STANDARDISATION OF METHOD FOR THE MANUFACTURE OF KHOA JALEBI

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By

NAWALE PRATIK K.

B.Tech. (Dairy Technology)

DIVISION OF DAIRY TECHNOLOGY

NATIONAL DAIRY RESEARCH INSTITUTE

(ICAR)

BANGALORE- 560 030, INDIA

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With a fresh look towards the harvest of prosperity and blessings ahead,
I seize each moment to reflect positively on my journey through
Traditional education to this summit.
Therefore, it is with immense thanks and invaluable appreciation
That I dedicate this work to the Lord,
Who by his abundant grace saw me through it all …
And to my loving family,
Whose spiritual and emotional acumen also thrusted a deeper sense
of inspiration, love and purpose in me.

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IN

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Approved By

(External Examiner) **(Dr. C.N. Pagote)**
Major Advisor
(Guide)

Members of Advisory Committee

1. **Dr. Satish Kulkarni**
   (Principal Scientist, Dairy Technology and Head, NDRI, Bangalore) _____
2. **Dr. K. Jayaraj Rao**
   (Senior Scientist, Dairy Technology) _____
3. **Dr. B. V. Balasubramanyam**
   (Principal Scientist, Dairy Technology) _____
4. **Dr. B. Surendranath**
   (Principal Scientist, Dairy Chemistry) _____

DIVISION OF DAIRY TECHNOLOGY
NATIONAL DAIRY RESEARCH INSTITUTE
(Deemed University)
(Indian Council of Agricultural Research)
BANGALORE- 560030 (KARNATAKA), INDIA

Dated: / /2010

Dr. C.N. Pagote, Ph.D.
Principal Scientist
Dairy Technology Section
National Dairy Research Institute
Southern Campus
Bangalore-560 030

CERTIFICATE

This is to certify that the thesis entitled, "**STANDARDISATION OF METHOD FOR THE MANUFACTURE OF KHOA-JALEBI",** submitted by PRATIK KESHAV NAWALE towards the partial fulfillment for the award of the degree of **MASTER OF TECHNOLOGY** in **DAIRY TECHNOLOGY** of the **NATIONAL DAIRY RESEARCH INSTITUTE (Deemed University)**, Karnal (Haryana), India, is a bonafide research work carried out by him under my guidance, and no part of the thesis has been submitted for any other degree or diploma.

(Dr. C.N. PAGOTE)
Major Advisor
(Guide)

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LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	:	Analysis of Variance
cfu	:	Centimeter
cfu	:	Colony forming units per gram
Fig.	:	Figure
g	:	Gram
kg	:	Kilogram
mg	:	Milligram
ml	:	Millilitres
mm/s	:	Milimeter per second
SNF	:	Solids not fat
SPC	:	Standard plate count
w/v	:	Weight by volume
min	:	Minutes
%	:	Per cent
Df	:	Degrees of freedom
^{0}C	:	Degree Celsius
PET	:	Polyethylene terephthalate
AL	:	Aluminium
PP	:	Polypropylene
LDPE	:	Low density polyethylene

1.0 INTRODUCTION

India is the world's largest producer of milk with an annual production of 108 million tonnes (Bhasin, 2010). An estimated 50-55% of milk produced in India is converted into a variety of traditional milk products using processes such as acid-coagulation, heat-desiccation, fermentation, etc. They add value to milk to the tune of 200%. Among Indian traditional milk products, *khoa* and *chhana* based milk sweets handle about 10% of total milk production. These milk based sweets are available throughout country in all seasons and possibly add Rs.20000/- crores to milk (Aneja, 2007). India's traditional dairy sector is poised for rapid expansion with the result of application of modern technologies in the production of indigenous sweets. The rising demand for fresh dairy products is widening the base of modern dairy sector.

The indigenous dairy products are the country's largest selling and most profitable segment. The growth of the sector is estimated as Rs.5000/- crores annually covering products such as ghee, *dahi*, *paneer*, *rosogolla* and *shrikhand* etc. (Aggarwal, 2007). The economic significance of traditional dairy products can be realized from the fact that they have huge market size estimated at more than Rs.100000/- crores, approximate share of individual products being *chhana* and *khoa* based sweets, Rs. 52000/- crores, ghee/ *makhan* Rs.31000/- crore , fermented products (*dahi, chakka, shrikhand*) Rs.18000/- crores and *paneer* Rs.2000/- crores (Dairy India, 2007).

Though India's milk production has crossed 108 million metric tones in 2008-2009, our share in world trade of dairy products is negligible (0.2 per cent). Global export of milk and milk products in milk equivalent terms is projected at 40.4 million metric tones in 2008. Despite the widespread popularity and acceptability of traditional products in the Indian milieu, the organized sector has still not been

able to fully tap their market potential for many reasons. Some of the most important ones are: i) Inadequacy of appropriate technologies for their large scale production, and ii) Inadequacy of appropriate packaging systems and labeling to take care of new patterns in consumer demand (Aneja , 2007).

The packaging aspects of traditional milk products are also in stage of infancy. The materials tried in packaging of these products vary from leaves, polyethylene pouches, paper board cartons to tin / aluminium cans. Use of cans is often expensive in Indian context. Thus, efforts should be made to study the utility of various types of flexible and semi rigid packaging films like polyethylene, polyvinyl chloride, polypropylene and various laminates for milk and indigenous milk products (Bandyopadhyay, 2006).

The preparations of traditional milk products are largely managed by the '*halwais*' where little or no innovative approaches are adopted. These products made by them are not of uniform quality and composition, and at times they are adulterated. The packaging aspects are in a stage of negligence and many times carried out under unhygienic conditions leading to microbial contamination. These naturally result in products with low shelf life. Standardization of some of the *khoa* and *chhana* based milk products have been done by many researchers.

India is a large subcontinent representing an amalgam of numerous cultures and cuisines. It has been the home of a vast diversity of traditional foods. Now-a-days many street food-products are popular and available every where. Many breakfast food items are being prepared along with milk based sweets. Some are popular deep-fried sweets which are consumed throughout India on various occasions. Among these food items, *jalebi* is one such product which is prepared and consumed with much interest.

Jalebi is the most popular traditional sweet and breakfast food item prepared and consumed everyday throughout India as a major breakfast item, and also on

different occasions like wedding, festival, birthday, feast, etc. It is mainly prepared by *halwais* as well as house-wife by traditional method. It is prepared from basic ingredients viz. maida, fine grained semolina or rice powder, etc. Flavours like cardamom, rose or *kewada* are also being used as per taste and choice (Pagote, 2009).

India is a country of festivals. There is a tradition of 'fasting' on religious occasions. Therefore, many varieties of sweets and other fasting food items are being prepared in Indian households. *Khoa-jalebi* is one of them. Hence, the present study was taken up with the following **objectives** to optimise the production parameters of *khoa-jalebi*.

1. To standardise the method for the preparation of *khoa-jalebi*.

2. To study the shelf life of the product prepared by standardised method.

2.0 REVIEW OF LITERATURE

The review of literature pertaining to the topic of present study has been reviewed in this chapter. Since the published information about *Khoa-jalebi* is scanty, the literature of closely related other fried products such as *gulabjamun, pantua* and c*hhana jhili* are included in this chapter.

2.1. KHOA BASED FRIED SWEETS

2.1.1. *GULABJAMUN*

Gulabjamun is a *khoa* based sweet popular throughout the country. Originally it was made with *khoa* and *maida*. Ghosh *et al.* (1986) recommended that *gulabjamun* should have the following desirable quality attributes:

Attribute	**Desirable characteristics**
Color	Light brown to dark brown
Smell	Slightly cooked
Taste	Sweet
Body	Soft, slightly spongy, juicy
Texture	Uniform, slightly granular
Shape	Spherical to oval

The corresponding hardness values were 0.007±0.001 and 0.004±0.0001 N/mm at 25^{o}C (Ranganadham, 1988). Ghosh *et al.* (1984) reported that the desired penetration value of *gulabjamun* should be 150.

2.1.1.1. Ingredients / Recipe

A formulation of *gulabjamun mix powde*r by using both roller dried and spray dried skim milk was also developed by them. Frying condition and other processing parameters were also standardized. The shelf life of mix in metallised laminate pouches was reported to be about 9 months at room temperature.

De (1989) reported a recipe of *gulabjamun* with 300 g *khoa*, 35 g *maida* and ½ tea-spoon baking powder. After frying, the balls are to be dipped in sugar syrup of 2-string- consistency at room temperature for 10-12 hours to attain proper sweetness and soaking.

2.1.1.2. Method of preparation

Traditionally, *gulabjamun* is prepared on small scale. In this process, 300 g *dhap* type of *khoa* (40-50 % moisture) is mixed with 100 g of wheat flour (*maida*) and 3 g of baking powder. The mixture is kneaded with sufficient water to make uniform dough and then rolled into small round or cylindrical shape. These are then deep fried in edible oil in a shallow pan until they acquire a golden brown colour. The fried balls are then put into 50 – 60% sugar syrup and allowed to soak for a few hours before being served.

Many works have been carried out on the standardization and mechanization of *gulabjamun* production. New technology for industrial production of *gulabjamun* has been developed using an assembly-line system and is in operation at the Sugam Unit of the Baroda District Co-operative Milk Producers' Union Ltd, Vadodara in Gujarat.

Ghosh *et al.* (1984) standardised the method of *gulabjamun* preparation from *dhap khoa* by blending 750 g *khoa*, 250 g *maida* and 5 g baking powder. The sugar syrup concentration of 60%, soaking temperature 60^{o}C and soaking period of 2 hours were recommended.

In an attempt to replace the sugar, Chetana *et al.* (2004) reported the use of sorbitol (sugar substitute) in *gulabjamun* where they found that *gulabjamun* with sorbitol scored a maximum sensory score of 8.0 after soaking in syrup of 54^0B at 65^0C for 3 hours.

Addition of trisodium citrate to the dough at a level of 0.5 to 0.8 % (w/w) of milk solids produced *gulabjamuns* of approved profile. The product was softer and showed more springiness and consequently absorbed more sugar syrup, enhancing juiciness (Thakkar *et al.*, 1994).

2.1.1.3. Composition

Dharam Pal (2007) reported that the gross chemical composition of *gulabjamun* varies widely depending on numerous factors such as composition and quality of *khoa*, proportion of ingredients, sugar syrup concentration etc. The composition of *gulabjamun* of drained weight was: moisture- 25-35 %, fat - 8.5-10.5 %, protein- 6-7.6 %, ash- 0.9-1 % and total carbohydrates- 43.0-48.0%. Sharma and Zariwala (1978) reported that the moisture of *gulabjamun* varied from 22.2 to 41.8 %, fat from 5.0-8.0%, protein from 0.0 to 3.4% and sucrose from 30.5 to 41.3%.

Minhas *et al*. (1985) studied the effect of mix formulations containing 70, 80 and 90 % of *khoa* and 30, 20, 10 % of wheat flour, frying temperature (130, 140 and 150^{o}C) and soaking time (2, 3 and 4h) on the chemical composition of *gulabjamun*. The proportion of *khoa* and flour in the formulation had significant effect on chemical composition. Fat uptake decreased significantly, as frying temperature increased from 130 to 150^{o}C; increased time of soaking in sugar syrup also decreased the fat content of *gulabjamun*.

Minhas *et al.* (1985) reported that *gulabjamun* made from mix having 80% *khoa* and 20 % flour had an average protein content of 9.6 %, fat 9.6% and total

carbohydrates 77.1% on dry matter basis. Chaurasia (1987) reported the average composition of *gulabjamun* made from mix powder as moisture 43.46%, fat, 9.11%, protein 3.98%, carbohydrate 42.53% and ash 1.01%.

Ranganadham (1988) analysed the samples of *gulabjamun* collected from Karnal market and those prepared in the laboratory for gross chemical composition. The average values were found to be moisture 32.20% and 30.63%, fat 8.11% and 8.73%, total protein 5.24% and 5.32%, total carbohydrates 53.53% and 54.40% and ash 0.92% and 0.93% for market and laboratory samples.

2.1.1.4. Shelf life

Dharam Pal (2000) reported that the shelf life of *gulabjamun* at ambient temperature in sugar syrup was 5-7 days and hot filling in polystyrene cups with addition of 0.1 % potassium sorbate could extend the shelf life to 3 weeks. According to Chaurasia (1987), tin container was the best packaging material for *gulabjamun*. The shelf life of *gulabjamun* packaged in tin container was 20 days while it was 16 days in laminate and 12 days in polystyrene cup at room temperature.

2.1.2. *PANTUA*

Pantua has its origin in Eastern parts of India. It is similar to g*ulabjamun* except that *pantua* dough is mainly made of a mixture of *khoa* and/or *chhana* with *maida* whereas g*ulabjamun* is made with *khoa* and *maida*.

2.1.2.2. Ingredients / Recipe

De (1989) gave method for *pantua* preparation and suggested the following ingreidients.

Khoa 300g

Chhana	300g
Maida	35g
Sugar	1kg
Water	1kg
Ghee	1kg
Baking powder	½ spoon

Traditionally *khoa* and *chhana* are broken into bits and kneaded with mixture of dry ingredients. The mass is kneaded into uniform dough, portioned and rolled into balls between the palms. The balls are deep fried in ghee in a shallow pan till they are deep brown in colour. The fried balls are dipped in 60 % sugar solution for a few hours before serving (Aneja *et al.*, 2002).

2.1.2.2. Method of preparation

A method of manufacture of *pantua* has been standardized, wherein cow milk *chhana* (58 % moisture) and *dhap* type *khoa* (40% moisture) were used. The final formulation contained *chhana* (50%), *khoa* (40%), *maida* (3%), arrowroot (3%), *suji* (3%), ground sugar (0.7%) and baking powder (0.3%). The ingredients were kneaded to form dough with 40 % moisture. The spherical balls (2.5cm diameter and 12 g weight) were deep fried in hydrogenated oil at 120^{o}C. The balls were then kept on perforated mesh for 10 min for draining of oil and cooling; then dipped in 55 % sugar syrup at 60^{0}C for four hours (Nath, 1992). According to Rajorhia and Srinivasan (1976) *dhap* type of *khoa* is more suitable for the preparation *pantua*.

2.1.2.3. Composition

Nath (1992) reported that gross chemical compostion of *pantua* was: total soilds 59.7%, fat 15.5%, protein 8.7%, ash 0.67%, sucrose 27.1% and other carbohydrates 7.7%.

2.2 *CHHANA* BASED FRIED SWEETS

2.2.1. *CHHANA JHILI*

Chhana jhili, a popular product of Orissa is made form *chhana*. It is traditionally prepared by mixing *chhana* and *maida*/ *suji* to form a batter which is then made into specific shape and deep fried in oil/ ghee and thereafter soaked in sugar syrup. It is irregular in shape, golden to dark brown in colour, has soft body, spongy texture and rich caramelized cooked flavor.

