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RESEARCH ARTICLE

Development of date-amaranth lassi enriched with popped amaranth flour, dates and dateseed powder

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Abstract: In today's fast-paced world, there is a growing need for functional foods that can improve nutrition and thus support overall good health of human being. Lassi is a well-known fermented dairy beverage in India, popular due to its sweet-sour refreshing taste. Combining amaranth, dates and dateseed powder with lassi can create a tailor-made functional beverage with 'health boosting' properties. Experimental trials were conducted for formulation of date amaranth lassi for partial replacement of sugar using date paste. The lassi sample containing 50:50 date paste-sugar ratio received superior scores viz. colour & appearance (8.24), mouthfeel/consistency (8.28), flavour (8.23), sweetness (8.06) and overall acceptability (8.20). In the next phase of study, the suggested solution from RSM analysis indicated that addition of 49.45 per cent dahi, 4.19 per cent popped amaranth flour and 1.00 per cent dateseed powder was most suitable for manufacture of date-amaranth lassi. The date-amaranth lassi exhibited 62.82% higher protein and 35.85% higher ash content, while it had 32.78% lower fat and 24.97% lower carbohydrate content compared to the control lassi. The developed date-amaranth lassi was free from pectin and other chemicals and showed 64.46 per cent higher viscosity, 144.80 per cent higher WHC and 17.69 per cent higher antioxidant activity compared to control counterpart.

Key words: Dates, Dateseed powder, Popped amaranth flour, Completely randomized design, Response surface methodology, Sensory evaluation

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Introduction

Lassi, made by blending dahi and water with different flavourings, is a ready-to-serve fermented milk beverage, popular for its sweet-sour taste and thirst-quenching properties. According to Rathaur and Solanky (2002), lassi is a type of fermented milk drink that is made through specific cultures, typically lactic streptococci, in milk that has been heat-treated and is either whole or partially skimmed.

Based on the analysis conducted by Data Bridge Market Research (2022), the fermented milk market was estimated at around USD 290 billion in the year 2023 and it is projected to achieve around USD 400 billion by 2030, showing a compound annual growth rate (CAGR) of 5.1 per cent. Based on a recent report, the trend towards functional beverages continues unabated with regional beverages being in vogue and associated with the term 'organic' by consumers. Functional foods and drinks benefit human health beyond adequate nutritional effects. The rising popularity of functional beverages is associated, among others, with their convenience and capacity to meet consumer needs (Kowalska et al. 2024). Thus, envisaging greater demand for fermented milk products, especially those with improved functional attributes.

Amaranth (*Amaranthus cruentus*) is a species that naturally grows in the Andean area of South America, which covers countries such as Argentina, Peru and Bolivia (FAO, 2023). Amaranth is a type of pseudo-cereal grain (presently categorized as millets), a part of the Amaranthaceae family and is gluten-free. It is acknowledged as a promising group of plants that offer superior protein, dietary fiber, unsaturated oil and many other beneficial components (USDA, 2019). Amaranth is mostly consumed during religious fasting in many regions of our country. Amaranth seed has the potential to contribute to improvement in nutrition of populations, especially in developing countries, because of its unique agricultural, nutritional, and functional properties. Amaranth, also known as *Rajgira* (Royal grain) or *Ramdana* (God's grain), is a powerhouse that can help prevent several chronic health conditions such as heart disease, cancer, stroke and also helpful in treating inflammatory issues like arthritis (Singhal et al. 2022).

The date palm tree, scientifically known as *Phoenix dactylifera L*., belongs to the Palmaceae family. Dates are among the oldest fruit trees that have been cultivated domestically throughout history (Vani, 2022). The Date palm is the successful and commercially significant crop in arid areas of the world, particularly in countries like, Saudi Arabia, the United Arab Emirates, Egypt, etc. Dates are nutritious, energy producing and assimilative fruits. In these countries, date products are generally used for human and animal feeding, medicines, firewood, cosmetics and carpentry (Ashraf and Hamidi, 2011). Date fruits are highly valued in human nutrition due to their essential nutrients such as carbohydrates, minerals, salts, fiber, fatty acids, vitamins, protein and amino acids. contain high amounts of dietary fiber, and are thought to be a good source of some minerals, viz. iron, potassium, and calcium (Shah et al. 2023). Additionally, dates are rich in phenolic compounds and flavonoid components, especially they contain significant amounts of lutein, β-carotene, zeaxanthin, and neoxanthin carotenoids. (Singh et al. 2023).

The glycemic index (GI) of dates varies depending on the type and ripeness, generally ranging from 35 to 55, placing them in the low to moderate GI category. In contrast, the GI of sucrose is approximately 65, which is considered moderate to high. The lower GI of dates means they cause a slower and more gradual increase in blood glucose levels compared to sucrose. This makes dates a better option for individuals managing blood sugar levels, such as those with diabetes, or for anyone looking to maintain steady energy levels (Foster-Powell et al. 2002).

