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RESEARCH ARTICLE

Optimisation of ingredients levels and shelf-life evaluation of fibre enriched instant halwa mix

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Abstract

Wheat bran was used for the development of instant wheat sooji halwa mix. Central composite design with 3 independent variables viz. wheat bran, sugar and hydrogenated fat with 3 responses viz taste, mouthfeel and overall acceptability was used for the optimization of ingredients levels for the preparation of halwa mix. Optimised instant halwa mix was evaluated for its shelf-life by monitoring different physico-chemical characteristics, sensory attributes. The chemical changes and overall acceptability scores were found to be negatively correlated ($P \leq 0.05$) during storage. The correlation between PV & OAA, FFA & OAA and TBA & OAA were found to be -0.95, -0.98 and -0.98 in case of samples packed in PP whereas -0.98, -0.97 and -0.96 in case of MP packed samples stored at room temperature conditions.

INTRODUCTION

Wheat forms the major source of protein and calories for large section of Indian population. Most of the wheat produced in India, is utilized in the preparation of chapaties and other bakery products. But with the changing food habits, wheat is milled into semolina used for the preparation of sweet and savoury preparation. Wheat sooji (semolina) halwa is a highly popular sweet dish relished by all segments of Indian population. It is prepared by roasting semolina in hydrogenated fat followed by sugar and water. Instant halwa mix developed earlier (Arya and Thakur,1986) forms a main part of Indian Armed Force rations like mini compo pack, one man compo pack, sub marine crew and Main Battle Tank. This instant halwa mix required 4-5 minutes heating in boiling water for reconstitution and having a shelf-life of 1 year at ambient room temperature conditions.

The increasing demand for healthier foods has motivated food technologists to design fibre enriched products. The new fronties in food research is the role of non nutritive components in human health. In the recent past, the importance of fibre in the diet has increased as a functional ingredient which has opened up the potential market for fibre rich products (Sharma et al., 2006). Fibre rich products have a great role for the Armed Forces deployed at high altitude, where constipation is one of the major problems. Consuming fibre enriched food products certainly help them in overcoming the problem of constipation. One of the effects of high altitude is that food digests very slowly which can be counteracted with foods enriched with high fibre. Wheat bran is a by product of wheat flour milling. It usually accounts for 14-19% of the grains weight (Javed et al., 2012). The composition of wheat bran depends greatly on wheat variety, cultivation conditions and separation methods. Wheat bran contains a high amount of dietary fibre, which is mainly located in outer cell walls of the bran. Wheat bran also consists of antioxidants and anti carcinogenic compounds, minerals, vitamins, carotenoids, polyphenols etc. Wheat bran consists of oligosaccharides which acts as prebiotics and improve the microbial flora in colon. Earlier Noort et al. (2010) studied the effect of wheat bran on the bread quality. They reported that use of wheat bran reduces the quality of bread resulting in a lower specific volume and denser crumb texture. Katina et al. (2007) and Lappi et al.

(2010) have shown that enzymatic treatments combined with sour dough fermentation can improve the baking quality of wheat bran. Lyly et al. (2009) showed that a beverage enriched with wheat bran increased the satiety and feelings of fullness. Due to relatively low price, wheat bran holds a great potential as an ingredient to be added into food products. Yadav et al. (2007) has developed instant halwa mix by incorporating soy sooji as the utilization of soy bean is one of the more promising means of alleviating the shortage of good quality protein in developing countries. Khan et al. (2012) developed instant sooji halwa mix by incorporating virgin coconut meal having a shelf-life of 12 months at ambient temperature conditions. Most of the previous studies have shown use of wheat bran in the development of bakery products and its health benefits. No data is available on the utilisaiton of wheat bran in the development of traditional Indian sweet products like sooji halwa. Therefore, attempts were made to optimize the ingredient levels for the development of instant sooji halwa mix by incorporating wheat bran and to evaluate its shelf-life.

