Optimization of instant *dalia* dessert pre-mix production by using response surface methodology

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Abstract *Dalia*, a wheat-based, particulate containing dairy dessert is popularly consumed as a breakfast food and is also considered as a health food. Though popular throughout Northern parts of the country, its limited shelf-life even under refrigeration imposes severe restrictions on its organized manufacture and marketing. In order to promote *dalia* dessert as a marketable product, in the present study, a process was developed for manufacture of instant *dalia* pre-mix, as a dry product with long shelf-life, which could be attractively packaged and easily reconstituted for consumption. During the investigation, the effect of different levels of milk solids and wheat solids was studied on *dalia* pre-mix quality by employing a central composite rotatable design (CCRD). The suggested formulation had 17.82 % milk solids and 2.87 % wheat solids. This formulation was found to be most appropriate for manufacture of instant *dalia* pre-mix with predicted sensory scores (Max. 100) of 85.35, 41.98 and 67.27 for mouthfeel, consistency and flavor, respectively; the viscosity of the product was 941.0 cp.

Keywords *Dalia* · Optimization · Response surface methodology · Wheat flour

Introduction

Dalia or cracked wheat, is a cereal-based product, which is cooked in milk to get a porridge like dairy dessert. It is popularly consumed as a breakfast food and is also considered as a health food. In spite of high popularity, its limited keeping quality even under refrigeration and lack of an industrial process for its large-scale manufacture has not allowed it to come out of the boundaries of the domestic kitchen. It is regarded more as a house-hold product cooked for immediate consumption rather than as a value added food product. Traditionally cereal based milk products have been produced for centuries in many South-East Asian countries including India. These are relished by the consumers for their unique organoleptic taste as well as synergistic effect of nutrition from both milk and cereals. Most of these products are prepared by using variety of cereals such as cracked wheat (*dalia*), rice, sabudana, *makhana*, vermicelli, semolina, etc. The ratio of cereal grains to milk may differ depending upon the type of cereal used and the type of consistency commonly liked by consumers in a particular product.

Wheat production in India is estimated to be 73.5 million tonnes in the year 2011–12, which is approximately 1.4 million tonnes more than the last year's production (IGC 2012). Major forms of utilization of wheat in the country include its conversion into *chapati* at domestic level and production of bread, pasta, cakes, biscuits, ready-to-eat and ready-to-cook products. There is a need to come up with more and more products and processes to enable full utilization of growing wheat production in the country, as most of the times there are reports which suggest that part of wheat stored in warehouses gets spoiled because of both lack of storage facilities as well as due to the poor storage conditions. Conversion of wheat into value-added convenience

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food products could be a real solution to solve the problem of spoilage and post-harvest losses. As, milk production is also continually increasing at a rate of 4–5 % per annum, it will be appropriate that processing methods are mechanized to manufacture milk-wheat based food products for large scale production and industrial application.

Dalia is a product which is obtained by cooking wheat grits in boiling water or milk along with sugar to sweeten the product. Several product development work have been reported for processing, packaging and value addition to *dalia* grains. The grits, upon heating, gelatinizes to increase the consistency of the product (Manohar et al. 1998; Gujral and Sodhi 2002). It is consumed as a breakfast food and is a preferred food for old age people as it is considered good for digestion. It is also given to convalescing patients to meet their nutritional requirements. Rao et al. (1994) prepared freeze dried wheat porridge (*dalia*), which had a shelf-life of about 6–9 months at 37 °C, when packaged in paper/foil/polyethylene laminated flexible pouches.

An instant porridge based on pre-cooked wheat *dalia* and milk solids has been developed for space astronauts by Defence Food Research Laboratory, Mysore, India (Arya 1998). A ready-to-eat breakfast cereal containing instant milk powder, wherein milk powder is uniformly distributed among the cereal pieces, resulted in a uniform proportion of cereal and liquid milk in each serving when water was added (Bodkin 1998). A wheat based *kheer* mix was developed based on reconditioned vermicelli (wheat), milk powder, sugar and flavourants having chemical and microbiological stability for 6 months at 37 °C. It was found that for one serving, 75 g of vermicelli *kheer* mix was required. For getting better consistency, about 2–3 g of vermicelli powder was also added to the mix (Jayathilakan et al. 2000). Jha et al. (2012) developed an in-can retort process for shelf-stable ready-to-serve *dalia* dessert and the optimally processed *dalia* dessert in 175 ml tin-free steel cans employing a rotary retort, which could keep well for at least 72 days at 37 °C.