Dateseeds are known to contain beneficial bioactive compounds (Al-Farsi and Lee, 2011) viz. polyphenols as well as dietary fiber (Hamada et al. 2002). In addition to their high polyphenol content, dateseeds provide carbohydrates, proteins and fats. Moreover, dateseeds are rich in various minerals like sodium (Na), potassium (K) and magnesium (Mg) (Abdillah et al. 2012).

Along with nutritional enrichment, amaranth, dates and dateseed powder have the potential to partially replace sugar as well as stabilizers in lassi. The main objective of present study was to incorporate amaranth, dates and dateseed powder into lassi to manufacture a natural product with enhanced functional properties and having clean label. Due to rich fiber content of dates and amaranth, the experimental lassi was not required to be added with any additional chemical stabilizer neither was it added with any chemical preservatives. The product with all natural, functional ingredients, can be claimed to be all-natural lassi entitled for clean label.

Materials and Methods

The methodology and formulation for production of lassi involved different stages for the process optimization as stated below.

Materials

The date-amaranth lassi was formulated using (4.5% fat, 8.5% SNF) from Anubhav Dairy, Department of Dairy Processing and Operations (DDPO), Kamdhenu University, Anand, starter culture from DSM Nutritional Products India Pvt. Ltd, Madhur brand sugar from local market of Anand, pectin from Himedia Laboratories Pvt. Ltd, amaranth was purchased from local market of Anand, Kimia variety of dates were purchased from local market of Anand and Ajwa dateseed powder was purchased from Ajfan Dates and Nuts Pvt Ltd.

Dahi making process

For preparation of dahi, homogenized milk having 4.5 per cent fat and 8.5 per cent SNF was received, heat treated to 90°C for 15 minutes and then cooled to an incubation temperature of 40±2°C. Direct set lyophilized thermophilic starter culture, which was obtained from DSM Food Specialties Ltd., was added at the dosage rate of 2 Units per 1000 kg milk. Then the milk was incubated for 5-6 hours until 0.9 %LA acidity was achieved. The dahi was then immediately cooled to refrigeration temperature. Dahi was ready for making lassi.

Preparation of date paste and popped amaranth flour

For the preparation of experimental lassi, the dates underwent a thorough process including washing, de-stoning and blanching at 80-85°C for 10 minutes; followed by peeling and then grinded to a smooth paste using mixer grinder ensuring the temperature was maintained at 50°C. To produce popped amaranth flour, a stainless-steel pan was heated on the stove before amaranth grains were added and popped within 10-15 seconds. Subsequently, the popped grains were transferred to a mixer for grinding into flour, which was then shifted through a metal sieve of BSS mesh number 72.

Manufacture of lassi

A precisely measured quantity of water was heated to 60°C before incorporating all dry ingredients such as sugar, date paste, popped amaranth flour and dateseed powder, which was then heated to 85°C for 5 min. Finally, the preparation was cooled down to 40°C for further processing. The prepared base was added to dahi at 40°C, followed by blending, cooling, packaging in PET bottles and then stored at refrigeration (7±1°C) temperature.

Analysis of date-amaranth lassi

The sensory evaluation of lassi samples were done by panel of 12 judges (semi-trained) using 9-point hedonic scale. The acidity was measured by ISO/TS 11869:2022. The total solid and ash content of the lassi sample was estimated as per the procedure given by Anarthe (2020). Fat in the lassi was measured gravimetrically by Mojonnier method. Protein content in the lassi sample was measured by the Kjeldahl method (ISO 8968-1:2016). The water-holding capacity (WHC) of lassi was determined based on method described by Yang et al. (2014) for fermented milks. The viscosity of the lassi sample was assessed using a rotational viscometer. The free fatty acid content of lassi sample was measured by the method described by Patel (2016). For measurement of antioxidant property, 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity was determined using modified procedure suggested by Song et al. (2010). Determination of the concentration of tyrosine was determined using Hull's method as per the procedure outlined by Arnott et al. (1957). LAB count as per ISO 17792:2006, coliform count as per ISO 4832:2006 and yeast and mold count as per ISO 21527-1:2008.

Statistical analysis

Three factors face centered Response Surface Methodology (RSM) and Completely Randomized Design (CRD) was used to analyze the data recorded throughout the research. The optimum formulation for the final product was filtered out using the Design Expert 13.0.1.0 program of RSM. Since the product was formulated using multiple ingredients viz. sugar, amaranth and dates, use of Response Surface Methodology (RSM) as statistical tool can optimize the recipe considering the interactive effect of all the ingredients affecting acceptability.