Materials and Methods

Raw materials

Ingredients like wheat sooji (semolina, 500 mesh sizes), hydrogenated fat, sugar, cashew nuts, wheat bran (brand) and cardamom were procured from local market. Chemicals used during analysis work were procured from E.Merck, India Ltd., Mumbai.

Milling of wheat bran

Wheat bran procured from local market was grinded in a mixer and sieved through 500 mesh size.

Roasting of wheat sooji and wheat bran

Required quantity of wheat sooji (semolina) was taken in a stainless steel vessel and continued heating with constant mixing till the temperature attained 130^{o}C. Once the required temperature was attained burner flame was put off and mixing continued till the roast temperature reached 60-70^{o}C. Wheat bran was roasted separately in a vessel till the temperature reaches 100^{o}C. Roasted sooji and wheat bran were packed in Metallised polyester packaging materials for further use.

Experimental design

A central composite rotatable design was used without any blocking for designing the experimental combinations. Parameters like colour, taste, mouth feel and overall acceptability scores on a 9 point hedonic scale were taken as responses as they influence the product quality and acceptability. Sugar powder, wheat bran and hydrogenated fat were taken as independent variables. The variables were standardized to simplify computation and deduce the relative effect of variables on the response. Since three independent variables were involved, the numbers of design points obtained were 20 with five centre point replication. Experimental runs were randomized in order to minimize the effect of unexpected variability in the observed responses. The independent variables with their coded and actual values with range of levels are given in table 1.

Preparation of instant halwa mix

Ingredients like hydrogenated fat, wheat bran and sugar were weighed separately according to the formulations obtained (Table 1). Weight of fried cashewnuts and cardamom powder were kept constant for all formulations. Hydrogenated fat was taken in a stainless steel and heated to 180^{o}C. Roasted sooji and wheat bran were added and mixing was continued till the temperature reached 155^{o}C. Once the required temperature was attained, heating was discontinued and the mixing was allowed to cool to a temperature of 60-70^{o}C. Sugar powder, fried cashewnuts and cardamom powder were added and mixed thoroughly.

Reconstitution of dry mix

Hundred gram of prepared instant halwa mix was added to 145 ml of boiling water and stirred continuously for 4-5 minutes until desired consistency was obtained.

Sensory evaluation

Sensory attributes like colour, taste and overall acceptability were evaluated by a panel of 15 semi trained judges on a 9 point hedonic scale with 9 as excellent in all respects and 1 as unacceptable one (Larmond, 1977).

Chemical Analysis

All the chemicals used for the study were of analytical reagent grade. Moisture, protein, fat, total ash, crude fibre were determined using standard AOAC methods (1990). Peroxide value (PV), free fatty acids value

(FFA) were estimated by the standard method of AOCS, 1990, whereas thiobarbituric acid value was determined using Tarledgis et al.(1960) method. Browning was measured by shaking 5 g sample with 100 ml 70% ethanol for 2 h, filtering and measuring optical density at 420 nm (Khan et al ., 2008)

Results and Discussion

RSM was used to develop instant sooji halwa mix by incorporating wheat bran. Table 1 shows the 20 experimental combinations of central composite rotatable design with 3 independent variables and 3 responses. As the sensory attributes plays an important factors in the acceptance of finished product, they were taken as responses. Earlier also Yadav et al. (2007) and Khan et al. (2012) has used sensory scores like taste, texture, colour and overall acceptability in their studies for the optimization of instant halwa mix by incorporating soy sooji and virgin coconut meal respectively.

Numerical optimization procedure of design expert software version -6 was used for the optimization of independent variables by maximization of the necessary responses along the fitted polynomial models. The solutions were sought to maximize the desirability function for the given criteria by being at random starting points. The best suitable fit model was taken as the optimized composition for the preparation of instant halwa mix incorporated with wheat bran.

Diagnostic checking of the fitted models

Validations of the fitted model responses for all the experimental design are given in table 2. All main, linear, quadratic and interactive effects were calculated for each model. The regression coefficients and correlation coefficients for each model are shown in table 2. The co-efficient of determination R^2 was more than 90% and lack of fit (LoF) was insignificant indicating the fitness of polynomial models used for describing the effect of independent variables on the responses. All three responses were considered adequate to describe the effect of variables on the quality of Fibre enriched instant halwa mix samples. The following equations in terms of coded factors explained the effect of variables on responses.

