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Research Article

OPTIMIZATION OF PROCESS VARIABLES FOR PREPARATION OF APPLE POMACE - BLACK SOYFLOUR BASED BISCUITS

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ABSTRACT
A study was conducted to utilize the apple pomace for manufacturing an edible and nutritious bakery product. Biscuits were prepared utilizing apple pomace and were incorporated with black soybean for further nutritional enrichment. Ingredient levels for apple pomace biscuits; for soy flour biscuits; and for apple pomace: soy flour biscuits were optimized using Central Composite Rotatable Design with four variables each at five levels. Biscuits were analyzed for thirteen responses i.e. diameter, thickness, weight, spread ratio, % spread factor, hardness, fracturability and sensory parameters. The data were analyzed and the response functions were developed using Response Surface Methodology. Results showed that quantity of apple pomace significantly affected % spread factor, hardness and fracturability and quantity of soy flour significantly affected all the four factors in apple pomace and soy flour biscuits respectively. Quantity of apple pomace: soy flour affected % spread factor and overall acceptability. % Spread factor increased and overall acceptability decreased with increase in the levels of apple pomace, soy flour and apple pomace: soy flour. Hardness increased with increase in apple pomace and soy flour levels in apple pomace and soy flour biscuits respectively. The sensory score on 9-point hedonic scale ranged from 5.6 to 8.8, 6 to9 and 6 to 8.9 for apple pomace, soy flour and apple pomace: soy flour biscuits respectively indicating the acceptability of apple pomace: soy flour biscuits. Study revealed that instead of allowing apple pomace to got waste, it could be utilized in manufacturing the value added products by incorporation of back soybean flour.

***Key Words**: Apple Pomace Powder, Soy Flour, % Spread Factor, Hardness, Fracturability, Sensory Parameters*

INTRODUCTION
Nutrition is an input to and foundation for health and development. A large part of the rural and tribal population in India is unable to get a balanced nutrition diet. To get the optimum health for the society, we need to supplement the diet nutritive food products by utilizing cheap and nutritionally rich sources which may be through nutritional supplements. One way to do it is by manufacturing and distributing nutritive food products by utilizing cheap and nutritionally rich sources which may otherwise go as a waste. This would not only find a solution to the menace of pollution, but also may result in a convenient food, which can help in obtaining enhanced income and food security for the people of our country and provide small and medium scale enterprises with increased opportunities.
India being the largest producer of fruits in the world and the 9th largest producer of apples, can utilize its processed fruit waste as a cheap source of nutrition (MFPI, 2003). Apple is the most favored fruit of millions of people and widely grown in temperate regions of the globe (FAO, 1989; Kaushal and Joshi, 1995). Apple according to scientists is a miracle fruit because of the several health benefits it offers (Kaur *et al.*, 2004). After apple juice production what remains is pomace, which being a part of the fruit retains its goodness. Apple pomace, though, is a rich source of fiber, minerals and vitamin C; but is not currently being utilized judiciously by the industry and is discarded as a waste. Apple pomace is a mostly unused, otherwise edible by-product of the apple juice industry, with a crude fiber content of approximately 14-30% of the dry weight (Walter *et al.*, 1985). Considering its value as a fiber source it can be used to develop edible products that could supplement fiber in the diet of people. Offering complete nutrition is

an important asset of any food developed. Hence, keeping this in mind black soybean an easily available, rich source of protein could also be used to further nutritionally enrich the food. An attempt has been made to prepare a fiber and protein rich biscuit using apple pomace powder and black soybean flour for fiber and protein enrichment respectively and product properties have been tried to find out using response surface methodology techniques with the following specific objectives (1) to develop apple pomace based biscuits using different composite blends and (2) to optimize different ingredient levels in biscuit preparation using RSM.

MATERIALS AND METHODS

Apples, black soybean, wheat flour and other ingredients were procured from the local market of Pantnagar, U.S Nagar, Uttarakhand, India.

Preparation of apple pomace powder

To prepare apple pomace, apples were cleaned, sliced and decored and dipped in 2000 ppm KMS solution. The apple pieces were crushed in the fruit crusher and juice was removed manually through muslin cloth. The remaining pulp was then pressed in the Carver press at 15 m tons of pressure for 90 minutes. The apple pomace thus obtained as dried in a tray drier at 60°C till 10-12% moisture content was obtained. The dried apple pomace was ground in the domestic grinder and packed in airtight polythene bags.

