Indian J Dairy Sci 72(6): 616-625
https://doi.org/10.33785/IJDS.2019.v72i06.006

RESEARCH ARTICLE

Assessing suitability of different forms of coconut for usage in manufacturing of *Paneer*-like soft cheese

Preeti Paul, Suneeta Pinto, Chetan Dharaiya, Mamata LChaudhary, Yashvantha R and Neha Vasava

Received: 03 August 2019 / Accepted: 30 September 2019 / Published online: 31 December 2019

Abstract: Coconut has been quietly gaining importance as a functional food around the world especially in south–east Asia. Being a good source of medium chain triglycerides, minerals and to some extent protein, it has been considered as one of the "superfoods". The objective of the present study was to develop a *paneer*-like soft cheese using milk and coconut milk solids to improve the quality of fat in the final product. The aim was to maintain the fat in *paneer* by mixing low fat milk (3.0% fat) with coconut milk solids, which is high in coconut fat. Four types of coconut milk solid sources viz. coconut milk powder (spray-dried), coconut milk (freshly extracted), UHT treated coconut milk and desiccated coconut shreds were used to prepare acid coagulated soft cheese. Based on sensory acceptability, coconut milk powder (6%) and UHT treated coconut milk (10%) were selected and used to prepare soft cheese which was eventually analyzed for its sensory, textural and compositional attributes. Improvement in the fatty acid profile was observed by analyzing control and developed product by GC-MS. Sensory evaluation was carried out using 9-point hedonic scale. All the data was statistically analyzed and interpreted using ANOVA.

Keywords: Coconut, Medium chain triglycerides, *Paneer*, Sensory evaluation, Texture

Dairy Technology Department, SMC College of Dairy Science, Anand Agricultural University, Anand, India

Chetan Dharaiya (✉)
Dairy Technology Department, SMC College of Dairy Science, Anand Agricultural University, Anand, India

Email: chetandharaiya@gmail.com; Mobile No.: +91 7573013697

Introduction

India is a country having a plethora of traditional dairy products. Products like khoa, chhana, *paneer*, burfi, kalakand, etc. are some of the most widely consumed traditional dairy products. *Paneer*, also known as Indian cottage cheese is one of the most versatile dairy products of our country. It is a source of good quality animal protein. The protein content in *paneer* ranges from 14 to 17%. This characteristic projects *paneer* to be a convenient source of protein in the diet for vegetarians. Other *paneer*-like products viz. tofu and cottage cheese are not well accepted in our country since Indian palate is more likely to prefer the taste of *paneer* and these products are not usually prepared in household kitchens. Moreover, the preparation of *paneer* involves less complicated steps. India's milk production increased by 6.6 per cent and was estimated to be 176.35 MMT during 2017-18. Milk production in the country which was 165.4 million tonnes during 2016-17 rose to 176.35 MMT (provisional) during 2017-18 (Anon, 2018). Out of this, an estimated 7 per cent of milk produced in India is converted to *paneer*. Due to the ever growing demand of *paneer* by people that are extremely health conscious, it becomes imperative to develop new types and varieties of *paneer* (Darji et al. 2015).

In recent times coconut has developed substantial interest in nutrition and is considered by many as a super food. It is also regarded as very healthy food in Ayurveda. Coconut is a rich source of nutritional components, especially fats. Coconut fats consist primarily of medium chain triglycerides (MCTs) (C12:0 and C14:0). In coconut fat about 50% of the fatty acids can be characterized as lauric acid. Lauric acid is recognized for its antiviral, antibacterial, and antiprotozoal properties. The digestion of these MCTs is very rapid and less complex as compared to long chain triglycerides. These MCTs are easily assimilated by the human body and do not contribute to fat deposits (Man and Manaf, 2006). MCTs are also preferred ergogenic aids for endurance athletes, runners and cyclists alike (Diwekar, 2016). The aqueous extract of the solid coconut endosperm is called coconut milk. The main carbohydrates present in the coconut milk are sugars (primarily sucrose) and some starch. It contains a small amount of water-soluble B vitamins and ascorbic acid (Seow and Gwee, 1997). The protein content of undiluted coconut milk ranges from 5 to 10% (on dry basis). A variety of minerals viz. calcium, copper, iron, potassium, magnesium, manganese, sodium, phosphorus and zinc can be found in coconut milk (Santos et al. 2014). Efforts have been made in the past to combine bovine milk and coconut milk to produce soft, fresh cheeses (Venkateswarlu, 2002). When a mixture of coconut milk and bovine milk is acid coagulated, it leads to development of a coagulum with a very soft and pasty body due to the differences in isoelectric point of proteins present in milk and coconut (Onsaard et al. 2005).Venkateswarlu (2002) reported that the rate of addition for coconut milk cannot exceed 10 % (w/w) of milk used for *paneer* making. The concept of adding only coconut oil to *paneer* milk, for enhancement of medium chain triglycerides involves homogenization of milk before *paneer* preparation. Homogenization is known to impair curd forming properties in *paneer* (Suthar et al. 2015). Therefore, instead of adding oil, other forms of coconut were tested for their suitability in this particular experiment. The objective of the present study was to select the most suitable source of coconut milk solids for manufacturing of a *paneer*-like soft cheese. Selection of the source of coconut solids for developed product depended on how similar the same is to conventional *paneer*.

Materials and Methods

Fresh, raw, chilled, mixed milk in variant (3.0 $\pm$ 0.07 % fat and 8.5 $\pm$ 0.08 % MSNF) obtained from Vidya Dairy, Anand, Gujarat (India) was used as the base material for manufacturing of the product. Packaged spray dried coconut milk powder and UHT processed coconut milk were procured from two different brands each. Fresh coconuts and desiccated coconut shreds were purchased from local market of Anand town. 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. Citric acid was supplied by Loba-Chemical Pvt. Ltd.

