Advancements in Manufacture of Paneer

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Paneer is a South Asian variety of soft cheese obtained by acid and heat coagulation of milk, entrapping almost all the fat, casein complexed with denatured whey proteins and a portion of salts and lactose. It is a non-fermentative, non-renneted, non-melting and unripened type of cheese. India has emerged as the largest milk producer in the world with 132.4 million metric tonne milk production in 2012-13 (15% of the world's total milk) (NCAER, 2012). Out of this, an estimated 7% of milk produced in India is converted to paneer. Due to the ever growing demand of paneer by varied health conscious consumers, it is necessary to develop new types and varieties of paneer. Sachdeva and Singh (1988) optimized the processing parameter for manufacture of paneer. It has short shelf life, moreover since it is rich in milk fat, it is a very costly product. Therefore, advancements in manufacture of paneer is necessary in order to increase the yield of paneer so to lower the production cost, increase the shelf life of paneer. Some recent advancements in manufacture of paneer is outlined in this article.

Ohmic Heating: Ohmic heating is an advanced thermal process and alternate method of pasteurization. Ohmic heating is technique that involves the passage of an alternating electrical current through a food product, allowing the generation of heat inside it. Because of generation of heat, reduction in microbial counts in product is possible. Ohmic heating of buffalo milk at 75°C for 15 seconds results in lower microbial counts than that of conventional heating of buffalo milk for paneer making. Salmonella is completely killed by ohmic heating. This results in extension of shelf life of paneer. Ohmic heated paneer has lower hardness and higher sensory profile than paneer prepared using standard method (Kumar *et al.*, 2014).

Membrane Processing: Membrane technology like Reverse Osmosis (RO), Ultrafiltration (UF), Microfiltration (MF) & Nanofiltration can be applied for paneer manufacturing. Its advantages are high recovery of solids, low energy requirements, reduced bulk and minimal thermal degradation of milk constituents. Paneer can be made by employing UF. The process involves use of standardized buffalo milk (2% fat, 9.2% SNF) and concentrating to 27% TS by UF followed addition of Glucono-δ-lactone at 0.9 % and filling the concentrated milk in retortable pouches and subjecting to texturization process at 118°C for 5 min. TS recovery (95%) is more in in-packaged paneer than the conventional product. It led to increase in the yield of paneer by 25%. The shelf life of in-packaged paneer is 3 months at 35°C. Paneer also has superior sensory quality. Concentration of skim milk up to four times (4X) by UF along with the addition of 2.5% starter culture and 0.5% salt can reduce the hardness of paneer made from skim milk. For paneer making, pasteurization of milk is necessary in order to make it safe from microbiological point of view but due to that thermal degradation of nutrients take place. This problem can be solved by use of alternate method known as microfiltration as it is non thermal process. The MF retentate from standardized cow milk can be utilized for the manufacture of paneer and $CaCl_2$ is added to the retentate @ 0.15%. Such additive helps in improving the organoleptic and textural properties of resultant paneer. Paneer can also be prepared by concentrating milk by RO to 1.5X (25% TS) and 2X (33% TS). This results in higher yield by 2–3% on original milk quantity basis as compare to control without affecting its sensory properties. When paneer is prepared from normal cow milk, then it is having hard, compact and dry characteristics because of high salt content. NF of

cow milk helps in overcoming these defects and produce better quality paneer. Concentration of cow milk to ~ 1.5 and 2.0X using NF membrane system at 50°C result in reduction in salt content of cow milk up to 74% in 1.5X concentration without affecting other major constituents (Khan and Pal, 2011).

Dehydration: Moisture is responsible for growth of microorganisms in any product. So by reducing moisture, reduction in microorganism is possible. Thus spoilage can be prevented and extension of shelf life of product is possible. Dehydration of paneer cubes (2 cm^3) to 15% moisture by keeping them in hot air drier at 75°C for 4 h give shelf life of 2 months. The intermediate moisture paneer has a shelf life of 4 months at room temperature and can be reconstituted within 5 minutes (Patil, 2006).

