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Khoa: A Heat Desiccated Indigenous Indian Dairy Product.

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ABSTRACT

India produces approximately 132.4 million tons of milk annually. Around 50% milk produced is converted to traditional Indian dairy products. *Khoa*, a heat desiccated indigenous Indian dairy product is the main base for the production sweet meat products. About 7% of milk produced n India is converted to *khoa*. *Khoa* is known by various names in India like *khoya*, *kava* and *mawa*. Sweets prepared from *khoa* are basically *gulabjamun*, *kalajamun*, *kalakand*, *burfi* etc. The estimated market size of *khoa* based sweets is 520 billion INR. Nearly, 36% of *khoa* is produced in Uttar Pradesh state in India. There are various traditional methods for *khoa* production and most of it is produced in an unorganized manner. However in recent years commercialization has led to development of innovative techniques for mechanized production of *khoa* such as Inclined Srapped Surface Heat Exchanger (ISSHE) and Thin Film Scrapped Surface Heat Exchanger (TSSHE). Various alternative methods are roller drying, membrane technology and reverse osmosis.

Keywords: Indian sweets, Traditional dairy products, Heat desiccated product, *Khoa*, Mechanization

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INTRODUCTION

In India, about 50% of the total milk produced (132.4 million tons in 2013) is converted into various traditional milk products (Rao & Raju, 2003; Bhasin, 2010; NDDB, 2014). These products account for 95% of all the milk products consumed and it is worth noting that the organized dairy industry handles only about 15-16% of the total milk produced in the country. Rest of the milk is used by small scale sweet meat shops (*Halwaies*) in unorganized manner.

Traditional Indian dairy products can be classified into six categories based on the principle of manufacture (Srinivasan and Anantakrishnan, 1964; De, 1980; Pal & Raju, 2007):

- Heat desiccated products
- Heat and acid coagulated products
- Fermented products
- Products made with addition of cereals
- Clarified butter fat (*ghee*)
- Frozen products

The production of traditional milk products presents unique opportunity to the organised dairy sector in India as they have a huge mass appeal and the market for these products far exceeds that of western style dairy products. The consumption of traditional dairy products is growing at an annual growth rate of more than 20%, but for the western dairy products the growth rates are relatively much lower (5-10%) (Patil, 2009). While the western dairy products (with the exception of malted milk and milk chocolates) add about 50% value to milk, the traditional Indian dairy products add about 200% value to milk (Aneja, 2007). Further, the raw material costs of certain Indian traditional dairy products viz. *shrikhand, rasogolla, gulabjamun, khoa*-based sweets (*peda*, *burfi*, *kalakand*), *sandesh* and *paneer* is 29, 33, 34, 35 and 65% of the selling price, respectively. For the western dairy products, comparative costs are relatively higher varying from 70-80% (Patil, 2009).

Significant headway has already been made in the industrial production of some traditional sweets such as *gulabjamun*, *peda* and *burfi*. This development is no less than a revolution in the production and marketing of all time popular traditional milk products that were hitherto the exclusive preserve of traditional *halwais* (sweetmeat makers) on a much smaller scale. The market size of ethnic milk products (Table 1) in India alone is estimated at more than 1000 billion INR with an annual growth estimated at 50 billion INR (Aggarwal, 2007). The present paper reviews the heat desiccated indigenous products of India.

Table1: Market size of traditional dairy products

Type of products	End products	Estimated market size (Rs. in billion)
Chhana- based sweets	*Rasogolla, sandesh, pantooa, rasomalai, cham-cham, chhana murki, rajbhog, chhana podo*, etc.	520
Khoa-based sweets	*Kulfi, rabri, basundi, burfi, peda, gulabjamun, kalakand, khurchan, dharwad peda, kunda*, etc.	
Paneer (Indian cottage cheese)		20
Fat-rich products	*Ghee* and *makkhan*	310
Fermented dairy products	*Dahi, misti dahi, lassi, chhach/mattha, shrikhand*, etc.	180

Source: Gupta (2007)

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Heat desiccated Indigenous Indian Dairy Products:

Heat desiccation is the most ancient technology used to process the milk and milk products. Scriptures from the early Buddhist and the Jain period have documented sweets made from heat-desiccated milk such as *sihakesara* and *morandeka*. These have been used as desserts at the end of meals. Lord Buddha allowed his followers to take sweets as a portable ration for journeys on routes where it was difficult to get foodstuffs. In the Maurya Period (268-233 BC), sweets were prepared from concentrated milk and honey or jaggery. The post Gupta period (750-1200 AD) literature also describes varieties of milk sweets (Aneja et al., 2002)

Heat desiccated milk products have thus been traditionally produced in Indian sub-continent since ancient times. *Khoa,* one of the most important heat desiccated product, is used as the base material for a large variety of sweet delicacies.