Preparation of Coconut Flavoured Soft Cheese (CFSC)

The product was prepared by modification of *paneer*-making method as suggested by Aneja et al. (2002). Mixed (cow and buffalo) milk (3.0 % fat) was blended with either coconut milk or coconut milk powder. Calcium chloride was added at the rate of 0.03 g/100 ml milk. For coconut milk powder, hydration time of 60 min was fixed in order to ensure proper dissolution in the milk. In the case of coconut milk, this step was omitted. The mixture of milk and coconut products was heated at 90 ^{0}C for 5 min and brought to 80^{0}C. Citric acid (2% solution at 80 ^{0}C) was added to milk with slow stirring until clear whey separated out. The coagulum was allowed to settle for 5 min and then filtered out using a clean muslin cloth. The coagulum was then filled in sanitized *paneer* hoops and pressed for 15 min by applying a pressure of 1.5 – 2.0 kg/cm^2. The product was removed from the *paneer* hoop and immersed in pasteurized chilled water (3 to 4^{0}C) for 2-3 h. 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).

Physico-Chemical analysis

The moisture content in soft cheese was determined according to IS (1983) procedure specified for *Paneer* under IS: 10484.The fat content of the cheese was determined as per the procedure described in IS: 2311 (1963). Titratable acidity was determined by the procedure as described by Boghra and Rajorhia (1982). The pH of *Paneer* was determined by blending 10g of *Paneer* with 10 ml of glass distilled water and dipping the electrode directly into the slurry as per the procedure followed for Cheddar cheese by O' Keeffe *et al*. (1975). 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).

Sensory Evaluation

Each block of CFSC was cut into rectangular pieces of approximately 25 g and tempered to 10$\pm$2°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, having equal no. of males and females, i.e. 5. There were 2 males and females each below 30 years; 2 males and females each between 30 and 45 years while 1 male and female each above 45 years. 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 9- point hedonic scale.

Textural Analysis

Compression testing of product samples was carried out using a texture analyzer (Lloyd Instrument, Hampshire, UK (Model No. 01/2962) using the following settings :

Load cell: 5 KN

Test Speed: 20 mm/min

Compressive load limit: 4900 N

Tensile load limit: 4000 N

Trigger force: 10 gf.

Tempering of the *paneer* samples was carried out for an hour at 23±1ºC before texture measurement. All the textural measurements were conducted in a room maintained at 23±1ºC temperature and 55 ± 1% relative humidity. Cubic samples of the experimental *Paneer*, with edges of 2.0±0.08 cm, were placed in the compression support plate. The cubic samples were compressed up to 70.0% of their initial size. Five cubic samples were used for each test sample and the average value of these readings was reported. The textural characteristics of the samples were obtained as a load vs. time graph (Kgf vs. seconds) as well as in tabular form.

Statistical analysis

The data obtained during this investigation were statistically analyzed employing completely randomized design (CRD) model proposed by Steel and Torrie (1980). The results were checked at 5 % level of probability.

Results and Discussion

The present investigation involved assessing the suitability of selected forms of coconut in the formulation of an acid coagulated *paneer* -like coconut flavoured soft cheese (CFSC) and their effect on the compositional, textural and sensory parameters.

Selection of source of coconut solids

Four products of coconut were tested for incorporation into CFSC viz. freshly prepared coconut milk, commercially available coconut milk, desiccated coconut shreds and coconut milk powder.

Maintaining the same fat content in milk, these coconut sources were used to prepare coconut flavoured soft cheeses to check their respective acceptability. Rates of addition were based on previously published literature regarding similar products (Venkateswarlu, 2002; Davide, 1988 ; Chauhan, 2016) All the four products were prepared three times and subjected to preliminary sensory evaluation by a panel of 10 judges. Each judge was asked to rate the product based on the overall acceptability. Results have been presented in Table 1.

Before preparation of the soft cheese, each coconut source was mixed with the milk. It was found that use of desiccated coconut shreds resulted in release of free fat which floated on the surface of milk. This led to fat loss through drainage of whey. Therefore, desiccated coconut shreds were not considered in the further study.

For manufacture of CFSC, freshly extracted coconut milk was also not considered because of the inherent variations in flavor and consistency existing between coconuts with every trial. Moreover, in a tropical climate, manual extraction of fresh coconut milk in a lab setup involves a risk of microbial spoilage and oxidation of fat, if immediate processing is not carried out. Therefore, two sources of coconut viz. commercially available coconut milk and coconut milk powder were screened for their suitability for use on CFSC.

Four brands of commercially available coconut milk powder were screened and on the basis of ranking test two brands viz. CMP1 and CMP2 were selected on the basis of sensory evaluation. Similarly three brands of commercially available coconut milk were screened, and on the basis of ranking test for preference, two brands viz. CCM1 and CCM2 were selected.