Taste(Y) : $8.54+0.15*X_1-0.11*X_2+0.32*X_3-0.025*X_1X_2-0.12*X_2X_3+0.10*X_1X_3-0.57X_1^2-0.57*X_2^2-0.45X_3^2$

Mouthfeel (Y): $8.58+0.17*X_1-0.074*X_2+0.37*X_3-0.037*X_1X_2-0.11*X_2X_3+0.038*X_1X_3-0.57X_1^2-0.53*X_2^2-0.48X_3^2$

OAA(Y): $8.55+0.14*X_1-0.11*X_2+0.36*X_3-0.062*X_1X_2-0.12*X_2X_3+0.056*X_1X_3-0.57X_1^2-0.55*X_2^2-0.45X_3^2$

Effect of variables on the sensory attributes of fibre enriched instant halwa mix

Table 2 revealed that at the linear level wheat bran and fat had a significant positive effect ($p \leq 0.05$), while sugar showed negative effect on the sensory responses instant halwa fortified with wheat bran. At the quadratic level all the variables had significant negative effect ($p \leq 0.05$) on all the sensory responses studied. At interactive level, the results showed that the interaction between wheat bran and sugar, fat and sugar had a negative effect while, wheat bran and fat had positive effect on the sensory responses studied. The effect of wheat bran, sugar and fat on the overall acceptability score of instant halwa mix fortified with wheat bran are shown in figure1. It is clear from the figures that all the responses were equally influenced by the levels of wheat bran, fat and sugar. The analysis of variance for different models is given in (Table 3). The F-values for taste, mouthfeel and overall acceptability were found to be significant and found to be 47.92, 55.80 and 44.12 respectively.

The level of ingredients used to obtain the best product was obtained using numerical optimization. The desired goals for each factor and response were chosen and different weights were assigned to each goal to adjust the shape of its particular desirability function. The solutions were sought to maximize the desirability function for the given criteria by being at random starting points. The solution with maximum desirability was selected as optimum ingredients composition. The optimized recipe for the preparation of instant hallway mix fortified with wheat bran was wheat bran 31g; sugar powder 119g and hydrogenated fat 79g with cashew nuts 7 g and cardamom powder 2g were kept constant based on 100g shoji for all the runs with a desirability of 0.967.

Storage studies of optimized fibre enriched instant halwa mix

Optimised wheat bran fortified instant halwa mix was packed in polypropylene and metallised polyester packaging materials and stored at ambient temperature. Initially and a regular interval of 3 months, halwa mix was analysed for different physico-chemical parameters like moisture, peroxide value, free fatty acid value, thiobarbituric acid values along with sensory and micriobiological attributes.

Optimised wheat bran fortified instant halwa mix had moisture 0.92%; fat 26.4%; protein 5.47%; Ash 0.48%; fibre 3.4% ; carbohydrates 66.73 (by difference) providing an energy of 526 K.cal / 100g.

Lipid peroxidation which results in the development of off flavor in low moisture foods is the major cause of rejection of processed foods by the consumer. The rate of lipid peroxidation was monitored by following changes in peroxide value, free fatty acids, thiobarbituric acid value and browning index in instant halwa mix. The changes in chemical parameters were correlated with sensory attributes to assess the shelf-life of instant halwa mix. Chemical changes and sensory changes in wheat bran incorporated instant halwa mix during storage have been presented in Table 4. It may be observed that the rate of autoxidation as measured by changes in PV and TBA values were significantly higher in samples packed in PP as compared to those packed in MP. The peroxide value of wheat bran incorporated instant halwa mix packed in PP increased from 3.38 to 20.48 meqO_2/Kg fat as compared to 3.38 to 17.88 meqO_2/Kg fat in MP packed samples. Free fatty acid values were found to increase from 0.44 to 1.28 % and 0.44 to 1.07 % oleic acids in samples packed in PP and MP packaging materials respectively. The increase was due to breakage of long chain fatty acids into individual moieties. Earlier also, Thakur and Arya (1987) and Khan et al. (2012) also reported an increase in PV and FFA contents in wheat semolina sooji halwa and VCM incorporated sooji halwa during storage irrespective of packaging materials. The TBA value which is an index of secondary lipid oxidation also followed similar pattern and found to increase from 0.065 to 0.203 and 0.177 mg MA/Kg samples in PP and MP packed samples respectively. After 12 months of storage, there was no significant increase in the browning intensity in wheat bran incorporated instant halwa mix.

