4.0 RESULTS

Kunda, an indigenous dairy product, is semi-solid with desirable brown colour and nutty flavour grainy textured milk delicacy. It is manufactured by prolonged heat desiccation of Khoa; sugar and water till the desirable characteristics are developed.

Heat desiccated milk products such as Khoa is the base for wide range of milk sweets. Heat processing results in production of desirable heat induced chemical interactions amongst milk constituents with extension of product shelf-life. The desirable flavours, texture and overall acceptability of these products are also enhanced by heat processing.

The coagulation of milk casein is brought about by heating to 132° to 136°C; while whey proteins are coagulated below 100°C. The factors that influence the heat coagulation and concomitant chemical changes are temperature and time of holding, concentration of casein, acidity of milk, salt balance and precise heat treatment. The colour of product changes from light brown to brown due to interaction of milk constituents. In view of the above factors, investigation was carried out in three phases: I. Process development and standardization, II. Process up-gradation and III. Shelf-life studies to study the factors influencing the characteristics of Kunda.

4.1 PROCESS DEVELOPMENT AND STANDARDISATION

4.1.1 Characterisation of market Kunda

Sweet makers manufacture Kunda by prolonged desiccation of high moisture Khoa, sugar and milk/ water in a karahi till typical brown colour and nutty flavour with grainy texture are attained. The end point is judged by oozing of milk fat in the form of
ghee on surface. There is no reported standard procedure so far for manufacture of Kunda. However information was collected from halwais regarding manufacturing, packaging, preservation and marketing. Samples were collected from market and analysed for physic-chemical and sensory characteristics. Results are presented in Tables 1 and 2.

The total solids of market Kunda varied from 70 to 83%, indicating wide variation in moisture content. Similarly fat, protein, lactose, sucrose and minerals also varied from 9.0 to 17.2, 6.0 to 11.3, 12.0 to 16.0 and 26.0 to 51.2, and 3.3 to 6.5 % respectively (Table 1). Among the constituents, cane sugar content varied maximum.

It was found that market samples varied in colour from light brown to dark brown. Flavour also varied with cooked and scorched flavours. Texture was also found to vary from slight grainy to loose texture (Table 2). It differed from manufacturer to manufacturer due to different ways of manufacturing procedures adopted.

### 4.1.2 Effect of extent of desiccation on physico-chemical properties of Kunda

Kunda has typical brown colour, nutty flavour and grainy texture. The development of these characteristics depends on the extent of desiccation of Khoa, sugar and water. As there are no standards for extent of desiccation, an experiment was conducted to standardize the extent of desiccation. Five treatments (T-1 to T-5) were planned to find out the desirable extent of desiccation for manufacture of Kunda. The samples were drawn after 0, 2, 4, 6 and 8 desiccations and were analyzed for physico-chemical properties of Kunda (Table 3) and sensory properties (Table 4).
**Moisture:**

The moisture percent in Kunda ranged from minimum of 19.32 per cent (T-4) to 20.36 (T-5). The data of moisture content presented in Table 3 was statistically not significant (P≥0.05).

**Browning index:**

Browning index increased significantly (P≤0.05) from 0.26 in the T-1 to 0.37 in T-5. The browning increased after every desiccation. The desiccations differed significantly (P≤0.05) from each other reflecting the profound effect on browning. The visual browning of the karahi contents was initiated from 4\(^{th}\) desiccation onwards and it reached optimum intensity after 8\(^{th}\) desiccation. There was no further increase in browning beyond eight desiccations as observed in preliminary trials. Hence, eight desiccations were observed to be necessary to get desirable brown colour in Kunda.

**Water activity:**

Water activity of Kunda ranged from 0.82 to 89 (Table 3). Water activity insignificantly differed (P≥0.05) between the desiccations as water was added after each desiccation.

**pH:**

The pH of kunda decreased from 6.43 in T-1 to 6.01 in T-5 (Table 3). The decrease in pH was significant (P≤0.05) as the desiccations increased. However, the decrease was not significant (P≥0.05) up to 4 desiccations.
4.1.3 Effect of extent of desiccation on sensory characteristics of Kunda

Kunda has typical sensory appeal to consumers. Its colour and appearance, typical nutty flavour; with grainy texture are characteristics which influence the acceptance of the products. A panel of judges evaluated the sensory quality of Kunda. The sensory evaluation was carried out on a 9-point hedonic scale (Amerine et al 1965). The scores were awarded to samples drawn after every two desiccations (Table 4).

**Colour and appearance:**

Colour and appearance scores significantly ($P \leq 0.05$) increased from 5.00 in T-1 and it increased to 7.0 in (T-5). Each desiccation contributed significantly ($P \leq 0.05$) to colour and appearance score with optimum of 8 desiccations.

**Flavour:**

The flavour scores started increasing after 4th desiccation. The flavour scores ranged from 5.80 in T-1 to 7.70 in T-5 (Table 4). The increase in flavour scores was significant ($P \leq 0.05$). However there was significant difference only after 4 desiccations. However, the increase in flavour score was not significant ($P \geq 0.05$) after 6th desiccation indicating that sufficient Maillard reaction has taken place from 4 to 6 desiccations. The optimum desiccation has been decided as “8” based on overall acceptability.

**Body and texture:**

Kunda has a typical texture and structure. It is a semi-solid product without any specific shape. The texture of Kunda is the contribution of grains developed during desiccation. The extent of desiccation certainly had influence on texture development. Body and texture scores increased from 4.90 to 7.40 (Table 4). The body and texture
scores significantly (P≤0.05) increased after 2 desiccations. However there was also no significant (P≥0.05) difference between 6 and 8 desiccations.

**Overall acceptance:**

The overall acceptance scores increased from initial 4.60 to 7.50 in “8” desiccations. (Table 4). The overall acceptance scores significantly increased after 2, 4 and 6 desiccations. It indicates that the extent of desiccation significantly contributed to the Kunda characteristics and its acceptance. The overall acceptance score had significantly (P≤0.05) differed between 6 and 8 desiccations.

### 4.1.4 Effect of cow milk and buffalo milk on yield and physico-chemical properties of Kunda

Cow and buffalo milks are used in India for the manufacture of traditional dairy products depending on the availability and suitability of milk for a particular product. The difference in cow and buffalo milk in relation to quality and quantity of traditional dairy products is due to the differences in quantitative and qualitative aspects of milk constituents which in turn lead to the differences in physical, chemical and functional properties of products.

**Yield:**

Yield is one of the important parameters during manufacture of dairy products. Yield is influenced by many factors during manufacture such as composition of milk, type of milk, method or technique of manufacturing and equipment used.

An experiment was conducted to study the effect of composition and type of milk on yield of Kunda. Five types of standardized mixed milk were studied (Table 5). The
results indicated that yield of Kunda decreased as the proportion of buffalo milk decreased. The yield decreased from 300gm/lit to 255gm/lit as buffalo milk proportion decreased from 100 to 0 percent. The decrease in yield was statistically significant (P≤0.05).

4.1.4.2 Physico-chemical properties

Moisture

The moisture content in Kunda prepared from variable proportions of cow and buffalo milk increased from 18.3 % in pure buffalo milk to 20.10 per cent in pure cow milk. This increase in moisture was significant (P≤0.05). There was considerable difference in moisture % between Kunda obtained from the two types of milk indicating effect of type of milk.

Total solids:

Total solids percent decreased with decrease in proportion of buffalo milk complementary to the values of moisture content. However, there was no critical difference in total solids of Kunda with varying proportions of cow and buffalo milk used (P≥0.05). The total solids decreased from 81.70 per cent in buffalo milk Kunda to 79.90 per cent in cow milk as shown in Table 5.

Acidity:

Acidity of Kunda ranged from 0.43 to 0.48 % L A. However, the acidity values were not statistically significant (P≥0.05) when cow and buffalo milk was mixed in different proportions.
4.1.5 Effect of cow milk and buffalo milk on sensory characteristics of Kunda

Traditional dairy products preparation was preferred based on suitability of type milk. The compositional differences between cow and buffalo milk have contributed for many defects in physico-chemical as well as sensory characteristics of traditional dairy products.

The effect of cow and buffalo milk and mixing of these milks in different proportions on sensory properties of Kunda was investigated.

**Colour and appearance:**

Colour and appearance of Kunda varied significantly ($P \leq 0.05$) with type of milk. Colour and appearance scores ranged from 7.30 to 8.00 (Table 6). Cow milk Kunda was bright brown in colour and buffalo milk Kunda was grey brown or light brown with dull appearance. Dull appearance vanished as the proportion of buffalo milk decreased. The maximum score of 8.0 was awarded to product made with equal proportion of mixed milk. Most of the treatments differed significantly ($P \leq 0.05$) with regard to colour and appearance scores. It is evident that the mixed milk Kunda scored highest for colour and appearance score.

**Flavour:**

Flavour scores of Kunda ranged from 7.30 to 8.00. Highest score was awarded to Kunda prepared from cow and buffalo milk mixed in equal proportions. The effect of pure cow milk or pure buffalo milk on flavour scores was, however, not statistically significant ($P \geq 0.05$).
Body and texture:

The Body and texture of Kunda was affected significantly (P≤0.05) by type of milk. Lowest body and texture scores (7.2) was awarded to pure cow milk and pure buffalo milk. Highest score (8.3) was awarded to 50:50 mixed milk (T-3). The buffalo milk Kunda developed abnormal grainy texture during manufacture. However, the simmering (slow boiling) of buffalo milk during Khoa making stage reduced the abnormal grain sizes. Cow milk Kunda was also awarded with lowest body and texture scores. Cow milk Kunda was sticky, gummy in texture. It formed cake like texture after cooling. There was significant (P≤0.05) increase in body and texture score awarded to 50:50 mixed milk compared with other treatments.

Overall acceptance:

The overall acceptance scores ranged from lowest score (7.2) for cow milk and highest score (8.2) awarded to mixed milk (50:50). The overall acceptance scores are presented in Table 6.

As observed with other sensory attributes Kunda made with 50:50 mixed milk scored highest for overall attributes and their scores were found to be significantly higher than other combinations except (T-2) 25:75 (P≤0.05).

4.1.6 Effect of type of milk Vs intensity of heating during Khoa making stage on physical properties of Kunda

The qualitative and quantitative differences between cow and buffalo milk are the primary causes for difficulties encountered during manufacturing of Kunda. Kunda prepared from cow milk had gummy texture, sticky body with bright brown colour.
Buffalo milk Kunda had uneven grainy texture due to its casein micellar size and properties. Uneven grainy texture problem of buffalo milk was solved by simmering (85 C to 99 C) of milk during Khoa making stage itself. Further, Kunda characteristics were improved by admixing standardized cow milk (5.0% fat and 8.5% SNF) and buffalo milk (6.0% and 9.0% SNF) in different proportions. It was found that mixing of standardized cow and buffalo milk in equal proportions (50:50) was most suitable to get desirable attributes. The results are summarized in Table7.

