Open Access
ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Research Journal of Agricultural Sciences
Volume 14; Issue 01; pp 028–034

Full Length Research Article

Development of Technology for Manufacture of Millet Based Chhana Cake

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Abstract

The present investigation was planned and conducted to develop a technology for the manufacture of millet based chhana cake. For selecting the level of fat in milk for chhana making, four batches of chhana were prepared from milk with four different levels of milk fat viz. 4.5, 5.0. 5.5 and 6.0%. It was found that chhana prepared from milk containing 5.5% fat had better acceptability compared to other levels studied viz. 4.5, 5.0 and 6.0% milk fat. Baking is the key processing steps for production of optimal quality of bakery product. From the different temperature/time combination, sample baked at 140˚C/80 min was found suitable for chhana cake. The proportion of barnyard millet, amaranth and little millet was optimized using Response Surface Methodology (RSM) i.e., Design Expert 13.0.5.0. The optimized solution was 31.86% barnyard millet, 32.69% amaranth and 35.45% little millet. The desirability of this model was 0.92.

***Key words*:** Gluten-free, Chhana cake, Amaranth, Barnyard millet, Little millet

Chhana cake is baked traditional Indian dairy product [1]. It is prepared using chhana as the base material. It has light brown crust, a spongy texture with a moderately soft body and a rich, caramelized flavour [2]. The major ingredients in chhana cake are chhana, sugar and binders viz. wheat products such as maida or suji. Maida/suji has a major role in the development of texture in cake. Chhana is the heat and acid coagulated Indian dairy product manufactured by heating and coagulating of milk through suitable acid. Fat considered as one of the major constituents of bakery products. It acts as shortening, provide richness and creamy flavour to the cake. It improves the aeration property and result in expansion of cake. It also improves the texture of cake [3]. The level of fat in milk used for chhana making has a direct influence on the quality of chhana cake. Barnyard millet (*Echinochloa frumentacea*) is an ancient, domesticated small millet. Nutritionally, it is decent source of protein and dietary fibre (both soluble and insoluble), lead to more fat and water absorption that may help in cake formation. Carbohydrate content is slowly digestible, which is beneficial for diabetes. It also contains unsaturated fat (linoleic acid and oleic acid). For diabetics and obese people, barnyard millet may be the perfect food [4]. It has a low glycemic index, which is helpful for type II diabetes persons [5]. The fibre present in barnyard millet, which helps to decrease LDL cholesterol from the body and increase HDL cholesterol [6].

Little millet has strong nutritional profile because it contains good amount of protein, mineral and vitamin content, that is equivalent to major cereal like rice and wheat. It is also good source of mineral specially iron (9.3 mg/100g) and phosphorus (220 mg/100g). Due to its high content of carbohydrates and dietary fibre, it is beneficial for diabetic patients and coronary heart disease [7]. It contains gama-amino butyric acid which is an essential inhibitory neurotransmitter in the mammalian central nervous system. It is also a good source of phenolic compounds which have a significant role in lowering the risk of several degenerative diseases like cancer, osteoporosis and cardiovascular disorders [8].

Amaranth is referred to as a pseudocereal. Amaranth seeds have higher protein (16%) as compared other common cereals like sorghum, rice, maize and wheat [9]. The high protein content of amaranth makes it suitable flour for baking. This protein has excellent digestibility (90%) [10]. It contains higher amount of minerals, especially iron (6.1 mg/100g) and calcium (139 mg/100g) and some lower extent potassium, phosphate and magnesium. It plays an important role in lowering plasma cholesterol, lowering blood glucose, boosting the immune system, acting as an antitumor agent and treating anemia-related diseases. Additionally, it also has antioxidant and anti-allergic properties. It reduces the blood cholesterol level because of fibre present in amaranth [11].

Received: 03 Oct 2022; Revised accepted: 18 Dec 2022; Published online: 04 Jan 2023

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Citation: Jambukiya H, Pinto S, Patel S. 2023. Development of technology for manufacture of millet based chhana cake. *Res. Jr. Agril Sci*. 14(1): 28-34.