Cutting across different regions of the Indian sub-continent, a number of heat desiccated milk confections are popular. These products are based on *khoa*/*mawa*, which is used as base material for sweets such as *gulabjamun, kalajamun*, *burfi*, *kalakand*, milk cake, *peda, rabri, khurchan, basundi, pantua, kunda* and *lalmohan*. Confections like *bal mithai, phirni, Kunthalgiri pedha, malaipoori, lal peda, Dharwad peda* and *thirattupal* are region-specific locally available sweets in different parts of India which are preferred by people for their characteristic taste and texture. A major market for Indian milk-based sweets is developing overseas.

The Indian diaspora presents an exciting avenue for globalization of sweetmeats (Rao & Raju, 2003; Patil, 2011). In North America alone, this market is estimated at US $ 500 million (Aneja, 2007).

About 600,000 metric tons of *khoa* is produced annually in Indian sub-continent, utilizing 7% of total milk production just in India. Traditional method of *khoa* production has been scaled up by different semi-continuous and continuous machines which are used in places where the quantity of milk is sufficiently large for *khoa* making. Alternative techniques have also been used for *khoa* production to assist the developed mechanized processes. Process of production and formulations for several heat desiccated traditional milk products have been upgraded and optimized by mechanization of traditional processes. Pal (2000) reviewed the technological advances in the manufacture of heat desiccated traditional Indian milk products. These products are rich in nutrition and also provide vital calories. Gross composition of some of the major heat desiccated dairy products is presented in Table 2.

Table2: Gross composition (%) of some heat desiccated traditional milk products

Product	Milk source	Moisture	Fat	Protein	Lactose	Sucrose	Ash	Reference
Khoa	Cow	30.4	22.2	18.8	24.9	-	3.7	Srinivasan & Anantkrishnan (1964)
	Buffalo	32.0	24.2	18.3	22.0	-	3.5	Srinivasan & Anantkrishnan (1964)
Rabri	Buffalo	49.8	15.5	9.5	11.3	12.0	2.0	Gayen & Pal (1991 a)
Khurchan	Buffalo	27.9	23.6	15.4	14.9	15.2	3	Gupta & Rao (1972)
Basundi	Cow	52.5	10.6	7.8	10.8	15.9	1.4	Patel & Upadhyay (2003b)
	Buffalo	52.9	11.4	10.1	11.1	12.5	1.8	Patel & Upadhyay (2003a)
Peda	Buffalo	14.4	19.3	15.3	15.2	33.3	2.5	Aneja, Mathur, Chandan & Banerjee (2002)
Milk cake	Buffalo	16.8	21.3	11.4	7.7	40.5	2.3	Patil (2002)

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Khoa:

Khoa, the principal heat desiccated dairy product, is used as a base material for a huge variety of sweet delicacies (Fig. 1). It is also called as *khoya*, *kava* or *mawa*. Its exact origin is not known but it has been prepared for centuries in Indian sub-continent as the base material for milk-based confections by milk traders and *halwais*. According to the Food Safety and Standards (Food Products Standards and Food Additives) Regulations (2011) of India, *khoa* by whatever variety of names it is sold, means the product obtained from cow or buffalo or goat or sheep milk or milk solids or a combination thereof by rapid drying. The milk fat

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content shall not be less than 30 percent on dry weight basis of finished product. It may contain citric acid not more than 0.1 percent by weight. It shall be free from added starch, added sugar and added colouring matter.

