Development of technology for *Khoa jalebi* dry mix — studies on formulation, packaging and shelf life

M.B. Chaudhary and C.N. Pagote

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**Abstract** A complete technology for the preparation of khoa jalebi dry mix (KJ-DM) is reported. Two different formulations were tried for KJ-DM development taking (1) skim milk powder (SMP) and (2) khoa powder (KP) as base materials. In SMP based formulation, 100 parts SMP was admixed with 12 parts of toukir and 75 parts ghee along with three levels of arrowroot powder viz. 40, 50 and 60 parts. Fifty parts arrowroot powder was found optimum in KJ-DM which gave optimum sensory and textural characteristics of khoa jalebi prepared from the mix. In khoa powder based formulation, 100 parts tray dried khoa powder was admixed with 7 parts toukir and 60 parts of arrowroot which yielded batter of low stickiness making coil formation very difficult. Coil integrity during frying was also affected. Enhancing the arrowroot powder level in the mix also was not helpful. Finally, SMP based KJ-DM was recommended. The selected SMP based KJ-DM contained 3.57% moisture, 31.08% fat, 13.88% protein, 21.52% lactose, 3.29% ash and 26.66% other carbohydrates. The shelf life of the KJ-DM packed in LDPE or metalized polyester pouches was observed to be more than 90 days at 30°C.

**Keywords**: Khoa, khoa jalebi, khoa powder, Khoa jalebi dry mix, skim milk powder, arrowroot powder, toukir, batter

**Introduction**

*Khoa jalebi* is one of the popular traditional sweets and breakfast food items (Pagote and Rao, 2011) prepared from *khoa*, admixed with water, arrowroot powder and *toukir*. The preparation of *khoa jalebi* is cumbersome and time consuming. The typical attributes of *khoa jalebi* have been reported by Pagote and Rao (2013). Recently, its method of preparation has also been standardized (Nawale, 2010) and several aspects like rate of sugar diffusion into jalebi coils (Singariya and Pagote, 2012) and shelf life enhancement (Bharat and Pagote, 2012) have been studied. For preparation of *khoa jalebi*, the batter should have cohesive and sticky nature (Rathod and Pagote, 2014), but pure khoa lacks in these attributes. Hence, khoa is mixed with arrowroot powder so that a sticky batter can be prepared to facilitate coil formation. A tuber based starchy material called toukir is also used in *khoa jalebi* preparation, which has a function of retaining sugar syrup inside the coils (Nawale, 2010; Pagote and Rao, 2014). Preparation of *khoa jalebi* is cumbersome because of batter making which can be made easy if a ready dry mix is available at hand. The dry mix of the khoa jalebi can be produced by blending the above mentioned ingredients in correct proportions.

The primary aim of this study is to develop a ready mix from which *khoa jalebi* can be prepared easily at domestic level. The dry mix will also have the advantage of long shelf life, so that it can be transported easily to super markets and can remain in market shelves for a number of days before picked up by prospective consumer.

**Materials and Methods**

Refined sugar (*Parry* Brand), skim milk powder (*Nandini* Brand) and arrowroot powder (*Cow* brand) used in the study were procured from the local market. Toukir was obtained from local market of Nagpur. Ghee was prepared from fresh cream obtained by separation of whole cow milk collected from Institute's Cattle Yard. Khoa powder used in the formulation was prepared as follows (Thompkinson and De, 1981): Milk obtained from the Experimental Dairy, National Dairy Research Institute was...
standardized to 4.0% fat and 8.5% solids-not-fat (SNF). The standardized milk was converted to khoa by heat desiccation method in an open steam jacketed kettle (steam pressure: 2 kg.cm$^{-2}$). For the preparation of khoa powder, khoa was manually broken into small clods and spread in tray up to 1 cm bed thickness. The tray was loaded into the drier and heaters started. After about two hours of drying at 65°C, the partially dried khoa clods were manually mixed in the tray itself and spread again. Drying was carried out further at 65°C for 10-12 h. After drying period, the tray was taken out and allowed for cooling to ambient temperature. The dried khoa particles were ground in a mixer into a fine powder. The khoa powder thus obtained was stored in a desiccator till further use.

