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Review Article

Advances in Paneer

Rekha Chawla*, Nitika Goel*

Abstract

Paneer is an important indigenous product which is obtained by heat treating the milk followed by acid coagulation. It has been a delicacy from ancient times which can be used in the preparation of a variety of culinary dishes and snacks. Paneer is a rich source of animal protein and is characterized with marble white color, sweetish, mildly acidic taste, nutty flavor, spongy body and closely knit and smooth texture. Conventional method of paneer has various limitations viz. wastage of milk solids, variation in quality of paneer, lack of mechanization in manufacturing, etc. Another constraint in large scale manufacturing of paneer is short shelf life. To meet ever growing demand of paneer and to overcome these limitations, myriads of studies has been done by researchers to develop new techniques for manufacturing paneer and to promote its hygienic production. Various technological innovations in paneer manufacture and methods of shelf life extension have been reviewed in this article. Paneer being an established product offers a great prospective for value addition.

Keywords: Paneer; Mechanization; Value Added Paneer; Shelf Life Extension.

Author Affiliation
*Assistant Professor (Dairy Technology), College of Dairy Science and Technology, Guru Angad Dev Veterinary and Animal Sciences University Ludhiana.

Reprint Request
Rekha Chawla, Assistant Professor (Dairy Technology), College of Dairy Science and Technology Guru Angad Dev Veterinary and Animal Sciences University Ludhiana-141001.
E-mail: mails4rekha@gmail.com

Introduction

Paneer is an acid coagulated product of the casein component prepared from milk. It has been a delicacy from ancient times till today for preparation of certain curries and can be eaten raw as well. Historically, the origin of *paneer* can be traced to the nomads of southwest Asia who were the first to develop various kinds of cheeses. Technically, *paneer* can be defined as a product obtained through heat and acid coagulation of the casein component of preferably standardized buffalo milk, entrapping through complex physico-chemical interactions almost all the fat, a part of denatured whey proteins and colloidal salts, as well as a part of the soluble milk solids (in proportion to the moisture content retained) (Aneja, 2007); or coagulating buffalo or blend of cow or buffalo milk and pressing the coagulum (Chandan, 2007) & resembles unripened cheese prepared either from whole milk or skim milk (Chopra and Mamtani, 1995).

According to PFA (2010), *paneer* can be defined as "the product obtained from cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid or citric acid. It shall not contain more than 70% moisture and milk fat shall not be less than 50% expressed on the dry matter. The milk fat of skim milk *paneer* shall not exceed 13.0% of the dry matter". Bureau of Indian Standards (BIS 1983) imposed a maximum of 60% moisture and minimum of 50% fat in dry matter for *paneer*.

Nutritive Value

Paneer is a rich source of animal protein available at a comparatively lower cost and forms an important

source of animal protein for vegetarians. Over and above its high protein content and digestibility, the biological value of protein in *paneer* is in the range of 80 to 86 (Shrivastava and Goyal, 2007). In addition, *paneer* is a valuable source of fat, vitamins and minerals like calcium and phosphorus. It has a reasonably long shelf life under refrigeration.

Present Status of Paneer Manufacturing

In India, around 4-5% of the total milk produced is being converted to *paneer* (Nayak and Bector, 1998, ICMR 2000; Chandan 2007). India's annual production is estimated at 0.2 million tonnes of *paneer* (Aneja *et al*., 2002) having market value around Rs. 18×10^9 annually (Aneja, 2007) exhibiting a growth of 13% in 2003-04 (Joshi, 2007; Shrivastava and Goyal, 2007). Method of production of *paneer* is well known to every household where milk is heated and coagulated using citric acid or lime (source of citric acid) or any other mild acid. The coagulum thus obtained is pressed for two hours or so after which the pressed mass is kept under chilled water and thence can be utilized for various purposes. Though the method of production remains the same at industrial level but the scale and process classification on the basis of automation varies. Under optimum conditions 22-24% yield can be obtained which mathematically resolves to 63-67 per cent recovery of milk solids in *paneer* (Chandan, 1996).