2.2.1.2. Method of preparation

Dyuthy (2009) standardized the process for the manufacture of *chhana jhili*. The moisture content of the batter was optimized to be 55-60 %. Frying at 150-160^{o}C for 10-15 minutes showed best body and texture and highest overall acceptability among 130-140^{0}C, 150-160^{0}C and 170-180^{0}C. The optimum sugar syrup soaking conditions were found to be at 70^{o}C in 40-45% sugar syrup for 3 hours. *Chhana jhili* made by using 4% fat in milk showed better quality than 3% fat in milk. Incorporation of *suji* in batter was preferred between *maida* and *suji*. *Suji* at 15% level resulted in spongy and soft product which was preferred maximum among 5, 10, and 15 % levels of addition.

2.2.1.2. Composition

The composition of *chhana jhili* was found to be 42.07%, 9.41%, 8.94%, 21.26%, 0.56% and 17.13% of moisture, fat, protein, sucrose, ash and other carbohydrates, respectively (Dyuthy, 2009).

2.2.1.3. Shelf life

The product packed in standy pouch with 1000ppm sorbic acid showed a maximum shelf life of 20-25 days at room temperature. Preservative added

samples showed maximum shelf life among control, hot filling and preservative added samples stored at both the temperatures (Dyuthy, 2009).

Table 2.1 Comparison of physicochemical characteristics of gulabjamun, pantua* and *chhana Jhili

Characteristics	*Gulabjamun*	*Pantua*	*Chhana jhili*
Ingredients (%)			
Khoa	74	40	-
Chhana	-	50	85 - 95
Maida/*suji*	25	03	05 - 15
Others	01	07	-
Shape	Mostly spherical	Cylindrical/ spherical	Irregular
Composition (%)			
Total solids	72.0	59.7	40.0 - 50.0
Fat	10	15.5	9.0 - 10.5
Protein	06	08.7	7.0 - 8.5
Carbohydrates	42	34.8	25.0 - 30.0
Other solids	14	-	-
Ash	-	0.67	0.7- 0.8
Sugar syrup (%)	62	55	35-45
References	Aneja *et al*. (2002)	Nath (1992)	Dyuthy (2009)

2.3. MAJOR INGREDIENTS USED IN ABOVE PRODUCTS

2.3.1. *Khoa*

Rajorhia and Srinivasan (1976) found that *Dhap* a high moisture variety of *khoa* with loose texture is suitable for *gulabjamun*. *Dhap* has 37-44% moisture and

20-23% fat. Prajapati *et al.* (1991) reported that *khoa* prepared from concentrated milk (40% T.S.) yielded *gulabjamun* with higher fat content but lower protein content. The use of *khoa* made from concentrated milk yielded *gulabjamun* with more porous texture thereby increasing sugar syrup absorption.

2.3.2. Binding agent

The type of binder and its rate of addition play an important role in deciding the composition, rheology and sensory attributes of product. Ghosh *et al*. (1984) reported that the hardness and porosity of g*ulabjamun* kept on increasing with decreasing quantities of starch in the mix powder. In gulabjamun making *maida* @ 10% of weight of *khoa* is the most widely used as binder (Gill and De, 1974). Ghosh *et al.* (1984) observed that replacement of a part of *maida* with *suji* gives a soft and uniform body. *Suji* has been found to improve the textural characteristics of g*ulabjamun* when used singly (Prajapati *et al*., 1992) or in combination with *maida* (Ghosh *et al.*, 1984). Verma (1989) reported that arrowroot, semolina and *maida* act as binding and texturising agent in *rosogolla*. He further reported that semolina increased the softness of *rosogolla*. A level of 2% was found to be the best. Prajapati *et al*. (1992) suggested that *suji* can be pre soaked and used in g*ulabjamun* preparation to give a superior quality product.

2.3.2.1. Maida

According to Prevention of Food Adulteration Act, 2008 *maida* means the fine product made by milling, grinding clean wheat free from rodent hair and excreta and bolting or dressing the resulting wheat meal. It shall conform to the following standards,

Moisture: >14.0% (when determined by heating at 130^{o}C-133^{o}C for 2h)

Total ash: > 1.0% (on DM)

Ash insoluble in dilute HCl: > 3.1% (on DM)

Gluten: <7.5% (on DM)

Alcoholic acidity: >0.12% expressed as H_2SO_4 (on dry weight basis with 90 percent alcohol)

Starch products like *maida* and *suji* (semolina) serve as binding agents in the production of c*hhana podo*. They hold moisture to give the taste of the product and bind other ingredients for the formation body and texture of *chhana podo*. Semolina is the inner, granular, starchy endosperm of hard or durum wheat (not yet ground into flour); used to make pasta and milk pudding. It is the gritty, coarse particles of wheat left after the finer flour has been extracted. The particles are mostly between 0.25 and 0.75 mm in diameter. Semolina made from durum wheat or other hard wheat (that is easier to grow than durum) is quite yellow in color. Semolina has 360 kcal nutritional value per 100g. It is rich source of carbohydrates (72.83%), protein (12.68%), fat (1.05%) and water (12.67%).

Maida and *suji* were tried at 5 and 10 % levels of *chhana* so as to assess the efficacy of these binding agents on the sensory characteristics of the final product with 30 % sugar on *chhana* basis. *Chhana podo* with 5% *suji* resulted in granular texture, whereas with *maida*, it gave a smooth bodied *podo*. This is because of the difference in the grain size of *maida* (fine particles) and *suji* (0.25-75mm) (Wikipedia, 2006). Both *maida* and *suji* could be used as additives to obtain an acceptable quality *podo* with spongy texture. Overall acceptability score indicated that incorporation of 5 % *suji* resulted in the best product among all other combinations (Ghosh *et al.*, 2007).

Ghosh *et al.* (1984) reported that the hardness and porosity of *gulabjamun* kept on increasing with decreasing quantities of starch in the mix powder. Verma (1989) reported that if arrowroot level was more than 6% in *rasogolla* then the

product become starchy. A higher level of arrowroot resulted in decrease in sugar absorption.

2.3.2.2. Semolina (*Suji*)

According to Prevention of Food Adulteration Act, 2008 semolina/*suji*/rawa means the product prepared from clean wheat free from rodent hair and excreta by process of grinding and bolting. It shall be free from musty smell and off-odour and shall be creamy yellow in colour. It shall conform to the following standards,

Moisture : not more than14.5% (when determined by heating at 130^0C- 133^0C for 2h)

Total ash : not more than 1.0% (on DM)

Ash insoluble in dilute HCl : not more than 0.1% (on DM)

Gluten : not less than 6.0% (on DM)

Alcoholic acidity : not more than 0.18% expressed as H_2SO_4 (on weight basis with 90% alcohol)

Rao *et al.* (1976) reported that semolina cooks to soft product within a short period (15 minutes). Ghosh *et al.* (1984) have reported that semolina has softening effect and helps in absorption of sugar syrup in g*ulabjamun*.

2.3.3. Baking powder

Ghosh *et al.* (1984) reported that a high level of baking powder resulted in soapy taste, extra porosity, big air cells and cracking of *gulabjamun* balls during frying. Low levels of baking powder caused hardness resulting in lesser absorption of syrup and too close texture in *gulabjamun*.

2.4. PROCESSING CONDITIONS / PARAMETERS

2.4.1. Moisture content of batter

Moisture content in dough or batter has an influence on the body and texture as well as final quality of the product. Overall sensory scores increased with increase in moisture content of *chhana* in *pantua* preparation. *Pantua* made from *chhana* with about 58 % moisture possessed all desirable sensory attributes and use of *chhana* with lower than 55 % moisture resulted in hard, chewy and dry product.

Desired moisture level in g*ulabjamun* dough has been reported to be 60± 2% (Prajapati *et al.,* 1991) whereas Rajorhia (1989) reported that the softness of g*ulabjamun* could be increased by increasing the quantity of water up to a certain level during dough making.

In case of *rosogolla*, about 55-58 % moisture in *chhana* was found to be optimum for good quality and acceptable product which showed a round shape, soft body and maximum spongy texture. As moisture content was decreased below 50 % level, a harder body and grainy and less spongy texture was observed. Moisture content of 60% and above resulted in a *rosogolla* with soft body, flattened shape and uneven texture (Bhattacharya and Des Raj, 1980).

2.4.2. Proportion of binder in dough/ batter

Addition of *maida* and arrowroot in equal amounts (3 % each) resulted in *pantua* samples with best flavor and body and texture. It was also observed that higher proportion of either *maida* or arrowroot significantly lowered sensory scores of the product. Addition of 3 % *suji* was found to be significantly acceptable, whereas *pantua* with less than 3 % *suji* produced slightly hard and dry body with low sugar syrup absorption and retention capacity. Use of 5% *suji* resulted in soggy and unduly soft product (Nath, 1992).

Srinivasan and Ananthakrishnan (1964) suggested the addition of 75-100 g of *maida* for 350-375 g of *khoa,* but Gill and De (1974) recommended 35 g of *maida* for 300g of *khoa* whereas Ghosh *et al.* (1984) reported 25 g of *maida* for 75g of *khoa* for g*ulabjamun* preparation. Prajapati (1991) found that incorporation of 10 % semolina/ *suji* in *khoa* resulted in best quality g*ulabjamun*. Rangi *et al.* (1985) reported that g*ulabjamun* prepared with 20 % refined flour and 80% *khoa* imparted excellent consumer acceptability. Increasing the flour to 30% showed hard texture whereas with 10% flour the product became too soft. Aneja *et al.* (2002) recommended *maida* in a proportion of 10 % of *khoa* for *gulabjamun* preparation. Tambat *et al.,* (1992) found that 2- 4 % level of *maida* was most acceptable to prepare *rosogolla*.

2.4.3. Frying temperature and time

Frying is one of the key parameters in manufacture of *gulabjamun*. Commonly used frying media is either vanaspati (Hydrogenated fat) or ghee, preferably cow ghee. The balls should be neither over fried nor under fried. Color should be light to medium brown. Prajapati *et al.* (1991) found that frying of g*ulabjamun* balls at 130^{o}C for 15-20 minutes resulted in good product with uniform brown coloured surface, whereas Rangi *et al.* (1985) reported that deep fat frying of *gulabjamun* at 130^{o}C for 15 minutes gave *gulabjamun* with excellent appearance (golden brown color), texture and overall acceptability. The higher frying temperature of 150^{o}C resulted in crust formation which inhibited the syrup penetration into *gulabjamun* adversely affecting quality. *Gulabjamun* units are fried at a temperature of 140^{o}C for 12-13 minutes by semi automatic fryer at Sugam Unit of Baroda District Co operative Milk Producer's Union for commercial production in (Aneja *et al.*, 2002). According to Ghosh *et.al.* (1984) the frying at 125±3^{o}C for 15 minutes was optimum. Frying at lower temperature resulted in improper cooking, fragile texture and light brown color. Selvanayagan (1983) reported that frying

temperature of 140°C, ball diameter 3 cm, ball weight 15g and frying time of 7 minutes were optimum.

A time-temperature combination of 120°C/20 minutes was found to be most suitable for *pantua* production. Frying at 130° C resulted in case hardening and excessive browning. It also showed doughiness due to lack of core cooking. Frying at 110°C resulted in under cooking of p*antua* with doughy taste and dull colour (Nath, 1992).

2.4.4. Sugar syrup concentration

Sugar as a preservative is well known in food industry. In liquid state, it is stable to yeast growth in the concentration range of about 66% and above. Date *et al.* (1958) observed that 50-55% concentration of sugar syrup was optimum. Srinivasan and Ananathkrishnan (1964) reported that syrup concentration is likely to influence the physico-chemical quality of *gulabjamun*. They recommended that sugar syrup concentration of 60% has most desirable. Ghosh *et al.* (1984) also recommended that sugar syrup concentration of 60% at a temperature of 60°C was most desirable for *gulabjamun* prepared from mix powder.

2.4.5. Sugar syrup soaking conditions

Nath (1992) observed that 55 % sugar syrup and 4 hours were optimum for soaking of *pantua*. A concentration level of 50 % failed to sweeten the product and a 60 % level was too sweet and which also required more time to penetrate into the product.

Date *et al.* (1958) found an optimum sugar syrup concentration of 50-55% for g*ulabjamun*. Srinivasan and Ananthakrishnan (1964) reported that syrup concentration is likely to affect the physico-chemical quality of *gulabjamun*. They reported 60% concentration as the best. Prajapati (1991) reported 50-60°C

temperature as the optimum for soaking *gulabjamun*. Ghosh *et al.* (1984) suggested 60% syrup at 60^{o}C whereas Rangi *et al.* (1985) observed that 50% (^{o}brix) at 70^{o}C for 4 hours for soaking of fried *gulabjamun* in sugar syrup showed best sensory appeal. Gill and De (1974) used 10-12 hours for the soaking of *gulabjamun* in 50% sugar syrup. At Sugam Unit of Baroda District Co-operative Milk Producer's Union the *gulabjamun* units after frying are soaked in 62.5% sugar syrup (Aneja *et al.*, 2002).

2.5. PACKAGING

Products like *gulabjamun*, *pantua* and *rosogolla* are to be marketed with sugar syrup as it is very important to retain their shape and body& texture. Tin can is the most suitable package for this group of products (Aneja *et al.*, 2002). Chaurasia (1987) reported that the tin containers are the best for packaging of *gulabjamun*. *Gulabjamun* had a shelf life of 20, 16, and 12 days in tin cans, laminates, polystyrene cups, respectively at room temperature.

Rajorhia and Pal (1989) reported the shelf life of *gulabjamun mix powder* was more than 6 months at 30^{o}C in polyethylene; saran coated cellophane, laminates of paper/ aluminium foil/LDPE and metallised poly ester/LDPE.

Packing of *rosogolla* in 0.4 mm thick cans with inside food grade epoxy phenolic compounds lacquering has shown shelf life of 60 and 140 days when stored at 30^{o}C and 7^{o}C. To reduce the expense in tin cans *rosogolla* and g*ulabjamun* are now being packed in metallised polyester or HDPE made "standy pouches". However, as compared to tin can the shelf life of the products are much shorter, with a maximum up to 28 days even at refrigerated condition of storage (Bandyopadhyay, 2006). The shelf life of rosogolla in metallised poly ester packaging was observed to be 14 days when stored at 30+1^{o}C and up to 28 days when stored at 7±1^{o}C (Sur *et al.*, 1999)

The influence of various packaging materials such as polystyrene, metallised polyester laminate and tin cans on shelf life of rosogolla revealed that tin cans offered maximum shelf life of 20 days at 30^{o}C without use of any preservative. A shelf life of 60 and 90 days was achieved by preservation of *rosogolla* in 40 and 50% sugar syrup, respectively. Addition of potassium metabisulphite at the rate of 100 mg SO_2/kg sugar syrup extended the shelf life to about six months at 30^{o}C (Rajorhia,1995). Aneja *et al.* (2002) reported shelf life of *rosogolla* as 6 months at room temperature when packed in lacquered tin cans.

