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Optimization of ingredients and selected processing parameters for development of coconut flavoured *Paneer*-like soft cheese

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Abstract
The objective of the present study was to develop a coconut flavoured *paneer*-like soft cheese using milk and coconut milk solids to attain value-addition of paneer by utilizing shelf stable derivative of coconut milk. To optimize level of ingredients and a few processing parameters, Response Surface Methodology (RSM) was used. The independent variables selected were Fat/MSNF ratio of milk (0.23 – 0.35), rate of addition of coconut milk powder (7 – 9% w/w of milk), rate of addition of calcium chloride (20 – 30 g/100 kg milk) and coagulation temperature (70–80 ^{0}C). Optimized solution with a desirability of 0.939 was given by a combination of fat to MSNF ratio of 0.31, 7.0% w/w of milk of coconut milk powder, 30.0 g/100kg of calcium chloride and coagulation temperature of 80 ^{0}C. At the optimized solution, the values of the responses were 45.1 flavour score, 31.8 body & texture score, 9.2 colour & appearance score, 91.2 total score, 27.24 Nmm chewiness,0.386 cohesiveness, 10.69 N hardness, 52.45% moisture and 27.86% fat. Fatty acid profile of the developed product revealed that the highest concentration was exhibited by Lauric acid (31.19%) followed by Palmitic acid (16.47%).

Keywords: *Paneer*, coconut, RSM, texture, sensory evaluation, medium chain triglycerides

Introduction
Paneer is a South Asian variety of soft cheese which is extremely popular in India. It is a very commonly used base for culinary dishes and gravies. It can be categorized as non-fermentative, non-renneted, non-melting and unripened type of fresh cheese. The general method of manufacturing involves acid and heat coagulation of milk which results in enmeshing of almost all the fat, complexing of casein with denatured whey proteins and retention of a portion of salts and lactose making it a product appreciated for its nutritive content. Good quality *paneer* is characterized by a creamy white colour, mildly acidic but sweetish taste and nutty flavour, spongy body and a smooth close knit structure (Boghra & Mathur, 1995) [8]. India is a country with a substantial number of vegetarian people. *Paneer* fits in the role of a "meat substitute" for vegetarians. The average composition of *paneer* is 53-55% moisture, 23-25% fat, 17-18% protein, 2.0-2.5% lactose and 1.5-2.0% minerals (Kanawjia and Singh, 1996) [19]. In recent years, a variety of studies have been conducted with the expectation of improvement in the nutritional quality of products like cheese and *paneer* by incorporating coconut and its products. A study was undertaken by David (2012) [9], where coconut *paneer* with a ratio of 90:10 buffalo milk and coconut milk was found to be best among others. Water-extracted coconut milk was used as a less expensive substitute for milk fat in the manufacture of fresh soft cheese (Davide *et al*., 1985) [11]. Davide (1986, 1988) [10, 12] developed a fresh soft cheese spiced with garlic (Queso de Ajo), from a blend of skim milk powder and coconut milk (Tipvarakarnkoon *et al*., 2017) [28]. Acceptable quality of white soft cheese was prepared by Sanchez and Rasco (1983) [25] by using a combination of cow milk and coconut milk in proportions of 50:50 and 60:40. Cheeses with improved nutritional value and consumer acceptability could be made from a ratio of 1:9 coconut milk and cow milk (Ekanem and Ojimelukwe, 2017) [2]. Coconut milk is the most popular derivative of the coconut (Leon and Delores, 2005) [21]. Coconut milk shows compatibility with dairy products making it a healthy option for improving the value of the final product. Over 60% of the triglycerides present in coconut fat belong to the category of medium chain triglycerides (C_8 to C_{12} chain length). Fatty acids having a length of C_{12} or less can be digested very easily by intestinal lipases and do not require action of pancreatic lipase, which is essential for digestion of the long-chain triglycerides (LCT). Consequently, absorption of MCT is easier and faster with no need for their incorporation into chylomicra by the intestinal mucosal cell. Moreover, coconut oil contains almost no cholesterol (Dayrit, 2000) [13]

and contains a good amount of minerals and electrolytes, including potassium, calcium and chloride (Amarasiri and Dissanayake, 2006) [2]. According to Enig (1997) [17], lauric acid, a medium chain fatty acid present abundantly in coconut fat, has antimicrobial properties and is the precursor to an antimicrobial lipid called monolaurin. Lauric acid also promotes brain development, boosts immune system and maintains elasticity of the blood vessels. It elevates high density lipoprotein cholesterol levels in blood (Seow and Gwee, 1997) [26]. It has been observed that coconut fat can be digested more rapidly than any other fats including butter (Lal *et al*., 2003) [20]. Coconut kernel protein has a large proportion of arginine that exhibits potent anti-diabetic activity and antioxidant activity (Deb Mandal and Mandal, 2011; Thaiphanit and Anprung, 2013). Proteins isolated from coconut kernel have also been found to have a lipid lowering effect in experimental animals. This beneficial effect of the kernel protein is attributed to its very low lysine/arginine ratio (2.13% lysine and 24.5% arginine) (Lal and Kumar, 2003) [20]. Also coconut milk is a rich source of minerals such as calcium, copper, iron, potassium, magnesium, manganese, sodium, phosphorus, and zinc which are beneficial for nutrition and health (Nunes *et al*., 2011) [24]. Therefore, the present study was aimed at development of a new process of developing a *paneer*-like product involving incorporation of coconut milk solids in order to achieve excellent value addition.

Materials and Methods

Materials

Fresh, raw, chilled, mixed milk in toned and double toned variants, obtained from Vidya Dairy, Anand, Gujarat (India) was used as the base material for manufacturing of the product. Packaged spray dried coconut milk powder (Moisture - 2.05%, Fat - 58.14%, Protein - 12.17%, Ash - 3.03%) was procured from KPL Oil Mills Pvt Ltd., Irinjalakuda, Thrissur, Kerala (India). Sagar spray dried skimmed milk powder was purchased from local market of Anand town, for MSNF standardization of milk. All the chemical reagents used in the investigation were of analytical reagent (AR) grade. Calcium Chloride, supplied by Hi-Media Pvt. Ltd., Mumbai was used as an additive.