Baking is the key processing steps for production of optimal quality of bakery product. It is one type of heat and mass transfer process in which moisture are evaporated and on outer surface crust are form. As compared to different bakery products, cake has higher sensory profile that cause it has high commercial value [12]. Especially during baking, protein interactions are important for cake structure development [13]. Two major wheat proteins called glutenin and gliadin are responsible for development of visco-elastic property of cake dough [14]. Increases in internal temperature of the dough, lead to several physico-chemical reactions are occur, that facilitate expansion of volume of cake and the formation of crust and crumb in the cake. After baking cake has characteristic like light weight, high volume, porous structure due to aeration and has characteristics flavour [15]. During recent years there has been a growing need for gluten-free bakery products. Persons suffering from celiac disease and persons who are allergic to gluten are interested in wheat free foods [16]. Production of gluten-free bakery products causes significant technological defects in the volume and texture [17]. As a result, gluten-free bakery products are often less desirable in terms of their appearance, taste, aroma and texture. Hence, the present project was contemplated to formulate a chhana cake replacing maida/suji with millets in the formulation of acceptable quality chhana cake.

MATERIALS AND METHODS

Whole milk was procured from Vidya Dairy, Anand. Barnyard millet was collected from local market of Anand city. Little millet and amaranth of "Gaaychap" brand, Ahmedabad was used. Sugar used in this study was of Madhur brand, Shree Renuka sugar Ltd., Mumbai. Baking powder of blue bird brand, Mumbai was used in this study. Extra pure GMS manufactured by Loba Chemie Pvt. Ltd.; Mumbai used as emulsifier. Eagle brand vanilla essence manufactured by Vijay industries; Vadodara was used as flavouring agent.

Preparation of chhana

Pasteurized milk contained four different level of fat viz. 4.5, 5.0, 5.5 and 6.0 % was filtered, heated to 90 °C for 5 min and cooled to 65 °C. Citric acid solution (0.5%) was heated to 65 °C and gradually added to the milk, stirring gently with a ladle until the milk coagulated. The whey was strained through muslin cloth, and the coagulated mass was hung for 5 min for complete whey drainage to obtain chhana

Method for manufacture of gluten-free chhana cake

The chhana prepared as outlined above served as the base for manufacture of gluten-free chhana cake. It was kneaded in the Hobart mixer for 1.5 to 2.0 min. GMS @ 1.5% (w/w of chhana) (dissolved in 15-20 times water) and vanilla flavour @ 0.4% (v/w of chhana) were added to the Hobart mixture and kneaded for 1 min. After that, all the dry ingredients viz., millet/pseudocereal blend @ 20% (barnyard millet, little millet, and amaranth in equal proportion), sugar @ 30%, and baking powder @ 1% (all w/w of chhana) were dry blended and added to the Hobart mixer and kneaded for 1.5 to 2.0 min. to form a smooth dough. The dough was then portioned (about 58 to 60 g each) and transferred into silicone cups (7x5x3.5cm^3) and baked at 140°C for 80 min. Thereafter it was cooled to room temperature and wrapped in PVDC cling film wrap and placed in PVC trays with lids. The trays were placed in cardboard boxes. The boxes were stored at refrigeration temperature i.e., 7±2 °C.

Chemical analysis

Gluten-free chhana cake samples were subjected to various compositional attribute and physical attributes tests as described below. Moisture content in chhana cakes were analyzed by the procedure given by IS: SP 18: part XI, 1981. The fat content of the gluten-free chhana cake was analyzed by the acid hydrolysis method given by the AOAC [18]. Protein content in chhana cake was determined by semi-micro Kjeldahl method IS:1479-Part-II, 1961, using Kjel-plus digestion system (M/s Pelican Instruments, Chennai, Model-KES 20LVA DLS) and Kjel-plus semi-automatic distillation system (M/s Pelican Instruments, Chennai, Model- Distil M). The ash content of the gluten-free chhana cake was analyzed by the procedure given by IS: 1547 (1985). Total carbohydrate of gluten-free chhana cake was determined by subtracting the total content of moisture, fat, protein and ash from 100 as per FSSAI [19]. The specific volume of gluten-free chhana cake was determined by the rapeseed displacement method [20].

Sensory evaluation

Stored cups were withdrawn from the refrigerator at 7±2 °C and microwaved at 2450 MHz frequency for 12 s before subjecting it for sensory evaluation. (Sensory analysis was done after 24 h of manufacturing of gluten-free chhana cake at a temperature of 23 ± 2 °C. The sensory panelist (n=10) includes staff members and post-graduate students working in the institution. The 9-point hedonic scale was used for this purpose. The sensory parameter was colour and appearance, volume, body and texture, flavour, crumb colour, crust colour and overall acceptability.

Statistical analysis

The mean values generated from the analysis of duplicate samples of chhana cakes obtained in three replications, were subjected to statistical analysis using completely randomized design (CRD) using the software developed by Anand Agricultural University, Anand. To carry out their optimization of selected parameters, an advanced statistical software program named Design Expert (Version 13.0.5.0.) was employed.