Blast Freezing: Use of simple freezing of paneer for its preservation purpose at –13°C and–32°C for 120 days, then its flavour and appearance are not affected but its body and texture become crumbly and fluffy on thawing due to large ice crystals formation. This problem can be solved by use of alternate method i.e., blast freezing which forms small ice crystals in product. Blast freezing of paneer blocks (1.5 cm^3) at -20°C enhance shelf life of paneer to more than one year at a storage temperature of below -19°C (Patil, 2006).

Individual Quick Freezing (IQF): IQF is continuous process in which the product is moving on the belt and is exposed to a blast of extremely cold air. This freezes it in a matter of seconds. This serves two purposes like there is no time for the product to deteriorate and because it is frozen instantly, the pieces do not stick to each other. The technology can be useful for preservation of paneer (Patil, 2006).

Hurdle Technology & Modified Atmosphere Packaging For Paneer: Shelf life of paneer can be extended by employing hurdle technology and modified atmosphere packaging. Paneer cubes are dipped in solution containing NaCl, citric acid and potassium sorbate (0.1%) which act as hurdles. The a_w is reduced by using NaCl and citric acid at 3 and 0.1% from 0.994 to 0.970 and pH from 5.5 to 5.1, respectively. MAP of paneer is done by using a mixture of CO_2 and N_2 in proportion of 50:50 and packed in the package (PET/PE). The HT adopted paneer with MAP extend the shelf-life from 1 to 12 days at room temperature (30±1°C) and 6 to 20 days at refrigeration (7±1°C) temperature (Thippeswamy *et al*., 2011).

Heat Sterilization: Shelf life of paneer can also be extended by heat sterilization. In this paneer is packed in tin along with water/brine and sterilised in an autoclave at 1 kg/cm^2 for 15 min. Such paneer lasts for 4 months. But perception of oxidized flavour renders product unacceptable afterwards. A slight amount of cooked flavour is accompanied by Maillard browning, the intensity of which increases slightly during storage.

Paneer For Health: Nowadays people are more conscious about their health therefore it is necessary to develop new varieties of paneer for such health conscious people.

Soy Paneer: This is prepared by whole or partial replacement of milk with soy milk for paneer making. Benefit of soy paneer is that high nutritive value, low cost, solve problem of milk availability and best for lactose intolerance people and for treatment of protein deficiency among undernourished children. Soy paneer can be prepared by using 70% buffalo Milk and 30% soy Milk, 1% acetic acid as coagulant and 85^{0}C coagulation temperature. Resultant paneer is had higher sensory profile and yield and lower microbial count (Verma and Chandra, 2012). Paneer can also be prepared by using soymilk and skimmed milk in 75:25 proportion and citric acid at a conc. of 1.5% as coagulant (Raja *et al*., 2014).

Egg Paneer: Egg is a good source of low-cost high-quality protein, fat-soluble vitamins (A, D and E), essential fatty acids minerals (Fe, Ca and Zn) and PDCAAS of it is 1. Three type of paneer can be prepared from egg i.e., egg yolk paneer, egg albumin paneer, whole egg paneer. A egg yolk paneer (EYP) can be prepared by incorporation of binders (wheat flour (17.5%), maltodextrin (2.0%), salt (1.4%), natural antioxidants (Garlic powder, 1%) citric acid (0.05%) and malic acid (0.05%) and egg yolk. Then drying is done at 85°C. Dehydrated EYP packed in metalised polyester pouches can be stored at ambient temperature (27±2°C) for 6

months. The product is sensorily acceptable and microbiologically safe and is similar to traditional milk paneer (Pawar *et al*., 2012).

