Fibres as an additive for oil reduction in deep fat fried *poori*

Deep Narayan Yadav · Anila Rajan

Revised: 22 December 2010 / Accepted: 27 December 2010 / Published online: 20 January 2011

© Association of Food Scientists & Technologists (India) 2011

Abstract Models capable of predicting the moisture and oil content as well as overall acceptability (OAA) of *poori*, prepared from wheat flour incorporated with wheat bran and oat bran were developed using response surface methodology. Central composite rotatable design with two independent variables (wheat bran and oat bran) at five levels (wheat bran, 3–9 g/100 g wheat flour and oat bran 6–12 g/100 g wheat flour) was used to optimize the bran level. Results showed that oat bran had significant ($p \leq 0.05$) positive effect on moisture retention and negative effect on oil absorption, while wheat bran had reverse effect. Based on compromise optimization, it was recommended to incorporate 3.0 g wheat bran and 11.0 g oat bran (per 100 g wheat flour) for making fibre rich (4.2% total dietary fibre, 1.3% soluble dietary fibre) *poori* with lower oil content (20% less as control) and optimum acceptability (88.6).

Keywords Bran · *Poori* · Moisture · Oil content · Overall acceptability

Introduction

Dietary fibre has become a matter of considerable public interest in recent years because of its well known beneficial physiological and metabolic effects. Oat products with high β -glucan content have been reported to be effective in reducing serum cholesterol levels and slowing glycemic

responses (Klopfenstein 1988; McIntosh et al. 1991; Kahlon and Chow 1997). Fibre from wheat bran is an effective fecal bulking agent (Anderson 1985) and can be used for treatment of constipation and other related disorders (Burkitt 1977). Several fibre rich food products such as extruded snacks (Sarojini and Maya 1998; Chakraborty et al. 2009), Turkish flat bread (Arzu and Hamit 1999), meatballs (Waszkowiak et al. 2001), Bread (Pomeranz et al. 1976; Rao and Rao 1991; Jinshui et al. 2002), breakfast foods (Duss and Nyberg 2004), hearth bread (Anette et al. 2004), cakes (Lee et al. 2004), biscuits (Sudha et al. 2005) and chapatti (Yadav et al. 2010) have been successfully developed. It is important from a food product development point of view that high fibre foods should not only supply fibre, but also provide enhanced functional properties and be tasty, thus encouraging continued high fibre intake. *Poori*, is a traditional deep fried product of India, prepared from wheat flour dough and usually had high oil content (28%–30%). Wheat dough sheeted to a circular shape of about 10–12 cm diameter and 1–3 mm thickness, deep fried in vegetable oil to soft pliable texture with typical aroma and consumed either as a meal or as a breakfast item. However, due to its high oil content it has limited use for fat conscious people (Vatsala et al. 2001). Apart from health benefits of fibres, it has also been reported to reduce oil uptake during frying especially soluble fibres. Lee and Inglett (2007) reported that oat β -glucan reduces oil uptake of batters during frying, since high water holding capacity and viscosity development have a great effect on the reduction of oil uptake. Kalinga and Mishra (2009) also used β -glucan concentrate as fat replacer for the development of low fat cakes. Therefore, the presented study envisages to incorporate fiber in *poories*; to reduce the oil uptake while frying, and to study and optimize level of fiber incorporation in accordance with acceptability of the product.

D. N. Yadav (✉) · A. Rajan
Food Grains and Oilseeds Processing Division,
Central Institute of Post Harvest Engineering and Technology,
Ludhiana 141 004, India
e-mail: dnyadav1977@yahoo.co.in

Materials and methods

Raw materials 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 and Company, Chennai, India) to obtain whole-wheat flour (100% extraction rate). Wheat bran and oat bran, salt and sunflower oil were also procured from local market.

Experimental design Central composite rotatable design (CCRD) was used to select variables level i.e. wheat bran 3.0–9.0 g/100 g wheat flour and oat bran 6.0–12.0 g/100 g wheat flour in each experiment. The levels of these variables along with the experimental plan have been given in Table 1. For the analysis of experimental design by the response surface, it was assumed that n -mathematical functions, f_k ($k=1, 2, \dots, n$), Y_k in terms of m independent processing factors X_i ($i=1, 2, \dots, m$) existed for each response variable.

$$Y_k = f_k(X_1, X_2, \dots, X_m) \quad (1)$$

In this case $n=3$ and $m=2$

The function was assumed to be approximated by a second order polynomial equation.

