread making and organoleptic properties of bread
- Shelf life of breads was studied on the basis of visual examination of mold growth under refrigerated and ambient temperature conditions

MATERIALS AND METHODS

Wheat flour was procured from M/s Luxmi Electric Roller Flour Mills, Ludhiana. Oat fibre and psyllium husk were purchased from local store. This study was conducted during years 2002-2005. Materials were procured fresh according to requirement from market during these years.

Other materials used in the investigations

Baker's yeast: Baker's yeast, i.e., prestige yeast (*Saccharomyces cerevisae*) manufactured by SAF yeast Co., Bombay was freshly obtained from a local store and kept in refrigerator for baking tests.

Fat: Bakery shortening (manufactured by: Amrit Vanaspati Ltd., Chandigarh Road, Rajpura-140401, Punjab) which had melting point of 37°C was obtained from the local market.

Sugar: Crystal cane sugar and ground sugar was purchased from the local store for use in bread and cookies.

Salt: Sodium chloride (BDH) was used in the study.

Leavening agent: Sodium bicarbonate was used as leavening agent in cookies preparation, manufactured by S.D Fine Chem. Ltd., Boisar-401506, India.

Oxidant: Potassium bromate (BDH-AR) was used as improver in bread making, manufactured by S.D. Fine Chem. Ltd., Boisar-401506, India.

Chemical composition of raw material: Standard AACC procedure (Anonymous, 1990) and AOAC procedure (Anonymous, 2001) were followed.

Functional properties

Oil absorption and hydration capacity: Oil absorption and hydration capacities were determined by the method of Rosario and Flores (1981). One gram sample was mixed with 10 mL distilled water or 10 mL oil (refined groundnut oil) for 30 sec in a mixer. The samples were then allowed to stand for 30 min at 30°C in a water bath and centrifuged at 3000 rpm for 20 min. The volume of supernatant was recorded to calculate the amount of hydration or oil absorption capacity.

Gelation: Least gelation concentration of samples was determined by the method of Iyen and Singh (1997). Sample suspension containing 8-15% (w/v) sample in 0.5% increments were prepared in 15 mL of distilled water. The test tubes were heated for 1 h in boiling water, rapidly cooled under running tap water and refrigerated for 3 h at 5°C. The least gelation concentration was determined as that concentration at which the sample did not fall down or slip from inverted test tube.

Bread: Straight dough AACC method (Anonymous, 1990) numbered 10-10 B was followed. The formula for control was as follows:

Ingredients	: Quantity (g)
Flour	: 100
Compressed yeast	: 3.0
Sugar	: 2.5
Bakery shortening	: 4.0
Salt/NaCl	: 1.5
Potassium bromate	: 10 ppm
Water	: Optimum (mL)

The dough was prepared and baking schedule as under was followed:

Mixing	: Optimum (3 min)
Fermentation	: 75 min (1.15 h)
Remixing	: 25 sec
Recovery	: 20 min
Sheeting and moulding	: ---------
Proofing (at 86°F, RH 75%)	: 55 min
Baking	: 25 min at 450°F

Experimental: The study was carried out by supplementing wheat flour with oat fibre at 0, 1, 2, 3, 4 and 5% and psyllium husk at 0, 1, 2, 3, 4 and 5% on flour weight basis for bread making.

Bread quality: The loaves were packed in polyethylene bags and analysed for volume, weight, specific volume and height. Sensory panel evaluation for appearance, crust color, crumb color, aroma, taste and overall acceptability was done next day by a panel of minimum six semitrained judges on nine point hedonic scale.

Bread storage: Breads were packed in polypropylene bags for shelf life study and kept at room and refrigerator temperature. During storage visual examination of mold growth was done over the period of 7 days at regular intervals.

Statistical analysis of data: The data collected on different characteristics were analysed with the help of factorial design in CRD (Piggot, 1987).

RESULTS AND DISCUSSION

Chemical composition and functional properties: Chemical composition and functional properties of Wheat flour, oat fibre and psyllium husk is given in Table 1 and 2, respectively. These materials regarding chemical composition were evaluated for moisture, protein, fat, ash, reducing sugars, non-reducing sugars, total sugars, starch, fibre and calorific value. Fibre content of oat fibre was found 15.0% and of psyllium husk- 8.1%. Functional properties studied were hydration capacity, oil absorption and least gelation concentration. Oil absorption of oat fibre was observed more whereas hudration capacity of psyllium husk was found more.

Effect of different levels of oat fibre and psyllium husk on bread making quality: Breads prepared after incorporation of oat fibre (0, 1.0, 2.0, 3.0, 4.0 and 5.0%) and psyllium husk (0, 1.0, 2.0, 3.0, 4.0 and 5.0%) showed statistically significant variations regarding baking absorption, loaf volume, loaf height and specific volume as tabulated in Table 3.

