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Effect of Dried Chicory Root Extract on Sensory and Physical Characteristics of Yoghurt-Ice Cream with Addition of Buttermilk using Response Surface Methodology

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Research Article

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ABSTRACT

Dried chicory (*Cichorium intybus* L.) root extract (2-6%) and buttermilk (10-50%) were used to prepare yoghurt-ice cream using stabilizer (0.5-0.25%) and emulsifier (0.5-0.25%). For the purpose of high nutritional yoghurt-ice cream, samples were analyzed for the sensory and physical properties. An experimental investigation was carried out with the aim of evaluating the effect of dried chicory root extract and buttermilk on the quality of yoghurt-ice cream. Results suggested that increasing the amount of dried chicory root extract in yoghurt-ice cream increased the colour, flavour, texture, sweetness, hardness, overrun, and OAA score while melting rate was decreased. Similarly, the effects of adding buttermilk, stabilizer and emulsifier on the aforesaid parameters were also evaluated. The optimum conditions generated from the analysis were 0.25% stabilizer, 0.25% emulsifier, 26.43% buttermilk and 4% dried chicory root extract. The predicted response in terms of colour, flavour, texture, sweetness, hardness, melting rate, overrun and OAA score were 7.218, 7.151, 7.422, 6.693, 40.161, 27.927, 40.090 and 7.200, respectively. The desirability of the optimum conditions was 0.833

INTRODUCTION

Ice cream is a delicious wholesome and nutritious frozen dairy product, which is widely consumed in different parts of the world. Taste and flavour are the most important property of dairy products from consumer's point of view. Yoghurt-ice cream is a nutritious and delicious product with a refreshing taste and has significantly longer stability as compared to plain yoghurt [1]. Yoghurt-ice cream has combined complex formulation of fermented frozen dairy dessert for physical and sensory characteristics of ice cream. It's attractiveness to consumers include providing a low calorie replacement for ice cream and the probiotic benefits of the live cultures present in the yogurt (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*).

In the dairy industry, buttermilk is used in the formulation of ice cream [2] or yogurt [3]. Buttermilk is in aqueous product, obtained during churning of cream in process of butter manufacturing and contains more phospholipids than milk due to high content in MFGM (milk fat globule membrane) material [4]. Total annual production of buttermilk in India is estimated at 35000 million kg [5] and this can be used as a valuable substitute for replacing of milk solids not fat (MSNF) in ice cream production. The high content of phospholipids in buttermilk makes a functionality of the emulsifying properties [6]. Addition of phospholipids has been shown to possess biological activity. Dillehay et al. and Schmelz et al. [7-9] demonstrated the anticarcinogenic potential of phospholipids, especially against colon cancer and Sprong et al. [10] reported their protective effect against bacterial toxins and infection.

Chicory (*Cichorium intybus* L.) is a bushy perennial herb of *Asteraceae* family. Chicory can be used in the forms of flowers, leaves and roots. Dried chicory root extract contains, by weight, approximately 98% inulin and 2% other compounds [11]. Chicory extracts are added to alcoholic and non-alcoholic beverages [12]. Barlianto and Marier [13] reported that roasted chicory root is used as a coffee substitute. Inulin is a major compound of chicory root and itis a polymer of fructose with β (2-1) glycosidic linkage. Hui et al. [14] reported that inulin has been identified as an ingredient for fat and sugar replacement as a low calorie bulking agent and

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as a texturezing agent. Inulin is a non-digestible food ingredient, known as probiotic supplement as it nourishes intestinal bacteria [15,16] and it also increases both the absorption and deposition of calcium in the bones [17]. Taper et al. [18,19] declared that inulin play a role in the prevention and inhibition of colon and breast cancer.

Replacing the costly dairy ingredients with other low cost alternatives will reduce the cost of production and will be of great help to the ice cream producers to boost up the sales. An attempt was made to prepare yoghurt-ice cream with dried chicory root extract and buttermilk at different level and its acceptability depends on sensory and physical characteristics.

MATERIALS AND METHODS

Materials

Emulsifier, stabilizer (sodium alginate) and materials such as standardized milk, buttermilk, sugar, cream and skim milk powder were procured from the local market of Varanasi, India. Roasted chicory root was purchased from Chaudhary Farm, Etawah, UP, India.

Experimental Design

Response surface methodology which involves design of experiments, selection of levels of variables in experimental runs, fitting mathematical models and finally selecting variable levels by optimizing the response [20] was employed in the study. A central composite rotatable design (CCRD) was used to design the experiments comprising of four independent variables **(Table 1)**. Thirty experimental trails were performed taking into account four factors, viz., stabilizer, emulsifier, buttermilk and chicory root extract. There were six experimental trails at centre point to calculate the repeatability of the method. The responses in this experiment were based on the sensory and physical characteristics of the yoghurt-ice cream viz. colour, texture, flavour, sweetness, hardness, melting rate, overrun and overall acceptability (OAA) scores.