RESULTS AND DISCUSSION

Selection of level of fat in milk for chhana making

It was observed that the use of standardized milk resulted in a course, dry product. Hence, trials were conducted to choose the most suitable level of fat in milk for chhana making. Four batches of chhana were prepared from milk with four different levels of milk fat viz. F1 (4.5%), F2 (5.0%), F3 (5.5%) and F4 (6.0%). Control (C) was prepared using suji @ 7.5 g and maida @ 2.5 g by replacing millet flour. All the gluten-free chhana cakes and control (C) were subjected to sensory evaluation by a panel of 10 judges using a 9-point hedonic scorecard at a temperature of 23±2 °C. Seven replications were conducted. The effect of different levels of fat in milk used for chhana making on the sensory scores of chhana cake was presented in (Table 1).

The average colour and appearance scores of F3 (6.30) were found to be significantly ($P<0.05$) highest, whereas F1 (5.39) were found to be lowest. However, the colour and appearance score of F3 was found to be significantly ($P<0.05$) lower than control (8.55). The lower scores of F1 and F2 were due to their cracks on the surface. The decrease in scores of F4 sample was attributed to the oozing of fat during dough preparation, baking and storage. The average volume score of F3 (6.13) were found to be significantly ($P<0.05$) highest, whereas F1 (5.11) were found to be the lowest. The mean volume scores of F3 was found to be acceptable, whereas other experimental

samples viz. F1 (5.11), F2 (5.51) and F4 (5.81) were found to be unacceptable because they had average colour and appearance scores of less than 6.

With respect to treatment, the mean body and texture score of F3 experimental (6.18) were found to be significantly (P<0.05) highest, whereas F1 (5.28) were found to be the lowest. The lower scores of experimental samples F1 and F2 were attributed to their heavy body and thick crust. The decrease in scores of experimental samples F4 was attributed to their very soft, loose and fragile body. The mean flavour score of F3 (6.24) were found to be significantly (P<0.05) highest, whereas F3 (5.14) were found to be the lowest. The increase in the flavour score of the sample with fat content up to 5.5% was attributed to the increased in richness and creaminess of the gluten-free chhana cake. However, at higher fat level viz. 6.0% the experimental sample was found to be greasy and oily defect. There was a significant (P<0.05) progressively increased in crumb colour score with increase in level of fat from 4.5 to 5.5% which was found to be significant (P<0.05) at each level studied. Thereafter with increase further level of fat viz. 6.0% the crumb colour score decreased significantly (P<0.05). With respect to treatment, the mean crumb colour score of F3 (6.18) were found to be significantly (P<0.05) highest, whereas F1 (5.11) were found to be the lowest. The average crust colour scores of all experimental samples were found to be lower as compared to control (C). There was a significant (P<0.05) progressively increased in crust colour score with increase in level of fat from 4.5 to 5.5% which was found to be significant (P<0.05) at each level studied. Thereafter with increase further level of fat viz. 6.0% the crust colour score decreased significantly (P<0.05). The decrease in crust colour scores of F4 experimental samples was attributed to their thin and very soft crust.

Table 1 Effect of level of fat in milk used for chhana making on the sensory score of gluten-free chhana cake

Level of fat in milk	Sensory scores (9-point hedonic scale)						
	Colour and appearance score	Volume score	Body and Texture score	Flavour score	Crumb colour score	Crust colour score	Overall acceptability score
Control (C)	8.55^{a}±0.16	8.22^{a}±0.11	8.41^{a}±0.21	8.49^{a}±0.15	8.35^{a}±0.23	8.37^{a}±0.29	8.43^{a}±0.15
F_1	5.39^{e}±0.08	5.11^{e}±0.20	5.28^{e}±0.06	5.14^{e}±0.10	5.11^{d}±0.18	5.10^{d}±0.15	5.25^{e}±0.18
F_2	5.68^{d}±0.10	5.51^{d}±0.14	5.58^{d}±0.10	5.50^{d}±0.24	5.48^{c}±0.14	5.49^{c}±0.14	5.60^{d}±0.07
F_3	6.30^{b}±0.17	6.13^{b}±0.18	6.18^{b}±0.17	6.24^{b}±0.16	6.18^{b}±0.25	6.14^{b}±0.20	6.25^{b}±0.17
F_4	6.01^{c}±0.09	5.81^{c}±0.16	5.85^{c}±0.12	5.90^{c}±0.09	5.82^{c}±0.11	5.77^{c}±0.17	5.89^{c}±0.11
	ANOVA Table						
S.Em.	0.07	0.09	0.09	0.10	0.11	0.11	0.08
CD (0.05)	0.23	0.29	0.28	0.33	0.35	0.36	0.26
CV (%)	1.94	2.58	2.50	2.87	3.07	3.20	2.25