The production of *paneer* has largely been confined to the unorganized dairy sector which employs traditional, inefficient methods of manufacture. As reported, *Paneer* may contain as high as 70% moisture which is conducive for microbial growth. Studies carried out on microbial quality of *paneer* have indicated that it is often contaminated with *Staphylococcus aureus* and Coliforms (Kumar and Sinha, 1989; Rajorhia, *et al.,* 1984). In a market survey carried out in India, covering state of Punjab, Chandigarh; *paneer* samples were collected to isolate and identify bacterial pathogens / contaminants therein. Fifty eight samples of *paneer* bought at random were cultured on several media and predominant organisms like *Staphylococcus* species, aerobic spore bearers*, Klebsiella pneumoniae, Campylobacter jejuni, Acinetobacter species* and *Streptococcus species* were isolated. The viable bacterial counts obtained ranged from 3×10^2 to 9.7×10^{10} cfu / ml. Authors expressed that contamination by pathogenic bacteria could be an important factor of gastrointestinal illnesses in the consumers. Also, micro flora can get entry into the *paneer* during various steps of manufacturing. Similar data was cited and reported by (Table 1) (Vaishnavi *et al.,* 2001). Due to ever growing demand of *paneer* and to promote the hygienic production during manufacturing, researchers were encouraged to develop new techniques for manufacturing *paneer*. Different manufacturing conditions, variants of *paneer* and mechanization process have been reviewed by Pal and Agrawala (2007).

Table 1: Microbial quality (cfu / g) at different stages of *paneer* production

Sample	Aerobic plate count	Coliforms
Milk	1.8×10^7	ND
Citric acid solution	ND	ND
Coagulated milk	$>10^7$	7×10^2
Chilled water	2.0×10^4	ND
Paneer	6.0×10^3	3.0×10^3
Handwashings of food handler (1)	$>10^7$	2.5×10^3
Handler (2)	$>10^7$	3.0×10^3

ND= not detected
Source: Anon, 2000

Table 2: Compostion of traditional and ultrafitered (UF) *paneer*

Parameter	Full fat	Low fat	Skim milk	UF paneer
Fat	23.41	8.60	0.20	7.20
Protein	18.33	21.56	25.83	15.92
Lactose	2.40	-	-	5.30
Ash	1.90	-	-	2.21
Total solids	46.04	38.28	35.42	30.63
Yield	20.00	16.30	14.10	25.00

Source: Gupta, 2006

Conventional Method of Paneer Manufacture

Although *paneer* can be made from variety of milk such as cow, buffalo or mixed milk, buffalo milk is preferred over other types. In traditional production of *paneer*, buffalo milk (6% fat; 9% SNF) is boiled in a vessel. To coagulate the milk while still hot, a suitable

coagulant (lime/alum/citric acid) is added, with slow stirring. Formation of clear whey is an indicative of complete coagulation. Stirring is stopped, as the coagulum tends to coalesce. After the formation of large lumps is complete, contents of the vessel are poured over a muslin cloth to separate the coagulum from whey. The coagulum so obtained is slightly pressed to facilitate formation of *paneer* blocks of suitable size, followed by their immersion in chilled water to impart them a distinctive texture. The cooling results in reabsorption of some water and this treatment presumably impart the characteristic springy and rubbery body to *paneer*. It displays integrity of texture and retains its shape and form during the frying or cooking of culinary dishes. It is usually wrapped in parchment paper, or loosely packed into polythene pouches. Alternatively, *paneer* blocks are floated in chilled water troughs at retail points and sold (Aneja *et al*., 2002)

A process for industrial scale production has been developed, using the available cheese/casein/tofu manufacturing equipment. Significant R&D at the National Dairy Development Board (NDDB), National Dairy Research Institute (NDRI) and several agricultural universities has resulted in the optimization of processing variables and the same has been depicted in *Figure 1.*