2.6. *JALEBI*

2.6.1 *Jalebi* from *maida*

India is a large subcontinent representing an amalgam of numerous cultures and cuisines. It has been the home of a vast diversity of traditional foods and a virtual treasure house of countless culinary craft pieces par excellence (Rao, 2000). Foods available on the street and in other public places lure a large number of people every day (Bajaj *et al.* 2002). *Jalebi* is the most common and popular commodity in street food service sector of India and adjoining countries. It is commonly prepared by using *maida*. *Jalebi* is a traditional sweet product and popular street food in the Indian subcontinent due to its unique shape, crisp texture and juicy mouth feel. It is manufactured in bulk quantities and consumed everyday throughout these countries as a major breakfast and snack item (Karki, 1986). It is popular throughout due to low-cost, attractive shape, texture and taste. It is also termed as the queen of sweets in India (Chitale, 2000). Being a traditional product, it varies widely in terms of the use of raw materials, processing conditions and obviously, the skill in the preparation that finally turns the product into crispy, and chewable sweet snack.

2.6.1.1. Method of Preparation

The *jalebi* preparation process comprises the formation of a thick batter from wheat flour followed by fermentation. A small portion of curd is added to wheat flour batter and the quantity added is between 2 and 3%. The addition of curd is conventionally practiced which reduces the fermentation time significantly and allowing the lactic acid bacteria to grow rapidly rather than a uncontrolled autofermentation process wherein microbes present in wheat flour would start growing. A few processors avoid curd and continue fermentation for a longer duration (even upto 24 hours) which undoubtedly depends on ambient temperature. The pH of the fermented batters is between 3.50 and 3.69 indicating the formation of adequate quantity of organic acids like lactic and acetic acids along with other organic acids due to the fermentation process. After thorough mixing with curd, the batter is allowed to ferment for 14-16h to have a highly sour batter such that the finished product also tastes marginally sour in addition to the prominent sweet taste. After fermentation, the batter is mixed again followed by pouring into the hot oil, maintained at a temperature between 165-175^{o}C. The practice of pouring the batter into hot oil varies widely of which flow through an opening of diameter between 4 to 5 mm in a cloth is common. In some occasions, the flowable batter is allowed to pour through a port/ spout by the influence of gravity and often with gentle pressure. Skilled artisans are required to pour the *jalebi* batter in a particular fashion to achieve the conventional attractive shape of *jalebi*. On frying for a span of 2-3 min, moisture escapes gradually and the soft strands show case hardening to offer a product having semi-rigid cylindrical cross section. The fried *jalebi*es are immediately dipped into warm sugar syrup (60-70^{o} Brix) having temperature between 50 and 75^{o}C for 1-2 min. Later, the soaked *jalebi*es are removed from syrup and become ready for consumption on cooling to offer the typical crisp *jalebi* texture in addition to an inherent juicy mouth feel (Bajaj *et al.*, 2002).

2.6.1.2. Desirable product characteristics

Chakkaravarthi *et al.*, (2009) reported that *jalebi* samples collected from different processors have 3 concentric strands. Though the number of strands usually three, two strand *jalebi*es are also available in other places. The colours of *jalebies* were light to dark brown in appearance while some of them were light yellowish due to added food colors. The glossy appearance of *jalebi* is due to the presence of fat and sugar solution on the surface but this gloss slowly disappears during storage to offer non-attractive dull appearance. The desirable attributes of appearance are the well shaped, uniform concentric complete uniform strands that do not adhere or fuse with each another and the knots joining the strands also should not be too bulky that offers less crispy texture but juicy mouth feel (Fig.2.1). Often, some knots overlap to form a lump at some positions of *jalebi*. This is a frequent problem of forming the strands but complete avoidance of this phenomenon may not be possible.



Fig 2.1 Photograph of maida jalebi

2.6.2 *Jalebi* from *khoa*

Pagote (2009) reported that *khoa-jalebi* is very tasty and sweet delicacy among all types of *jalebi*, and widely preferred for eating during fasting days in Maharashtra and parts of Madhya Pradesh and Rajasthan. Its method of preparation is very delicate and artistic; it is being prepared by experienced person (*halwais*) only. Whereas, *maida jalebi* is prepared by housewives and

halwais. For making *khoa-jalebi*, *khoa* and arrowroot are mixed to form a batter. The batter is then passed through the hole of cloth to give a coil like shape and put in to hot oil for deep fat frying till getting light to dark brown colour. The fried units are then dipped in warm sugar syrup for few minutes before serving.

2.6.2.1 Characteristics of *khoa-jalebi*

Information on *khoa-jalebi* is being collected as a part of survey work being conducted by NDRI, Bangalore (Pagote and Jayaraj Rao, 2009). From the information collected so far, it was reported that the *jalebi* pieces possessed brown color from higher shade to darker shade. The *jalebi* pieces had moist appearance because of sugar syrup. The interior of the *jalebi* pieces were lighter and softer than the crust portion. The body of the *khoa-jalebi* was firm, but slightly juicy with syrup oozing out when chewed but not to the extent observed in traditional *jalebi*. The flavour was described as pleasantly sweet and slightly caramelized.

2.6.2.2. Ingredients used in *khoa-jalebi*

a. Arrowroot

Arrowroot **(***Maranta arundinacea*), is a large perennial herb of genus *Maranta* found in rainforest habitats. Arrowroot is also the name of the edible starch from the rhizomes (rootstock) of West Indian arrowroot.

Arrowroot tubers contain about 23% starch. They are first washed, then cleaned of the paper-like scale, washed again, drained and finally reduced to a pulp by beating them in mortars or subjecting them to the action of the wheel-rasp. The milky liquid thus obtained is passed through a coarse cloth or hair sieve and the pure starch, which is insoluble, is allowed to settle at the bottom. The wet starch is dried in the sun or in a drying house. The powder obtained is then packed in air-tight cans, packages or cases.

Pure arrowroot, like other pure starches, is a light, white powder (the mass feeling firm to the finger), odorless when dry, but emitting a faint, peculiar odor when mixed with boiling water, and swelling on cooking into a perfect jelly, which can be used to make a food for vegetarian.

Arrowroot is used as an article of diet in the form of biscuits, puddings, jellies, cakes, hot sauces, etc., and also with beef, tea, milk or veal broth, noodles in Korean cuisine. Arrowroot makes clear, shimmering fruit gels and prevents ice crystals from forming in homemade ice cream. However, arrowroot is almost pure carbohydrate and devoid of protein, thus it does not equal wheat flour nutritionally. Arrowroot thickens at a lower temperature than does flour or cornstarch, is not weakened by acidic ingredients, has a more neutral taste, and is not affected by freezing.

b. Toukir

Toukir is the plant source material. It is white in colour and available in powder form with variable size of small clods. Its powder/clods are dispersed easily in water without forming gel. But it forms opaque loose gel on heating and odourless and carbohydrate in nature. It does not contain any protein or fat (Pagote, 2010).

2.7. EPILOGUE

The review of literature reveals that the published information on *maida jalebi* is very limited, whereas there is no information available on *khoa-jalebi*. Only the market survey on *khoa-jalebi* is being conducted to gather information. However, *khoa-jalebi* has potential to emerge as one of the popular traditional Indian milk products in the market. Hence, there is a need to carry out research on all aspects of *khoa-jalebi*

3.0 MATERIALS AND METHODS

The materials utilized during the course of the present investigation and the methodologies adopted in processing are detailed in this chapter. The first part deals with the details of the materials and the second part deals with the details of methodologies of processing and analysis.

3.1 MATERIALS

3.1.1 INGREDIENTS

3.1.1.1 *Khoa*

The fresh *khoa* was prepared by desiccating milk with 3.5% fat in an open steam jacketed kettle at Experimental Dairy of the Institute, Southern Campus, NDRI, Bangalore.

3.1.1.2 Arrowroot and toukir

Commercially available *arrowroot* and *toukir* procured from the local market were used for the production of *khoa-jalebi*.

3.1.1.3 Sugar

Commercially available cane sugar procured from the local market was used for preparation of *khoa-jalebi*.

3.1.1.4 Hydrogenated fat

Hydrogenated fat of reputed brands were used for the frying of *khoa* batter to *khoa-jalebi*.

3.1.2 INSTRUMENTS

3.1.2.1 Gerber centrifuge

Gerber centrifuge was used for the determination of fat in milk, which was used for *khoa* making.

3.1.2.2 pH meter

Digital pH meter -Digisun Electronics, Hyderabad, Model: DI 707 was used to measure pH during the investigation.

3.1.2.3 Refractometer

Refractometer (40-85%) was used for estimating the concentration of sugar syrup.

3.1.2.4 Digital water activity meter

Rotronic Hygroskop, Switzerland was used for measuring the water activity during the period of investigation.

3.1.2.5 Protein digestion and distillation assembly

Protein digestion and distillation assembly of Gerhardt Instruments, Germany, was used to estimate protein content.

3.1.2.6 Texture analyzer

The consistency of the product was determined using Texture Analyzer XT *Plus*, Stable Micro Systems, U.K.

3.1.3 CHEMICALS, GLASSWARES AND PACKAGING MATERIALS

3.1.3.1 Chemicals/ Reagents

Analytical grade chemicals/ reagents for analysis were used as prescribed by the analytical methods.

3.1.3.2 Microbiological media

The dehydrated microbiological media supplied by Himedia, Mumbai were used in the microbiological analyses of the product.

3.1.3.3 Glassware

Glassware of Borosil were used during the study. They were cleaned using laboratory soap solution, washed thoroughly with water and then rinsed with distilled water and dried before use.

3.1.3.4 Packaging materials

a. **Multilayered pouch:** Multilayered pouches with three layer configurations of PET/ Al / PP with a size of 22.5 X 15.5 cm were used for packing the product.

b. LDPE pouch: The low density polyethylene pouches with 60 µm thicknesses and having size of 20cm length and 13.5cm breadth was used for packing the product.

3.2 METHODS

3.2.1 Preparation of *khoa jalebi*

Khoa-jalebi was prepared as illustrated in the following flow diagram:

Khoa
↓
Kneading
↓
Addition of *toukir*/arrowroot*
↓
Addition of water
↓
Formation of batter
↓
Extrusion through the hole of thick cloth
↓
Deep frying*
↓
Soaking in sugar syrup*
↓
Khoa-jalebi
↓
Packing*
↓
Storage

Note: * Variables studied and optimised

3.2.2 ANALYTICAL METHODS

3.2.2.1 Preparation of samples for chemical analysis

The *khoa-jalebi* units were taken into a mortar and pestle and a homogeneous mixture was made by crushing and mashing. From this mixture required mass of sample was weighed for different chemical analyses.

3.2.2.2 Physico-chemical properties

a. pH

The electrode assembly of a digital pH meter (Digisun Electronics, Hyderabad, Model: DI 707) was calibrated against standard buffer of pH 7.0 and 4.0 (Qualigens Fine Chemicals) . Then the pH of the samples was determined using the calibrated digital pH meter at 20^{o}C.

About 10 g of *khoa-jalebi* sample was mixed with 10 ml of luke warm distilled water in a 50 ml beaker, mixed well and the pH of *khoa-jalebi* was measured by inserting the electrode into the slurry. A direct reading was recorded.

b. Water activity (Aw)

A digital water activity meter (Rotronic Hygroskop, Switzerland model: BT-RS1) was used for measuring the water activity of *khoa-jalebi* samples.

Procedure: The equipment was switched on and 15 minutes warm up time was allowed before measurement of water activity. Sample cup was filled uniformly up to half marked level and positioned below the sensor probe inside the holder. Both temperature and water activity readings were noted when arrows equalized in the display unit.

Same procedure was followed for measuring water activity of concentrated whey using digital water activity meter.

c. Moisture

The moisture and total solids contents of *khoa-jalebi* were determined by the method as detailed in IS: SP: 18, Part XI, 1981.

About 2g of mashed *khoa-jalebi* was taken into a dish which was previously dried and weighed. The dish was then heated in the electrical oven maintained at 102 ± 1^0C for 2-3 hours. Then the dish was cooled in the desiccator and weighed. The process of drying, cooling and weighing was repeated at 30 minute interval until the difference between the two consecutive weighings was less than 1mg. The lowest weight was recorded.

$$\text{Moisture per cent by weight} = \frac{100\ (W_1 - W_2)}{(W_1 - W)}$$

where,

W_1= weight in g of the dish with the material before drying,

W_2= weight in g of the dish with material after drying, and

W = weight in g of the empty dish

d. Fat

The fat content of *khoa-jalebi* was determined using Mojonnier Fat-Extraction apparatus according to the method detailed in IS: SP: 18, Part XI, 1981.

Well mixed *khoa-jalebi* sample of about 2 g was weighed into a small beaker. Added 9ml of warm distilled water and 9 ml of 0.5% (w/v) sodium chloride solution, and mixed well. The mixture was then transferred into Mojonnier fat extraction tube. Alcohol (95 to 96 per cent v/v) of 10 ml was then added into the tube, stoppered and shaken vigorously for about 15 minutes. Alcohol prevents formation of a jelly or colloid like substance which always forms when

ethyl ether is added without the presence of alcohol. The contents were then mixed well.

This was followed by addition of 25 ml of diethyl ether, after which the tube was stoppered and shaken vigorously for about 1.5 minutes. Diethyl ether dissolves the fat. Next, 25 ml of petroleum ether (40 - 60^{0}C) was added and the tube was again vigorously shaken for 1.5 minutes. The petroleum ether takes out the last traces of moisture from ethyl ether extract and aids in absorbing the fat. The tube was allowed to stand until the ether layer was clear and completely separated from the aqueous layer, which is usually for not less than 30 minutes. The ether mixture containing the extracted fat was then carefully decanted into a fat dish which had been previously dried and weighed.

The extraction of fat was repeated from the residue in the Mojonnier tube by adding 5 ml of alcohol and vigorously shaken. This was followed by addition of 15 ml each of ethyl ether and petroleum ether and shaking for 30 seconds after addition of each reagent. Similarly third extraction was carried out in the same manner as the second, omitting the addition of alcohol. After allowing the tube to stand for complete separation of aqueous layer, the ether mixture was carefully poured off into the same fat dish as used for the first extraction, taking care not to pour any residue. The solvents were then evaporated from the fat dish carefully by keeping on a water bath maintained at about 80^{0}C. Then this residual fat was dried in the oven at about 100^{0}C for an hour for removal of any traces of alcohol. The dish was then cooled in a desiccator and weighed. This drying was repeated for periods of half an hour until successive weighings did not show a loss in weight by more than 1mg.

$$\text{Fat per cent} = \frac{\text{Weight of fat} \times 100}{\text{Weight of sample}}$$

e. Protein

The total nitrogen content of *khoa-jalebi* sample was determined by Micro Kjeldahl method as described by Menefee and Overman (1940) with slight modifications.