Each observation is mean ± SD of 3 replicate experiments (n=3)

^{A,b,c,d,e}Superscript letters following numbers in the same column denote significant difference (P < 0.05)

The overall acceptability scores of experimental samples containing 5.5% fat (6.25) were found to be acceptable, whereas the other experimental samples were found to be unacceptable because these samples had average flavour scores of less than 6. There was progressively increase in sensory score of gluten-free chhana cake with increase in fat content in milk up to 5.5 % fat, above this level started decreasing. The decrease in sensory score of gluten-free chhana cake was due to excessive softness and fat leakage during processing and storage in such sample. Based on the results obtained in this study, chhana prepared from milk containing 5.5% fat was found suitable for use in chhana and was selected and used in the remaining part of the study.

Table 2 Effect of different temperature/time combination of baking on sensory attributes of chhana cake

Temperature/time combination for baking	Sensory scores (9-point hedonic scale)						
	Colour and appearance	Volume	Body and texture	Flavour	Crumb colour	Crust colour	Overall acceptability
120 °C /120 min	6.10^{d} ±0.14	6.14^{d}±0.17	6.13^{d} ±0.13	6.16^{d}±0.09	6.06^{d}±0.19	6.01^{d}±0.17	6.12^{d} ±0.16
130 °C /100 min	6.46^{c} ±0.17	6.49^{c}±0.14	6.44^{c} ±0.14	6.42^{c}±0.17	6.54^{c}±0.15	6.44^{c}±0.19	6.47^{c} ±0.17
140 °C /80 min	7.20^{a} ±0.13	7.15^{a}±0.17	7.13^{a}±0.10	7.10^{a}±0.12	7.25^{a}±0.25	7.32^{a}±0.20	7.20^{a} ±0.10
150 °C /60 min	6.82^{b} ±0.12	6.59^{b}±0.23	6.79^{b}±0.17	6.79^{b}±0.15	6.88^{b}±0.11	6.91^{b}±0.21	6.81^{b} ±0.25
	ANOVA Table						
S.Em.	0.08	0.10	0.08	0.08	0.10	0.11	0.10
C.D. (0.05)	0.26	0.33	0.26	0.25	0.32	0.37	0.33
C.V. (%)	2.11	2.68	2.08	2.04	2.56	2.92	2.66

Each observation is mean ± SD of 3 replicate experiments (n=3)

^{A,b,c,d,e}Superscript letters following numbers in the same column denote significant difference (P < 0.05)

Selection of baking temperature/time combination

The baking temperature/time combination was optimized by baking at four temperature/time combinations, viz., 120 °C/120 min, 130 °C/100 min, 140 °C/80 min, and 150 °C/60 min. The effect of different baking temperatures on the sensory scores of chhana cake was presented in (Table 2).

The colour and appearance score of the experimental sample baked at 140 °C/80 min (7.20) was found to be the highest, whereas the sample baked at 120 °C/120 (6.10) was found to be the lowest compared to other samples. The decrease in colour and appearance score baked at 150 °C/60 min is attributed to the highly brown crust. It can be seen from (Table 2) that the sample baked at 140 °C/80 min had a higher volume score (7.15) compared to the others. The volume score of a sample baked at 120 °C/120 (6.14) was found to be the lowest compared to other samples. The decrease in volume score baked at 150 °C/60 min was attributed to the highly brown crust. The body and texture score of the experimental sample baked at 140 °C/80 min (7.13) were found to be the highest, whereas the sample baked at 120 °C/120 (6.13) were found to be the lowest.

The decrease in body and texture score baked at 150 °C/60 min was attributed to the highly hard crust and crumb. The preferential order of temperature/time combination for baking in relation to the flavour of the experimental products was observed to be 140 °C/80 min > 150 °C/60 min > 130 °C/100 min >120 °C/120 min. Samples baked at 120 °C/120 min had a raw flavour defect, whereas samples baked for 150 °C/60 min had a highly caramelized flavour. The data presented in (Table 2) revealed that the crumb colour score of an experimental sample baked at 140 °C/80 min was found to be the highest (7.25), whereas a sample baked at 120 °C/120 min was found to be the lowest (6.06). The slightly brown crumb colour as compared to others is responsible for the decrease in crumb colour score baked at 150 C for 60 minutes. The crust colour score of a sample baked at 140 °C/80 min was found to be the highest (7.32), whereas a sample baked at 120 °C/120 min was found to be the lowest (6.01). The data presented in (Table 2), reveals that the experimental samples baked at 140 °C/80 min had significantly ($P<0.05$) overall acceptability scores (7.20) compared to other samples. Hence it was selected and used in the next part of the study.