Formulation of khoa jalebi dry mix (KJ-DM)

Skim milk powder based formulations: Khoa jalebi dry mix was prepared by dry blending of skim milk powder, ghee, arrowroot powder, and toukir in different proportions: SMP-100 parts, Ghee-75 parts, arrowroot-40, 50 and 60 parts and toukir-12 parts. Quantities of SMP, ghee and toukir were kept constant and amount of arrowroot was varied to study the effect of arrowroot level on the quality of khoa jalebi.

Skim milk powder was taken in a vessel and mixed thoroughly with arrowroot powder and toukir. Molten ghee was added in small lots and mixed thoroughly into the mixture. The final mixture obtained was then taken in Hobart mixer and blended to obtain the jalebi dry mix.

Khoa powder based formulation: Khoa jalebi dry mix was prepared by dry blending of khoa powder, arrowroot powder and toukir in different proportions: Khoa powder-100 parts, arrowroot-60 parts and toukir-5 parts. The same blending technique as described above was adopted for the preparation of the khoa powder based dry mix.

Preparation of khoa jalebi from the dry mix

Khoa jalebi was prepared from the above mixes and the effect on the sensory and textural quality of the product was studied.

A known quantity of KJ-DM was taken in a mixing bowl, desired quantity of water (40-45 ml per 100 g of dry mix) was added in lots and kneaded into a smooth and sticky batter. Freshly prepared batter was extruded through the hole (4-6 mm) made in a thick cloth to form jalebi coils which were deep fried in refined oil (Brand- Fortune) at 150-160°C. Frying was carried out in flat bottom pan for uniform frying of the jalebi coils. Frying was continued till surface colour of the coils became light golden brown to golden brown. The fried units were then dipped in sugar syrup (60% concentration) and soaked for 6-7 minutes at 60°C. After that, khoa jalebi was evaluated for its size, shape and quality characteristics. The entire process is shown in flow diagram (Fig.1).

For preparation of control sample, khoa jalebi batter was prepared by mixing (100 parts) khoa, (25 parts) arrowroot powder and (5 parts) toukir and rest of procedure of the jalebi preparation was same as described by Nawale (2010) with little modification of soaking time.

Packaging of KJ-DM

LDPE and metalized pouches of 350 gauge and 320 gauge thickness, respectively were filled with 125 g KJ-DM each and heat sealed with minimum air space.

Storage of KJ-DM

The packaged KJ-DM samples were stored at 30°C in thermostatically controlled incubator (‘Apollo’, Bangalore). At regular intervals of 15 days, the mix sample was drawn and used for khoa jalebi preparation. The khoa jalebi was evaluated for textural and other sensory attributes. The mix was analysed for change in moisture, TBA (oxidation) and reflectance values (colour).

Analytical methods

Sensory evaluation

Sensory analysis is a limiting factor to determine the critical point of acceptance and also the product shelf life time. Sensory assessment is critical in stability tests before any other evaluations (Lawless and Heymann, 1999; Minim, 2006). In this study, for the sensory evaluation during storage, rating test was used, in which the degree of liking of visual color,
flavor, appearance and acceptance was evaluated using a nine-point hedonic scale anchored at both extremes: 1="dislike extremely" and 9="like extremely" (Lawless and Heymann, 1999). Sensory evaluation was carried out by a panel of judges. The tests were performed in the sensory laboratory under fluorescent light and at 30°C. During storage study, after cutting open the packets, the emanating odour was checked for any off flavours.

Chemical analysis

The packet containing dry mix was cut open and emptied into pestle and mortar and mashed to smoothen all the clods/lumps. The uniformly smoothened mix was taken for chemical analyses. The khoa jalebi was also mashed in pestle and mortar and the mashed jalebi was taken for analysis.

Fat, total protein and ash contents in KJ-DM were determined according to AOAC (2005). Moisture content in KJ-DM and khoa jalebi, and lactose content in KJ-DM were determined as per BIS (1981), and other carbohydrate by difference. Thiobarbituric acid (TBA) value, which gives extent of oxidation in samples, was measured by the method described by Sidwell et al. (1955). Reflectance was determined using reflectancemeter ('Elico' - Hyderabad) by the method prescribed by manufacturer. The mix was stuffed into a clean, scratch free petri-plate and the bulb of reflectancemeter was placed on the surface of the plate. The light reflected by the sample in petri plate was measured as shown on the dial scale in terms of per cent reflectance. Measurements were made at 4-6 places on the petri plate and average of them was expressed as per cent reflectance of the sample. The higher the value, lighter is the sample and vice versa.