Increase in level of incorporation of oat fibre showed increase in baking absorption in comparison to control whereas oat fibre at 2.0% level showed maximum (72.5 mL) baking absorption and with increase in level of incorporation, baking absorption was found to decrease but was more than control (67.3 mL) at all incorporation levels. Handling of dough was smooth at all levels of incorporation of oat fibre. Non significant variations were observed regarding loaf weight of breads at different levels of incorporation of oat fibre. Loaf volume and loaf height decreased significantly with increase in level of incorporation of oat fibre whereas loaf volume at 1.0 and 2.0%

Table 1: Chemical composition of ingredients used in the study

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)	Starch (%)	Fibre (%)	Calorific value (Kcal/100 g)
Wheat flour	13.30	10.05	0.94	0.61	0.25	1.79	2.04	67.4	0.30	318.46
Oat fibre	6.89	0.20	0.15	3.05	0.38	1.22	1.60	52.1	15.0	210.55
Psyllium husk	10.56	0.40	0.15	2.28	0.28	0.30	0.58	30.4	8.10	124.55

Table 2: Functional properties of ingredients used in the study

Sample	Hydration capacity (mL g^{-1})	Oil absorption (mL g^{-1})	Least gelation concentration (w/v)
Wheat flour	1.70	0.90	8.0
Oat fibre	1.50	1.60	8.5
Psyllium husk	3.00	1.00	8.0

Table 3: Effect of different levels of oat fibre and psyllium husk on bread making quality

Sample	Levels (%)	Baking absorption (mL)	Dough handling	Loaf weight (g)	Loaf vol (cc)	Loaf height (cm)	Specific vol (cc g^{-1})
Control	0.0	67.3	Smooth	142.0	565.00	9.30	3.97
Oat fibre	1.0	72.0	Smooth	144.0	575.00	9.50	3.97
	2.0	72.5	Smooth	144.0	570.00	9.20	3.96
	3.0	71.0	Smooth	143.0	560.00	9.00	3.91
	4.0	71.0	Smooth	140.0	542.00	8.40	3.87
	5.0	71.5	Smooth	140.0	541.00	8.30	3.86
CD (0.05)		1.26	-	NS	1.77	1.77	0.17
Psyllium husk	1.0	69.5	Smooth	150.0	540.00	9.00	3.60
	2.0	69.3	Smooth	149.0	530.00	9.00	3.55
	3.0	72.0	Smooth	148.0	525.00	8.90	3.54
	4.0	72.0	Slightly tough	152.0	475.00	8.40	3.12
	5.0	72.0	Tough	152.0	445.00	7.90	2.92
CD (0.05)		1.32		NS	1.77	1.77	0.74
CD (0.05)		1.28		1.62	1.08	1.00	0.29

level of oat fibre incorporation was higher (575 and 570 cc, respectively) as compared to control (565 cc). Specific volume was also found to decrease with increase in level of incorporation of oat fibre. This might have been due to dilution of gluten protein.

Baking absorption increased with increase in level of incorporation of psyllium husk at increasing levels. The increase in baking absorption with addition of psyllium husk could be attributed to its high hydration capacity (3 mL g^{-1}) as mentioned earlier in Table 1. Significant observations were made regarding handling of dough. Upto 3.0% level of incorporation of psyllium husk, dough handling was smooth and beyond 3% level of incorporation dough handling was difficult. Loaf volume, loaf height and specific volume decreased with increase in level of incorporation of psyllium husk. In earlier studies, Ahluwalia *et al.* (1995) reported non-significant decrease in specific volume of bread. Liangli *et al.* (2003) reported that psyllium incorporation showed difficulty in handling of dough due to its gelling and water absorbing qualities. Park *et al.* (1997) substituted 7:3 (w/w) mixtures of wheat fibre and psyllium husk fibre for preparation of bread. The fibre bread showed a 10.0% reduction in loaf volume and a somewhat inferior crumb grain with an off flavour caused by small black specks on a dark grey background.

Effect of different levels of oat fibre and psyllium husk on organoleptic quality of bread: Statistically significant variations were observed regarding organoleptic quality (appearance, crust colour, crumb colour, aroma, taste and overall acceptability) of breads when evaluated by semitrained panel of judges on nine point hedonic scale (Table 4).