In the present study, attempts were made to develop a process for instant *dalia* pre-mix production. Response surface methodology (RSM) was used for optimization of *dalia* dessert pre-mix constituents. RSM has been used earlier to optimize the various parameters in the production of food products with desired quality (Henika 1972; Henselman et al. 1974; Castro et al. 2000; Kurien and Mishra 2008; Jha et al. 2011, 2012; Bunkar et al. 2012). A critical appraisal of these reported references show how various product and process variables through RSM could enable the product development specialists to come up with newer products.

Materials and methods

Materials

For the manufacture of instant *dalia* pre-mix, buffalo milk was obtained from the Experimental Dairy of the National Dairy Research Institute, Karnal, India. Whole wheat of four different varieties i.e. PDW-233, WH-896 (*Triticum durum* types) and HD-2687, PBW-343 (*Triticum aestivum* types), used in the present investigation, were obtained from the Directorate of Wheat Research, Karnal, India. Wheat grains were ground into fine powder in a local flour mill and the particle size of the powder ranged from 0.1 to 2.0 mm. Commercially available cane sugar was obtained from the Experimental Dairy of the National Dairy Research Institute, Karnal, India. Commercially available cardamom was procured from the local market of Karnal, India. It was dehusked and ground to a fine powder, and stored under refrigeration. Whole milk powder used for preliminary laboratory studies was procured from Modern Dairy (India) Ltd., Karnal, India. Butylated hydroxyl anisole (BHA), an anti-oxidant, used as an additive into instant *dalia* mix was procured from Sigma (St-Louis, MO, USA). All the chemicals used in analyses were of AR grade.

Particle size analysis The particle size of the ground wheat grains was determined using a Malvern Mastersizer 2000 equipped with Hydro 2000MU wet dispersion unit (Malvern Instruments Ltd., UK). The size was analyzed by the method given by Srikaeo and Sopade (2010).

Thickening effect of wheat solids *Dalia* comprises both the liquid and the particulate phase. During *dalia* making, solids from *dalia* grains ooze out into the milk phase, and increases its viscosity and total solids, due to concentration of milk and also due to oozing out of wheat starch. To provide this thickening in reconstituted *dalia*, ground *dalia* of four different varieties (WH-896, PDW-233, HD-2687 and PBW-343) was added at 3 different levels (2, 3 and 4 %) to water and heated in a water bath at 90 °C for 1 h (as this temperature is above the gelatinization temperature of wheat starch). These were then cooled to 25 °C. The mixture was then subjected to measurement of viscosity at 20 °C and sensory mouthfeel characteristics.

Gelatinization of ground *dalia* in concentrated milk system In order to determine the time required for gelatinization of ground *dalia* and also to select variety of wheat, wheat flour

(30 % by weight of milk) was added to reconstituted whole milk powder (18 % TS), the mixture was taken in a beaker (500 ml) and heated in water bath at 90 °C for 60, 75, 90, 105 and 120 min. The contents of the beaker were stirred every 5 min for proper mixing. These were then cooled to 25 °C. The mixture was subjected to viscosity measurement at 20 °C and also to sensory mouthfeel characteristics. Sedimentation test was done according to the method used by Fureby and Smith (2007).