Approximately 1g of sample was transferred to a 300ml Kjeldahl digestion flask followed by the addition of 2 g of digestion mixture (K_2SO_4: $CuSO_4$ in 50:1 ratio) and 10 ml concentrated H_2SO_4. The contents were then digested until a clear liquid was obtained. After cooling to room temperature, the contents of the Kjeldahl flask were transferred into 100 ml volumetric flask. Kjeldahl flask was rinsed with distilled water and the contents in volumetric flask were made up to 100ml with the distilled water. After mixing thoroughly, 20 ml was taken into a semi micro Kjeldahl distillation tube. About 25ml of 50% NaOH was added to make the solution alkaline. The contents were steam distilled and the liberated ammonia was trapped in 25 ml of saturated boric acid solution containing 2-3 drops of mixed indicator (mixing 1 part of 0.2% alcoholic methyl red solution with 5 parts of 0.2% alcoholic bromo cresol green solution). Distillation was continued until about 65ml of distillate was collected and then it was titrated against N/35 H_2SO_4 to end point of violet colour. The blank was carried out simultaneously using all the reagents and 0.5g sucrose as sample. The percentage of protein was calculated as follows:

$$\text{Per cent Nitrogen} = \frac{14x\ (S-B)\ x\ \text{Normality of } H_2SO_4\ x\ 100\ x\ 5}{\text{Weight of the sample in mg}}$$

Per cent protein = 6.38 x per cent nitrogen

Where, S = Volume of H_2SO_4 used for sample titration

B = Volume of H_2SO_4 used for blank titration

f. Sucrose (Lane-Eynon Method)

The sucrose content of *khoa-jalebi* was estimated using the procedure given for canned rosogolla in IS: SP:18, PART:XI, 1981.

A well mixed sample of *Khoa-jalebi* was accurately weighed (40 g) followed by addition of hot water at 80-90^{0}C. The contents were mixed thoroughly and transferred to a 200 ml measuring flask, washing it with distilled water at about 60^{0}C, till the volume was 120 to 150 ml. The mixture was cooled to room temperature and 5 ml of dilute ammonia solution (10 ml of concentrated ammonia (sp. gravity 0.88) solution was diluted to 100 ml in water) was added. Then it was mixed and allowed to stand for 15 min. This was then neutralized by adding acetic acid (2.5 ml). Then 12.5 ml of zinc acetate solution (21.9 g of crystallized zinc acetate was dissolved in water with 3 ml of glacial acetic acid and made up to 100 ml with water) was added followed by addition of 12.5 ml potassium ferrocyanide solution (10.6 g of crystalline potassium ferrocyanide was dissolved in 100 ml water). It was mixed thoroughly and volume was made up to 200 ml. Solution was allowed to settle and then filtered. This solution was marked as B_1. Fifty ml of B_1 solution was hydrolyzed with 5 ml of concentrated hydrochloric acid by heating at 70^{0}C for 5 min. Hydrolyzed solution was cooled and neutralized with 1 N sodium hydroxide solution. Then the volume was made up to 100 ml. This solution was marked as A_1. The solution A_1 and B_1 were diluted to such a concentration that volume required to react with 10 ml of Fehling's solution was between 15 to 50 ml. These solutions were marked as A_2 and B_2 respectively.

The solution A_2 was filled in the burette and titrated against a mixture of 5 ml each of Fehling's- A and Fehling's- B solutions in boiling conditions using methylene blue as an indicator. The titre values were noted down to compute

the sucrose content of *khoa-jalebi* sample. Similarly solution B_2 was filled in burette and titration was carried out. The sucrose content of k*hoa-jalebi* sample was calculated using following formula:

Sucrose (per cent, by mass) = 20 m/M X ($2f_2$ /v2 – f_1/v_1) X 0.95

where,

m = mass in mg of invert sugar corresponding to 10 ml of Fehling's solution

M = mass in g of materials taken for determination

f_2 = dilution factor for solution A_2 from A_1

v_2 = volume in ml of A_2 corresponding to 10 ml Fehlings' solution

f_1 = dilution factor for solution B_2 from B_1

v_1 = volume of B_2 corresponding to 10 ml Fehlings' solution

$$\text{Lactose (percent,by mass)} = \frac{m \times 250 \times f1 \times 100}{V1 \times M \times 1000}$$

Where,

m = mass in mg of invert sugar corresponding to 10 ml of Fehling's solution

f_1 = dilution factor for solution B_2 from B_1

v_1 = volume of B_2 corresponding to 10 ml Fehlings' solution

M = mass in g of materials taken for determination

g. Ash

The ash content of *khoa-jalebi* was determined by the method as described in IS: SP: 18, Part XI, 1981.

About 2g of the sample was accurately weighed in the previously dried and weighed silica dish. The dish was gently heated on a flame at first and then strongly in a muffle furnace at 550±20^{0}C for about 4-5 hours till white ash was obtained. The dish was cooled in a desiccator and weighed. The process of heating at 550±20^{0}C and subsequent cooling was repeated till two successive weighings was less than one milligram.

$$\% \text{ Ash} = \frac{\text{Weight of Ash} \times 100}{\text{Weight of sample}}$$

h. Total carbohydrate

Total carbohydrates were determined by the difference method (AOAC, 1970), and calculated as follows.

Total carbohydrate= 100 – (Total protein + fat + ash + moisture)

3.2.2.3 Textural properties

a. Firmness and consistency:

Consistency of the product was determined using texture analyzer (Fig.3.1). The following TA-XT plus settings were selected:

Settings for consistency

Mode	**Measure force**
Options	Return to Start
Pre test speed	1.0 mm/s

Test speed	1.0 mm/s
Post test speed	10.0 mm/s
Distance	30.0 mm
Trigger force	2 g
Tare mode	Auto
Advance options	ON

Measurement of consistency of batter:

Before starting the test, the probe was calibrated to a distance of 50 mm. Sample was poured into a plastic container and tempered to required temperature. The plastic container containing the sample was placed below the probe and probe was brought close to the product surface. The probe travelled to a distance of 30 mm into the product and returned to original position, generating a force-time curve.

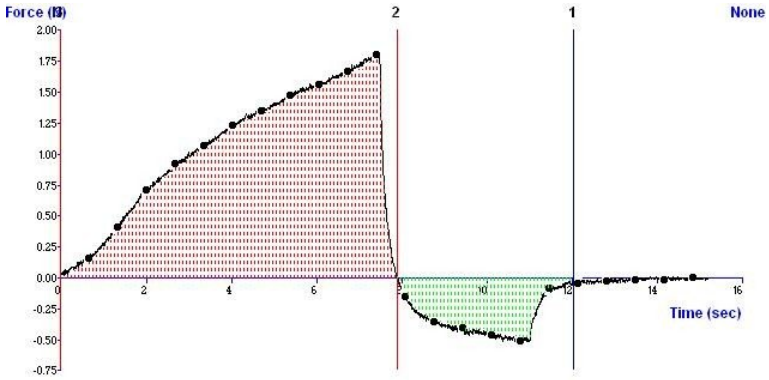
With the help of anchors, the area of the positive curve was determined and expressed it as consistency (N.sec).

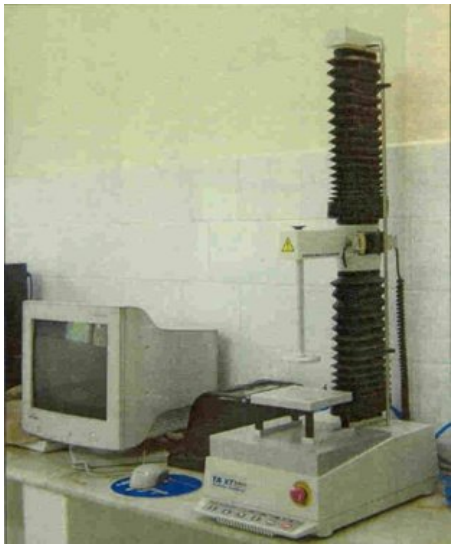
Measurement of firmness and consistency of *khoa-jalebi*:

Before starting the test, the probe was calibrated to a distance of 50 mm. Sample was placed on the platform. For this test pin ball (p/0.25s) probe was used. The probe was brought close to the product surface. The probe travelled to a distance of 10 mm into the product and returned to original position, generating a force-time curve.

With the help of anchors, the area of the positive curve was determined and expressed as consistency (N.sec). The highest peak force was taken firmness of the product and expressed in terms of Newton (N) (Fig.3.1).

***Fig.3.1*: A typical force-time curve obtained in texture analyzer showing consistency**





3.2.3 Microbiological Analyses

4.2.3.1 Standard plate count

The enumeration of standard plate count was carried out as per procedure given in IS: (SP: 18, Part IX, 1981).

Khoa-jalebi sample of 11g was transferred into 99ml of sterile saline aseptically. Thus a 1:10 dilution was obtained. Further dilution to desired level was carried out serially by transferring 1ml of diluted sample to test tube having 9ml sterile saline. The dilutions were prepared so as to give between 30 and 300 colonies per plate. One ml of the dilution was poured into a sterile petri plate. Duplicates were prepared.

The sterilized agar medium (Plate Count Agar) was melted and was kept at 48-50^{0}C. The medium was introduced aseptically at 42 to 44^{0}C, into petri dishes and mixed by rotating the dishes. Care was taken to prevent spreading over the edges. The mixture was spread evenly over the bottom of the plate. It was then allowed to solidify. The plates were inverted and incubated at 37^{0}C for 48

hours. Thereafter, count was taken and expressed as logarithmic value of colony forming units.

3.2.3.2 Yeast and mold count

Yeast and mold count was determined by plating 1:10, 1:100 and 1:1000 dilutions using Potato Dextrose Agar, the pH of which was adjusted to 3.5 by adding 1-2 drops of sterile tartaric acid solution (10 per cent) to each plate before pouring the medium. The count was taken after 3-5 days of incubation at 25-30^{0}C and expressed as logarithmic value of colony forming units per gram of sample.

3.2.4 Sensory evaluation

The organoleptic quality of *khoa-jalebi* was evaluated by an expert panel of judges on 9 point hedonic scale where a score of 9 represented 'like extremely' and score of 1 represented 'dislike extremely'. The samples for evaluation were coded appropriately. The evaluation was carried out in the sensory evaluation room under proper conditions. The parameters judged were: colour and appearance, flavor, body & texture and overall acceptability (Appendix I).

3.3 Statistical analysis

Data obtained from various experiments during standardization and storage study was statistically analysed by analysis of variance as described by Snedecor and Cochran (1994), and employing appropriate computer package MS-Office 2007 (MS-Excel).

4.0 RESULTS AND DISCUSSION

This Chapter deals with the results obtained during present investigation on standardization of the method of production for *khoa-jalebi*. The physico-chemical, sensory and microbial analyses of the product were carried out. The first phase of this study was concerned with the optimization of the parameters for the production of *khoa-jalebi*. The physico-chemical and microbial properties of the product were also investigated. In the second phase, studies were conducted on the shelf life of the product. The results have been presented mostly in tabulated form, but wherever necessary, they were further interpreted with the help of suitable illustrations. The results obtained in the present investigation have been discussed in two parts viz. i) Standardization of method for preparation of *khoa-jalebi* and ii) Storage study

4.1 STANDARDISATION OF METHOD FOR THE PREPARATION OF *KHOA-JALEBI*

Since all of the *khoa-jalebi* manufacture is in the hands of small scale halwais, method and preparation of *khoa-jalebi* has not been standardised so far. Manufacturing steps of *khoa-jalebi* are given in section 3.2.1. Some of the steps like batter formation, cloth, frying medium, frying time and soaking conditions have their own impact on quality characteristics of the product. Therefore, different aspects of *khoa-jalebi* preparation have been studied and the results are presented hereunder.

4.1.1 Method of batter formation for *khoa-jalebi* preparation

The initial study was undertaken to estimate an optimum level of moisture content in the batter for making *jalebi* coils. The extrusion behavior of batter

was also recorded using different size of specially prepared cloth holes for making *jalebi* coils.

Moisture content in the batter affects the body and texture qualities of the final product. Initially, a batter was formed by using *khoa* with varying proportions of arrowroot and kneaded by hand smoothly with varying amount of water. Moisture content in the batter was varied to assess its impact on the formation and retention of shape, size, frying qualities as well as *jalebi* quality characteristics. Kneaded batter was extruded through the hole made in a thick cloth to give a typical shape formed in hot oil for deep frying at around 150^0C. Frying was carried out in flat bottom pan for uniform frying of the *jalebi* coils. Frying continued till surface colour became light golden brown to golden brown. The fried units were then dipped in sugar syrup for 2-3 minutes. After that, *khoa-jalebi* was judged for its size, shape and quality characteristics.

Initially when an arbitrary amount of water was added in batter, more force was required to extrude it through the cloth hole. The *khoa-jalebi* units formed were very big and thick. The fried *khoa-jalebi* was hard in nature and big in size. At this level the moisture content of the batter was determined and was found to be approximately 35-40 %. The final product after dipping in sugar syrup was hard and juiciness was less.

To the above batter some more water was added to enhance the flowability and again tried forming *khoa-jalebi* units. This time, the batter passed easily through the cloth-hole with application of very less force and formed the desired shape and also retained the shape. *Khoa-jalebi* units expanded enough after frying and they were also soft. The moisture content in batter at this time was found to be between 45-50 %. The final *khoa-jalebi* was soft and spongy.

Further addition of water to the fore mentioned batter resulted in a thinner batter. This batter could easily be passed through the hole but the retention of shape and size was observed to be not satisfactory. These units stuck to the

bottom of the frying vessel during frying. At this stage, the moisture content of batter was observed to be 60-65 %. The final product had non-uniform size, irregular shape and had oily flavour due to absorption of more oil.

Thus, it was concluded that a batter with 45-50 % moisture was found to be optimum for *khoa-jalebi* preparation which not only facilitated shape formation but also yielded good/best quality *khoa-jalebi*. Role of moisture in *chhana* as well as in dough on the quality of the product has also been reported by several researchers. Desired moisture level of 60± 2 % in *gulabjamun* dough has been reported by Prajapati *et al*. (1992). Rajorhia (1989) reported that the softness of *gulabjamun* could be increased by increasing the quantity of water in dough preparation. Nath (1992) reported that *pantua* made from *chhana* with about 58 % moisture possessed all desirable sensory attributes. Sensory characteristics observed during feasibility trials are tabulated in Table 4.1

Table 4.1: Effect of different moisture levels in batter on sensory characteristics of khoa-jalebi

Moisture content of batter	**Observation**
35-40%	Batter is very thick, Requires more kneading, Requires force to pass through hole of the cloth, After frying *jalebi* becomes bigger in shape
45-50%	Batter pourability is optimum, Optimum shape and size of coils, Can be easily poured into frying medium
60-65%	Batter flows through the cloth, Difficult to maintain circular shape. Looses the body after soaking in sugar syrup

4.1.2 Optimisation of arrowroot level in batter (*Khoa*: arrowroot)

Khoa and arrowroot should be mixed in suitable proportion for preparing product with optimum sensory characteristics.