All the different forms of coconut were analyzed for their fat, protein, ash and moisture content. The average composition of coconut products used in this experiment is presented in Table 2

Table 1 Effect of different sources of coconut solids on organoleptic quality of coconut flavoured soft cheese

Source of coconut solids	Rate of addition (kg/100 kg milk)	Preference based on organoleptic evaluation	Observations
Coconut milk (freshly extracted)	10	++	Pleasant sweet flavor of coconut, high moisture, crumbly body, lacked smoothness and springiness, fat loss observed in the whey
Coconut milk (UHT treated)	10	++	Pleasant coconut flavor but with a faint rancid taste, crumbly body, high moisture, richness in the mouthfeel, less fat in whey
Desiccated coconut shreds	3	-	Lack of smooth mouthfeel, absence of richness, no cohesiveness in the texture, very high amount of fat expelled with whey
Spray dried coconut milk powder	6	+++	Pleasing coconut flavor, crumbly body but smooth mouthfeel, with respect to texture, closest to conventional paneer, least fat loss in whey

++++ Highly acceptable +++ Acceptable ++ Moderately acceptable +Slightly acceptable - Not acceptable

Paneer, which was prepared using standardized milk (4.5% fat) without addition of coconut, was served as control (C). The experimentation involved preparation of 5 batches of CFSC viz. C, CMP1, CMP2, CCM1 and CCM2. For preparation of CFSC, the rate of addition of coconut milk powder and commercially available coconut milk were 6% w/w and 10% w/w of milk respectively. These levels were selected based on preliminary trials and reports available in literature (Venkateswarlu, 2002; Davide 1988).The method described by Aneja *et al.* (2002) was slightly modified and used for manufacture of CFSC. Each treatment was replicated 4 times.

Influence of different sources of coconut solids on the compositional attributes of CFSC

As shown in Table 3, the average fat values ranged from 22.20% (C) to 29.16% (CMP2). FDM ranged from 50.75% (C) to 62.41% (CMP2). Moisture content ranged from 52.23% (CMP1) to 56.26% (C). The control sample had the least fat and FDM content and highest moisture content. Source of coconut solids was found to have a significant ($P<0.05$) effect on fat content. Fat content of C was significantly ($P<0.05$) lower than all the other samples studied. The fat content of CMP1 was significantly ($P<0.05$) higher than CMP2. At the same time, fat contents of CCM1 and CCM2 were also significantly different ($P<0.05$) to each other. Incorporation of coconut milk and coconut milk powder lead to higher fat content in CFSC compared to control *paneer*. This could be attributed to the high fat content in coconut milk i.e. 17.95-19.09% and coconut milk powder i.e. 58.14-62.98 %. Increase in the amount of coconut milk was attributed to increase in the % fat content of *paneer* samples prepared using a combination of buffalo milk and fresh coconut milk (David, 2012). Thus, the results obtained for fat are in agreement with those reported in literature.

FDM content of C was significantly lower ($P<0.05$) than that of all the other samples analyzed. FDM content of CMP1, CMP2, CCM1 and CCM2 were significantly different ($P<0.05$) as compared to each other. FDM content of Control was significantly ($P<0.05$) lower than all other samples (Table 3).

Moisture content of control was significantly ($P<0.05$) higher than that of other samples. Moisture content of CCM1 and CCM2 were statistically similar ($P>0.05$) to each other. For the samples C, CMP1 and CMP2, moisture content was statistically ($P<0.05$) different for all the samples. It can be seen from the observations that moisture content of samples prepared using coconut milk powder (CMP1 and CMP2) had a lower moisture content than the samples made using commercially available coconut milk (CCM1 and CCM2). Similar results have been demonstrated by Venkateswarlu (2002), wherein there has been a reduction in moisture content as the amount of coconut milk increases while preparing *paneer* using a blend of skim milk and coconut milk.

The pH values of experimental samples depicted in Table 3 reveal that pH values of different samples vary between 5.16 (CMP2) to 5.33 (C). Amongst different sources of coconut solids studied, C had significantly ($P<0.05$) the highest pH value of 5.33 as compared to CMP1 (5.19), CMP2 (5.16), CCM1 (5.22) and CCM2 (5.23). The differences in values can be linked to the buffering capacity of milk and also to difference in the quantities of citric acid added to each sample.

Table 2 Average composition of coconut products

Coconut source	Moisture (%)	Fat (%)	Protein (%)	Ash (%)
CMP1	2.05±0.07	58.14±0.06	12.17±0.13	3.03±0.06
CMP2	3.25±0.34	62.98±0.31	8.64±0.38	3.22±0.03
CCM1	78.32±1.46	17.95±0.10	1.79±0.06	0.84±0.05
CCM2	76.23±0.01	19.09±0.21	1.71±0.05	0.60±0.02

*Average of 3 trials; CMP – Commercially available Coconut Milk Powder, CCM – Commercially available UHT coconut milk

Table 3 Influence of different sources of coconut solids on the average composition, pH and acidity of CFSC samples

Sources of Coconut solids	Fat (%)	FDM (%)	Moisture (%)	pH at 25 ^{0}C	Acidity (% LA)
Control (C)	22.20±0.40^a	50.75±0.89^a	56.26±0.21^d	5.33±0.05^b	0.409±0.02
CMP1	28.40±0.52^d	59.44±0.88^d	52.23±0.27^a	5.19±0.08^a	0.419±0.03
CMP2	29.16±0.34^e	62.41±1.48^e	53.26±0.71^b	5.16±0.03^a	0.411±0.02
CCM1	25.02±0.44^b	55.66±0.87^b	55.05±0.85^c	5.22±0.03^a	0.408±0.02
CCM2	26.14±0.40^c	57.65±1.37^c	54.65±0.79^c	5.23±0.06^a	0.414±0.02
SEm	0.21	0.56	0.31	0.03	0.01
CD (0.05)	0.64	1.70	0.94	0.08	NS
CV %	1.64	2.98	1.14	1.00	4.78

Each observation is a mean ± SD of four replicate experiments (n=4); $^{a-e}$Superscript letters following numbers in the same column denote significant difference ($P<0.05$)

The values pertaining to acidity of CFSC as depicted in Table 4.2 reveal that acidity of the samples ranged from 0.408 % LA (CCM1) to 0.419 % LA (CMP1). These values were found to be statistically similar (P>0.05) to each other. Similar results were reported by Venkateswarlu (2002), who reported that acidity increased in *paneer* when amount of coconut milk added to the blend of coconut milk and skim milk increased.