Process for preparation of coconut flavoured *paneer*-like soft cheese (CFSC)

Milk with desired fat to MSNF ratio was taken in a clean container and gradually warmed till 40 ^{0}C. Coconut milk powder was measured in a clean and dry container and added slowly to the warm milk. This was followed by addition of calcium chloride. The mixture was stirred slowly and kept aside for 60 minutes under refrigeration in order to ensure dissolution of powder. After 60 min, the milk was heated to 90^{0}C and held at this temperature for 5 minutes. Then the milk mixture was cooled to coagulation temperature. Simultaneously, a solution of citric acid (2% w/v concentration) at the same coagulation temperature was prepared. Addition of this citric acid solution to the milk mixture resulted in formation of a coagulum. Coagulum was separated from the whey formed using a clean muslin cloth. This coagulum was filled into sanitized stainless steel *paneer* hoops. Pressure of 1.5 to 2.0 kg/cm^2 was applied to the coagulum for 15 min. This was followed by removing the pressed coagulum from the hoop and dipping it in chilled water (3 - 4 ^{0}C for 2 – 3 h). The pressed coagulum was kept on to a sanitized wire rack for draining off the chilled water. These blocks were packed in metalized pouches (12 µ polyester + 12 µ high optical density metalized polyester + 50 µ LD/LLDPE laminate) and vacuum sealed before storage under refrigeration (7 ± 1 ^{0}C).

Physicochemical analyses

Moisture content in CFSC was determined according to BIS (1989) procedure specified for *paneer* under IS: 10484. The fat content of the product was determined as per the procedure for Mojonnier fat extraction, described by IS: 2311-1963. Total nitrogen or total protein in the final product was determined by standard micro Kjeldahl as described in AOAC (2005) [4]. The ash content of product was estimated by the method of BIS (1981) [6]. Methyl esters of fatty acids were separated and quantified by gas chromatograph. Auto sampler Agilent GLC – 7890B system equipped with flame ionization detector, Sr. no. US15243005 and column of fused silica capillary with 2.5 m length, 0.2 mm internal diameter and 0.25 µm film thickness (Superco spm 2560) was used for evaluating fatty acid profile of fat extracted from CFSC (A.O.C.S., 1971) [1].

Sensory Evaluation

Each block of CFSC was cut into rectangular pieces of approximately 25 g and tempered to 10 + 2^{0}C before judging. The plates were labelled with three digit codes. The order of presentation of samples was randomized across subjects. Subjects judged a maximum of 4 samples in one session. The sensory panel (n=10) was composed of staff members and post graduate students working in the institution. The selection criterion was that the subject has to be regular consumers of the product as well as their similar behaviour between sensory evaluation sessions. Panellists were instructed to use lukewarm water as rinsing agent as and when required. The overall acceptability of CFSC as measured by the characteristics of the *paneer* which are colour and appearance, flavour, body and texture and total score were evaluated using the 100 point score-card (IS 15346, (2003).

Texture Analysis

Texture analysis of CFSC was performed on the Texture analyzer [Lloyd Instrument, Hampshire, UK (Model No. 01 /2962)] using 5 KN load-cells with a moving speed of 20 mm/min. Trigger force was maintained at 10 gf. Limits for compressive and tensile load were 4900 N and 4000 N respectively. Textural analysis of tempered samples (samples were tempered at 25 ± 1ºC for an hour) were conducted in a room maintained at 25 ± 1ºC temperature and 65 ± 1% RH. Samples were cut into cubes with edges of 2.00 ± 0.06 cm, and kept on the compression support plate. The cubic samples were compressed up to 70.0% of their initial size. Each observation was an average of data obtained by analysis of 5 sample cubes. The textural characteristics of the *paneer* samples were directly displayed on the monitor of the computer as derived values in tabular form as well as in the form of a graph (Load vs. time i.e. Kgf vs. s).

Experimental Design

In order to investigate the effect of selected parameters on the physicochemical, textural and sensory characteristics of CFSC samples Response surface methodology (RSM) with four factor central composite rotatable design (CCRD) was used with 6 replications at the centre point and total 30 experiments. Based on preliminary trials, the four variables selected were – fat/MSNF ratio in milk (0.23 to 0.35), rate of

addition of coconut milk powder (7 to 9% w/w of milk), rate of addition of calcium chloride (20 to 30 g per 100 kg milk) and coagulation temperature (70 to 80 ^{0}C). For each response, regression analysis was performed for the experimental data and fitted to a 2nd order polynomial equation (Equation-1)

$$Y = b_0+b_1x_1+b_2 x_2+b_{11}x_1^2+b_{22}x_2^2+b_{12}x_1x_2+\varepsilon \quad \text{(Equation-1)}$$

where Y is the response variable, b_0 is the constant term, b_1, b_2, are coefficients of the linear effect, b_{11} b_{22}, are co-efficients of quadratic effect and b_{12} is coefficient of interaction effect; x_1, x_2 are the independent variables and ε is error.

Results and Discussion

Selection of process parameters for the preparation of coconut flavoured *paneer*-like soft cheese

Preliminary trials were conducted in order to standardize the basic procedure for the preparation of the product. Initially, coconut flavoured *paneer* – like soft cheese (CFSC) was prepared from milk having different fat contents, by slight modification of the method proposed by Aneja *et al*., (2002) [3]. It was observed that milk having 3.0% fat was the most suitable for CFSC manufacturing. Coconut milk powder was initially added at the rate of 6% w/w of milk, and yielded a product similar to conventional *paneer*. The idea was to increase the amount of coconut milk powder to a level where it did not affect end product texture adversely. Coagulation temperature in the earlier trials was selected to be 75 ^{0}C. Combination of previously stated parameters led to a product which was very crumbly and easy to break. Based on earlier literature, it was understood that addition of calcium chloride helps in improved texture of *paneer*. Therefore, for RSM studies the parameters selected were- fat/MSNF ratio, rate of addition of coconut powder, rate of addition of calcium chloride and coagulation temperature.