Based on the feasibility trials carried out to optimize the moisture content, it was found that minimum 30 parts of arrowroot was required to retain the typical shape of the *jalebi*. Therefore, arrowroot was taken in 30, 40 and 50 parts for the study. These three parts of the arrowroot mixed in 100 parts of the *khoa* and potable water was added and ground properly to form batters with the help of domestic mixer-grinder to obtain proper consistency and smoothness to the batter. The hydrogenated fat was taken in flat-bottom frying pan on medium flame fire. Then batter was extruded through a cloth-hole (having 4 mm diameter) directly into hot oil and fried at around 160^0C temperature for 5-6 minutes. After the optimum frying, the *jalebi* coils were soaked in sugar syrup of 60% concentration. *Jalebis* were soaked for 1-2 minutes and then removed from syrup. Product prepared was then judged sensorily and the scores and comments were recorded. The sensory scores for product samples prepared with three different proportions are tabulated in Table 4.2

Table 4.2: Effect of different proportions khoa and arrowroot on sensory scores of khoa-jalebi

Proportion (***Khoa*: arrowroot**)	**Sensory scores**			
	Colour and Appearance	**Flavour**	**Body and Texture**	**Overall Appearance**
100:30	7.27± 0.28	7.30± 0.08	7.24± 0.33	7.30± 0.16
100:40	6.86± 0.23	7.21± 0.06	7.04± 0.23	6.88± 0.24
100:50	7.04± 0.43	7.09± 0.40	6.95± 0.27	6.91± 0.36

Average scores obtained for product sample, with 100:30 proportion of *khoa* and arrowroot, for color and appearance, flavor, body and texture and overall acceptability were 7.27± 0.28, 7.30± 0.08, 7.24± 0.33 and 7.30± 0.16, respectively. Flavor scores of product sample prepared with 100:30 proportion of *khoa* and arrowroot differed significantly from the product samples with proportion of 100:40 and 100:50. It was mainly attributed to the rich flavour of the *khoa* compared to the other two proportions. Body and texture scores were 7.24± 0.33, 7.04± 0.23 and 6.95± 0.27 for products with 100:30, 100:40 and 100:50 proportions of *khoa* and arrowroot (Table 4.2). This shows that the product with proportion of 100:30 has got more score because of its rich flavour and firmness of the product as compared to the products with 100:40 and 100:50 proportions. Overall acceptability scores for these three different proportions revealed that 100:30 proportion was more suitable.

The comments obtained for sensory characteristics of the product samples are tabulated in Table 4.2a.

Table 4.2a: Effect of different proportions of khoa and arrowroot on sensory characteristics of khoa-jalebi

Proportion (***Khoa*: arrowroot**)	**Comments on sensory characteristics**			
	Colour and Appearance	**Flavour**	**Body and Texture**	**Overall Acceptability**
100:30	*Light to medium brown, coils not uniform*	*Pleasant and sweet*	*Smooth and firm body*	*Most acceptable*
100:40	*Medium to dark brown, more bulky portion*	*Pleasant optimum sweetness*	*Smooth and firm body*	*Acceptability reduced due to less khoa*
100:50	*Medium brown, coils have more bulky portion*	*Lacks richness of khoa*	*Dry, hard body and gritty texture*	*Less acceptable because of more arrowroot*

Table 4.2b: Effect of different proportions of khoa & arrowroot on rheological properties of khoa-jalebi

Proportion	Firmness(N)	Consistency(N.sec)
100:30	9.87	22.58
100:40	12.03	18.49
100:50	10.08	17.84

Textural properties of the product were analysed by textural analysis. The firmness values of the *khoa-jalebi* samples were 9.87N, 12.03N and 10.08N for 100:30, 100:40 and 100:50, respectively (Table 4.2b). Firmness of the product increased with increase in proportion of arrowroot but the flavor score of the product decreased. Consistency values decreased with the increase in level of arrowroot. Consistency values were 22.58N.sec, 18.49 N.sec and 17.84 N.sec, respectively (Table 4.2b).

4.1.3 Optimisation of *toukir* level in batter (*khoa*: arrowroot: *toukir*)

Toukir is the polysaccharide compound used in making of *khoa-jalebi* in various parts of India. *Toukir* granules contain various impurities so prior to addition to the batter it is necessary that *toukir* be washed thoroughly. Calculated amount of *toukir* was added with known quantity of water and mixed properly. This mixture was allowed to stand for some time which clarified the impurities and *toukir* settled to the bottom. Then water was decanted and again washing was carried out for 2-3 times. Clarified *toukir* was then used for the batter making.

Toukir gives sugar holding capacity as well as firmness to the *khoa-jalebi*(Table 4.3b). Therefore, arrowroot proportion selected in previous trials was partly

replaced with the *toukir*. Then *toukir* was taken in 5, 10, 15 parts for the study along with the *khoa* and arrowroot.

Table 4.3: Effect of different proportions of khoa, arrowroot and toukir on sensory scores of khoa-jalebi

Proportion (*Khoa*:arrowroot: *toukir*)	**Sensory scores**				
	Colour and Appearance	**Flavour**	**Body and Texture**	**Juiciness**	**Overall Acceptability**
100:30:0	7.25±0.32	7.41±0.19	7.30±0.13	7.30±0.26	7.25±0.20
100:25:5	7.62±0.10	7.59±0.17	7.53±0.08	7.57±0.07	7.63±0.06
100:20:10	7.33±0.18	7.26±0.11	7.13±0.12	7.23±0.06	7.26±0.07
100:15:15	7.14±0.17	7.13±0.14	7.12±0.09	7.03±0.15	7.07±0.11

Average scores obtained for product sample, with 100:25:5 proportions of *khoa*, arrowroot and *toukir*, for color and appearance, flavor, body and texture, juiciness and overall acceptability were 7.26± 0.10, 7.59± 0.17, 7.53± 0.08 7.57± 0.07 and 7.63±0.06, respectively. Flavor scores of product sample prepared with 100:25:5 proportion of *khoa* and arrowroot differed significantly from the product samples with proportion of 100:20:10 and 100:15:15. It was mainly attributed to the rich flavour of the *khoa* and sugar syrup compared to the other two proportions (Table 4.3a). Body and texture scores were 7.30± 0.13, 7.53± 0.08, 7.13± 0.12 and 7.12± 0.09 for products with 100:25:5, 100:20:10 and 100:15:15 proportions of *khoa* and arrowroot. This shows that the product with proportion of 100:25:5 has got more score because of its rich flavour and firmness of the product as compared to the products with 100:20:10 and 100:15:15 proportions. Overall acceptability scores for these three different proportions revealed that 100:25:5 proportions was more suitable (Table 4.3).

Table 4.3a: Effect of different proportions of khoa, arrowroot and toukir on sensory characteristics of khoa-jalebi

Level of ingredients (Khoa: arrowroot: toukir)	**Sensory comments**
100:30:0	*Lacks firmness, more soft body as compared to others*
100:25:5	*Glossy/shiny appearance, moist surface, Slightly crispy and juicy Light to medium dark color, rich nutty flavor and sweet*
100:20:10	*Medium brown color, sweetness is more, dry appearance with hard body, used coils look more bulky*
100:15:15	*Dark brown color, hard body, juiciness more, more bulky than others*

Table 4.3b: Effect of different proportions of khoa, arrowroot and toukir on rheological properties of khoa-jalebi

Proportion	**Firmness(N)**	**Consistency(N.sec)**
100:30	10.875	17.135
100:25:5	17.407	27.372
100:20:10	18.914	29.90
100:15:15	21.114	34.86

4.1.4 Optimisation of frying time and temperature for *khoa-jalebi* preparation

Frying determines the nature of the product. It provides characteristic features to the product. The typical product qualities like golden brown colour, crispy body, rich nutty flavour etc. are generally obtained during frying operation.

In order to optimize the frying temperature and time combination, *khoa-jalebi* was made with 100 parts *khoa*, 25 parts arrowroot and 5 parts *toukir*. It was extruded into desired shape and fried in hydrogenated fat. At a time 3-4 units were fried in 0.8 – 1.0 L hydrogenated fat. Three different temperature ranges of 140-145^{0}C, 150-155^{0}C and 160-165^{0}C were chosen for the study. Development of golden to dark brown colour of the product was considered as the end point. The time required to get an end point was recorded for each temperature range. The hot fried units were then transferred to 60 % sugar syrup and temperature of syrup was around 40^{0}C.

It was found that at lower temperatures i.e. 140-145^{0}C the product attained brown color gradually. At this temperature, time required for frying was 8-10 minutes. At the temperature 150-155^{0}C the product got optimum color within 4-5 minutes. As the temperature was increased to 160-165^{0}C the product became dark brown rapidly within 2-3 minutes and it was very difficult to maintain the colour at this temperature.

However, frying of batter at 160-165^{0}C produced a final product which was of superior quality in flavour than those fried at 140-145^{0}C and 150-155^{0}C with the rich pleasant flavour. The sample fried at lower temperature between 140-145^{0}C was disliked since it possessed a dough-like flavour.

The body and texture was affected by frying temperatures. At lower temperatures (130-140^{0}C) the product became hard and chewy since the time required for frying was more. As the temperature of frying was increased to 160-165^{0}C the chewiness and hardness decreased and the product became soft and crispy (Table 4.4b). The product fried at temperatures 140-145^{0}C showed hard surface. Faster surface frying took place at this temperature and a hard crust was formed. The cores remain uncooked and soft. Case hardening led to lesser intake of sugar syrup into the product and the core had doughy flavour.

The product fried at 160-165^{0}C scored a highest score of 7.73, whereas it was lowest score of 6.95 for the product fried at 140-145^{0}C (Table 4.4).

The overall acceptability of the product also changed according to frying temperature. The average scores varied from 6.94 for 130-140^{0}C to 7.64 for 160-165^{0}C. The pleasant flavour, soft body of the product was obtained at 160-165^{0}C which resulted in maximum acceptability score of the product (Table 4.4). For all sensory attributes, *khoa-jalebi* samples fried at 160-165^{0}C scored maximum followed by the samples fried at 150-155^{0}C and 140-145^{0}C. It was also observed that the scores differed significantly due to the variation of three different temperatures of frying (Table 4.4a).

Table 4.4: Effect of frying temperatures on sensory scores of khoa-jalebi.

Frying temperature	**Sensory scores**				
	Colour and Appearance	**Flavour**	**Body and Texture**	**Juiciness**	**Overall Acceptabiliy**
140-145^{o}C	7.33± 0.19	7.12± 0.09	6.90± 0.16	6.95± 0.13	6.94± 0.11
150-155^{o}C	7.18± 0.35	7.26± 0.31	7.10± 0.41	7.24± 0.31	7.19± 0.44
160-165^{o}C	7.58± 0.07	7.65± 0.0	7.66± 0.09	7.73± 0.09	7.64± 0.11

Table 4.4a: ANOVA for effect of frying temperatures on sensory scores of khoa-jalebi.

Source	df	Colour and Appearance		Flavour		Body and Texture		Juiciness		Overall Acceptability	
		MSS	**F**	**MSS**	**F**	**MSS**	**F**	**MSS**	**F**	**MSS**	**F**
Between replications	2	0.1206	2.25**	0.2255	6.41*	0.4681	6.89*	0.4681	11.80*	0.3991	10.99*
Between proportions	6	0.0535		0.0351		0.0679		0.0396		0.0363	
Total	8	0.1741		0.2606		0.5360		0.5077		0.4354	

**Significant difference at $P \leq 0.05$. **Not significant at $P \geq 0.05$.*

Table 4.4b: Effect of frying temperatures on physico-chemical and rheological properties of khoa-jalebi

Temperature → / Parameter	140-145°C	150-155°C	160-165°C
Moisture	24.21%	24.56%	23.68%
pH	6.53	6.52	6.53
A_w	0.886	0.880	0.878
Firmness	16.50 N	14.92 N	13.46 N
Consistency	23.18 N.sec.	22.87N.sec.	23.78 N.sec

Table 4.4c: Effect of frying temperatures on sensory characteristics of khoa-jalebi

Frying temperature °C	**Frying Time**	**Sensory comments**
140-145°C	*8-10 minutes*	*Hard body, lacks sweetness, sugar syrup is not properly absorbed, prolonged frying time (more than 8 minutes), medium dark colour*
150-155°C	*4-5 minutes*	*Slight hard body, dark brown colour, sweetness is slightly less, sugar syrup is not properly diffused*
160-165°C	*3-4 minutes*	*Smooth body, sweetness is optimum, pleasantness is more, light to medium golden brown colour*

Considering the time taken for frying and the sensory attributes, the temperature-time combination of 160-165^{0}C for 3-4 minutes was found to be

the optimum condition for frying of *khoa-jalebi*. Nath (1992) reported a time temperature combination of 120^0C/20 minutes to be the most suitable for *pantua* production. Prajapati *et al*. (1991) found that frying of *gulabjamun* balls at 130^0C for 15-20 minutes resulted in good product with uniform brown colored surface. Here in case of *khoa-jalebi* a higher temperature was found to be better for the desired crispiness and soft body probably because of higher moisture in batter.

4.1.5 Optimisation of sugar syrup concentration and soaking conditions for *khoa-jalebi* preparation

The concentration of sugar syrup not only provides taste and correct sweetness of the product but also has an influence on soaking characteristics of *jalebi coils* and shelf life. Further, uniform soaking depends on temperature of syrup and time of soaking. Therefore, an attempt was made to find out suitable soaking conditions for uniform absorption of sugar syrup in a minimum time. The 100 parts of *khoa* was mixed with 25 parts arrowroot and 5 parts *toukir* and smooth batter was made with added water. It was then extruded through cloth hole (4-5 mm dia.) and deep fried in oil at 160-165^0C. The fried units were kept dipped in sugar syrup of 50, 60 and 70 % concentration at 40^0C for 2 minutes.

It was found that 50 % sugar syrup imparted less sweetness to the product. Increasing the temperature decreased the time required for complete soaking. The 60 % concentration of sugar syrup was found to give acceptable sweetness to the product when soaked for 2 minutes. It was found that soaking of the product for more than 2 minutes loosened the body of the product and coils structure got disturbed. The 70 % concentration of sugar was less acceptable by judges (Table 4.5).