4.1.7 Effect of steam pressure on yield and physico-chemical properties of Kunda

Manufacture of Kunda requires high heat treatment for long time for development of typical Kunda attributes. Temperature requirement is around 100° to 140°C. To study the effect of temperature on development of browning in Kunda, the product was manufactured using two steam pressures in the steam jacket namely, 0.5 to 1.0 kg/sq.cm (T-1) and 1.0 to 2.0kg/sq.cm (T-2). Kunda was manufactured according to earlier standardized method, (Section 3.22.2. Kunda samples from the above experiment were analyzed for the following parameters.(Table 8)

Yield:

Yield of Kunda was expressed as gm/lit (Table 8) Yield of Kunda was significantly higher in T-2 (250 gm/lit) than T-1 (253 gm/lit).
Physico-chemical properties

Total solids:

Total solids influence the quality of Kunda. The effect of steam was not significant (P≥0.05) though the T-1 was having higher total solids (80.80 %) and difference was only 0.27%.

Water activity:

Water activity is the property to be considered for judging the stability. Water activity of Kunda was within the range of intermediate moisture foods. The difference water activity was only 0.007 with lower water activity in T-2. (Table 8).

Browning index:

Higher browning index was found in T-2 (0.31) compared to T-1 (0.21). The difference was significant (P≤0.05); more brown compounds produced at higher temperature.

4.1.8 Effect of steam pressure on sensory characteristics of Kunda

Development of typical Kunda characteristics requires desiccation at high temperature ≥100° C. The development of brown colour and flavour distinctly differed with extent of heat treatment. The pleasant flavour and brown colour development depends on extent of heating. The Maillard reaction products are produced maximum at temperature more than normal boiling point of milk. Steam pressure more than 2.0 kg/sq. cm (> 150° C ) causes burning due to high temperature.
To study the effect of steam pressure on Kunda characteristics an experiment was conducted with steam pressure $\leq 1.0 \text{ kg/sq.cm} \ (T-1)$ and using steam pressure ranging from 1.0 to 2.0 kg/sq.cm. (T-2)

**Colour and appearance:**

Colour and appearance scores were 6.3 in T-1 and 7.9 in T-2 (Table 9). The difference was significant ($P \leq 0.05$) indicating that higher steam pressure resulted in optimum colour, appearance and body and texture. The heat treatment was $\leq 100^\circ\text{C}$ is not sufficient for development of brown colour. Colour in T-1 was light brown. Steam pressure ranging from 1.0 kg/sp. cm to 2.0kg/sq.cm increases the temperature from 100°C to 140°C.

**Flavour:**

Flavour compounds’ production in heat processing depends on extent of heat treatment. Various flavours are produced during Kunda manufacturing. Flavour score for T-1 was 7.20 and for T-2 it was 7.80 (Table 9). The difference in flavour scores was significant ($P \leq 0.05$). As the steam pressure increased flavour production also increased significantly.

**Body and texture:**

Body and texture of Kunda was affected by extent of heating with significant difference between T-1 and T-2, the scores being 8.00 and 8.20, respectively ($P \leq 0.05$).
Overall acceptance:

The overall acceptance scores of T-1 was 7.10 and T-2 was 8.00. Overall acceptance scores were statistically significantly different (P≤0.05).

4.1.9 Effect of different sugar levels on yield and physico-chemical properties of Kunda

Sugar is the most influencing ingredient in the sweet food products. Kunda is also milk based sweet. There is no standard level of sugar added to Kunda. For Khoa based sweets like Peda, normally 7.0 per cent sugar (on milk basis) is added. Kunda manufacturing may require more sugar than Peda and burfi due to prolonged desiccation during manufacture. Hence, an experiment was planned with three levels of sugar (7.0, 9.0 and 11.0 per cent) to choose the optimum percent of sugar for both physico-chemical properties and sensory attributes. The following parameters have been evaluated on effect of physico-chemical properties (Table 10).

Yield:

Yield of Kunda varied significantly (P≥0.05) from 265 gm/lit with 7.0 per cent sugar, 270 gm/lit with 9.0 per cent and 285 gm/lit with 11.0 per cent sugar on milk basis. The yield increased significantly (P<0.05) with increase in per cent of sugar.

4.1.9.2 Physico-chemical properties

Total solids:

Total solids per cent decreased from 81.20 with 7.0 per cent level sugar to 80.67 per cent in 9.0 per cent sugar level and further to 80.48 per cent in 11.0 sugar level. With the increase in level of sugar, per cent of total solids decreased (Table 10).

Water activity:

The water activity of Kunda varied from 0.88 with 7.0 per cent sugar, 0.89 with 9.0 per cent and 0.87 with 11.0 per cent of sugar levels. The variation in water activity
was significant (P≤0.05). However, 9.0 % sugar level was superior 7.0 % and 11.0 % of sugar levels.

**Browning index:**

Browning index is the expression of browning compounds concentration. From the results presented in Table 10, it was observed that with the increased level of sugar there was no increase in browning index. The browning index values varied from 0.13 to 0.21. It implies that production of browning compounds was not statistically significant (P≥0.05) with increased levels of sugar.

**4.1.10 Effect of different sugar levels on sensory characteristics of Kunda**

Sugar is added to food products to increase the sweetness and in turn to increase the palatability. Sugar addition has certain levels which can influence quality of food products. The excess or deficit sugar levels adversely affect the quality attributes. A study was conducted with 7.0, 9.0 and 11.0 per cent levels of sugar.

**Sweetness:**

Three levels of sugar on milk basis were tried for manufacture of Kunda specifically to study the difference in sweetness. Sweetness was evaluated on 9-point hedonic scale. The levels of sugar had significant effect on sweetness of Kunda (P≤0.05). Sweetness evaluation was conducted along with other sensory attributes. The sweetness scores were 7.10 in 7.0% sugar products, 8.0 in 9.0% and 7.5 in 11.0 per cent sugar levels products (Table11). The critical difference between the different levels was significant (P≤0.05). Among the three levels tried, nine per cent sugar level was found to give optimum sweetness in Kunda.
**Colour and appearance:** From the results presented in Table 11, it can be observed that the levels of sugars were significantly influenced colour and appearance scores. The production of brown compounds during Maillard reaction is one of the important factors to produce brown compounds. Highest colour and appearance score of 7.7 was awarded to 9.0 per cent sugar level followed by 7.2 for 7.0 % and 6.2 for 11.0% sugar level. Nine per cent sugar was superior in colour and appearance significantly (P≤0.05).

**Flavour:**

Flavour of Kunda is pleasant nutty flavour. Flavour compounds are produced during desiccations due to interactive effect of reducing sugars and proteins under suitable conditions. Kunda flavour score varied from 7.2 in 7.0 per cent sugar to 8.8 in 9.0 per cent sugar level (Table 11). The effect of different level sugar on flavour scores was significant (P≤0.05). Nine per cent in milk used for Kunda making resulted in optimum flavour production.

**Body and texture:**

Body and textural properties are influenced by the sugar levels in milk sweets. The lower or higher levels of sugar influence the texture and stickiness of sweets. The sugar level also affects the microbial growth and water activity.

Body and texture scores increased from 7.00 in 7.0% sugar level to 8.00 in 9.0% and decreased to 6.9 % in 11.0 % sugar level. The increased sugar levels significantly influenced the body and texture scores of Kunda (P≤0.05). Nine per cent sugar level was awarded higher body and texture scores followed by 7.0% and 11.0% sugar levels.
Overall acceptance:

Overall acceptance scores of Kunda were also in similar trend as with other sensory properties. The overall acceptance scores increased from 7.00 in 7.0 % sugar level to 8.80 in 9.0 % sugar, and then decreased to 7.1 in 11.0 % sugar level. The difference in overall acceptance scores was significant (P≤0.05). Higher overall acceptance scores were awarded to 9.0 % sugar levels compared to 7.0 % and 11. % Indicating that use of 9 % sugar in milk yielded optimum sensory properties of Kunda.

4.1.11 Characterization of standardized kunda

The physico-chemical composition and sensory characteristics of Kunda made by the standardized process are given in Table 12

4.1.12 Effect of extent of desiccation on development of total carbonyls and browning index vis-à-vis sensory characteristics of Kunda

Carbonyls are the flavour compounds produced during desiccations for manufacture of Kunda. The carbonyls are produced due to interaction of proteins, carbohydrates and fat during desiccations.

During Kunda manufacture, samples were drawn at the end of different desiccations and evaluated for total carbonyl content by steam distillation method. The results were expressed as optical density. Samples were also utilized for determination of other parameters like browning index, pH and sensory properties. The data obtained are presented in Table 13.

Total carbonyls:
Development of total carbonyls was significant ($P \leq 0.05$). The total carbonyls increased from 0.18 in the beginning of desiccations to 1.80 at end of 8 desiccations. Most of the treatments differed significantly ($P \leq 0.05$) with each other. The carbonyls production increased significantly after 0, 2, 4, 6 and 8 desiccations, with total carbonyls of 0.18, 0.58, 0.88, 0.140 and 1.80 respectively as the extent of desiccations progressed (Table 13).

**pH:**

pH is also a parameter determined to know the interactions of various compounds and their effects. pH decreased from 6.43 in T-1 to 6.01 in T-5 treatment. The decrease was significant ($P \leq 0.05$). It was observed that pH decreased with the increase in desiccations (Table 13).

**Browning index:**

The production of brown pigments is influenced by many factors like pH, moisture percent, water activity, temperature, duration, reactants types and their concentration. Determination of browning index reflects the concentration of brown pigments. Brown pigments were determined at 280 nm as a function of optical density. The browning index increased from 0.26 to 0.37 at the end of eight desiccations. The production of brown pigment was significant as the desiccations increased ($P \leq 0.05$). The significant increase in browning index was observed after 4 desiccations and then increased up to 8 desiccations (Table 13).

**Sensory characteristics:**
Sensory evaluation is the objective analysis of the acceptable quality of food products. Sensory evaluation of Kunda was conducted on 9-point hedonic scale indicating the preferential acceptance for sensory parameters such as colour and appearance, flavour, body and Texture and overall acceptances.

**Colour and appearance:**

Colour and appearance scores increased from 5.00 in T-1 to 7.7 in T-5 treatments (8 desiccations). The scores significantly increased (P≤0.05) as the desiccations progressed (Table 13) however; the increase in colour and appearance scores was not significant up to 4 desiccations.