Table 1. Experimental design for manufacturing of yoghurt-ice cream and response values for sensory and physical property of yoghurt-ice cream.

Run	Stabilizer	Emulsifier	Buttermilk	Dried chicory Root Extract	Colour	Flavour	Texture	Sweetness	Hardness	Melting Rate	Overrun%	OAA
1	0.25	0.05	50.00	2.00	6.25	6.32	6.22	6.55	39.63	26	40.52	6.52
2	0.25	0.25	10.00	6.00	7.72	7.52	8.15	7.26	39.24	28	41.21	6.93
3	0.05	0.05	10.00	6.00	7.77	7.30	6.24	7.14	40.22	26	39.64	6.17
4	0.05	0.05	50.00	6.00	7.60	7.56	6.02	7.32	41.00	26	40.6	6.54
5	0.25	0.05	50.00	6.00	7.52	7.41	7.12	7.31	41.27	26	40.24	6.15
6	0.15	0.15	30.00	4.00	7.20	7.20	6.00	6.93	40.85	26	39.60	7.21
7	0.15	0.15	30.00	0.00	4.87	5.01	5.33	6.25	38.00	25	38.20	6.00
8	0.25	0.05	10.00	6.00	7.60	7.72	7.28	7.00	39.92	27	38.00	6.30
9	0.15	0.15	70.00	4.00	6.80	6.70	6.85	7.17	40.52	27	39.42	7.12
10	0.05	0.25	10.00	2.00	6.40	6.26	5.86	6.25	39.32	25	39.51	6.62
11	0.35	0.15	30.00	4.00	7.10	6.98	8.28	6.92	40.00	26	38.22	7.24
12	0.05	0.25	50.00	2.00	6.15	6.32	6.43	6.86	38.54	27	38.84	6.82
13	0.25	0.25	50.00	2.00	6.00	6.21	7.24	6.87	40.03	27	39.58	7.12
14	0.15	0.15	30.00	8.00	8.00	7.20	6.86	7.12	42.54	28	38.46	6.20
15	0.15	0.15	30.00	4.00	7.10	7.00	6.55	6.65	40.02	26	37.85	6.86
16	0.05	0.25	50.00	6.00	7.52	7.46	6.37	7.24	39.52	27	41.52	6.43
17	0.25	0.05	10.00	2.00	6.45	6.82	6.52	6.25	39.00	25	38.00	6.12
18	0.25	0.25	50.00	6.00	7.40	7.53	7.35	7.22	41.55	29	42.22	7.28
19	-0.05	0.15	30.00	4.00	7.30	7.21	5.56	6.84	40.08	26	38.87	7.21
20	0.15	0.15	30.00	4.00	7.10	6.90	6.81	6.95	40.26	26	39.65	6.83
21	0.25	0.25	10.00	2.00	6.35	6.23	7.52	6.21	39.00	26	38.51	6.84
22	0.15	0.15	30.00	4.00	7.10	7.14	6.91	6.78	40.00	27	39.23	6.93
23	0.15	0.15	-10.00	4.00	7.40	7.38	6.27	6.20	38.92	26	38.00	6.43

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24	0.05	0.25	10.00	6.00	7.60	7.27	6.65	6.82	41.00	26	39.42	6.81
25	0.05	0.05	10.00	2.00	6.50	6.50	5.83	6.00	38.54	24	37.53	6.47
26	0.15	0.15	30.00	4.00	7.30	7.42	6.24	6.91	39.63	26	39.52	6.85
27	0.15	0.05	30.00	4.00	7.32	7.10	6.00	6.34	41.12	25	38.04	6.44
28	0.15	0.15	30.00	4.00	7.20	7.53	6.12	6.33	40.53	26	38.04	6.76
29	0.15	0.35	30.00	4.00	7.37	7.29	6.23	6.37	40.64	27	40.05	6.94
30	0.05	0.05	50.00	2.00	6.10	6.00	6.18	6.26	39.00	26	37.81	6.22

Manufacturing of Yoghurt Ice Cream

Yoghurt-ice cream was prepared in the combination of yoghurt (ice cream mix fermented with yoghurt culture) and plain ice cream mix. Ice cream mix was prepared by using cow milk and buttermilk with the addition of dried chicory root extract, stabilizer and emulsifier. Buttermilk was used for replacement of cow milk. Level of buttermilk, dried chicory root extract, stabilizer and emulsifier was used as per the response surface design **(Table 1)**. Ice cream mix was standardized (fat 10% and total solids 36%) by the addition of cream and skim milk together with the addition of 12% sugar in all treatments. The ice cream mix was pasteurized at 80°C for 20 second and rapidly cooled to about 10°C. 1/3 portion of ice cream mix was used for preparation of yoghurt by fermenting it with yoghurt culture (mixed flora 1:1 of *L. bulgaricus* and *S. thermophilus*) inoculated with 2% (w/v) and incubated at 45°C for 4 hours (until pH reached 4.7).

