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RESEARCH PAPER

Effect of Incorporation of Soy Fortified: Cow Milk and Coagulation Temperature on Quality of *Paneer*

Prashant Tanhaji Satpute and Shrikant Baslingappa Swami*

Department of Post-harvest Engineering, Post-graduate Institute of Post-harvest Management, Killa-Roha. Dist: Raigad (Maharashtra State) (Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli-Campus Roha) India

*Corresponding author: swami_shrikant1975@yahoo.co.in

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ABSTRACT

In this paper effect of incorporation of soy fortified cow milk and coagulation temperature on quantity of *paneer* has been studied. The different levels of soy fortified cow milk were 100:00, 75:25, 50:50, 25:75 and 00:100 and coagulation temperature were 75°C, 85°C and 95°C. The product were optimized by using the Response Surface Methodology (RSM) with desirable properties of Textural Profile Analysis i.e. hardness was in the range of 89.9 to 227.0 (g), springiness was in the range of 0.36 to 1.96, adhesiveness was in the range of 2.2 to 53.3 (J), gumminess was in the range of 16.3 to 147.0 (g), chewiness was in the range of 7.6 to 164.6 (g), cohesiveness was in the range of 0.21 to 1.13 (g), stickiness was in the range of -53 to -5 (g) and colour (whiteness) was in the range of 16.15 to 28.08. The data obtained for sensory properties viz. flavor was in the ranged between 17.72 to 40.63, body and texture was in the range between 16.63 to 26.72, colour and appearance was in the range between 5.1 and 8.6 and package of *paneer* was in the range between 2.6 and 4.4. The contour plot showed the superimposed optimum level of Coagulation Temperature and Soy milk proportion of Soy fortified cow milk *paneer* was (20-30):(80-70) % and coagulation temperature 93°C- 95°C the product achieved the desirable qualities i.e. hardness 195 (g), springiness 1.45, adhesiveness 29 (J), gumminess 76 (g), chewiness 118.5 (g), cohesiveness 0.41, stickiness -30 (g) and whiteness index 20.85 respectively. The result were correlated with the sensory score flavor 30.81, body texture 25.00, colour and apperance 6.70 and packaging 3.25. The soymilk incorporation at 25% and coagulation temperature 95°C resulted the optimum product quality having hardness 164.6 g, springiness 1.42, adhesiveness 39.2, gumminess 69.3 g, chewiness 110.6 g, cohesiveness 0.47, stickiness -25.6 g, whiteness index 22.44.

Keywords: Soy fortified *paneer*, sensory properties, RSM, Textural Profile Analysis

Paneer is a popular heat and acid-coagulated Indian milk product analogous to the western cottage cheese. It is prepared by coagulating milk with citric acid and pressing the resulting curd into blocks or cubes. The product has a shelf life of 6 days at 10 °C (Jagannath *et al.* 2001). *Paneer* consists usually of the protein and nearly all the, insoluble salts and colloidal materials, together with part of the moisture of serum of the original milk in which are contained lactose, whey proteins, soluble fats, vitamins and other milk components. It contains approximately 53–55% moisture, 23–26% fat, 17–18 % protein, 2–2.5 % carbohydrate and 1.5–2.0 % minerals (Kanawjia and Singh, 2000). The pilot process for manufacture of *paneer* from buffalo milk with 6 % fat which was heated at 82 °C for 5 min in a jacketed vat (Bhattacharya *et al* 1971). One per cent hot citric acid solution was added at 70 °C. The mixture was

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stirred continuously till coagulation is complete. The *paneer* thus formed was separated and pressed (Rao *et al*. 1992). The conventional *paneer* is quite rich in fat content, which not only pushes up the price of *paneer* but also makes it unsuitable to those consumers who are conscious of high fat as milk fat increases the risk of coronary heart disease. Recent research has shown that quite good quality *paneer* could be manufactured from milk with fat content as low as 3.0 % (Kanawjia and Singh 2000). Milk and milk products appear to be almost perfect foods, but in view of the high cost and increasing occurrence of coronary complications there is considerable interest to reduce/replace the milk fat in *paneer*. This leads to the manufacture of *paneer* like products utilizing nonconventional food solids, which are not only cheaper but also can be converted into product that resembled closely to *paneer* in textural and nutritional characteristics. Soybean is one such food material, which is popular for producing low cost high nutritional value product. Soybean products represent an inexpensive and abandoned source of protein. Replacing a part of milk used in making *paneer* with soybean milk may result into economical and nutritional product. Addition of the soy solids in milk influences textural and sensory characteristics of *paneer* (Uprit *et al.* 2004). Soybean is rich source of good quality protein that has been consumed in Asian Nations for many centuries (Winarno *et al.* 1984). The soybean protein is equivalent to animal protein (Mateos-Aparicis *et al.* 2008). Soybean protein provides all the essential amino acids in the amount needed for human health. The rapid growing population of the developing countries is facing acute shortage of protein. It can furnish protein supply to bridge up the protein deficiency gap at low cost than any other crop. The soy foods are healthy because it consist of vegetable protein along with oligosaccharides dietary fibre, phytochemical (especially isoflavones) and minerals. The average protein content of the most of beans varies from 20-25%, whereas the protein content in soybean is about 40%. Soybean protein is low in sulphur amino acid but contained sufficient lysine which is deficient in most of the cereals. In soybean meal 480 g/kg dry matter (DM) is protein and the protein quality is high (Fan *et al.* 1995). Soybean is used for many different products both edible and non-edible. The soybean based human foods includes soypaneer, miso, soy-sause, natto, tempeh, soymilk, soy flour, soy oil, concentrates and isolates and soy sprouts. The soybean meal is the supplemental protein source most widely used in animal feeds. Soya products are increasingly becoming popular especially amongst health-conscious people. Among the numerous soy food items, Soymilk (extract of soybean) had been the first product ever prepared and consumed by human since long ago. The major soybean producing nations are the United States, Brazil and Argentina (Wang, *et al.* 1983). The three countries denominate global production accounting for 80% of world soybean supply. Production of soybean is above 283 million tones, accounting for nearly 57% of the global oilseed production (Ali, 2016). Production of Soybean in India is dominated by Maharashtra and Madhya Pradesh contributes 89 % of the total production and remaining 11% is contributed by Rajasthan, Andhra Pradesh, Karnataka, Chhattisgarh and Gujarat (Anonymous, 2014 Soybean Update: International and Domestic Scenario).

Soymilk is used in various food products such as soy *paneer*, fruit flavoured puddings, calcium and protein rich soymilk. Soy *paneer* is one of the most popular soy products and is prepared by coagulation of soymilk. The quality of soy *paneer* depends on several parameters such as coagulation method, processing condition texture, the content of two storage protein components glycinin and β-conglycinin and their ratio (Saio *et al.* 1979), concentration and type of the coagulant used (Sun, *et al.* 1991), and temperature of coagulation. Soypaneer has been reported as low calories food and rich source of iron calcium, low in saturated fat and a source of isoflavones which can mimic human enstrogens and can have beneficial effects on human health (Setchell, 1998).

Milk coagulation is a key step that is mainly affected by the protein composition of milk and that strongly influences the efficiency of final product formation. During coagulation of milk the fat and casein are concentrated, while the other components of milk, mainly water, are removed with the whey (Fox and Mc Sweeney, 2004; Walstra *et al.* 2006). Amiot *et al.* (2002) defined milk coagulation as the destabilization of the casein micelles, which flocculate and aggregate to form a gel enclosing the soluble milk components. It can be caused by acidification, by the action of an enzyme or by a combination of the two.

The coagulation process in *paneer* manufacture is regarded as a consequence of the chemical and physical changes in casein brought about by the combined influence of heat and acid treatment. This phenomenon involves the formation of large structural aggregates of casein from the normal colloidal dispersion of discrete casein micelles, in which milk fat and coagulated serum proteins are entrapped together with whey. During the formation of coagulum, the major changes that take place include (i) the progressive removal of tricalcium phosphate from the surface of casein and its conversion into mono calcium phosphate and soluble calcium salt, and (ii) progressive removal of calcium from calcium hydrogen caseinate to form soluble calcium salt and free casein. When the pH of milk system drops, the colloidal particles become isoelectric, i.e. the net electric charge becomes zero with the formation of "zwitter-ion". Under such circumstances the dispersion is no longer stable, the casein gets precipitated and forms a coagulum (Ling, 1956).

Textural and rheological properties of coagulated dairy product are affected by their structure. The microstructure of these products consists of a continuous protein matrix with a loss and open structure with space occupied by the globules dispersed through the protein network (Bryant *et al.* 1995). The structural arrangement of network determines the textural characteristics and is affected by the factors such as composition and manufacturing process.

Good quality *paneer* is characterized by a marble white colour, sweetish, mildly acidic taste, nutty flavour, spongy body and closely knit, smooth texture. It shall contain no more than 70% moisture and the fat content should not be less than 50% expressed on "dry matter". Milk solids may also be used in preparation of *paneer*. Bureau of Indian Standards (BIS 1983) reported that the *paneer* should have maximum of 60% moisture and minimum of 50% fat in dry matter for *paneer*.

Due to the ever growing demand of *paneer* by varied health conscious consumers, researchers were encouraged to develop new types and varieties of *paneer*. Examples of these include skim milk *paneer*, low-fat *paneer*, reduced-fat *paneer*, fibre enriched low-fat *paneer*, low-fat *paneer* enriched with whey protein concentrate/soy protein isolate, soy *paneer*, filled *paneer*, protein-enriched filled *paneer*, microfiltered *paneer*, ultrafiltered *paneer*, vegetable impregnated *paneer*, *paneer* curry, *paneer* spreads, *paneer* pickles, spiced *paneer*, masala *paneer*, fruit *paneer*, processed *paneer*, long-life *paneer*, Kradi cheese (Khan *et al.* 2011).

Various researchers have tried to develop the *paneer* from soy-buffalo milk (Parmar *et al.* 1989; Babaje *et al.* 1992); Corrot incorporated soy *paneer* (Butool *et al.* 2015); Soy-groundnut *paneer* (Khodke *et al.* 2014); Skimmed milk and soymilk (Raja *et al.* 2014); Soy milk and tonned dairy milk (Jain and Mhatre *et al.* 2009). Attempt has been made to develop soy fortified cow milk based *paneer* using varied coagulation temperature.

MATERIALS AND METHODS

Raw Material

Soybean required for experimentation was purchased from the Agriculture Produce Market Committee, Washi, Mumbai. The soybean was cleaned by removing infected seed, damage seeds and stones.