Optimizing proportion of barnyard millet, little millet and amaranth flour in the millet flour blend using response surface methodology

Preliminary trials were undertaken before utilizing the process parameters for the development of an acceptable quality gluten-free chhana cake. The selection of flour was based on the prelimary trial. The two factors were barnyard millet (ranging from 30 to 35%) and amaranth (ranging from 30 to 35%) were optimized by adopting a Central composite rotatable design (CCRD) consisting of total 13 experiments. The ranges of millet/pseudocereal were selected based on preliminary trials. The sensory score of gluten-free chhana cake made from different combinations of barnyard millet and amaranth (w/w of chhana) is presented in (Table 3).

Table 3 Design matrix with the experimental data on sensory attributes of gluten-free chhana cake for response analysis

Exp. No.	Compositional variable		Sensory scores (9-point hedonic scale)						
	A: Barnyard millet (%)	B: Amaranth (%)	Colour and appearance score	Volume score	Body and texture score	Flavour score	Crumb colour score	Crust colour score	Overall acceptability score
1	35.00	35.00	7.80	7.66	7.67	7.66	7.81	7.83	7.74
2	32.50	28.96	7.64	7.70	7.10	7.66	7.69	7.53	7.67
3	30.00	30.00	7.78	7.93	7.81	7.65	7.76	7.78	7.79
4	35.00	30.00	7.33	7.55	7.45	7.53	7.57	7.53	7.49
5	32.50	32.50	7.88	7.85	7.89	7.79	7.81	7.93	7.86
6	32.50	32.50	7.85	7.87	7.83	7.84	7.81	7.89	7.85
7	32.50	32.50	7.90	7.82	7.86	7.82	7.84	7.91	7.86
8	30.00	35.00	7.80	7.53	7.79	7.75	7.68	7.76	7.72
9	28.96	32.50	7.76	7.64	7.88	7.87	7.72	7.60	7.75
10	36.04	32.50	7.78	7.41	7.70	7.51	7.68	7.69	7.63
11	32.50	32.50	7.93	7.85	7.82	7.80	7.86	7.86	7.85
12	32.50	36.04	7.74	7.70	7.65	7.69	7.60	7.72	7.68
13	32.50	32.50	7.89	7.9	7.91	7.86	7.85	7.91	7.89

Table 4 Coefficient of the full second order polynomial model for coded sensory responses to different levels of ingredients of gluten-free chhana cake

Terms		Sensory scores (9-point hedonic scale)						
		Colour and appearance score	Volume score	Body and texture score	Flavour score	Crumb colour score	Crust colour score	Overall acceptability score
Intercept		7.8900	7.8580	7.8620	7.8220	7.8340	7.9000	7.8610
Linear level	A: Barnyard millet (%)	-0.0527^{ns}	-0.0719^{**}	-0.0918^{*}	-0.0899^{**}	-0.0146^{ns}	-0.0066^{ns}	-0.0546^{**}
	B: Amaranth (%)	0.0789^{*}	-0.0363^{ns}	0.1222^{*}	0.0341^{ns}	0.0041^{ns}	0.0686^{*}	0.0246^{*}
Interactive effect	A × B	0.1125^{*}	0.1275^{**}	0.0600^{ns}	0.0075^{ns}	0.0800^{**}	0.0800^{*}	0.0779^{**}
Quadratic level	A^2	-0.0731^{ns}	-0.1528^{**}	-0.0116^{ns}	-0.0748^{**}	-0.0589^{*}	-0.1050^{**}	-0.0867^{**}
	B^2	-0.1131^{*}	-0.0653^{*}	-0.2191^{**}	-0.0823^{**}	-0.0864^{**}	-0.1150^{**}	-0.0917^{**}
P value		0.0181	0.0004	0.0024	0.0049	0.0023	0.0021	<0.0001
R^2		0.8174	0.9340	0.8804	0.8757	0.8676	0.8736	0.9648
Model F-value		7.5100	29.8300	16.1200	12.4900	16.3400	16.9600	62.2800
APV		7.3017	11.4860	10.3465	7.6947	7.8749	8.3229	17.6108
Suggested model		Quadratic	Quadratic	Quadratic	Quadratic	Quadratic	Quadratic	Quadratic