Results and Discussion

Standardization of the level of date paste and sugar for manufacture of date-amaranth lassi

Based on standard method of production, lassi is usually added with 12 percent sucrose. Dates are known to have a sweetness index in the range of 50-67 per cent in comparison to sucrose (Jain., 2013). Hence, on an average date have 60 percent sweetness ratio in comparison to sucrose and accordingly, the replacement ratio is shown in Table 1, to get equivalent sweetness in lassi as that given by 12 per cent sucrose. The quantity of popped amaranth flour, dateseed powder, curd and water content had been kept constant at 3 per cent, 1 per cent, 45 per cent and 39 per cent, respectively. The experimental lassi samples were prepared by the addition of different ratios of date paste and sugar (100:0, 60:40, 50:50, 40:60, 0:100 and denoted as A1, A2, A3, A4 and A5, respectively) and control (C1) was prepared with 12.0 percent sugar level.

As shown in Table 1, all the treatment of date-amaranth lassi containing varying levels of date paste and sugar were evaluated by a panel of 12 judges and their sensory scores showed significant differences. Furthermore, it can be observed in Table 1 that the A3 lassi sample received sensory scores similar to control lassi viz. colour & appearance (8.24), mouthfeel/ consistency (8.28), flavour (8.23), sweetness (8.06), overall acceptability (8.20). All the sensory parameters of the A3 sample containing 50:50 date paste-sugar ratio was observed to be significantly ($p<0.05$) higher compared to other samples. Thus, A3 sample (containing 50:50 date paste-sugar ratio) was selected for further study due to its superior sensory scores that was at par with control lassi sample.

Optimization of the level of amaranth and dateseed powder for manufacture of lassi

The optimization of amaranth, dateseed powder and dahi was conducted based on sensory properties such as colour & appearance, mouthfeel/consistency, flavour, sweetness, overall acceptability as well as physicochemical attributes like total solids, viscosity and acidity. Successive regression analysis produced quadratic models for each response, with the coefficient of determination (R^2) ranging from 0.810 to 0.972 (Table 2).

Table 1: - Effect of date paste and sugar ratio on sensory characteristics of date-amaranth lassi

Treatment (Date paste: Sugar)	Date paste: Sugar (g)/100g lassi*	Sensory Score (9-point hedonic scale)				
		Colour & Appearance	Mouthfeel/ Consistency	Flavour	Sweetness	Overall Acceptability
A_1 (100:0)	20.0:0	7.93±0.28^{bc}	7.29±0.22^{d}	7.03±0.10^{d}	6.96±0.28^{a}	7.10±0.18^{c}
A_2 (60:40)	12.0:4.8	7.73±0.25^{cd}	7.99±0.18^{bc}	7.76±0.30^{c}	7.83±0.15^{b}	7.91±0.23^{b}
A_3 (50:50)	10.0:6.0	8.24±0.22^{ab}	8.28±0.09^{ab}	8.23±0.11^{ab}	8.06±0.10^{bc}	8.20±0.07^{ab}
A_4 (40:60)	8.0:7.2	8.06±0.24^{abc}	8.00±0.41^{bc}	7.93±0.28^{bc}	7.99±0.40^{bc}	8.10±0.45^{ab}
A_5 (0:100)	0:12.0	7.55±0.18^{d}	7.82±0.08^{c}	7.67±0.17^{c}	8.06±0.10^{bc}	7.90±0.10^{b}
C (control)	0:12.0	8.43±0.16^{a}	8.41±0.08^{a}	8.34±0.11^{a}	8.39±0.03^{c}	8.39±0.08^{a}
SEm±	-	0.12	0.10	0.11	0.13	0.10
CD (0.05)	-	0.38	0.30	0.35	0.39	0.30
CV %	-	2.65	2.13	2.49	2.79	2.11

*Date paste level calculated considering 60% sweetness in comparison to sucrose

Values within a column with different superscripts differed significantly ($p<0.05$); n=3

Effect of variables on colour & appearance score of date-amaranth lassi

The colour and appearance of a product plays an important part in its overall perception and are vital variables in judging product quality. The maximum colour and appearance score was attained at the level of 50 per cent dahi, 4 per cent popped amaranth flour and 1.5 per cent dateseed powder; and the lowest score was attained at the level of 40 per cent dahi, 6 per cent popped amaranth flour and 2 per cent dateseed powder. It can be seen in Table 3 that the dahi content (A) had a non-significant negative effect on the colour and appearance score. The Popped amaranth flour (B) had a non-significant positive effect, while dateseed powder (C) had a significant ($p<0.05$) negative impact on colour and appearance score at linear term. The interaction effect A×B, A×C and B×C indicated a non-significant negative effect, significant ($P<0.05$) positive effect and significant ($P<0.05$) negative impact on colour and appearance score, respectively by varying dahi, popped amaranth flour and dateseed powder in lassi. The dahi content had a non-significant negative effect, popped amaranth flour significant ($P < 0.05$) negative effect and dateseed powder non-significant positive on the colour and appearance at quadratic terms.