Preparation of Soymilk and *Paneer*

The soymilk was extracted as per the procedure described by (Raja *et al.* 2014). The soybean was soaked in water, the soybean: water ratio was 1:3 for 10 h (Sopade *et al.* 1990). The soaked water was decanted and the seeds were washed with fresh water. Hundred grams of soaked soybean seeds per 300 ml of water was used for wet grinding. The seeds were wet grounded in a food processor (Make: M/s Jaipan Kitchen Appliances, India; Model: 12045). The wet grinding was performed at power level knob placed at low, medium and high 18000-24000 RPM for 5 min ON/ 3 min OFF to reduce the particle size. The resulting suspension was filtered through a double layered muslin cloth. The muslin cloth was wrapped around the bean pulp, okara and squeezed by hand till all the liquid was fully extracted squeezing was stopped when there is no liquid is coming out. The filtrate obtained (soymilk) was pasteurized for 15 min in a beaker placed in water bath at 80°C. The soymilk was then cooled and refrigerated for few hours (Raja *et al.* 2014).

500g of soybean yield 3 liters of soy milk. The obtained milk was then pasteurized 70°C for 15 min, cooled at room temperature for 30 min and stored at refrigerated temperature (6±1°C) for further utilization.

Then cow milk was freshly obtained from dairy farm. The blends were prepared by mixing soy milk: cow milk at the different levels of proportion, which was considered as treatments. Treatments T_1 is (100:00), T_2 is (75:25), T_3 is (50:50), T_4 is (25:75), T_5 (00:100) respectively. The treatments T1, T2, T3, T4, and T5 were used for the preparation of *paneer*. The process flow chart for preparation of *paneer* for all these treatments were given in the flow chart in Fig. 2. The milk samples in the treatments T1 to T5 were heated at 75, 85 and 95°C for 15 min and coagulant citric acid solution was added ($C_6H_8O_7$) (MW 19.723 g/mol) 1:5% (w/v) slowly with gentle and continuous stirring. After the complete coagulation the stirring was stopped, and the content were left undisturbed at room temperature for 15 minutes whey was then removed by pressing the coagulated mass under the hand operated press (HOPP) for 30 minute till all the whey was droped out from the compressed mass (*Paneer*) through the screen at the process. The *paneer* was cut into pieces 1cm × 1cm × 1cm cubes. The *paneer* $1cm^3$ were obtained by the process were exposed to various quality tests i.e. Textural Profile Analysis, colour measurement.

Determination of Moisture Content

The moisture content of *paneer* was determined as per AOAC, (2000). The *paneer* was taken into a pre weighted moisture boxes 3no. and placed in the Hot air oven (Make: M/s Aditi Associate Mumbai; Model: ALO-136). The Hot air oven was set at 105ºC and

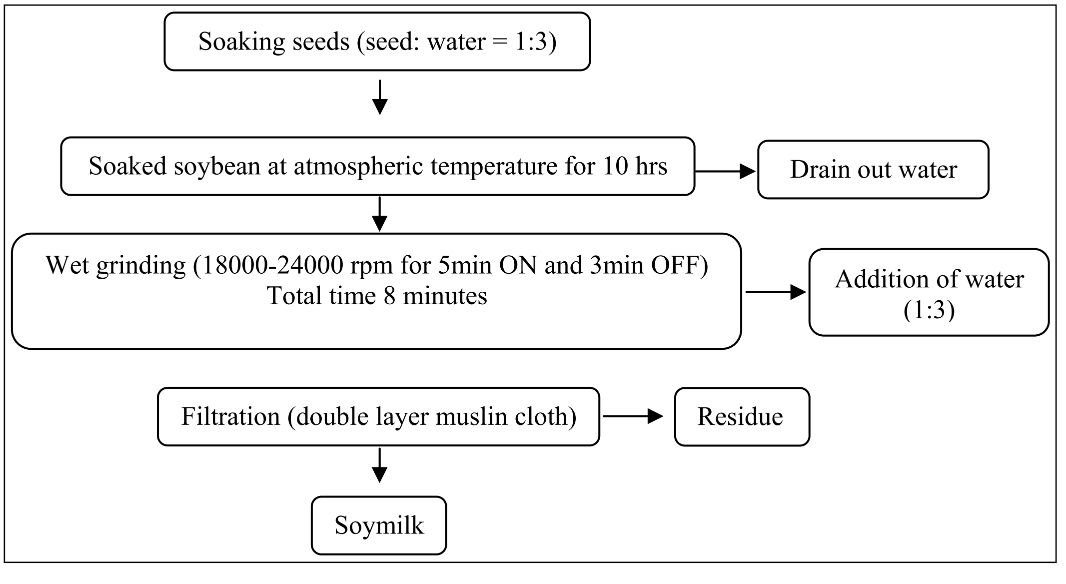

Fig. 1: Flow chart for the preparation of soymilk

samples were loaded with open lid. The sample was exposed to 105ºC± 1ºC for 24 h and the weight of the *paneer* sample after 24 hrs were recorded.

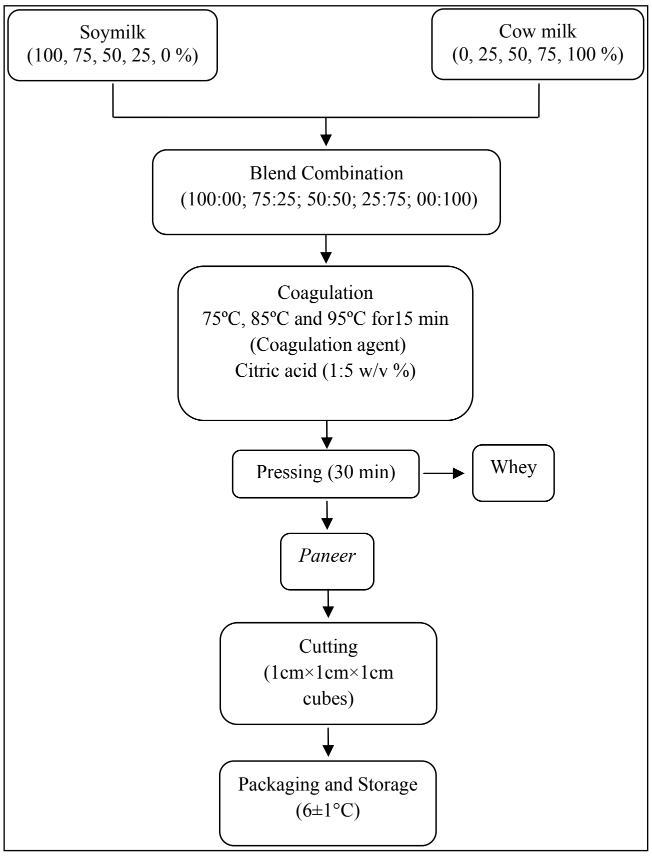

Fig. 2 Flow chart for *paneer* preparation for treatment combinations

The moisture content (% d.b) was recorded by using the following equation (1).

$$Mc = \frac{M1 - M2}{M1} \times 100 \qquad \dots (1)$$

Where,

$M1$ = Initial weight, *g*

$M2$ = Final weight, *g*

Texture

The texture of *paneer* was measured with TexVol Texture analyzer. (Make: M/s Perten Instrument; Model: TexVol TVT- 300 XP). The above mentioned soy *paneer* cubes of 1cm×1cm×1cm were exposed to double compression test with probe no 5 and size 5mm diameter and pretest speed was 1mm/s, compression depth was 5mm and trigger load was 5g for soybean *paneer*. The equipment gives the value hardness, springiness, adhesiveness, gumminess, chewiness, cohesiveness and stickiness. The typical textural profile curve obtained with one complete run is presented in Fig. 3.

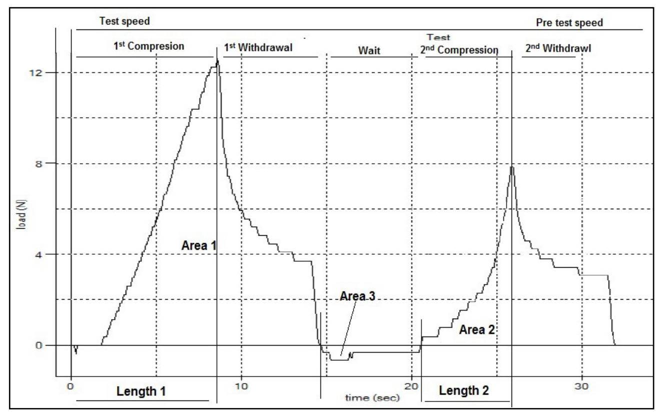

Fig. 3: Typical force vs. time curve for compression of soy fortified *paneer* obtained from TPA

The data obtained from the graph was used for determining following textural parameters Mhatre *et al.* (2008).

1. Hardness: Value of the peak force of the first compression of the product.

Hardness, *g* (*H*) = Max. Force of first compression …(2)

2. Cohesiveness: The strength of the internal bonds making up the body of the product or degree to which the sample deforms before rupture..

$$\text{Cohesiveness (Ch)} = \frac{\text{Area under } 1^{st} \text{ compression}}{\text{Area under } 2^{nd} \text{ compression}} \quad \dots(3)$$

3. Adhesiveness: Work necessary to overcome the attractive forces between the dissimilar materials, i.e., food surface and the food contact surface.