Finally yoghurt was blended with the ice cream premix with continued agitation at 45°C. Mix was homogenized at 1000 rpm/45 ± 1°C by using a micro tissue homogenizer (Capacity 10 LPH, Ralliwolf Limited, Ahmednagar, India) until no clumps were present. The mixtures were aerated and frozen by a self-contained freezing unit and stored in 100 mL cups at -28°C.

Sensory and Physical Analysis of Yoghurt Ice Cream

Yoghurt-ice cream was analyzed for different sensory characteristics like colour, flavour, texture, sweetness and OAA scores. The panelists were asked to evaluate the samples on a nine point hedonic scale, where a score of nine represents 'extreme liking' and one denotes 'extreme disliking' [21]. The overrun and melting rate was determined according to the method of Marshall and Arbuckle [22]. The hardness of yoghurt-ice cream was determined according to the method of Supavititpatan and Kongbangkerd [23] with some modification.

EXPERIMENTAL DESIGN AND STATISTICAL ANALYSIS

Optimization Using Central Rotatable Composite Design (CCRD)

Response surface methodology was used for the optimization of the response which includes design of experiments, selection of levels of variables in experimental runs, fitting mathematical models and finally selecting variable levels shown in **Table 1** [20]. CCRD was used to design experiments, model and optimize eight response variables namely colour, texture, flavour, sweetness, hardness, melting properties, overrun and OAA scores. Twenty four experiments were enlarged with six replications at the centre points to evaluate the pure error and to fit a quadratic model. The optimum point predicted by the quadratic model was expressed as follow (Equation 1):

$$y=\beta o + \sum\beta_1 A + \sum\beta_2 B + \sum\beta_3 C + \sum\beta_4 D + \sum\beta_{12} AB + \sum\beta_{13} AC + \sum\beta_{14} AD + \sum\beta_{23} BC + \sum\beta_{34} CD + \sum\beta 11A2 + \sum\beta 22B2 + \sum\beta 33C2 + \sum\beta 44D2 \quad (1)$$

Where,

Y: Response variable

β_0, β_1, β_2,β_3 and β_4: Regression coefficient

A, B, C and D are coded terms for the four independent variables, i.e., stabilizer, emulsifier, buttermilk and chicory root extract respectively.

The statistical software package Design-Expert version 9, Stat-Ease Inc., Minneapolis, USA was used for regression analysis of experimental data and to plot response surface.

RESULTS AND DISCUSSION

The FCCD-RSM experiments contained 30 trials including 24 experiments for axial points and 6 experiments for the replication of the central points. The results of the colour, texture, flavour, sweetness, hardness, melting properties, overrun and OAA scores are presented in **Table 1**. The independent variable (factor; x) and dependent factor (responses; y) were fitted to the second order polynomial function and examined for the goodness of fit.

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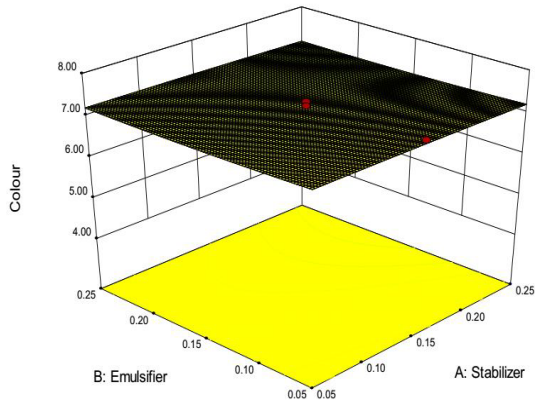
a.



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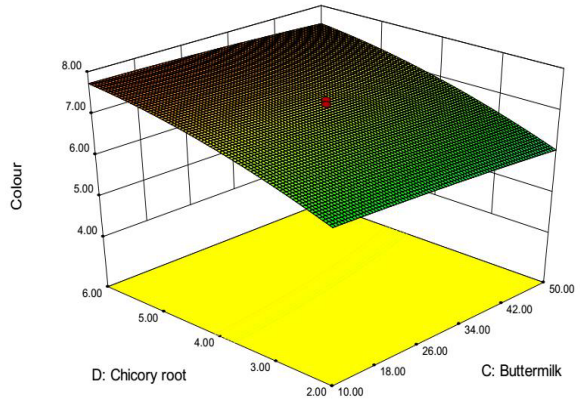

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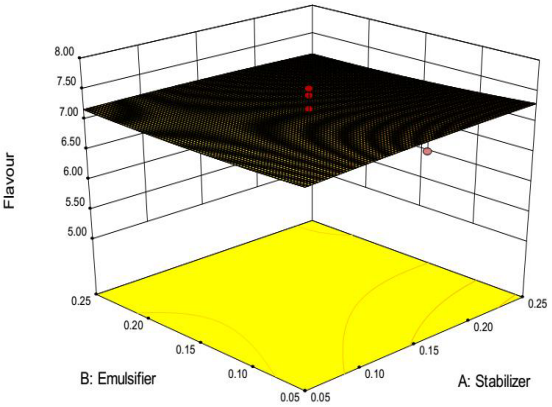

