

Research Article

Quality Characteristics of Paneer from Solar Assisted Heat Exchanger

J B Raol^{1*}, R R Gajera² and M.T. Kumpavat³¹SAUs Council, Gandhinagar²Post Harvest Technology, College of Horticulture, Anand Agricultural University, Anand-388 110, Gujarat, India**Abstract**

Paneer is similar to a soft cheese obtained by acid and heat coagulation of milk. Heating of milk to about 85⁰C required for preparation of paneer and can be achieved using solar thermal assisted double pipe multi pass heat exchanger with necessary accessories. Such system was designed and developed for the manufacture of the paneer and the experimental trials were conducted to evaluate the effect of solar radiation on performance parameters for its various quality characteristics. No significant difference was found between experimental paneer and control one in terms of overall acceptability. The hardness of paneer in trial sample was higher than the control indicated greater hardness. The average yield of paneer was obtained nearly 15.08 % of milk and also was at par with the control sample. Chemical compositions of various attributes; fat, moisture content, total solid, free fatty acid and ash content of paneer were in line with reported literature. The prepared paneer in the present study was satisfied both the FSSAI and the BIS standards in terms of the chemical composition.

Keywords: Paneer; Solar; Heat exchanger; Sensory; Hardness; Chemical, Quality

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Introduction

The operation flood programme, one of the world's largest and most successful integrated dairy development programme initiated in 1970 had led India to emerge as the world's largest producer of milk. The milk production of India in the year 2014 was 140.6 million metric tons [1], which is about 17 % of the world's total milk production. The milk utilization pattern revealed that about 50-55 % of the total milk produced in India is converted into traditional milk products, which is mainly confined to the cottage scale in the non-organized sector [2, 3]. The market for traditional Indian milk products is very large, fast growing and is likely to increase at an annual growth rate of about 20 % [4]. A variety of traditional milk products such as khoa and khoa based sweets, paneer, shrikhand, rabri, kheer, halwa, basundi, fermented products and many region specific traditional ethnic products are being manufactured in India. The manufacture of traditional dairy products helps milk producers to fetch better price of milk and provides an opportunity for employment generation in rural and semi-rural areas. Looking to the demand and profitability, many organized dairy plants have entered in the business of traditional dairy products adopting improved technology and mechanization in the manufacture of some traditional dairy products.

Paneer is similar to a soft cheese obtained by acid and heat coagulation of milk. It is a non-fermentative, non-renneted, non-melting product analogous to a un- ripened type of cheese. paneer is very popular throughout South Asia and many countries of the world and is used in raw form or in preparation of several varieties of culinary dishes and snacks. The ability of paneer to be deep fried is one feature that has led to its wider acceptance and a favorite for making snacks, pakoras or fried paneer chunks [5]. It is estimated that about 5% of milk produced in India is converted to paneer [6]. In preparation of paneer, heat energy is required to raise the temperature of the milk for coagulation of milk. The use of non-conventional renewable energy especially solar energy is one of the ways to reduce the use of fossil fuels in generation of electrical power. Renewable energy is also termed as "green energy", "clean energy", "sustainable energy" and "alternative energy" [7]. Heating of milk required for preparation of paneer can be achieved by using solar thermal system and appropriate design of heat exchanger. Temperature profile of heating the milk in the solar assisted heat exchanger was different as compared to heating of milk using steam and hence the various quality attributes of the paneer was evaluated.

Materials and Methods***Raw materials and preparation***

The standardized pasteurized milk procured from Anubhav Dairy, AAU, Anand was used for the experimental trials.

The temperature of milk was measured and it was heated to achieve required temperature in the double pipe multi pass heat exchanger. The total surface area of the heat transfer is divided into four separate units which also facilitate the counter and parallel flow arrangement. In design of experimental heat exchanger, the inner pipe was kept for milk flow while the service fluid for heating was being circulated in the annular space between two pipes. The milk was heated by using hot water from solar thermal system hot water heater. Paneer was prepared by standard procedure as described by Bhattacharya et al [8].