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

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 The chemical parameters like moisture, protein, crude oil and ash were determined using the standard AOAC (1997) methods. Carbohydrate was calculated by subtracting the sum of moisture, protein, fat and ash from 100 (Merrill and Watt 1973). For the estimation of dietary fibre, the defatted *poori* samples obtained during the course of crude fat estimation were finally powdered using a mixer blender, to pass through a 100 mesh sieve. This fine powder of each sample was utilized for the estimation of soluble (SDF), insoluble (IDF) and total dietary fibre (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 poori The *poori* was prepared from the dough consisting of flour, water (70%–78%, based on mixograph), salt (2% flour basis) and different levels of wheat bran and oat bran (Table 1). All the ingredients were mixed and kneaded well for 10 min in Hobart dough kneader (HL 120 HZ 50/60; Hobart Troy, Ohio, USA). The dough was allowed to rest for 15 min and divided into 25.0 g of pieces. Each dough piece was formed into spherical ball, placed between two wooden plates and pressed using a manual chapati pressing machine into a circular dough sheet (100.0 mm diameter and 2.0 mm thickness) and then fried in sunflower oil at 180 ± 5 °C for 40–45 s. A control (without added fibre) *poori* sample was also prepared for comparison.

Sensory evaluation The sensory evaluation of *poori* samples was carried out by using the sensory score card

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

Exp No.	X_1	X_2	Wheat bran, g/100 g wheat flour	Oat bran, g/100 g wheat flour	Moisture, %	Oil, % dwb	OAA
1	−1	−1	3	6	22.6	27.2	95 ^b
2	+1	−1	9	6	18.6	28.9	72
3	−1	+1	3	12	22.1	23.6	88
4	+1	+1	9	12	19.2	28.7	68
5	−1.414	0	1.76	9	27.6 ^b	19.3 ^a	92
6	+1.414	0	10.24	9	18.3 ^a	30.5 ^b	65 ^a
7	0	−1.414	6	4.76	20.2	29.4	84
8	0	+1.141	6	13.24	23.9	25.7	80
9	0	0	6	9	22.2	26.5	82
10	0	0	6	9	22.0	26.4	83
11	0	0	6	9	22.1	26.6	82
12	0	0	6	9	22.2	26.5	82
13	0	0	6	9	22.0	26.3	81

^a minimum, ^b maximum; dwb dry weight basis; OAA overall acceptability

(Table 2) consisting of eight quality factors namely, colour, nature of spots, shape, hand feel, texture, oiliness, mouth feel and taste and aroma. A maximum score of 100 consisted of 10 each for colour, nature of spots, shape and taste and aroma and 15 each for hand feel, texture, oiliness and mouth feel. It was rated as excellent to not acceptable based on the total marks (Indrani and Rao 2001).

Analysis of data Multiple regression analysis was used to develop an equation fitting the experimental data. Maximization and minimization of polynomials was carried out through numerical optimization (Design expert (R) software ver. 7.0, 2006, Minneapolis, MN, USA) dealing with the constraints. The constraints are set to get the coded value of variable between 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 were combined into an overall desirability function, seeking to maximize the function. The goals began at a random starting point and proceeded up the steepest slope to a maximum.

Results and discussion

Whole wheat flour (WWF), wheat bran (WB) and oat bran (OB) samples were analyzed for moisture, protein, fat, ash and total carbohydrate content and the corresponding values were 10.6 ± 0.15 , 13.4 ± 0.10 , 1.3 ± 0.03 , 1.6 ± 0.06 and 69.3 ± 0.08 g/100 g for WWF and 2.2 ± 0.05 , 16.5 ± 0.20 , 4.8 ± 0.15 , 4.3 ± 0.06 and 40.6 ± 0.07 g/100 g for WB and 2.5 ± 0.05 , 16.8 ± 0.20 , 8.6 ± 0.10 , 1.5 ± 0.05 and 55.0 ± 0.06 g/100 g for OB, respectively. The total dietary fibre (TDF), insoluble dietary fibre (IDF) and soluble dietary fibre (SDF) contents of WWF were 3.8 ± 0.06 , 2.9 ± 0.03 , 0.8 ± 0.03 and for WB, 31.5 ± 0.21 , 26.7 ± 0.30 , 4.7 ± 0.20 and for OB, 15.6 ± 0.20 , 6.4 ± 0.22 and 9.2 ± 0.23 g/100 g, respectively. The actual response values for moisture, oil content and overall acceptability of *poori* samples have been presented in Table 1. The moisture content ranged from 18.3 to 27.6, oil content 19.3%–30.5% and overall acceptability scores from 65 to 95.