Textural analysis

Textural characteristics of batter as well as khoa jalebi were measured using Texture Analyzer (TA-XT plus, Stable Micro Systems, England).

The firmness and consistency of batter were measured as per the method described by Rathod and Pagote (2014 under the following test conditions of Texture Analyser: Mode: Measure force, Options: Return to Start, Pre test speed: 1.0 mm/sec, Test speed: 1.0 mm/sec, Post test speed: 10.0 mm/sec, Distance:30.0 mm, Trigger force: 2 g.

Batter was poured into a plastic container (60 mm dia x 105 mm height) up to 3/4th of volume and tempered to 30°C. The plastic container containing the sample was placed below the probe of Texture Analyser (p/45 plastic disc) and the probe was brought close to the product surface. Up on prompting, the probe travelled to a distance of 30 mm into the product and returned to original position, generating a force-time curve.

Fig.2: A typical force-time curve of the jalebi batter and khoa jalebi obtained in Texture Analyzer (A - Area of positive curve, consistency, N.sec; B - Maximum force on positive curve, firmness, N)
During the travel of the probe downwards, the batter was forced to travel upwards through a gap between the probe and inner wall of the plastic container. This is called back extrusion technique in which resistance offered by the batter to the travelling disc probe is measured. 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 as firmness of the product and expressed in terms of Newton (N).

The firmness and consistency of khoa jalebi were measured using Warner - Bratzler knife probe of Texture Analyser under the following test conditions: Mode: Measure force, Options: Return to Start, Pre test speed: 1.0 mm/sec, Test speed: 1.0 mm/sec, Post test speed: 10.0 mm/sec, Distance: 30.0 mm, Trigger force: 0.5 g. Jalebi coil tempered to 30oC was placed on the slot of Warner - Bratzler accessory and up on initiation, the knife travelled down and cut the coil generating a force - time curve (Fig. 2). 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 as firmness of the product and expressed in terms of Newton (N).

Springiness of jalebi coil was measured by Texture Profile Analysis (TPA) technique described by Bourne (2002). The test was performed under the following test conditions: Mode: Measure force in compression under TPA mode, Pre test speed: 1.0 mm/sec, Test speed: 1.0 mm/sec, Post test speed: 10.0 mm/sec, Distance: 5.0 mm, Time: 5 sec, Trigger force: 5 g; Probe: p/75 disc. The jalebi coil was carefully cut into 1x1x1 cm cube and tempered to 30oC. It was placed on the platform and upon prompting, the probe moved down compressing the sample by 5 mm twice in a gap of 5 sec, thereby generating a typical TPA curve. From the TPA curve, various TPA parameters were computed as described by Bourne (2002). However, the most relevant TPA characteristic of jalebi coil, i.e. springiness is presented in this study. The higher the value, the higher is the springiness. Since it is a ratio, does not carry units. It represents per cent recovery of sample height after initial compression.

Statistical analysis

The sensory evaluation data was subjected to one way analysis of variance as described by Snedecor and Cochran (1980) employing MS Excel package. Where F-test was significant, further analysis was proceeded with computation of critical difference to know the significant difference between any pair of treatments at 5% level of significance (Sundararaj et al., 1972).

Results and Discussion

Two types of mix were formulated viz. SMP based- and khoa powder- based mixes. In the first formulation, arrowroot powder and SMP were taken as base materials, and in the second arrowroot and khoa powder formed the base materials. The quality of batter and the jalebi depend to a great extent on the proportion of arrowroot powder in the mix. Hence, effect of arrowroot content of the mix was studied first. The ingredients used in KJ-DM were skim milk powder, ghee, khoa powder, arrowroot powder and toukir. The proportion of these ingredients was optimized.