**Flavour:**

Kunda has a typical nutty flavour developed during heat desiccation for long time at high temperature under desirable conditions. Effect of desiccations on development of flavour in Kunda was significant (P≤0.05). Kunda flavour scores increased from 5.60 at initial desiccations to 7.80 at the end of 8 desiccations. The difference in flavour scores was not significant up to 4 desiccations. However, the flavor scores increased significantly after 6 desiccations (p <0.05).

**Body and texture:**

Body and texture scores increased significantly (P≤0.05) from 5.8 to 7.63 (Table 13). Body and texture scores were not significant (P≥0.05) from 2 to 4 desiccations.
Overall acceptance:

Overall acceptance scores of Kunda ranged from 5.50 to 7.70 (Table13). The increase in overall acceptance score was significant (P≤0.05). However, the acceptable range scores were awarded only after 6\textsuperscript{th} desiccation. So, it can be inferred that the acceptable quality Kunda can be produced after 6\textsuperscript{th} desiccation with desirable flavour and colour. The difference between the treatments was significant (P≤0.05) in all treatments indicating that there was significant effect of desiccations on “overall acceptance” scores.

4.2 PROCESS UP-GRADATION

4.2.1 Effect of different caramelized sugar levels on processing time and sensory properties of Kunda

Kunda manufacturing requires prolonged desiccation at high temperature. Lot of heat energy is consumed in the process. In view of this, an experiment was conducted to study the energy savings during Kunda manufacture. Addition of caramelized sugar solution for early browning in Kunda was planned. Sugar was caramelized at three levels i.e. 30%, 40% and 50% of total sugar to be added to Kunda (9.0%). Caramelised sugar at these levels was added in the form of a solution at the beginning of desiccations (at Khoa stage). Kunda was prepared according to standardized method in section 3.2.2.5. The following parameters were determined and the data is presented in Table 14

Processing time:

Processing time required to Kunda making ranged from 68 min in control (T-1) to 30 min in T-4 (50% caramel). The processing time required was significantly reduced (P≤0.05) from 68 min in control to 30 min in 50% caramelized sugar added treatment
Processing time decreased as the per cent of caramelized sugar addition increased (Table 14).

Processing time reduced due to reduction in no. of desiccations employed. Processing time in 30% caramelised sugar solution addition was 40 min, for 40% caramelized sugar it was 35 min and for 50% caramel sugar addition it was 30 min. It was observed that the decrease in processing time was statistically significant (P ≤0.05).

Moisture:

High moisture % leads to early spoilage and low moisture causes hard textured products. Moisture % maintenance at the end of the manufacturing is most important for Kunda characteristics.

Moisture per cent ranged from 19.10% in T-2 to 19.60% in T-3; followed by 19.20% in T-1 and 19.50% in T-4. 40 % caramelized sugar added Kunda was containing more moisture (19.6%) than other treatments. The critical difference was significant (P ≤0.05).

Sensory characteristics

Colour and appearance:

Kunda manufactured after addition of 30%, 40% and 50% caramelized sugar was evaluated for sensory properties on 9- point hedonic scale by a panel of experienced judges (Table 14).
Colour and appearance scores ranged from lowest scores of 7.20 in 50% caramel sugar added Kunda to highest score of 8.20 in 40% caramel sugar added product. A score of 7.80 was awarded to 30% caramel added Kunda and 8.00 for control Kunda. Addition of different levels of sugar caramel solution significantly influenced the colour and appearance scores. The critical difference between the treatments was significant (P≤0.05).

**Flavour:**

Flavour compounds are produced during desiccation of Kunda at high temperature. Flavour compounds production increases with increased desiccation. Kunda flavour produced during the experiment was significant with the addition of caramel sugar solution. Maximum flavour scores was awarded to 40% caramel sugar addition (8.5); followed by 8.30 to control, 7.30 to 30% caramel and 6.5 in 50% camel sugar containing product. 40% caramel sugar product flavour score was on par with control.

**Body and texture:**

Body and texture of Kunda depends upon the composition of milk and heat treatment during Khoa making. Body and texture score was 8.30 in control; 7.40 in 30 % caramel product; 8.50 in 40% caramel product and 7.30 in 50% caramel sugar added Kunda. Addition of caramel sugar solution had significantly reduced no. of desiccations (P≤0.05). Highest body and texture score was awarded to 40% caramel sugar solution added Kunda. Body and texture scores of 40% caramel sugar product and control were almost same. However, 40% sugar solution added Kunda significantly differed with other levels of caramel sugar solution addition.
Overall appearance:

Overall acceptance scores ranged from 7.10 in 50% caramel sugar solution addition, 7.40 in 30% caramel, 8.20 in control and 8.50 in 40% caramel sugar solution addition. Forty per cent caramel sugar added Kunda critically differed ($P \leq 0.05$) with an overall acceptance score of 8.5 than other treatments. It was almost equal to control (8.2).

4.2.2 Effect of caramelized sugar (40%) on steam utilization and energy consumption during Kunda manufacture

Kunda manufacturing requires large amount of steam or fuel for prolonged heat desiccation. Desiccation for long time is required for development of brown colour and typical flavour. Addition of caramelized solution reduces the heat desiccation requirement. Quantity of steam utilized during manufacture of Kunda was estimated. The steam utilized during Kunda making in Khoa kettle is equal to the quantity of condensate collected.

The quantity of condensate released from the Khoa kettle was collected in a vessel and immediately temperature and quantity was recorded. The quantity of condensate released in each stage of Kunda manufacture has also been recorded. Results are presented in Table 15.

Quantity of condensate:

The quantity of condensate collected from T-1 and T-2 has been recorded at each stage. Quantity of condensate collected (steam utilized) in Khoa making stage in T-1 was 1.228 kg and in T-2 it was 1.230 kg. The quantity of condensate collected in each stage in T-1 for Kunda making and T-2 is presented in Table 15. Eight desiccations were required
in T-1 for Kunda making and four desiccations in T-2. The overall quantity of condensate collected was 3.761 kg in T-1 and 2.750 kg in T-2. The difference (1.011 kg) in steam utilization was significant (P≤0.05).

**Energy consumption:**

The difference in heat energy utilization between T-1 and T-2 was significant (P≤0.05). The heat energy requirement for Kunda manufacturing has been computed. Data are presented in Table 16. The net heat energy consumption (kJ) has been estimated as 8262.61 kJ in T-1 and 6038.99 kJ in T-2. The difference in net heat energy utilization is significant (P≤0.05). The per cent of steam utilization was 73.09. There was 26.91 % saving is net energy utilization (Table 16)

### 4.2.3 Effect of addition of caramelized sugar (40%) during processing on processing time and physico-chemical properties of Kunda

**Number of desiccations:**

There was a marked difference in number of desiccations required for Kunda manufacturing with and without added caramelized sugar. Eight desiccations were required for T-1 and only four desiccations in T-2. Number of desiccations required was reduced by half by addition of caramelized sugar solution (Table 17)

**Processing time:**

Kunda manufacturing requires prolonged heat desiccation for development of desirable attributes like brown colour and nutty pleasant flavour. Time requirement for T-1 was 68 min and for T-2 was 44.0 min. The difference in time requirement between two treatments was significant (P<0.05).
Physico-chemical properties

Moisture:

Addition of caramelized sugar solution (40%) has affected the quality attributes of Kunda. However moisture per cent significantly differed (P≤0.05) with 19.81 % in T-1 and 20.20 % in caramelized solution added Kunda. The moisture content of Kunda depends upon the extent of desiccation at the end of manufacturing.

Acidity:

Acidity of Kunda is higher than acidity of milk from which it is made. The acidity is produced during manufacturing due to break down of fat, protein and lactose as well as their inter actions. Acidity in T-1 was 0.47 % lactic acid and in T-2 was 0.53 %. The difference in production of acidity between control and caramelized was not significant.

Yield:

Yield is the ultimate economic product of any food production operation. Yield of Kunda in control (T-1) was 298 gm/lit and in caramelized sugar solution added (T-2) was 295.0 gm/lit. The difference between two treatments in yield was not significant (P≥0.05). As the ingredients and processing conditions were similar; only the desiccations required differed. The yield of Kunda has not been affected with the addition of caramelized sugar solution.

4.2.4 Effect of addition of caramelized sugar (40%) during processing on sensory characteristics of Kunda

Addition of caramelized sugar solution (40%) has reduced the desiccations from “8” to “4” during processing of Kunda. Kunda obtained after ‘8” desiccation (T-1) and 4
desiccations (T-2) were evaluated for sensory properties on a 9 point hedonic scale by experienced panel of judges. Sensory scores are presented in Table 18.

**Colour and appearance:**

Colour and appearance in Kunda depends on production of browning compounds. There are three main mechanisms by which non-enzymic browning can be produced in food products. (i) Ascorbic acid oxidation, (ii) Maillard reaction and (iii) caramelization of sugars.

Addition of caramelized sugar solution can produce brown colour at early stage of desiccation. Colour and appearance scores were significantly different (P≤0.05) between T-1 and T-2. Colour and appearance scores in control Kunda was 7.17 and in caramel added Kunda it was 7.70. More browning and glassy appearance of caramel solution has influenced appearance in T-2 than T-1.

**Flavour:**

Flavour in Kunda is developed both due to Maillard reaction and addition of caramelized solution. Flavour score in control (T-1) was 7.60 and in caramel added Kunda it was 7.73 (T-2). The difference between two treatments in production of flavour compounds was not significant (P ≥ 0.05), though T-2 was desiccated for only 4 desiccations.

**Body and texture:**

Body and texture of Kunda depends upon the extent of heating specifically during Khoa making. The extent of heating in T-1 was 8 desiccations; and in T-2 it was 4
desiccations. Even though the number of desiccations in T-2 was only 4; the difference in body and texture scores of Kunda was not significant (P≥0.05). Khoa making was common for both T-1 and T-2. Texture of Kunda was influenced by development of grainy texture in product particularly at Khoa making stage. Khoa making is common for both T-1 and T-2. There were no textural changes between them. Body and texture in T-1 is 7.53 and in T-2 it was 7.43.

**Overall acceptance:**

Overall acceptance represents the integrated quality of food product. Overall acceptance scores of T-1 was 7.13 and in T-2 it was 7.73. As colour and appearance was more influencing factor; the overall acceptance scores were also in similar trend as colour and appearance. The difference was significant (P≤0.05) between T-1 and T-2. T-2 scores more overall acceptance score due to brightness and shining and browner colour of caramel solution.

**4.2.5 Effect of additives on yield and physico-chemical properties of Kunda**

Kunda manufacturing requires more energy for prolonged heat desiccation. Heat energy is required for evaporation of water during desiccations. Dilution and desiccations are necessarily required to maintain the required moisture per cent to facilitate Maillard reaction. During Maillard reactions, brown colour pigments are produced. Additives change the pH, so browning is expected to increased.