Experimental design along with response values have been shown in Table-1.Regression coefficients, p-values, R^2 and coefficient of variation values are shown in Tables 2 and 3. Fig 1 and 2 show 3-D surface plots that depict the interaction among independent variables in relation to the observed responses.

Effect of selected parameters on sensory properties of CFSC

Flavour: CFSC samples prepared using combinations suggested in run order 5,17,21 and 30 were scored highest in terms of flavor (Table 1). Panelists scored CFSC prepared using 0.29 Fat: SNF ratio, 10% (w/w) coconut milk powder, 25 g $CaCl_2$ per 100 kg milk and 75 ^{0}C, the lowest among all the runs for flavor score (Table 1). Analysis of variance showed that model F-value of 61.40 was significant (P< 0.05). R^2 value of 0.9829 indicates that 98.29% variation was accounted for by the model. The values presented in Table 2 reveal that at linear level, P value for percentage of coconut milk powder (B) showed a significant (P< 0.01) negative effect on the flavor score of CFSC. Coagulation temperature (D) showed a significant (P< 0.01) positive effect on the flavor score. Similarly as shown in Table 2, the P values of interaction between coconut milk powder and coagulation temperature (BD) had a significant (P< 0.01) effect on flavor score. A significant (P< 0.05) negative effect on flavor was observed with higher level of F/S ratio (A^2). Higher levels of coconut milk powder (B^2) resulted in a significant (P< 0.01) negative effect on flavor scores of CFSC. These results are in agreement with those concluded by Venkateswarlu (2002) [29] who reported that *paneer* prepared using a blend of skim milk and coconut milk exhibited a significant reduction in flavor score as the amount of coconut milk increased from 10% to 15%.

Body and Texture

The samples prepared from a combination of 0.35 F/S ratio, 9% w/w coconut milk powder, 30 g per 100 kg calcium chloride, 80 ^{0}C coagulation temperature and 0.35 F/S ratio, 7% w/w coconut milk powder, 30 g per 100 kg calcium chloride, 80 ^{0}C coagulation temperature were rated highest for body score (Table 1). CFSC prepared in the run order no. 3 scored the lowest for body and texture by the panelists. Analysis of variance showed that model F-value of 8.48 was significant (P< 0.05). R^2 value of 0.8879 indicates that 88.79% variation was accounted for by the model. The values presented in Table 2 revealed that at linear level the coagulation temperature (D) significantly (P< 0.01) affects body and texture of CFSC. No data are reported in the literature on effect of coagulation temperature on the body and texture scores of any product similar to CFSC.

Colour and Appearance Score

The CFSC prepared from a combination of 0.29 F/S ratio, 8% w/w (of milk) coconut milk powder, 25 g $CaCl_2$ per 100 kg milk and 65 ^{0}C coagulation temperature, was the least preferred sample by the panelists (Table 1). CFSC prepared using parameter combination as prescribed in Run No. 19 was scored the highest for colour and appearance (Table-1). Analysis of variance showed that model F-value of 71.48 was significant (P< 0.05). R^2 value of 0.9852 indicates that 98.52% variation was accounted for by the model. The values presented in Table 2 revealed that in linear terms, the amount of Calcium chloride (C) and coagulation temperature (D) during manufacturing of CFSC significantly (P< 0.01) influences the colour and appearance score of the final product in a positive trend. A significant (P< 0.01) negative effect on colour and appearance was found with the higher level of calcium chloride (C^2) and coagulation temperature (D^2). No data is available in literature on effect of level of calcium chloride on the colour and appearance of any product similar to CFSC.

Total Score

The CFSC prepared in run order no. 30 was rated highest for total score (Table 1). Whereas, CFSC prepared in run order no. 3, using milk with 0.29 F/S ratio, 8.0% (w/w of milk) coconut milk powder, 25 g calcium chloride per 100 kg milk and 65 ^{0}C coagulation temperature had the least total score by the panelists (Table 1). Analysis of variance showed that model F-value of 21.30 was significant (P< 0.05). R^2 value of 0.9521 indicates that 95.21% variation was accounted for by the model. The values presented in Table 2 revealed that the P values of coconut milk powder (B), calcium chloride (C) and coagulation temperature (D), showed significance (P< 0.01) in linear terms. This indicates that the increase in the amount of coconut milk powder, calcium chloride and coagulation temperature increases the total score significantly (P< 0.01). A part of these results is in accordance with the study carried out by Venkateswarlu (2002) [29] on *paneer* prepared using a combination of skim milk and coconut milk. It was reported that with the increase in the amount of coconut milk from 10 to 20% (w/w of skim milk), the overall acceptability scores reduced significantly.

Effect of different levels of selected parameters on compositional and textural properties of CFSC

Chewiness (Nmm)

From the Table 1, CFSC sample prepared using a combination of 0.29 F/S ratio, 8% (w/w of milk) coconut milk powder, 25 g calcium chloride per 100 kg milk and 65^{0}C coagulation temperature was the least chewy. CFSC prepared using the combinations mentioned in Run Order No. 13 was the chewiest product among all the other samples. ANOVA revealed that model –F value (5.53) was significant (P< 0.05). Value of the coefficient of determination (R^2) was 0.8378 which indicated 16.22% variation was not explained by the model. The values presented in Table 3 revealed that coagulation temperature (D), showed highly significant (P< 0.01) effect on the chewiness values in linear terms. Interaction between F/S ratio and coagulation temperature (AD) and coconut milk powder and calcium chloride (BC) had a significant (P< 0.05) positive effect on chewiness of the experimental sample. Interaction between level of coconut milk powder and coagulation temperature (BD) and level of calcium chloride and coagulation temperature (CD) had a highly significant (P< 0.01) positive effect on chewiness of CFSC. This observation is in accordance with the findings of Mathare *et al.* (2009) [23] who observed that chewiness of soy *paneer* increased with increase in coagulation temperature upto 90 ^{0}C.