Preparation of black soybean flour

The black soybean grains were dehulled in the mini dhal mill and then ground in the grinder to obtain black soybean powder.

Preparation of flour (for biscuits)

Apple pomace powder, black soybean flour and wheat flour were sieved through the sieve of 250-micron mesh size. Then they were stored in airtight zip-lip polythene bags till use.

Preparation of biscuits

Sweet biscuits were prepared using the traditional creamery method described by Whitley (1970).

Measurement of variables

The physical parameters were measured according to the procedure given in AACC, 1967. The rheological parameters i.e. hardness and fractuarbility of biscuits were measured using (Stable Micro Systems TA.Hdi) Texture Analyzer. To conduct the sensory analysis a panel of 10 untrained judges was selected and the product was evaluated on a 9-point hedonic scale. The products were also analyzed for their nutritional characteristics i.e. moisture content (IS 12711: 1989, total ash (IS 12711: 1989), acid insoluble ash (IS 12711: 1989), crude fat (IS 12711: 1989), crude protein (AOAC, 1984) and crude fiber (IS 12711: 1989) contents.

Data were analyzed using the statistical package DESIGN EXPERT 7.0 and graphs were plotted using SURFER 6.0and the response functions were developed using multiple regression. The adequacy of the model was examined based on three criterion, F value, Lack of Fit (LoF) and adequate precision value. The optimization was done by numerical optimization. Constraints were set to get the optimized coded value of the variable between the upper and lower limits of the variable.

Design of experiments

Three sets of experiments i.e. optimizing the ingredient levels in apple pomace biscuits, soy flour biscuits and apple pomace: soy flour (50:50) biscuits were designed using Response Surface Methodology, and attempts were made to fit the multiple regression equations correlating responses to obtain an optimized quality composition, which can be represented by a second order quadratic equation.

The Central Composite Rotatable Design with four variables, each at five levels was selected to design the experiments. The variables selected for the experiment were apple pomace and soy flour with a combination (each) of 5, 10, 15, 20 and 25% wheat flour replacement, apple pomace: soy flour (10, 20, 30, 40 and 50 % wheat flour replacement), baking powder (0.1, 0.2, 0.3, 0.4 and 0.5), ammonium bicarbonate (0.3, 0.4, 0.5, 0.6 and 0.7) and sodium bicarbonate (0.2, 0.25, 0.3, 0.35 and 0.4). Designed experiments were conducted randomly to optimize the levels of ingredients of the three products. Each product was evaluated for thirteen responses, which were grouped into three categories namely physical parameters of the product, which include diameter, thickness, weight, spread ratio and % spread factor; rheological parameters, which include hardness and fracturability; and sensory parameters i.e. top grain, color, texture, odor, taste and overall acceptability. Of the thirteen responses for which the biscuits were analyzed, four important parameters namely % spread factor, hardness, and fracturability and overall acceptability were selected to find the optimum conditions.

The range selected from the numerical optimization had a maximum and a minimum value for each variable in each product category. To set a range for the parameters within which the product obtained would have good acceptability, the minimum values for each variable and the maximum values for each variable were selected and hence two set of experiments for each product were designed one having all the minimum values and one having all the maximum values of the independent variables. Thus, in total six optimized products were made two from each product category.

RESULTS AND DISCUSSION

Data obtained from the statistical analysis was utilized to get the optimized conditions of the independent variables. Numerical optimization was done after setting the constraint values for the responses and the independent variables and optimized range for the variables were decided from the solutions obtained. Also, graphical optimization was done by overlapping the contours and optimized range was obtained for each independent variable. The details of the effect of response for optimized products (Table 1) on sensory parameters, physical and rheological parameters are given below.

Sensory parameters

The sensory analysis of the optimized products revealed that all the scores for various parameters of sensory analysis lie within the range i.e. like extremely to like very much (9 to 8) and like very much to like moderately (8 to 7). The sensory analysis results are presented in Table 2.

The sensory scores for top grain ranged from 7.5 for soy flour biscuit having 10.94g of soy flour to 8.21 for apple pomace biscuit having 9.12g of apple pomace. The top grain score for apple pomace: soy flour biscuit (8.07 and 8.14) was intermediate between the apple pomace and soy flour biscuits.For color the maximum score was for apple pomace biscuit having 9.12g of apple pomace and minimum for soy flour biscuit having 10.94g of soy flour. The soy flour biscuits had the lowest scores i.e. 7.21 and 7.71. The score for apple pomace: soy flour biscuits were 8.07 and 8.14.For texture also the lowest score was for soy flour biscuit having 10.94g of soy flour and in general soy flour biscuits had lower scores (7.36 and 7.89). The apple pomace: soy flour biscuit (having 4.26g each of apple pomace and soy flour) had the highest score of 8.21. The scores for apple pomace biscuits were 7.86 and 8.14.