Diagnostic checking of the fitted models All the main, linear, quadratic and interactive effects were calculated for each model (Table 3). 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-ratio was more than the table one (2.32 at 5% level) and

Table 2 A reference sensory score card used for sensory evaluation of *poori* samples

Parameters	Sample	Score points
1. Colour	a) creamish white	10
	b) brownish white	6
	c) dark brown	2
2. Nature of spots	a) uniform light brown	10
	b) non uniform light brown	8
	c) uniform dark brown	6
	d) non uniform dark brown	4
	e) charred spots	2
3. Shape	a) circular	10
	b) non circular	5
4. Hand feel	a) soft, pliable	15
	b) slightly soft	10
	c) fragile	6
	d) hard	4
	e) very hard	2
5. Texture	a) soft, slightly chewy	15
	b) slightly highly slightly	10
	c) tough	5
6. Oiliness	a) optimum	15
	b) medium	10
	c) oily or dry	5
7. Mouth feel	a) easy break down no residue	15
	b) difficult to break down, residue remaining	10
	c) sticky or doughy or dry	5
8. Taste and aroma	a) typical, pleasant	10
	b) foreign, bland off flavour	0

Overall quality: Excellent (100–90), very good (89–80), good (79–70), satisfactory (69–60), fair (59–50), poor (49–40), very poor (39–30), not acceptable <30

Table 3 Coefficients of second order polynomial regression models with their significance

Coefficient	Moisture, %	Oil, %	Overall acceptability
β_0	22.10	26.46	82.00
β_1	-2.51^*	2.83^*	-10.15^*
β_2	0.67^*	-1.13^*	-2.08
β_{11}	-0.044	-0.56	-1.62^*
β_{22}	-0.49	0.76	0.13
β_{12}	0.28	0.85	0.75
R^2 , %	82.54	87.49	98.99
F value	5.12	9.79	137.37
P, %	0.027	0.0045	0.0001

* $p \leq 0.05$

R^2 value was more than 80% (Henika 1982). The R^2 value for the responses i.e. moisture, oil content and overall acceptability were 82.54, 87.49 and 98.99%, respectively, indicating that the models fitted well. The calculated F-value was also more than the table one (2.32 at 5% level) for all the responses indicating the adequate fit of the models. Thus, all the three responses were considered adequate to describe the effect of variables on the quality of *poori* samples and the models were as follows:

$$\text{Moisture} = 22.10 - 2.51X_1 + 0.67X_2 - 0.044X_1^2 - 0.49X_2^2 + 0.281X_1X_2$$

$$R^2 = 82.54$$

(3)

$$\text{Oil} = 26.46 + 2.83X_1 - 1.13X_2 - 0.56X_1^2 + 0.76X_2^2 + 0.85X_1X_2$$

$$R^2 = 87.49$$

(4)

$$\begin{aligned} \text{Overall acceptability} = & 82.00 - 10.15X_1 - 2.08X_2 - 1.62X_1^2 \\ & + 0.13X_2^2 + 0.75X_1X_2 \dots R^2 = 98.99 \end{aligned}$$

(5)

Effect of variables on moisture content of poori The variable WB had significant ($p \leq 0.05$) negative effect on moisture content of *poori* samples at linear level, while OB had significant ($p \leq 0.05$) positive effect. At quadratic and interactive levels no significant effect was observed for either of variables. It seems that insoluble nature of WB fibres was responsible for moisture reduction, while soluble nature of OB fibres contributed in moisture retention during frying of *poori* samples. The effect of both the variables on moisture content of *poori* samples had been presented in Fig. 1a. Lee and Inglett (2007) also reported that the batters containing oat- β -glucan rich hydrocolloid (C-Trim-30) retained more moisture during frying.

Fig. 1 Response surface plots showing the effects of wheat and oat bran on moisture (a), Oil (b) and on OAA (c) of *poori* samples

Table 4 Analysis of variance data for the overall effect of process variables

Process variables	F-value		
	Moisture, %	Oil, %	Overall acceptability
Total individual effect			
Wheat bran, X_1	7.73*	13.40*	219.91*
Oat bran, X_2	12.18*	13.32*	19.64*
Combined effect of all variables at			
Linear	15.60*	16.81*	429.27*
Interactive	0.16	1.35	2.25
Quadratic	0.39	2.08	7.48*