Cohesiveness

From the table 1 it is noted that CFSC sample prepared in Run Order No. 3 was the least cohesive among all the samples. However CFSC prepared using a combination 0.23 F/S ratio, 7% (w/w of milk) coconut milk powder, 20 g calcium chloride per 100 kg milk and 70^{0}C coagulation temperature was the most cohesive of all the samples. ANOVA revealed that model –F value (6.15) was significant (P< 0.05). R^2 value of 0.8518 indicated that 14.82% of the total variation was not accounted for by the model. The values presented in Table 3 indicated that P value of coconut milk powder (B) had a significant (P< 0.05) negative effect on the cohesiveness of the sample. Temperature of coagulation (D) showed a highly significant (P< 0.01) effect on the cohesiveness of the final CFSC. P values of interaction between F /S ratio and calcium chloride (AC) and level of coconut milk powder and coagulation temperature (BD) had a significant (P< 0.05) positive effect on cohesiveness of the experimental sample. The interaction within F/S ratio and coagulation temperature (AD) and level of calcium chloride and coagulation temperature (CD) had a highly significant (P< 0.01) positive effect on cohesiveness of CFSC. A significant (P< 0.05) positive effect on cohesiveness was found with the higher level of F/S ratio (A^2) and higher amount of calcium chloride (C^2). This observation is in accordance with the findings of Mathare *et al.* (2009) [23] who reported that cohesiveness of soy *paneer* increased with increase in coagulation temperature upto 90 ^{0}C.

Hardness

From the table 1 it is noted that CFSC sample prepared in Run Order No. 3 was the softest among all the samples. However CFSC prepared using a combination 0.35 F/S ratio in milk, 9.0% (w/w of milk) coconut milk powder, 30 g calcium chloride per 100 kg milk and 80 ^{0}C coagulation temperature was the hardest of all the samples. ANOVA revealed that model –F value (4.39) was significant (P< 0.05). R^2 value of 0.8039 indicated 19.61% of the error was not explained by the model. As observed in Table-3, in the case of coagulation temperature (D), P value shows a highly significant (P< 0.01) effect on the hardness of CFSC. At interactive level, interactive effect between F /S ratio and calcium chloride (AC), F/S ratio and coagulation temperature (AD) and level of coconut milk powder and coagulation temperature (BD) had a significant (P< 0.05) positive effect on how hard CFSC would be. P values for interaction between level of coconut milk powder and level of calcium chloride (BC) and level of calcium chloride and coagulation temperature (CD) had a highly significant (P< 0.01) positive effect on hardness of CFSC. This observation is in accordance with the findings of Mathare *et al.* (2009) [23] who observed that hardness increased with increase in coagulation temperature upto 90 ^{0}C.

Fat

From the Table 1 it was noted that CFSC sample prepared in Run Order No. 6 had the lowest fat among all the samples. However CFSC prepared using a combination 0.35 F/S ratio in milk, 9.0% (w/w of milk) coconut milk powder,30 g calcium chloride per 100 kg milk and 80 ^{0}C coagulation temperature had the highest fat as compared to all the other samples. A high value of R^2 (0.8674) indicated a better fit of the model to the data. As shown in Table 3 a highly significant (P< 0.01) effect is observed by the P value of F/S ratio (A) on the fat content of CFSC. Similarly, amount of coconut milk powder (B) also shows a highly significant effect on the fat content of the final product. Coagulation temperature (D) had a significant (P< 0.05) positive effect on fat content of CFSC at a linear level. A significant (P< 0.05) negative effect on fat was found with the higher amount of coconut milk powder (B^2) and calcium chloride (C^2). No data are reported in the literature on effect of the previously discussed parameter on any product similar to CFSC.

Moisture

From the table 1 it is noted that CFSC sample prepared in Run Order No. 6 had the highest moisture among all the samples. However CFSC prepared using a combination 0.35 F/S ratio in milk, 9.0% (w/w of milk) coconut milk powder, 30 g calcium chloride per 100 kg milk and 80 ^{0}C coagulation temperature had the least moisture among all samples. An R^2 value of 0.8096 indicated that 19.04% of the variation was not accounted for by the model. ANOVA indicated that model F value (4.55) was significant (P< 0.05). As shown in Table 3, P values of F/S ratio of milk (A) and coconut milk powder (B) have a highly significant (P< 0.01) but negative effect on the moisture level of CFSC, which meant that increased fat content of milk and higher amount of coconut milk powder would lead to reduction in the moisture level of the product. P value of coagulation temperature (D) had significant (P< 0.05) effect on the moisture of the product. This implies that when the coagulation temperature was increased, it led to greater moisture expulsion in the CFSC samples. This is in accordance with the results of Masud *et al.* (2007) [22] who reported that during manufacture of *paneer* from buffalo milk, moisture tends to decrease from 50.4% to 46.81% when coagulation temperature increases from 75 ^{0}C to 90 ^{0}C. Fat to MSNF ratio (A^2), amount of coconut milk powder (B^2) and calcium chloride (C^2) has a significant (P< 0.05) effect on the moisture of CFSC at quadratic level. Observation is in agreement with the results reported by Venkateswarlu (2002) [29] who reported that when the amount of coconut milk increases from 10% to 20% in the blend of skim milk and

coconut milk prepared for *paneer* making, there is a reduction in the moisture content of the final *paneer*.