Adhesiveness, g.mm (*A*) = Negative area in the graph (A_3) …(4)

4. Springiness: Degree or rate at which the sample returns to its original shape/ size after partial compression between tongue and palate.

$$\text{Springiness } (S) = \frac{\text{Length 1}}{\text{Length 2}} \quad \ldots(5)$$

5. Chewiness: Energy required for masticating a solid food material until it is ready for swallowing.

6. Gumminess: Energy required to disintegrate a semisolid food material to a state of ready for swallowing.

7. Stickiness: The stickiness of the *paneer* against the palate and around the teeth during mastication.

Fig. 4: TEX VOL (TVT) texture analyzer

Colour

A colour of *Paneer* cubes of all treatments were measured by (Make: M/s Konica Minolta, Japan; Model: Meter CR-400) colour measuring device as shown in Fig. 5. The colour of *paneer* cubes were measured in dark room. The *paneer* cubes were placed on white surface, placing colori reader as the top of the product and colour was measured. The colour was measured as per 10°/D_{65} (ASTM) standard. It represents L, a and b value. Degree of lightness or darkness of the sample was represented by 'L' value, redness or greenness by 'a' and yellowness to blueness by 'b' value on hunter scale. The experiment was repeated five times and average values were reported. The whiteness index samples (10 mm thickness and 10 mm diameter) were measured in 4no. for each sample to estimate the degree of lightness (L), redness/greenness (a) and yellowness/ blueness (b) using a colorimeter. Whiteness index was calculated by the following equation (6) of Park, (1994):

$$\text{Whiteness} = [(100 - L)]^2 + a^2 + b^2]^{1/2} \quad \ldots(6)$$

Where,

L^* values, which indicate lightness of the product

a^* represents redness (+ a) to greenness (- a)

and yellowness b^* represents (+ b) to blueness (- b)

Fig. 5: Konica Minolta, Japan colour analyzer

Sensory Analysis

The sensory attribute of fresh *paneer* was evaluated with trained panelists as per Indian Standard BIS

IS 15346:2003. The Panelists were trained for the product testing and were familiar with product sensory evaluation. *Paneer* was cut into cubic samples and placed of plastic plate. The *paneer* prepared for all the treatments were coded from A to P. There are around 16 different sample out of which 15 were from the different treatments and one was Control (Cow milk) for evaluation of sensory parameter i.e. flavor, body texture, colour and appearance and packaging attributes. The rating was based on 50 scales for flavor attribute, 35 scales for body and texture attribute, 10 scales for colour and appearance attribute and 5 scales for package attribute. The attribute were summed up for total score 100 for each panelist. The average score for total 11panelist have been reported. The data were analyzed statistically for the significance of each attributes by ANOVA.

Correlation between the optimum value of Textural parameter, colour (whiteness index) and the best Sensory score

The effect of soy milk: cow milk composition and Coagulation temperature as the various parameters i.e. hardness, springiness, adhesiveness, gumminess, chewiness, cohesiveness, stickiness and whiteness of the soy fortified cow milk *paneer* were assessed by Response Surface Methodology (RSM) described by Myers, (1971). The desirable textural parameter i.e. maximum hardness, maximum springiness, moderate adhesiveness, moderate gumminess, maximum chewiness, moderate cohesiveness, maximum stickiness and moderate whiteness are correlated with the best sensory score from the panelists so that best treatment was adjudged from the correlation between these.

Based on preliminary trials and review of literature, the constant parameters and independent variables with their ranges and the dependent variables were selected for the final experiments. Central Composite Rotatable Design (CCRD) was chosen because, it is the most popular response surface design, and it gives very good predictions in the middle of design space.

RSM was used to determine the effect of the independent variables on the dependent variables statistically. A second order mathematical model of the following form was fitted to all the response data.

$$Y = \beta_{ko} + \sum_{i=1}^{n} \beta_{ki} X_i + \sum_{i=1}^{n} \beta_{kii} X_i^2 + \sum_{i=1}^{n} \sum_{j=i+1}^{n} \beta_{kij} X_i X_j \quad \ldots(7)$$

where,

β_{ko}, β_{ki}, β_{kii}, β_{kij} are regression coefficients, X_i and X_j are independent variables in coded form, *k* is the number of independent variables and *Y* is a response. Before optimization, goals were set for each independent variable and one response. The criteria for allotment of the goals were based on the desirable textural parameter i.e. maximum hardness, maximum springiness, moderate adhesiveness, moderate gumminess, maximum chewiness, moderate cohesiveness, maximum stickiness and moderate whiteness. All the independent variables and hardness were kept in range on the basis of results of preliminary trials so that an optimum product could be obtained with respect to its composition, sensory and textural properties. Overall acceptability was set for maximum goal setting so that an acceptable product is made from consumer point of view.

RESULTS AND DISCUSSION

Effect of incorporation of Soymilk (%) and Coagulation Temperature (°C) on Textural properties of Soy Fortified Cow Milk *Paneer*.

1. Peak force (Hardness) (g)

Fig. 6 (a) shows the surface plot showing effect of incorporation of Soymilk (%) and the Coagulation Temperature (°C) on peak force of soy fortified cow milk *paneer*. The peak force (g) was in the range of 89.6 to 227.0 g. As the soymilk proportion increases (0-100%) the peak force decreases. Similarly as the coagulation temperature (°C) increases from 75°C to 95°C the peak force increases gradually. It can be clear from the contour plot Fig. 6 (b) as both the soymilk proportion and coagulation temperature increases the peak force was found to be increased.

Fig. 6 (a) Surface plot showing the effect of incorporation of Soya milk (%) and Coagulation Temperature (°C) on peak force of Soya fortified *paneer*.

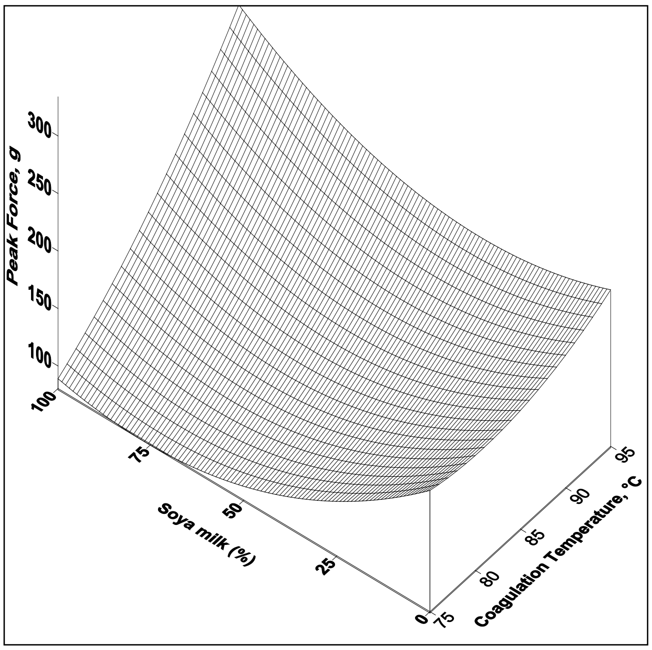

Fig. 6 (a): Surface plot showing the effect of incorporation of Soya milk (%) and Coagulation Temperature (°C) on peak force of Soya fortified *paneer*

The ANOVA for the effect of soy milk (%) and coagulation temperature (°C) on peak force (g) of *paneer*. It indicated that both soymilk (%) proportion and coagulation temperature (°C) had significant influence at p≤0.01. The interaction had also significant influence at p≤0.01 on the peak force of *paneer*. The equation (6) shows the second order polynomial equation fitted to the experimental data for peak force (g). The equation was well fitted with ($R^2 = 0.960$; $MSE = 1.9936 \times 10^3$).

$$P_f = 1339.49 - 8.4227(S_m) + 0.0180\,(S_m)^2 - 2.866\,(C_t) + 0.0753\,(S_m \times C_t) + 0.1773\,(C_t)^2 \quad R^2 = 0.960) \qquad \ldots(6)$$

Where, P_f is the peak force (Hardness), S_m is the soymilk (%) and C_t is the coagulation temperature.

The decrease in peak force of SFP can be attributed to increase in moisture content of the product due to increase in soymilk proportion in the blend. The increase in peak force at 100% soymilk proportion might be because of decrease in fat content that might be because of impact of protein matrix with less open space, which is occupied by milk fat globule (Uprit *et al.* 2004). With reduction in fat content of SFP compact appearance of the protein network increased and number of milk fat globule dispersed within the network decreased (Bryant *et al.* 1995). The above results were in agreement with the results obtained by Jain and Mhatre *et al.* (2009); Uprit *et al.* (2004); Mhatre *et al.* (2008) and Muradia *et al.* (2010) respectively.

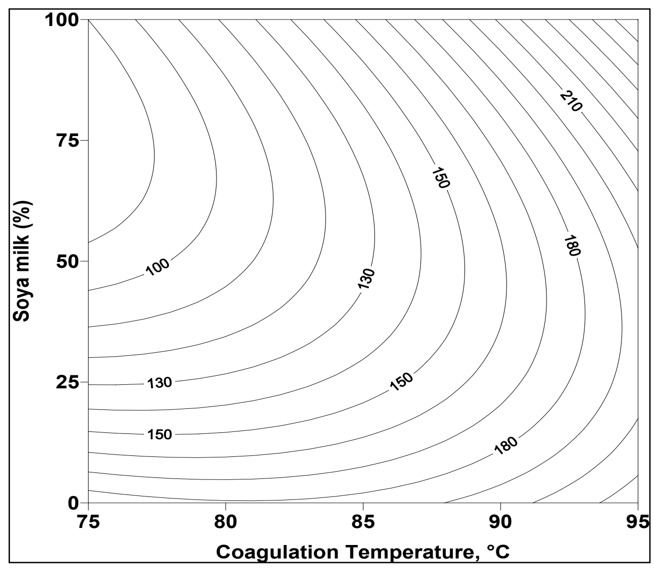

Fig. 6 (b): Contour plot showing the effect of incorporation of incorporation of Soya milk (%) and Coagulation Temperature (°C) on peak force of Soya fortified *paneer*

2. Springiness

Fig. 7 (a) shows the surface plot showing effect of incorporation of Soymilk (%) and the Coagulation Temperature (°C) on springiness of soy fortified cow milk *paneer*. The springiness was in the range of 0.36 to 1.96. As the soymilk proportion increases (0-100%) the springiness decreases. Similarly as the coagulation temperature (°C) increases from 75°C to 95°C the springiness value of *paneer* increases. It can be clear from the contour plot Fig. 7 (b) when both the soymilk proportion and coagulation temperature increases the springiness increases.

