J Food Sci Technol (March–April 2010) 47(2):166–173
DOI: 10.1007/s13197-010-0036-y

ORIGINAL ARTICLE

Effect of fiber incorporation on rheological and *chapati* making quality of wheat flour

Yadav D. N. · Rajan A. · Sharma G. K. · Bawa A. S.

Revised: 28 July 2009 / Accepted: 3 August 2009

Abstract Traditional Indian unleavened bread (*chapati*) was prepared by incorporating wheat bran (insoluble fiber) and oat bran (soluble fiber) at different levels into whole wheat flour. Central composite rotatable design with 2 independent variables (wheat bran and oat bran) at 5 levels (wheat bran 3–9, oat bran 6–12%) was used to design the experiments. The flour samples containing different concentration of bran were analysed for pasting and mixing characteristics. Wheat bran had a negative (p 0.05) ef fect on peak viscosity, break down and final viscosity, whereas oat bran had a positive (p 0.05) ef fect on set back and final viscosity. Among mixing characteristics, the peak value was negatively affected (p 0.05) with increase in the level of both variables. Both variables had positive (p 0.05) ef fect on hardness of chapati while the cohesiveness, chewiness and overall acceptability scores were negatively affected. Based on compromise optimization, it is recommended to incorporate 5.5 g wheat bran and 9.7 g oat bran per 100 g flour for making optimally acceptable fiber rich chapati.

Keywords Fiber · Pasting and mixing characteristics · *Chapati* · Textural profile

Yadav D. N. · Rajan A. · Sharma G. K. · Bawa A. S.
Defence Food Research Laboratory,
Siddarthanagr, Mysore - 570 011, India

Yadav D. N. (✉)
E-mail: dnyadav1977@yahoo.co.in

Introduction

Dietary fiber has been consumed for centuries and recognized as having health benefits. Fiber intake through the consumption of foods rich in dietary component, such as fresh vegetables, fruits, whole grains and nuts is associated with reduction in plasma and LDL-cholesterol, attenuating glycemic and insulin response, increasing stool bulk and improving laxation (Schneeman 1998). Dietary fiber components, isolated from native plants, provide many functional properties that affect the technological function of foods. These functional properties also influence food products properties during processing and final product quality and characteristics. Bran is perhaps the best source of dietary fiber. Wheat bran is the outer layer of wheat grain making up about 13% of weight of whole grain and a good source of proteins and minerals apart from being a rich source of dietary fiber. The fiber in wheat bran is mainly of insoluble type.

Water soluble, -glucans, the main constituent of soluble dietary fiber in oats, occurs at higher level in oat bran. In contrast to insoluble fibers, which have no significant effect on viscosity in the small intestine, water soluble oat -glucans exert their effects mainly by increasing viscosity in the small intestine. In the intestine, oat -glucans absorb fl uids and contribute to viscosity during digestion, resulting in an extended digestion period. -Glucan is known for reduction in the risk of colon cancer, reduction in the absorption of glucose in the digestive system and for its hypocholesterolmic effect (Duss and Nyberg 2004). About 75% of the total wheat production of India is used for the preparation of *chapati* and other traditional foods (Bedekar 2001). Several fiber rich food products like, bread (Pomeranz et al. 1976, Jinshui et al. 2002), fiber rich snack (Sarojini and Maya 1998), Turkish flat bread (Arzu and Hamit 1999), meatballs (Waszkowiak et al. 2001), break fast foods (Duss and Nyberg 2004), hearth bread (Anette et al. 2004), cakes (Lee et al. 2004), biscuits (Sudha et al. 2005) and rice bran rich cookies and *chapaties* (Ghufran Saeed et al. 2009) have been successfully developed and are available in the market. At one hand, numerous beneficial effects of soluble and insoluble fibers on human physiology have been observed by several researchers and on the other hand the most staple food of the country like *chapati* lacks in fiber content, particularly soluble fiber. Therefore, the present investigation was planned to develop optimally acceptable fiber (soluble and insoluble) rich *chapaties* as well as to study the effect of fibers (wheat bran and oat bran) addition on rheological changes in wheat flour.

Materials and methods

Commercial medium hard variety of wheat (*Triticum aestivum, c.v.*- 'Bansi'), was procured from local market, manually cleaned and milled to 400–500 micron particle size in a disc mill (Model EGM-467K, Dia: 18 inch, Ganesha & Company, Chennai, India) to obtain whole-wheat flour (100% extraction rate). Wheat bran and oat bran (Beggreys brand), salt and sunflower oil were also procured from local market.