The model F-values for the colour and appearance, volume, body and texture, flavour, crumb colour, crust colour and overall acceptability were 7.51, 29.83, 16.12, 12.49, 16.34, 16.96 and 62.28, respectively (Table 4). The calculated F-values were greater than the tabulated F-which suggested that the model was significant ($P<0.05$). The coefficient of determination (R^2) was measured as the proportion of variability. The value for the same should be greater than 0.8. The values of R^2 for colour and appearance, volume, body and texture, flavour, crumb colour, crust colour and overall acceptability of gluten-free chhana cake were 0.8174, 0.9340, 0.8804, 0.8757, 0.8676, 0.8736 and 0.9648 respectively. A value greater than 0.8 of R^2 indicated the selected quadratic model was better to fit. The adequate precision value estimates the signal to noise ratio. The value for the same should be greater than 4.0. The adequate precision values for colour and appearance, volume, body and texture, flavour, crumb colour, crust colour and overall acceptability were 7.3017, 11.4860, 10.3465, 7.6947, 7.8749, 8.3229 and 17.6108, respectively. All these values were more than 4, indicated that adaptability of the model to explore the design.

Colour and appearance score: The formulation with 35% barnyard millet and 30% amaranth obtained a minimum score, while the formulation with 32.50% barnyard millet and 32.50% amaranth obtained a maximum score. The coefficient of determination (R^2) for colour and appearance was 0.8174, which was greater than 0.80 and the adequate precision value (APV) was 7.3017, which was greater than 4.0. The model F-value was 7.51, revealed that the model was fitted the data well (Table 4). Barnyard millet had a non-significant ($P>0.05$) negative effect on colour and appearance score at linear terms. A decrease in colour and appearance score with an increase in barnyard millet content was also observed by Goswami *et al*. [21] for barnyard millet-based muffins. They observed that replacement of Maida with barnyard from 0 to 100% significantly decreased the colour and appearance score of the muffins. Amaranth had a significant ($P<0.05$) positive effect on colour and appearance score at linear terms. An increase in colour and appearance score with an increase in amaranth flour was also observed by Mandle [22] for cookies made with amaranth flour. They observed that replacement of *Maida* with amaranth flour in cookies from 0 to 100% significantly increased the colour and appearance score. However, in quadratic terms, barnyard millet (A^2) had a non-significant ($P>0.05$) negative effect. Amaranth (B^2) had a significant ($P<0.05$) negative effect in quadratic terms.

Volume score: The formulation with 36.04% barnyard millet and 32.50% amaranth obtained a minimum score, while the formulation with 30.00% barnyard millet and 30.00% amaranth obtained a maximum score. The coefficient of determination (R^2) for volume score was 0.9340, which was greater than 0.80 and the adequate precision value (APV) was 11.4860, which was greater than 4.00. The model F-value was 29.83, revealed that the model was fitted the data well (Table 4). Barnyard millet had a significant ($P<0.01$) negative effect on volume score at linear terms. A decrease in volume with an increase in barnyard millet content was observed by Goswami *et al*. [21] for barnyard millet-based muffins. They observed that replacement of refined wheat flour with barnyard millet flour from 0 to 100% in muffins significantly decreased the volume. Amaranth had a non-significant ($P>0.05$) negative effect on volume at linear terms. A decrease in volume score with an increase in amaranth levels was observed by Lemos *et al*. [23] for amaranth incorporated cheese bread. They incorporated amaranth flour in the proportion of 10.0, 15.0 and 20.0% cheese bread and observed that this significantly decreased the volume score with an increase in the level of amaranth. Barnyard millet (A^2) had a significant ($P<0.01$) negative effect at quadratic terms. Amaranth (B^2) had a significant ($P<0.05$) negative effect at quadratic terms.

Body and texture score: The body and texture score of gluten-free chhana cake was observed in the range from 7.10 to 7.91. The formulation with 32.50% barnyard millet and 28.96% amaranth were obtained minimum score while formulation with 32.50% barnyard millet and 32.50% amaranth were obtained maximum score. The coefficient of determination (R^2) for body and texture score was 0.8804, which was greater than 0.8 and the adequate precision value (APV) was 10.3465, which greater than 4.00. The model F-value was 16.12 which was analysed statistically which was indicated that model was fitted the data well (Table 4). Barnyard millet had a significant ($P<0.05$) negative effect on body and texture score at linear terms. A decrease in body and texture score with increase in barnyard millet content was also observed by Goswami *et al*. [21] for barnyard millet-based muffins. They replaced Maida with barnyard millet flour from 0 to 100% and observed that significantly decreased the body and texture score of muffins. Amaranth had a significant ($P<0.05$) positive impact on body and texture score at linear terms. Improve in body and texture with increased in amaranth of cookies was also observed by Mandle [22]. They replaced Maida with amaranth flour from 0 to 100% and observed that significantly increased the body and texture score of cookies. Barnyard millet (A^2) had a non-significant ($P>0.05$) negative effect at quadratic terms. Amaranth (B^2) had a significant ($P<0.01$) negative affect at quadratic terms.