Changes in overall acceptability score of the reconstituted halwa mix samples stored under ambient temperature conditions in PP and MP packaging materials have been shown in table 4. Initially, halwa mix had an overall acceptability score of 8.5 on a 9 point hedonic scale. After 12 months of storage, halwa mix packed in PP and MP received OAA score of 7.0 and 7.2 indicating that irrespective of packaging materials instant halwa mix remained stable and acceptable during the entire store period of 12 months. However, acceptability of the product was higher in MP as compared to PP packed ones.

The chemical changes and overall acceptability scores were found to be negatively correlated ($P \leq 0.05$) during storage. The correlation between PV & OAA, FFA & OAA and TBA & OAA were found to be -0.95, -0.98 and -0.98 in case of samples packed in PP whereas -0.98, -0.97 and -0.96 in case of MP packed samples stored at room temperature conditions. The negative correlation indicated that with the increase in PV, FFA and TBA, the overall acceptability of halwa mix during storage decreased.

Table 1. Design of experiments for wheat bran incorporated instant sooji halwa

	Variable levels (used) (based on 100g semolina (suji)			Responses		
Expt. No.	Wheat bran (g), X_1	Sugar (g), X_1	Fat (g), X_3	Taste	Mouthfeel	OAA
1	20	110	65	6.5	6.4	6.5
2	40	110	65	7	6.9	6.9
3	20	130	65	6	6.2	6.1
4	40	130	65	6.6	6.7	6.6
5	20	110	85	7.3	7.4	7.5
6	40	110	85	7.5	7.6	7.55
7	20	130	85	7.4	7.5	7.45
8	40	130	85	7.3	7.4	7.35
9	13	120	75	6.7	6.6	6.6
10	46	120	75	7.2	7.3	7.2
11	30	103	75	7.1	7.2	7.2
12	30	136	75	6.8	6.9	6.8
13	30	120	58	7	6.8	6.9
14	30	120	91	7.6	7.6	7.6
15	30	120	75	8.5	8.5	8.5
16	30	120	75	8.4	8.5	8.4
17	30	120	75	8.7	8.7	8.7
18	30	120	75	8.65	8.6	8.6
19	30	120	75	8.5	8.5	8.5
20	30	120	75	8.6	8.7	8.6

Table 2. Coefficients for different responses for preparing fibre enriched instant halwa mix

Factors	Estimated Coefficients		
	Taste	Mouthfeel	OAA
X_0	8.56	8.58	8.55
X_1	0.15*	0.17*	0.14*
X_2	-0.11*	-0.074*	-0.11*
X_3	0.32*	0.37*	0.36*
$X_1 X_2$	-0.025	-0.037	-0.062
$X_2 X_3$	-0.12	-0.11	-0.12
$X_1 X_3$	0.10	0.038	0.056
X_1^2	-0.57*	-0.57*	-0.57*
X_2^2	-0.57*	-0.53*	-0.55*
X_3^2	-0.45*	-0.48*	-0.45*

*significant ($p \leq 0.05$)

Table 3. Analysis of variance for different models

Responses	Source of variance	Sum of squares	d.f.	Mean square	F-value
Taste	Model	12.51	9	1.39	47.92
	Residual	0.29	10	0.029	
	Cor.Total	12.80	19		
Mouthfeel	Model	12.57	9	1.40	55.80
	Residual	0.25	10	0.025	
	Cor.Total	12.82	19		
OAA	Model	12.39	9	1.38	44.12
	Residual	0.31	10	0.031	
	Cor.Total	12.70	19		