In view of the above facts, an experiment on effect of addition of disodium phosphate (DSP) and tri-sodium citrate (TSC) to milk during Kunda manufacturing was carried out to reduce the processing time. The effect of addition of DSP and TSC at two
levels (0.05 % and 0.10%) on yield, water activity, browning index, pH and moisture was studied. Data are presented in Table 19.

**Yield:**

Yield of Kunda in gm/lit has been presented in Table 19. The yield ranged from 270gm/lit to 280 gm/lit. There was only a narrow difference up to 10 gm amongst the various treatments applied. Increase in yield between the treatments was not significant (P≥0.05) in all paired comparison of treatments.

**Physico-chemical properties**

**Water Activity:**

Water activity ranged from 0.89 to 0.91. The water activity of control Kunda was 0.89. Water activity increased as per cent of additives increased. The increase was, however, not statistically significant (P≥0.05). Earlier, it indicates that addition of disodium phosphate and tri-sodium citrate at 0.05 per cent and 0.10 per cent did not have any influence on water activity. It was observed in our preliminary trials that more than 0.10 per cent tri-sodium citrate and disodium phosphate addition resulted in pasty texture of Kunda.

**Browning**

Browning index varied from 0.19 in control sample to 0.20 in 0.10 per cent TSC Kunda. It was also observed that there is no statistically significant difference among the treatments other than control, (Table 19).

**pH:**
pH of Kunda has not changed with addition of DSP and TSC at 0.05 per cent and 0.10 per cent levels. pH of samples varied from 5.95 to 6.05. This difference was statistically not significant (P≥0.05) indicating that the additives made no difference to the pH of final product.

Moisture:

Moisture per cent presented in Table 19 ranged from 19.30 in control (T-1) sample to 19.80 in 0.10 per cent DSP (T-5) sample. Though the moisture content was more at higher levels of additives (0.10 per cent), it was not statistically significant (P≥0.05).

4.2.6 Effect of additives on sensory characteristics of Kunda:

Colour and appearance:

As per cent of addition of DSP and TSC increased the colour and appearance score decreased, but the decrease was not significant (P≥0.05). None of the paired combination of treatments differed significantly. In preliminary studies, it was observed that product turned pasty when the per cent of additives used was > 0.10 per cent (Table 20)

Flavour:

The taste of Kunda is sweet with pleasant nutty flavour. The flavour increases with production of flavour compounds during heat desiccation. Flavour scores of Kunda
decreased significantly as the per cent of additives DSP and (TSC) increased. Flavour scores decreased from 8.0 in control Kunda to 7.1 in 0.10 per cent of TSC.

Addition of DSP at 0.05 per cent and 0.10 per cent levels resulted in decreased flavour scores, but this decrease was not significant (P≥0.05) indicating that use of DSP up to 0.10 per cent level has no influence on flavour quality of Kunda. Results also indicated that use of TSC at 0.05 per cent levels did not have any influence on the flavour of Kunda (P≥0.05). TSC at 0.10 per cent level significantly (P≤0.05) reduced flavour acceptance.

**Body and texture:**

In preliminary studies, it was observed that TSC and DSP addition during Kunda processing affected the body and texture. So the addition was restricted to 0.10 per cent or less so that the acceptable quality Kunda could be manufactured.

Body and texture scores decreased from 8.0 in control to 6.0 in T-4 and T-5 (Table 20). The decrease in body and texture scores was statistically significant (P≤0.05). However, addition of DSP at 0.05 per cent level significantly reduced the body and texture scores. There was no significant difference in body and texture scores between DSP and TSC added at 0.10 per cent levels. TSC has reduced body and texture scores significantly than DSP.

**Overall acceptance:**

The overall acceptance scores decreased from 7.9 in control Kunda to 6.5 in 0.10 per cent TSC and DSP addition. The decrease was significant (P≤0.05). However, at 0.05
per cent level there was no statistical difference indicating that 0.05 per cent addition of these additives did not have any adverse influence on quality of Kunda.

4.2.7 Effect of homogenization of milk on yield and physico-chemical properties of Kunda

Milk is homogenized for the purpose of splitting of large sized fat globules to uniform globule size to obtain beneficial attributes in certain products.

Kunda wasprepared using the milk treated as in section 3.2.2.3 and evaluated for physico-chemical as well sensory properties. The results of physico-chemical properties are presented in Tables 21 and Table 23. These were analysed in three way (2X3X2) factorial design and the statistical means are presented in Table 25.

Yield:

The yield of Kunda increased when Kunda was prepared from high pressure homogenized raw milk and skim milk. The highest yield (284.gm) was obtained in Kunda prepared from high pressure homogenized milk, followed by low pressure homogenized milk (279gm) and control (270gm). The yield has decreased significantly (P<0.05) as the homogenization pressure decreased (Table 25).

Yield of Kunda significantly increased when milk was homogenized without presence of fat (SM) (279.83 gm) compared to homogenization of raw milk (275.33gm) (Table 25). Yield of Kunda also significantly increased when milk was homogenized in the absence of sugar (278.28gm) as compared to 277 gm obtained by homogenization of milk in presence of sugar. The yield of Kunda was significantly higher when milk was homogenized at higher pressure with or without milk fat (P<0.05). The interactions
between type of milk, homogenization pressure and addition of sugar during homogenization do not have any significant influence on yield of Kunda (P≥0.05).

4.2.7.2 Physico-chemical properties

**Moisture**: The homogenized milk Kunda was having more moisture compared to control Kunda. The moisture percent varied from 20.67% to in low pressure homogenized skim milk Kunda (2:1:1) to 19.30 % in control Kunda (1:3:1).

Variation in moisture % in Kunda was significant with respect to type of milk, homogenization pressures, and addition of sugar during homogenization of milk. The use of skim milk added with cream later was found to result in more moisture per cent (20.62%) compared to use of homogenized milk. Higher homogenization pressure resulted in more moisture (21.19%) followed by low pressure (20.00%) homogenization and control Kunda sample. More moisture per cent was also found in Kunda sample homogenized without addition of sugar (20.59%). The interaction between milk types, homogenization pressures and addition of sugar during homogenization was found to be significant (P≤0.05) (Table 25).

**Water activity**:  

Highest water activity of 0.93 was observed in skim milk homogenized at high pressure (140 kg/sq.m) and lowest aw (0.88) was found in low-pressure homogenized raw milk Kunda. However, effect of homogenization pressure was not significant (P≥0.05) on water activity. Kunda prepared from homogenization of milk without addition of sugar was having more water activity (0.90) compared to milk homogenized with sugar (0.88). The interactions between types of milk; homogenization pressure and sugar additions were significant (P≤0.05) in increasing water activity of Kunda (Table 25).

**Browning index**: 
When Kunda was prepared from homogenized milk both at low pressure and high pressures, the desirable brown colour did not develop even after “8” desiccations. Kunda was light green in colour while control Kunda was optimum brown in colour.

Kunda was analysed for its browning index (as optical density of brown pigments) spectrometrically. The browning index results were not significant due to any of the treatments, such as type of milk used for homogenization, homogenisation pressures used as well as addition of sugar. The browning index values were found to be more in high pressure homogenized Kunda as compared to low pressure homogenized Kunda. Highest browning Index was observed in control Kunda (1:3:1) (Tables 21, 23 and 25).

**pH:**

pH of Kunda is similar to pH of Khoa. pH of Kunda varied from 6.45 in control Kunda (Table 21) to lowest of 6.00 in skim milk high pressure homogenized Kunda (Table 22). The decrease in pH of Kunda was not significant (P≥ 0.05) with respect to type of milk used for homogenization pressure. Kunda prepared without addition of sugar was found to have higher pH (6.43) compared to that obtained from milk homogenized with sugar (Table 25). The interactions between types of milk used for homogenization, homogenization pressure used as well as their 3 way interactions were not significant in decreasing the pH.

**4.2.8 Effect of homogenization of milk on sensory characteristics of Kunda**

Homogenization increases the whiteness in milk and milk products. Homogenization of milk for manufacture of Kunda adversely affected Kunda
characteristics. There was little brown colour formation in Kunda prepared from homogenized milk (Plate 1). The texture as well as overall acceptance attributes was severely affected. There was no Maillard reaction products formation even after 8 desiccations. Sensory characteristics were evaluated on 9-poit hedonic scale with typical characteristics produced by control Kunda. The results relating to sensory characteristics are presented in Tables 22 and 24. The data were analysed by three way factorial design and the statistical means are presented in Table 26.

**Colour and appearance:**

Colour and appearance scores of homogenized milk Kunda were quite low. Colour and appearance of homogenized milk Kunda were low compared to control milk Kunda irrespective of homogenization with or without fat and sugar. Highest colour and appearance scores of 7.80 was awarded to control milk Kunda. (Table 25) Colour and appearance scores were below the acceptance limits in most of homogenized milk Kunda samples. The effect of homogenization was significant (P≤0.05) with respect to type of milk, homogenization pressures and sugar addition during homogenization of milk. Lowest scores for type of milk was awarded to raw homogenized milk (5.88) Kunda compared to homogenized skim milk Kunda (6.22). The maximum colour and appearance scores (7.80) was awarded to control Kunda, followed by low pressure homogenized Kunda (5.36) and high pressure (4.99). There was a significant difference between pairs of homogenization pressure. Addition of sugar also significantly affected the colour and appearance scores. Higher colour and appearance score (6.14) was awarded to Kunda prepared from homogenized milk without addition of sugar whereas the product prepared from milk homogenized in presence of sugar was awarded 5.97.
However, the interactions between type of milk and addition of sugar were not significant on colour and appearance scores. The 3-way interaction was also not significant (Table 26).

**Flavour:**

Flavour of Kunda was adversely affected by homogenization of milk. Kunda made from homogenized milk was as sweet as control Kunda. The flavour scores ranged from 8.03 (control) to 5.13 awarded to high-pressure homogenized raw milk Kunda (Table 22).

Flavour scores between type of milk; homogenized pressures and addition of sugars and their interactions were significantly different. Raw milk homogenized Kunda was awarded less flavour score (6.22) compared to skim milk homogenized Kunda (6.89). Lowest flavour scores were awarded to high-pressure homogenized milk Kunda (5.99), followed by low pressure homogenized milk Kunda (6.28) and control Kunda (8.00). Control Kunda significantly scored higher flavour scores compared to homogenized milk Kunda. Addition of sugar during homogenization of milk significantly reduced the flavour scores (P≤0.05). Type of milk, homogenization pressures and addition of sugar during homogenization and their interactions were significant in reducing flavour scores.(Table 26).