Experimental design: The central composite rotatable design was used for selecting combination levels of variables in each experiment. The variables used were, level of wheat bran (3–9 g/100 g flour) and oat bran (6–12 g/100 g flour). The levels of these variables along with experimental plan have been given in Table 1. The variables were standardized to simplify computation and to deduce their relative effect on the responses. The magnitude of the coefficients in second order polynomials shows the effect of concerned variable on the responses. For the analysis of experimental design by the response surface, it was assumed that n-mathematical functions, f_k (k=1, 2….. n), Y_k in terms of m independent processing factors X_i (i= 1,2, ……………., m) existed for each response variable.

$$Y_k = f_k (X_1, X_2………, X_m)$$

In this case n = 14 and m=2

$$Y_k = b_{k0} + \sum_{i=1}^{2} b_{kii} X_i + \sum_{i=1}^{2} b_{kii} X_i^2 + \sum_{i=1}^{2}\sum_{j=i+1}^{2} b_{kij} X_i X_j$$

where b_{k0} is the value of the fitted response at the centre point of the design i.e. point (0,0) and $b_{ki,}$, b_{kii} and b_{kij} are the linear, quadratic and interactive regression terms, respectively.

Chemical analysis: Moisture, ash, crude fat and total protein were determined using AOAC (1997) methods. The carbohydrate content of the samples was calculated by difference. For the estimation of dietary fiber, the defatted residues of *chapati* samples obtained during the course of analysis of crude fat were finally powdered using a mixer blender to pass through a sieve of 100 mesh. This fine powder of each sample was utilized for the estimation of soluble dietary fiber (SDF), insoluble dietary fiber (IDF) and total dietary fiber (TDF) contents following the method of Asp et al. (1983). All the chemicals used in this investigation were of analytical grade and procured from M/s E-Merck, Mumbai, India.

Preparation of chapaties: Dough from wheat flour samples containing different amounts of wheat and oat bran were prepared by mixing in Hobart dough kneader (HL 120 Hz 50/60) for 10 min, adding water (based on 10 g moving mixograph) and salt (2 g /100 g flour). The dough was allowed to rest for 15 min and divided into 40 g pieces. Each dough piece was formed into spherical shape, placed between 2 wooden plates and pressed using a manual *chapati*-pressing machine into a flattened circular dough sheet (diameter 150 mm and thickness 2 mm). The flattened circular dough sheets were baked on a hot plate at 230±5°C for 1–2 min on either side with application of vegetable oil.

Pasting properties: Pasting properties of flour samples containing different amounts of wheat and oat bran were measured using Rapid Visco-Analyser 4D (Newport Scientific Pvt Ltd Warie Wood, Australia). Flour sample (3.5 g on 14% moisture basis) was dispersed in 25 ml of distilled water. The rotating speed of paddle was 160 rev/min except for first 10 sec (960 rev/min). The suspension was equilibrated at 50°C for 1 min and heated at the rate of 12°C/min to 95°C and then held at 95°C for 2.5 min. The sample was then cooled to 50°C at the rate of 12°C/min and then held for 3 min at 50^0C. Peak viscosity (PV), break down viscosity (BD), set back viscosity (SB), hot paste viscosity (HPV, minimum viscosity at 95°C), cool paste viscosity (CPV, final viscosity at 50°C) were recorded. Break down (BD) = PV- HPV, Set back (SB) = CPV-HPV. All measurements were carried out in triplicate and parameters recorded in terms of rapid viscosity units (RVU).

Mixing properties: The flour samples containing different concentration of fibers were analysed for mixing

Table 1 Experimental design matrix for *chapati* preparation and levels in coded and uncoded form

Exp Nr	X_1	X_2	Wheat bran (X_1 g/100 g WF)	Oat bran (X_2 g/100 g WF)
1	–1	–1	3	6
2	+1	–1	9	6
3	–1	+1	3	12
4	+1	+1	9	12
5	–1.414	0	1.76	9
6	+1.414	0	10.24	9
7	0	–1.414	6	4.76
8	0	+1.141	6	13.24
9	0	0	6	9
10	0	0	6	9
11	0	0	6	9
12	0	0	6	9
13	0	0	6	9

WF: wheat flour

characteristics using the 10 g moving mixograph (National Mfg, Division, TMCO, Lincoln, USA). Water absorption level used in the mixograph analysis was selected based on moisture and protein content of the sample. Both midline and envelope (curves defining the centre top and bottom of the mixogram) analyses were produced. The peak time and height, ascending and descending slopes and work function (integral of percent torque × time, min) were recorded from the midline analysis.