Moringa Paneer: Dry leaves of moringa are highly nutritional. Paneer prepared by adding moringa leaves extracts is means of increasing nutritional quality of paneer. Fresh Paneer prepared from cow milk (420ml) and moringa leaves extract (80 ml) had higher protein, lactose, fat and ash content (Sachan *et al*., 2010).

Low-fat Paneer: Paneer containing milk fat is high in saturated fatty acids and consumption of it causes coronary heart disease, obesity and increase blood pressure. Therefore it is necessary to develop low fat paneer. Simply preparation of low fat paneer from low fat milk results into hard body, coarse, rubbery, chewy texture, bland flavour, poor mouth feel, mottled colour & appearance of paneer. This problem can be solved by incorporation of certain additives like dietary fiber, Whey protein concentrate, lecithin, soy protein isolate and NaCl.

Low-fat paneer with dietary fiber: Incorporation of dietary fiber in low fat paneer improves texture properties of paneer and besides that it also improve digestion, give protection against CHD, diabetes, obesity. When low fat paneer is prepared from milk with 2.5% fat and 0.56% soy fiber or 1.8% fat and 4.5% inulin yield a paneer similar to that prepare from full cream milk (6% fat) with respect to sensory quality (Kantha, 2005).

Low-fat paneer with whey protein concentrate & lecithin: Incorporation of WPC and lecithin in low fat paneer improve texture properties of paneer as it is having water binding capacity, act as emulsifier, and impart creaminess, opaqueness. This is also means of protein enrichment in paneer and reduction in cost of paneer is possible. Low fat paneer containing WPC at 0.2 % and lecithin at 0.025 % (w/w of milk) has ~50 % lower fat, 36% lower FDM content, ~17 % higher protein, higher overall acceptability scores and can be priced affordably (Bhatt, 2013).

Low-fat paneer with soy protein isolate: Incorporation of SPI in low fat paneer improves texture properties of paneer as it is having water binding capacity, act as emulsifier. This is also means of protein enrichment in paneer**.** SPI can be used as fat replacer in low fat paneer. Paneer with 0.2% SPI and $CaCl_2$ (0.2%, w/v as coagulant) has higher protein, lactose, ash content and lower fat, better textural & sensory quality. More than 0.2% SPI incorporation imparts beany flavour to paneer (Kumar *et al.,* 2011).

Low-fat paneer with NaCl: Incorporation of NaCl in low fat paneer improves texture properties of paneer as it is having water binding capacity. Addition of 0.25% NaCl to buffalo milk (2% fat, 9% SNF) prior to coagulation at 60^0C is recommended for making good quality low fat paneer containing about 30% FDM (Sanyal and Yadav, 2000).

Filled Milk Paneer: This can be prepared by replacement wholly or partially milk fat with vegetable fat during manufacturing of paneer. Purpose of development of filled milk paneer is that milk fat are high in saturated fat and excessive intake of saturated fat is a major causative factor in obesity, high blood pressure, coronary heart disease and linked to a number of other disorders. On other hand vegetable fat are high in polyunsaturated fatty acids.

Paneer prepare from milk having a milk fat and vegetable fat (Saffola) in a ratio of 2:3 and 60^0C coagulation temperature has the highest score of body and texture and flavour after frying (Verma and Chandra, 2012).

Filled Milk Dietetic Paneer: The substitution of 3:2 (cow milk fat: vegetable fat) and 20% soy milk is found to be the most appropriate for manufacture of filled milk dietetic paneer (Kumari *et al*., 2013).

Paneer From Milk Powder: During lean season, production of milk reduces hence production of paneer also reduces. This leads to increase in cost of paneer. In order to overcome this problem it is necessary to prepare paneer from milk powder. Reconstitution levels of 1:5 and 1:6 (Milk powder: water) can be used for the manufacture of good quality paneer without any need for the modifications in the processing conditions (Khan *et al.,* 2012).

Additives

Preservatives: Paneer can be stored for only 6 days at 10°C without much deterioration in its quality, though the freshness of the product is lost after 3 days. Paneer cannot be stored for more than 1 day at room temperature in tropical countries. Therefore it is necessary to add preservatives in order to extend shelf life of paneer (Table 1).