Khoa has a uniform whitish colour with just a tinge of brown, a slightly oily or granular texture, and a rich nutty flavour which is associated with a mildly cooked and sweet taste due to the high concentration of lactose. About 600,000 metric tons of *khoa* is produced annually in India which utilize 7% of total milk production (Aneja, 1997). Nearly 36% of India's total *khoa* production takes place in Uttar Pradesh. The traditional trade usually pays for milk on the basis of the yield of *khoa* (with 28% moisture). The quality of *khoa* produced from buffalo milk is superior to *khoa* produced from cow milk because *khoa* from cow milk results in moist surface, salty taste with sticky and sandy texture which is not considered suitable for the preparation of sweetmeats. Also, buffalo milk results in higher yield of *khoa.* Cow milk usually yields 17-19% of *khoa* by weight. The yield from buffalo milk is reported to be 21-23% by weight (De, 1980). Buffalo milk fat is more easily emulsified due to the presence of larger proportion of butyric acid containing triglycerides and release of more free fat compared to cow milk which may be responsible for smooth and mellow texture of *khoa* (Sindhu, 1996).

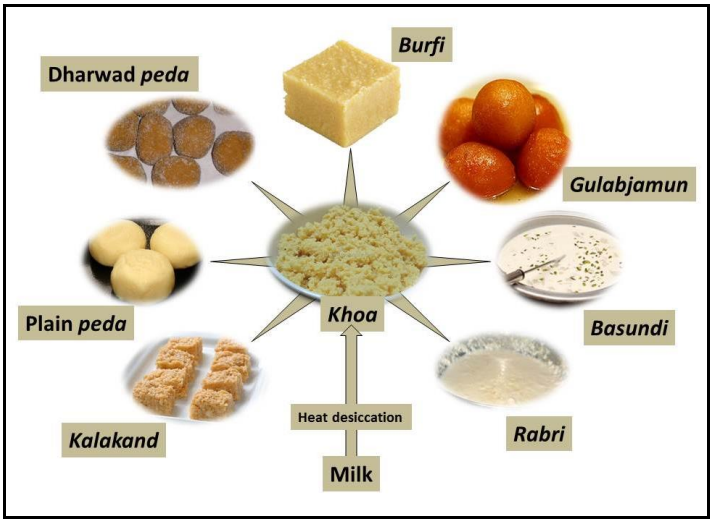

Fig1: An illustration showing a variety of heat desiccated (*khoa*-based) sweets of Indian sub-continent

Types of *khoa:*

Khoa is classified by the Bureau of Indian Standards into three major types depending upon the specific end uses i.e. *pindi, danedar and dhap* (IS 4883, 1980). Milk of high acidity produces a granular *khoa* known as *danedar* type. *Pindi khoa* is characterized as a circular ball of a hemispherical pat with smooth and homogenous body and texture and free from burnt particles as well as any browning defects. It is most suitable for making *peda*. *Danedar khoa* is characterized by its granular texture and uneven body. The size of grains depends upon the amount of coagulant added and the quality of milk used. This type of *khoa* is used as a base for the preparation of *kalakand*, cakes and pastries where granulation is valued to a great extent. *Dhap khoa* is characterized by loose and sticky body and smooth texture. It contains less than 60 percent by mass total solids and higher moisture content than *pindi* and *danedar* types. *Dhap khoa* is preferred for the preparation of *gulabjamun* as it forms uniform balls with desired rheological qualities after frying and soaking in sugar syrup. Table 3 represents the various types of *khoa* and their preferred end uses.

Table3: Types of *khoa* and their preferred end uses

Type of *khoa*	TS (%)	Fat (%)	End uses
Dhap	56-63	20-23	*Gulabjamun, pantua*
Pindi	67-69	21-26	*Burfi, peda*
Danedar	60-65	20-25	*Kalakand,* milk cake

Source: Aneja et al. (2002)

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Table4: Defects in *khoa*, their causes and prevention