* $p \leq 0.05$

Effect of variables on oil content of *poori* At linear level, WB had positive effect ($p \leq 0.05$) on oil content, while OB had negative effect ($p \leq 0.05$). Waszkowiak et al. (2001) also reported that wheat dietary fibre in meat balls increased oil absorption capacity during frying. The negative effect of OB is due to its soluble nature (high moisture holding capacity) and this characteristic makes it more suitable for use in fried products. Lee and Inglett (2007) studied the effect of oat- β -glucan rich hydrocolloid (C-Trim-30) on oil uptake during frying of batters and reported that high water holding capacity of oat bran caused batters to have high viscosity, great batter pickup and less moisture loss, thus synergistically contributed to lower oil uptake. Moreover, oil binding is in part related to its chemical composition, but is more or less a function of the porosity of the fibre structure rather than the affinity of the fibre molecule for oil. By hydrating a fibre with water, the water molecule occupies the fibre pores, thus significantly reducing the oil binding and enhancing the crispiness of the fried product. Figure 1b represented the effect of both variables on oil content. As the concentration of WB increased the oil content of *poori* samples also increased, while curvature in figure shows that as percentage of OB increased up to 11.0 g/100 g wheat flour, the oil content decreased, and remained constant thereafter. Altunakar et al. (2004) also reported that high water holding capacity and viscosity development had a great effect on reduction of oil uptake in deep fried products.

Effect of variables on overall acceptability of *poori* Table 3 reveals that at linear level, WB had negative effect ($p \leq 0.05$) on overall acceptability (OAA) scores of *poori* samples, while effect of OB was insignificant as depicted in Fig. 1c. The unit change in WB brought more change in OAA scores as compared to OB. At quadratic level, WB had negative effect ($p \leq 0.05$), while insignificant effect was observed by either of variables at interactive level. The positive effect of OB on OAA score may be attributed to negative effect on oil uptake and positive effect on moisture retention, thus making the product crispier with enhanced acceptability.

Analysis of variance When a model had been selected, an analysis of variance was calculated to assess how well the model represented the data. F-value for all the responses, representing their overall individual as well as combined effect at linear, quadratic and interactive level (Table 4) indicated that both the independent variables affected the responses significantly ($p \leq 0.05$). Combined effect of both the variables at linear level was maximum followed by quadratic with no interactive effect. On this basis, it can be concluded that the selected models adequately represented the data for moisture and oil content as well as overall acceptability scores of *poori* samples.

Optimization of independent variables For the optimization of bran level all the three responses i.e., moisture, oil content and OAA scores were considered. These responses were used for the numerical optimization of the variables

Table 5 Constraints, criteria for optimization and solution along with predicted and actual response values

Constraints	Goal	Lower limit	Upper limit	Importance	Solutions	Actual response
Wheat bran, g/100 g wheat flour	In range	3	9	3	3.0	—
Oat bran, g/100 g wheat flour	In range	6	12	3	11.02	—
Moisture, %	In range	18.3	27.6	3	25.2	25.8 $\pm$ 0.20
Oil, %	Minimize	19.3	30.5	3	17.2	16.5 $\pm$ 0.22
Overall acceptability	Maximize	65	95	3	88.6	86.0 $\pm$ 1.50

and the criteria used along with predicted and actual values of the responses have been presented in Table 5. Using the given criteria (Table 5), the solution obtained was—wheat bran 3.0 and oat bran 11.0 g/100 g wheat flour. *Poori* samples were prepared based on the solution and the measured responses were very much close to the predicted ones, re-confirming the adequacy of the models. Therefore, the optimised level of bran has been recommended for the preparation of fibre rich *poori*. The optimized fibre rich *poori* samples along with normal *poori* (without added fibre) were also evaluated for proximate composition as well as fibre content and the corresponding values were moisture 25.8 ± 0.20 , protein 8.3 ± 0.10 , oil 16.5 ± 0.12 , ash 0.9 ± 0.05 , carbohydrate 40.2, TDF 4.2 ± 0.10 , IDF 2.9 ± 0.12 , SDF 1.3 ± 0.05 g/100 g in case of optimized (wheat bran 3.0 and oat bran 11.0 g/100 g wheat flour) *poori* while for control (without bran) the values were 24.2 ± 0.20 , 7.37 ± 0.12 , 21.4 ± 0.10 , 0.8 ± 0.05 , 44.0, 2.1 ± 0.10 , 1.7 ± 0.05 and 0.4 ± 0.05 g/100 g, respectively. The optimized *poori* prepared using recommended level of fibre had 20% less oil content as compared to control samples while, TDF and SDF increased significantly ($p \leq 0.05$) from 2.1 to 4.2 and 0.4–1.3 g/100 g, respectively. In India, the *poori* is consumed as meal and it is assumed that 3–4 *poori* (equivalent to 100 g wheat flour) are eaten as one serving by an adult. Thus, such developed *poories* may be enjoyed by those interested consumers, who want to take deep fried *poori* but can not because of high oil content.