Texture profile analysis: Textural profile analysis of *chapaties* was performed using texture analyzer plus (LLOYD Instruments, UK Model Nr 01/TALS/LXE, UK), following the method of Szczesniak (1975). The bite test on *chapati* was carried out using the Volodke bite set (part nr 01/2663) as per instrument manual. The Volodke bite set is designed to imitate incisor teeth shearing through a food sample. The set comprises upper and lower teeth which during the test penetrate the sample twice to obtain the peak force and the texture profile at the preset speed and position. The *chapati* strips (2 × 150 mm) were axially compressed to 90% of their original height, avoiding fracture. Force-time deformation curve were derived with a 20 kg load cell applied at a crosshead speed of 10 mm/min. Attributes were calculated as follows: hardness value is the peak force (N) of the first compression of the sample; cohesiveness is the area of work during the second compression divided by the area of work during the first compression (dimensionless); springiness is the distance (mm) that the sample recovers after the first compression; chewiness (Nmm) is the product of the attributes (gumminess × springiness) and in sensory terms corresponds to the energy required to chew a solid food product. Ten measurements per replication were taken for all textural analysis.

Sensory evaluation: The sensory attributes of *chapati* in each experimental block were evaluated in terms of colour, aroma, taste and texture by a semi-trained panel consisting of 10 members from the scientific staff of the laboratory with knowledge of consumer's preference using 9-point Hedonic

Table 2 Chemical composition (%) of whole wheat flour (WWF), wheat bran (WB) and oat bran (OB)

	WWF	WB	OB
Moisture	10.6 ± 0.15	2.2 ± 0.05	2.6 ± 0.05
Protein	13.4 ± 0.10	16.5 ± 0.20	16.8 ± 0.22
Fat	1.3 ± 0.03	4.9 ± 0.15	8.6 ± 0.11
Ash	1.6 ± 0.06	4.3 ± 0.06	1.5 ± 0.05
Carbohydrate	69.3 ± 0.08	40.7 ± 0.07	55.0 ± 0.06
Total dietary fiber	3.8 ± 0.06	31.5 ± 0.20	15.6 ± 0.20
Insoluble dietary fiber	2.9 ± 0.03	26.8 ± 0.32	6.4 ± 0.20
Soluble dietary fiber	0.9 ± 0.03	4.7 ± 0.20	9.2 ± 0.22

n=3

Table 3 Actual response values for pasting and mixing properties of flour as well as textural and sensory quality of *chapaties*

+Exp Nr	Pasting				Mixing					Texture profile				Sensory
	PV, RVU	BD, RVU	SB, RVU	FV, RVU	DDT, min	PT, % torque	AS, % torque/min	DS, % torque/min	IP, % torque x min	H, N	Coh	Sp, mm	Chew, N	OAA
1	126.0	45.4	61.1	141.7	2.11	47.0**	13.7	–3.4	81.1	7.3	0.21	1.03	1.60	8.4
2	112.3	41.1	57.4	128.5	2.52	45.7	16.3**	–2.8	86.4	8.3	0.27	0.96	2.13	7.5
3	119.8	41.0	61.4	140.2	2.42	40.8*	5.6	–3.8*	82.6	9.4	0.19*	0.79	0.96*	7.8
4	107.3*	37.4*	62.2	132.0	2.84**	42.7	13.3	–2.4	90.6	9.8**	0.29	0.71*	1.59	7.3
5	126.8**	44.5	61.7	144.0**	1.76*	46.1	15.0	–2.5	64.1*	6.6	0.29	1.13	2.16	8.5**
6	114.3	41.1	60.3	134.1	2.72	43.8	14.0	–1.8**	92.4**	8.0	0.36**	0.93	2.70**	7.0*
7	116.1	45.1	55.6*	126.6*	1.95	44.2	15.9	–2.0	64.6	5.8*	0.22	1.19**	1.55	7.7
8	116.0	40.1	63.1**	139.0	2.53	42.8	4.3*	–3.2	86.2	8.4	0.21	0.90	1.18	7.4
9	122.8	50.1**	62.6	135.2	2.02	45.5	13.5	–3.6	75.1	6.4	0.20	1.15	1.51	7.8
10	121.0	48.7	62.2	134.5	2.02	45.4	13.5	–3.5	75.2	6.5	0.21	1.15	1.57	7.9
11	122.5	49.7	60.7	133.6	2.03	45.4	13.6	–3.6	76.0	6.5	0.20	1.16	1.50	8.0
12	123.3	49.8	62.5	136.0	2.03	45.8	13.5	–3.5	75.3	6.6	0.22	1.19	1.72	7.8
13	124.3	48.8	60.9	136.4	2.04	45.2	13.4	–3.5	75.5	6.4	0.20	1.18	1.50	7.8