Flavour score: Flavour is a crucial requirement for sensory acceptability of any newly developed product. The flavour score of gluten-free chhana cake was observed in the range from 7.51 to 7.87. The formulation with 36.04% barnyard millet and 32.50% amaranth were obtained minimum score while formulation with 28.96% barnyard millet and 32.50% amaranth were obtained maximum score. The coefficient of determination (R^2) was 0.8757 for flavour score, which was greater than 0.8 and the adequate precision value (APV) was 7.6947, which was greater than 4.00. The model F-value which was analysed statistically indicated that the model was fitted the data well (Table 4). Barnyard millet had a significant ($P<0.01$) negative effect on flavour score at linear terms. A decrease in flavour score with increase in barnyard millet content was also observed by Goswami *et al*. [21] for barnyard millet-based muffins. They observed that replacement of Maida with barnyard millet flour in muffins from 0 to 100% significantly decreased the flavour score. Amaranth had a non-significant ($P>0.05$) negative effect on flavour score at linear terms. The flavour score decreased with increased in amaranth flour in bread was observed by Ayo [24]. They observed that amaranth flour increases in bread from 0 to 50% significantly decreased the flavour score and this impact was significant at above 15% of added amaranth flour. Barnyard millet (A^2) and amaranth (B^2) had a significant ($P<0.05$) negative affect at quadratic terms.

Crumb colour score: The formulation with 35.00% barnyard millet and 30.00% amaranth were obtained minimum score while formulation with 32.50% barnyard millet and 32.50% amaranth were obtained maximum score. The coefficient of determination (R^2) for crumb colour score was 0.8676, which was greater than 0.8 and the adequate precision value (APV) was 7.8749, which greater than 4.00. The model F-value was 16.34 which analysed statistically which indicated that model was fitted the data well (Table 4). Barnyard millet (A^2) had a significant ($P<0.05$) negative effect at quadratic terms. Amaranth (B^2) had a significant ($P<0.01$) negative effect at quadratic terms.

Crust colour score: The coefficient of determination (R^2) for crust colour score was 0.8736, which was greater than 0.8 and the adequate precision value (APV) were 8.3229, which greater than 4.00. The model F-value for crust colour score was 16.96 which analysed statistically which indicated that model was fitted the data well (Table 4). Amaranth had a significant ($P<0.05$) positive effect on crust colour score at linear terms.

Overall acceptability score: The overall acceptability score of gluten-free chhana cake was observed in the range from 7.49 to 7.89. The formulation with 35.00% barnyard millet and 30.00% amaranth were obtained minimum score while formulation with 32.50% barnyard millet and 32.50% amaranth were obtained maximum score. The coefficient of determination (R^2) for overall acceptability score was 0.9648, which was

greater than 0.8 and the adequate precision value (APV) was 17.6108, which was greater than 4.00. The model F-value was 62.28 which analysed statistically was indicated that model was fitted the data well (Table 4).

Barnyard millet had a significant (P<0.01) negative impact on overall acceptability score at linear terms. Same results were also observed by Goswami *et al*. [21] for barnyard millet-based muffins. They replaced Maida with barnyard millet flour from 0 to 100 % and observed that there was significantly decreased the overall acceptability score with an increase in barnyard millet of muffins. Amaranth had a significant (P<0.05) positive impact on overall acceptability score at linear terms. A same result was observed by Mandle [22] for cookies from amaranth flour. He replaced Maida with amaranth flour from 0 to 100% and observed that there was a significant increase in overall acceptability score with an increase in amaranth for cookies. Barnyard millet (A^2) and amaranth (B^2) had a significant (P<0.01) negative impact at quadratic terms.