Coconut milk: Coconut milk is rich in several minerals like Ca, P, Fe, Se, Zn, K, and Mg and it is rich source of lauric acid which is only found in mother milk. Addition of 10% of coconut milk (25% fat) to skim milk results in highly acceptable quality paneer.

Buttermilk: Buttermilk is a by-product of butter industry. So use of buttermilk for making paneer is means of utilization of by-product. When paneer is prepared from sour buttermilk then two steps are necessary i.e., neutralization of sour butter milk to 0.15% titratable acidity by sodium bicarbonate and washing of curd with hot water (72°C) before pressing. This mitigates the problems of self-

Table 1 - List of preservatives that can be added for making paneer

Preservatives	Added rate	Control	Extended shelf life
Lactoferrin	Dip in 20 ppm solution	2 d at 30°C, 7 d at 4°C	7 d at 30°C, 15 d at 4°C
Nisin	Dip in 12 ppm solution	7 d at 7±1°C	12 d at 7±1°C
Brining	Dip in 5% brine solution	6 d at 8-10°C	20 d at 8-10°C
Black pepper	0.6%	14 d at 7°C	21 d
Cardamom	0.6%		21 d
Clove	0.6%		<28 d
Cinnamon	0.4 %	7 d at 7°C±1°C	>28 d
Turmeric	0.6 %	14 d at 7°C	12 d on at 7°C±1°C
Essential oil of cardamom	0.01%	-	By 10 d
Sorbic acid adding to milk & wrapping in sorbic acid coated paper	0.15%	-	36 d at room temp.

Stabilizers: Various stabilizers can be added for making paneer. These improve functional characteristics of paneer like water binding capacity, consistency, yield, total solids recovery (fat, FDM) etc. This helps in reduction in the cost of paneer manufacture (Table 2).

Table 2 - List of stabilizers that can be added for making paneer

Stabilizers	Added rate	Function
Sago powder	0.3 %	Desirable quality Paneer
Bhendi gum	0.45 %	Reduce cost
Lesser yam burk powder	0.30 %	
Sodium alginate	0.10%	Increase yield
Carrageenan	0.15%	
Pre-gelatinized starch	0.15%	
Pre-gelatinized starch along with high coagulation temp (90ºC)	0.1%	Improve body, texture & yield of filled paneer
CMC	0.1%	Reduce oil uptake in deep fat fried paneer during frying

coagulation of milk during heating, development of acidic smell, sour taste and grainy texture in paneer.

Fruit juices: Amla juice can be used as coagulant for manufacturing of paneer. This is means of fortification of paneer with Vitamin C and iron. Amla juice diluted with water to 1:1.21 can be used as coagulant for paneer making with increased overall acceptability (Gediya, 2013).

Herbs: Incorporation of coriander and mint @ 10% by weight in paneer improved the overall acceptability score and yield of paneer.

Ready To Serve Spiced Paneer: For making easy conveniences in use of paneer by consumer, it is necessary to develop ready to serve spiced paneer. This can be prepared by marinating cubes of paneer with 10 % ginger, 5 % garlic, 1.25 % red pepper and 0.25 % black pepper. It is packed and heat treatment is given at 15 psi for 10 minutes. Maturation time of 60 min & heat treatment for 10 min is found most suitable for making RTS spiced paneer (Gupta *et al*., 2007).

Conclusion: With increasing demand for paneer, advancement in its manufacture is needed. This will result in increased yield of paneer, reduction in production cost, and increase in shelf life of paneer as well as production of new varieties of paneer for health conscious people will be possible. Various advanced techniques can be applied in this venture but main problem with application of such techniques is consumer awareness regarding changes in textural & sensory quality of paneer. In this way, increase in paneer market as well as its availability to consumer at low cost throughout the year may also be possible.

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