*Minimum; **Maximum; PV = peak viscosity; BD = break down viscosity; SB = set back viscosity; FV = final viscosity; RVU = rapid viscosity units; DDT = dough development time; PT = peak torque; AS = ascending slope; DS = descending slope; IP = integral at peak; H = hardness; Coh = cohesiveness; Sp = springiness; Chew = chewiness; OAA = overall acceptability score; +1–13 as in Table 1; (n=3) scale (9 extreme liking and 1 extreme disliking) (Larmond 1977). The overall acceptability score was calculated by taking the average of scores for all 4 parameters.

Analysis of data: Multiple regression analysis was used to fit the model, represented by an equation to the experimental data. Maximization and minimization of the polynomials thus fitted were done by numeric techniques, using the numerical optimization technique given in the software package (Design expert (R) software version 7.0, 2006, Minneapolis, MN, USA) that deals with constraints. The constraints are set to get the coded value of a variable between the lower and upper limits (in the present case: –1.414 to +1.414) for an optimum response. A weight was assigned to each goal to adjust the shape of its particular desirability function. The goals are combined into an overall desirability function. The program seeks to maximize this function. The goals begin at a random starting point and proceeded up the steepest slope to a maximum. Starting from several points in the design shape, chances improve for finding the 'best' maximum combinations. The mapping of the fitted response was achieved using software.

Results and discussion

Chemical composition of whole wheat flour (WWF), wheat bran (WB) and oat bran (OB) samples is presented in Table 2. The peak viscosity (PV) ranged from 107.3–126.8 RVU, break down (BD) 37.4–50.1 RVU, set back (SB) 55.6–63.1 RVU, final viscosity (FV) 126.6–144.0 RVU, dough development time (DDT) 1.76–2.84 min, peak torque (PT) 40.8–47%, ascending slope (AS) 4.3–16.3% torque/min, descending slope (DS) –1.85 to –3.79% torque / min and integral at peak (IP) 64.1–92.4 (% torque × min) (Table 3). Among textural properties of *chapaties*, the hardness value varied from 5.8 to 9.8 N, cohesiveness 0.19–0.36, springiness 0.71–1.19 mm, chewiness 0.96–2.70 N and overall acceptability (OAA) scores 7.0–8.5.

Diagnostic checking of fitted models: All main, linear, quadratic and interactive effects were calculated for each model (Table 4). The adequacy of the models was tested using F-ratio and coefficient of determination (R^2). The models were considered adequate when the calculated F-value was more than table F-value (at 5% level) and R^2 value was more than 80% (Henika 1982). The R^2 value was higher than the 80% for all the responses except for DS and IP, which were 0.71 and 0.67, respectively. The calculated F-value was also more than the table F-value (at 5% level) for all the responses, indicating the adequacy of the models. However, most of the models statistically showed their adequacy to describe the effect of variables on the responses, though for getting optimum combination of variables, mapping of the more response plots on each other is difficult. Therefore, the most effective responses like PV, FV, PT, AS of flour samples and hardness, springiness, chewiness as well as OAA of the *chapati* samples were selected to get the optimum combination of fibers.

Table 4 Coefficients of second order polynomial models for pasting and mixing properties of flour as well as textural and sensory quality of *chapaties*