Table 4.5: Effect of sugar syrup concentrations on sensory scores of khoa-jalebi

Sugar syrup concentration	Sensory scores				
	Colour and Appearance	**Flavour**	**Body and Texture**	**Juiciness**	**Overall Acceptability**
50%	7.32± 0.17	7.11± 0.06	6.88± 0.15	6.95± 0.13	6.94± 0.11
60%	7.57± 0.07	7.63± 0.02	7.66± 0.03	7.73± 0.12	7.63± 0.11
70%	7.14± 0.07	7.26± 0.22	7.16± 0.22	7.26± 0.31	7.21± 0.44

The sugar syrup concentration of 60 % was found to impart good sweetness to *khoa-jalebi*. So, it was inferred that a sugar syrup concentration varying from 60% can be used for soaking of *khoa-jalebi*. Nath (1992) observed that 55 % sugar syrup and 4 hours were optimum for soaking of *pantua*.

Date *et al* (1958) found an optimum sugar syrup concentration of 50-55% for g*ulabjamun*.

Table 4.5a: Effect of sugar syrup concentrations on physico-chemical properties of khoa-jalebi

Concentration → / Parameter	**50 %**	**60 %**	**70 %**
Moisture	24.71%	24.26%	22.68%
Sucrose	17.34%	19.23%	23.16%
pH	6.53	6.53	6.54
A_w	0.886	0.877	0.872

Table 4.5b: ANOVA for effect of sugar syrup concentrations on sensory scores of product

Source	**df**	**Colour and Appearance**		**Flavour**		**Body and Texture**		**Juiciness**		**Overall Acceptability**	
		MSS	**F**	**MSS**	**F**	**MSS**	**F**	**MSS**	**F**	**MSS**	**F**
Between replications	2	0.1449	2.39**	0.2131	11.74*	0.4656	18.90*	0.4620	11.19*	0.3608	5.04*
Between proportions	6	0.0604		0.0181		0.0246		0.0412		0.0716	
Total	8	0.2054		0.2313		0.4903		0.5033		0.4324	

**Significant difference at $P \leq 0.05$. **Not significant at $P \geq 0.05$.*

From the physico-chemical properties of the product it was found that product prepared using 50% concentration contained more moisture as compared with other two concentrations (Table 4.5a). Water activity of the 50%, 60% and 70% concentration products was 0.886, 0.877 and 0.872, respectively. pH of the three different concentration products has not differed significantly.

Table 4.5c: Effect of sugar syrup concentrations and soaking time on sensory characteristics of khoa-jalebi

Sugar syrup concentration	Soaking time	Sensory comments
50%	*1-2 minutes*	*Less sweet, loose body, lacks crispiness, less soaking time*
60%	*2-3 minutes*	*Optimum sweetness, slight crispness, shiny appearance, more juiciness*
70%	*More than 3 minutes*	*More sweet, more hard body, more soaking time as concentration is more, shiny appearance*

4.2 OPTIMISED PROCESS OF *KHOA-JALEBI* MAKING

After optimization of individual parameters, *khoa-jalebi* was manufactured as per optimized conditions mentioned in Figure 4.1. *Khoa-jalebi* was prepared from *khoa* made from milk with 3.5 % fat. *Khoa* was mixed with 25 parts of arrowroot, 5 parts *toukir* and water to form a smooth and uniform batter having about 45-50 % moisture. Kneaded batter was extruded through a hole made in a thick cloth, into hot oil for deep frying at 160-165^{0}C till surface colour became light-golden brown to dark brown. The fried units were then dipped in sugar syrup (40^{o}C) for 2-3 min. Then, *khoa-jalebi* (Fig. 4.2) was analysed for its physico-chemical characteristics.

Fig.4.1 Process Flow diagram of khoa-jalebi preparation

Khoa (100 parts)

↓

Kneading

↓

Addition of 25 parts *Arrowroot*

↓

Addition of water (55-60 ml)

Addition of *Toukir* slurry (5 parts) →

↓

Formation of batter (Moisture ~ 50%)

↓

Extrusion through hole of a thick cloth (4-5 mm)

↓

Deep frying (~160^{0}C for 3-4 min.)

↓

Soaking in sugar syrup
(60 % sugar syrup, 40^{o}C, and maximum 2 minutes)

↓

Khoa-jalebi

↓

Packaging (Pouch)

↓

Storage

Fig. 4.2: Photograph of final product (Khoa-jalebi)



4.3 ANALYSIS OF OPTIMISED *KHOA-JALEBI*

Khoa-jalebi was prepared as per optimized conditions mentioned in Fig. 4.1 by using *khoa*, *arrowroot* and *toukir*. The physico-chemical and sensory characteristics of the final product are mentioned below:

4.3.1 Physical properties

The *khoa-jalebi* was having golden brown colour and irregular circular shape (Fig.4.2). The product was soft and crispy with porous core. Approximately 3-4 units were fried at a time in 800-1000 ml of hydrogenated vegetable fat. The initial weight of the raw *khoa-jalebi* units (batter) was about 28-30 g. There was a reduction of 5-6 g of weight due to release of moisture during frying. Fried units were dipped in sugar syrup at 40^{o}C. After soaking in sugar syrup for 2 minutes, the average final weight of a *khoa-jalebi* unit was about 29 g. Therefore, each unit normally absorbed 20-22 % of sugar syrup by the weight of fried units during soaking.

4.3.2 Chemical characteristics

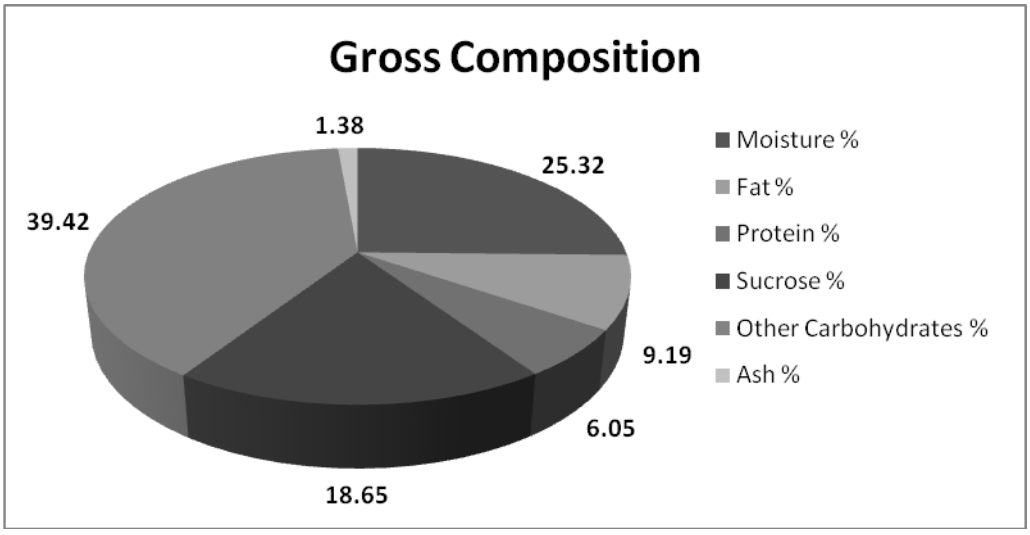
The average moisture content of *khoa-jalebi* was found to be 25.32 %. The fat content was estimated to be 9.19 %. The ash content was 1.38 % while protein content of *khoa-jalebi* was found to be 6.05 per ent. Sucrose was 18.65 %. Carbohydrates (excluding sugar) including added starch was 27.72 % (Table 4.6). The pH of the final product was 6.52 and the water activity was 0.88.

Table 4.6: Chemical composition of khoa-jalebi

Constituent	**Percentage (Mean* ± SE)**
Moisture	25.32±0.51
Fat	9.19±0.07
Protein	6.05±0.12
Sucrose	18.65±1.38
Lactose	11.70±0.44
Other carbohydrates	27.72±0.54
Ash	1.38 ± 0.04

**mean of three trials*

Fig. 4.3: ***Gross composition of the final product (Khoa-jalebi)***



4.4 STORAGE STUDY

The product prepared by standardized method was packed in low density polyethylene (LDPE) and multilayered packaging materials (Metallised polyester pouches: PET/Al/PP) and kept for storage study at 30°C. The product quality was evaluated at 2 days interval for its sensory, physico-chemical and 5 days interval for its microbiological quality.

Stored products were subjected to sensory evaluation by a panel of judges on 9–point hedonic scale. Scores obtained for various attributes are given in corresponding tables.

4.4.1 Effect of storage period on the sensory quality of *khoa-jalebi* during storage at 30°C

4.4.1.1 Effect on colour and appearance of the product during storage

Table 4.7: Effect of storage period on colour and appearance scores of khoa-jalebi

Storage period (days)		0	2	4	6	8	10	12
C&A score	S-1	7.58	7.55	7.54	7.4	7.38	7.46	6.81
	S-2	7.58	7.59	7.62	7.45	7.43	7.46	7.2

S-1: Product packed in LDPE. S-2: Product packed in multilayered pouches.

During the storage study, there was no significant change found in color of the product but the appearance changed from moist to dry after four days of the storage. The initial score for color and appearance was 7.58 for both LDPE and multilayered pouches. In case of LDPE pouches, mold growth appeared on product after 8th day of storage, whereas in case of multilayered pouches mold growth was found after 10 days of storage. The scores were analyzed statistically by ANOVA which revealed that there is no significant difference existed in colour and appearance of product over the entire period of storage.

The effect on colour and appearance over a period of time during storage is shown in Fig.4.4.

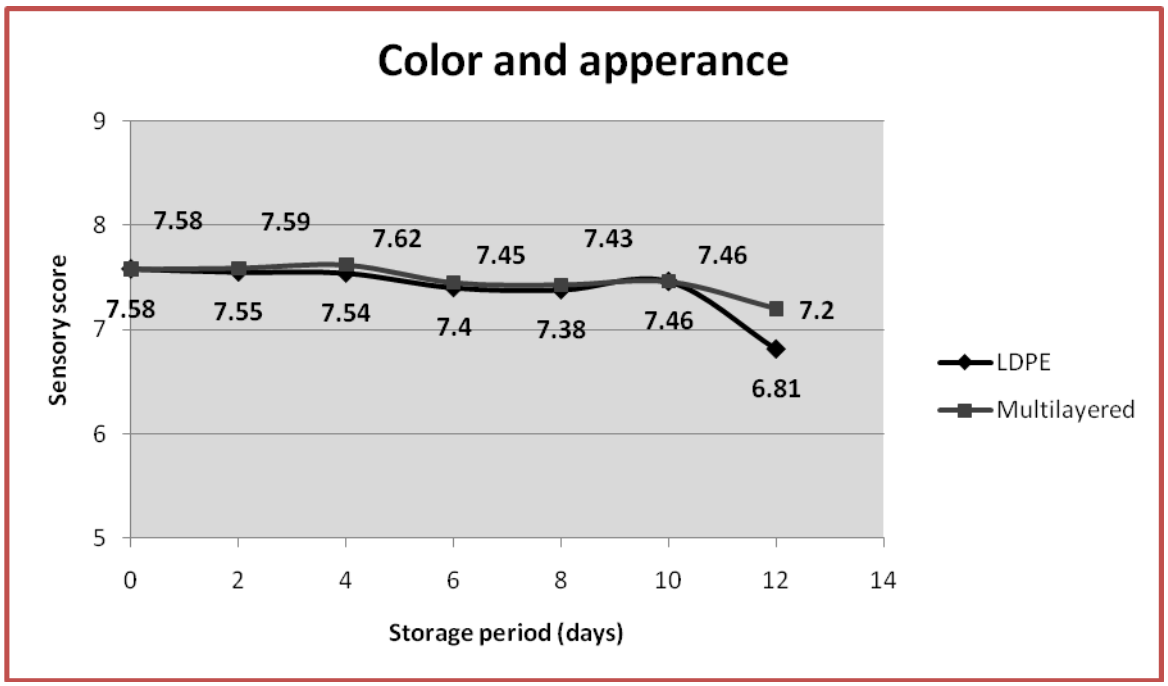


Fig. 4.4: ***Effect of storage period on colour and appearance scores of khoa-jalebi***

4.4.1.2 Effect on flavour of the product during storage

Table 4.8: Effect of storage period on flavour scores of Khoa-jalebi`

Storage period (days)		0	2	4	6	8	10	12
Flavour score	**S-1**	7.8	7.65	7.52	7.42	7.16	7.05	6.7
	S-2	7.8	7.68	7.54	7.43	7.27	7.1	6.95

S-1: Product packed in LDPE. S-2: Product sterilized packed in multilayered pouches.

The flavour score showed a decreasing trend during storage period. The initial score of the sample (7.8) decreased to 6.7 in LDPE pouch packed product and to 6.95 in multilayered pouch packed product after 12 days of storage at 30^{o}C temperature. It may be seen from the data given in the Table 4.8 that the sensory scores for flavour were 7.8, 7.65, 7.52, 7.42, 7.16, 7.05, 6.7 and 7.8, 7.68, 7.54,

7.43, 7.27, 7.1, 6.95 for the products prepared with standardized method and packed in LDPE and multilayered pouches, respectively (Fig. 4.5). The scores were analyzed statistically which revealed no significant difference in flavour of product over the period of storage.

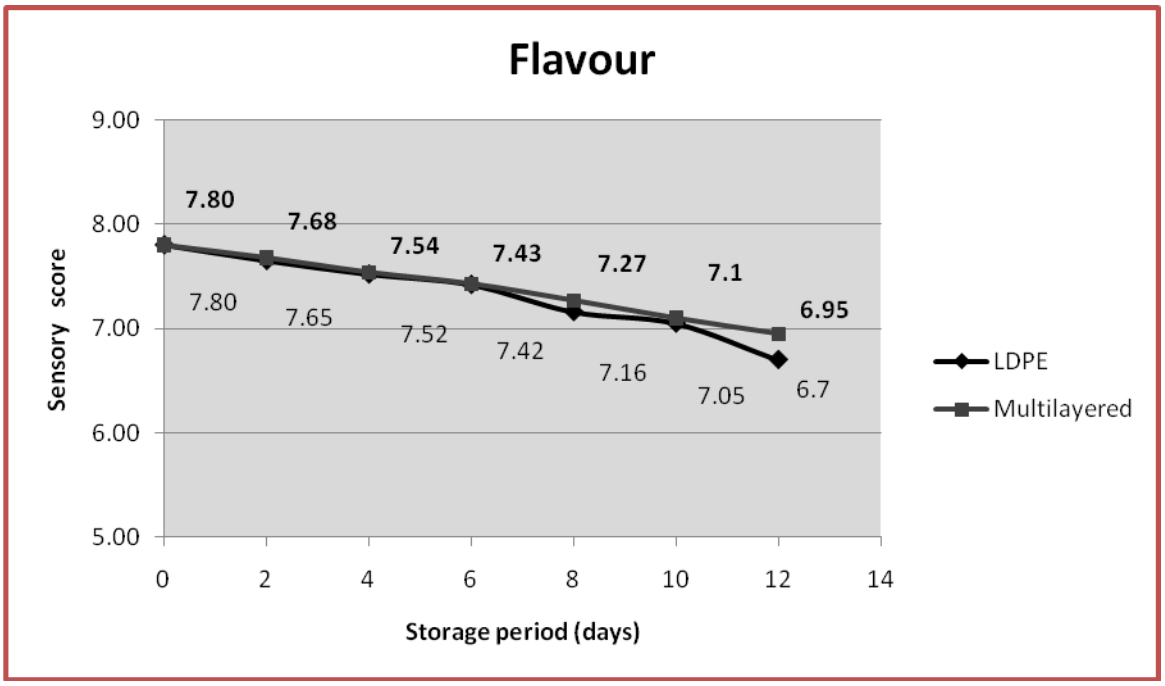


Fig. 4.5: ***Effect of storage period on flavour scores of khoa-jalebi***

4.4.1.3 Effect on body and texture of the product during storage

Table 4.9: Effect of storage period on body and texture scores of khoa-jalebi

Storage period (days)		0	2	4	6	8	10	12
B&T score	**S-1**	7.67	7.55	7.48	7.30	7.22	7.00	6.7
	S-2	7.67	7.62	7.55	7.48	7.30	6.92	6.79

S-1: Product packed in LDPE. *S-2: Product packed in multilayered pouches.*

The initial body and texture score of both the samples packed in LDPE pouch and multilayered pouch was 7.67. The *khoa-jalebi* stored for 0, 2, 4, 6, 8, 10, 12 days was awarded average sensory scores of 7.67, 7.55, 7.48, 7.3, 7.22, 7.00, 6.70 and 7.67, 7.62, 7.55, 7.48, 7.30, 6.92, 6.79 for products packed in LDPE

and multilayered pouches, respectively for body and texture (Table 4.9). The product stored in LDPE pouches showed significant decrease in body and texture score of the product whereas in multilayered pouches the score decreased significantly after 6 days of the storage (Table 4.6). Up to 4th day of the storage the product was uniform with soft body, and then it became harder with sugar crystals forming inside the coils.