The highest sensory score for odor was 8.21 for both the apple pomace biscuits. The score of 7.93 for apple pomace: soy flour biscuits followed it. The lowest scores were for soy flour biscuits i.e. 7.36 and 7.89 due to the soy like flavor. The taste scores were highest for apple pomace biscuits (8.57 and 8), probably due to the sweet taste imparted by apple pomace. The lowest scores were for soy flour biscuits due to the presence of soy flavor. The score for apple pomace: soy flour biscuit (7.93) was intermediate between these two.

In the category of overall acceptability the highest score was for apple pomace biscuit having 9.12g of apple pomace. The score for both the apple pomace: soy flour biscuits followed at 8.21. The lowest overall acceptability was for soy flour biscuits.

For apple pomace biscuits the interaction terms of APP & BP, APP & ABC, APP & SBC and ABC & SBC had negative effects on overall acceptability. Interaction terms of BP & ABC and BP & SBC had positive effects on overall acceptability. Contours were plotted pertaining to the significant factors of the overall acceptability (Fig 1). When APP was taken on x-axis and BP on y-axis (Fig 1a), the contour showed an increase in the overall acceptability with increase in the quantity of the BP. With increase in the quantity of APP, overall acceptability first increased slightly but then started to decrease. Contour with APP on x-axis and ABC on y-axis (Fig 1b), the contour points towards the same pattern with increase in APP as in the earlier case. With increase in the quantity of ABC, overall acceptability showed an increase. In the contour plotted with APP at x-axis and SBC at y-axis (Fig 1 c), overall acceptability increased with increase in the quantity of SBC and APP, but decreased slightly towards the end with increase in APP.

Interaction terms for soy flour biscuits of SF & ABC and BP & ABC had negative effects and interaction terms of SF & BP, SF & SBC, BP & SBC and ABC & SBC had positive effects on overall acceptability of the product. Contour was plotted (Fig 2a) with SF on x-axis and BP on y-axis it showed that overall acceptability decreased with increase in both SF and BP. In the contour plotted with SF on x-axis and ABC on y-axis (Fig 2b), after showing a slight increase initially overall acceptability decreased with increase in SF in the blend. With increase in the quantity of ABC, overall acceptability increased but showed a little decrease in the end. The center values of SF and SBC had the maximum score for overall acceptability with decrease on either side, in the contour having SF on x-axis and SBC on y-axis (Fig 2c).

In apple pomace: soy flour biscuits APP: SF & BP, APP: SF & ABC, BP & ABC, BP & SBC and ABC & SBC interaction terms had negative effects on the overall acceptability of the product. Interaction term between APP: S F & SBC had positive effect on overall acceptability of the biscuits. The contour plotted (Fig 3a) with APP: SF on x-axis and BP on y-axis indicates that BP had no effect on the value of overall acceptability and overall acceptability values decreased with increase in APP: SF. Contour was plotted taking APP: SF on x-axis and ABC on y-axis (Fig 3 b). Overall acceptability decreased with increase in APP: SF and increased with increase in ABC. Also contour was plotted with APP: SF on x-axis and SBC on y-axis (Fig 3 c), indicating that overall acceptability decreased with increase in the levels of both APP: SF and SBC.

Physical and rheological parameters

The results of the physical and rheological parameters are given in Table 3. Percentage spread factor was high for all the biscuits as was desired. Hardness values for all the biscuits fell in the optimum range given as constraint (8774.5 to 12275 for apple pomace biscuits, 9000 to 14000 for soy flour biscuits and 10000 to 15000 for apple pomace: soy flour biscuits) for each product except for the sixth product for which the hardness value was a little lower than the constraint given. Fracturability values for apple pomace biscuits were within the constraint range (48.757 to 135.544), for soy flour biscuits it was higher than the constraint value (75 to 98) and for apple pomace: soy flour biscuits it was in the optimum range (14.219 to 86.067).