Influence of different sources of coconut solids on the textural attributes of CFSC

The influence of different sources of coconut solids on the textural attributes of coconut flavoured *paneer*-like soft cheese is presented in Table 4. The hardness (N) value range from 7.79 N (CCM1) to 12.15 N (C). On comparing with control, samples prepared using coconut milk powder exhibited similar hardness values. Samples prepared using coconut milk showed hardness values less than control. Hardness values of control and CMP1 are statistically (P>0.05) at par with each other and significantly (P<0.05) higher than the other samples. Hardness value of CMP2 was significantly (P<0.05) lower than CMP1. Hardness of CCM1 was the lowest (P<0.05) among all the samples. As observed in Table 4, moisture content of samples prepared using coconut milk powder (viz. CMP1 and CMP2) were less than that prepared using commercial coconut milk (viz. CCM1 and CCM2). The lower hardness in coconut milk paneer could be attributed to lower iso-electric point of coconut protein, i.e. around 3.5 (Tangsuphoom and Coupland, 2008) which resulted in higher moisture and ultimately lower hardness.

Cohesiveness values of samples lie between 0.31 (CCM2) to 0.41 (Control) as depicted in Table 4. Cohesiveness was observed to be highest for the control. Cohesiveness values of control, CMP1 and CCM1 were at par (P>0.05) with each other. Also cohesiveness of CMP1, CMP2 and CCM1 were also similar (P>0.05) to each other. Similarly cohesiveness of CMP2, CCM1 and CCM2 were also statistically (P>0.05) similar to each other. Data pertaining to cohesiveness indicates that all the samples containing coconut solids were less cohesive as compared to the control. The reason could be introduction of coconut solids into the milk. The proteins present in coconut milk have a different iso-electric point pH as compared to casein (Samson et al.1971; Balchandran and Arumughan,1992). Consequently, the coagulum fails to fuse together completely into a uniform body, because of the disconnected linkages between the caseins, due to presence of coconut solids. This could have lead to a less cohesive product. No reports are available in literature for comparison of cohesiveness of CFSC with a similar product.

Springiness of the samples ranged from 5.79 mm (Control) to 6.40 mm (CMP2). Springiness of the control sample was statistically (P>0.05) similar to CCM2. Other samples viz. CMP1, CMP2 and CCM1 had springiness values at par (P>0.05) with each other. There was slight increase in springiness in samples containing coconut milk powder (viz CMP1 and CMP2) compared to samples containing coconut milk (viz. CCM1 and CCM2). This can be linked to increased hardness as explained previously in this section. Springiness follows the same trend as that of hardness. Coconut milk powder addition led to increased values for both hardness and springiness.

As depicted in Table 4, it can be seen that gumminess values range from 2.68 N (Control) to 4.91 N (CMP2). It can be observed from Table 4 that gumminess values of CMP1 and CMP2 are statistically (P>0.05) at par with each other. Gumminess values of both samples prepared using coconut milk powder are significantly (P<0.05) higher than those prepared using coconut milk powder. The reason for these values could be additives added to the coconut milk powder. Ingredients like maltodextrins and caseinates are added to coconut milk powder to stabilize emulsions post reconstitution (Matsuura et al. 2015). They have a tendency to bind more moisture and result in a gummy product. Moreover, coconut proteins are known to have superior emulsion properties (Tangsuphoom and Coupland, 2009). Comparatively gumminess is less in the samples prepared form coconut milk since they do not contain any of the aforementioned ingredients.

Chewiness values associated with the control and with samples prepared using coconut milk are lower than the values belonging to samples prepared using coconut milk powder (Table 4). Chewiness values of control (16.47 Nmm), CCM1 (19.62 Nmm) and CCM2 (18.62 Nmm) are statistically (P>0.05) at par with each other. Chewiness of both the samples made using coconut milk powder (viz. CMP1 and CMP2) were statistically (P>0.05) similar to each other. The higher values of chewiness observed in such samples may be associated with reduced moisture, increased hardness and high springiness of the samples containing coconut milk powder as seen in Table 4.

As seen in Table 4, adhesiveness values were highest for CMP2 (0.50 Nmm) and lowest for control (0.40 Nmm). Adhesiveness values for CMP2 and CCM1 are statistically (P>0.05) similar to each other. There is no significant (P>0.05) difference between adhesiveness values of CMP1 and CCM2. None of the experimental samples are comparable to the control value of adhesiveness since it has the least value. Increased adhesiveness was observed in samples containing coconut solids. The sugars present in coconut could have caused the increase in adhesiveness of the experimental samples. Published data on influence of addition of coconut solids on textural attributes of CFSC is not available for comparison.

Effect of different sources of coconut solids on fat and TS recovery, amount of coagulant used and yield of CFSC

The data on average recovery of these particular in CFSC as affected by incorporation of two types of coconut solids viz. coconut milk powder and coconut milk is presented in Table 5.

The ranges of mean values for recovery for fat and TS were 97.08 % (C) to 98.67 % (CMP2) and 57.38 % (C) to 61.69 % (CMP2) respectively.

From the table, it is clear that recovery of fat in CMP2 is statistically (P>0.05) at par with CMP1 and CCM2. Control sample had statistically similar (P>0.05) fat recovery as compared to CMP1, CCM1 and CCM2. Total solids recovery for control was statistically (P<0.05) different than all the other samples. Recovery of total solids was statistically (P>0.05) at par for CCM1 and CCM2. Total solids recovery for CMP1 and CMP2 was also statistically similar (P>0.05) to each other. Table 5 also shows that amount of coagulant used for coagulation of CCM1 and CCM2 was significantly (P<0.05) higher than that used for samples prepares using coconut milk powder. Control (C) used the least amount (P<0.05) of citric acid for coagulation.