Production of instant *dalia* pre-mix The production protocol for instant *dalia* pre-mix consisted of separate preparation of an instant milk-wheat powder representing the liquid fraction of *dalia* and instant *dalia* grains representing the particulate phase. Fresh buffalo milk (6.5 % fat and 9.3 % SNF) was standardized to a fat and SNF level of 3.0 and 8.5 %, respectively, for the manufacture of *dalia* mix powder. Standardized milk was heated at 95 °C/15 s in a pre-heater and concentrated to 21.5 % total solids using a vacuum pan with 3 steam coils for indirect heating (John Moore Co., Australia). BHA as an antioxidant was added at the rate of 0.01 % of finished powder (dry matter) in order to enhance the shelf-life of spray dried *dalia* mix. The milk concentrate was mixed with wheat flour (@ 3.5 % by weight of the concentrate). This milk-wheat flour slurry was heated to a temperature of 90 °C/90 min for gelatinization and cooking of wheat flour. The milk-wheat slurry was dried in a two-stage spray dryer (SSP Ltd., Faridabad, India). The feed pressure was 100 kg/cm² and feed rate was kept at 60 kg/h. WH-896 variety of wheat was instantized by using a pilot-scale fluidized bed dryer (SSP Ltd. Faridabad, India). Wheat was cooked in excess water for 30 min in a stainless steel steam jacketed kettle. The cooked grains were then removed from the SS kettle and placed on a SS sheet to remove the excess moisture. The grains were then transferred to a perforated SS sheet in the fluidized bed dryer and dried under the current of hot air (135 °C). The instantized grains were cracked into *dalia* by using *dalia* making machine (Lab Con, USA). The *dalia*-milk solids mix powder was blended with instantized *dalia* grains and ground sugar in a batch type mixer (APV Engg. Co., Kolkata, India) of 10 kg capacity for 30 min. Instant *dalia* mix as obtained above was packaged in the metallized polyester LDPE bags (250 g/bag).

Sensory evaluation of the *dalia* dessert pre-mix A consumer survey was conducted for sensory evaluation of pre-mix *dalia*. A group of 100 people including scientists, technicians, administrative staff, supporting staff, and students of

the National Dairy Research Institute, Karnal, India as also general public were served with 100 g pre-mix *dalia* and their responses in terms of sensory attributes viz. mouthfeel, consistency and flavor were evaluated on a 100-point scale. Respondents were asked to reconstitute the dry mix in the manner described below.

Reconstitution of *dalia* dessert pre-mix Potable water was boiled in a pan and the contents of one pouch (approx. 70 g) was added to it in the ratio of 1:4 (dry mix: water). Water temperature was kept at 90 °C for 5 min, after which the desired consistency was achieved. Reconstitution was also attempted at 50, 70 and 80 °C and the ratio between the dry mix and water was also attempted at 1:2, 1:3 and 1:5, but was sensorily not found acceptable. While, mixing and heating, product was also gently stirred. Reconstituted product was allowed to cool to 25 °C, before being subjected to sensory evaluation.

Apparent viscosity Apparent viscosity of *dalia* dessert, prepared by reconstitution of the *dalia* dessert pre-mix as discussed above, was measured at 20 °C using Visco-Star Plus programmable rotational viscometer (FUNGI Lab, S.A., Spain) fitted with the T-spindles (PB, PC and PD) with Heldal mechanism raising and lowering the spindle within the sample during the measurement.

Bulk density The bulk density of the *dalia* pre-mix was determined by the method used by Sjollem (1963).

Total solids The total solids was determined by the method described by AOAC (1995)

Experimental plan Response surface methodology was employed in this study to design the experiments, select levels of variables in the experimental runs, fitting mathematical models and finally selecting variable levels by optimizing the response. A central composite rotatable design was used to design the experiments comprising two independent processing parameters. Thirteen experiments were conducted in the present research work for optimization of milk solids and wheat flour levels in the premix.

Statistical analysis The data generated from the experiments were analyzed for optimization of processing parameters with respect to the responses, viz. mouthfeel, consistency, flavor and viscosity. The experimental data to correlate the relationship between the response value and the variables

were explained by the following second-order polynomial model:

$$Y = \beta_0 + \sum \beta_i X_i + \sum \beta_{ii} X_i^2 + \sum \sum \beta_{ij} X_i X_j \quad (1)$$

Where, Y is the predicted response, β_0 is the model constant, β_i is the linear coefficient, β_{ii} is the quadratic coefficient, β_{ij} is the interaction coefficient and X_i and X_j are the coded independent variables or factors.

Results and discussion

The present study was undertaken with an objective to develop a process for the production of *dalia* dessert premix in a dry form, which could be used for the production of ready-to-reconstitute *dalia*. Initially, basic studies such as selection of wheat variety and optimization of gelatinization time were performed. Further, on the basis of these studies, optimization of level of wheat solids and milk solids was done to obtain the acceptable quality *dalia* desert pre-mix.