Table 5 Criteria/responses chosen for process optimization of gluten-free chhana cake

Parameter	Goal	Lower limit	Upper limit	Lower weight	Upper weight	Importance of level
A: Barnyard millet (%)	In range	30.00	35.00	1	1	3
B: Amaranth (%)	In range	30.00	35.00	1	1	3
Colour and appearance (9-point hedonic scale)	Max.	7.33	7.93	1	1	3
Volume (9-point hedonic scale)	Max.	7.41	7.93	1	1	3
Body and texture (9-point hedonic scale)	Max.	7.10	7.91	1	1	3
Flavour (9-point hedonic scale)	Max.	7.51	7.87	1	1	3
Crumb colour (9-point hedonic scale)	Max.	7.57	7.86	1	1	3
Crust colour (9-point hedonic scale)	Max.	7.53	7.93	1	1	3
Overall acceptability (9-point hedonic scale)	Max.	7.49	7.89	1	1	3

Optimization of proportion of barnyard millet, little millet and amaranth for manufacture of gluten-free chhana cake

Optimization of proportion of barnyard millet and amaranth was carried out with purpose of determining the best optimal combinations of both factors viz. barnyard millet (A) and amaranth (B) that would result in most acceptable product in terms of sensory attributes. The goals were defined for obtaining the best possible combination was presented in (Table 5). Recommended best solution from RSM for gluten-free chhana cake was 31.86% barnyard millet, 32.69% amaranth and 35.45% little millet in the flour blend. The desirability of this model was 0.92.

Table 6 Comparison of predicted v/s actual values of responses used for optimization of gluten-free chhana cake

Response	P Value	Predicted Value *	Actual Value @	Calculated t-Value#	Level of Significance
Colour and Appearance (9-point hedonic scale)	0.57	7.90	7.96	0.60	NS
Volume (9-point hedonic scale)	0.63	7.86	7.92	0.51	NS
Body and texture (9-point hedonic scale)	0.67	7.89	7.83	0.46	NS
Flavour (9-point hedonic scale)	0.47	7.84	7.89	0.78	NS
Crumb colour (9-point hedonic scale)	0.15	7.83	7.97	1.64	NS
Crust colour (9-point hedonic scale)	0.71	7.90	7.94	0.40	NS
Overall acceptability (9-point hedonic scale)	0.19	7.87	7.93	1.47	NS

*Predicted values of Design Expert 13.0.5.0 package; @ Actual values are average of seven trials for optimized product; # t-values found non-significant at 5 per cent level of significance; NS = Non-significant; Tabulated t-value = 2.45 (Calculated t-value less than tabulated value)

The final optimized product was prepared by applying the suggested proportion of barnyard millet, amaranth and little millet and the actual sensory score was obtained. This actual sensory score was compared with predicted score. These both score were analyzed by t-test. The calculated t-value for all the sensory parameters was displayed in Table 6. The values for the t-test was less than the tabulated values, which indicated that there was no significant (P>0.05) difference between the predicted sensory score and actual sensory score as seen in (Table 6).

For manufacture of gluten-free chhana cake by developed method, chhana was prepared from milk (fat 5.5% and SNF 8.5%); it heated to 90°C for 5 min and then to cool to 65°C temperature. Citric acid solution (0.5%) was heated to 65°C, was gradually added in the milk with gentle stirring with the help of ladle till the milk was coagulated. The content was kept in hot whey for about 5 min. The whey was strained through muslin cloth, and the coagulated mass was hung for 5 minutes for more whey drainage. After that, Chhana was collected. First, chhana was kneaded in Hobart mixture for about 1.5 to 2.0 min. Then GMS @ 1.5% (w/w of chhana) solution (dissolved in 15-20 times water) and vanilla flavour @ 0.4% (v/w of chhana) were added to the Hobart mixture and kneaded for about 1 min. Then all the dry ingredients viz., 20% millet/pseudocereal blend (barnyard millet @ 6.37 %, amaranth @ 6.54%, little millet @ 7.09%), sugar @ 30% and baking powder @ 1% (all w/w of chhana) were dry blended together and added to the Hobart mixture and it was again kneaded thoroughly for 1.5 to 2.0 and smooth dough was

prepared. The dough was then poured into silicone moulds and kept in the oven for baking at 140°C for 80 min.

CONCLUSION

A method was developed for manufacture of acceptable quality gluten free chhana cake. Chhana prepared from milk containing 5.5% fat had better acceptability compared to other levels studied viz. 4.5, 5.0 and 6.0% milk fat. Replacement of wheat flour with millets. The optimized solution was 31.86% barnyard millet, 32.69% amaranth and 35.45% little millet. The desirability of this model was 0.92. From the different temperature/time combination, sample baked at 140 °C/80 min was found suitable for chhana cake.

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