The higher fat recovery in CMP1 and CMP2 could be ascribed to higher quantity of fat retained in the product because of addition of coconut milk powder which already contains high amount of fat (58.14 to 62.98 % fat). Coconut proteins are known to have superior emulsification properties (Tangsuphoom and Coupland, 2009). Their presence might have led to better recovery of fat. Addition of caseinates in the coconut milk powder might also have imparted a stronger framework to the coagulum leading to improved fat recovery.

Higher TS recovery observed in CMP1 and CMP2 could be due to addition of coconut solids, over and above the existing total solids in the milk since coconut milk powder was added @ 6 % in CMP1 and CMP2. In case of CCM1 and CCM2, addition of coconut milk led to dilution of the mixture. As a result the recovery of total solids in CCM1 (44.59 %) and CCM2 (44.36 %) is less than that of control C (57.38 %).

Yield (kg/100 kg) values for C and CCM2 were (P>0.05) at par with each other. Similarly, product yields for CCM1 and CCM2 were statistically similar to each other (P>0.05). Yield obtained when coconut milk powder was used as a source of coconut solids i.e. CMP1 and CMP2 was statistically (P>0.05) at par with each other and was significantly (P<0.05) higher than all the other experimental samples. Yield of *paneer* is dependent on the initial total solid content of milk and also on the pressure applied to extract whey after coagulation (Spurgeon et al. 1981). When

Table 4 Influence of different sources of coconut solids on the textural properties of CFSC

Sources of Coconut solids	Rheological properties					
	Hardness (N)	Cohesiveness	Springiness (mm)	Gumminess (N)	Chewiness (Nmm)	Adhesiveness (Nmm)
Control	12.15±0.43^{a}	0.41±0.01^{a}	5.79±0.08^{b}	2.68±0.17^{b}	16.47±0.29^{b}	0.40±0.01^{c}
CMP1	12.07±0.57^{a}	0.39±0.003^{ab}	6.38±0.26^{a}	4.49±0.13^{a}	28.69±1.93^{a}	0.44±0.03^{b}
CMP2	10.97±0.70^{b}	0.34±0.04^{bc}	6.40±0.06^{a}	4.91±0.02^{a}	29.96±1.33^{a}	0.50±0.01^{a}
CCM1	7.79±0.20^{d}	0.36±0.05^{abc}	6.16±0.21^{a}	2.95±0.61^{b}	19.62±3.24^{b}	0.49±0.02^{a}
CCM2	9.41±0.30^{c}	0.31±0.02^{c}	6.09±0.11^{ab}	2.99±0.13^{b}	18.62±0.87^{b}	0.45±0.01^{b}
SEm	0.33	0.02	0.11	0.21	1.30	0.01
CD (0.05)	1.03	0.06	0.36	0.65	4.09	0.04
CV g/100g	5.40	9.21	3.21	9.99	9.91	4.71

Each observation is a mean ± SD of four replicate experiments (n=4); $^{a\text{-}c}$Superscript letters following numbers in the same column denote significant difference (P<0.05)

Table 5 Influence of different sources of coconut solids on fat recovery and total solids recovery and amount of coagulant used for manufacture of CFSC

Sources of Coconut fat	Amount of Coagulant Used (g citric acid / kg milk)	Percent recovery		Yield (kg/100 kg milk)
		Fat	Total Solids	
Control (C)	1.48±0.05^{c}	97.08±0.96^{b}	57.38±0.83^{b}	16.36±0.27^{a}
CMP1	1.71±0.02^{b}	98.52±0.57^{ab}	61.92±0.43^{a}	21.34±0.47^{c}
CMP2	1.74±0.04^{b}	98.67±0.35^{a}	61.69±0.40^{a}	21.59±0.38^{c}
CCM1	3.07±0.13^{a}	97.65±0.46^{b}	44.59±0.54^{c}	16.84±0.15^{ab}
CCM2	3.01±0.10^{a}	97.95±0.55^{ab}	44.36±0.39^{c}	16.73±0.28^{b}
SEm	0.04	0.31	0.27	0.16
CD (0.05)	0.12	0.93	0.82	0.50
CV g/100g	3.64	0.63	1.01	1.78

Each observation is a mean ± SD of four replicate experiments (n=4); $^{a\text{-}c}$Superscript letters following numbers in the same column denote significant difference (P<0.05)