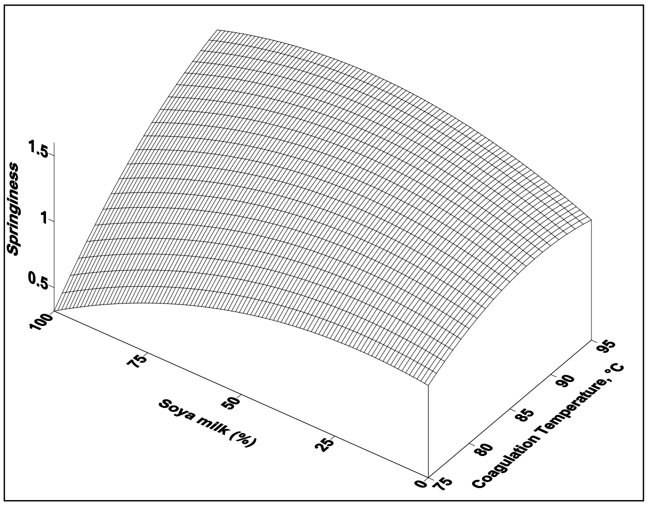

Fig. 7 (a): Surface plot showing the effect of incorporation of Soya milk (%) and Coagulation Temperature (°C) on springiness of Soya fortified *paneer*

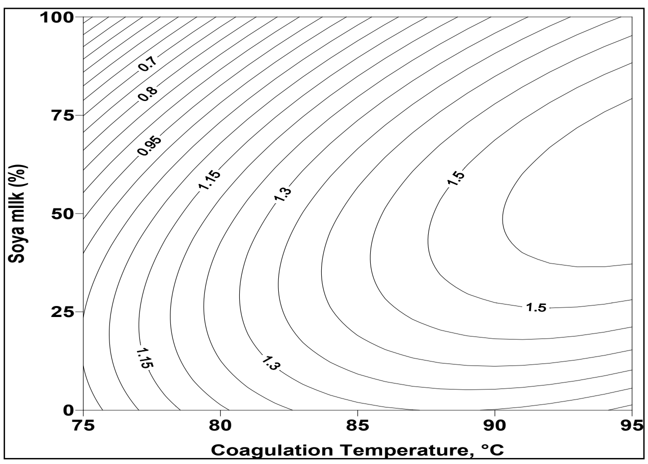

Fig. 7 (b): Contour plot showing the effect of incorporation of incorporation of Soya milk (%) and Coagulation Temperature (°C) on springiness of Soya fortified *paneer*

The ANOVA for the effect of only soy milk (%) and coagulation temperature (°C) on springiness of soy fortified cow milk *paneer*. It indicated that only soymilk (%) proportion had significant influence on springiness of the *paneer* at p≤0.01. The coagulation temperature (°C) and interaction has no significant influence on the springiness of *paneer* at p≤0.01. The equation (7) shows the second order polynomial equation fitted to the experimental data for springiness. The equation was well fitted with (R^2 = 0.979; MSE = 0.053).

$$S_p = -10.0959 - 0.02910\,(S_m) - 0.00010\,(S_m)^2 + 0.27750\,(C_t) + 0.00043\,(S_m \times C_t) - 0.2775(C_t)^2\ (R^2 = 0.979) \quad \ldots (7)$$

Where, S_p is the springiness, S_m is the soymilk (%) and C_t is the coagulation temperature.

The increase in springiness of *paneer* might be due to low fat content in *paneer* due to incorporation of soymilk (%) the same results were observed for low-fat cheeses have increased springiness by (Gwartney *et al.* 2002; Yates and Drake, 2007). The results are in agreement with the results obtained for soy fortified *paneer*, soy *paneer* reported in literature by Uprit *et al.* (2004); Mathare *et al.* (2009) respectively.

3. Adhesiveness (J)

Fig. 8 (a) shows the surface plot showing effect of incorporation of Soymilk (%) and the Coagulation Temperature (°C) on adhesiveness (J) of soy fortified cow milk *paneer*. The adhesiveness was in the range of 2.2 to 53.3 J. As the soymilk proportion increases (0-100%) the adhesiveness increases. Similarly as the coagulation temperature (°C) increases from 75°C to 95°C the adhesiveness increases linearly. It can be clear from the contour plot Fig. 8 (b) as both the soymilk proportion and coagulation temperature increases the adhesiveness was found to be increased in soy fortified cow milk *paneer*.

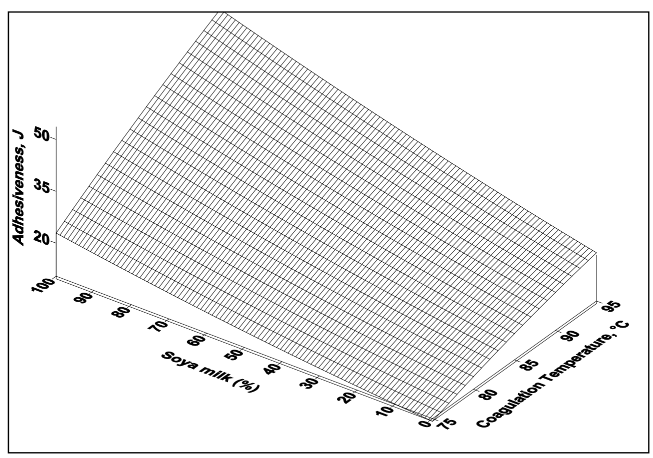

Fig. 8 (a): Surface plot showing the effect of incorporation of Soya milk (%) and Coagulation Temperature (°C) on adhesiveness of Soya fortified *paneer*

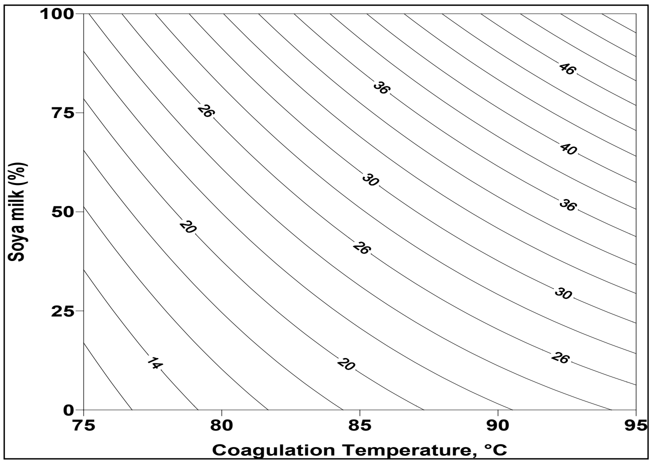

Fig. 8 (b): Contour plot showing the effect of incorporation of incorporation of Soya milk (%) and Coagulation Temperature (°C) on adhesiveness of Soya fortified *paneer*

The ANOVA for the effect of soy milk (%) and coagulation temperature (°C) on adhesiveness (J) of soy fortified cow milk *paneer*. It indicated that both soymilk (%) proportion and coagulation temperature (°C) had significant influence at p≤0.01. The interaction has also significant influence at p≤0.01 on the adhesiveness of *paneer*. The equation (8) shows the second order polynomial equation fitted to the experimental data for adhesiveness (J). The equation was well fitted with ($R^2 = 0.940$; $MSE = 9.64317 \times 10^1$).

$$A_d = -111.27 - 0.5161(S_m) + 0.00049\,(S_m)^2 + 2.3521\,(C_t) + 0.00798\,(S_m \times C_t) - 0.009720(C_t)^2\ (R^2 = 0.940) \quad \ldots(8)$$

Where, A_d is the adhesiveness, S_m is the soymilk (%) and C_t is the coagulation temperature.

The increase in adhesiveness of SFP can be attributed to increase in protein content due to increase in soy milk (%), the protein content has been the dominant factor influencing adhesiveness of protein rich product of varying composition Chen *et al.* (1979) and also because of the fibrous texture formed by coagulated product, including milk Jain and Mhatre *et al.* (2009). The above results were in agreement with the results obtained by Jain and Mhatre *et al.* (2009); Uprit *et al.* (2004); Mhatre *et al.* (2008) and Muradia *et al.* (2010) respectively.

4. Gumminess (g)

Fig. 9 (a) shows the surface plot showing effect of incorporation of Soymilk (%) and the Coagulation Temperature (°C) on gumminess (g) of soy fortified cow milk *paneer*. The gumminess was in the range of 16.3 to 147.0 g. As the soymilk proportion increases (0-100%) the gumminess was found to be in increasing and decreasing trend. Similarly as the coagulation temperature (°C) increases from 75°C to 95°C the gumminess was found to be constant upto 85°C and then further decreases up to 90°C. It can be clear from the contour plot Fig. 9 (b) as both the soymilk proportion and coagulation temperature increases the gumminess was found to be decreased.

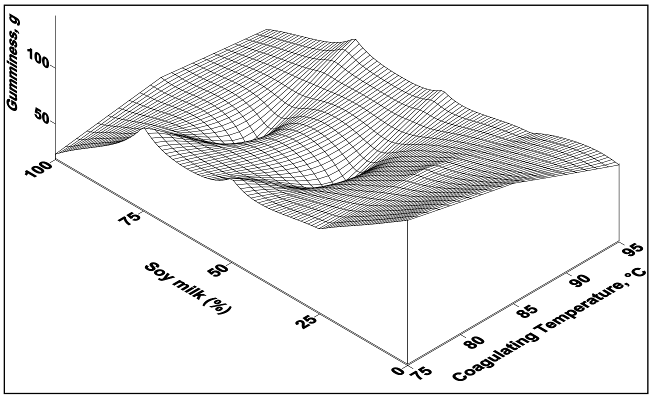

Fig. 9 (a): Surface plot showing the effect of incorporation of Soya milk (%) and Coagulation Temperature (°C) on gumminess of Soya fortified paneer

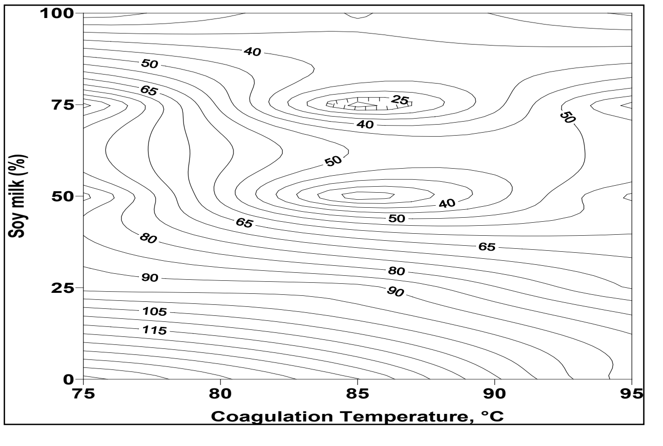

Fig. 9 (b): Contour plot showing the effect of incorporation of incorporation of Soya milk (%) and Coagulation Temperature (°C) on gumminess of Soya fortified *paneer*

The ANOVA for the effect of soy milk (%) and coagulation temperature (°C) on gumminess (g) of soy fortified cow milk *paneer*. It indicated that both soymilk (%) proportion and coagulation temperature (°C) had significant influence on gumminess of soy fortified *paneer* at p≤0.01. The interaction also has significant influence on the gumminess of *paneer* at p≤0.01. The equation (9) shows the second order polynomial equation fitted to the experimental data for gumminess (g). The equation was well fitted with $R^2 = 0.952$; $MSE = 5.05004 \times 10^2$.

$$G_m = 1498.32 - 3.2265 (S_m) + 0.0036 (S_m)^2 - 30.1501 (C_t) + 0.02359 (S_m \times C_t) - 0.16202 (C_t)^2 \quad R^2 = 0.952 \quad \ldots (9)$$

Where, G_m is gumminess, S_m is the soymilk (%) and C_t is the coagulation temperature.