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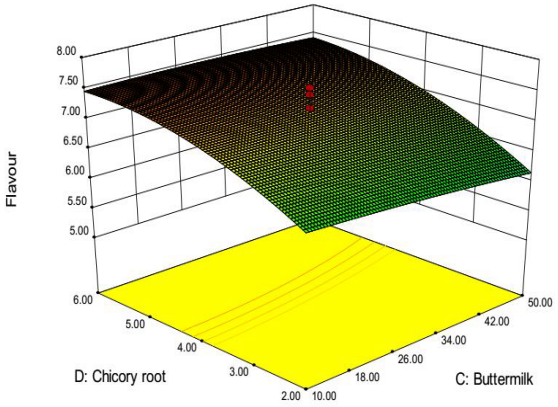

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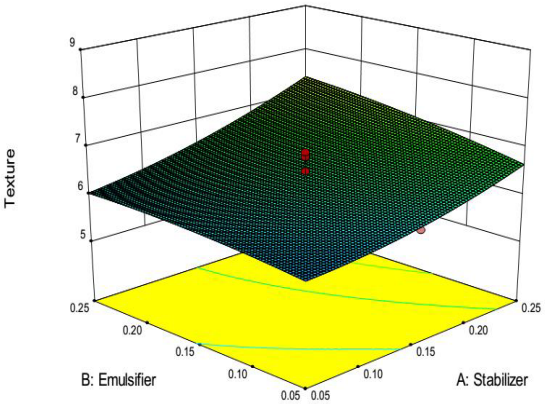

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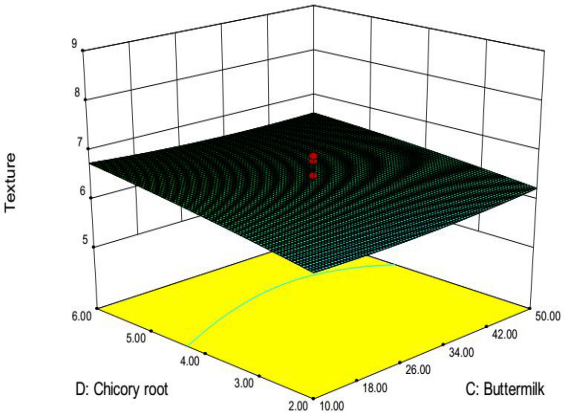

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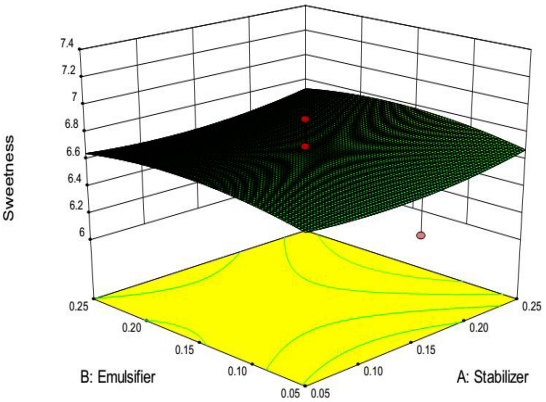

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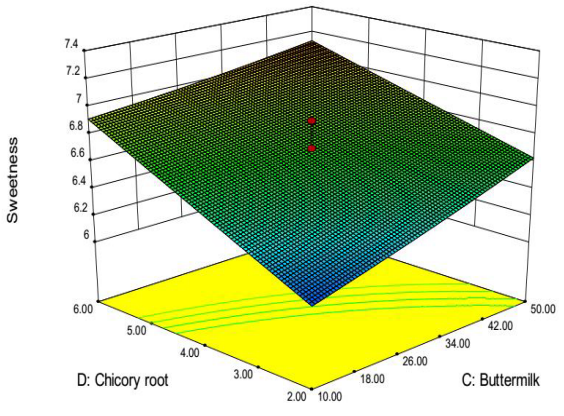