**Body and texture:**

Body and texture scores of Kunda were adversely affected by homogenization of milk. The texture of Kunda was powdery compared to grainy in control Kunda. The body and texture scores reduced from 8.03 in control Kunda to 5.17 in raw milk homogenized
Kunda. There was significant difference in reducing body and texture scores of Kunda between type of milk and homogenization pressures (P≤0.05). However, there was no significant effect on reducing body and texture scores of Kunda due to addition of sugar; and interactions between type of milk, homogenization pressures and addition of sugar during homogenization (Table 26).

Among the type of milk, higher scores were awarded (6.79) to skim milk compared to whole raw milk (6.15). Among the homogenization pressures, low-pressure homogenization Kunda was awarded highest body and texture scores (6.07) followed by high pressure homogenized product (5.82).

**Overall acceptance:**

Overall acceptance scores were in similar trend. Overall acceptance scores decreased from 8.03 in control Kunda to 5.20 in high pressure homogenized sugar added Kunda. Kunda obtained from homogenized milk was chalky in texture and had powdery appearance without typical brown colour and nutty flavour. There was no significant interactive effect of type of milk; homogenization pressures and addition of sugar on overall acceptance scores. The sensory attributes were below the acceptance limit of 5.4 in some of Kunda samples.

**4.3 SHELF-LIFE STUDIES**

**4.3.1 Effect of preservatives on physico-chemical and microbiological characteristics of Kunda during storage**

**4.3.1.1 Physico-chemical characteristics:** Food additives that are added specifically to prevent the deterioration or decomposition of food product have been referred as
chemical preservatives. Preservatives may inhibit microorganisms by interfering with their cell membranes, their enzyme activity or their genetic mechanism and metabolic activity.

Preservatives are used to prevent the growth of bacteria and fungi. The most important fungicides are sorbates and nisin. These preservatives were added at the permitted levels (2000 ppm) to Kunda at the end of eighth desiccation and hot packaging was made in LDPE pouches. The sealed samples was cooled to room temperature and stored at two temperatures, 30° and 5°C. The samples were analyzed at regular intervals for moisture per cent, water activity, bacterial counts (SPC/gm), yeasts and moulds counts and coliform counts. The results of physico-chemical changes are presented in Tables 27 and 29.

Moisture:

Moisture is an important variable that affects the quality of the stored food product. It also enhances the deterioration due to microbial growth or enzymatic reactions. It was observed that there was decrease in moisture content of Kunda during storage irrespective of temperature. Storage temperature was found to have significant effect on moisture loss ($P \leq 0.05$) (Table 31). Moisture per cent of Kunda stored decreased from an initial value of 20.02 per cent to lowest value of 17.90 per cent after 42 days of storage at 30 °C irrespective of preservative used (Table 27), and to 18.0 per cent at 5°C (Table 29). There was significant ($P \leq 0.05$) decrease in moisture content from fresh Kunda samples to stored Kunda samples both at 30°C and at 5°C. Moisture content in Kunda samples stored with different preservatives decreased significantly ($P \leq 0.05$). The interactions between durations and preservatives as well as preservatives and temperatures had significant ($P \leq 0.05$) effect on decrease in moisture per cent in Kunda during storage (Table 31).except duration and temperature.
Water activity:

Water activity is also an important factor that influences the deterioration of food quality. Water activity influences both microbial spoilage and chemical reactions. Water activity of Kunda ranged from 0.89 in fresh Kunda to 0.750 in Kunda stored at 30°C for 42 days and, from 0.89 to 0.78 at 5°C. Water activity estimated means ranged from 0.84 to 0.81 for preservatives. Mean values of aw of Kunda for 30°C was 0.828 and for 5°C was 0.84 (Table 31). However, the water activity values were not significantly (P ≥ 0.05) affected both by temperatures. However, it was significantly affected (P ≤ 0.05) by both by durations and preservatives. (Table 31).

Acidity:

Acidity of Kunda expressed as lactic per cent was determined for various samples stored with different preservatives at 30°C and at 5°C for different durations. The acidity of fresh Kunda was 0.55 per cent. It increased to 0.81 per cent after storage at 30°C for 42 days in control sample (Table 27) and to 0.68 per cent after 90 days at 5°C. (Table 29). There was significant increase (P ≤ 0.05) in acidity (0.81 per cent) of Kunda stored at 30°C for 42 days compared with stored at 5°C for 90 days (0.61 per cent). However, preservative had no significant effect on increase in acidity (P ≥ 0.05) (Table 31). There was no significant increase in acidity as the duration increased.

Browning index:

Browning index of Kunda stored with different preservatives decreased from 0.380 in nisin added Kunda to 0.31 in control Kunda stored at 30°C for 42 days. The mean BI values of preservatives were 0.34, 0.35 and 0.34 in Pr-1, Pr-2 and Pr-3.
respectively. The mean BI values for duration of storage decreased significantly (P<0.05) from 0.366 in fresh samples to 0.303 in stored sample after end of storage. The mean BI values increased in sample stored at 5°C than at 30°C, however the same is not significant (P≥0.05). The BI values decreased significantly (P≤0.05) from 0.366 to 0.303 at the end of storage. There was no significant (P≥0.05) effect on BI of Kunda due to storage temperature and preservative. The interaction effects were not significant at less than D-5 duration (P≥0.05). However, it was significant after D-5 duration (P≤0.05). As duration increased, BI decreased significantly.

4.3.1.2 Microbiological characteristics:

Bacterial counts:

Bacterial counts (SPC/gm) indicate the bacterial load in stored food products. Kunda is an intermediate moisture food (IMF). It is a shelf-stable food product. It contains high per cent (30) of sugar which is a natural preservative. It increases the osmotic pressure in microbes. In general it was observed that there was a decrease in bacterial count during storage, however, in case of control sample, the bacterial load first decreased, then increased, then again further decreased as storage period progressed at 30°C. When potassium sorbate was used, there was an initial increase in SPC, but thereafter decreased. In case of nisin, there was a regular decrease in SPC of Kunda during storage (Table 27). The SPC was log10 4.38-cfu/g cfu/gm in the beginning and it decreased to 4.1 after 42 days in Kunda stored with nisin at 30°C (Table 27). SPC for Kunda stored with potassium sorbate at 5°C was 3.3log 10 cfu/g after 90 days (Table 29). The decrease was significant (P≤0.05) (Table 31). Nisin Kunda had lowest SPC.
compared to other preservatives. The decrease in SPC was also significant in Kunda stored at 5 °C due to interactions of durations, preservatives and temperature (Table 31).

**Yeast and Mould Counts (YMC):**

Yeast and moulds growth is common in food products containing high percent of sugar. These products are well suited for growth of Saccharolytic moulds and yeasts. Kunda is more susceptible to yeast and mould spoilage. The market samples which contain high moisture (> 20.0 per cent) coupled with unscientific packaging are most vulnerable for moulds and yeasts growth.

Yeasts and moulds counts decreased from 4.70-log10 cfu/gm in the beginning to lowest in samples stored with potassium sorbate at 30°C for 42 days. There was decrease in YMC after 15 days at 5°C irrespective of preservative (Table 29). There was significant decrease in YMC as the duration increased. The decrease in YMC was also significant (P≤0.05) when Kunda stored with different preservatives as well as at different temperatures (Table 31). The interactive effects of durations, preservatives and temperatures were statistically significant. The mean YMC values decreased from a mean of 4.70 log 10 cfu/ gm in the beginning to a mean of 3.50 log 10 cfu/gm after storage (Table31). YMC was highest in control samples (4.29 log 10 cfu/gm) and lowest in Kunda stored with potassium sorbate (4.05 log 10 cfu/gm). More YMC was observed in (4.22 log 10 cfu/gm) in Kunda stored at 30°C than at 5°C (4.12 log 10 cfu/gm).

**Coliform counts:**
There was no growth of coli form as the product was subjected to intense heat during manufacture (more than 100°C for prolonged period). Moreover, hot Kunda was packed with sterilized appliances.

4.3.2 Effect of preservatives on sensory characteristics of Kunda during storage

Sensory evaluation of Kunda was carried out on 9 point hedonic scale (Amerine et al 1965). Kunda was evaluated periodically for four attributes: 1) Colour and appearance, 2) Flavour 3) Body and texture and 4) Overall acceptance.

**Colour and appearance:**

Colour and appearance scores ranged from 7.85 to 6.0 (Table 28 and Table 30). Colour and appearance scores decreased significantly (P≤0.05) as the storage period advanced. The colour and appearance scores also decreased significantly between preservatives. However there was slight decrease in Kunda samples stored at 30 °C and 5 °C. All treatments and their interactions were significant (P≤0.05). The average scores for duration decreased from 7.70 in fresh Kunda to 6.0 after 42 days/ 30°C and 7.15 after for 90 days at 5°C. Lowest colour and appearance scores was awarded to control. Between temperatures, 30°C was awarded least scores (7.33). All the treatment pairs of duration were statistically significant (P≤0.05). There was significant difference between Kunda samples stored with Potassium sorbate and nisin (P<0.05) (Tables 32).

**Flavour:**

Flavour, which is the combination of smell and taste, is the prime attribute for acceptance or rejection of a food product. Kunda has typical nutty flavour developed during desiccations. Flavour scores of Kunda decreased from 7.85 in fresh sample to 5.8
in Kunda stored at 30°C after 42 days of storage (Table 28 and 30). The decrease in flavour scores was significant ($P \leq 0.05$) for durations, preservatives, and temperature treatments. The interactive effects between durations, preservatives, temperatures were also significant in decreasing flavour scores ($P \leq 0.05$).

The mean flavour scores for duration decreased from 7.86 to 7.05 as the duration increased. Amongst the preservatives control sample scored lowest (7.42) flavour scores. Between the temperatures; 30°C storage had lowest scores (7.47) compared to 5°C (7.56).

The decrease in flavour scores for duration was significant between the pairs of all samples ($P \leq 0.05$). Amongst the preservatives there was significant ($P < 0.05$) difference between control and treated samples but (potassium sorbate and nisin) (Table 32).

**Body and texture:**

Body and texture is the sensory attribute affecting food acceptance after flavour. Texture is the sensory and functional manifestation of the structural and mechanical properties of foods, detected through the sense of vision, hearing, touch and kinesthetic.

Kunda has unique texture with grains. It is desirable characteristics in Kunda; developed during desiccations. Body and texture reflects the structure and texture attributes arranged in the product. Body and texture characteristics not only depend on grains but also on other properties like gumminess, chewiness, stickiness affected by
various parameters. Body and texture scores of Kunda decrease from 7.83 in fresh Kunda to 5.9 in Kunda stored at 30°C for 42 days. Flavour scores were significantly decreased as the duration increased. The flavour scores were also significantly decreased in samples stored with different preservatives at different temperatures (P≤0.05).