Selection of wheat variety In order to select the variety of wheat to be incorporated as flour in the dessert premix, thickening effect of wheat flour in water at three different levels, viz., 2, 3 and 4 % was studied. The flour-water dispersion heated to a gelatinization treatment of 90 °C for 1 h was subjected to sensory mouthfeel and apparent viscosity analysis.

The results for different varieties of wheat at different levels are presented in Table 1. The sensory mouthfeel characteristic scored on a 100-point scale (0–100) varied from 70.0±0.20 to 80.0±0.69 for different varieties at 2 % flour level and viscosity varied from 6.6±0.2 to 7.3±0.4 cP, while the mouthfeel score at 3 % flour level varied from 60±0.3 to 75±0.9 and viscosity varied from 13.03±0.17 to 15.2±0.18 cP. At 4 % flour level, the mouthfeel score varied from 40.0±0.69 to 70.0±0.77 and viscosity varied from 26.8±0.47 to

32.4±0.21 cP. Based on the sensory mouthfeel scores and apparent viscosity, 3 % flour level was selected for further studies.

Effect of the wheat variety on physical properties of 3 % flour slurry in milk (18 % TS) was studied in order to arrive at the most suitable wheat variety to be incorporated in the premix. The wheat flour-milk slurry was subjected to viscosity and sensory mouthfeel analysis. The results are presented in Table 2. The sensory mouthfeel score, scored on a 100-point scale (0–100) was highest for variety WH-896 (81.0±0.61), followed by HD-2687 (80.0±0.86), PDW-233 (77.0±0.32) and PBW-343 (71.0±0.73). PDW-233 and PBW-343 were perceived to have slightly sandy mouthfeel. The apparent viscosity at a shear rate of 17 s⁻¹ for variety PBW-343 was the highest (527.0±0.33 cP), followed by WH-896 (438.5±0.71 cP), HD-2687 (359.3±0.52 cP) and PDW-233 (327.0±0.33 cP). Further, in order to account for the effect of particle size on the mouthfeel score, bulk density as an indicator of particle size was studied for all the varieties of wheat. Bulk density was 0.70±0.01 for HD-2687, 0.71±0.09 for WH-896, 0.72±0.03 for PDW-233 and 0.75±0.06 g/ml for PBW-343. Since the mouthfeel score of WH-896 (81.0±0.61) was higher than that of other wheat varieties viz., HD-2687 (80.0±0.86), PDW-233 (77.0±0.32) and PBW-343 (71.0±0.73), it was selected as the most suitable variety of wheat for use in *dalia* dessert pre-mix manufacture.

Optimization of gelatinization time In order to optimize the gelatinization time of wheat flour (3 %) in milk (18 % TS), the milk flour slurry was subjected to gelatinization at a temperature of 90 °C for varying time, viz., 60, 75, 90, 105 and 120 min. The treated slurries were subjected to sensory mouthfeel score (0–100 point scale), apparent viscosity and sedimentation analysis. The results are presented in Table 3. The apparent viscosity measurement showed initially an increasing trend from

Table 1 Thickening effect of wheat flour in water flour dispersion (Subjected to a gelatinization treatment of 90 °C for 1 h) as influenced by the wheat variety and flour level

Wheat variety	Apparent viscosity (cP) ^a at 20 °C			Sensory mouthfeel score ^b		
	2 % flour	3 % flour	4 % flour	2 % flour	3 % Flour	4%flour
WH-896	6.8±0.30 (61.2)	14.4±0.51 (61.2)	30.5±0.32 (66.0)	80.0±0.61	75.0±0.90	70.0±0.77
PDW-233	6.7±0.68 (61.2)	14.2±0.83 (61.2)	32.4±0.21 (66.0)	75.0±0.43	70.0±0.41	60.0±0.30
HD-2687	6.6±0.21 (61.2)	13.03±0.17 (61.2)	26.8±0.47 (66.0)	80.0±0.69	70.0±0.66	60.0±0.51
PBW-343	7.3±0.42 (61.2)	15.2±0.18 (61.2)	28.0±0.73 (66.0)	70.0±0.20	60.0±0.28	40.0±0.69