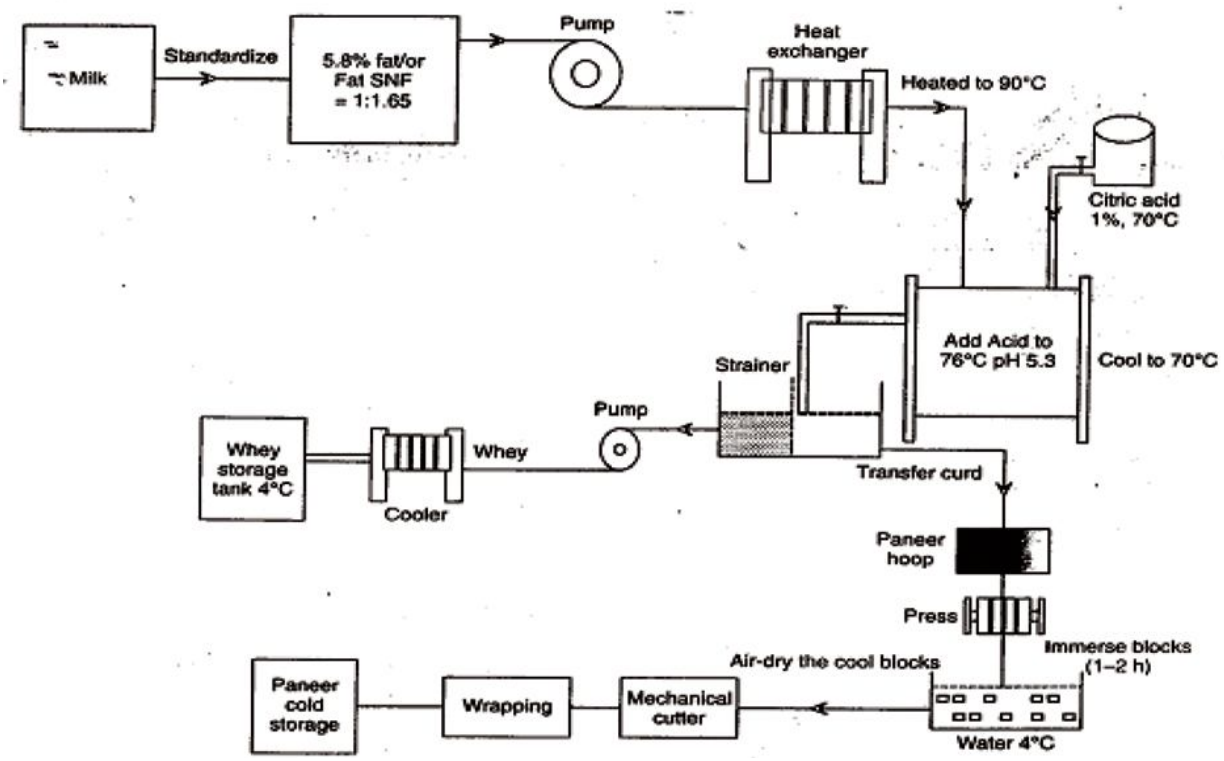

Fig. 1: Schematic presentation for the manufacture of *paneer*

Conventional approach of *paneer* making suffers from various limitations viz. wastage of milk solids in the form of whey, variation in quality of *paneer* from batch to batch, absence of 'in-process' quality control, lower shelf life, lack of mechanization in manufacturing, packaging operations, and many more.

Technological Advances in Manufacturing Paneer

Various technological modifications have been introduced in manufacturing of *paneer* to produce uniform quality, improved shelf life, increased yield and a nutritionally better product. Sachdeva and Singh (1987) gave a small-scale method for producing *paneer*, an acid coagulated Cottage cheese-type product, involved heating buffaloes' milk (6% fat) to 82°C for 5 minutes followed by cooling to 70°C and adding 1% citric acid, draining and pressing the obtained curd in moulds for 15-20 min. The curd was then cut, cooled in chilled water (5°C) for 2-3 h and packed in paper. According to authors, for minimum possible industrial scale production, good quality *paneer* could be obtained by the following certain modifications like heating milk to 90°C with no holding; elimination of cooling to 70°C by adding