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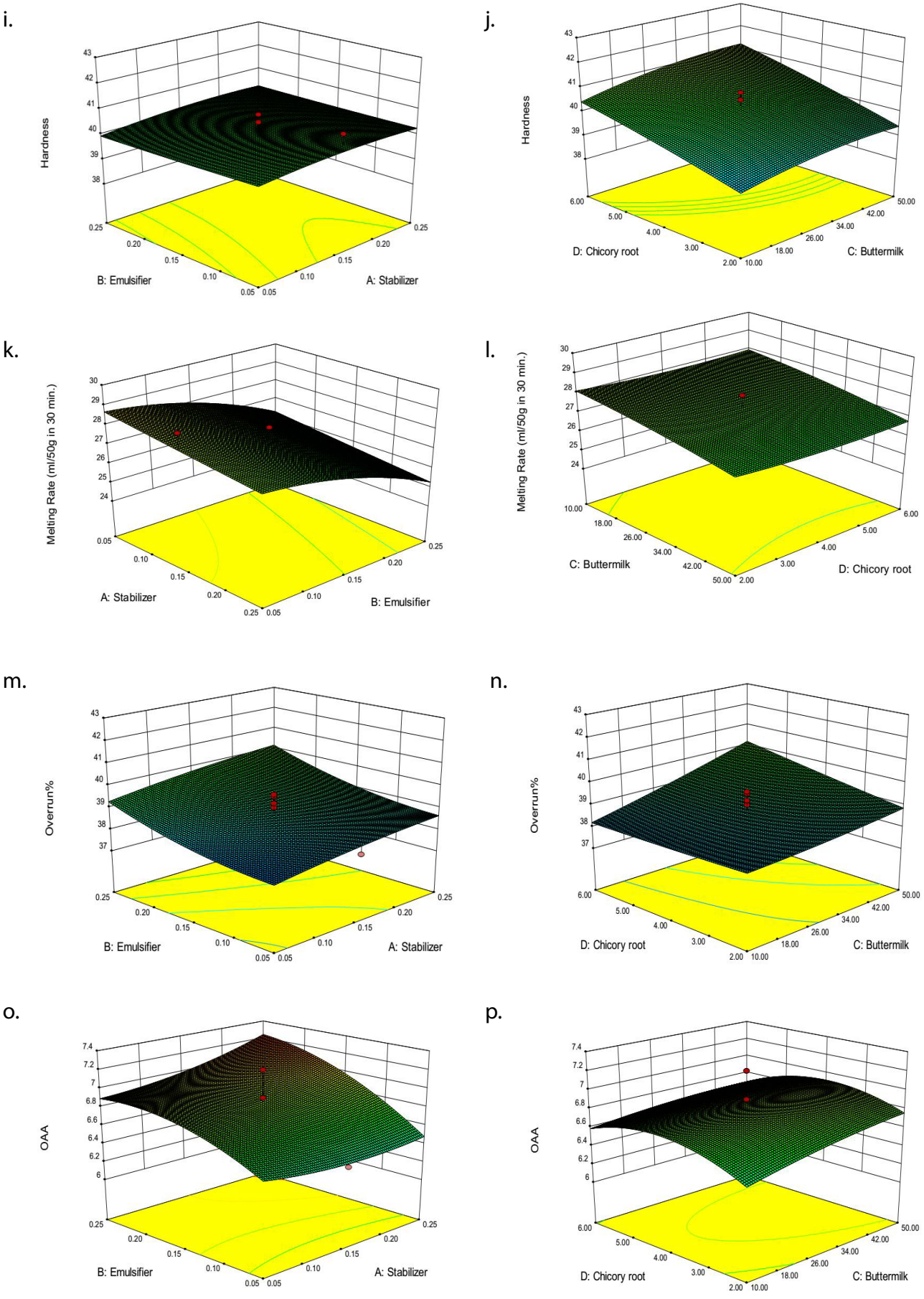

Figure 1. Response surface plots showing the effect of dried chicory root extract, buttermilk, stabilizer and/or emulsifier on the quality of yoghurt-ice cream.

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Colour

Results of colour were recorded in the range from 4.87 to 8.00 **(Table 1)**. A model of equation was generated by using quadratic model to predict the colour as a response to the independent parameter or factors. A model of p-value below 0.05 was regarded as significant and was selected in forming the equation as shown below (Equation 2):

Colour = +7.18 -0.031*A -0.032*B -0.13*C +0.70*D -3.125E-003*AB -3.125E-003*AC -9.375E-003*AD -9.375E-003*BC +9.375E -003*BD +0.034*CD -0.010*A^2 +0.036*B^2 -0.035*C^2 -0.20*D^2 (2)

On the basis of the above equation, dried chicory root extract showed positive effect on the colour score and other factors given less negative impact. In this study, the value of R^2 for colour was 0.9825 (more than 0.98) indicating that high correlation between experimental and predicted value [24]. Additionally, high adequate precision value (31.852) of more than 4 suggested that the model was satisfied for optimization process [25]. The coefficient of estimation of colour showed that as the level of dried chicory root extract increased the score for colour of the product was increasing, whereas the level of stabilizer, emulsifier and buttermilk was having very less negative effect **(Table 2)**. From **Figures 1a and 1b**, it can also be observed that with the increase in the level of dried chicory root extract, the colour of the product was highly increasing whereas buttermilk was decreasing. Mona et al. [26] also reported that Nescafe' blend chicory root (50% roasted roots) had coarse perforated and light colour granules, thus the consumer acceptability was described as very acceptable and very close to pure Nescafe' in colour. Dried chicory root extract exhibited positive response on colour. The maximum appearing of colour was predicted with increase in the level of dried chicory root extract.

Table 2. Coefficient estimate for sensory and physical property of yoghurt-ice cream.