Gumminess is the product of hardness and cohesiveness Chen *et al.* (1979). According to Bourne, (2002), gumminess is directly proportional to firmness, and therefore, gumminess decreases with reduced firmness. The above results were in agreement with the results obtained by Reeta *et al.* (2012) respectively.

5. Chewiness (g)

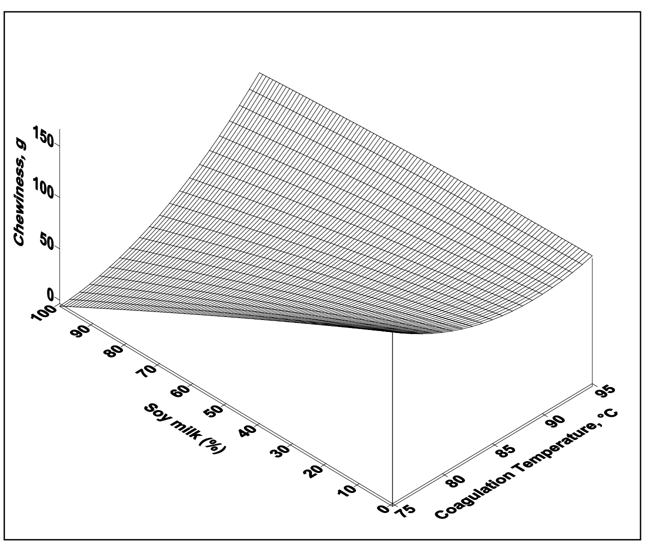

Fig. 10 (a): Surface plot showing the effect of incorporation of Soya milk (%) and Coagulation Temperature (°C) on Chewiness of Soya fortified *paneer*

Fig. 10 (a) shows the surface plot showing effect of incorporation of Soymilk (%) and the Coagulation Temperature (°C) on chewiness (g) of soy fortified cow milk *paneer*. The chewiness was in the range of 7.6 to 164.6 g. As the soymilk proportion increases (0-100%) the chewiness decreased. As the coagulation temperature (°C) increases from 75°C to 85°C the chewiness was found to decreased and again gradually increases with further increase in coagulation temperature up to 95°C. It can be clear from the contour plot Fig. 10 (b) as both the soymilk proportion and coagulation temperature increases the chewiness was found to be slightly increased.

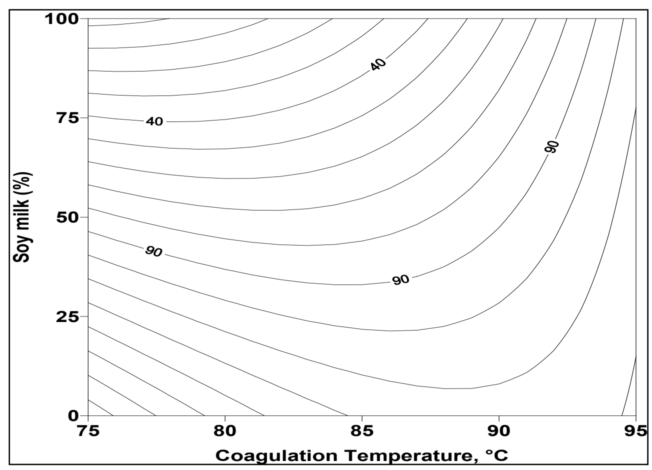

Fig. 10 (b): Contour plot showing the effect of incorporation of incorporation of Soya milk (%) and Coagulation Temperature (°C) on chewiness of Soya fortified *paneer*

The ANOVA for the effect of soy milk (%) and coagulation temperature (°C) on chewiness (g) of soy fortified cow milk *paneer*. It indicated that both soymilk (%) proportion and coagulation temperature (°C) had significant influence on chewiness of soy fortified *paneer* at p≤0.01. The interaction also has significant influence on the chewiness of *paneer* at p≤0.01. The equation (10) shows the second order polynomial equation fitted to the experimental data for chewiness (g). The equation was well fitted with $R^2 = 0.936$; $MSE = 1.13429 \times 10^3$.

$$C_h = 2128.9 - 7.3445 (S_m) - 0.0009 (S_m)^2 - 45.042 (C_t) + 0.07653 (S_m \times C_t) + 0.2516 (C_t)^2 \quad R^2 = 0.936 \quad \ldots (10)$$

Where, C_h is the chewiness, S_m is the soymilk (%) and C_t is the coagulation temperature.

The decrease in chewiness of soy fortified cow milk *paneer* as increases soymilk proportion from (0-100%) was due to typical fibrous texture of *paneer* (Mhatre *et al.* 2008). The chewiness is marginally higher with lower fat content in *paneer* (Kumar *et al.* 2011). The textural characteristics of the SFP were found to be affected negatively by both the variables fat and soy incorporation (Uprit *et al.* 2004). The above results were in agreement with the results obtained by Reeta *et al.* (2012); Kumar *et al.* (2011); Singh *et al.* (2015); Uprit *et al.* (2004); Mhatre *et al.*(2008); Muradia *et al.* (2010) and Mathare *et al.* 2009 for *paneer* samples of soy-cow milk i.e. 100:00, 75:25, 50:50, 25:75 and 00:100 respectively.

6. Cohesiveness

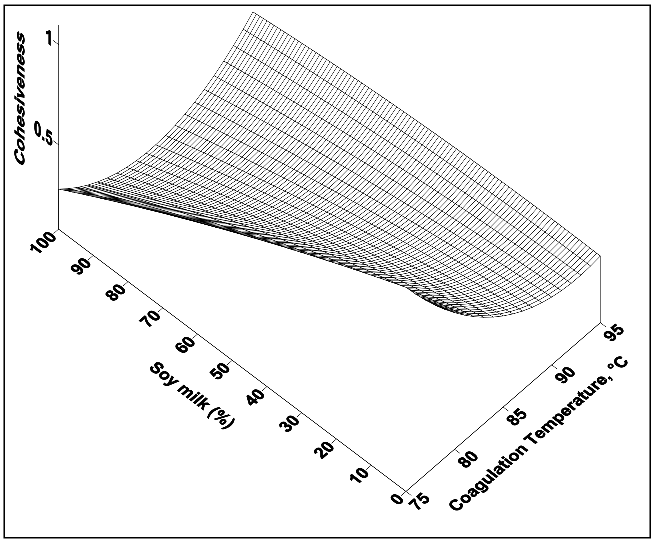

Fig. 11 (a) Surface plot showing the effect of incorporation of Soya milk (%) and Coagulation Temperature (°C) on cohesiveness of Soya fortified *paneer*

Fig. 11 (a) shows the surface plot showing effect of incorporation of Soymilk (%) and the Coagulation Temperature (°C) on cohesiveness of soy fortified cow milk *paneer*. The cohesiveness was in the range of 0.21 to 1.13 g. As the soymilk proportion increases (0-100%) the cohesiveness decreased. As the coagulation temperature (°C) increases from 75°C to 95°C the cohesiveness was found to decreased gradually. It can be clear from the contour plot Fig. 11 (b) as both the soymilk proportion and coagulation temperature increases the cohesiveness was found to be decreased.

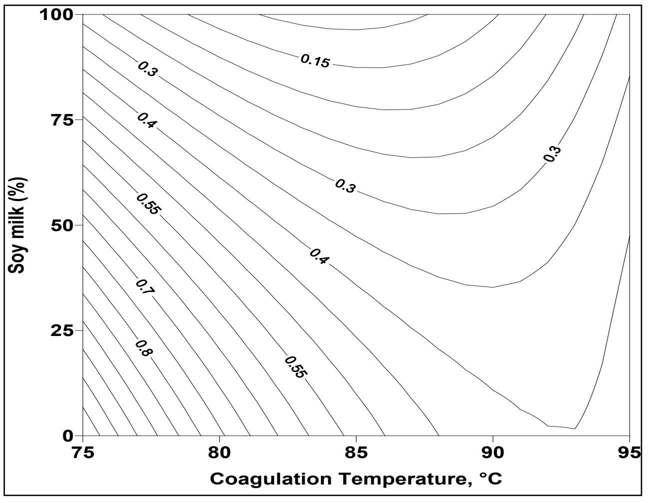

Fig. 11 (b): Contour plot showing the effect of incorporation of incorporation of Soya milk (%) and Coagulation Temperature (°C) on cohesiveness of Soya fortified *paneer*

The ANOVA for the effect of soy milk (%) and coagulation temperature (°C) on cohesiveness of soy fortified cow milk *paneer*. It indicated that soymilk (%) proportion had significant influence on cohesiveness of soy fortified *paneer* at $p \leq 0.01$ but coagulation temperature (°C) had no significant influence on cohesiveness of soy fortified *paneer* at $p \leq 0.01$. The interaction has significant influence on the cohesiveness of *paneer* at $p \leq 0.01$. The equation (11) shows the second order polynomial equation fitted to the experimental data for cohesiveness. The equation was well fitted with ($R^2 = 0.973$; $MSE = 0.0131$).

$$C_o = 19.4164 - 0.0342\,(S_m) - 0.00012\,(S_m)^2 - 0.4100\,(C_t) + 0.0003\,(S_m \times C_t) + 0.0022\,(C_t)^2 \quad R^2 = 0.973 \qquad \dots (11)$$

Where, C_o is the cohesiveness, S_m is the soymilk (%) and C_t is the coagulation temperatur.

The cohesiveness decreases as the coagulation temperature increases this might be due to the strength of internal bonding of the molecule of protein matrix which is strongest at 75°C and weakest at 95°C. The nature of protein matrix and extent of fat dispersion may contribute to cohesiveness or tendency to adhere itself Uprit *et al.* (2004). The results were in general agreement with the results obtained by Jain and Mhatre *et al.* (2009); Uprit *et al.* (2004); Mhatre *et al.* (2008); Muradia *et al.* (2010) for *paneer* samples of soy-cow milk i.e. 100:00, 75:25, 50:50, 25:75 and 00:100 respectively.