Defects	Causes	Prevention
Flavour		
Smoky	Smoky fire used for boiling and dehydration of milk.	Using non-smoky fire for boiling and dehydration of milk.
Sour/ Acid	Excessively high acidity in milk.	Using fresh sweet milk.
Rancid	Fat hydrolysis due to lipase action in *khoa* during storage (at temperature and above).	Early disposal/marketing of *khoa*.
Stale	Excessively long period of storage of *khoa* at low temperature (5-10°C).	Early disposal/marketing of *khoa*.
Body & Texture		
Hard body	Excessively low fat content of milk used.	Using milk of optimum fat content.
	Excessively low moisture content of *khoa* due to faulty production technique.	Optimum moisture content of *khoa* by adopting correct production technique.
	Adulteration of milk with starch.	Using unadulterated milk.
Coarse texture	Excessively high acidity in milk used.	Using fresh sweet milk.
	Excessively low fat content of milk used.	Using milk of optimum fat content.
	Excessively high temperature of dehydration, especially in the last stages.	Optimum temperature of dehydration, especially in the last stages.
	Excessively low speed when stirring milk/pan contents.	Optimum speed when stirring milk/pan contents.
Gritty texture	Presence of sand-like particles due to incorrect stirring of milk.	Correct stirring of milk.
	Presence of large crystals of lactose due to incorrect method of manufacture.	Correct method of manufacture.
Colour & Appearance		
Dry surface	Excessively low fat content of milk used.	Using milk of optimum fat content.
Visible dirt/ foreign matter	Incorrect or no straining of milk used.	Correct straining of milk.
	Heating-pan and/or stirrer not cleaned.	Heating-pan and/or stirrer well cleaned.
	Dirty/windy surroundings during manufacture and/or handling of *khoa*.	Clean surroundings during manufacture and/or handling of *khoa*.
	Transport of unpacked *khoa*.	Transport of properly packed *khoa*.
Browning and/or presence of burnt particles	Excessively high heating temperature, especially in the last stages.	Optimum heating temperature, especially in the last stages.
	Excessively low speed when stirring-cum-scraping pan contents.	Optimum speed when stirring-cum-scraping pan contents.
Mouldy surface	Excessively high moisture content of *khoa* in the storage.	Optimum moisture content of *khoa* in storage.
	Excessively high humidity of storage room.	Optimum humidity of storage room.
Fat and/or water leakage	Air-leaky packaging of *khoa*.	Airtight packaging of *khoa*.
	Incorrect method of manufacture of *khoa*.	Correct method of manufacture of *khoa*.

Source: Aneja et al. (2002)

Khoa manufacturing has been the easiest way of preserving rurally-produced milk in the flush season. In many places, *khoa* manufactured in winter season is cold-stored for use in the summer season. Such type of *khoa* acquires a green colour due to mould growth on the surface. It is therefore known as *hariyali* (green) *khoa*. This *khoa* is preferred for the preparation of *gulabjamun* as it gives a grainy texture to the product. This type of *khoa*, on removal from the cold store is immediately mixed with flour and made into *gulabjamun*. *Hariyali khoa*, if left at room temperature for long, starts giving off-flavour and breaks down physically. In view of this, it is converted into end product immediately. Common defects in *khoa*, along with their causes and prevention, are given in Table 4.

Standardization of milk for *khoa* making:

Buffalo milk is preferred for *khoa* making because it yields a whiter product with a soft, loose body and a smooth granular texture which makes it suitable for the preparation of high-grade *khoa* sweets. The fat level is maintained to 4% and 5% for cow and buffalo milk, respectively. Lower levels of fat result in undesirable hard body and coarse texture (De, 1980). Beniwal et al. (2010) standardized the buffalo milk for the production of *khoa* through a semi-automatic machine. Based on physico-chemical parameters and sensory evaluation, fat/SNF ratio of 0.611 in milk was found to be the most suitable for preparation of *khoa.* The Bureau of Indian Standards (BIS) standards for the three *khoa* varieties are given in Table 5.

Table5: BIS* standards for three *khoa* varieties

***Khoa* type**	**Total solids, minimum (%)**	**Fat in dry matter, minimum (%)**	**Ash in dry matter, maximum (%)**	**Titratable acidity, (% lactic acid in mass), maximum**
Dhap	55	37	6	0.6
Pindi	65	37	6	0.8
Danedar	60	37	6	0.9

Source: Aneja et al. (2002)
*BIS: Bureau of Indian Standards

Technological innovations in *khoa* making:

The prehistoric process of *khoa* making in mild steel shallow open pans on open flame of fire with vigorous mixing using a wooden or steel ladle has been scaled up by different semi-continuous and continuous machines which are used in places where the quantity of milk is sufficiently large for *khoa* making. The first model of continuous *khoa* making machine of 50 litres per hour capacity was developed by Banerjee et al. (1968). The process involved a steam jacketed cylinder fitted with rotary scrappers followed by final concentration in an open cascading steam jacketed pan with mechanical scrapping agitators. Subsequently, the process was standardized with several modifications suggested by De & Singh (1970).