Co-efficients	Pasting				Mixing					Texture profile				Sensory
	PV, RVU	BD, RVU	SB, RVU	FV, RVU	DDT, min	PT, % torque	AS, % torque/min	DS, % torque/min	IP, % torque × min	H, N	Coh	Sp, mm	Chew, N	OAA
0	122.772	49.372	61.768	135.134	2.028	45.460	13.510	–3.541	75.400	6.483	0.206	1.168	1.560	7.860
1	–5.503*	–1.607*	–0.612	–4.403*	0.274*	–0.310*	1.095	0.364	6.665*	0.409*	0.033*	–0.053*	0.241*	–0.440*
2	–1.420	–1.914*	1.963*	2.442*	0.180*	–1.388*	–3.442*	–0.192	4.522	0.920*	–0.002	–0.111*	–0.213*	–0.153*
11	0.301	0.164*	1.116	1.259	0.004*	0.817	1.279	0.206*	0.709	–0.133*	0.010*	–0.002*	0.023*	0.100*
22	–1.602*	–3.657*	–0.292*	1.881	0.163*	–0.302*	0.488*	0.504	3.509	0.795	0.051	–0.110*	0.351	–0.030*
12	–3.860	–3.753	–1.133	–1.248	0.163	–1.027	–1.727	0.290	2.084	0.674	–0.003	–0.103	–0.180	–0.130
R^2, %	0.91	0.97	0.86	0.85	0.890	0.850	0.870	0.710	0.670	0.860	0.910	0.810	0.860	0.930

Significant *p 0.05; PV, BD, SB, FV, R VU, DDT, PT, AS, DS, IP, H, Coh, Sp, Chew, OAA: As in Table 3; R^2 coefficient of determination

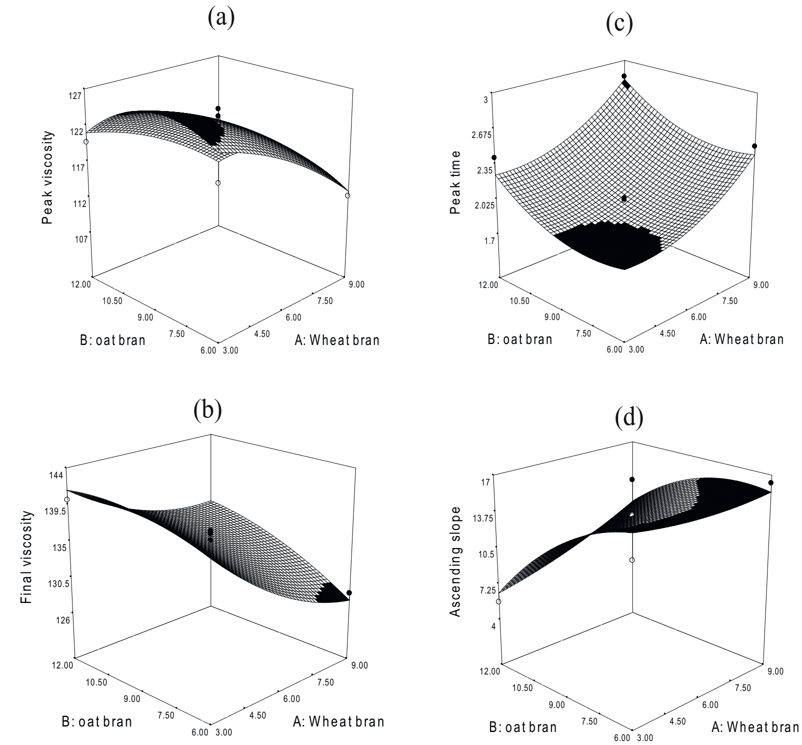

Fig. 1 Response surfaces plots showing the effect of wheat and oat bran on peak viscosity (a), final viscosity (b), peak time (c) and ascending slope (d) of wheat flour as per design expert software