Oat fibre at increasing levels showed increase in scoring by panelists for all parameters regarding organoleptic quality. Maximum scores were given at 5.0% level of incorporation of oat fibre in bread. Panelists gave fewer score for appearance, crust colour, aroma and taste for oat fibre at 5.0% level of incorporation in comparison to control. Overall acceptability scores of oat bread at best level were less (7.79) in comparison to control (7.86). However, Mckechnie (1983) reported that oat flour could be substituted for as much as 30.0% of the wheat flour in bread. Krishnan *et al.* (1986) substituted white wheat flour with 10 to 15% level of commercial oat bran for bread quality and taste panel preferred 15% bran bread than 10% bran bread. But in this study 5.0% incorporation level of oat fibre was found best.

Table 4: Effect of different levels of oat fibre and psyllium husk on the mean panel scores (max 9) for sensory evaluation of bread

Sample	Levels (%)	Appearance	Crust colour	Crumb colour	Aroma	Taste	Overall acceptability
Control	0.0	7.66	8.16	7.66	7.83	8.00	7.86
Oat fibre	1.0	6.91	7.33	7.75	7.91	7.91	7.56
	2.0	6.50	7.33	7.75	7.66	8.00	7.44
	3.0	7.25	7.25	7.91	7.34	7.50	7.39
	4.0	7.41	7.50	8.08	7.58	7.83	7.68
	5.0	7.46	7.80	8.17	7.59	7.93	7.79
CD (0.05)		0.74	0.10	0.17	0.33	0.13	0.18
Psyllium husk	1.0	7.91	7.58	7.91	8.08	7.75	7.84
	2.0	7.91	7.58	7.75	7.75	7.75	7.84
	3.0	7.95	7.88	7.80	7.80	8.00	7.88
	4.0	7.25	7.08	7.41	7.41	7.75	7.38
	5.0	6.25	6.41	7.08	6.91	7.41	6.81
CD (0.05)		0.18	0.74	0.74	0.74	0.10	0.18
CD (0.05)		0.49	0.50	0.49	0.55	0.81	0.65

Table 5: Apparent spoilage (visual observation for mold growth) at room temperature (18.7-22.9°C) and refrigerator temperature (4°C) during storage of bread

		Days													
		1		2		3		4		5		6		7	
	Levels														
Bread	(g/100 g)	RT	RF	RT	RF	RT	RF	RT	RF	RT	RF	RT	RF	RT	RF
Control	0	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	+ve	-ve
Oat bread	5.0	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	+ve	-ve
Psyllium bread	3.0	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	+ve	-ve

RT: Visual spoilage recorded in bread stored at room temperature. RF: Visual spoilage recorded in bread stored at refrigerated temperature

Breads prepared with incorporation of psyllium husk were awarded more scores by panelists upto 3.0% level and showed better overall acceptability (7.88) in comparison with control (7.86). Crust colour of breads was given lower scores as compared to control (8.16) at different levels of incorporation of psyllium husk. This could have been because of appearance of black specks on dark brown background and these were increased with increase in levels of incorporation of psyllium husk. Similar results were reported by Park *et al.* (1997) that fibre bread showed somewhat inferior crumb grain with an off flavour caused by small black specks on a dark grey background. Ahluwalia *et al.* (1995) reported that supplementing wheat flour with psyllium husk upto 3.0% level produced acceptable quality of bread.

In this study the levels were selected on the basis of bread making and organoleptic quality of breads prepared after incorporation of oat fibre and psyllium husk. Oat fibre at 5.0% and psyllium husk at 3.0% levels of incorporation were selected.

Shelf life of bread: Shelf lives of selected levels of breads (on the basis of bread making and organoleptic quality) were studied. Breads were analysed for apparent spoilage by visual observation for mold growth under ambient temperature (room temperature) and refrigerated temperature (4°C) conditions (Table 5).

Spoilage of breads due to mold growth was observed during storage study. After packing, breads were stored under refrigerated and room temperature (18.7-22.9°C) conditions. Under refrigerated

conditions, no spoilage was recorded upto seventh day of storage. Whereas, at room temperature on fifth day of storage, oat bread and psyllium bread showed fungal growth. On 6th day of storage control bread also showed mold growth along with these breads. The baking process ordinary destroys all bacterial cells, yeast and mold spores (Frazier, 1967). Islam (1982) reported that loaves made without any preservative spoiled by the fifth day of storage.

CONCLUSION

Cereal based foods like bread is part of our daily diet and is excellent vehicle for addition of functional ingredients like oat fibre and psyllium husk to increase the fibre content. These formulations can be easily adopted by the bakeries to prepare value added health foods required by a particular segment of population who are health conscious and consider food as medicine. Oat fibre at 5% level and psyllium husk at 3% level of incorporation was optimised on the basis of bread making and organoleptic quality of bread. Shelf life of these breads was found to be 5 days at room temperature conditions.

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