Fig. 1 Chromatogram of Control

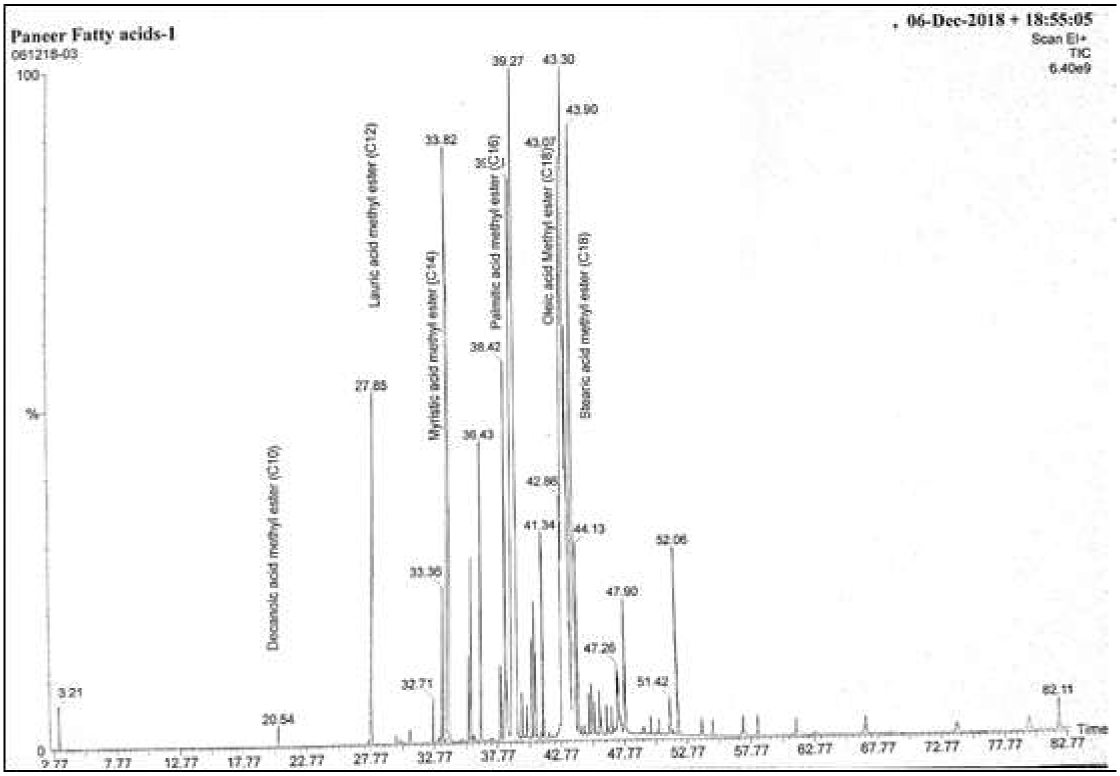
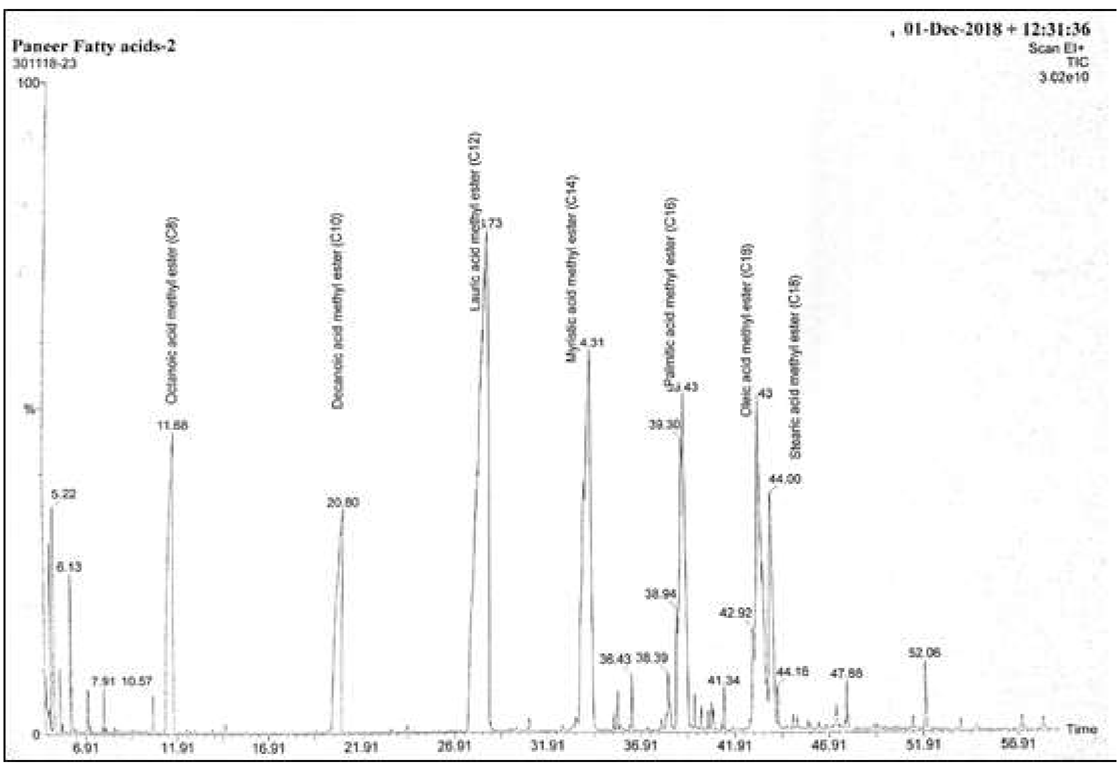


Fig. 2 Chromatogram of CFSC



coconut solids were added to mixed milk before preparing CFSC, an increase in the solids content was observed. In the case of coconut milk powder (CMP1 and CMP2), added powder contains approximately 96 g total solids per 100 g powder. This could be the reason behind higher yield of the final product. Published data on the recovery of fat and total solids as affected by addition of coconut milk solids are not available for comparison.

The average values of coagulant used for different samples were found to vary from 1.48 (C) to 3.07 g citric acid/kg milk for sample at a coagulation temperature of 75°C. It can be seen from Table 5 that there was an increase in amount of coagulant used for sample prepared using coconut milk as a source of coconut solids. Addition of coconut milk resulted in increase in the volume of the mixture. Larger volume of milk would require higher amount of citric acid. Published data on amount of coagulant used for making coconut flavoured *paneer* like soft cheese as affected by different types of coconut milk solids is not available for comparison.