Optimisation of arrowroot level in SMP based KJ-DM formulation

Effect of arrowroot level in khoa jalebi dry mix on rheology of batter

Arrowroot acts as a binder in khoa jalebi making. It holds moisture and bind other ingredients for the formation of body and texture of khoa jalebi. Results show that increasing arrowroot level in the mix increases the firmness and consistency of the batter made from the mix. Firmness of batter increased from 2.4 N for 40 parts arrowroot to 4.5 N for 60 parts arrowroot level (Table 1). Similarly, consistency of batter increased from 23.3 N.Sec for 40 parts arrowroot level to 41.3 N.Sec for 60 parts arrowroot level. Arrowroot has about 85 % starch (Perez and Lares, 2005) which when added to water in non-gelatinised form absorbs water (Watanabe and Fukuoka, 2001) and makes a viscous mixture. This property of arrowroot helps in formation of jalebi coils whose integrity is retained even after frying and soaking. During batter making, the level of water used was kept constant (@40 ml/100 g formulated dry mix) in all the mixes. Batter making was easy in all the proportions and the batter possessed enough stickiness and cohesiveness so that the coils retained the shape and size after frying and soaking.

In gulabjamun mix, which is a popular product in the market similar in composition to jalebi mix, maida is used as source of starch, whereas in khoa jalebi preparation, arrowroot powder is used as source of starch (Pagote and Rao, 2012). The water binding ability of arrowroot powder is similar to that of refined wheat flour (maida) (Ciacco and D’Appolonia, 1977), and helps in retention of coil shape during extrusion and frying. In gulabjamun, the function of starch is to hold the shape of ball and provide gulabjamun with a good body and texture. In case of khoa jalebi, arrowroot aids in firm coil formation as well as retain the coil shape during and after soaking in sugar syrup. Arrowroot when fried develops a rigid structure, interacts with milk powder casein and imparts a firmer texture, body and texture, sweetness and overall acceptability. The sensory scores secured by the samples are presented in
Table 1  Effect of arrowroot level in KJ-DM on rheological characteristics* of batter

<table>
<thead>
<tr>
<th>Arrowroot level per 100 parts SMP</th>
<th>Firmness (N)</th>
<th>Consistency (N.Sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 parts</td>
<td>2.4±0.25a</td>
<td>23.3±2.53a</td>
</tr>
<tr>
<td>50 parts</td>
<td>3.2±0.30b</td>
<td>29.3±2.64b</td>
</tr>
<tr>
<td>60 parts</td>
<td>4.5±0.12c</td>
<td>41.3±1.94c</td>
</tr>
<tr>
<td>CD_{0.05}</td>
<td>0.295</td>
<td>3.011</td>
</tr>
</tbody>
</table>

*Average of five trials; KJ-DM: Khoa jalebi dry mix; Note: Values with different superscripts in a column are significantly different (P<0.05); CD- Critical Difference

Table 2. The change in arrowroot level in SMP based mix did not significantly affect the colour and appearance scores of khoa jalebi. However, the maximum score for the colour and appearance was 7.78 ± 0.13 for the 50 parts arrowroot level followed by the control, 40 parts and 60 parts arrowroot. The body and texture scores indicate that all the 4 samples significantly differed from each other. However, the maximum score for the body and texture was 8.01 ± 0.07 for the control followed by 50, 40 and 60 parts arrowroot level. The sweetness scores indicated that control sample prepared from khoa had maximum value of 8.14 ± 0.08 followed by 7.53 ± 0.16, 7.49 ± 0.14 and 7.07 ± 0.22 for 50, 40 and 60 parts arrowroot level, respectively. The flavour scores of the samples were observed to be highest for the samples prepared by the addition of 50 parts arrowroot level, which scored 7.61 ± 0.10 while the samples prepared by 40 parts arrowroot level containing mix had a score of 7.54 ± 0.11 followed by 60 parts arrowroot level (7.21 ± 0.19) but the control sample prepared from khoa scored maximum of 8.45 ± 0.15. The overall acceptability scores indicate that the 50 parts arrowroot level differed significantly from control sample but 40 and 50 parts arrowroot level mixes were not statistically different from each other. Arrowroot level had significant effect on the body and texture because of variation in binding of water with change in arrowroot contents. Use of 40 parts arrowroot produced khoa jalebi with soft body and slightly compact texture, but 60 parts arrowroot resulted in firmer body and more compact texture and dry appearance of khoa jalebi due to less sugar absorption during soaking in sugar syrup. Arrowroot at 50 parts level produced optimum body and texture with pleasant flavor. As it is known that starch can interact with proteins under the conditions existing in dairy foods (Considine et al., 2011), arrowroot starch also might have interacted with milk proteins present in SMP during batter preparation as well as frying and imparted desirable body to the jalebi coil. Use of arrowroot has not yet been reported in products such as jalebi, but in gulabjamun making, maida is commonly used as binding agent. For fresh khoa, up to 20% maida addition is recommended to get good texture in gulabjamun (Rangi et al., 1985). Nawale (2010) reported that 25 parts arrowroot with 5 parts toukir for 100 parts khoa gave good body and texture with pleasant flavor in khoa jalebi. Maida could also be tried in khoa jalebi dry mix preparation, but instead arrowroot has been used so that the product could be consumed even by people who observe fasting on religious ground.