Figures in parentheses indicate shear rate

^a Data represent means of three replicates ($n=3$)

^b Mouthfeel scored on a 100 point scale (100 to 0) ($n=8$)

Table 2 Effect of wheat variety on physical properties of 3 % flour slurry (Gelatinization at 90 °C for 1 h) in milk (18 % TS)

Wheat variety	Apparent viscosity ^{a,c} (cP) at 20 °C	Bulk density of flour ^a (g/ml)	Mouthfeel score ^b
WH-896	438.5±0.71	0.71±0.09	81.0±0.61
PDW-233	327.0±0.33	0.72±0.03	77.0±0.32 (slight sandy)
PBW-343	527.1±0.76	0.75±0.06	71.0±0.73 (slight sandy)
HD-2687	359.3±0.52	0.70±0.01	80.0±0.86

TS total solids

^a Data represent means of three replicates ($n=3$)^b Mouthfeel score on 100 point scale (100–0) ($n=8$)^c Shear rate 17 s⁻¹

231.6±0.71 to 255.0±0.57 cP, which later started to decrease from 236.1±0.40 to 184.9±0.83 cP as can be seen from Table 3. The mouthfeel score varied from 62.5±0.91 to 81.5±0.61. The sedimentation value decreased initially and later remained constant from 90 to 120 min. Hence, it can be concluded that the optimum gelatinization time was 90 min, as it showed lower sedimentation value and comparatively reduced viscosity.

Effect of levels of milk solids and wheat solids on sensory attributes and apparent viscosity Acceptability of any product is assessed by its sensory evaluation. For evaluating the sensory attributes of wheat flour suspension in milk, the 100-point scale was used. The sensory characteristics judged included mouthfeel, consistency and flavour. The apparent viscosity was also measured. The average sensory scores of

Table 3 Physical properties of wheat flour slurry (3 %) in milk (18 % TS) as influenced by the gelatinization temperature of 90 °C

Gelatinization time (min)	Apparent viscosity ^{a*} (cP) at 20 °C	Mouthfeel ^b Score	Sedimentation ^a (ml)
60	231.6±0.71	81.5±0.61	2.0±0.5
75	242.7±0.22	78.5±0.33	1.6±0.3
90	255.0±0.57	67.5±0.69	1.5±0.7
105	236.1±0.40	73.5±0.44	1.5±0.1
120	184.9±0.83	62.5±0.91	1.5±0.9

TS total solids

^a Data represent means of three replicates ($n=3$)*Shear rate=17 s⁻¹^b Mouthfeel score on 100 point scale (100–0) ($n=8$)

the attributes and the viscosity measurements are given in Table 4.

The results showed that the CCRD model designed for selecting the level of ingredients for dessert premix had an efficiency of 73.8 %, which is more than the minimum required level of 50 %. The leverage was 0.4615, which is less than the value of 1, desirable in developing a model. The condition number of coefficient matrix was 1.3, which is less than 100, a value of more than 100 indicates moderate multicollinearity problem in the model. It could be concluded that developed model for sensory quality and viscosity fits well in all the aspects of model efficiency check.

Effect on mouthfeel score The average mouthfeel score varied from 72.3 to 90.8 (Table 4). The minimum and maximum score was obtained for Experiment Nos. 6 and 12, respectively. In the Experiment No. 6, flour milk slurry had 26 % milk solids and 2 % wheat solids, while experiment No. 12 had 19.5 % milk solids and 2 % wheat solids. The data fitted the following quadratic model:

$$X_1 = 88.1 - 3.3A - 3.3B - 41A^2 - 21B^2 + 2.6AB \quad (2)$$

The coefficient of determination (R^2) was 0.8. The adequate precision (measure of signal to noise ratio) was 6.7. Hence, the model could be used to navigate the design space.