Effect of different sources of coconut products on sensory attributes of CFSC

Desai (2007) described the desirable sensory attributes for *Paneer* as a characteristic blend of flavour of heated milk and acid i.e. pleasant, nutty, mildly acidic and sweet. Good quality *paneer* is expected to have a slightly springy body with a firm and cohesive close-knit texture that yields in a velvety body while cutting and at the same time does not resist mastication. Ideally *paneer* made from mixed milk should have a clean smooth crack free surface with a creamy white colour. The average sensory scores (using a 9 point hedonic scale score card) of CFSC incorporated with different sources of coconut solids is presented in Table 6. The average flavour scores ranged from 8.03 (C) to 6.75 (CCM2). The flavour score of control was significantly (P<0.05) higher compared to all the experimental samples. The flavour scores of samples containing coconut milk powder viz. CMP1 and CMP2 were significantly (P<0.05) higher compared to samples containing coconut milk viz. CCM1 and CCM2.

The reduction in flavour scores of CFSC containing coconut solids could be attributed to absence of milk fat in the final product. Milk fat imparts a characteristic richness to *paneer*. As the experimental samples contain 10 % coconut milk (w/w) (CCM1 and CCM2) and 6 % coconut milk powder (w/w) (CMP1 and CMP2), milk fat content decreases. CFSC samples made with coconut milks scored least compared to all the other samples. Venkateswarlu (2002) while studying the effect of addition of coconut milk at different levels viz. 10 to 20 % for manufacture of coconut milk *paneer* also reported a decline in flavour scores of *paneer* containing coconut milk.

From Table 6 it can be observed that the body and texture scores of all the experimental samples were lower than control. Control sample obtained the highest score of 8.23. Experimental samples prepared using coconut milk powder viz. CMP1 and CMP2 scored 7.47 and 7.27 respectively which was found to be significantly (P<0.05) lower than control. CFSC samples utilizing commercially available coconut milk scored the least. Scores obtained by CCM1 and CCM2 were 6.83 and 6.73 respectively. Although these scores were statistically at par (P<0.05) with each other, they were significantly (P<0.05) lower than control sample as well as experimental samples containing coconut milk powder as the source of coconut solids viz. CMP1 and CMP2.

The lower body and texture scores of experimental samples could be linked to the difference in the iso-electric point pH of coconut protein and milk protein resulting in incomplete coagulation of coconut proteins. The isoelectric point of coconut proteins is 3.5 to 4.0 (Tangsuphoom and Coupland, 2008), i.e. much lower than the iso-electric point of casein. This could have led to weak structure of the final product. Since moisture content of coconut milk powder was approximately 4%, addition to milk did not cause any dilution. On the other hand, addition of coconut milk diluted the milk solids before coagulation resulting in a product with weak body. This could have reduced the chances of uniform acidification and coagulation leading to a weak body. Venkateswarlu (2003) also reported that incorporation of coconut milk in manufacture of *paneer* resulted in a product with soft,

Table 6 Average sensory score of Coconut flavoured paneer like soft cheese incorporated with different sources of coconut solids

Source of coconut	Sensory attributes			
	Flavour	Body & texture	Colour and Appearance	Overall acceptability
Control	8.03±0.17[a]	8.23±0.15[a]	8.30±0.16[a]	8.23±0.15[a]
CMP1	7.40±0.16[b]	7.47±0.2[b]	7.70±0.08[b]	7.65±0.13[b]
CMP2	7.13±0.12[b]	7.27±0.12[b]	7.50±0.24[b]	7.27±0.31[b]
CCM1	6.77±0.09[c]	6.83±0.06[c]	7.47±0.12[b]	6.80±0.26[c]
CCM2	6.75±0.08[c]	6.73±0.21[c]	7.63±0.17[b]	6.70±0.35[c]
		ANOVA TABLE		
SEm	0.09	0.13	0.09	0.15
CD (0.05)	0.28	0.40	0.29	0.46
CV g/100g	2.26	2.91	2.18	3.47

Each observation is a mean ± SD of four replicate experiments (n=4); [a-c]Superscript letters following numbers in the same column denote significant difference (P<0.05) weak, fragile body. Thus, the results corroborate with those reported in literature.

Colour and appearance scores of all the experimental samples were lower than the control. Experimental samples made with coconut milk powder scored 7.70 (CMP1) and 7.50 (CMP2). The colour and appearance scores of samples made with fresh and commercial coconut milk viz. CCM1 and CCM2 were 7.47 and 7.63 respectively. The statistical analysis revealed that there was significant difference ($P<0.05$) in colour and appearance score between control and all other experimental samples. Colour and appearance scores of all the experimental samples were statistically ($P<0.05$) at par with each other which were significantly ($P<0.05$) lower than control.

CFSC made with coconut milk powders scored less than control because of the unusual stark whiteness of the final product compared to pleasing creamy white colour in control. Similarly for the experimental samples prepared using commercial coconut milk, the end products had a bluish tinge along with a very bright white colour which was similar to the colour of extracted coconut milk. This adversely affected the colour and appearance scores of samples containing coconut milk.

It can be seen from Table 6 that the overall acceptability scores of control was the highest i.e. 8.23 followed by CMP1 scoring 7.65 and CMP2 scoring 7.27. These were followed by CCM1 (6.8) and CCM2 (6.7) scoring minimum marks. The overall acceptability scores of CMP1 and CMP2 were significantly ($P<0.05$) higher than the other experimental samples viz. CCM1 and CCM2. The overall acceptability score of CMP1 and CMP2 were at par ($P>0.05$) with each other. The overall preference of samples were in the order Control>CMP1>CMP2>CCM2>CCM1. CMP1 was preferred the most with respect to all the attributes studied from amongst all the experimental samples. The overall acceptability scores of CMP1 and CMP2 were at par ($P>0.05$) with each other.

On analyzing the sensory and texture parameters, it was observed that soft cheese CMP1 showed a similar trend to that of control sample. Hence coconut milk powder (CMP1) was selected to be the most suitable for manufacture of CFSC.