Factor	Coefficient Estimate							
	Colour	Flavour	Texture	Sweetness	Hardness	Melting Rate	Overrun%	OAA
Intercept	7.18	7.18	6.39	6.68	40.27	26.60	38.80	6.86
A-Stabilizer	-0.031	0.026	0.55	0.042	0.11	0.042	0.40	0.076
B-Emulsifier	-0.032	-0.039	0.25	0.028	-0.043	1.04	0.72	0.28
C-Buttermilk	-0.13	-0.090	-3.374E-016	0.18	0.32	0.63	0.63	0.092
D-Chicory root extract	0.70	0.56	0.26	0.33	0.83	-0.12	0.30	7.500E-003
AB	-3.125E-003	-0.046	0.13	-4.354E-017	0.044	0.19	0.038	0.099
AC	-3.125E-003	-0.052	-0.14	0.013	0.37	-0.063	0.11	0.051
AD	-9.375E-003	5.625E-003	0.088	0.013	-0.16	0.062	-0.100	0.011
BC	-9.375E-003	0.081	-0.012	0.038	-0.12	-0.31	-0.35	-1.250E-003
BD	9.375E-003	0.026	-0.037	-0.087	-0.094	-0.69	0.26	0.014
CD	0.034	0.069	-0.075	-0.075	0.081	-0.19	0.36	-0.039
A^2	-0.010	-0.019	0.16	0.064	-0.13	0.17	-0.098	0.068
B^2	0.036	0.040	-0.082	-0.082	0.020	-0.063	0.30	-0.14
C^2	-0.035	-0.033	0.074	0.014	-0.21	-0.21	0.065	-0.032
D^2	-0.20	-0.27	-0.039	1.644E-003	-0.068	0.044	0.027	-0.19

Flavour

Flavour score varied from 5.01 to 7.53. A model of equation was generated by using quadratic model to predict the flavour as a response to the independent parameter or factors. A model of p-value below 0.05 was regarded as significant and was selected in forming the equation as shown below (Equation 3):

Flavour = +7.18 +0.026*A -0.039*B -0.090*C +0.56*D -0.046*AB -0.052*AC +5.625E -003*AD +0.081*BC +0.026*BD +0.069*CD -0.019*A^2 +0.040*B^2 -0.033*C^2 -0.27*D^2 (3)

On the basis of the above equation, stabilizer and dried chicory root extract showed positive effect on the flavour response and other factors given less negative impact. The value of R^2 for flavour was 0.9427 and this indicates that the model equation has good prediction capability. The coefficient of estimation of flavour showed that as the level of stabilizer and dried chicory root extract increased, the flavour of the product increased as well, whereas the level of emulsifier and buttermilk exhibited very less negative effect **(Table 2)**. From **Figures 1c and 1d**, it can also be observed that with the increase in the level of dried chicory root

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extract, the flavour of the product also increased. The maximum flavour was predicted when the level of dried chicory root extract increased. Mona et al. [26] also reported that as for drinks, the panelists gave Nescafe' / chicory blends scores very close to pure Nescafe' in taste and aroma.

Texture

The texture of yoghurt-ice cream ranged from 5.33 to 8.28 **(Table 1)**. Among the tested models, a quadratic model was found to be the best fit model for texture response was highly significant (P<0.0001). The texture can be predicted using a quadratic model equation generated as follows (Equation 3):

Texture = +6.39 +0.55*A +0.25*B -3.374E-016* C +0.26*D +0.13* AB -0.14*AC +0.088*AD -0.012* BC -0.037*BD -0.075*CD +0.16*A^2 -0.082*B^2 +0.074*C^2 -0.039*D^2 (3)

Above equation shows that the all three factors showed positive influence except buttermilk on the texture response. The coefficient of determination (R^2) for the relationship between effects of variables viz. stabilizer, emulsifier buttermilk and dried chicory root extract on the texture was 0.8375 and this indicates that the model equation has good prediction capability. The coefficient of estimation of texture showed positive correlation between the level of stabilizer, emulsifier and dried chicory root extract, however, a negative correlation was observed between the level of buttermilk and texture **(Table 2)**. The relationship between the factors and the response are shown in **Figures 1e and 1f t**hat with the increase in the level of stabilizer, emulsifier and dried chicory root extract, the texture increases; however the level of buttermilk does not show any significant effect on the texture. Supavititpatana and Kongbangkerd [23] stated that the body and texture scores of the samples significantly increased with increasing sodium casinate concentration due to the increase in gummy texture.