Effect of variables on mouthfeel/consistency score of date-amaranth lassi

Mouthfeel/consistency plays a vital role in the acceptability of liquid milk products like lassi. The mouthfeel/consistency scores (out of 9) of date-amaranth lassi are shown in Table 2 that ranged from 6.79 to 8.31 on a 9-point hedonic scale. The date-amaranth lassi prepared using 40 per cent dahi, 6 per cent amaranth flour, 2 per cent dateseed powder had the lowest mouthfeel/consistency score (out of 9) of 6.79; while sample containing 50 per cent dahi, 4 per cent amaranth flour, 1 per cent dateseed powder received the highest score of 8.31. The dahi, popped amaranth flour and dateseed powder had a non-significant negative effect on the mouthfeel/consistency score on linear term (Table 3). The interaction effects A×B, A×C and B×C indicated a non-significant positive, non-significant positive and significant ($P<0.05$) negative impact on mouthfeel/consistency score respectively, by varying dahi, popped amaranth flour and dateseed powder in lassi. As can be seen in Table 3, the dahi, amaranth flour and dateseed powder had a non-significant negative effect, significant ($P<0.05$) negative effect and non-significant positive effect, respectively on the mouthfeel/consistency in quadratic terms.

Effect of variables on flavour score of date-amaranth lassi

For measuring the quality of any product, flavour is most likely the most essential parameter, which affects its acceptability. The flavour score of date-amaranth lassi samples ranged from 7.20 to 8.36 on a 9-point hedonic scale as shown in Table 2. The lowest date-amaranth lassi flavour score was 7.20 for the recipe made with 40 per cent dahi, 6 per cent amaranth flour and 2 per cent dateseed powder. The highest score was 8.36 for the recipe made with 50 per cent dahi, 4 per cent amaranth flour and 1.5 per cent dateseed powder. Dahi had a non-significant positive impact and popped amaranth flour showed a non-significant negative effect on the flavor score at the linear term. In contrast, dateseed powder had a significant ($P<0.05$) negative impact on the flavor score (Table 3). The combined impact of A×B and A×C on the flavour of date-amaranth lassi, as influenced by the different levels of dahi, amaranth and dateseed powder was positive but was statistically non-significant. The impact of B×C was a non-significant negative effect on flavour. Dahi, amaranth flour, and dateseed powder influenced flavor at quadratic terms differently: dahi had a non-significant negative effect, popped amaranth flour had a significant negative effect ($P<0.05$) and dateseed powder had a non-significant positive effect. The response surface 3D graphs for these values are shown in Figure 1.

Effect of variables on sweetness score of date-amaranth lassi

As depicted in Table 2, for experimental runs 1 and 3, the lowest value for sweetness score was attained and it was composed of 6 percent amaranth flour, 40 percent dahi and 2 percent dateseed powder. Experimental run 15 received the maximum score, which contained 4 percent amaranth flour, 50 percent dahi and 1.5 percent dateseed powder. The values presented in Table 3 reveal that the value for the level of dahi (A) and popped amaranth flour (B) showed a non-significant negative effect on sweetness score, whereas levels of dateseed powder (C) had non-significant negative effect on sweetness score at linear level. For the interactive level, the interaction of dahi and amaranth (AB) had a non-significant positive effect on the sweetness score. Whereas, other interactions namely dahi and dateseed powder (AC) as well as amaranth flour and dateseed powder (BC) had a non-significant positive effect on the sweetness score. For the quadratic level dahi (A^2) and dateseed powder (C^2) had a non-significant negative effect, while popped amaranth flour (B^2) had a significant ($P<0.05$) negative impact on the sweetness score.

Effect of variables on overall acceptability score of date-amaranth lassi

The overall acceptability score of date-amaranth lassi ranged from 7.25 to 8.27 (out of 9) as shown in Table 2. The lowest result was obtained for experimental run 1 and the highest result was obtained for experimental run 15. At the linear level, data shown in Table 3 indicates that dahi had a non-significant negative effect on overall acceptability, while popped amaranth flour had a non-significant positive effect. In contrast, dateseed powder had a significant (Pd"0.05) negative impact on overall acceptability. For the interactive level, two combinations i.e., dahi and popped amaranth flour (AB) as well as dahi and dateseed powder (AC) showed a non-significant positive effect on the overall acceptability score of date-amaranth lassi; whereas amaranth &

Table 2: Experimental design matrix, sensory attributes, total solids, viscosity and acidity of date-amaranth lassi