Effect of arrowroot level in KJ-DM on instrumental textural characteristics of khoa jalebi

The effect of addition of different levels of arrowroot in khoa jalebi dry mix (KJ-DM) on textural characteristics of khoa jalebi was studied and results are presented in Table 3. It was observed that as arrowroot levels increased firmness and consistency values also increased but springiness was not much affected by the arrowroot level. With 60 parts of arrowroot, the firmness was 15.40 N, whereas with 40 parts of arrowroot, it was 8.69 N. The consistency of khoa jalebi also increased with increase in arrowroot in the mix. Forty parts of arrowroot yielded 90.85 N.Sec consistency whereas it increased to 130.31 N.Sec for 60 parts arrowroot level. Nawale (2010) reported that khoa jalebi made from khoa had 17.407N firmness and 27.372 N.sec which are lower than the values obtained in the present study because of different test settings employed in his work. The arrowroot starch and protein interaction leads to formation of a complex which possesses elastic property that is responsible for springiness of the fried coil as well as soaked jalebi coil. Chen et al. (2001) reported that starch is the major component responsible for body of crust of batter fried products. During frying, protein aggregation and protein-starch interactions take place imparting a firm structure to the fried product. Same phenomenon is responsible for enhanced firmness of jalebi by enhanced levels of arrowroot in the jalebi mix.

Optimization of soaking time of khoa jalebi in sugar syrup

The coils formed from batter are fried and soaked in sugar syrup during manufacture of jalebi. During soaking, sugar syrup is absorbed by the coils, and the extent of the syrup absorption controls the body and texture of the final product. The syrup absorption not only affects the texture but also flavor in terms of sweetness. Hence, the extent of sugar absorption during soaking of coils was studied. The extent of
sugar absorption not only depends on arrowroot level, but also time allowed for soaking.

The maximum weight gain was obtained in 50 parts (98.67% in 8 minutes) followed by 40 parts and 60 parts of arrow root in the mix. Weight gain was more in 50 parts followed by 40 parts and 60 parts at all levels of soaking time. As the soaking time in sugar syrup increased, there was increase in % weight gain of jalebi piece. Weight gain was highest in 8 minutes soaked product followed by 6 minutes and 4 minutes soaked ones. Results also revealed that the maximum moisture content was observed in 40 parts (22% in 8 minutes) followed by 50 parts and 60 parts arrowroot in the mix. Moisture content after soaking was highest in 40 parts arrowroot mix product followed by 50 parts and 60 parts arrowroot mixes (Table-5). Thus it was shown that as the arrowroot level in khoa jalebi increased, the moisture content in khoa jalebi decreased. As the soaking time in sugar syrup increased there was increase in moisture content of jalebi piece. Moisture content was highest in khoa jalebi which was soaked in sugar syrup for 8 minutes followed by 6 minutes and 4 minutes.

It was also observed that as the soaking time increased the khoa jalebi became softer and juicier. Of the three time intervals, with 4 minutes soaking time, the khoa jalebi was found to be most firm. With 6 minutes soaking time the khoa jalebi became softer. On further increase of the soaking time to 8 minutes khoa jalebi became more soft and juicier (Table 6). Thus, the khoa jalebi with soaking time of 6 minutes was found to be optimum and acceptable. It was also seen that as the arrowroot level increased, the product became harder. The arrowroot level of 50 parts was found to be optimum and acceptable because it gave pleasant taste with juiciness at 6 minutes soaking time.