7. Stickiness (g)

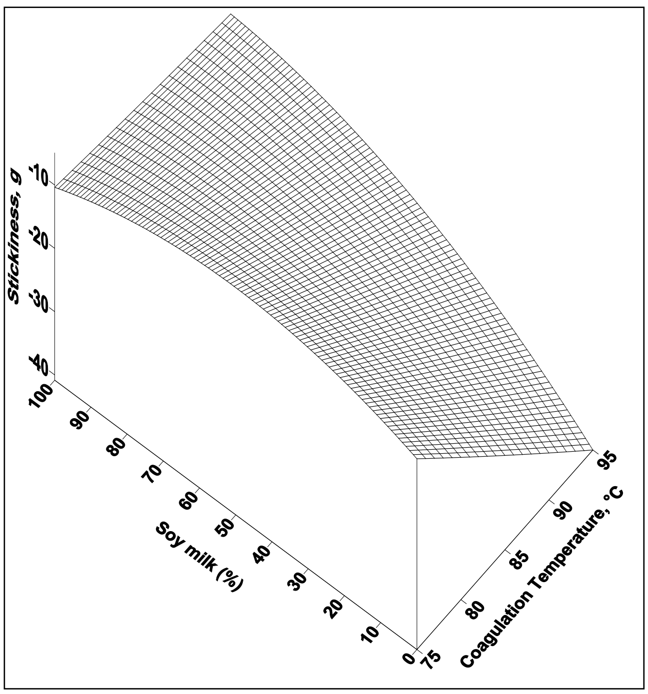

Fig.12 (a): Surface plot showing the effect of incorporation of Soya milk (%) and Coagulation Temperature (°C) on stickiness of Soya fortified *paneer*

Fig. 12 (a) shows the surface plot showing effect of incorporation of Soymilk (%) and the Coagulation Temperature (°C) on stickiness (g) of soy fortified cow milk *paneer*. The stickiness was in the range of -53 to -5 g. As the soymilk proportion increases (0-100%) the stickiness increases. As the coagulation temperature (°C) increases from 75°C to 95°C the stickiness was found to decreased linearly. It can be clear from the contour plot Fig. 12 (b) as both the soymilk proportion and coagulation temperature increases the stickiness was found to be increased slightly.

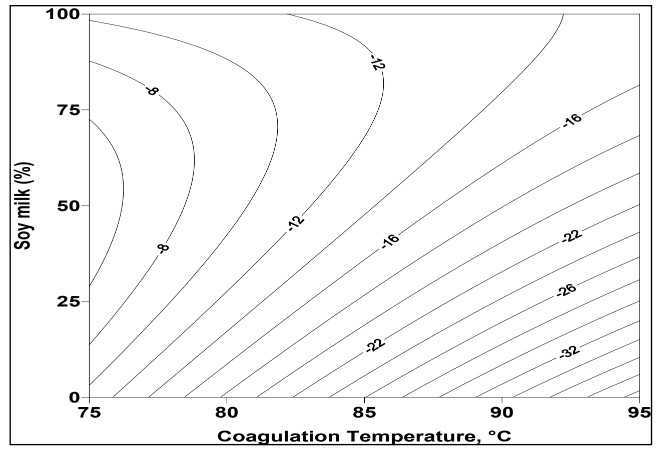

Fig. 12 (b): Contour plot showing the effect of incorporation of incorporation of Soya milk (%) and Coagulation Temperature (°C) on stickiness of Soya fortified *paneer*

Fig. 12 (a) shows the surface plot showing effect of incorporation of Soymilk (%) and the Coagulation Temperature (°C) on stickiness (g) of soy fortified cow milk *paneer*. The stickiness was in the range of -53 to -5 g. As the soymilk proportion increase (0-100%) the stickiness increases. As the coagulation temperature (°C) increases from 75°C to 95°C the stickiness was found to decrease linearly. It can be clear from the contour plot Fig. 12 (b) as both the soymilk proportion and coagulation temperature increases the stickiness was found to be increased slightly.

Table 1(g) shows the ANOVA for the effect of soy milk (%) and coagulation temperature (°C) on stickiness (g) of soy fortified cow milk *paneer*. It indicated that both soymilk (%) proportion and coagulation temperature (°C) has significant influence on stickiness of soy fortified *paneer* at $p \leq 0.01$. The interaction also has significant influence on the stickiness of *paneer* at $p \leq 0.01$. The equation (12) shows the second order polynomial equation fitted to the experimental data for stickiness (g). The equation was well fitted with ($R2 = 0.895$; $MSE = 6.986 \times 10^1$).

$$S_t = 114.145 - 0.7482\,(S_m) - 0.0022\,(S_m)^2 - 1.7890\,(C_t) + 0.0130\,(S_m \times C_t) + 0.001660\,(C_t)^2 \quad R^2 = 0.895 \quad \ldots(12)$$

Where, S_t is the Stickiness, S_m is the soymilk (%) and C_t is the coagulation temperature.

Bandyopadhyay *et al.* (2007) and Olson and Johnson, (1990) reported that reduce in fat content with high moisture, increases stickiness. Hence as soymilk proportion increases (0-100%) the stickiness increases. The results were in general agreement with the results obtained by for *paneer* samples of soy-cow milk i.e. 100:00, 75:25, 50:50, 25:75 and 00:100 respectively.

8. Whiteness Index

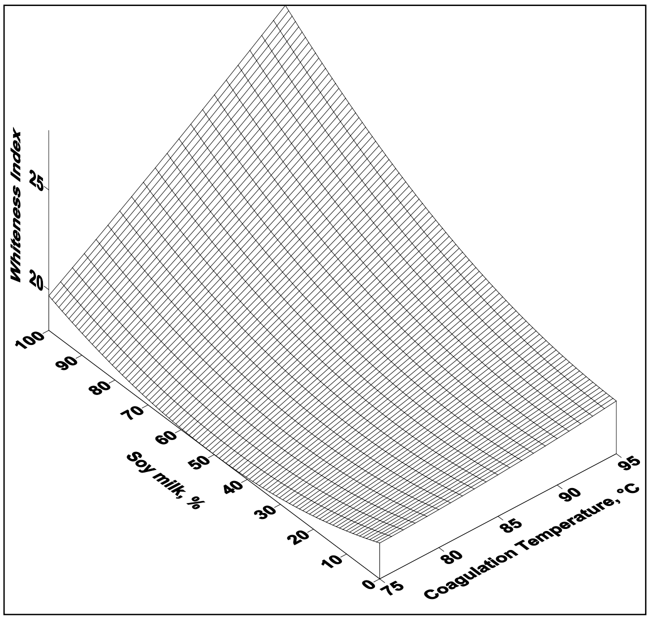

Fig. 13 (a): Surface plot showing the effect of incorporation of Soya milk (%) and Coagulation Temperature (°C) on whiteness index of Soya fortified *paneer*

Fig. 13 (a) shows the surface plot showing effect of incorporation of Soymilk (%) and the Coagulation Temperature (°C) on whiteness index of soy fortified cow milk *paneer*. The whiteness index was in the range of 16.15 to 28.08. As the soymilk proportion increases (0-100%) the whiteness index of soy fortified *paneer* decreases up to 50% and further again increases up to 100%. As the coagulation temperature (°C) increases from 75°C to 95°C the whiteness index goes on increasing till last temperature i.e. 95°C linearly. It can be clear from the contour plot Fig. 13 (b) as both the soymilk proportion and coagulation temperature increases the whiteness index was found to be increased.

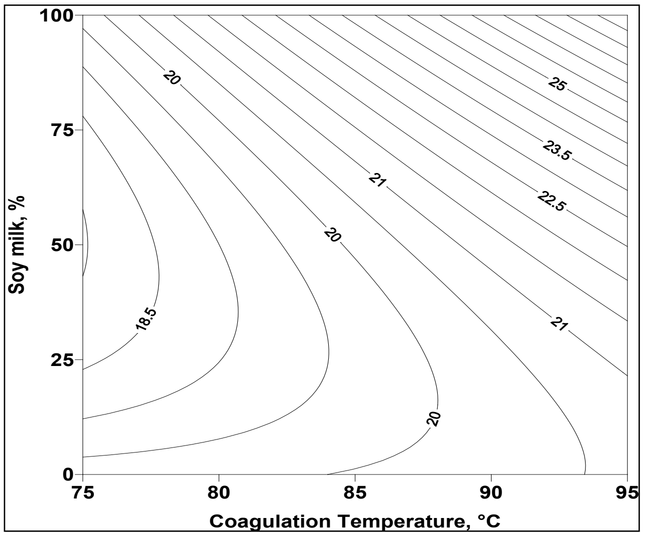

Fig. 13 (b): Contour plot showing the effect of incorporation of incorporation of Soya milk (%) and Coagulation Temperature (°C) on whiteness index of Soya fortified *paneer*

Table 1(h) shows the ANOVA for the effect of soy milk (%) and coagulation temperature (°C) on whiteness index of soy fortified cow milk *paneer*. It indicated that both soymilk (%) proportion and coagulation temperature (°C) had significant influence on whiteness index of soy fortified *paneer* at $p \leq 0.01$. The interaction also has significant influence on the whiteness index of *paneer* at $p \leq 0.01$. The equation (13) shows the second order polynomial equation fitted to the experimental data for whiteness index. The equation was well fitted with ($R^2 = 0.995$; $MSE = 3.636$).

$$W_i = 26.691 - 0.3499 (S_m) + 0.0007 (S_m)^2 - 0.1989 (C_t) + 0.0037 (S_m \times C_t) + 0.0014 (C_t)^2 \quad R^2 = 0.995 \quad \ldots (13)$$

Where, W_i is the whiteness index, S_m is the soymilk (%) and C_t is the coagulation temperature.

The pressure treatment before thermal treatment of peanut milk inactivated the enzymes responsible for browning in the product instantly making the *paneer* lighter in colour and at the same time showing less redness value which otherwise increase during browning of the product (Chauhan *et al.* 2015). The white color of the pH 5.0 cheese was attributed to the fact that the cheese pH was approaching the isoelectric point of caseins, which caused the casein molecules to aggregate and exhibit this white color (Lee *et al.* 2005). The results were in general agreement with the results obtained by Chauhan *et al.* 2015 respectively.