The coefficient estimates of mouthfeel model (Table 5) showed that the level of milk solids and wheat solids had significant ($P<0.05$) effect on mouthfeel. With increased levels of milk solids and wheat solids, there was a significant decrease in the mouthfeel score. The quadratic terms for the effects of milk solids and wheat solids were also negative, but only that for milk solids, it was significant ($P<0.05$). The interactive effect of milk solids and wheat solids was non-significant. Figure 1a shows the response surface plot for mouthfeel score. It can be seen that the mouthfeel score decreased with increasing wheat solids especially at milk solids level, the decrease being more rapid at higher wheat solids concentrations. The score increased with increasing milk solids up to about 19 % and then rapidly decreased with further increase in milk solids. Thus, maximum mouthfeel score was at wheat solids close to the lowest level and milk solids at intermediate levels in the range studied. In a similar study on wheat porridge made with soy protein isolate and skimmed milk powder, Manohar et al. (2011) reported an increase in mouthfeel scores with increased milk solids.

Effect on consistency score The average consistency score varied from 6.5 to 96.0 (Table 4). The minimum and maximum score was obtained for Experiment Nos. 7 and 8, respectively. In Experiment No. 7, flour-milk slurry had 19.5 % milk solids and 0 % wheat solids, while Experiment No. 8 had 19.5 % milk solids and 4 % wheat solids. The data

Table 4 Sensory attributes and apparent viscosity of wheat flour (WH-896) suspension in milk containing different milk solids and wheat solids

Exp. No.	Milk solids (%)	Wheat solids (%)	Sensory attributes ^b			Apparent viscosity ^{a,c} (cP)
			Mouthfeel	Consistency	Flavour	
1	14.9	0.6	88.5	13.8	79.0	4.8
2	24.1	0.6	80.0	21.3	77.5	26.2
3	14.9	3.4	81.3	46.8	65.8	315.9
4	24.1	3.4	81.8	76.8	43.8	12297.0
5	13.0	2.0	85.5	10.8	85.5	13.3
6	26.0	2.0	72.3	78.3	47.0	1082.3
7	19.5	0.0	90.3	6.5	68.5	6.6
8	19.5	4.0	75.3	96.0	51.5	1010.0
9	19.5	2.0	89.5	28.3	77.0	61.0
10	19.5	2.0	85.5	36.5	65.5	61.3
11	19.5	2.0	84.8	22.0	61.3	63.5
12	19.5	2.0	90.8	29.8	75.3	60.7
13	19.5	2.0	89.8	25.8	69.3	61.1

Mouthfeel: 100–0

Consistency: 0–100

Flavour: 100–0

^a Data represent means of three replicates ($n=3$)^b Data represent means of sensory scores of 8 panelists ($n=8$)^c at 20 °C

fitted the following quadratic model:

$$X_2 = 28.5 + 16.6A + 26.9B + 6.0A^2 + 93B^2 + 5.6AB \quad (3)$$

The coefficient of determination (R^2) was 0.9. The adequate precision (measure of signal to noise ratio) was 11.6. Hence, the model could be used to navigate the design space.

The coefficient estimates of consistency model (Table 5) showed that the level of milk solids and wheat solids had significant ($P<0.01$) effect on consistency. With increased

levels of milk solids and wheat solids, there was a very significant increase in the consistency score. The quadratic terms for the effects of milk solids and wheat solids were also positive, but non-significant. The interactive effect of milk solids and wheat solids was non-significant. Figure 1b shows the response surface plot for consistency score. It can be seen that the consistency score considerably increased with increased wheat solids as well as increased milk solids, the former having a greater impact. Thus, lowest viscosity was found to be at the lowest levels of the two variables and the highest viscosity was at the highest levels of the same in the range studied.

Table 5 Coefficients of full second order polynomial model of coded factors for different levels of ingredients in dessert premix

Factors	Mouthfeel	Consistency	Flavour	Apparent viscosity
Intercept	88.1	28.5	69.7	1158.7
A: Milk solids	−3.3*	16.6*	−9.7**	1689.3
B: Wheat solids	−3.3*	26.9**	−8.9*	1750.1
A ²	−4.1*	6.0	−0.9	—
B ²	−2.1	9.3	−4.0	—
AB	2.3	5.6	−5.1	2990.0*
Model	Significant	Significant	Significant	Significant