Conclusion

RSM was successfully utilized in the optimization of bran level (soluble and insoluble fibre) for the preparation of fibre rich acceptable *poories*. The developed mathematical models for the various responses could be successfully used for their prediction while incorporating the fibre source in wheat flour and preparing *poori* from it. The developed *poori* had 4.2 g TDF and 1.3 g SDF per 100 g (3–4 *poories*) as well as approximately 20% lower oil content as compared to control. Such *poori* may be enjoyed by those who are health conscious and do not want to take much oil. Moreover, outcome of this study showed that soluble fibres from oat had a negative effect on oil absorption during frying and this potential of soluble fibres needs to be harnessed in deep fried products.

Acknowledgment Authors thank, Director, Defence Food Research Laboratory, Mysore, India for providing all the facilities necessary to carry out this research work.

References

- Altunakar B, Sahin S, Sumnu G (2004) Functionality of batters containing different gums for deep fat frying of carrot slices. *J Food Eng* 75:522–528
- Anderson JW (1985) Dietary fibre in nutrition and management of diabetes. In: Vahouny GV, Kritchevsky D (eds) *Dietary fibre: basic and clinical aspects*. Plenum Press, New York, pp 343–361
- 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 Chemists, Gaithersburg
- 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
- Burkitt DP (1977) Food fibre: benefits from a surgeon's perspective. *Cereal Foods World* 22:6–9
- Chakraborty SK, Singh DS, Kumbhar BK, Singh D (2009) Process parameter optimization for textural properties of ready-to-eat extruded snack food from millet and pulse-brokens blends. *J Texture Stud* 40:710–726
- Duss R, Nyberg L (2004) Oat soluble fibers (β -glucans) as a source for healthy snack and breakfast foods. *Cereal Foods World* 49:320–325
- Henika RG (1982) Use of response surface methodology in sensory evaluation. *Food Technol* 36(1):96–101
- Indrani D, Rao GV (2001) Optimization of the quality of South Indian parotta by modeling the ingredients composition using the response surface methodology. *Int J Food Sci Technol* 36:189–197
- 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
- Kahlon TS, Chow FI (1997) Hypocholesterolemic effects of oat, rice and barley dietary fibres and fractions. *Cereal Foods World* 42:86–92
- Kalinga D, Mishra VK (2009) Rheological and physical properties of low fat cakes produced by addition of cereal β -glucan concentrate. *J Food Process Preserv* 33(3):384–400
- Klopfenstein CF (1988) The role of cereal β -glucans in nutrition and health. *Cereal Foods World* 33:865–872
- Lee S, Inglett GE (2007) Effect of an oat β -glucan-rich hydrocolloid (C-trim30) on the rheology and oil uptake of frying batters. *J Food Sci* 72:222–226
- Lee S, Inglett GE, Carriere CJ (2004) Effect of nutrim oat bran and flaxseed on rheological properties of cakes. *Cereal Chem* 81:637–642
- McIntosh GH, Whyte J, McArthur R, Nestel PJ (1991) Barley and wheat foods: influence on plasma concentrations in hypocholesterolemic men. *Am J Clin Nutr* 53:1205–1209
- Merrill AL, Watt BK (1973) Energy value of foods: basis and derivation, *Agriculture Handbook* nr 74, USDA, pp 2–4
- Pomeranz Y, Shogren MD, Finney KF, Bechtel DB (1976) Fiber in bread making-effects on functional properties. *Cereal Chem* 54:25–41
- Rao HP, Rao HM (1991) Effect of incorporating wheat bran on the rheological characteristics and bread making quality of flour. *J Food Sci Technol* 28:92–97
- Sarojini KD, Maya P (1998) A novel food snack containing wheat bran. *Indian J Nutr Diet* 25:229–233

- Sudha ML, Vetrmani 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
- Vatsala CN, Saxena CD, Rao HP (2001) Optimization of ingredients and process conditions for the preparation of *poori* using response surface methodology. *Int J Food Sci Technol* 36:407–414
- Waszkowiak K, Gorecka D, Janitz W (2001) Influence of wheat dietary fibre on the quality of meat dishes. *Zuwnosc* 3:53–61
- Yadav DN, Rajan A, Sharma GK, Bawa AS (2010) Effect of fibre incorporation on rheological and chapatti making quality of wheat flour. *J Food Sci Technol* 47(2):166–173