Run No.	Dahi (%)	Popped amaranth flour (%)	Dateseed powder (%)	Sensory scores (9-point hedonics scale) Colour & Appearances	Mouthfeel/ Consistency	Flavour	Sweetness	Overall Acceptability	Total solids (%)	Viscosity @ 20°C (cP)	Acidity (% LA)
1	40	6	2	7.21	6.79	7.20	7.50	7.25	25.05	2285	0.41
2	50	4	1.5	7.93	8.21	8.36	8.29	8.25	22.20	1176	0.55
3	40	2	2	7.27	7.79	7.50	7.50	7.39	19.80	772	0.47
4	50	4	1.5	7.93	7.98	8.20	8.07	8.23	22.70	990	0.54
5	50	4	1.5	7.84	7.56	7.78	7.88	7.99	20.20	860	0.58
6	40	4	1.5	8.06	8.25	7.94	8.06	8.03	19.90	810	0.48
7	50	4	1.5	8.11	8.14	8.06	8.11	7.97	21.20	884	0.57
8	40	2	1	7.75	7.68	7.81	7.94	7.72	18.80	458	0.47
9	60	4	1.5	7.63	7.76	7.70	7.81	7.53	23.30	1680	0.69
10	60	2	2	7.72	7.78	7.67	7.61	7.30	22.09	1464	0.68
11	60	2	1	7.28	7.17	7.67	7.61	7.42	21.63	1198	0.65
12	50	6	1.5	7.45	7.11	7.52	7.67	7.90	24.43	1860	0.49
13	60	6	1	7.79	7.83	7.83	7.70	7.96	24.21	1820	0.67
14	40	6	1	8.20	7.63	7.50	7.75	7.72	20.90	910	0.40
15	50	4	1.5	8.17	8.17	8.33	8.35	8.27	21.60	1142	0.59
16	60	6	2	7.53	7.33	7.38	7.58	7.38	23.70	1760	0.66
17	50	4	2	7.80	8.10	7.88	7.80	7.50	22.98	1386	0.57
18	50	4	1.5	8.30	8.30	8.04	8.20	8.02	20.09	864	0.57
19	50	2	1.5	7.64	7.50	7.90	7.80	7.50	20.23	940	0.57
20	50	4	1	8.20	8.31	8.30	8.00	8.20	19.78	742	0.57

Table 3: Partial coefficients of regression equations of suggested models for a sensory score of date-amaranth lassi

Terms	Sensory scores (9-point hedonics scale) Colour & Appearance	Mouthfeel/ Consistency	Flavour	Sweetness	Overall Acceptability	Total solids (%)	Viscosity @ 20°C (cP)	Acidity (% LA)
Intercept	8.003	8.045	8.097	8.094	8.059	21.423	1044.710	0.567
A: Dahi	-0.055	-0.028	0.030	-0.043	-0.054	1.048*	268.700*	0.112*
B: Popped amaranth flour	0.053	-0.123	-0.111	-0.026	0.088	1.574*	380.300*	-0.015*
C: Dateseed powder	-0.168*	-0.083	-0.148*	-0.100	-0.219*	0.830*	253.900*	-0.004
AB	-0.009	0.160	0.062	0.031	0.095	-0.395	-130.875	0.009
AC	0.207*	0.107	0.021	0.072	0.012	-0.650	-185.375*	0.001
BC	-0.151*	-0.258*	-0.055	0.009	-0.076	0.273	91.875	-0.006
A^2	-0.094	-0.015	-0.234	-0.075	-0.187	0.041	112.227	0.018
B^2	-0.392*	-0.715*	-0.341*	-0.279*	-0.264*	0.771	267.227	-0.037*
C^2	0.062	0.180	0.038	-0.112	-0.115	-0.179	-68.773	-0.002
R^2	0.844	0.860	0.817	0.810	0.838	0.820	0.881	0.972
Model F-value	6.020	6.850	4.960	4.750	5.750	5.050	8.190	38.670
APV	8.394	9.644	8.531	5.884	7.647	9.281	11.906	21.517
Suggested model	Quadratic	Quadratic	Quadratic	Quadratic	Quadratic	Quadratic	Quadratic	Quadratic