The equipment for the production of *khoa* under rural conditions was developed by Sawhney & Kumar (1986) providing a semi-jacketed, shallow open pan and using a swinging hanger type scraper for stirring during the desiccation process. The 2/3rd of pan is filled with water placed over the furnace. Steam generated inside the jacket, is regulated by a safety valve to control the pressure and temperature. Steam pressure inside the jacket varies from 0 to 4 kg/cm^2. On the basis of principle of scrapped surface heat exchanger, More (1987) designed a semi-mechanized batch type process for *khoa* manufacturing which consisted of jacketed drum with vapour exhaust and scrapper assembly. Christie & Shah (1988, 1990 & 1992) have extensively worked on mechanization of *khoa* using steam jacketed cylinder with several modifications.

An Inclined Scraped Surface Heat Exchanger (ISSHE) was developed for continuous *khoa*-making by National Dairy Development Board, Anand, India (Punjrath et al. 1990). The plant comprises of a balance tank, a positive displacement pump and an ISSHE. Milk concentrate of about 42-45% total solids, is used as feed. The inclination of ISSHE permits the formation of a pool of vigorously boiling milk important to the formation of *khoa. Khoa* prepared by ISSHE is similar to the conventional product from sensory point of view and also maintains compositional and rheological uniformity during continuous operation. A thin film scrapped surface

heat exchanger (TSSHE) was also developed by Dodeja et al. (1992) at National Dairy Research Institute (NDRI), Karnal, India for the continuous manufacture of *khoa*. TSSHE unit consisted of two mild steel SSHE arranged in cascade fashion. The milk is concentrated to 40-45% total solids in first SSHE and finally to *khoa* in second SSHE. Unlike in ISSHE, the feed for this unit is buffalo milk and thus rendering it suitable for small and large organised manufacturers and entrepreneurs. Bhadania et al. (2005) studied the energy requirements of SSHE during manufacture of *khoa* and concluded that three-stage SSHE could be successfully used for the continuous manufacture of *khoa*. The steam requirement for the manufacture of *khoa* varies between 1.28 - 1.62 kg per kg of water evaporated under various operating conditions of the SSHE. The quality of *khoa* prepared from different mechanized systems is given in Table 6.

Table6: Quality of *khoa* prepared from different mechanized systems

Characteristics	ISSHE	Conical Vat	Contherm-convap	Roller process
Total Solids (%)	65.6	63.1	63.8	70.9
Fat (%)	21.9	21.2	21.5	27.7
Free fat (% of total fat)	35.0	43.5	58.4	51.1
Acidity (%)	0.5	0.5	0.6	0.6
Colour (Lovibond tintometer readings)	1.61y	1.68y + 0.3R	2.03y + 0.5R	1.5y
Hardness (mN)	47.5	58.1	52.01	89.7
Cohesiveness	0.5	0.5	0.4	0.4
Adhesiveness (mN)	0.3	0.7	0.8	0.5
Springiness (mN)	4.8	7.3	8.0	6.2
Gumminess (mN)	29.3	26.0	22.6	36.4
Chewiness (mm.mN)	116.4	191.2	181.1	223.9

Source: Rajorhia et al. (1991)

Alternative techniques for *khoa* making:

Alternative techniques have also been used for *khoa* production to assist in the development of mechanized processes. Singh & Rajorhia (1989) studied the possibility of adopting a roller dryer for *khoa* production. The process was found to be highly energy-intensive and *khoa* obtained by this method was flaky, dry and completely lacked the desired consistency. Dehydration is a common method used for extended preservation of foods. *Khoa* powder, a desiccated product, potentially offers an economically attractive, long life product that can supplement the traditional, perishable *khoa*. Pal & Londhe (2006) extensively reviewed the application of membrane technology for the production of traditional dairy products. The use of pre-concentrated milk has been suggested in several previously reviewed mechanized processes for the *khoa* production. Pre-concentration of cow milk, 2 fold (Pal & Cheryan, 1987) and buffalo milk 1.5 fold (Kumar & Pal, 1994) using reverse osmosis technique followed by heat desiccation in a steam jacketed open pan has been successfully demonstrated.