Optimization of CFSC and validation of model

RSM software used for optimizing the selected independent variables was Design Expert, Trial version – 10.0.2 (Stat-Ease Inc.). Independent variables were kept in range during optimization. Chewiness, cohesiveness, hardness, moisture and fat were in range; flavour, body and texture, color and appearance and total score were aimed to be maximized. Optimized solution with a desirability of 0.939 was given by a combination of fat to MSNF ratio of 0.31, 7.0% w/w of milk of coconut milk powder, 30.0 g/100kg of calcium chloride and coagulation temperature of 80 ^{0}C. At the optimized solution, the values of the responses were 45.1002 flavour score, 31.8758 body & texture score, 9.2427 colour & appearance score, 91.2186 total score, 27.241 Nmm chewiness,0.386 cohesiveness, 10.6902 N hardness, 52.447% moisture and 27.862% fat. The final product was manufactured employing this suggested formulation and the actual results obtained were compared with predicted values of the criteria/responses selected for process optimization. There was no significant difference between the predicted and actual values of responses. Validation of optimized CFSC formulation was performed by preparing the product seven times and comparing the actual observed results with the optimized predicted data suggested by RSM software, using two-tailed, one sample t - test.

Proximate composition and fatty acid profile of optimized product

The average values of the proximate composition of CFSC were - 54.52% moisture, 27.89% fat, 12.67% protein 3.09% carbohydrate content (by difference) and 1.83% ash. The developed sample was compared with control *Paneer* for their respective fatty acid profile using Gas chromatography. As presented in Table 4, for the control sample, Palmitic acid was present in the highest concentration (32.67%) followed by Oleic acid (22.24%), Stearic acid (15.65%), Myristic acid (9.64%), Butyric acid (2.97%), Lauric acid (2.12%), Linoleic acid (2.07%), Caproic acid (1.60%), Caprylic acid (0.861%), Linolenic acid (0.624%), Arachidic acid (0.338%) and Behenic acid (0.208%). Concentration of Arachidonic acid was below the limit of quantification. The trend of these fatty acid concentrations were observed to be similar to that reported by Dorni *et al.*, (2017) [15]. In CFSC, highest concentration was exhibited by Lauric acid (31.19%) followed by Palmitic acid (16.47%). Coconut fat has been proven to be rich in medium-chain triglycerides. Thus the concentration of Myristic acid (15.82%) was expected to be high as compared to control. Oleic acid (12.03%) was also amongst the most prominent fatty acids in CFSC. Oleic acid was followed by stearic acid (6.92%), Caprylic acid (5.73%), Capric acid (4.57%), Linoleic acid (1.219%), caproic acid (1.083%), Butyric acid (0.962%), Linolenic acid (0.24%) and arachidic acid (0.17%). Medium chain triglycerides have a variety of health benefits as highlighted previously. Some of them are immune-modulating activities, metabolic-enhancing properties, antimicrobial and antifungal properties (Enig, 1997) [17]. Medium chain triglycerides are also easily assimilated by the human body compared to long-chain fats (Aziz *et al.*, 2014) [5]. Hence their presence in CFSC proves the nutritional superiority of the developed product versus control *paneer*.

Table 1: Experimental design matrix and sensory scores of coconut flavoured paneer-like soft cheese

Runs	A	B	C	D	Fl	BT	CA	Tot.	CHW	COH	HAR	Fat (%)	Moisture (%)
1	0.16	8	25	75	35.2	22.4	8.6	71.2	24.334	0.410	8.776	55.64	22.58
2	0.23	9	30	70	27.5	23.8	8.6	64.9	13.677	0.330	6.801	55.86	23.94
3	0.29	8	25	65	27.5	15.4	6	53.9	9.733	0.278	6.217	55.22	25.5
4	0.23	9	20	80	38.5	28	7.4	78.9	18.847	0.356	9.044	54.49	24.83
5	0.35	7	20	80	45.1	29.4	7.4	86.9	24.746	0.379	11.438	55.73	26.23
6	0.23	7	20	70	37.4	19.6	6.6	68.6	36.542	0.455	13.814	58.78	22.11
7	0.35	9	20	70	27.5	21	6.6	60.1	12.810	0.295	7.281	48.91	30.58
8	0.29	8	25	75	38.5	25.9	8.6	78	20.743	0.326	9.568	50.04	29.01
9	0.29	8	25	75	38.5	25.9	8.6	78	19.414	0.325	9.073	50.29	28.84
10	0.35	9	20	80	38.5	29.4	7.4	80.3	19.519	0.360	8.240	48.19	31.08
11	0.35	9	30	70	27.5	25.2	8.6	66.3	15.008	0.307	7.929	51.35	28.89
12	0.29	8	25	85	44	30.1	8	87.1	32.115	0.360	13.287	46.86	31.17
13	0.35	9	30	80	38.5	33.6	9.2	86.3	57.802	0.443	18.437	37.61	38.46
14	0.35	7	20	70	37.4	21	6.6	70	24.256	0.341	11.029	50.38	30.02
15	0.35	7	30	70	37.4	25.2	8.6	76.2	18.646	0.349	8.823	54.17	27.34
16	0.23	7	30	70	37.4	23.8	8.6	74.8	20.125	0.375	8.072	51.03	27.15
17	0.23	7	20	80	45.1	28	7.4	85.5	19.132	0.339	8.357	55.76	24.08
18	0.29	8	25	75	38.5	25.9	8.6	78	19.718	0.360	8.581	48.26	30.22
19	0.29	8	35	75	38.5	25.2	9.6	78.3	18.793	0.321	9.142	54.02	26.31
20	0.29	8	25	75	38.5	25.9	8.6	78	22.214	0.392	9.061	51.96	27.71
21	0.23	7	30	80	45.1	32.2	9.2	91.5	26.094	0.391	10.640	53.37	25.62
22	0.29	8	25	75	38.5	25.9	8.6	78	15.418	0.313	7.891	50.54	28.68
23	0.42	8	25	75	35.2	22.4	8.6	71.2	18.605	0.348	8.200	50.74	29.79
24	0.29	8	15	75	38.5	19.6	6.6	69.7	26.851	0.400	9.982	55.89	25.05
25	0.23	9	30	80	38.5	32.2	9.2	84.9	16.407	0.364	6.970	51.85	26.54
26	0.29	8	25	75	38.5	25.9	8.6	78	18.700	0.357	7.926	52.52	27.33
27	0.29	6	25	75	42.35	25.9	8.6	81.85	19.934	0.359	8.261	58.42	23.62
28	0.29	10	25	75	23.1	25.9	8.6	62.6	19.087	0.360	8.203	50.51	28.44
29	0.23	9	20	70	27.5	19.6	6.6	58.7	14.964	0.332	6.770	52.17	26.33
30	0.35	7	30	80	45.1	33.6	9.2	92.9	30.452	0.407	11.599	53.96	27.48