*: $p < 0.05$; R^2 =Coefficient of determination, APV= Adequate Precision Value

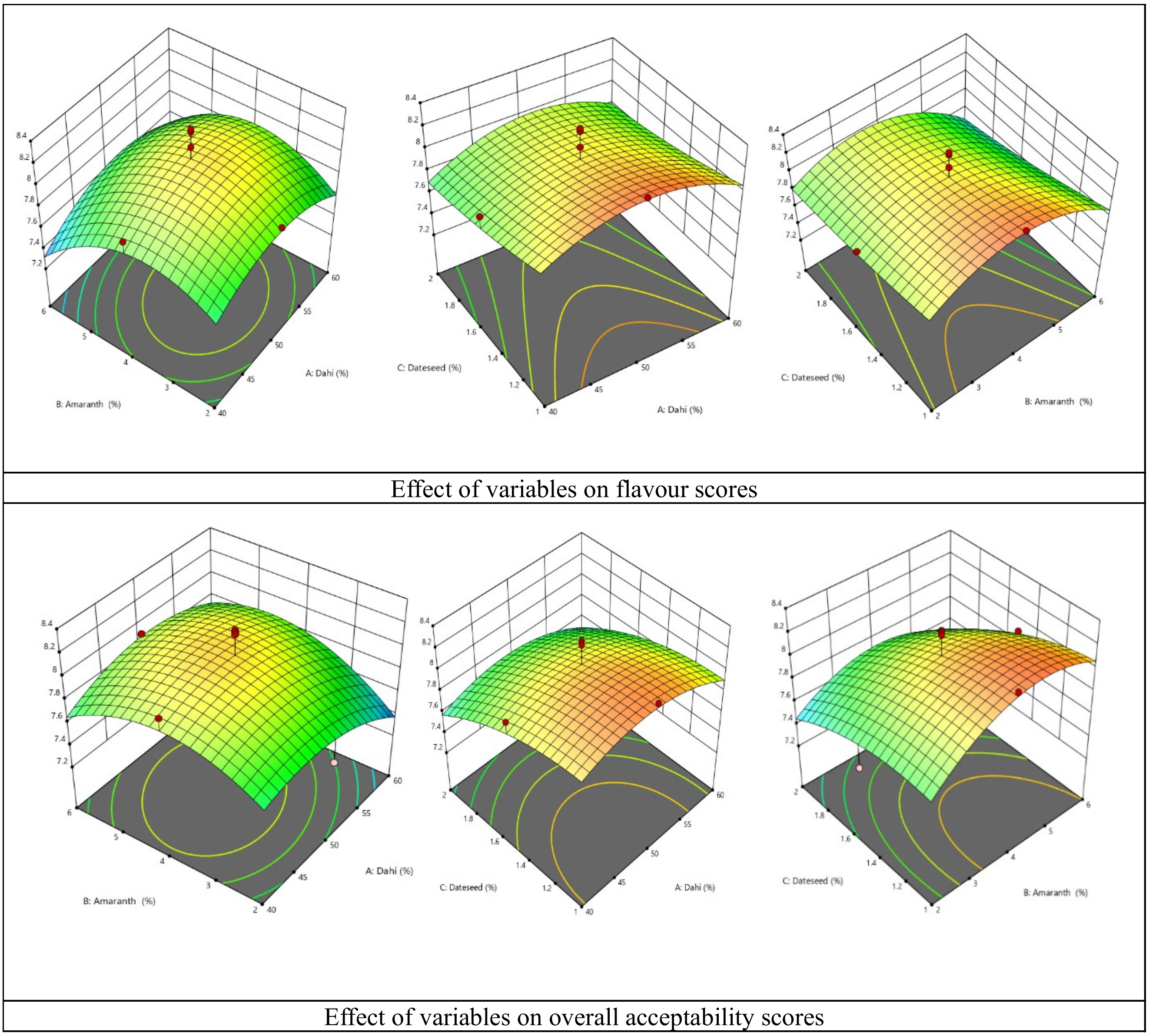

Fig. 1 Response surface plot of flavour and overall acceptability scores of lassi as influenced by the level of dahi, popped amaranth flour and dateseed powder

dateseed powder (BC) depicted a non-significant negative effect on overall acceptability scores of date-amaranth lassi. For the quadratic level, both dahi (A^2) and dateseed powder (C^2) had a non-significant negative effect, while amaranth flour (B^2) had significant ($P<0.05$) negative effect on overall acceptability scores of the experimental lassi samples. Figure 1 represents the three-dimensional response surface plots on the overall acceptability of date-amaranth lassi.

Effect of variables on total solids content of date-amaranth lassi

Total solids content was observed to be positively affected by the dahi (A), amaranth flour (B) and dateseed powder (C) at a 5 per cent level ($P<0.05$) in linear terms (Table 3). The interactive effect of A×B and A×C had a non-significant negative impact, while B×C exhibited non-significant positive effect on total solids. in quadratic terms, the effect of dahi (A^2) and Amaranth flour (B^2) on viscosity was positively correlated and non-significant. Dateseed powder (C^2) showed a negative but non-significant effect on total solid content at the quadratic level.