Microbiology of *khoa:*

Khoa is a favourable medium for the growth of microbes on account of its nutritive value and moisture content. The unsatisfactory practices generally followed in its production, handling and storage in unorganized sector results in poor shelf life (Sharma et al. 1972). Although during manufacture of *khoa*, milk is subjected to drastic heat treatment, the aerobic spore formers are known to survive such heat treatment and may outnumber other types of micro-organisms, thereby suggesting that the survivors might multiply during subsequent storage. The possibility of contaminants gaining entry into these products during subsequent handling also cannot be ruled out (Rudreshappa & De, 1971). Table 7 shows the typical microflora of market *khoa.*

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Table8: Typical microflora of market *khoa*

Group	Genera
Yeasts	*Saccharomyces, Candida, Rhodotorula, Aspergillus, Geotricum, Mucor, Syncephalostrum, Fusarium, Rhizopus, Cladosporium*
Bacteria	*Streptococci, Micrococci, Bacillus*
Pathogenic bacteria	*Staphylococci*

Rajarajan et al. (2006) studied the effect of antifungal agents on keeping quality of *khoa*. They treated the samples with natamycin (0.5%) and potassium sorbate (0.3%). It showed lower yeast and moulds counts during storage at 30^{o}C and also at 5^{o}C. Chavan & Kulkarni (2006) made efforts to improve the microbiological quality of *khoa* by solar radiation and microwave heating. The application of microwave heating was observed to be quite superior in reducing the total bacterial count, yeast and mould count (YMC) and spore count. It also showed very slow rate of increase during storage for a week. Use of solar radiation through convex lens showed promising results in reducing microbial counts and particularly more effectively on YMC.

A study was conducted to analyze bacterial contaminants /pathogens in *khoa* samples sold in Chambal region of Madhya Pradesh in India. A total of 50 samples of *khoa* were brought from different localities of Chambal region at random. Bacterial colony counts were also performed on these samples. *Staphylococcus* and *Streptococcus* species were the predominant isolates. The viable counts obtained ranged from 1.3x10^{4} to 2.1x10^{6} cfu/g. Contamination of *khoa* by pathogenic bacteria could be an important factor of gastrointestinal infections including food poisoning and food borne illness Adequate consumer protection can be achieved by assessment of the microbiological data of the product (Bhatnagar et al. 2007). Heat processing of milk having 3.5-6.5% fat at either 63^{o}C or 73^{o}C, eliminated all *Escherichia coli*. Under similar processing conditions, *Staphylococcus aureus* was recovered, but only when heated in milk at 63^{o}C containing 6.5% fat. Potassium sorbate (3000 ppm) appeared more effective in inhibiting the growth of selected yeast and molds in *khoa* at 7^{o}C, compared to ascorbic acid (3000 ppm). Reducing the water activity (a_w) of *khoa* from 0.97 to 0.93 did not appear to enhance the preservative effect. The reduction of *E.coli* or *Staphylococcus aureus* in *khoa* during prolonged storage at 6–7^{o}C, was less than one log cycle, regardless of a_w or preservative type. Survival of *Staphylococcus aureus* in *khoa* appeared to be enhanced with a decrease in a_w (Sohal et al. 1993).

A study was conducted to identify the incidence of different microorganisms in air and *khoa* samples collected from different sections of a *khoa* plant. *Penicillium citrinum* was found to be predominantly present in both air (24%) and *khoa* samples (27%). The other molds encountered were *Geotricum candidum, Mucor racemosus, Aspergillus niger, Syncephalastrum oxysporum, Rhizopus stolonifer, Cladosporium cladosporioides, Absidia corymbifera and Pacilomyces variotti* (Rajarajan et al. 2007).

CONCLUSION

Khoa is a basic material used to manufacture various s sweet meat products. However, the quality of *khoa* manufactured in India varies considerably due to highly unorganized production and variable raw material quality. Mechanization of *khoa* production has brought some relief to this problem to some extent.

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