Sweetness

The second degree polynomial equation obtained by the response surface analysis of the data showing the effect of stabilizer, emulsifier, buttermilk and dried chicory root extract on sweetness resulted in the following equation (Equation 4):

Sweetness = +6.68 +0.042*A +0.028*B +0.18*C +0.33*D -4.354E-017*AB +0.013*AC +0.013*AD +0.038*BC -0.087*BD -0.075*CD +0.064*A^2 -0.082* B^2 +0.014*C^2 +1.644E-003*D^2 (4)

The quadratic model was significant (P<0.0001) and sweetness varied from 6.00 to 7.32. The coefficient of determination (R^2) was 0.8095. The coefficient of estimation of sweetness score showed that the level of stabilizer, emulsifier, buttermilk and dried chicory root extract was increased, sweetness score increased **(Table 2)**. It could also be observed from **Figures 1g and 1h** that with the increase in the level of stabilizer, emulsifier, buttermilk and dried chicory root extract, the sweetness score increases continuously. Chicory root contains a polymer of fructose known as inulin that is a substitute of fat or sugar [14,27]. The increased sweetness was in acceptable range and had very minor effect on the actual sweetness of the product.

Hardness

Hardness is an important rheological property for any food material that increases the consumer acceptability. The effect of stabilizer, emulsifier, buttermilk and dried chicory root extract on physical score of yoghurt-ice cream could be described by the following equation (Equation 5):

Hardness = +40.27 +0.11*A -0.043*B +0.32*C +0.83*D +0.044*AB +0.37*AC -0.16*AD-0.12*BC -0.094*BD +0.081*CD -0.13*A^2 +0.020*B^2 -0.21*C^2 -0.068*D^2 (5)

The hardness score varied from 38.00-42.54 **(Table 1)**. The model F-value of 4.64 implies that the model is significant. R^2 was found to be 0.8125, indicating that 81.25% of the variability in the response could be explained by the model. The coefficient of estimation of hardness score showed that the increased level of stabilizer, buttermilk and dried chicory root extract had positive effect, while increased level of emulsifier given negative effect **(Table 2)**. The interaction among stabilizer, buttermilk and chicory root extract shows that dried chicory root extract increased more hardness than buttermilk as shown in **Figures 1i and 1j**. The interaction between stabilizer and emulsifier **(Figure 1i)** demonstrate that as increase in the level of stabilizer score got slightly increased while interaction effect of emulsifier shows very less significant effect. Cardarelli, et al. [28] studied that the addition of 5% inulin into chocolate mousse can significantly increase the firmness and adhesiveness of samples. Sofjan and Hartel [29] reported that increased overrun caused a decrease in hardness of ice cream.

Melting Rate

The quadratic equation obtained by the response surface analysis of the data showing the effect of stabilizer, emulsifier, buttermilk and chicory root extract resulted in the following equation (Equation 6):

Melting Rate = +27.44 -0.50*A -1.20* B -0.58*C -0.083* D +2.049E -015*AB +1.693E-015*AC +1.653E-015*AD +0.25*BC+0.50*BD +1.727E-015*CD +0.012*A^2 -0.47*B^2 -0.11*C^2 +0.14*D^2 (6)

The quadratic model was highly significant (P<0.0001). Melting rate of yoghurt-ice cream varied from 24 to 29 ml. The coefficient of determination (R^2) was 0.8710. The coefficient of estimation of melting rate showed that as the level of stabilizer, emulsifier, buttermilk and dried chicory root extract was increasing, melting rate was decreasing **(Table 2)**. **Figures 1k and 1l**

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shows that melting rate score of yoghurt-ice cream decreased with increasing the different levels of emulsifier, buttermilk, dried chicory root extract and stabilizer. Lin [30] indicate that adding inulin and oligofructose at the 4% level significantly improve the meltdown properties. Similar results were found by El-Nagar et al. [31] who reported that adding inulin up to 5% level significantly increased the viscosity and slowed down the melting rate of yoghurt-ice cream. Hanumantha Rao [32] studied that the substitution of buttermilk powder had no significant effect on the melt down of the ice cream samples.

Overrun Percent

Ice cream contains a considerable quantity of air, up to half of its volume. This air is referred to as overrun. The effect of stabilizer, emulsifier, buttermilk and dried chicory root extract on overrun score of yoghurt-ice cream could be described by the following equation (Equation 7):

$$\text{Overrun \%} = +38.78 +0.100*A +0.48*B +0.48*C +0.52*D +0.025*AB +0.29*AC -0.11*AD -0.12*BC +0.25*BD +0.16*CD +0.040*A^2+0.30*B^2+0.12*C^2 +0.015*D^2 \quad (7)$$

The overrun score for yoghurt-ice cream varied from 37.81 to 42.52 **(Table 1)**. The model F-value of 2.51 implies that the model is significant. R^2 was found to be 0.7011, indicating that 70.11% of the variability in the response could be explained by the model. The coefficient of estimation of stabilizer, emulsifier, buttermilk and dried chicory root extract showed positive effect on the colour score **(Table 2)**. **Figures 1k and 1l** shows that overrun score of yoghurt-ice cream increased with increasing the different levels of emulsifier, buttermilk, dried chicory root extract and stabilizer. Similar findings given by Arbuckle [33] that the incorporation of emulsifiers into ice cream results in a product that whips more easily, is drier, has improved melt-down resistance, and has a smoother body and texture. In addition to this ice cream has a higher overrun; the air is more finely dispersed. Marshall and Arbuckle [22] also reported that the percentage of overrun for ice cream is between 30 and 60% depending on total solids used in the formulation. Percentage of overrun increases with the amount of total solids. Akalin et al. [34] reported that overrun value of frozen yoghurt in his study ranged from 22.37% to 39.38%. The low overrun may be due to using a batch type household ice cream maker. Lin [30] indicate that adding inulin and oligofructose at the 4% level significantly increase the overrun, firmness, and viscosity of ice cream samples and also improve the meltdown properties.