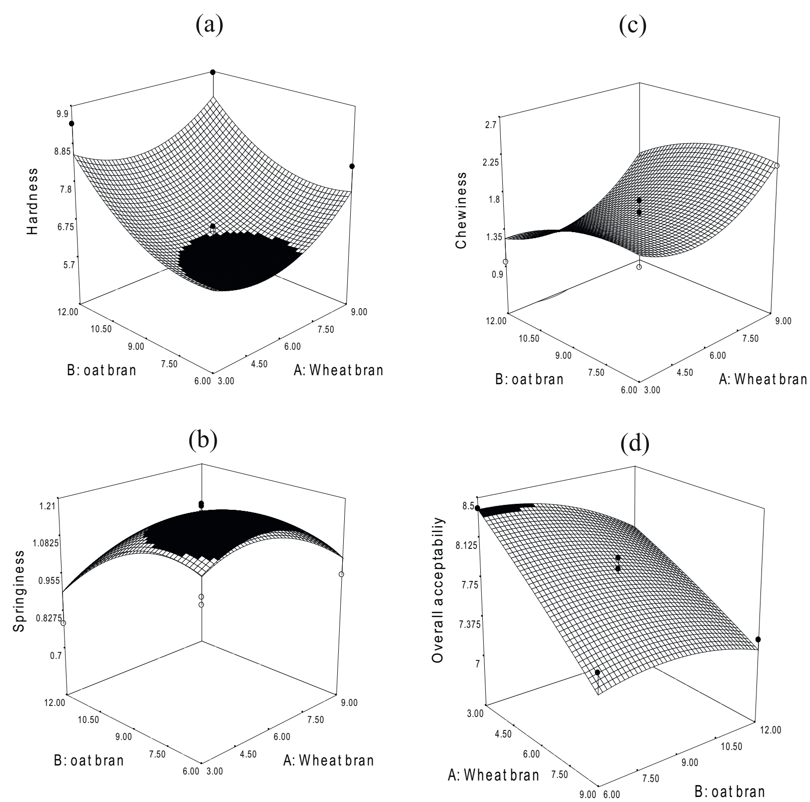

Fig. 2 Response surfaces plots showing the effect of wheat and oat bran on hardness (a), springiness (b), chewiness (c) and overall acceptability (d) of *chapaties*

Table 5 Analysis of variance data (F value) for the overall effect of process variables on pasting and mixing characteristics of flour as well as textural profile and sensory quality of *chapaties*

Process variables	Pasting				Mixing					Texture profile				Sensory
Total individual effect	PV, RVU	BD, RVU	SB, RVU	FV, RVU	DDT, min	PT, % torque	AS, % torque/ min	DS, % torque/ min	IP, % torque × min	H, N	Coh	Sp, mm	Chew, N	OAA
Wheat bran, X_1	15.81*	38.22*	2.63	10.20*	12.66*	5.43*	2.03	4.85*	3.37*	2.29	24.22*	4.26*	9.63*	5.20*
Oat bran, X_2	7.31*	42.52*	13.75*	3.55*	7.24*	12.36*	13.96*	1.70	1.49	2.02	6.93*	6.84*	4.30*	5.97*
All combined effect of variables														
Linear	8.55*	1.41	7.78*	11.33*	9.05*	8.93*	10.17*	1.82	6.28*	3.55*	1.98	3.03	2.68	29.60*
Interactive	0.02	0.01	2.70	0.68	0.00	2.10	1.32	0.43	0.04	0.06	0.16	0.00	0.01	1.42
Quadratic	10.23*	84.93*	4.18*	3.33*	7.91*	4.50*	4.18*	5.15*	1.19	5.06*	25.08*	8.23*	13.31*	3.08*

Significant *p 0.05; PV; BD; SB; FV; R VU; DDT; PT; AS; DS; IP; H; Coh; Sp; Chew; OAA: As in Table 3

Table 6 Constraints, criteria for optimization, solution along with predicted and actual response values (ARV)

Constraints	Goal	Limit		Weight	Solution	ARV
		Lower	Upper			
Wheat bran, % WF	In range	3	9	3	5.5	-
Oat bran, % WF	Maximize	6	12	5	9.7	-
PT, % torque	In range	40.76	46.986	3	45.1	45.2 ± 0.22
AS, % torque/ min	In range	4.29	16.298	3	12.5	12.2 ± 0.12
PV, RVU	In range	107.25	126.83	3	123.1	125.1 ± 2.56
FV, RVU	In range	126.58	144.0	4	136.3	135.6 ± 2.18
H, N	Maximize	5.786	9.854	5	6.7	6.6 ± 0.12
Sp, mm	In range	0.705	1.192	3	1.1	1.2 ± 0.05
Chew, N	In range	0.96	2.696	3	1.5	1.5 ± 0.04
Sensory OAA	Maximize	7.0	8.5	5	7.9	7.8 ± 0.10

PT; AS; PV; FV; RVU; H; Sp; Chew; OAA as in Table 3

Table 7 Chemical composition (%) of optimized and control *chapati*

Parameters	Optimized	Control
Moisture	31.0 ± 0.20	30.2 ± 0.21
Protein	10.6 ± 0.15	10.3 ± 0.10
Fat	4.5 ± 0.12	4.5 ± 0.10
Ash	1.3 ± 0.05	1.1 ± 0.05
Carbohydrate	47.9 ± 0.13	51.2 ± 0.2
Total dietary fiber	4.7 ± 0.12	2.7 ± 0.12
Insoluble dietary fiber	3.4 ± 0.10	2.1 ± 0.08
Soluble dietary fiber	1.4 ± 0.05	0.66 ± 0.045