With regard to sensory acceptance, it depended on arrowroot content of the mix. In case of mix containing 40 parts arrowroot as the soaking time increased the overall acceptability of the jalebi also increased. In 50 parts arrowroot mix, the maximum overall acceptability was in 6 minute (7.69) followed by 8 minutes (7.63) and 4 minutes (7.58). In 60 parts, overall acceptability increased and then became constant in 6 minutes and 8 minutes soaking time. Thus, it was seen that the maximum overall acceptability was obtained in 50 parts arrowroot containing mix with 6 minutes soaking time. Nawale (2010) reported that as arrowroot level decreased and toukir level increased, it resulted in firmer and harder khoa jalebi but it increased juiciness in the jalebi.

Formulation of khoa powder based dry mix

Yawale and Rao (2013) reported that acceptable quality of gulabjamun could be prepared from khoa powder based gulabjamun mix. Hence, in order to impart typical khoa like flavor, KJ-DM was prepared using khoa powder itself as base material in place of SMP.

Khoa jalebi dry mix was formulated using khoa powder, arrowroot and toukir. One hundred parts khoa powder was admixed with 60 parts arrowroot and 7 parts toukir. It was observed that use of khoa powder affected water binding character of the batter. Minimum 60 parts arrowroot was required to produce batter with some stickiness. Addition of more than 60 parts arrowroot improved stickiness and smoothness of batter but it caused water separation during extrusion of batter through cloth. High level of denaturation of proteins might have occurred during manufacturing of khoa powder from khoa. This might have led to decrease in tendency towards water binding during batter making resulting in water separation during extrusion through cloth. It was very difficult to form full jalebi coil and also during frying most of water evaporated causing shrinkage in jalebi coil diameter. Khoa jalebi made from khoa powder mix was also darker in colour and had hard, crispy body and rough texture (Table 7). This may be attributed to copious Maillard reactions initiated during khoa manufacture. These reactions might have been accelerated during frying resulting in charring of proteins imparting dark brown colour to the jalebi. The darkening of products during frying is ascribed to evaporation of moisture and then charring of proteins at high temperatures (Chen et al., 2001).

Final formulation of KJ-DM

The optimized khoa jalebi dry mix was as follows: Skim milk powder 100 parts, ghee 75 parts, arrowroot 50 parts and toukir 12 parts. These ingredients were mixed thoroughly to form KJ-DM.

Chemical composition of KJ-DM

The average gross chemical composition of the KJ-DM was: moisture 3.57, fat 31.08, protein 13.88, lactose 21.52, ash 3.29 and other carbohydrates (by difference) 26.66%.

Packaging and storage study of KJ-DM

The KJ-DM was packaged in a high moisture barrier (Metalized polyester pouch) and a low moisture barrier (LDPE) packaging material and studied for shelf life at ~ 30oC.

Changes in sensory quality of KJ-DM during storage

There were no significant changes in the visual appearance of the KJ-DM, however, colour of the mix became slightly more brown during storage; but, there was no staling defect. Similar observations were made by Rajorhia and Pal (1989) in
Regarding the quality of khoa jalebi prepared from stored KJ-DM, there was a gradual decrease in the colour and appearance, body and texture, flavour and overall acceptability scores (Fig. 3 and 4). At 30°C, the shelf-life of KJ-DM packed in LDPE and metalized polyester pouch, as determined by sensory evaluation of khoa jalebi, was found to be more than 90 days. The overall acceptability of khoa jalebi from initial score of 7.72 ± 0.13 decreased to 7.22 ± 0.13 for samples...
packed in LDPE pouch and 7.38 ± 0.07 for samples packed in metalized polyester pouch. Colour and appearance, body and texture, sweetness and flavour scores also followed the same trend. Rajorhia and Pal (1989) reported that gulabjamun was of acceptable quality till more than two months of gulabjamun mix powder (GMP) storage, but after three months storage developed stale flavour.