Over All Acceptability (OAA)

The quadratic equation obtained by the response surface analysis of the data showing the effect of stabilizer, emulsifier, buttermilk and dried chicory root extract on OAA score is shown below (Equation 8):

$$OAA = +6.86 +0.076*A +0.28*B +0.092*C +7.500E\text{-}003*D +0.099*AB +0.051*AC +0.011*AD -1.250E\text{-}003*BC +0.014*BD -0.039*CD +0.068*A^2 -0.14*B^2 -0.032*C^2 -0.19*D^2 \quad (8)$$

The value of R^2 (0.8564) indicates that 85.64% of the variability in the response could be explained by the model. The coefficient of estimation of stabilizer, emulsifier, buttermilk and chicory root extract showed positive effect on the OAA score **(Table 2)**. OAA score for yoghurt-ice cream varied from 6.00 to 7.28 **(Table 1)**. **Figures 1m and 1n** shows that increasing the levels of emulsifier with buttermilk, stabilizer and dried chicory root extract (up to 4%) the OAA score for yoghurt-ice cream increased and therefore, chicory root extract further increase the dried chicory root extract levels (>4%) lead to decrease the overall score. Mona et al. [26] also reported that in case of drinks, the panelists gave Nescafe/chicory blends(up to 50%) scores very close to pure Nescafe' in taste, aroma and acceptability, while pure chicory can be considered far from original Nescafe sensory properties. Cardarelli et al. [28] also mentioned that consumers gave significantly higher overall acceptance scores to cheese samples which contained oligofructose.

Thus, in the present study, stabilizer, emulsifier, buttermilk and dried chicory root extract levels influenced the colour, texture, flavour, sweetness, hardness, melting properties, overrun and OAA scores. The model showed that the factors were found significant for all responses.

Optimization

The numerical optimization technique was used for simultaneous optimization of the multiple responses. The constraints have been listed in **Table 1**. The desired goals for each factor and response were selected. Responses obtained after each trial were analyzed to visualize the interactive effect of various parameters on sensory and physical properties of yoghurt-ice cream. Optimized solutions obtained from the Design Expert software for the colour, texture, flavour, sweetness, hardness, melting properties, overrun and OAA scores are presented in **Table 3**. **Figure 1** shows the response surface plot for the desirability of the product according to the optimized yoghurt-ice cream selected **(Table 3)**. The desirability of the yoghurt-ice cream higher until the level of sodium alginate ranges from 2 to 6%.

The level of stabilizer, emulsifier, buttermilk and dried chicory root extract show much significant effect on the desirability. Out of 5 suggested formulations, the formulation No. 1 was found to have a better score of colour (7.218), texture (7.422), flavor (7.151), sweetness (6.693), hardness (40.161), melting rate (27.927), overrun (40.090) and OAA (7.200) than all other formulations. It also has the desirability was 0.833, which was the highest following all other formulations **(Table 3)**.

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Table 3. Optimized solutions with predicted responses for yoghurt-ice cream using design expert software 9.0.

No.	Stabilizer	Emulsifier	Buttermilk	Dried chicory root	Colour	Flavour	Texture	Sweetness	Hardness	Melting Rate	Overrun %	OAA	Desirability	
1	0.250	0.250	26.431	4.000	7.218	7.151	7.422	6.693	40.161	27.927	40.090	7.200	0.833	Selected
2	0.249	0.250	26.922	4.000	7.213	7.151	7.404	6.697	40.179	27.927	40.097	7.200	0.832	
3	0.250	0.250	25.460	4.000	7.212	7.154	7.431	6.682	40.129	27.912	40.073	7.193	0.831	
4	0.249	0.250	26.711	3.986	7.205	7.147	7.411	6.694	40.167	27.930	40.087	7.200	0.831	
5	0.250	0.250	25.112	4.000	7.118	7.154	7.434	6.678	40.118	27.906	40.066	7.190	0.831	

CONCLUSION

Optimization of the levels of stabilizer, emulsifier, buttermilk and dried chicory root extract for the best delivery formulation of the yoghurt-ice cream is predicted based on score of colour, texture, flavour, sweetness, hardness, melting rate, overrun and OAA characteristics using RSM package. The formulation with 0.25% stabilizer, 0.25% emulsifier, 26.43% buttermilk and 4% dried chicory root extract was considered to be the most appropriate combination for the yoghurt-ice cream. It obtained the optimum responses of colour, texture, flavour, sweetness, hardness, melting properties, overrun and OAA.

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