n=3

Effect of variables on pasting and mixing quality of wheat flour: The variable WB negatively affected (p 0.05) PV, BD and FV at linear level whereas at quadratic level it had effect (p 0.05) on only BD viscosity . The negative effect on viscosity of wheat flour samples caused due to WB addition may be because of its high content of insoluble fiber. The variable OB had negative effect (p 0.05) on BD and positive ef fect (p 0.05) on SB and FV at linear level. The positive effect on viscosity by the addition of OB was attributed to its soluble nature as Lee et al. (2004) also observed increase in final viscosity of cake batter with addition of nutrim oat bran. The increase in SB viscosity by the addition of OB indicated more reterogradation of starch on cooling; this may be the reason for the increase in the hardness of *chapaties* added with OB. At quadratic level it has negative effect (p 0.05) on all pasting properties except FV. No significant interactive effect of variables was observed on pasting properties. Fig. 1 represented the changes in peak viscosity and final viscosity of WWF samples added with different levels of WB and OB. Among mixing characteristics, WB had negative effect (p 0.05) on PT and positive effect (p 0.05) on DDT and IP at linear level. At quadratic level it affected (p 0.05) DDT and DS. The variable OB at linear level affected (p 0.05) DDT, PT and AS and also similar effect was observed at quadratic level whereas, no interactive effect of variables was observed on mixing characteristics. Fig. 1 showed the changes in peak time and ascending slope as affected by the addition of bran. Archana and Prakash (2001) also observed an increase in dough development time and decrease in mixing tolerance index and dough stability with the addition of wheat bran in WWF and reported that it was due to insoluble nature of WB.

Effect of variables on textural and sensory quality of chapaties: The variable WB had positive effect (p 0.05) on hardness, cohesiveness and chewiness of *chapaties*, while it negatively affected springiness and OAA scores at linear level. At quadratic level it had significant (p 0.05) effect on all textural as well as OAA scores. The variable OB had positive effect (p 0.05) on hardness, whereas the responses springiness, chewiness and OAA scores were negatively affected (p 0.05) at linear level. Only springiness and OAA scores were affected (p 0.05) by OB at quadratic level. No significant effect on any textural and OAA scores were observed at interactive level. Lee et al. (2004) also reported that addition of nutrim oat bran increased the hardness of cake and lowered the springiness. Onwulata et al. (2000) prepared high fiber (40% oat bran) rich extruded snacks and reported increase in hardness of snacks. Fig. 2 represented the changes in hardness, springiness, chewiness and OAA scores of *chapaties* as affected by the addition of bran.

Analysis of variance: When a model had been selected, an analysis of variance was calculated to assess how well the model represented the data. It is clear from Table 5 that both independent variables affected the responses significantly (p 0.05). Combined ef fect of both the variables at linear level was maximum followed by quadratic and no interactive effect of both the variables was observed. On this basis, it can be concluded that the selected models adequately represented the data for pasting and mixing characteristics of flour and textural as well as sensory scores of *chapaties*.

Optimization of independent variables: For the optimization of bran level the responses i.e., peak value, ascending slope, peak viscosity, final viscosity, hardness, springiness, chewiness and OAA were selected on the basis that these responses had direct effect on acceptability and quality of *chapaties*. These responses were used for numerical optimization of variables and the criteria used along with predicted and actual values of the responses have been presented in Table 6. By using the given criteria (Table 6), the solution obtained was i.e. WB 5.5 and OB 9.7 g/100 g of wheat flour. *Chapaties* were prepared based on solution obtained and responses were measured. The measured response values were very close to the predicted values, reconfirming the adequacy of the models. Therefore, the optimised level of bran was recommended for the preparation of fiber rich *chapaties*. The optimized fiber rich *chapati* samples along with normal *chapati* (without fiber added) were also evaluated for proximate composition. The proximate composition of optimized *chapati* remained similar to the control while, the TDF and SDF increased significantly (p 0.05) from 2.7 to 4.7 and 0.66 to 1.4 g/100 g, respectively (Table 7). In India, *chapati* is a staple food and it is common that 3-4 *chapaties* (about 100 g flour) are eaten in one serving by an adult. According to FDA (1998) any food claimed as fiber rich for its health benefit should contain at least 4 g TDF and 0.75 g SDF. Considering FDA (1998) standards, this optimized fiber enriched *chapati* may be claimed as fiber rich for the functional health benefits.