**Significant at 1 per cent level ($P< 0.01$); *Significant at 5 per cent level ($P< 0.05$); A- Fat : MSNF ratio in milk, B- level of coconut milk powder (w/w of milk), C - level of addition of $CaCl_2$ (g/100 kg milk), D- coagulation temperature (^{0}C), Fl – Flavour score, BT – Body and texture score, CA- Colour and appearance score, Tot.- Total score, CHW – Chewiness (Nmm), COH – Cohesiveness, HAR – Hardness (N)

Table 2: P values and partial coefficients of regression equation of suggested models for sensory parameters of coconut flavoured paneer-like soft cheese

Response	Fl		BT		CA		Tot.	
	Partial coefficient	P value	Partial coefficient	P value	Partial coefficient	P value	Partial coefficient	P value
Model	38.5	< 0.0001**	25.9	< 0.0001**	8.6	< 0.0001**	78	< 0.0001**
Linear								
A	0	1	0.466667	0.2807	0	1	0.466667	0.4521
B	-4.35417	< 0.0001**	0	1	0	1	-4.35417	< 0.0001**
C	0	1	1.86667	0.0004	0.883333	< 0.0001**	2.75	0.0004**
D	4.49167	< 0.0001**	4.025	< 0.0001**	0.4	< 0.0001**	8.91667	< 0.0001**
Interactive								
AB	0	1	0	1	0	1	0	1
AC	0	1	0	1	0	1	0	1
AD	0	1	0	1	0	1	0	1
BC	0	1	0	1	0	1	0	1
BD	0.825	0.008**	0	1	0	1	0.825	0.2826
CD	0	1	0	1	-0.05	0.2487	-0.05	0.947
Quadratic								
A^2	-0.561458*	0.0157*	-0.335417	0.4034	-0.0208333	0.5226	-0.917708	0.1254
B^2	-1.18021	< 0.0001**	0.539583	0.1868	-0.0208333	0.5226	-0.661458	0.2603
C^2	0.263542	0.2203	-0.335417	0.4034	-0.145833	0.0004**	-0.217708	0.7056
D^2	-0.423958	0.0575	-0.247917	0.5346	-0.420833	< 0.0001**	-1.09271	0.0724
CV %	2.9184		7.980		2.054		3.912	
APV	27.1482		11.1457		31.1127		17.034	
R^2	0.9829		0.8879		0.9852		0.9521	

**Significant at 1 per cent level (P< 0.01); *Significant at 5 per cent level (P< 0.05); A- Fat : MSNF ratio in milk, B- level of coconut milk powder (w/w of milk), C - level of addition of $CaCl_2$ (g/100 kg milk), D- coagulation temperature (^{0}C), Fl – Flavour score, BT – Body and texture score, CA- Colour and appearance score, Tot.- Total score

Table 3: P values and partial coefficients of regression equation of suggested models for textural and physico-chemical parameters of coconut flavoured paneer-like soft cheese

Response	CHW		COH		HAR		Fat		Moisture	
	Partial coefficient	P value	Partial coefficient	P value	Partial coefficient	P value	Partial coefficient	P value	Partial coefficient	P value
Model	19.3676	0.0011**	0.3432	0.0006**	8.683	0.0036**	28.3619	0.0003**	50.6004	0.003**
Linear										
A	0.310107	0.7254	-0.00877058	0.0527	0.536238	0.1016	-1.50302**	0.0014**	2.01586**	< 0.0001**
B	-1.41304	0.1237	-0.00927399*	0.0419*	-0.357325	0.2634	-1.74288**	0.0004**	1.03157**	0.0016**
C	0.417245	0.637	0.00028347	0.9467	0.0792827	0.8	-0.200437	0.6111	0.127791	0.6411
D	4.18626**	0.0002**	0.0162592**	0.0014**	1.19324**	0.0015**	-0.902604*	0.0336*	0.574368*	0.0494*
Interactive										
AB	1.65549	0.1396	0.0049981	0.3432	0.403635	0.3008	-0.593465	0.2285	0.35463	0.2981
AC	2.20063	0.0557	0.0112482*	0.0437*	0.875801*	0.0345*	0.607758	0.218	-0.447841	0.1936
AD	3.00482*	0.0126*	0.022888**	0.0004**	0.925779*	0.0266*	0.449479	0.3567	-0.296225	0.3822
BC	2.803*	0.0185*	0.00408064	0.4367	1.13407**	0.0088**	0.486912	0.3193	-0.35473	0.298
BD	3.37489**	0.0062**	0.0146879*	0.0115*	1.0909*	0.0111*	-0.405419	0.4045	0.297256	0.3806
CD	4.2727**	0.0011**	0.0162043**	0.0063**	1.13272**	0.0088**	-0.79986	0.1113	0.504213	0.1462
Quadratic										
A^2	0.826037	0.3242	0.00986459*	0.0231*	0.0698206	0.8115	0.575788	0.1316	-0.548541*	0.0453*
B^2	0.336311	0.684	0.00505512	0.2145	0.00580642	0.9842	0.894833*	0.0256*	-0.586194*	0.0340*
C^2	1.16418	0.1714	0.0105379*	0.0164*	0.33835	0.2578	1.01729*	0.0130*	-0.674053*	0.0171*
D^2	0.689801	0.4081	-0.00509455	0.2111	0.385864	0.1997	0.0386841	0.9161	-0.00990122	0.9691
CV %	19.4866		5.6817		16.1581		4.8425		3.5929	
APV	10.6624		10.3071		9.9489		9.1932		6.9793	
R^2	0.8378		0.8518		0.8039		0.8674		0.8096	