* values are significant at $P<0.05$ ** values are significant at $P<0.01$

Effect on flavour score The average flavour score varied from 43.8 to 85.5 (Table 4). The minimum and maximum score was obtained for Experiment Nos. 4 and 5, respectively. In Experiment No. 4, flour-milk slurry had 24.1 % milk solids and 3.4 % wheat solids, while, Experiment No. 5 had 13 % milk solids and 2 % wheat solids. The data fitted the following quadratic model:

$$X_3 = 69.7 - 9.7A - 8.9B - 0.9A^2 - 4.0B^2 - 5.1AB \quad (4)$$

The coefficient of determination (R^2) was 0.8. The adequate precision was 8.1. Hence, this model could be used to navigate the design space.

Fig. 1 Response surface plots for quality of *dalia* dessert premix as influenced by levels of milk solids and wheat solids **a** mouthfeel **b** consistency **c** flavour **d** apparent viscosity

The coefficient estimates of flavour model (Table 5) showed that the level of milk solids and wheat solids had significant ($P < 0.01$ and $P < 0.05$, respectively) effect on flavour. With increased levels of milk solids and wheat solids, there was a significant decrease in the flavour score. The quadratic terms for the effects of milk solids and wheat solids were also negative, but non-significant. The interactive effect of milk solids and wheat solids was non-significant. Figure 1c shows the response surface plot for flavour score. It can be seen from the figure that the flavour score decreased with increasing wheat solids, the decrease being much more prominent at higher milk solids level. There was little effect of the milk solids at low wheat solids levels, but appreciable negative impact at higher wheat solids level was observed. Manohar et al. (2011) reported an increase in flavour score of wheat porridge with an increase in milk solids.

Effect on viscosity The viscosity of the pre-mix varied from 4.8 to 12.3 cP (Table 4). Manohar et al. (2011) also reported a similar apparent viscosity of wheat porridge with addition of milk solids. In the present study, the minimum and maximum value for viscosity was obtained for Experiment Nos. 1 and 4, respectively. In Experiment No. 1, the flour milk slurry had 14.9 % milk solids and 0.6 % wheat solids, while Experiment No. 4 had 24.1 % milk solids and 3.4 % wheat solids. The data fitted the following 2 FI (2 factor interaction) model:

$$X_4 = 1158.7 + 1689.3A + 1750.1B + 2990.0AB \quad (5)$$

The coefficient of determination (R^2) was 0.6. The adequate precision was 7.0. Hence, the model could be used to navigate the design space. The coefficient estimates of mouthfeel model (Table 5) showed that the level of milk solids and wheat solids had positive effect on viscosity, but were non-significant. However, the interactive effect of milk solids and wheat solids had significant ($P < 0.05$) positive effect on viscosity. Figure 1d shows the response surface plot for viscosity. It can be seen from the figure that the apparent viscosity largely reflected the pattern observed with

Table 6 Constraints fixed for optimization and the predicted score of the suggested formulation

Name	Goal	Lower limit	Upper limit	Predicted scores
Milk solids	in Range	14.9	24.1	17.8
Wheat solids	in Range	0.6	3.4	2.9
Mouthfeel	Maximize	72.3	90.8	85.4
Consistency	target	6.5	96.0	42.0
Flavour	Maximize	43.8	85.5	67.3
Viscosity	in Range	4.8	12297.0	941.0
Desirability	—	—	—	0.7

Lower weight: 1, Upper weight: 1, Importance: 3

sensory consistency. It tended to increase with increasing wheat solids and increasing milk solids, the increase being dramatic at higher levels of the two variables. Increase in apparent viscosity with increased flour solids concentration has also been reported in the fermented finger millet thin porridge by Ojijo and Shimoni (2004), which is in agreement with our current findings.

Optimization of levels of milk solids and wheat solids in dessert premix From the results achieved by analysis of data obtained through sensory evaluation and viscosity measurement of the dessert premix, suitable level of milk solids and wheat solids was selected for further investigation. The goals of sensory quality, viscosity, desirability and factors along with predicted score were in the range as given in Table 6. The suggested formulation had 17.8 % milk solids, 2.9 % wheat solids and the predicted score for mouthfeel was 85.4, for consistency it was 42.0, for flavour the score was 67.3 and viscosity was 941.0cP.