Effect of variables on viscosity of date-amaranth lassi

The viscosity of date-amaranth lassi samples ranged between 458 cP and 2285 cP which is shown in Table 2. At a 5 per cent

Table 4: Comparison of predicted v/s actual values of responses used for process formulation of date-amaranth lassi

Response	Predicted Value *	Actual Value @	Cal. t-Value#	P Value	Level of Significance
Colour and Appearance	8.26	8.37	2.02	0.09	NS
Mouthfeel/ Consistency	8.32	8.26	1.94	0.10	NS
Flavour	8.27	8.35	0.96	0.37	NS
Sweetness	8.08	8.21	1.13	0.32	NS
Overall Acceptability	8.18	8.09	0.55	0.61	NS
Total solid (%)	20.46	21.33	2.09	0.10	NS
Viscosity (cP) at 20°C	728.19	716.58	2.27	0.06	NS
Acidity (%LA)	0.56	0.52	1.41	0.23	NS

* Predicted values of Design Expert Package
@ Actual values are an average of seven trials for optimized product
\# t-values found non-significant at a 5 per cent level of significance
NS = Non-significant
Tabulated t-value = 2.447 (cal. t-value less than tabulated value)

Table 5: Average proximate composition, physico-chemical properties, microbiological quality and sensory score of control and date-amaranth lassi

Attributes Proximate composition (%)	Control lassi (P_1)	Date-amaranth lassi (P_2)
Total Solid	24.17±0.29	20.52±0.17
Fat	3.20 ±0.24	2.41±0.12
Protein	2.34±0.08	3.81±0.11
Ash	0.53±0.06	0.72±0.04
Carbohydrate (By difference)	18.10±0.52	13.58±0.46
Crude fiber (%)	-	0.24
Potassium, mg/100g	110	117.20
Calcium, mg/100g	90	90.97
Iron, mg/100g	ND	0.13
Physico-chemical properties		
pH	3.96±0.09	4.39±0.019
Acidity (% LA)	0.66 ±0.05	0.53±0.04
Water activity (a_w)	0.96±0.02	0.91±0.01
Viscosity (cP)	437.80±2.99	720.00±3.45
WHC (%)	14.06±0.36	34.42±0.82
FFA (% oleic acid)	0.028±0.002	0.026±0.002
DPPH (% inhibition)	71.06±1.85	86.53±1.18
Tyrosine value (µg tyrosine/5ml)	85.89±0.67	158.25±0.74
Microbiological count		
LAB (log_{10} cfu/g)	8.81±0.18	8.41±0.2
Coliform (cfu/g)	Absent/g	Absent/g
Yeast and Mold (cfu/g)	Absent/g	Absent/g
Sensory score (9-point hedonic scale)		
Colour & Appearance	8.34±0.14	8.31±0.09
Mouthfeel/ Consistency	8.41±0.14	8.30±0.10
Flavour	8.29 ±0.07	8.25±0.05
Sweetness	8.37±0.08	8.17±0.17
Overall Acceptability	8.29±0.06	8.20±0.08

* Mean values ± SD; n=5; WHC- water holding capacity

level, a positive effect was observed (P<0.05) from the dahi (A), amaranth flour (B) and dateseed powder (C). The interactive effect A×B had a non-significant negative effect on viscosity while A×C and B×C had significant (P<0.05) negative and non-significant positive effects on viscosity at 20°C. In quadratic terms, dahi (A^2) exhibited a non-significant positive effect on viscosity. Additionally, amaranth flour (B^2) and dateseed powder (C^2) demonstrated a non-significant positive and non-significant negative impact on viscosity, respectively.

Effect of variables on acidity of date-amaranth lassi

The overall range of acidity (% LA) of date-amaranth lassi samples were from 0.40 to 0.69 which is indicated in Table 2. As shown in Table 3, dahi (A) imparted a significant (P<0.05) positive effect on acidity. Popped amaranth flour (B) bestowed a significant (P<0.05) negative effect on acidity; while dateseed powder (C) conferred a nonsignificant negative effect on acidity in linear term. The interactive effect of A×B and A×C had a non-significant positive effect on acidity of lassi. Conversely, B×C was associated with a statistically non-significant negative effect on acidity. The quadratic terms, dahi (A^2), amaranth flour (B^2) and dateseed powder (C^2) had a non-significant positive, significant (P<0.05) negative and non-significant negative effect on acidity.

Optimization of product formulation for date-amaranth lassi

The goals were set to maximize the scores for colour and appearance, mouthfeel/consistency, flavour, sweetness and overall acceptability as these are the key parameters for sensory analysis in lassi. Suggested optimized formulation for date-amaranth lassi as shown below included dahi @ 49.45 per cent, popped amaranth flour @ 4.19 per cent and dateseed powder @1 per cent with desirability of 0.946.