The interactions between durations, preservatives and temperatures were also significant (P≤0.05) in decreasing flavour scores. The mean flavour scores for duration decreased from 7.8 in fresh samples to 6.90 after storage for 42 days/30°C and 90 days/5°C. The computed means flavour scores for preservatives decreased with lowest score being 7.32 in control sample. The low computed means score of 7.26 for temperatures awarded to samples stored at 30°C. All the paired means treatments were significantly differed (P≤0.05).

Overall acceptance:

The overall acceptance scores of Kunda decreased from 7.80 in fresh samples to 5.90 in Kunda stored for 42 days at 30°C (Table 28). Overall acceptance scores of Kunda samples stored at 30°C and 5°C are presented in Table 28 and Table 30, respectively. The decrease in overall acceptance scores was statistically significant (P≤0.05) for durations, preservatives and temperatures. The overall acceptance scores were also significant (P≤0.05) for interaction effect of durations, preservatives and temperatures (Table 32).

The computed overall acceptance scores decreased from 7.80 in fresh samples to 5.9 in Kunda stored after 42 days/30°C and 7.290 days/5°C. Lowest overall acceptance scores were also awarded to control Kunda samples compared to
preservatives treated Kunda samples. However no significant difference (P≥0.05) between preservatives treated Kunda samples was observed. The computed overall acceptance scores for durations were significant (P≤0.05). All interactions were statistically significant (P<0.05).

### 4.3.3 Effect of packaging materials on physico-chemical and microbiological characteristics of Kunda during storage

Packaging forms an integral part of food production, marketing and distribution. Development of suitable packaging system is essential for modernization of traditional dairy products processing. Four most important functions of packaging are: (i) Protection (ii) Presentation (iii) Consumers friendly and (iv) Effect on environment.

Traditional dairy products mostly are produced under unhygienic conditions. Kunda is packaged in loose polythene bags. Most contaminations in market Kunda are due to post-manufacture contamination. No proper packaging materials have been developed. Hence, a study was undertaken to select the suitable packaging materials for stability of Kunda during storage and distribution.

**Physico-chemical properties:** Kunda as it is manufactured by halwais from high moisture Khoa is more easily susceptible to growth of moulds due to high moisture and sugar content. Kunda shelf-life studies were carried out to evaluate the product contamination with, bacteria, moulds and yeasts; as well as coli form contamination during storage.

**Moisture:**
Moisture per cent is the important factor which affects the stability of Kunda. 20 per cent moisture has been standardized in our earlier experiment. Moisture per cent ranging from 18-20% is most suitable for Kunda. Moisture more than 20.0% is susceptible for molds growth. Moisture per cent less than 18.0 per cent affects the products texture.

The moisture per cent in Kunda decreased from 20.0 per cent in fresh Kunda sample to 18.0 per cent in Kunda stored at 30 °C for 42 days in LDPE (P-1) packaging. The decrease in temperature was significant (P≤0.05). Lowest moisture per cent (19.15) was observed in P-1; followed by P-2 (metalised polyester) and P-3 (aluminium cans). The difference in moisture per cent between these three packaging were significant (P≤0.05) (Table 33 and 35).

There was also a difference in moisture content of Kunda samples stored at 30°C (18.99 %) to 5 °C (19.50%) storage. Similarly the moisture per cent decreased from 20.0 per cent in fresh Kunda to 18.50 in Kunda stored for 90 days at 5°C. The decrease in moisture per cent was progressively found significant (P≤0.05) when different multiple comparisons of duration was made there was also significant decrease in moisture per cent due to interactions of packaging and temperature, packaging and durations as well as temperature and duration. However the 3-way interactions of packaging, temperature and duration was not significant (P≥0.05) in reduction in moisture per cent in Kunda (Table 37).

**Water activity:**
Water activity is an important factor influencing food product stability. The growth of microorganisms is specific to their water activity requirements. The intermediate moisture foods (IMF) like Kunda have the water activity ranging from 0.90 to 0.080 which is suitable for growth of yeasts and moulds.

Water activity of Kunda decreased from 0.810 to 0.750 at 30°C after 28 days storage. The decrease in moisture per cent was significant (P≥0.05). With water activity from 0.798 in P-1 packaging to 0.799 in P-2 followed by 0.789 in P-3. The decrease was significant (P≤0.05). There was significant difference between 30°C and 5°C storage temperature with lower water activity of 0.788 observed in 30°C. The water activity decreased significantly (P≤0.05) as the duration increased from (0.810) in fresh Kunda to 0.770 in Kunda at the end storage period. However there was no significant decrease in water activity of Kunda samples stored for varying durations. The interaction between packaging, temperature and duration was not significant (P>0.05). The water activity is independent of interactive effect of these parameters either in 2 way comparison as well as 3-way comparisons (Table 33, 35 and 37).

**Acidity:**

Acidity increase is the indication of deteriorative quality of any milk and milk products. Acidity of Kunda also increases as the storage period increases. Acidity of Kunda is similar to acidity of Khoa. The acidity increase with increase in temperature and duration.

The acidity of Kunda increased from 0.405 per cent lactic acid in fresh Kunda to 0.676 in Kunda stored at 30 °C for 42 days. The increase in acidity is statistically
significant. The lowest acidity (0.50% LA) was observed in P-3 Package, followed by P-2 (metalised polyester) and P-1. The increase in acidity between the packagings was significant (P≤0.05). There was significant difference between the two temperatures of storage. Lowest acidity (0.48 per cent) was found in 5°C storage temperature compared to 30°C. The mean acidity per cent increased from 0.412 per cent in fresh Kunda sample to 0.60 per cent at end of the storage period. The duration of storage was also significant in increase in acidity of Kunda.

There was significant (P≤0.05) interactions between packaging and temperature; packaging and duration; temperature and duration in increase in acidity of Kunda. The 3-way interaction was also significant in increase in acidity of Kunda.

**Browning Index**: Browning Index of kunda stored in different packaging materials (Table 31) ranged from 0.37 to 0.31. The browning index decreased as the storage durations increased. The decrease in browning index was also observed in kunda stored at 30°C and 5°C. The decrease in browning index was not significant between different packaging materials (P>0.05) and different temperatures. However there was significant difference between the different storage durations.

The browning Index decreased from 0.37 in fresh samples to 0.32 at the end of the storage period. There was significant (P<0.05) differences between packaging materials and durations, temperature and duration. It was only due to effect of durations. The fading of colour of kunda stored both at 30°C and 5°C, was due to drying of kunda. It may be due to reduction of Melonoidin (Namiki 1988).
Browning in other heat-treated dairy products like khoa-based sweets i.e.; peda, Burfi, kalakand and Gulab jamun is compared to Kunda. Only 5 HMF is produced in these products, as it is in the early stage of Maillard reactions where as in Kunda, browning is in advanced stage. The temperature treatment in Kunda is in the range of .100 c to 140 C for about 30 to 45 min. Hence no reactants (proteins-sugars 0 are available for further increase in maillard reactions. So that the browning index in stored kunda decreased as duration increased. It may be due to reduction of brown compounds (Melonoidins). HMF is estimated in UHT milk, which is the indication of browning and not end products of MRP.

4.3.3.2 Microbiological characteristics:

Bacterial counts (SPC):

The SPC counts decreased from 4.37 log 10 cfu/gm in fresh Kunda sample to 3.71 log 10 cfu/gm in Kunda stored at 30°C for 42 days. Similarly SPC was also decreased from 4.37 log 10 cfu/gm in fresh sample stored at 5°C to 3.73 log 10 cfu/gm in Kunda stored in P-2. The decreasing trend was also observed in both the temperatures. The mean SPC (cfu/gm) for P-1 was 4.24log 10 cfu/gm in P-1; 4.20 in P-2 and 4.15 log l0 cfu/gm in P-3 packaging. The mean SPC was lowest in 5°C storage 4.10 log/10 cfu/gm compared to 4.29 in Kunda stored at 30°C. The SPC was also decreased as the storage duration increased. It was 4.36 log 10 cfu/gm in fresh samples which decreased to 3.96log 10 cfu/gm at end of storage.

Yeasts and moulds counts (YMC):

Yeasts and moulds counts decreased from 4.60 log 10 /cfu/gm in fresh samples to 3.05 log 10 cfu/gm in Kunda stored at 5°C after 90 days. The decrease in YMC was significant (P≤0.05) with respect to packaging materials, storage temperatures and storage durations as well as their inter actions. The Yeasts and Moulds counts were more in P-1 compared to P-2 and then P-3. The highest YMC (4.32) was found in Kunda stored
at 30°C compared to 3.92 log 10 cfu/gm in Kunda stored at 5°C. YMC decreased from 4.43 log 10 in fresh Kunda samples to 3.80 log 10 cfu/gm in Kunda at the end of storage period (Table 37).

**Coli form counts:**

Coliform counts which is the indication of contamination of food products is after manufacturing /during manufacturing. Kunda is a high heat treated product where it will be heated 120° to 140°C for more than 30 to 50 min. Kunda was packaged in sterilized packaging materials with warm packaging. No other equipment was used during packaging except the stirrer used for Kunda manufacture which was very much sterilized. Hence, there was no chance of any coli form contamination either through packaging materials or through some other means. So, there was no coli form count found in any Kunda sample during storage.

**4.3.4 Effect of packaging materials on sensory characteristics of Kunda during storage**

Sensory characteristics of food products are changed during preservation. The changes are affected by many factors such as (i) food composition, (ii) food packaging materials and (iii) storage conditions. These changes are affected by the packaging used for storage. Sensory evaluation is one of the important method to judge the quality of food, in addition to physico-chemical as well as microbiological quality. Based on the sensory evaluation food can be accepted or rejected.
Sensory quality of Kunda packaged in different packages and stored at 30°C and at 5°C undergone changes. The changes have been evaluated on 9-point hedonic scale as mark of quality. Results are presented in Table 34, 36 and 38.

**Colour and appearance:**

Colour of Kunda is brown, which is a typical desirable characteristic. The colour and appearance score decreased significantly \((P \leq 0.05)\). Colour and appearance score in fresh Kunda sample was 8.5 and it decreased to 6.50 after 42 days of storage at 30°C in P-1 package. Similar decreasing trend was also observed in other packaging (P-2 and P-3) at 30°C storage as well as at 5°C. The highest colour and appearance score (7.69) was awarded to P-2 followed by P-3 and P-1, respectively (6.43 and 6.33).

The highest colour and appearance score (7.68) was awarded to 30°C followed by 5°C (7.63). Colour and appearance scores decreased from 8.09 in fresh Kunda samples to 7.11 at the end of storage period. The decrease was significant \((P \leq 0.05)\) between different durations. The interactions were also significant \((P \leq 0.05)\) Data is presented in Tables 34, 36 and 38.