Changes in textural characteristics of khoa jalebi

In food products, storage related changes in texture are common, especially when many constituents are involved. These changes occur possibly as a result of chemical reactions taking place during storage or changes in the structural conformations of constituents. From the texture profile analysis (TPA) parameters of khoa jalebi prepared from the KJ-DM during storage intervals, it was found that firmness, consistency and springiness increased during the storage. The firmness of khoa jalebi from initial value of 10.36 N increased to 12.75 N for samples packed in LDPE and 12.25 N for metalized polyester pouch (Fig. 5 & 6). The consistency increased from initial value of 107.7 N.Sec to 141.23 N.sec for LDPE and 135.43 N.sec for metalized polyester pouch. The springiness from initial value of 0.834 increased to 0.85 for samples packed in LDPE and 0.848 for metalized polyester pouch during the storage period of 90 days. The textural changes may be attributed to interactions among the constituents of the mix. Proteins and carbohydrates are known to interact among themselves (Gothwal and Bhavadasan, 1992). In milk products like dried milks, protein-protein interactions reduce solubility during storage (Singh, 2007). According to Mimouni et al. (2010), the progressive loss of solubility of milk powder especially high protein powder, during storage could be attributed to changes in rehydration kinetics rather than formation of any insoluble compounds.

Changes in physico-chemical characteristics of KJ-DM during storage

Moisture content

At 30°C, the initial moisture value for samples packed in

Table 6  Effect of soaking time on overall acceptability of khoa jalebi prepared from KJ-DM containing different levels of arrowroot

<table>
<thead>
<tr>
<th>Arrowroot level per 100 parts SMP</th>
<th>Soaking time in sugar syrup</th>
<th>4 min</th>
<th>Score</th>
<th>6 min</th>
<th>Score</th>
<th>8 min</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 Parts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 Parts</td>
<td>Slightly hard and dryness was observed</td>
<td>7.36±0.19</td>
<td>Soft and juicy</td>
<td>7.55±0.13</td>
<td>Softer and juicier</td>
<td>7.58±0.12</td>
<td></td>
</tr>
<tr>
<td>50 Parts</td>
<td>Slightly juicy, syrup soaking is normal</td>
<td>7.58±0.16</td>
<td>Soft and juicy, has pleasant flavor</td>
<td>7.69±0.19</td>
<td>Softer and juicier but less pleasant</td>
<td>7.63±0.11</td>
<td></td>
</tr>
<tr>
<td>60 Parts</td>
<td>Hard and dry, least juicy among all</td>
<td>7.02±0.12</td>
<td>Hard but sweetness is normal</td>
<td>7.13±0.22</td>
<td>Slightly hard and slightly juicy</td>
<td>7.13±0.24</td>
<td></td>
</tr>
</tbody>
</table>

* Expressed as score on 9-point hedonic scale; All the values are mean of three trials; Values with different superscripts in a column are significantly different (P<0.05); KJ-DM - Khoa jalebi dry mix; C&A: Colour and appearance; B&T: Body and texture and OA: Overall acceptability; CD- Critical Difference

Table 7  Sensory comments and score of khoa jalebi prepared from KJ-DM formulated using khoa powder

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Sensory score</th>
<th>Sensory comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour &amp; Appearance</td>
<td>5.15±0.32</td>
<td>Darker colour and broken jalebi coil, unacceptable colour and appearance</td>
</tr>
<tr>
<td>Body &amp; texture</td>
<td>6.15±0.2</td>
<td>Hard and crispy body due to less swelling and hard rough texture</td>
</tr>
<tr>
<td>Sweetness</td>
<td>7.30±0.25</td>
<td>Slightly juicy and sweet</td>
</tr>
<tr>
<td>Flavour</td>
<td>7.83±0.24</td>
<td>Cooked and pleasant flavor</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td>5.28±0.21</td>
<td>As per flavour &amp; sweetness it was acceptable but colour and appearance wise it was rejected</td>
</tr>
</tbody>
</table>