Date-amaranth lassi was prepared by adding amaranth, dateseed powder and dahi as suggested by RSM. The predicted values for colour and appearance, mouthfeel/consistency, flavour, sweetness, overall acceptability, total solids, viscosity and acidity were 8.26, 8.32, 8.27, 8.08, 8.18, 20.46 per cent, 728.19 cP and 0.56 % LA, respectively. The observed values for these parameters were not significantly different from the predicted values (Table 4), confirming that the selected levels of dahi, amaranth flour and dateseed powder are optimal for achieving desirable sensory quality, total solids, viscosity and acidity values in the date-amaranth lassi.

Analysis of date-amaranth lassi

As seen in Table 5, the average total solids, fat, protein, ash and total carbohydrates of the optimized date-amaranth lassi (P_2) samples were 20.52±0.17, 2.41±0.12, 3.81±0.11, 0.72±0.04 and 13.58±0.46 per cent, respectively. The optimized product (P_2) had crude fiber content of 0.24 per cent, potassium 117.20 mg/100g, calcium 90.97 mg/100g and iron 0.13 mg/100g (calculations were done on the basis of the values obtained for the functional components viz. mixture of dates, amaranth flour and dateseed powder). Average total solids, fat, protein, ash and total carbohydrates of the control sample (P_1) were 24.17±0.29, 3.20±0.24, 2.34±0.08, 0.53±0.06 and 18.10±0.52, respectively, while it had potassium content of 110 mg/100g and calcium 90 mg/100g. The crude fiber and iron content could not be detected in P_1 sample. The date-amaranth lassi had 62.82 per cent more protein, 35.85 per cent more ash, 6.55 per cent more potassium and 1.08 per cent more calcium compared to the control lassi, while it had 32.78 per cent lower fat, 17.79 per cent lower total solids and 24.97 per cent lower carbohydrate content compared to control lassi. As can be seen in Table 5, optimized date-amaranth lassi (P2) had pH, acidity, water activity, viscosity, water holding capacity (WHC), free fatty acid (FFA) content, DPPH and tyrosine values of 4.39±0.019, 0.53±0.04 per cent LA, 0.91±0.01, 720.00±3.45 cP, 34.42±0.82 (%), 0.026±0.002 (% oleic acid), 86.53±1.18 (% inhibition) and 158.25±0.74 (µg tyrosine/5ml filtrate), respectively. Physico-chemical characteristics for control lassi can be seen in Table 5 had pH, acidity, water activity, viscosity, water holding capacity (WHC), free fatty acid (FFA) content, DPPH and tyrosine values of 3.96±0.09, 0.66 ±0.05 per cent LA, 0.96±0.02, 437.80±2.99 cP, 14.06±0.36 (%), 0.028±0.002 (% oleic acid), 71.06±1.85 (% inhibition) and 85.89±0.67 (µg tyrosine/5ml filtrate), respectively. It is evident that the experimental sample had 7.69 per cent lower FFA values, while the viscosity and antioxidant activity were respectively, 64.46 per cent and 17.69 per cent higher compared to control lassi. The LAB count (log_{10} cfu/g) was 8.81 in the control lassi and 8.41 in the date-amaranth lassi. Both dates and amaranth are good source for fiber and are known to improve water holding capacity in dairy products (Elleuch et al. (2008); Nandan et al. 2024). Amaranth, dates and dateseed powder are known to have bioactive compounds, micronutrients and phenolic compounds that can increase the rate of proteolysis during storage (Al Farsi and Lee, 2011; Klimczak and Gliszczynska-Swiglo, 2020; Habib and Ibrahim, 2011). The coliform as well as yeast and mold count were absent/g in both P_1 and P_2 samples. The average colour and appearance score, mouthfeel/consistency score, flavour score, sweetness score and overall acceptability score of the control lassi (P_1) were 8.34±0.14, 8.41±0.14, 8.29 ±0.07, 8.37±0.08 and 8.29±0.06; for date-amaranth lassi were 8.31±0.09, 8.30±0.10, 8.25±0.05, 8.17±0.17 and 8.20±0.08, respectively.

Conclusion

The lassi sample containing 50:50 date paste-sugar ratio; dahi @ 49.45 per cent, popped amaranth flour @ 4.19 per cent and dateseed powder @1 per cent was selected as the optimized solution for manufacturing of date-amaranth lassi. The date-amaranth lassi had 62.82 per cent higher protein and 35.85 per cent higher ash content compared to the control lassi, while fat and carbohydrate content were lower by 32.78 and 24.97 per cent, respectively when compared to control lassi. The analyzed data also indicated improved crude fiber content and enrichment of developed lassi in terms of minerals such as potassium, iron and calcium as well as higher antioxidant activity by 17.69 per cent. Thus, value added date-amaranth lassi was prepared from all-natural ingredients and did not resort to use of stabilizers and other chemical food additives, thus entitling clean labelling for the product.

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