**Significant at 1 per cent level (P< 0.01); *Significant at 5 per cent level (P< 0.05); A- Fat : MSNF ratio in milk, B- level of coconut milk powder (w/w of milk), C - level of addition of $CaCl_2$ (g/100 kg milk), D- coagulation temperature (^{0}C), CHW – Chewiness (Nmm), COH – Cohesiveness, HAR – Hardness (N)

Table 4: Comparison of Fatty acid composition of CFSC with control

Fatty acid	(% of total fatty acids)	
	Control	CFSC
Butyric acid (C4:0)	2.971	0.962
Caproic acid (C6:0)	1.603	1.083
Caprylic acid(C8:0) *	0.861	5.737
Capric acid (C10:0) *	1.759	4.572
Lauric acid (C12:0) *	2.122	31.196
Myristic acid (C14:0) *	9.641	15.829

Palmitic acid (C16:0)	32.671	16.472
Stearic acid (C18:0)	15.659	6.929
Oleic acid (C18:1)	22.242	12.028
Linoleic acid (C18:2)	2.076	1.219
Linolenic acid (C18:3)	0.624	0.243
Arachidic acid (C20:0)	0.338	0.174
Arachidonic acid (C20:4)	Below limit of quantification	Below limit of quantification
Behenic acid (C22:0)	0.208	Below limit of quantification

*Medium chain triglycerides

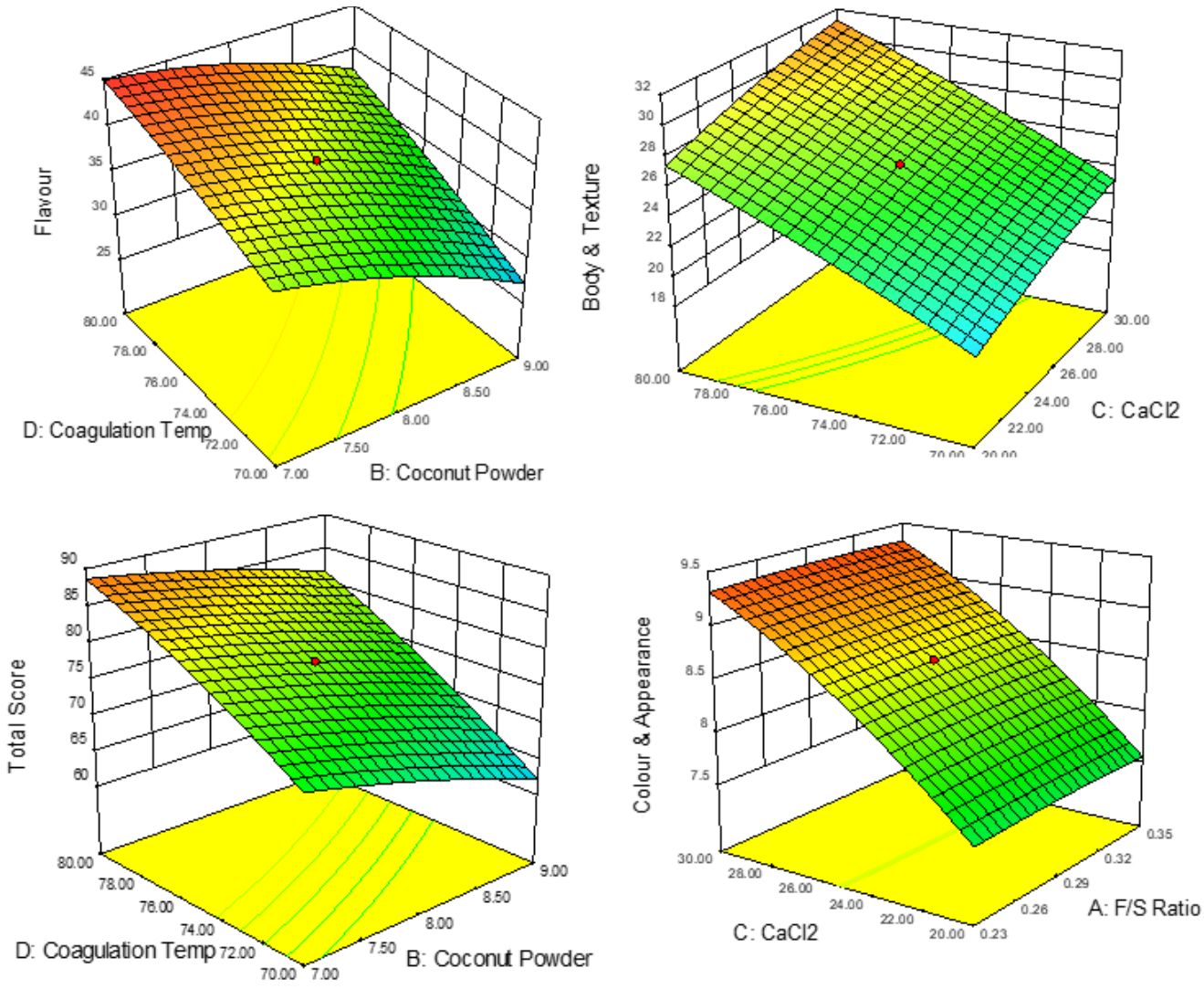
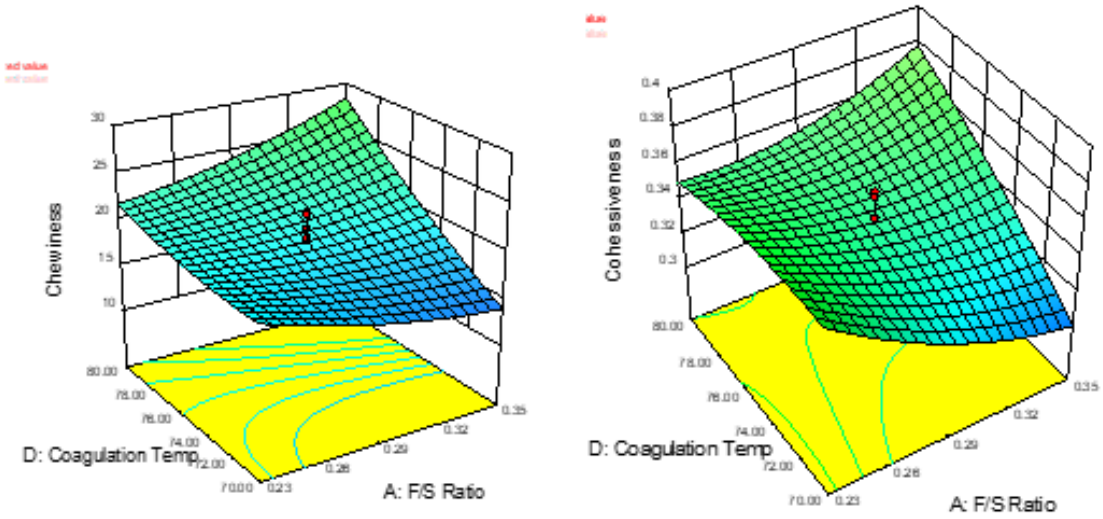