Chemical analysis

The results of the chemical analysis are given in Table 4. Addition of apple pomace results in lower moisture in the final product probably due to the presence of high fiber content, which is evident from the high crude fiber value of apple pomace biscuits (8.9 and 8.08 for first and second product respectively). Protein content is lower for apple pomace biscuits. Chen *et al.* (1988) also reported less moisture, ash and protein content of apple pomace biscuits. Crude fiber content for apple pomace: soy flour biscuits were also marginally higher. Composition of the biscuits did not have any significant effect on the total ash and crude fat contents of the biscuits. Addition of soy flour resulted in an increase in the protein contents of the biscuits due to the high protein content in soybean. Also higher ash content was observed in soy flour biscuits.

Consumer validation of the optimized flour blends

Flour blends (apple pomace-wheat flour, 9.152-54.84; soy flour-wheat flour, 11.04-52.96; and apple pomace: soy flour-wheat flour, 8.512-55.48) were prepared from the optimized flour quantity (maximum value of the range) and given to a local bakery unit. They prepared biscuits using the given flour blends according to their own recipe. Then sensory analysis was done for theses biscuits, conducted by a heterogeneous group. The results are presented in the Table 5.

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The results obtained indicate that the apple pomace biscuits prepared in the lab had higher sensory scores than those prepared by the baker. But still they had good overall acceptability showing the prospects of using these blends in the commercial use especially for those requiring health benefits.

Table 1 **Sensory analysis of the optimized products**

Final product	Top grain	Color	Texture	Odor	Taste	Overall acceptability
1	7.78	7.86	7.86	8.21	8.57	8.43
2	8.21	8.21	8.14	8.21	8	8
3	7.5	7.21	7.36	7.43	7.64	7.5
4	8.07	7.71	7.89	7.79	7.5	8
5	8.07	8.07	8.21	7.93	7.93	8.21
6	8.14	8.14	8.07	7.93	7.93	8.21

Table 2 Physical and rheological parameters of the optimized products

Response	Final product					
	1	2	3	4	5	6
Diameter (cm)	4.67	4.85	4.89	4.79	4.88	4.87
Thickness (cm)	0.54	0.60	0.64	0.62	0.55	0.56
Spread ratio	8.71	8.05	7.67	7.78	8.89	8.64
% Spread factor	148.17	136.96	130.57	132.34	151.37	147.10
Weight (g)	5.53	6.31	7.57	7.32	6.58	6.41
Hardness (g.s)	10732	11804	10875	9570	10561	9367
Fracturability	94.01	90.64	112.08	117.13	83.88	77.27

Table 3 Chemical analysis of the optimized products

Parameter	Final product					
	1	2	3	4	5	6
Moisture, %	**3.99**	**4.12**	**4.5**	**4.63**	**5.02**	**5.14**
Total ash, %	**1.14**	**1.06**	**1.49**	**1.11**	**1.09**	**1.26**
Crude fat, %	**14.19**	**14.15**	**14.61**	**14.33**	**14.95**	**14.00**
Crude protein, %	**6.01**	**6.12**	**11.63**	**11.47**	**7.14**	**7.48**
Crude fiber, %	**8.90**	**8.08**	**4.58**	**4.57**	**5.00**	**5.73**

Table 4 Sensory analysis of the biscuits prepared in the local bakery unit

Final product (Bakery)	Top grain	Color	Texture	Odor	Taste	Overall acceptability
1	7.93	8.5	8.21	7.57	8	8.14
2	7.43	7.71	8.21	7.79	8.28	8.43
3	7.57	7.64	8.14	8.29	8.28	8.28

The sensory scores for soy flour biscuits and apple pomace: soy flour blend biscuits prepared by the baker had higher sensory score than those prepared in the lab. They also showed good acceptability. Hence indicating a possibility of commercial use for such blends. Soy flour biscuits excelled in the taste and overall acceptability, but lagged behind in color, odor and top grain. Apple pomace biscuits had higher sensory scores for color and top gain categories. Biscuits made from apple pomace and soy flour combination had higher scores for odor and texture. These interpretations differ from those of the biscuits prepared in the lab, probably due to the different recipe and method of preparation followed at the commercial level. From the responses of the heterogeneous groups for biscuits made in the local bakery, it can be concluded that the overall acceptability for apple pomace: soy flour biscuit was observed to be the best.

Conclusion

Apple pomace biscuits nutritionally enriched with black soybean flour can be successfully prepared with acceptable results, which is evident from the high sensory scores of the products (6.0 to 8.9). Value addition of apple juice industry waste can be successfully achieved. Given the acceptability of biscuits even in the rural area of the country, the product innovations needs to be attained and should be backed by a highly efficient business system to succeed.

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