KJ-DM - Khoa jalebi dry mix
LDPE and metalized pouches was 3.56% and the values correspondingly increased to 4.17 and 4.08%, at the end of 90 days of storage (Fig. 7). The moisture gain in sample packed in LDPE pouch was slightly faster compared to sample packed in metalized pouch. This was because of water vapour transmission rate (WVTR) of LDPE was much higher than laminates of poster paper/Al. foil/ LDPE and Metalized films (Kumar and Srinivasan, 1983). Kiesker and Clarke (1984) reported that in skim milk powder studies initial moisture levels were below 3.5% and the maximum moisture uptake of
the powders over the 18 months storage period was less than 0.2%. The KJ-DM in the present study contained about 55% of skim milk powder. In SMP, lactose exists in amorphous state which when exposed to humidity readily absorbs moisture leading to lactose glass transition and crystallisation (Thomas et al., 2004). Therefore increase in moisture content of the mix was observed during storage. This also resulted in slight caking behavior displayed by the mix at the end of storage of 90 days.

Thiobarbituric acid (TBA) value

The TBA value can be taken as a measure of progress of
oxidation during storage because the oxidation products of fat have the tendency to react with TBA forming colour compound (Botsoglou et al., 1994). The increase in TBA value was slightly faster in the samples packed in LDPE pouch than the sample packed in Metalized polyester pouch as evident in Fig.8. It was observed that the TBA values in LDPE sample increased from an initial value of 0.014 to 0.107 OD and the TBA values in Metalized polyester pouch sample increased from an initial value of 0.014 to 0.082 OD during 90 days of storage at 30°C. However, sensory acceptance was not affected by the increase in TBA value. Even in the KJ-DM, the 'oxidized' flavor could not be detected. This shows that the KJ-DM could have a shelf life longer than 90 days. Increase in TBA value is a proof that oxidation continued to take place in KJ-DM during storage. Oxidation is expected to progress in the KJ-DM because definite free fat is present in the KJ-DM sourced from the ghee. However, during the storage period of 90 days in the present study, the oxidation reaction did not proceed to the extent of spoilage level. Other workers also reported progress of oxidation reactions in dry mixes. Ghosh et al. (1984) measured the TBA values in GMP in terms of OD to assess the extent of oxidation during storage. In the fresh samples, there was no oxidation as evidenced by zero TBA value whereas at later stages of storage there was a gradual increase in TBA values. The rate of increase was slightly faster in WMP base mix. Addition of BHA helped in arresting the oxidation, TBA values of GMP were almost doubled in 90 days stored samples having no BHA at 30±10°C (Ghosh et al., 1984); however, in the present study no anti-oxidants were used.

Reflectance

In the present study, the browning was measured as reflectance value expressed in percentage. The zero day sample of KJ-DM showed higher reflectance values than 90 days sample. On storage at 300C, the reflectance values decreased in the samples packed in LDPE and Metalized polyester pouches (Fig. 9). The initial reflectance value was 88.0% which decreased to 86.0% (LDPE pouch) and 85.5% (Metalized polyester pouch). Higher value means that the samples were 'whiter' and the lower value mean the samples were browner. The decrease in the reflectance values can be attributed to browning reactions taking place in the mix during storage. This was because of presence of sufficient amounts of protein and reducing sugar in the mix which could proceed with Maillard browning reactions (Namiki, 1988). Renner (1988) reported browning of SMP during storage which supported the observation made in the present study.

Similar observations were reported in other dry mixes. In a study, it was observed that SMP based gulabjamun mix showed higher browning rate than the WMP based one, the average values being 0.149 and 0.125, respectively (Ghosh et al., 1984); in this case browning was measured as 5-HMF values expressed in OD at 470 nm.

Conclusions

A dry mix for the preparation of khoa jalebi has been developed using skim milk powder and arrowroot powder as main ingredients; consumers can easily prepare khoa jalebi at house hold level using the mix. Manufacturing method of the mix involves dry blending technique which is industry friendly, so entrepreneurs can easily adopt this technology on commercial scale.

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References

Indian J. Dairy Sci. 68(3), 2015

khoa jalebi at 30oC. Indian J. Dairy Sci 65 (6): 461-466
Singh H (2007) Interactions of milk proteins during the manufacture of milk powders. Lait 87: 413-423
Sundararaj N, Nagaraju S, Venkataramu MN, Jagannath MK (1972) Design and analysis of field experiments, University of Agricultural Sciences, Bangalore