Fatty acid profile analysis of coconut flavoured paneer-like soft cheese

The concentration of major nutrients present in the developed *paneer*-like product was compared with conventional *paneer*. The samples were prepared five times and analyzed for their composition. It was observed that *paneer* prepared by addition of spray dried coconut milk powder at the rate of 6% (w/w of milk) had moisture content of 53.52±0.42%, 27.89±0.29% fat, 12.67±0.40% protein, 1.83±0.09% ash and 3.09±0.61% carbohydrate (by difference). Whey obtained after separation of the coagulum had a total solid content of 7.3% out of which only 0.2% was fat.

Fatty acid analysis was conducted using gas chromatography and the results have been shown in Fig 1 and 2. In both the figures, the concentration of each fatty acid (% of total fatty acids) has been shown on the tip of each peak. It is clearly visible that area of peaks for C_8, C_{10} and C_{12} was greater in the case of product that contained coconut milk powder (Fig 2). These peaks depict the medium chain triglyceride content in the sample. Comparatively, there is a peak of C_{16} and C_{18} with a greater area, in the control sample which is expected due to milk fat (Fig 1).

Conclusions

From this experiment, it can be concluded that a *paneer*-like acid coagulated soft cheese of acceptable quality can be prepared by mixing milk with coconut milk powder. Out of all the different forms of coconut tested, spray-dried coconut milk powder was selected because of closest similarity to conventional *paneer*. It was observed that addition of only coconut milk resulted in a texturally inferior product. This was noted to improve when coconut milk powder was used for the same purpose. Using coconut milk powder helped to increase the coconut nutrients in the final product due to increased yield. Moreover, there was not a great loss of fat in the whey. The medium chain triglycerides in the developed product project nutritional superiority of the coconut flavoured *paneer*-like soft cheese.

References

Aneja RP, Mathur BN, Chandan RC, Baneerjee AK (2002) Heat acid coagulated products. In: Technology of Indian milk products. A Dairy India Publication, Delhi, India, pp 133–158

Anon (2018) Milk production up 6.6 per cent at 176.35 MMT in 2017-18 (2018). The Hindu, 27th July, 2018

AOCS (1971) Official and tentative methods of the American Oil Chemist Society, III Ed. American Oil Chemists' Society, Champaign, Illinois, pp 3-9

Balachandran C, Arumughan C (1992) Solubility and electrophoretic characteristics of proteins in different regions of coconut endosperm. J Food Sci Technol 29:91-96

Boghara VR, Rajorhia GS (1982) Chemical quality of some marketed indigenous milk products – I. Major constituents and mineral composition of paneer. J Food Sci Technol 28:57-68

Chauhan S, Chandra R (2016) Preparation and Shelf Life Extension of Fiber Enriched Paneer. Int J Life Sci Res 2:566-569

Darji K, Patel HG, Gokhale AJ (2015) Advancements in Manufacture of Paneer. In: Souvenir, National Seminar on "Indian Dairy Industry - Opportunities and Challenges, held at SMC College of Dairy Science, AAU, Anand. January 8-9, 2015. pp 170-175

David J (2012) Preparation of functional paneer from buffalo milk blended with coconut milk. Res J Anim Hus Dairy Sci 3:88-90

Davide CL (1988) Utilization of water-extracted coconut milk in modified dairy products processing. In: Coconut Processing and By-Product Utilization, College, Laguna (Philippines), 28-29 Jan 1988

Davide CL, Peralta CN, Sarmago IG, Yap MT, Sarmago LE (1987) Fresh soft cheese from skim milk powder-coconut milk blend. Philippine J Coconut Studies 12:23

Desai HK (2007) Sensory profile of traditional dairy products. In: Gupta S (ed) Dairy India. New Delhi: Dairy India Yearbook. pp. 408

Diwekar R (2016) Indian Superfoods. New Delhi, India: Juggernaut Books

IS: 10484 (1983) Specification for paneer. Bureau of Indian Standards, New Delhi, pp: 1-11

ISI: 2311 (1963) Fat extraction apparatus for milk and milk products (first revision), Indian Standards Institution, Manak Bhavan, New Delhi.

Man YC, Manaf MA (2006) Medium-chain triacylglycerols. Nutraceut Sci Technol 5:27

Matsuura T, Ogawa A, Tomabechi M, Matsushita R, Gohtani S, Neoh TL, Yoshii H (2015) Effect of dextrose equivalent of maltodextrin on the stability of emulsified coconut-oil in spray-dried powder. J Food Eng 163:54-59

O'keeffe RB, Fox PF, Daly C (1976) Contribution of rennet and starter proteases to proteolysis in Cheddar cheese. J Dairy Res 43:97-107

Onsaard E, Vittayanont M, Srigam S, McClements DJ (2005) Properties and stability of oil-in-water emulsions stabilized by coconut skim milk proteins. J Agric Food Chem 53:5747-5753

Samson AS, Khaund RN, Cater CM, Mattil KF (1971) Extractability of coconut proteins. J Food Sci 36:725-728

Seow CC, Gwee CN (1997) Coconut milk: chemistry and technology. Int J Food Sci Technol 32:189-201

Steel RGD, Torrie JH (1980) Principles and Procedures of Statistics. 2nd ed. New York: McGraw-Hill.

Suthar J, Jana AH, Modha HM, Balakrishnan S (2018) Yield and quality characteristics of paneer made from milk blend containing homogenized milk. Asian J Dairy Food Res 37:267-272

Tangsuphoom N, Coupland JN (2008) Effect of surface-active stabilizers on the microstructure and stability of coconut milk emulsions. Food Hydrocolloids 22:1233-1242

Venkateswarlu U (2002) Preparation of Paneer from skim milk by incorporating coconut milk (Doctoral dissertation, Sri Venkateswara Veterinary University Tirupati-517 502 (AP) India)