a stabilizer, e.g. 0.15% pregelatinized potato starch; use of cheaper acids, soured whey or acid-producing bacteria, e.g. *Lactobacillus acidophilus* for coagulation; standardizing pH to 5.30-5.35; use of a 2:1 mixture of buffaloes' and cows' milk; and vacuum packaging to improve shelf-life. In another study, Sachdeva *et al*. (1993) developed the process of *paneer* making which involved standardization and heating of milk followed by concentration of milk solids using membrane processing- Ultra filtration (UF). The concentrated mass thus obtained contained about 40 percent total solids (TS), was cold acidified to get the desired pH. Till this point, the product was flowable and could be easily dispensed into the containers with automatic dispensing machines. The filled containers were then dispensed subjected to texturisation by microwave heating in a domestic microwave oven. This could also be achieved in a continuous process by using microwave tunnels. Such tunnels comprises of a series of magnetrons under which the product moved continuously on the conveyer belts. The resulting product showed typical characteristics of a normal *paneer*. In another approach, an in-package process was developed using UF process for manufacturing long shelf life *paneer* like product (Rao, 1996) wherein standardized buffalo milk was concentrated partly by vacuum concentration and partly by employing UF to a level of total solids desired in the final product. After packing in moralized polyester pouches, product was formed by a texturising process at 115ÚC, which also led to sterilization. The process permitted greater product yield (35%) due to retention of whey solids compared to 15% obtained by conventional batch process. Ewes' milk can also be employed for *paneer* making by coagulating the same using 2.0% strength of citric acid heated upto 90ÚC (Pal *et al.,* 2008).

Texture plays an important role in acceptance of any product. Various technological upgradations have been attempted to produce good quality *paneer* using skim milk. Processes like UF has advantage of higher yield and softer structure of *paneer* made from skim milk which is normally very hard and rubbery. In a study, concentration of standardized milk (2% fat, 9.2% SNF) to 27% TS using ultrafiltration for the manufacture of *paneer* resulted in a greater proportion of whey proteins bound to the casein network than the *paneer* made from non-concentrated milk, giving 95% TS recovery on the basis of ultrafiltrate (Kanawjia and Singh 2000). Similar findings were reported by Rao and Mathur (1990). Addition of certain additives has also been reported to improve the sensory quality of *paneer* made from skimmed milk. Incorporation of small amounts of fermented skim milk and salts improved the nutritional and sensory qualities of reduced fat *paneer* (Chawla *et al*., 1987; Sanyal and Yadav, 2000). Salt added at a rate of 0.75% can increase the yield of reduced fat *paneer* by 19.59% above that of control (Sanyal *et al*., 2004). Similarly, concentration of skim milk up to four times by UF along with the addition of 2.5% starter culture and 0.5% salt can reduce the hardness of *paneer* (Sivakumar *et al*., 2005).

Kanawjia and Rizvi (2000) employed Microfiltration (MF) technology for selective fractionation and concentration of standardized cow milk and addition of calcium chloride ($CaCl_2$) @ 0.15% in the MF retentate resulted in an improved organoleptic and textural properties of resultant *paneer*. In another study, MF was employed to concentrate skim milk and the retentate thus obtained was blended with different fat sources viz. butter oil, cooking butter and plastic cream and blend thus obtained was homogenized to prepare a good quality *paneer* (Kanawjia and Rizvi, 2003).

Gupta and Pal (1995) concentrated milk by reverse osmosis (RO) to 25% (1.5X) and 33% (2X) TS. *Paneer* prepared by RO concentrated milk was reported to be 2-3% higher in yield on original milk amount basis as compared to control with comparable sensory attributes. Pal et al. (2002) prepared *paneer* with nanofiltration (NF) concentrated cow milk wherein milk was concentrated 1.5X and 2X at 50^0C. *Paneer* prepared from NF concentrated milk was reported to have reduced hardness, compactness and drying characteristics compared to control. NF also reduced the salt content of cow milk upto 74% in 1.5 X concentration without affecting the other characteristics.

Continuous process of *paneer* making has several advantages over batch process as this permits a uniform and consistent quality of *paneer.* In a study it was observed that continuous process of *paneer* making enhanced the shelf life of *paneer* from four to ten months due to hot packaging**.** The yield of product was also higher by about 10 per cent over all conventional processes. It might be due to the capture of the fine particles which otherwise would normally be lost with the whey. Pilot studies on the UF process indicated excellent scope for scaling up of operation on industrial scale. Also, such from such operations provides the same sensorlogical properties as conventional *paneer* for example market study results revealed the consumer acceptability of UF *paneer* similar to that of the traditional *paneer*. Also, the chemical composition of UF *paneer* was similar to the traditional *paneer* (Table 2). A continuous *paneer*-making system was also designed at National Dairy Research Institute, Karnal by Agrawala *et al*. (2001)

which employed twin-flanged apron conveyor cum filtering system for obtaining the desired moisture content and textural attributes.