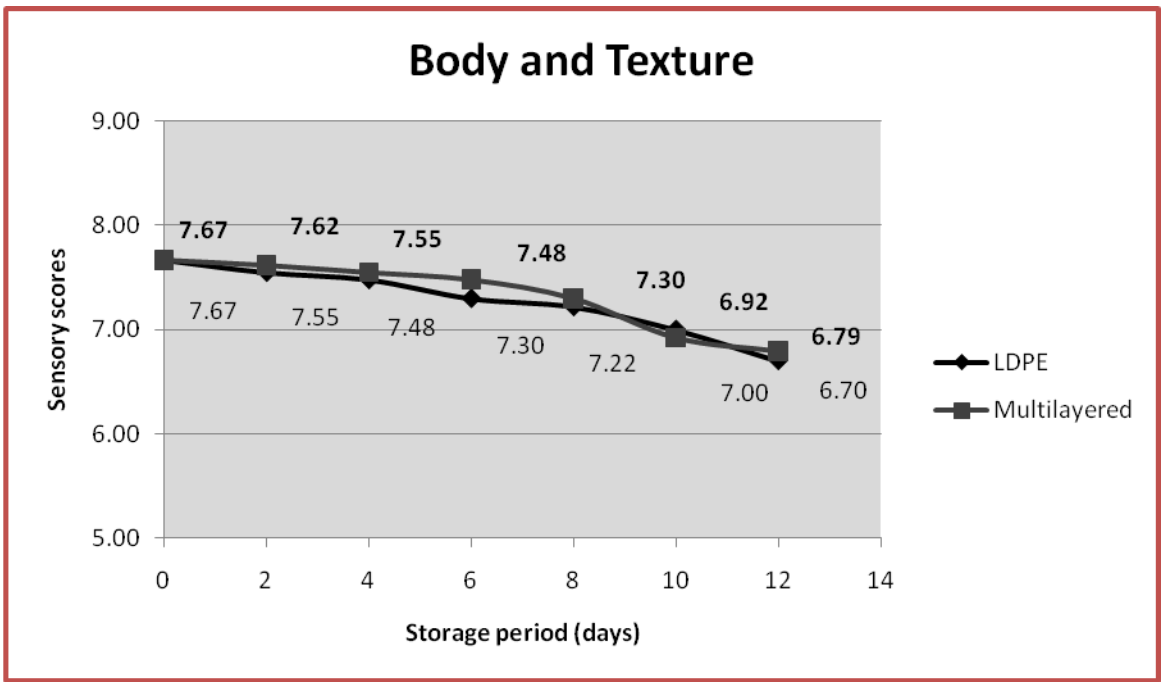


Fig. 4.6: Effect of storage period on body and texture scores of khoa-jalebi

4.4.1.4 Effect on juiciness of the product during storage

Table 4.10: Effect of storage period on juiciness scores of khoa-jalebi

Storage period (days)		0	2	4	6	8	10	12
Juiciness score	**S-1**	**7.72**	**7.54**	**7.5**	**7.30**	**7.18**	**6.92**	**6.83**
	S-2	**7.72**	**7.61**	**7.57**	**7.43**	**7.30**	**7.18**	**7.00**

S-1: Product packed in LDPE. S-2: Product packed in multilayered pouches

Initial 0th day sensory score for juiciness was 7.72 which significantly decreased after 4th day of the storage for both packaging materials. Sensory scores

decreased to 6.83 and 7.00 for LDPE and multilayered pouches, respectively. Mainly it was found that after 4th day of storage, the product packed in LDPE pouches became dry in appearance and sugar syrup was slightly crystallized. In multilayered pouches it was found that after 6th day, the product had less juiciness and the sensory score was 7.43. The graph (Fig. 4.7) shows that after 4th day of the storage the scores decreased significantly for both the packaging materials.

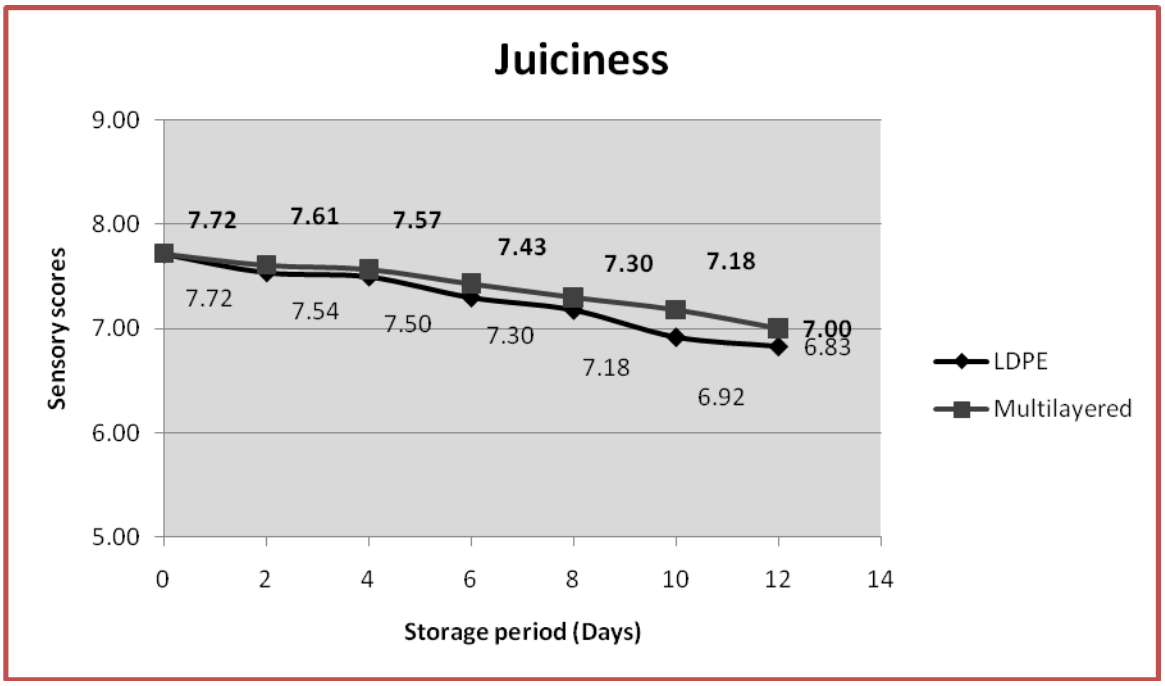


Fig. 4.7: ***Effect of storage period on juiciness scores of khoa-jalebi***

4.4. 1.5 Effect on overall acceptability of the product during storage

Table 4.11: Effect of storage period on overall acceptability scores of khoa-jalebi

Storage period (days)		0	2	4	6	8	10	12
OA score	**S-1**	7.82	7.65	7.60	7.38	7.25	7.02	6.75
	S-2	7.82	7.71	7.65	7.45	7.32	7.12	6.80

S-1: Product packed in LDPE. *S-2: Product packed in multilayered pouches*

Sensory scores for overall acceptability of the product packed in LDPE and multilayered pouches were 7.82, 7.65, 7.60, 7.38, 7.25, 7.02, 6.75 and 7.82, 7.71, 7.65, 7.45, 7.32, 7.12, 6.80, respectively (Table 4.11). From the Fig 4.8, it can be inferred that the sensory scores for overall acceptability decreased gradually after 4th day of storage. Hence, it can be concluded that product had better sensory attributes for up to 4-6 days of storage.

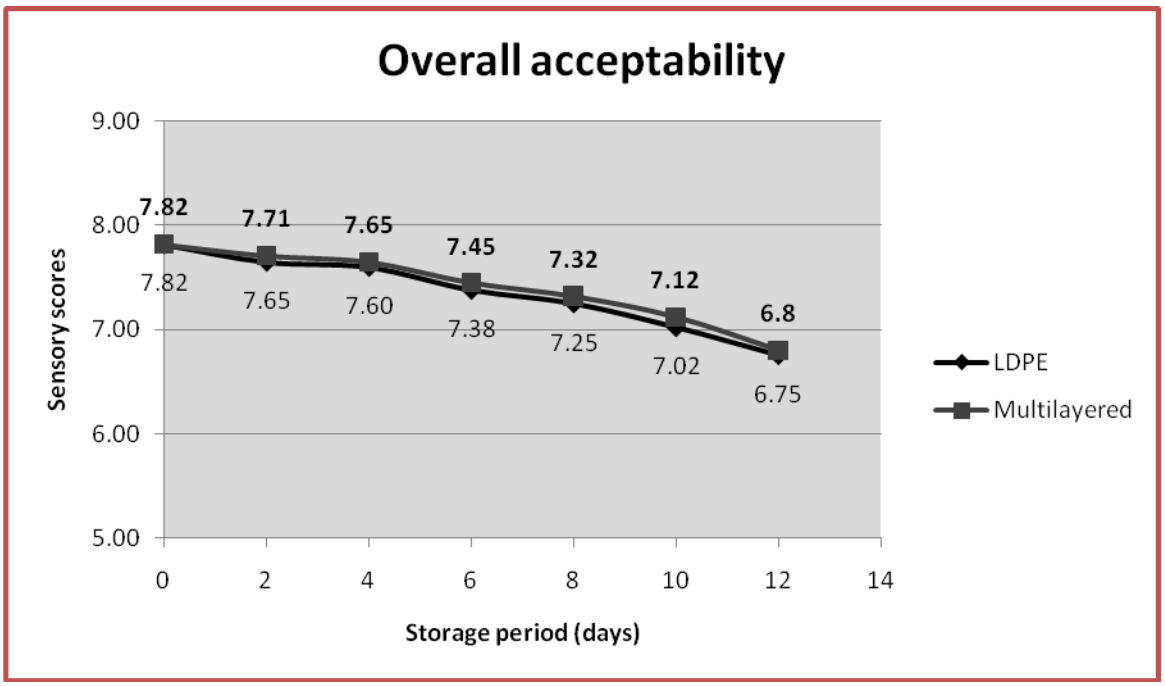


Fig. 4.8: ***Effect of storage period on overall acceptability scores of khoa-jalebi***

4.4.2 Effect of packaging materials on the chemical characteristics of *khoa-jalebi* during storage at 30^{o}C

4.4.2.1 Effect on moisture content of the product during storage

The initial moisture content of the product packed in both LDPE and multilayered pouches were 25.86%. The moisture content of both the samples decreased over the period of storage. In case of LDPE pouch packed samples, there was no significant effect found up to 6th day of storage but after that moisture content decreased significantly. After 6th day, moisture from the

product evaporated and condensed on packaging material. In case of multilayered pouches, moisture from the product decreased but not significantly. The moisture content decreased from 25.86% to 24.86% moisture and 25.86% to 25.54% in case of LDPE and multilayered pouches respectively (Fig.4.9). The product packed in LDPE pouches became hard after 8th day of storage whereas other product packed in multilayered pouches was soft throughout the storage.

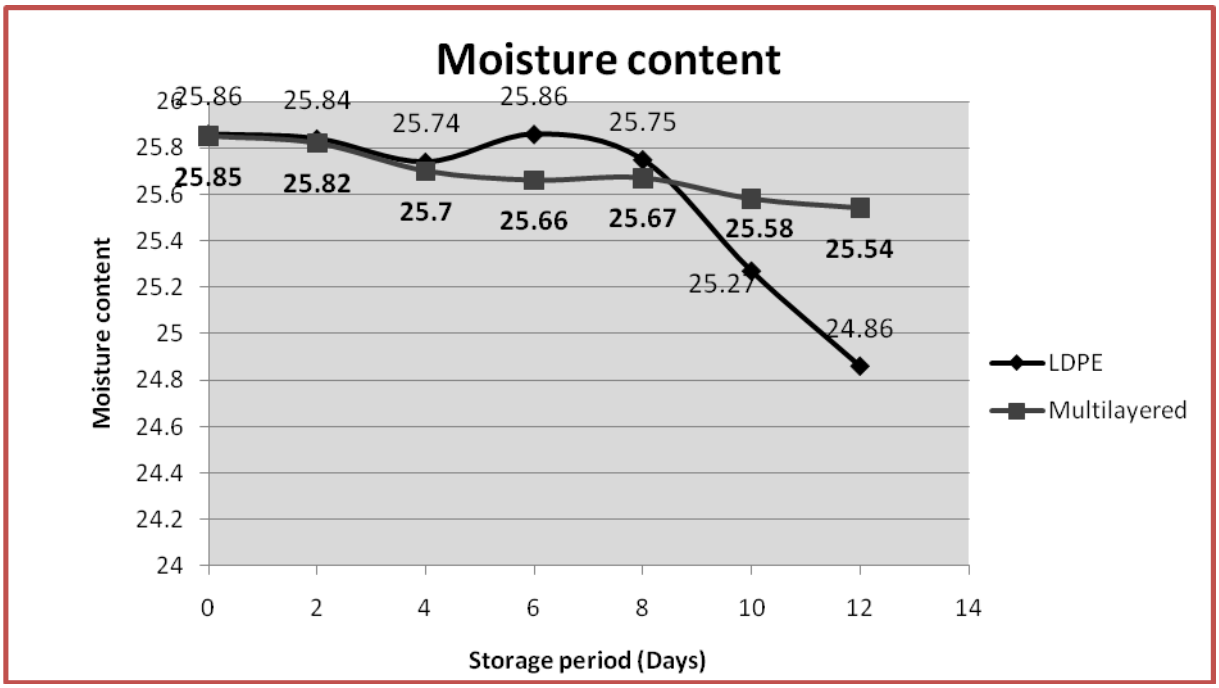


Fig. 4.9: ***Effect of storage period on moisture content of khoa-jalebi***

4.4.2.2 Effect on pH of the product during storage

The pH of both the samples packed in LDPE and multilayered pouch decreased as days of storage increased due to activity of microorganisms. The initial pH of product was 6.54. In case of LDPE packed samples, the change in pH was at faster rate than in multilayered pouch packed samples (Fig.4.10). On the 6th day of storage, the pH of LDPE packed sample was 6.5 and multilayer packed sample was 6.52. Lower pH in LDPE pouch packed samples may be due to the more growth of microorganisms.