**Flavour:**

The flavour of Kunda has typical “pleasant nutty flavour” produced during desiccations. The flavour deteriorated during storage. Flavour scores decreased from 8.5 in fresh Kunda samples to 6.10 in P-3 package stored at 30°C. The decrease in flavour scores was significant. The mean flavour scores for P-2 packaging were 7.73; followed 7.68 for P-3 and 7.66 for P-1. The differences between the packaging materials were only slightly significant. The higher flavour scores were awarded to 30°C storage (7.72)
compared to 7.65 for 5°C storage temperature. The difference was significant (P≤0.05). The flavour scores decreased from 8.18 in fresh samples to 6.04 at the end of the storage period. The decrease was also significant between the different pairs of comparison of durations. The interactions were also significant (Table 34, 36 and 38).

**Body and texture:**

Texture of Kunda is grainy with no shape. However some defects could occur due to changes in composition of milk, type of milk, and heat treatment during processing. These results in some defects like gumminess, chewiness, abnormal grain sizes. Body and texture scores of Kunda samples stored decreased from 8.50 in fresh samples to 6.03 after storage at 30°C for 42 days. Similar decreasing in body and texture score of Kunda was also observed in Kunda samples stored at 5°C. The decrease was significant (P≤0.05)

The highest mean body and texture scores (7.67) was awarded to P-3; followed by 7.62 for P-2 and 7.46 for P-1 wit significant differences (P≤0.05) amongst the packaging. The mean body and texture scores for 30°C storage was 7.67 and for 5°C was 7.49. The difference was significant with highest score awarded to 30°C. The body and texture scores decreased from 8.09 in fresh Kunda samples to 6.81 at the end of storage period. The decrease in body and texture scores during storage was significant. The comparisons between pairs of durations were also significant. The interactive effects of packaging and durations were also significant (Table 38).

**Overall acceptance:**

Overall acceptance scores are comprehensive evaluation of food products for acceptance. The overall acceptance scores decreased from 8.5 in fresh Kunda samples to
6.40 in Kunda samples stored at 30°C for 42 days. Similar decreasing trend was also observed in Kunda samples stored at 5°C. The decrease in overall acceptance scores was significant (P≤0.05).

Highest overall acceptance scores was awarded to P-3 (7.73); followed by 7.63 (P-3) and 7.49 (P-1). The difference in overall acceptance scores was significant between packaging. The mean overall acceptance scores at 30°C were 7.66 and at 5°C were 7.42. The difference was also significant (P≤0.05). The overall acceptance scores decreased from 8.5 in fresh Kunda samples to 7.23 at the end of storage period. The decrease was significant as duration increased. The pair wise comparisons of overall acceptance scores were also significant. The interactive means of overall acceptance scores for packaging, durations were also significant. The sensory evaluation scores in all 4 parameters were above the acceptance limit of 5.4 in any of Kunda samples stored (Table 38).

5.0 DISCUSSION

Traditional dairy products enjoy mass appeal give high profit margins and have more export potential for Indians staying in abroad. Traditional milk products represent the most prolific segment of Indian dairy industry. Indian dairy products have not only served as a cultural link with the modern dairy industry as well as provide technological base for diversification, export promotion and as a value added product to make the modern dairy industry economically strong. There is vast scope for development and adoption of modern technologies in mass production, product quality, hygiene and shelf-life with modern packaging and preservation.
Kunda is one of the Khoa based traditional milk based delicacy of India. The product has characteristic rich taste with a pleasant nutty flavour. There are no prescribed compositional standards. Kunda is prepared by halwais under unhygienic condition. An investigation was conducted for development of manufacturing technology, with standard composition and characteristics. The results generated are discussed in this chapter.

5.1.1 Effect of extent of desiccation on physico-chemical properties of Kunda.

Kunda is prepared by heat desiccation of high moisture Khoa, sugar and water for quite long time in a karahi with vigorous boiling, till characteristic nutty flavour, grainy texture and brown colour is developed. However the method of desiccation varies from halwais to halwais. Some manufacturers prepare by mixing all ingredients at a time and then boiling; while others prepare by desiccation of Khoa, sugar with addition of water or milk in batches till characteristics are developed. There are no published literature on Kunda is available. In this regard the only available literature is Net work project report of NDRI, SRS, Bangalore (Anon, 2006). Fox (1981a,1982) found that the changes that take place when milk is exposed to high temperatures for prolonged periods include acid production, transfer of soluble salts to the colloidal phase, Maillard browning, dephosphorylation and hydrolysis of casein, and denaturation of whey proteins and their interaction with casein micelles.

In view of the above facts experiments were conducted to study the extent of desiccation required for manufacture of Kunda with characteristic flavour, texture and colour. The method of manufacture has been cited in section 3.2.2.1. Results are presented in Table 3 and Table 4.
Moisture:

Maillard reaction proceeds in aqueous solution, but it occurs much more apparent in dried and concentrated foods. Very low moisture levels retard reaction. showed that when dry glucose and dry glycine were ground and stored at 50 °C with 2,5and 10 % water the maximum browning was found in sample containing 10% moisture.

Moisture% in Kunda ranged from 20.13% in “0” desiccation to 19.49% in 2 desiccation, 19.66% in 4 desiccation, 19.32% in 6 desiccation and 20.36 % in 8 desiccation. The variation was statistically not significant (P≥0.05). For development of desirable characteristics optimum heat treatment is necessary. De (2004) reported that temperatures below the optimum produce undesirable appearance, flavour and texture in Khoa.

To facilitate continuous heat treatment (desiccation) for development of brown colour and pleasant nutty flavour, the mixture was added with water (10-25%) to make the mixture slurry. Moisture content of 10 to 30 °C is required for Maillard reaction. More browning occurred at 30% moisture.

When the moisture content was either 0 or 90% no browning was observed. The rate of Maillard reactions are maximized at intermediate water activity values (Aw 0.5 to 0.7) (Labuza et al., 1970).

Browning Index:

Brown colour is the typical desirable characteristic of Kunda. Development of brown colour depends upon extent of desiccation. Brown colour is produced during
desiccations, due to interaction of reducing sugar and proteins under suitable conditions. Hodge (1953) has subdivided the Maillard reaction into three stages: (i) Initial stage, (ii) Intermediate stage and (iii) Final stage. The initial stage does not produce brown colour. Similar results were also obtained in Kunda (Table 3). Kunda manufacturing requires “8” desiccations. The browning index was not significantly increased till 4th desiccation. Browning index significantly increased ($P \leq 0.05$) after 6 and 8 desiccations. Phill-soon song et al. (1966) reported that in initial stage of Maillard reaction no coloration was detected. It was thought to represent the preliminary stage and was referred to as “induction period”.

Colour in Khoa is slightly brown or light yellow. The colour in early desiccation of Kunda manufacture was similar to Khoa. As the desiccations advanced brown colour was increased. Hurrel and Carpenter (1994) reported that as much as (76%) ε-amino lysine groups had reacted in an albumin glucose mixture after 30 days storage at 37°C and when same mix was heated for 15 min, at 121°C it was 85%.

**Water activity:**

Water activity of food products influences the textural properties as well as shelf-life. Water activity is also important factor influencing Maillard reaction. Water activity of Kunda was 0.883, 0.840, 0.851, 0.821 and 0.890 after 0.2, 4, 6 and 8 desiccations, respectively. Water activity was not statistically significant ($P \leq 0.05$) between the desiccations. The results pertaining to moisture content in kunda were also similar.

Both moisture and water activity of a food system exert a major influence on the Maillard reaction. Water may influence the rate of reaction by controlling the liquid
viscosity and by dissolution, concentration or dilution of reactants (Labuza, 1980). Generally accepted rates of Maillard reactions are maximum at intermediate Aw values (0.5 to 0.7). Aw plays a major role not only in shelf-life of Kunda, but also influences the textural characteristics (Labuza et al., 1970).

**pH:**

When milk is heated in the temperature range of 90° to 140° C at pH values below 6.7, denatured whey proteins complex on to the micellar surfaces, involving k-casein, but at higher values, denatured whey proteins remain in the intermicellar fluids as fibrous strands (Singh and Fox, 1985; 1986).

pH of Kunda decreased from 6.43 in ‘0’ desiccation to 6.24, 6.13, 6.04 and 6.01 after 2, 4, 6 and 8 desiccations. pH of Kunda was reduced due to production of acids during desiccation. During desiccations proteins; sugars and fat undergo breakdown to produce amino acids, organic acids such as formic acid, acetic acid. O’Brien and morrissey(1989) found that pH of a product decreases during the course of Maillard browning due to disappearance of basic amino acids.

Maillard reaction can occur in acidic or alkaline medium although it is favored under more alkaline conditions. Number of studies has demonstrated that reaction rate is increased by rise in pH. Lowering of pH decreases the degree of browning obtained, since the browning potential of the 1, 2 enol is less than that of the 2, 3 enediol (Nursten, 1986). The role of buffers in Maillard reaction has been shown to increase the rate of browning for sugar-amino acid systems as a result of the ionic environment (Eiskin et al., 1971). Saunders and Jervis (1966) observed that using sodium phosphates and sodium
citrate in glucose-glycine systems, the acid products formed during the course of reaction were probably buffered by these salts; thereby maintaining an alkaline environment favourable for the browning process to proceed.

5.1.2 Sensory properties

Sensory properties are the acceptance index of food products. Sensory attributes are unique with characteristic brown colour; grainy texture and pleasant nutty flavour. These characteristics are developed during desiccations. (Table4.).

Colour and appearance:

Colour of Kunda is light brown to brown. Brown colour develops as the desiccations increased. Colour of Kunda in initial stage was Khoa colour. It changed to brown as the desiccation increased. Initially up to 4 desiccation there was no visible brown colour. The colour and appearance scores increase was statistically significant (P≤0.05) with 5.0, 5.7, 5.9, 6.8 and 7.6 after 0, 2, 4, 6 and 8 desiccations respectively. Colour of Kunda is different from Khoa as Kunda manufacturing requires heat desiccation at much higher temperature (100° to 140°C) than Khoa.

Flavour:

Flavour of Kunda is pleasant nutty flavour. Initially, flavour scores were similar to Khoa. There was no significant difference (P≥0.05) in flavour scores upto 4 desiccations. Though sweet taste was observed in initial stage due to presence of Khoa and sugar. But typical nutty flavour was not produced. Sensory scores were lower at initial stages; then increased in later desiccations. Flavour scores were significantly increased (P≤0.05). Maximum score were awarded to product after 6 and “8”
desiccations. It was thus found that about “8” desiccations are necessary to produce desirable flavour production.