Storage Period (months)	PV*		FFA*		TBA*		OAA**	
	PP	MP	PP	MP	PP	MP	PP	MP
0	3.38^{a}	3.38^{a}	0.44^{a}	0.44^{a}	0.065^{a}	0.065^{a}	8.5^{a}	8.5^{a}
3	6.17^{bx}	5.9^{b}	0.71^{bx}	0.66^{b}	0.083^{bx}	0.79^{b}	8.1^{bx}	8.3^{b}
6	9.78^{cx}	8.13^{c}	0.85^{cx}	0.78^{c}	0.109^{cx}	0.099^{c}	7.5^{cx}	7.9^{c}

9	14.33^{dx}	12.33^{d}	1.04^{ex}	0.98^{d}	0.157^{dx}	0.118^{d}	7.3^{dx}	7.6^{d}
12	20.48^{ex}	17.88^{e}	1.28^{fx}	1.07^{e}	0.203^{ex}	0.177^{e}	7.0^{ex}	7.2^{e}

Table 4. Changes in peroxide value (meqO_2/kg fat); free fatty acid value (FFA, % oleic acid); thiobarbituric acid value (TBA, mg MA/Kg sample) and overall acceptability score (OAA) of instant halwa mix packed in PP and MP and stored at ambient temperature conditions.

*mean ± SD (n = 3); **Mean ± SD (n = 15);
$^{a-e}$:values within the same column with different superscripts differ significantly ($p \leq 0.01$); ^{x}:significantly different from their corresponding PP packed samples($p \leq 0.01$).

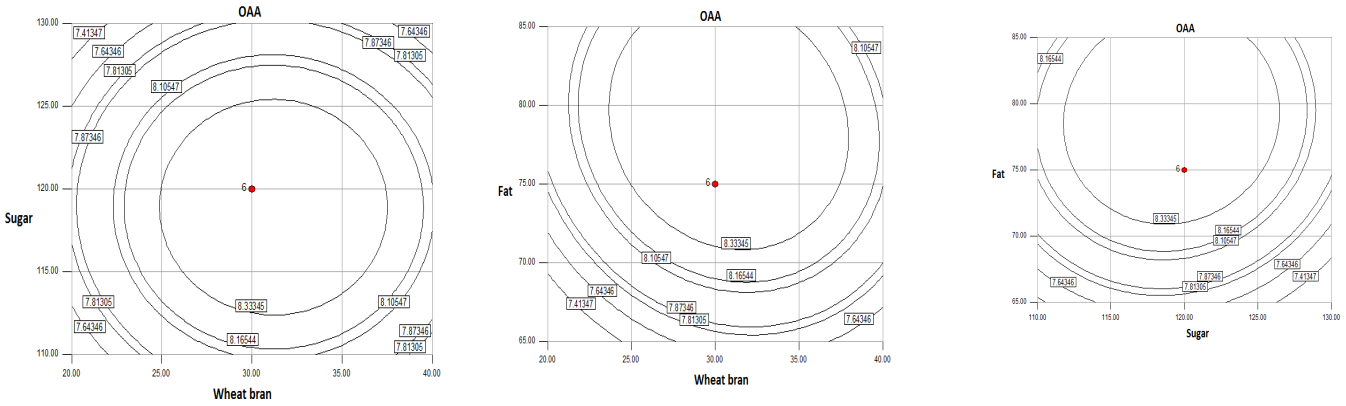

Fig-1. Counter plots showing effect wheat bran, sugar and fat on the OAA of wheat bran incorporated instant halwa mix.

Conclusions

The ingredients level for the preparation of instant halwa mix prepared by incorporating wheat bran was successfully optimized using response surface methodology and shelf-life studies showed that halwa mix remained stable and acceptable for 12 months irrespective of packaging materials.

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