Quality of the products

Sensory characteristics like, flavour, body texture, colour & appearance and overall acceptability of the paneer was evaluated by 9-point hedonic scale. Each block of paneer was cut in to cubical pieces of approximately 2cm x 2cm x 2cm. The prepared samples of paneer were subjected to sensory evaluation by panel of six judges using 9 point hedonic scale. Rheological (textural) properties like Hardness, Gumminess, Chewiness, Springiness and Cohesiveness of experimental paneer were evaluated. Five samples of each experimental paneer were subjected to uniaxial compression to 40 per cent of the initial sample height, using a Food Texture Analyzer of Lloyd Instruments LRX Plus material testing machine, England; fitted with 0-50N load cell. The force-distance curve was obtained for a two-bite deformation cycle employing a cross head speed of 50 mm/min, Trigger 10 gf and 40 per cent compression of the samples to determine various textural attributes. The calculations of area under the force-distance curve, statistical analysis of data generated and their conversion into various textural attributes were carried out by direct transfer of the data to Lloyd Instruments NEXYGEN data analysis and applications software. Comparing the prepared paneer with FSSAI standard, some physical and chemical properties like moisture content, fat content, TS, acidity, FFA and ash content were determined with standard procedure. The data collected for quality attributes were analyzed as per statistical design.

Results and Discussion

Production of paneer

The heat exchanger was designed to heat the milk using solar thermal energy for the preparation of paneer. The operating conditions in terms of flow rate of hot water, flow pattern, number of pass to be used for solar thermal heating etc., were standardized using chilled water in place of milk as it requires several experimental trials in different months. It was found that counter current flow pattern and 20lpm flow rate gave higher U values and better thermal performance. Therefore, the experiments for heating of milk were carried out under optimized operating conditions of the heat exchanger. Usually, pasteurized milk is used for the preparation of paneer and hence pasteurized chilled milk was used in the experimental trials. The initial temperature of standardized milk brought from Anubhav Dairy, AAU, Anand was in the range of 7-9^oC. The milk was heated in the heat exchanger to attain temperature around 82±1 ^oC. The chilled milk flow rate was maintained at 1.0 lpm by control valve. The heated milk was collected in a collecting tank. The cooling of heated milk was not required as flash cooling gave temperature of about 70±1 ^oC required for precipitation. Utilizing solar energy for milk heating for preparation of paneer, it was revealed that around 94% of the total heat requirement was fulfilled by the solar energy.

Quality Characteristics

Sensory quality

Acceptability of any product is assessed based on the evaluation of sensory characteristics by a panel of trained judges. Any product development process and sensory attributes play vital role in deciding the acceptability of the product. The sensory parameters chosen to assess the quality of paneer were flavour, body and texture, colour and appearance and overall acceptability. The average and statistical values of sensory score for all four trials are depicted in **Table 1**.

Flavour

The most important criteria for evaluating the quality of any dairy products is flavour, which in turn determines its acceptability. The flavour score of paneer was in the range from 7.87 to 8.11 (out of 9). There was no a significant difference between flavour scores of the paneer which was prepared by heating the milk in the heat exchanger using solar energy and control product.

Table1 Sensory quality value of the experimental paneer

Trial No.	Sensory attribute			
	Flavour	Body& Texture	Colour& Appearance	Overall acceptability
1	8.11	7.98	7.01	7.61
2	8.04	7.98	6.95	7.53
3	7.93	7.89	7.01	7.67
4	7.87	7.86	6.93	7.28
Mean	7.98	7.93	6.96	7.52
Control	8.41	8.24	7.57	7.78
S. Em	0.164	0.205	0.274	0.147
Test	NS	NS	NS	NS
C V %	3.532	4.447	6.051	3.393

Body and texture

Body of any food is its standing up property while texture is that property of food which is associated with the sense of feel or touch experienced by fingers or the mouth. Body and texture explain the physical nature of the product with respect to smooth or coarse or uniform or settled. Table 1 show the body and texture score of experimental paneer which ranged from 7.86 to 7.98 (out of 9). It is noticed that there was no significant difference between body and texture score of the experimental paneer and control sample. The data indicated that heating of milk by this heat exchanger had no any adverse effect on body and texture of the paneer.