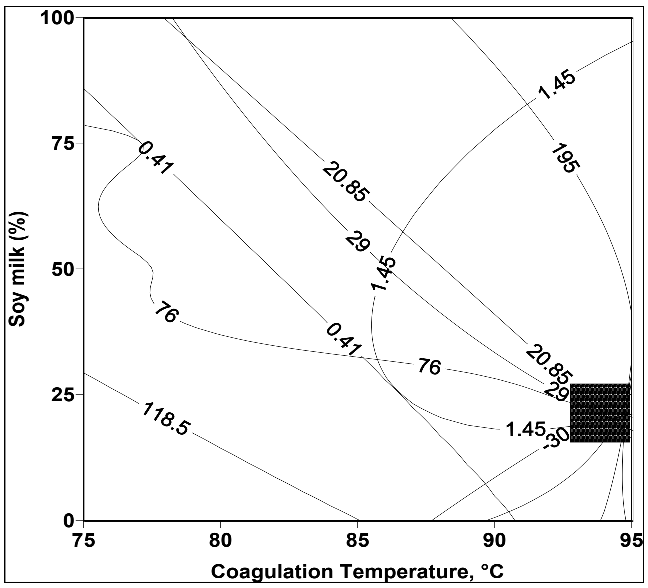

Fig. 14: Superimposed contour plot showing the optimum level of Coagulation Temperature and Soy milk proportion of Soy fortified cowmilk *paneer*

The desirable properties of *paneer*, maximum hardness, springiness, chewiness, stickiness and moderate adhesiveness, gumminess, cohesiveness and whiteness, based on the desirable properties the contour plots of hardness, springiness, adhesiveness, gumminess, chewiness, cohesiveness, stickiness and whiteness have been superimposed and the desirable properties at the superimposed contour plots are peak force 195g, springiness 1.45, adhesiveness 29, gumminess 76 g, chewiness 118.5 g, cohesiveness 0.41, stickiness -30 g and whiteness index 20.85 was observed at the Optimum Level. The soymilk (%) was 25:75 and coagulation temperature at the optimum level was 95°C respectively.

Sensory Analysis

The data obtained for sensory properties viz. flavor, body and texture, colour and appearance and package of *paneer* as per the BIS 15346:2003 of *paneer* determined by trained panel are givenin Table 2. The average flavor scores for fresh *paneer* ranged between 17.72 to 40.63. It can be seen from Table 3(a) that ANOVA for the effect of soy milk (%) and coagulation temperature (°C) on flavour of soy fortified cow milk *paneer*. It indicated that soymilk (%) proportion and coagulation temperature (°C) had no significant influence on flavour of soy fortified *paneer* at p≤0.01. The interaction also had no significant influence on the flavour of *paneer* at p≤0.01.

The average body and texture score for fresh *paneer* range between 16.63 to 26.72. It was seen from Table 3(b) shows the ANOVA for the effect of soy milk (%) and coagulation temperature (°C) on body and texture of soy fortified cow milk *paneer*. It indicated that both soymilk (%) proportion and coagulation temperature (°C) had no significant influence on body and texture of soy fortified *paneer* at p≤0.01. The interaction also had no significant influence on the body and texture of *paneer* at p≤0.01. The average color and appearance scores for fresh *paneer* range between 5.1 and 7.86. It can be seen from Table 3(c) shows the ANOVA for the effect of soy milk (%) and coagulation temperature (°C) on color and appearance of soy fortified cow milk *paneer*. It indicated that both soymilk (%) proportion and coagulation temperature (°C) had no significant influence on color and appearance of soy fortified *paneer* at p≤0.01. The interaction also had no significant influence on the color and appearance of *paneer* at p≤0.01.

The average packaging score for fresh *paneer* range between 2.6 and 4.53 respectively. It can be seen from Table 3(d) shows the ANOVA for the effect of soy milk (%) and coagulation temperature (°C) on packaging of soy fortified cow milk *paneer*. It indicated that soymilk (%) proportion and coagulation temperature (°C) had no significant influence on color and appearance of soy fortified *paneer* at p≤0.01. The interaction also had no significant influence on the color and appearance of *paneer* at p≤0.01.

Total score indicated that soy: cow milk proportion 100: 00, 75:25, 50:50, 25:75, 00:100 and coagulation temperature75°C, 85°C and 95°C, the sensory score was highest 64.31 with in combination criteria as

Table 2: Statistical Analysis of Textural parameters of Soy-fortified cow milk *paneer*

Parameter	Source of Variance	d.f.	Sum of squares	Mean Square	F_{cal}	F_{tab} 1%	Result
(a) Peak Force	(soy: cow milk) Composition (C_g)	4	127521.8	31880.44	132.7491	4.017877	Sig at 1 %
	Coagulation Temperature(C_t)	2	7271.511	3635.756	15.13917	5.390346	Sig at 1 %
	Interaction (C_t×C_T)	8	44673.16	5584.144	23.2522	3.172624	Sig at 1 %
	Error	30	7204.667	240.1556			
(b) Springiness	(soy: cow milk) Composition (C_g)	4	3.946822	0.986706	6.081349	4.017877	Sig at 1 %
	Coagulation Temperature(C_t)	2	0.964778	0.482389	2.973101	5.390346	Non Sig
	Interaction (C_t×C_T)	8	1.587244	0.198406	1.22283	3.172624	Non sig
	Error	30	4.867533	0.162251			
(c) Adhesiveness	(soy: cow milk) Composition (C_g)	4	2201.508	550.377	40.37974	4.017877	Sig at 1 %
	Coagulation Temperature(C_t)	2	328.0545	164.0273	12.03426	5.390346	Sig at 1 %
	Interaction (C_t×C_T)	8	6483.157	810.3947	59.45656	3.172624	Sig at 1 %
	Error	30	408.9009	13.63003			
(d) Gumminess	(soy: cow milk) Composition (C_g)	4	10211.47	2552.867	47.19762	4.017877	Sig at 1 %
	Coagulation Temperature(C_t)	2	889.6	444.8	8.2235	5.390346	Sig at 1 %
	Interaction (C_t×C_T)	8	54895.07	6861.883	126.8631	3.172624	Sig at 1 %
	Error	30	1622.667	54.08889			
(e) Chewiness	(soy: cow milk) Composition (C_g)	4	40824.36	10206.09	236.9835	4.017877	Sig at 1 %
	Coagulation Temperature(C_t)	2	4684.044	2342.022	54.38132	5.390346	Sig at 1 %
	Interaction (C_t×C_T)	8	69713.51	8714.189	202.3418	3.172624	Sig at 1 %
	Error	30	1292	43.06667			
(f) Cohesiveness	(soy: cow milk) Composition (C_g)	4	1.178556	0.294639	8.891329	4.017877	Sig at 1 %
	Coagulation Temperature(C_t)	2	0.027213	0.013607	0.410609	5.390346	Non Sig
	Interaction (C_t×C_T)	8	2.112898	0.264112	7.970125	3.172624	Sig at 1 %
	Error	30	0.994133	0.033138			
(g) Stickiness	(soy: cow milk) Composition (C_g)	4	2767.644	691.9111	8.521073	4.017877	Sig at 1 %
	Coagulation Temperature(C_t)	2	961.3778	480.6889	5.919814	5.390346	Sig at 1 %
	Interaction (C_t×C_T)	8	2239.289	279.9111	3.447181	3.172624	Sig at 1 %
	Error	30	2436	81.2			
(h) Whiteness index	(soy: cow milk) Composition (C_g)	4	194.3242	48.58106	432.8633	3.767427	Sig at 1 %
	Coagulation Temperature(C_t)	2	10.64251	5.321256	47.41305	5.110318	Sig at 1 %
	Interaction (C_t×C_T)	8	336.533	42.06663	374.8189	2.935341	Sig at 1 %
	Error	45	5.050435	0.112232			

Table 3: Sensory quality of soy-fortified cow milk *paneer*

Soy: cow milk	Coagulation temperature	Sensory responses				
		Flavor (50 marks)	Body and Texture	Colour and Apperance	Package	Total
100: 00	75°C	17.72	16.63	5.98	3.72	44.07
75:25	75°C	25.27	19.27	6.16	4.00	54.70
50:50	75°C	26.90	21.45	6.72	3.90	59.00
25:75	75°C	25.00	19.45	5.90	3.18	53.54
00:100	75°C	33.36	19.36	6.09	2.63	61.45
100: 00	85°C	25.54	22.09	5.99	4.52	58.15
75:25	85°C	23.27	21.27	5.1	3.98	53.62
50:50	85°C	26.09	20.90	7.04	3.90	57.95
25:75	85°C	27.00	19.72	6.50	3.18	56.40
00:100	85°C	30.54	25.36	7.00	3.83	66.74
100: 00	95°C	28.63	23.63	6.58	4.40	65.08
75:25	95°C	23.72	20.72	5.86	4.00	54.31
50:50	95°C	28.18	23.09	6.30	4.18	61.76
25:75	95°C	30.81	25.00	6.70	3.25	64.31
00:100	95°C	40.63	26.72	7.86	3.74	78.97
Market Sample		44.27	31.00	8.68	4.40	88.36

Table 4: Statistical Analysis of Sensory attributes of Soy-fortified cow milk *paneer*

Parameter	Source of Variance	d.f.	Sum of squares	Mean Square	F_{cal}	F_{tab} 1%	Result
(a) Flavour	(soy: cow milk) Composition (C_g)	4	1803.939	450.9848	2.367216	3.446745	Non Sig
	Coagulation Temperature(C_t)	2	544.9212	272.4606	1.430144	4.749493	Non Sig
	Interaction (C_t×C_T)	8	1767.442	220.9303	1.159662	2.631898	Non sig
	Error	150	28576.91	190.5127			
(b) Body and Texture	(soy: cow milk) Composition (C_g)	4	745.5515	186.3879	2.129778	3.446745	Non Sig
	Coagulation Temperature(C_t)	2	26.52121	13.26061	0.151524	4.749493	Non Sig
	Interaction (C_t×C_T)	8	362.2667	45.28333	0.517434	2.631898	Non sig
	Error	150	13127.27	87.51515			
(c) Colour and appearance	(soy: cow milk) Composition (C_g)	4	17.33903	4.334758	1.679902	3.446745	Non Sig
	Coagulation Temperature(C_t)	2	9.047394	4.523697	1.753124	4.749493	Non Sig
	Interaction (C_t×C_T)	8	38.26715	4.783394	1.853767	2.631898	Non sig
	Error	150	387.0545	2.580364			
(d) Package	(soy: cow milk) Composition (C_g)	4	7.273697	1.818424	1.065143	3.446745	Non Sig
	Coagulation Temperature(C_t)	2	1.488364	0.744182	0.435905	4.749493	Non Sig
	Interaction (C_t×C_T)	8	30.72921	3.841152	2.249956	2.631898	Non Sig
	Error	150	256.0818	1.707212			

compare with control sample. The score flavor, body and texture, colour and appearance and package was non significant at 1≤0.01. Form the sensory score it can be concluded that treatment soy: cow milk proportion 25:75 % and the coagulation temperature 95°C has the highest score resulted the best treatment average the all treatments.