Fig 1: Surface plot (3-D) for sensory characteristics of coconut flavoured paneer-like soft cheese



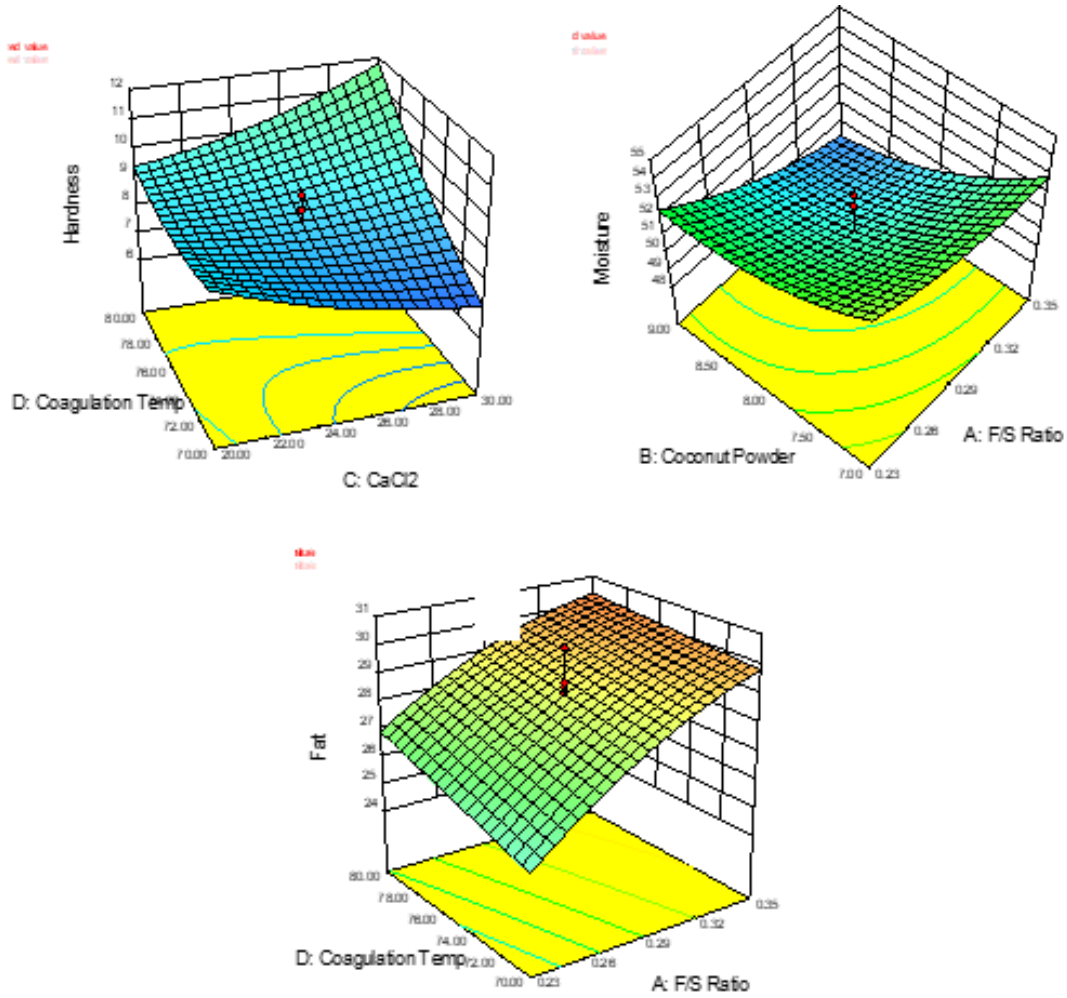


Fig 2: Surface plot (3-D) for physico-chemical and textural characteristics of coconut flavoured paneer-like soft cheese

Conclusion

It can be concluded on the basis of this study that coconut flavoured *paneer*-like soft cheese can be successfully prepared from milk standardized to 0.31 Fat:MSNF ratio using citric acid as a coagulant and using a coagulation temperature of 80 ^{0}C. The optimized formulation consisted of addition of 7.0% coconut milk powder (w/w of milk) and 30 g $CaCl_2$ per 100 kg milk. CFSC was manufactured with the concept of maintaining the texture as close as possible to conventional *paneer*. The developed CFSC was found to contain 10 times higher levels of medium chain fatty acids compared control. The lauric acid content in CFSC was about 15 times higher than control. This can imply that the developed product holds a potential to be an alternative to conventional *paneer*, with better quality of fat. Moreover, this study explores use of spray dried coconut milk powder which is easier to handle, has more consistent quality and has better shelf stability than freshly extracted coconut milk, thereby making production of CFSC easier to scale-up.

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