Conclusions

Optimization of levels of milk solids and wheat solids for manufacture of instant (ready-to-reconstitute) *dalia* dessert pre-mix could be predicted on the basis of sensory and rheological parameters using RSM. Four wheat varieties were analyzed for suitability to be used in the product, of which WH-896 wheat variety was found to be the best in terms of sensory mouthfeel and apparent viscosity basis. The formulation with 17.8 % milk solids and 2.9 % wheat solids was found to be the most appropriate for manufacturing of instant *dalia* dessert pre-mix for which the predicted scores were 85.4 for mouthfeel, 42.0 for consistency, 67.3 for flavour and viscosity was 941.0cP. It can be concluded that instant *dalia* dessert pre-mix could be used as an intermediate product for manufacturing the dessert in dry form to encourage value addition and product diversification for the dairy and food processing industry.

References

- AOAC (1995) Official methods of analysis of AOAC international, 16th edn. AOAC International, Arlington
- Arya SS (1998) Defence and food processing industries: Past, present and future. In Proceedings of 4th International Food Convention (IFCON), November 23–27, 1998, Mysore, India
- Bodkin LE (1998) Breakfast cereal with milk pieces. US Patent. No. 5827564
- Bunkar DS, Jha A, Mahajan A (2012) Optimization of the formulation and technology of pearl millet based ‘ready-to-reconstitute’ *kheer* mix powder. J Food Sci Technol. doi:10.1007/s13197-012-0800-2
- Castro IA, Tirapegui J, Silva RSSF (2000) Protein mixtures and their nutritional properties optimized by response surface methodology. Nutr Res 20:1341–1353
- Fureby AM, Smith P (2007) In situ lecithination of dairy powders in spray-drying for confectionary applications. Food Hydrocoll 21(5):920–927
- Gujral HS, Sodhi NS (2002) Back extrusion properties of wheat porridge (*dalia*). J Food Eng 52:53–56
- Henika RG (1972) Simple and effective system for use with response surface methodology. Cereal Sci 39:943–946
- Henselman MR, Donatoni SM, Henika RG (1974) Use of response surface methodology in the development of acceptable high protein bread. J Food Sci 39:943–946
- IGC (2012) International Grains Council Grain Market Report. GMR No. 418. Report of 19-1-2012
- Jayathilakan K, Radhakrishna K, Gopala Rao KR, Vijaya Rao D (2000) Development of instant vermicelli mix. Indian Food Packer 6:125–130
- Jha A, Tripathi AD, Alam T, Yadav R (2011) Optimization of process for manufacture of pearl millet-based dairy dessert. J Food Sci Technol. doi:10.1007/s13197-011-0347-7
- Jha A, Murli, Patel AA, Gopal TKS, Ravishankar CN (2012) Development of a process for shelf stable dairy dessert *dalia* and its physicochemical properties. LWT Food Sci Technol 49(1):80–88
- Kurien V, Mishra HN (2008) Modeling of acidification kinetics and textural properties in *dahi* (Indian yogurt) made from buffalo milk using response surface methodology. Int J Dairy Technol 61:284–289
- Manohar RS, Manohar B, Rao PH (1998) Rheological characterization of wheat porridge (cooked *dalia*), a semi-liquid breakfast food. J Cereal Sci 27:103–108
- Manohar RS, Urmila Devi GR, Bhattacharya S, Rao GV (2011) Wheat porridge with soy protein isolate and skimmed milk powder: rheological, pasting and sensory characteristics. J Food Eng 103:1–8
- Ojijo NKO, Shimoni E (2004) Rheological properties of fermented finger millet (*Eleusine coracana*) thin porridge. Carbohydr Polym 57:135–143
- Rao DV, Radhakrishna KA, Jayathilakan K (1994) Manufacture of freeze dried breakfast and dessert foods. J Food Sci Technol 31:40–43
- Sjollem A (1963) Some investigation on the free flowing properties and porosity of milk powders. Neth Milk Dairy J 17:245–253
- Srikaeo K, Sopade PA (2010) Functional properties and starch digestibility of instant Jasmine rice porridges. Carbohydr Polym 82(3):952–957