In another study conducted by Das and Das (2009), an impact type device was designed for continuous production of *paneer* in which channa was kept in cages made from special type screen and cages were subjected to impact force. Total amount of energy imparted to *chhana* during impacts was correlated with reduction in moisture, increased hardness and the solid lost through whey from pressed *chhana* which was found to follow first order rection kinetics which was further confirmed with the prototype of an impact type device.

Alternate technologies like *paneer* manufacturing by centrifugal process has also been developed at the Indian Institute Technology (IIT), Kharagpur, by Aggarwal (1996). In this method of *paneer* production, buffalo milk was preferred over cow-milk, owing to its intense softness to withstand deep fat frying and common cooking operations. Traditionally, *paneer* is made by pressing the curd and cooling the pressed curd in chilled water and texture of *paneer* was observed to be affected by various factors viz. the initial thickness of curd, applied pressure, duration of pressing and the time of chilling the pressed curd. In centrifugal process, pressing and chilling of curd can be done by the centrifugal method which considerably reduced the time required for production**.**

Shelf life Extension of Paneer

Paneer has relatively shorter shelf life of not more than 1 day at room temperature in tropical countries owing to higher moisture content. Bhattacharya et al. (1971) reported that *paneer* could be stored for only 6 days at 10^0C without much deterioration in its quality, though the freshness of the product got vanished after 3 days. Spoilage of *paneer* is mainly due to the surface growth of microorganisms and in this arena researchers are trying to develop ways to curb the growth of microorganisms to improve the shelf life of *paneer*.

Salt along with potassium sorbate has been known widely to preserve the quality of *paneer*. Several workers have reported significant improvement in shelf life of *paneer* when it is dipped into salt solution. Sachdeva and Singh (1990) reported an improved keeping quality with better palatability when *paneer* cubes were immersed in 5% brine solution. In another approach, use of 0.1% sorbic acid in milk along with irradiation of product @2.5KGy was reported to improve the shelf life of *paneer* to 30 days at ambient temperature (Singh *et al*., 1991) whereas Deshmukh *et al*. (2009) reported increase in yield of *paneer* with the use of acidified and cultured whey. Pal *et al*. (1993) studied the improvement in the shelf life of low-fat *paneer* cubes by parafinning. This technique improved the shelf life by over 10 days. Hot (60ÚC for 5 min) and cold (8-10ÚC for 6-10 hrs) diffusion of *paneer* cubes with sodium chloride and potassium sorbate followed by microwave drying was reported to extend the shelf life of *paneer* (Singh and Rai, 2004).

Heat sterilization was also reported to enhance the shelf life of *paneer* to a considerable extent. In a study, Kanawjia and Singh (2000) brined *paneer* packed in tins was sterilized in autoclave at 1 kg / cm^2 for 15 min. and such heat sterilized *paneer* was reported stay well for 4 months at room temperature. Use of concentration by thermal evaporation under vacuum or ultrafiltration followed by acidification to desired pH (5.4) and in-package thermal texturisation at 115^0C led to sterilization of *paneer*, resulting in shelf life of about 3 months at room temperature (Rao 1996, Kanawjia and Khurana 2006).

In a study conducted by Uprit and Mishra (2004) on textural kinetics of *paneer* wherein the effect of different variables such as temperature of salt solution, conc. of salt, time of exposure etc. was studied in soya fortified *paneer* during salting treatment revealed that with the progression of salting treatment, hardness showed the decreasing trend following the zero order reaction kinetics whereas chewiness showed the reverse trend showing higher chewiness following second order reaction. The increase in values was more prominent at higher temperatures compared to lower temperature. Similar observations were earlier reported by Desai *et al*. (1991). The results obtained for hardness were in accordance to observation made by Rao and Patil (2006) in a research experiment for controlling a_w and pH during *paneer* processing using hurdle technology. A ready to eat *paneer* curry was prepared having a water activity of 0.95 and a pH of 5.0 and potassium sorbate content of 0.1%, and canned at a F value of 0.80 (lethality). The product was stored at 15, 30 and 45°C. During storage, observations indicated that textural attributes such as Cohesiveness and chewiness increased, but hardness decreased. These changes were attributed to continued changes in texture initiated by frying of *paneer* and canning process. These were also linked to Maillard browning which progressed during storage as measured by hydroxymethyl furfural content. These changes were found to be slower vis-à-vis those observed in the product, which was sterilized at conventional F value of 15.0 (control).