Colour and appearance

Colour of any product is typical and basic sensory perception that appeals to the consumer for its acceptability or rejection. Colour and appearance of the product is the visual perception, which in turn, defines product quality. Table 1 shows the colour and appearance score of paneer prepared from milk heated by solar system ranged from 6.93 to 7.01 (out of 9) with a mean value of 6.96. There was no significant difference between colour and appearance score of the experimental paneer and control samples.

Overall acceptability

Overall acceptability is indicative parameter of sensory quality of products in totality, and consists of flavour, colour and appearance, body and texture characteristics which represent the total performance of the product in the mind of consumers. The overall acceptability score of prepared paneer was ranged from 7.28 to 7.67 (out of 9) with an average score of 7.52 as shown in Table 1. Overall acceptability scores of paneer revealed that there was no significant difference in experimental paneer and control sample.

Rheological properties

The quality of product is monitored not only by the sensory properties but also by their rheological/textural profile. The instrumental method of texture assessment aims at quantifying objectively the textural characteristics of the product. The textural characteristics of paneer are greatly influenced by its composition, type and quality of raw material (milk) used and manufacturing practices / parameters followed. The textural profile of paneer was measured in terms of hardness, stiffness, adhesiveness, cohesiveness and chewiness. The rheological properties of the paneer are depicted in **Table 2**. The values presented in Table 2 indicated that hardness₁ of paneer ranged from 13.661 to 11.013 N for control to trial sample. The hardness₂ of paneer in trial sample were in ranged from 11.406 to 13.441 N and was higher than the control sample. A higher value was indicative of greater hardness. It is observed that values of chewiness of paneer varied from 27.102 to 46.478Nmm.

Chemical composition

The physical and chemical properties as well as yield of experimental paneer were determined by standard methods and depicted in **Table 3**.

Table 2 Rheological properties of the experimental paneer

Properties	Trial-1	Trial-2	Trial-3	Trial-4	Control
Hardness1 (N)	14.552	15.480	13.806	16.013	13.661
Hardness2 (N)	11.924	13.441	11.406	13.158	10.074
Cohesiveness	0.425	0.397	0.423	0.481	0.357
Springiness (mm)	5.883	5.617	5.742	6.040	5.554
Gumminess (N)	6.182	6.138	5.833	7.695	4.879
Chewiness (Nmm)	36.369	34.481	33.493	46.478	27.102
Adhesiveness (Nmm)	1.599	5.617	0.460	0.554	5.043
Stiffness (N/mm)	2.110	2.648	2.313	2.527	2.236

Table 3 Chemical composition and yield of the experimental paneer

Trial No.	Yield (%)	Physical properties			Chemical properties		
		Fat (%)	Moisture (%)	TS (%)	Acidity (%)	FFA (%)	Ash (%)
1	15.08	23.6	45.50	54.50	0.61	0.08	1.57
2	15.76	25.0	47.40	56.60	0.53	0.13	1.26
3	14.99	24.7	52.70	47.30	0.73	0.09	1.37
4	16.18	23.7	50.00	50.00	0.49	0.09	1.48
Control	16.78	24.7	49.79	53.62	0.53	0.08	1.36

The literature on chemical composition of paneer indicates that the moisture, fat, protein, lactose and ash content of paneer vary from 47.68 to 59.70, 22.90 to 27.00, 16.81 to 33.27, 2.07 to 2.61 and 1.30 to 2.18 per cent respectively [8-10]. Therefore, in the present study data obtained for chemical composition of paneer are well within those reported in the literature. The yield of paneer ranged from 14.99 to 16.18% of milk. The yield and chemical composition of the paneer was at par with the control sample. The prepared paneer in the present study was satisfied both the FSSAI and the BIS standards in terms of the chemical composition.

Conclusions

Paneer is an important heat and acid coagulated milk product which is used as a base material for the preparation of a large number of culinary dishes. The various unit operations involved in preparation of paneer are heating and cooling of milk, acid coagulation, whey removal and pressing. The design of double pipe four pass heat exchanger having flexibility of admitting backup hot water as per the requirement can be successfully used for the preparation of paneer using solar energy. The sensory, rheological and chemical properties of paneer prepared using solar assisted multi-pass heat exchanger were found at par with the control sample.

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Publication History

Received	11.07.2019
Revised	05.08.2019
Accepted	10.08.2019
Online	30.08.2019