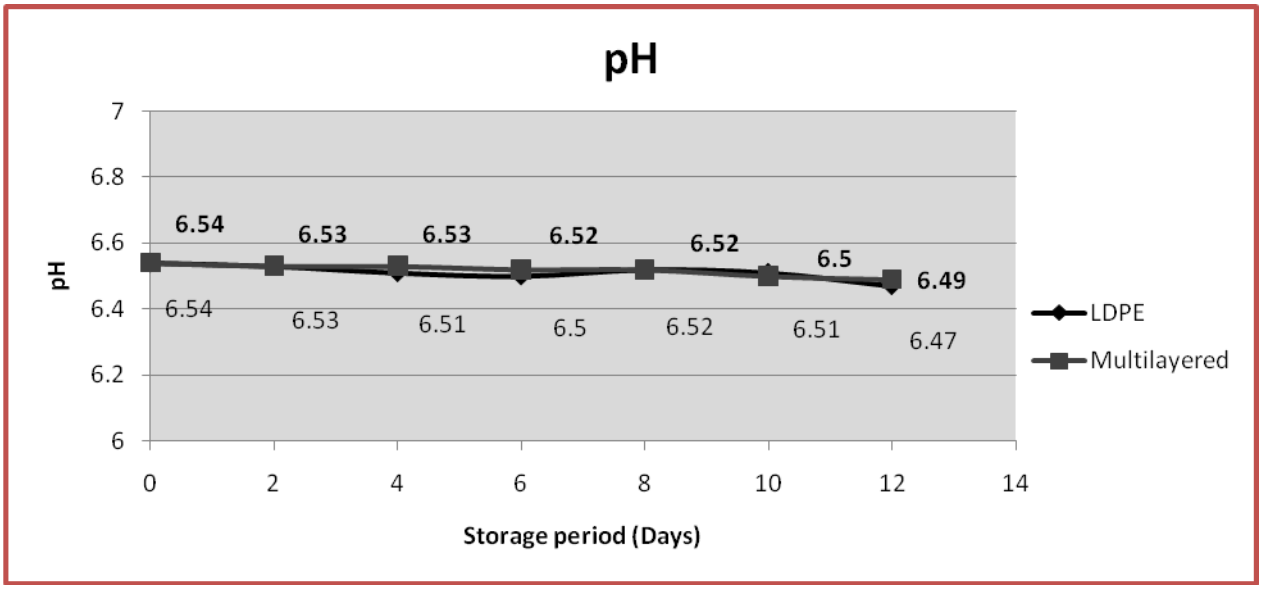


Fig. 4.10: ***Effect of storage period on pH of khoa-jalebi***

4.4.2.3 Effect on water activity of the product during storage

From Fig. 4.11, it can be concluded that water activity of the *khoa-jalebi* decreased over the period of storage for both the packaging materials. The intial water activity of the product was 0.876 at zero day of the storage. Then it decreased to 0.865 and 0.866 for the LDPE and multilayered pouches, respectively. However, this difference could not be considered as significant throughout storage of the product.

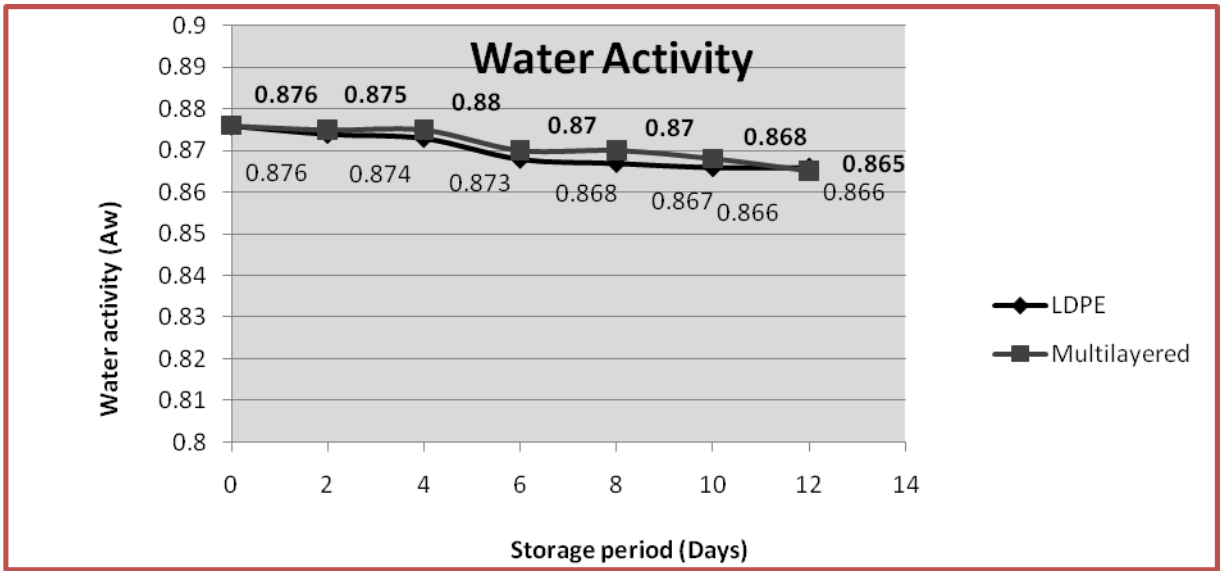


Fig. 4.11: ***Effect of storage period on water activity of khoa-jalebi***

4.4.3 Effect of storage period on microbiological characteristics of *khoa-jalebi*

Microbiological characteristics in terms of standard plate count and yeast and mold counts is given in Table 4.12

Table 4.12: Microbiological changes of *khoa-jalebi* samples packed in LDPE and multilayered pouches during storage at 30°C

Storage Days		Log_{10} cfu/g	
		LDPE	LAMINATE
0	SPC	5.04	5.04
	Y&M	0.95	0.95
5	SPC	5.36	5.16
	Y&M	1.67	1.59
10	SPC	5.87	5.65
	Y&M	2.38	2.32

4.4.3.1 Standard Plate Count

The total bacterial count was found to increase with the increase in storage period (Table 4.12). The initial count of 5.04 log cfu/g increased to 5.87 log cfu/g after 10 days of storage in LDPE pouch packed samples and to 5.65 log cfu/g in multilayered pouch packed samples.

The microorganisms were able to grow at the room temperature and increased their population. The count was found to increase in the products packaged in both the packaging materials during storage at 30°C temperature. Due to the better favourable conditions, prevailing in samples packed in LDPE pouches, the growth was found to be more.

4.4.3.2 Yeast and mould count

The main spoilage of *khoa-jalebi* was due to visible yeast and mould growth. The initial count of the *jalebi* was 0.95 log cfu/ g. It then increased to 2.38 log cfu/ g in LDPE pouch packed sample and 2.32 log cfu/ g in multilayered pouch packed samples (Table 4.12).

At 12^{th} day of the storage it was found that both the products packed in LDPE and multilayered pouches were spoiled due to mold growth on the surface of the product. In case of LDPE pouches, mould growth was found visible after 8^{th} day of the storage in some of the packets, whereas in multilayered pouches it was found after 10^{th} day of storage. But from the sensory scores it was observed that the flavour, body & texture and overall acceptability decreased significantly after 4^{th} day of the storage.

5.0 SUMMARY AND CONLUSION

5.1. SUMMARY

India is the home of a vast diversity of traditional foods. Many street food products are popular and available everywhere. Among them, several breakfast food items are also being prepared along with milk based sweets by sweet makers or *halwais*. *Khoa-jalebi* is one of them which is being manufactured and consumed every day in some parts of India viz. Maharashtra, Madhya Pradesh and Rajasthan. Since, there is no any scientific study about the processing and production of *khoa-jalebi*, the need was felt for the standardisation of method for its production. Hence, present study has been undertaken.

To standardise the method of *khoa-jalebi*, the moisture content of batter was optimized first. The extrusion behavior of batter was also recorded using a specially prepared cloth for making *jalebi*-coils. It was observed that when the moisture content in batter was about 40 %, *jalebi* became thick and hard. Increasing the moisture content in batter beyond 60%, gave a product which had difficulty in retaining the shape and which stuck to the pan while frying. The batter with 45-50 % moisture was found to be optimum for *khoa-jalebi* preparation because it not only facilitated the shape formation but also yielded desirable characteristics to *khoa-jalebi*.

Khoa-jalebi is an item which is mostly consumed during fasting days. It does not contain maida, arrowroot is used during study for making *khoa-jalebi* samples. Arrowroot was taken in 30, 40 and 50 parts with 100 parts of *khoa* during the study. Required amount of water was added to form batters of proper consistency and smoothness. The effect of these arrowroot levels on the sensory attributes of

khoa-jalebi has been studied. It was observed that addition of 30 parts arrowroot gave desired firmness and rich flavour of *khoa* to the *jalebi*, whereas 40 and 50 parts of arrowroot lacked richness of *khoa*-flavour in *jalebi*. Therefore, on the basis of sensory scores, the proportion of *khoa* with arrowroot at 100:30 ratio has been selected for achieving acceptable characteristics in the product during further studies.

For the optimization of *toukir* level, arrowroot was replaced with *toukir* at three different levels, viz. 5, 10 and 15 parts without change in *khoa* portion. The batters were tried for making *khoa-jalebi*. The effect of these levels on sensory and other attributes of *khoa-jalebi* was studied. It was found that addition of 5 parts *toukir* resulted in a product with crispy texture and juicy body. When 10 parts of *toukir* was added, the *jalebi* became hard in body and less smooth in surface. While 15 parts of *toukir* produced *jalebi* with very hard body and more juiciness and sweetness. An addition of 5 parts *toukir* gave comparatively better characteristics such as soft, juicy and crisp body and uniform texture.

During the above studies on the optimization of ingredients, the proportion of *khoa*, arrowroot and *toukir* has been considered with the ratio of 100:25:5 parts for further work.

Frying determines the nature of the product. It provides characteristic features to the product. The typical product characteristics like golden brown colour, crispy body etc. are generally obtained during frying. Three levels of frying temperatures (i.e. 140-145^{0}C, 150-155^{0}C and 160-165^{0}C) of *jalebi* batter were taken for examination. Frying at lower temperature resulted in hard, chewy product and with under-cooked core of the product. The product fried at 140-145^{0}C took more time (around 8-10 minutes) to have optimum color to the product. At 150-

155^{0}C of frying temperature with 4-5 minutes time, the *jalebi* became slightly hard and required more soaking time in sugar syrup. Whereas, the frying temperature of 160-165^{0}C for 3-4 minutes, resulted in comparatively good characteristics to the product.

The sugar syrup concentration and soaking conditions were also studied using three levels, viz. 40, 50 and 60 percent. It was found that 60 % sugar concentration in syrup at 40^{0}C for minimum 2-3 minutes soaking time was the optimum. While, reducing the sugar concentration to 50 % resulted in *khoa-jalebi* with less sweetness. Lower temperature of soaking i.e. 40^{0}C was required for complete absorption of sugar syrup into the product. Whenever higher temperature was used for soaking in sugar syrup, it loosened the body of the product.

Analysis of *khoa-jalebi* showed the average composition as follows: moisture 25.32 %, fat 9.19 %, protein 6.05 %, sucrose 18.65 %, lactose 11.70 %, ash 1.38 % and other carbohydrates 27.72 %.

Storage studies were conducted at 30^{o}C for 12 days. During storage study, it was observed that the pH of *khoa-jalebi* decreased with the increase in total bacterial counts and yeast & mold counts, irrespective of packaging material and temperature during storage. The initial pH was 6.54 and it was reduced to 6.47 in *khoa-jalebi* packed in LDPE pouch, whereas for multilayered pouch it reduced to 6.49 at the end of 12 days storage. Initially, the total bacterial count was 5.04 log cfu/g for the freshly packed samples. It was then increased to 6.37 log cfu/g for the samples packed in LDPE pouches and 6.15 log cfu/g for the samples packed in multilayered (laminated) pouches, on 10th day of storage at 30^{o}C temperature. Yeast and mold count increased very fast from 0.95 log cfu/g of 0th day to 2.38 log cfu/g on 10th day for the samples packed and kept at room temperature. Shelf life of *khoa-jalebi* at 30^{o}C without any treatment hold was 6-8 days when packed in

LDPE pouch, and about 8 days when packed in multilayered pouch. But from the sensory scores it was observed that the flavour, body & texture and overall acceptability decreased significantly after 4^{th} day of the storage.

5.2. CONCLUSION AND RECOMMENDATIONS

In the present work, various parameters such as batter formation, arrowroot and *toukir* levels, frying temperatures and sugar syrup concentrations have been studied to standardize them. However, there is further scope to improve the parameters to produce with the most acceptable characteristics matching with the products presently sold in Maharashtra and Madhya Pradesh. Most of the market samples are having medium to more hard body, sufficient sweetness, no oozing out of sugar syrup, and storage life of 20-30 days at ambient temperature from 20 to 30 days depending on variable weather conditions. Therefore, it is necessary to carry out further studies in detail about the effect of different ingredients and processing parameters on physico-chemical and sensory characteristics of *khoa-jalebi*. Further, it is also necessary to establish the interrelationships among the ingredients used, processing parameters and product characteristics. The product standardized during this study has achieved the storage life of about 6-8 days only at 30^{o}C. Hence, shelf life improvement studies also equally important to carry out as a further investigation.

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APPENDIX

SCORE CARD FOR EVALUATION OF LIKING OF SENSORY PARAMETERS FOR KHOA-JALEBI

Please examine and score the samples for sensory attributes on the basis of 9-point Hedonic Scale, and give the remarks:

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Sample No. / **Sensory attributes**	**1.**	**2.**	**3.**	**4.**	**5.**	**6.**
Color and Appearance						
Flavor						
Body and texture						
Sweetness /Juiciness						
Overall Acceptability						

Remarks, if any: -

1. _____

2. _____

3. _____

4. _____

Date: / /

Judge's Name : _____

Signature : _____