Conclusion

The rheological properties like pasting and mixing of wheat flour were greatly influenced while adding the bran sources and thus influencing the acceptability of *chapaties*. The developed mathematical models for the responses could be successfully used for their prediction while incorporating the fiber source in flour and preparing *chapaties* from it. The developed *chapati* had 4.7 g TDF and 1.4 g SDF per 100 g flour (3-4 *chapaties*) and meets the standards of FDA (1998) for claiming the functional health benefits of fiber rich *chapaties*.

References

Anette A, Ellen MM, Ellen MF (2004) Effect of protein quality, protein content, bran addition, DATEM, proving time and their interaction on hearth Bread. Cereal Chem 81:722–734

AOAC (1997) Official methods of analysis, 16th edn, Association of Official Analytical Chemist, Maryland, USA

Archana SH, Prakash J (2001) Wheat bran (*Triticum aestivum*): composition, functionality and incorporation in unleavened bread. J Food Qual 25:197–211

Arzu B, Hamit K (1999) Properties and composition of Turkish flat bread (Bazlama) supplemented with barley flour and wheat bran. Cereal Chem 76:506–511

Asp NG, Johansson CG, Hallma H, Siljestron M (1983) Rapid enzymatic assay of insoluble and soluble dietary fiber. J Agric Food Chem 31:476–482

Bedekar BR (2001) *Chapati* – Indian bakery product of the 21st century. Indian Food Ind 20(1):21–24

Duss R, Nyberg L (2004) Oat soluble fibers (-glucans) as a source for healthy snack and breakfast foods. Cereal Food World 49:320–325

FDA (1998) Food labeling, Health claims: Soluble fiber from certain foods and risk of coronary heart disease. 21 CFR © 101.81, Code of Federal Regulations. Washington DC

Ghufran Saeed SM, Saqib A, Mubarak A, Rashida A, Fred S (2009) Influence of rice bran on rheological properties of dough and in the new product development. J Food Sci Technol 46:62–65

Henika RG (1982) Use of response surface methodology in sensory evaluation. Food Technol 36(11):96–101

Jinshui W, Cristina MR, Carmen BB (2002) Effect of addition of different fibres on wheat dough performance and bread quality. Food Chem 79:221–226

Larmond E (1977) Laboratory methods for sensory evaluation of foods. Canada Dept of Agric, Ottawa, p 1637

Lee S, Inglett GE, Carriere CJ (2004) Effect of nutrim oat bran and flaxseed on rheological properties of cakes. Cereal Chem 81:637–642

Onwulata CI, Konstance RP, Strange ED, Smith PW, Holsinger VH (2000) High fibre snacks extruded from triticale and wheat formulations. Cereal Food World 45:470–473

Pomeranz Y, Shogren MD, Finney KF, Bechtel DB (1976) Fiber in bread making-Effects on functional properties. Cereal Chem 54:25–41

Sarojini KD, Maya P (1998) A novel food snack containing wheat bran. Indian J Nutr Dietet 25:229–233

Schneeman BO (1998) Dietary fiber and gastrointestinal function. Nutr Res 18:625–632

Sudha ML, Vetrimani K, Leelavathi K (2005) Influence of fiber from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. Food Chem 100:1365–1370

Szczesniak AS (1975) General food texture profile revised- ten years perspective. J Texture Stud 6:5–17

Waszkowiak K, Gorecka D, Janitz W (2001) Influence of wheat dietary fiber on the quality of meat dishes. Zuwnosc 3:53–61

IMPACT OF JFST – 2008

1. Journal Impact Factor (IF)

Cites in 2008 to articles published in 2007 = 28 and in 2006 = 40; Sum = 68

Nr of articles published in 2007 = 151 and in 2006 = 156; Sum = 307

IF = Cites to recent articles/Nr of recent articles = 68/307 = 0.221

2. 5-Year Journal Impact Factor (5Y IF)

Cites in 2008 to articles published during 2003 – 2007 = 188

Nr of articles published during 2003 – 2007 = 772

5Y IF = 188/772 = 0.244

3. Journal Immediacy Index (II)

Cites in 2008 to articles published in 2008 = 2

Nr of articles published in 2008 = 123

II = Cites to current articles/Nr of current articles = 2/123 = 0.016

4. Journal Cited Half-Life

The cited half – life for the journal is the median age of its articles cited in the current JCR year. Half of the citations to the journal are to articles published within the cited half-life.

Cited Half – Life > 10 years

5. Journal Citing Half-Life

The citing half-life calculation finds the number of publication years from the current JCR year that account for 50% of citations in the journal.

Citing Half – Life > 10 Years

Source: Journal Citation Reports (JCR) – 2008