Co-relation between the objective and subjective scores

The optimum product at from section 3.1 soymilk: cow milk proportion 25:75 and coagulation temperature 95°C the product achieved the desirable qualities i.e. hardness 164.66 (g), springiness 1.42, adhesiveness 39.26 (J), gumminess 69.33 (g), chewiness 110.66 (g), cohesiveness 0.47, stickiness -25.66 (g) and whiteness index 22.44 respectively.

The best sensory score of the product have been obtained from section 3.2 at soymilk: cow milk proportion 25:75 and at coagulation temperature 95°C, the product achieved the highest flavor 30.81, body texture 25.00, colour and texture 6.70 and package 3.25.

From both the instrumental texture profile analysis, colour measurement and the sensory the best product i.e. soy fortified cow milk based *paneer* could be prepared from soy: cow milk blend 25:75 and coagulation temperature 95°C.

CONCLUSION

The best quality of soy fortified with cow milk could prepare from the soy: cow milk proportion 25:75 and at coagulation temperature 95°C. The *paneer* produced by this combination had hardness 164.66 (g), springiness 1.42, adhesiveness 39.26 (J), gumminess 69.33 (g), chewiness 110.66 (g), cohesiveness 0.47, stickiness -25.66 (g) and whiteness index 22.44 with sensory score flavor 30.81, body texture 25.00, colour and texture 6.70 and package 3.25 respectively.

REFERENCES

Ali, N. 2016. Soy based health foods and pharmaceuticals strengthening protein security and health care. *Souvenir of National Conference on Innovative Food Processing Technologies for Food and Nutritional Security, CIPHET, Ludhiana* (Punjab), 1-6.

Amiot, J., Fournier, S., Lebeuf, Y., Paquin, P., Simpson, R. and Vignola C.L. 2002. (Ed.), Science et technologie du lait: Transformation du lait, Presses Internationales Polytechnique, Fondation de Technologie Laitière du Québec, pp. 1–73.

Anonymous, 2014. Soybean Update: International and Domestic Scenario, 2014.

Babaje, J.S., Rathi, S.D., Ingle, U.M. and Syed, H.M. 1992. Effect of blending soymilk with buffalo milk on qualities of *paneer*. *Journal of Food Science and Technology*, **29**: 119–120.

Bandyopadhyay, M., Chakraborty, R. and Raychaudhuri, U. 2007. Physical and sensory characteristics of low fat dairy dessert (Rasogolla) fortified with natural source of β-carotene, *Journal of Scientific and Industrial Research*, **66**: 757-763.

Bhattacharya, D.C., Mathur, O.N., Srinivasan, M.R. and Samlik, O. 1971. Studies on the method of production and shelf life of *paneer. Journal of Food Science and Technology*, **8**(5): 117–120.

BIS, 1983. Specification for *paneer*. IS 10484 *Bureau of Indian Standards.*, New Delhi, pp. 3–8.

BIS, 2003. Method for sensory evaluation of *Paneer*/Chhana. IS 15346, *Bureau of Indian Standards.*, New Delhi, pp. 1–3.

Bourne, M. 2002. Food Texture and Viscosity: Concept and Measurement. 2nd ed. San Diego: Academic Press, pp. 415.

Bryant, A., Ustunol, Z. and Steffe, J. 1995. Texture of Cheddar cheese as influenced by fat reduction. *Journal of Food Science*, **60**(6): 1216-1219.

Butool, M. and Butool, S. 2015. Studies on Carrot Incorporated Soypaneer. *International Journal of Development Research*, **5**(4): 4124-4130.

Chauhan, O.P., Kumar, S., Nagraj, R., Narasimhamurthy, R. and Raju, P.S. 2015. Effect of high pressure processing on yield, quality and storage stability of peanut *paneer*. *International Journal of Food Science and Technology*, **50**(6): 1515-1521.

Chen, A.H., Larkin, J.W., Clark, C.J. and Irwin, W.E. 1979. Textural analysis of cheese. *Journal of Dairy Science*, **62**(6): 901-907.

Fan, M.Z, Sauer, W.C. and de Lange, C.F.M. 1995. Amino acid digestibility in soyabean meal, extruded soyabean and full-fat canola for early-weaned pigs. *Animal Feed Science and Technology*, **52**: 189-203.

Fox, P.F. and Mc Sweeney, P.L.H. 2004. Cheese: chemistry, physics and microbiology. Vol. 1. General aspects. London: Elsevier Academic Press.

Gwartney, E.A., Foegeding, E.A. and Larick, D.K. 2002. The texture of commercial full-fat and reduced-fat cheese. *Journal of Food Science*, **67**(2): 812-816.

Jagannath, A., Ramesh, M.N. and Varadaraj, M.C. 2001. Response surface model for predicting the behavior of yersinia enterocolitica in *paneer*—a heat and acid coagulated milk product of India. *Acta Horticulturae*, **566**: 487–491.

Jain, S.K. and Mhatre, S.S. 2009. The textural properties of soy *paneer*. *International Journal of Dairy Technology*, **62**(4): 584-591.

Kanawjia, S.K. and Singh, S. 2000. Technological advances in *paneer* making. Indian *Dairyman*, **52**(10): 45–50.

Khan, S.U., Pal, M.A., Wani, S.A. and Salahuddin, M. 2011. Effect of different coagulants at varying strengths on the quality of *paneer* made from reconstituted milk. *Journal of Food Science and Technology*, (DOI 10.1007/s13197-011-0525-7)

Khodke, S., Pardhi, M., More, P. and Kakade, A. 2014. Characteristic evaluation of soy-groundnut *paneer*. IOSR *Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, **8**(9): Ver. II, 12-16.

Kumar, S.S., Balasubramanian, S., Biswas, A.K., Chatli, M.K., Devatkal, S.K. and Sahoo, J. 2011. Efficacy of soy protein isolate as a fat replacer on physico-chemical and sensory characteristics of low-fat *paneer*. *Journal of Food Science and Technology*, **48**(4): 498-501.

Lee, M.R., Johnson, M.E. and Lucey, J.A. 2005. Impact of modifications in acid development on the insoluble calcium content and rheological properties of Cheddar cheese. *Journal of Dairy Science*, **88**: 3798–3809.

Ling, E.R. 1956. A textbook of Dairy chemistry Volume I (Third edition revised) chapinam and I-Iall Ltd, London).

Mateos-Aparicio, I., Redondo Cuenca, A., Villanueva-Suárez, M.J. and Zapata-Revilla, M.A. 2008. Soybean, a promising health source. *Nutrición Hospitalaria,* **23**: 305 – 312.

Mathare, S.S., Bakal, S.B., Dissanayake, T.M.R. and Jain, S.K. 2009. Effects of coagulation temperature on the texture and yield of soy *paneer* (tofu). *Journal of the National Science Foundation of Sri Lanka*, **37**(4): 263-267

Mhatre, S.S., Jain, S.K., Murdia, L.K. and Jain, H.K. 2008. Effect of different coagulation temperature on texture and yield of soy *paneer* (Tofu). *International Journal of Food Engineering,* **4**(8): 1-14.

Murdia, L.K. and Wadhwani, R. 2010. Effect of processing parameters on texture and yield of tofu. *Journal of Agriculture and Food Industry*, **3**(2): 232-241.

Myers, R.H. 1971. Response Surface Analysis and design of experiments in block *In* R. H. Myers (Ed:) Response Surface Methodology (pp. 126-196) Boston: Myers and Bacon.

Olson, N.F. and Johnson, M.E. 1990. Light cheese products: characteristics and economics. *Food Technology (USA)*. **44**(10): 93-96.

Park, J.W. 1994. Functional protein additives in surimi gels. *Journal of Food Science,* **59**: 525-527.

Parmar, S.S., Singh, S. and Sharma, R.S. 1989. Compositional and quality characteristics of *paneer* made from soya beans and buffalo milk under different heat treatments. *Journal of the Science of Food and Agriculture*, **47**(4): 463-473.

Raja, J., Punoo, H.A. and Masoodi, F.A. 2014. Comparative Study of Soy *Paneer* Prepared from Soymilk, Blends of Soymilk and Skimmed Milk. *Journal of Food Processing and Technology,* **5**: 301.

Rao, K.V.S.S., Zanjad, P.N. and Mathur, B.N. 1992. *Paneer* technology: A review. *Indian Journal of Dairy Science*, **45**(6): 281-291.

Reeta, Kumar, A. and Kumbhar, B.K. 2012. Study of Sensory and Textural Properties of *Paneer* Using Edible Coating. *Open Access Scientific Reports,* **1**: 562.

Saio, K. 1979. Tofu-relationship between texture and fine structure. *Cereal Foods World,* **24**(8): 342-354.

Setchell, K.D. 1998. Phytoestrogens: the biochemistry, physiology, and implitations for human health of soil isoflavones. *The American Journal of Clinical Nutrition*, **68**: 1333S-1346S.

Singh, G., Kumar, A., Kumbhar, B.K. and Dar, B.N. 2015. Optimization of processing parameters and ingredients for development of low-fat fibre-supplemented *paneer*. *Journal of Food Science and Technology,* **52**(2): 709-719.

Sopade, P.A. and Obekpa, J.A. 1990. Modelling water absorption in soybean, cowpea and peanuts at three temperatures using Peleg's equation. *Journal of Food Science,* **55**(4): 1084-1087.

Sun, N. and Breene, W.M. 1991. Calcium sulfate concentration influence on yield and quality of tofu from five soybean verities. *Journal of Food Science*, **56**(6): 1604-1610.

Table of Taiwan Food Composition, 1971. Food Industry, Research and Development Institute, Hsincho, Taiwan.

Uprit, S. and Mishra, H.N. 2004. Instrumental Textural Profile Analysis of Soy Fortified Pressed Chilled Acid Coagulated Curd (*Paneer*). *International Journal of Food Properties,* **7**(3): 367–378.

Walstra, P., Wouters, J.T. and Geurts, T.J. 2006. Dairy science and technology. Boca Raton, FL, USA: Taylor and Francis Group.

Wang, H.L., Swain, E.W. and Kwolek, W.F. 1983. *Effect of soybean varieties on the yield and quality of tofu,* **60**(3).

Winarno, F.G. and Muchtadi, D. 1984. Appropriate technology in soybean utilization: its prospect for nutritional improvement program. *In:* "human Nutrition; Better Nutrition Better Life. Proceeding of the 4th Asian Congress of Nutrition" V. Tanphaichitr, A. Valyasevi, W. Dahlan, and V. Suphakarn, (Eds), Aksonsmai press, Bangkok, Thailand, pp. 461-467.

Yates, M.D. and Drake, M.A. 2007. Texture properties of Gouda cheese. *Journal of Sensory Studies*, **22**(5): 493-506.