Contrary to heating, freezing at zero and sub-zero temperature also serve as important method of shelf life extension. Blast freezing is in exceptional demand in his horizon. Blast freezing refers to the process in various industries whereby objects are quickly frozen by subjecting them to cryogenic temperatures. Blast freezing is used in the food industry to quickly freeze perishable food items. In this case, food items are subjected to temperatures well below water's melting / freezing point (32°F or 0°C), causing the water inside the foods to freeze in a very short period of time without forming large crystals, thus avoiding damage to cell membranes. This rapid freezing is done by submerging the sample in liquid nitrogen or a mixture of dry ice and ethanol. Punjrath *et al*., 1997 used blast freezing (-21^{0}C) to enhance the shelf life of *paneer* blocks to more than 1 year at -19^{0}C.

The effect of various modified atmosphere (MA) (100% N_2, 50% N_2+50% CO_2, 100% CO_2) and different packaging materials viz., P1 (PET / PE) and P2 (PET / PE / Metellosin / PE) was studied on the quality of *paneer* stored at 30 ± 1°C by Karthikeyen *et al*., 2006. Results revealed that chemical, microbiological, rheological and sensory qualities of fresh *paneer* packed under various MA in P1 and P2 packaging materials did not differ significantly from control samples. During storage at 30 ± 1°C, *paneer* under 100% CO_2, had significantly lower acidity, soluble nitrogen (SN), free fatty acids (FFA), coliforms, standard plate count (SPC) and yeast and mould count (YMC), and had higher pH, hardness, springiness, cohesiveness, chewiness, higher flavour, body and texture and total scores than control. The interaction effect between gas and packages was found to be non-significant for all the parameters during the storage period. The control *paneer* samples and the modified atmosphere packaged *paneer* showed a shelf life of 1 and 2 day, respectively, at 30 ± 1°C.

Market Status

In India, the potential growth of indigenous products is still to be and till date major part is confined to local players which process the commodity at small scale and unorganized level without maintenance of hygiene standards which often results in undesirable outbreaks of various microbial-borne illnesses. Recently some major players have entered into this market and with the result *paneer* now can be seen in many shelves of the superstores. *Paneer* is currently marketed by many brands such as Amul, Britannia, Mother Dairy etc. and among them Amul is the national brand leading its sales year by every year. Since the product is available in tamperproof sealed poly- pouches, the quality of Amul Fresh *Paneer* does not get much affected and can be stored in the refrigerator for 15 days whereas Frozen *Paneer* can be stored for 180 days. The same is easy to use as it can be cut, fried and grated as per the choice. AMUL frozen *paneer* manufactured by Amul Dairy commissioned country's first fully-automatic *paneer* plant having manufacturing lines of capacity upto 30 tones / day and was established on 1st Nov'2009. With over 50 per cent share in organized market, Amul is presently the only national brand that sells *paneer*, the dairy product that counts for an estimated Rs 1,000 crore business combining both organized and unorganized players where the share of organized players stands at around Rs. 150 crore. Mother Dairy *paneer* is vacuum packed and is available in 100g, 250g and 1 kg pack. 200 g vacuum packed *paneer* from Britannia is also available in market and confers a shelf life of 5 days at refrigerated temperature.

Conclusion

Paneer is an important indigenous nutritious and wholesome dairy product. It is of great value in diet because it is a rich source of high quality protein, fat, minerals and vitamins. *Paneer* is used as a base material for the preparation of large number of culinary dishes and it is a popular food product at the common household level as well as in ever increasing organized food chains. Most of the *paneer* is produced in unorganized sector in very small quantities using conventional methods. Myriads of work have been done in scaling up the production of *paneer*. Use of mechanized and semi-mechanized systems viz. membrane processes, centrifugal method, in-package texturisation needs to be undertaken for larger production of *paneer* at industrial level. This will not only result in uniform quality of *paneer* with better yield but will also improve the microbial status of *paneer*. Shelf life is again a limitation for large scale production of *paneer*. Use of various methods viz antimicrobials, biopreservatives, heat sterilization techniques, blast freezing, modified atmosphere packaging etc. can improve the shelf life of product many folds.

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