(Hurrell, 1982) observed that many flavours are produced during Maillard reactions. Flavour compounds formed as a consequence of “Strecker degradation” reactions are aldehydes derivatives formed through the oxidative degradation of equimolar amino acids and sugars Hodge et al. (1972) reported that different aromas were produced by different combination of amino acids and sugars at different temperatures

**Body and texture:**

Texture of Kunda is typical with uniform grains. Grains are formed due to aggregation of casein during prolonged desiccation of Khoa, sugar and water mixture at higher temperature. Casein micelles undergo aggregation due to heat induced coagulation. It is due to casein micellar properties. Creamer (2003) has reported that once sufficient calcium has become associated with the protein to reduce the net charge on the protein to almost zero, casein aggregates become very large.

Body and texture scores of Kunda increased from 4.9 in initial stage to 5.5, 6.6, 7.2 and 7.4 after 2, 4, 6 and 8 desiccations respectively. There was significant increase (P≤0.05) increase in body and texture scores after 4, 6 and 8 desiccations. Aggregation of casein increases as the pH approaches acidic conditions. It is evident from results that for development acceptable scores of more than 5.4 with grainy texture sufficient heat treatment (“8” desiccations) is necessary. Heating milk at 140°C for 10 min causes an increase in the diameter of the casein micelle due to deposition of denatured whey
proteins on to the micellar surfaces and precipitation of calcium phosphate (Carroll et al., 1971).

**Over all acceptance:**

Over all acceptance scores of Kunda was also in similar trend with other sensory properties. Scores were 4.6, 5.5, 6.1, 7.0 and 7.0 respectively after 0, 2, 4, 6 and 8 desiccations. The over all acceptance scores increase significantly (P≤0.05) with increase in desiccations.

### 5.1.3.1 Effect of cow milk and buffalo milk on physico-chemical properties of Kunda

Traditional milk products originated based on the innovative ideas of villagers to conservation of milk solids depending upon type of milk, region and dietary habits. Most of traditional milk products are manufactured by using buffalo milk. Cow milk is preferred for some smooth textured products. The difference between cow and buffalo milk in relation to quality of traditional products is due to differences in physical and functional properties.

Buffalo milk has higher specific gravity, viscosity, curd tension, pH, oxidation-reduction potential (Eh), thermal conductance and thermal expansion. Heat stability of concentrated buffalo milk is lower than the heat stability of concentrated cow milk. Due to differences in constituents and physical properties, milk from two species behaves differently when heat processed for the manufacture of various dairy products. Buffalo milk has higher content of fat, SNF, protein, lactose and colloidal calcium than cow milk. Buffalo milk contains more cat ions (Ca2+ and Mg2+) and less anion (phosphate and citrate) in comparison to cow milk. It has lower soluble calcium, magnesium and citrate.
Acidity and free amino-n increased and pH decreased progressively when milk was heated at 100 °C for 9 hours (EL-Hagaravy, 1962). More acidity was produced in cow milk and more amino-N was increased in buffalo milk. Heating milk <100°C did not increase amino-N in both milk (Singh, 1986, 1988).

Sharma et al. (1990) reported that satisfactory quality Khoa can be manufactured from milk having fat/SNF ratio of 0.549 to 0.659. Fat <5.0% had stickiness due to release of less free fat. Texture scores were maximum for 6% fat (fat /SNF ratio 0.659) Fat >6.0% released more free fat. De (2004) have reported that higher fat% delays the desiccation due to release of more free fat. Similar results were also obtained in our preliminary trials and it was decided to standardize the milk to 5.0% fat and 8.5% SNF in cow milk and 6.0% fat and 9.0% SNF in buffalo milk. The fat/SNF ratios in Kunda ranged from 0.588 in pure cow milk, 0.666 in pure buffalo milk, 0.608 in 75:25, 0.6285 in 50:50 and 0.648 in 25:75 mixed milk.

An experiment was conducted to study the effect of cow and buffalo milk and to standardize the type and composition of milk for optimal characteristics of Kunda. Kunda obtained in the experiment was analysed according for various attributes to section3.2.4.10. The data is presented in Table 5, 6 and 7.

**Moisture:**

Moisture per cent in Kunda ranged from 18.3% in T-1, 18.5% in T-2, 19.58% in T-3, 19.78% in T-4 and 20.1% in T-5. There was no significant difference (P≥0.05) between 100% and 75% buffalo milk as well as 75% and 100% cow milk Kunda. The moisture content significantly decreased (P≤0.05) as the per cent age of buffalo milk
increased. Similar results are also reported by De and Ray (1952) in Khoa. They have observed that the moisture content in Khoa decreased as the fat% in milk increased due to increased desiccation to obtain “Pat”. If the fat% in milk was more than certain minimum, it caused delay in pat formation, requiring more moisture to be removed and vise-versa. They also found that moisture content in Khoa varies directly with the SNF/fat ratio between 1.2 to 2.4. Further increase in ratio (>2.4) decreased the moisture.

**Total solids:**

The per cent of total solids influences the quality attributes of food product. The total solids percent significantly decreased (P≤0.05) from 81.7, 81.5, 80.42, 80.22 and 79.9%. The decrease in per cent age of buffalo milk has decreased total solids,(Aneja *et al.*, 2002) and Mathur *et al.* (1999). De and Ray (1952) have reported that the per cent loss of total solids in the course of conversion increases with the increasing proportion of buffalo milk ascribing to the more loss of milk fat from buffalo milk. Ranganadham and Rajorhia (1989) have also found that as the fat per cent increased, the free fatty acids per cent increased due to more rupture of fat during Khoa making.

**Yield:**

Yield of Kunda decreased from 300g/lit to 270,265 and 255gm/lit in T-1, T-2, T-3, and T4/T5. The decrease in yield was significant (P<0.05) with decrease in buffalo milk. Similar results were also obtained in total solids content of Kunda.

De (2004) has reported that the increase in yield per cent of Khoa has closely approximated with the increase in total solids in milk. The maximum recovery of total solids was due to their basic difference in the ratio of solids-not-fat. The higher yield in
buffalo milk Khoa was largely due to larger retention of moisture. The loss in total solids was gradually reduced till a minimum of 4% and 5% fat for cow and buffalo milk respectively. The presence of more fat than the optimum causes a sharp rise in per cent loss of total solids. The duration of heat-coagulation of cow milk ranges from 2.83 to 3.57, and in buffalo milk, is 2.48 to 3.05 min.

**Acidity:**

Acidity of Kunda was 0.44%, 0.43%, 0.45%, 0.46% and 0.48% LA in T-1 to T-5 respectively. The acidity increase in Kunda was significant (P≤0.05) when the percentage of buffalo milk was decreased from 100% to 75%, However, it was not significant (P>0.05) after 50:50 ratio. The significant in acidity (P≤0.05) may be due to production of more organic acids in buffalo milk Kunda during desiccation (Namiki, 1988).

**5.1.3.2 Effect of cow milk and buffalo milk on sensory properties of milk**

Most of the indigenous milk products were developed according the food habits of the people in regions. Cow and buffalo milk was preferred depending upon suitability of type of milk.

Kunda is also influenced by the difference between cow and buffalo milk. To study the effect of cow and buffalo milk and thus composition on quality attributes of Kunda an experiment was conducted. Kunda obtained was analysed for sensory characteristics. Data is presented in Table 6.

**Colour and appearance:**
Colour and appearance scores of Kunda was 7.3, 7.5, 8.0, 7.4 and 7.3 in T-1, T-2, T-3, T-4 and T-5. The variation in colour and appearance scores was significant (P<0.5). Lowest scores (7.3) was awarded to pure, cow milk and pure buffalo milk. Maximum score (8.0) was awarded to mixed 50:50 milk.

It was observed that Kunda prepared from pure cow milk was bright brown in odour; with small grains; where as the buffalo milk Kunda was dull brown in colour; Buffalo milk Kunda was having abnormal grainy texture with loose body; cow milk Kunda was compact with stickiness.

The above difference is due to compositional difference between cow and buffalo milk. Brown colour in cow milk is due to presence of more glycoprotein and Hexose. The lactose/protein ratio is also higher in cow milk than buffalo milk. (Mathur et al., 1999).

The equimolar reactants concentration i.e. free reducing sugar and free N-terminal amino acids are essential for maximum production of brown pigment (melanoidins) during Maillard reaction (O’Brien, 1995)

**Flavour:**

Flavour of Kunda is produced during desiccation due to protein-sugar interaction at high temperature. Flavour scores of Kunda (Table 4) were 7.5, 7.5, 8.0, 7.3, and 7.4 in T-1, T-2, T-3, T-4, and T-5 respectively. The variation in flavour scores was not significant (P> 0.05). Pure buffalo milk had more flavour score (7.5) than pure cow milk (7.4); maximum flavour scores was awarded to mixed milk (50:50). The flavour scores decreased as the buffalo milk percentage decreased. More of rich flavour is produced
from buffalo milk due to more of fat %. Nutty flavour in Kunda produced during Maillard reactions. The flavours are formed due to Strecker degradation products arised from carbohydrates, lipids and protein (Hodge, 1967, Hurrell, 1982).

**Body and texture:**

Kunda is having slightly loose body, semisolid with opening texture. The loose body is due to granular texture of Kunda. Soft body, grainy texture is one of the desirable characteristics of Kunda. Body and Texture scores of Kunda was 7.2, 7.5, 8.3, 7.3, 7.2, respectively in T-1, T-2, T-3, T-4, and T-5; the body and Texture scores significantly varied from 7.2 to 8.3 (P<0.05).

The grainy texture of Kunda is due to temperature induced coagulation of caseins and aggregation of whey proteins in the casein. Heating milk at temperature >90°C causes denaturation of whey proteins and their interaction with casein micelles. Heating milk upto 90°C, causes only minor changes in the size of the casein micelles, but severe heat treatment at 90°C for 10 min causes substantial whey proteins aggregation with the formation of intermediate sized (casein) whey protein particles (Sigh, 1988).

When milk is heated in the temperature range of 90-140°C, at pH values below 6.7, denatured whey proteins complex on to casein the micellar surfaces, involving casein, but at higher pH values (7.3), whey proteins complex on the micellar surfaces but do not attach to the micelles: they are dissociated (Singh, 1988).
Creamer (2003) reported that once sufficient calcium has become associated with the protein or reduce the net charge on the protein to almost zero, casein aggregation became very large.

Adhikari et al. (1993) found that prolong and high temperature heating during Khoa manufacture caused extensive dephosphorylation and calcium leading to their precipitation on the casein micelles either as Ca$^{+2}$ or Ca$^{3}$ (PO$_4$) which render precipitation of the micelles.

Buffalo milk containing higher proportion of calcium, phosphorous and citrate than that of cow’s milk might have resulted faster precipitation of calcium phosphates onto the casein micellar along with whey proteins, and lactose, forming a thread like, loose matrix against compact and comparatively smooth body in cow milk Khoa. (Adhikari et al., 1993) similar aggregation of casein has also been observed in Kunda. (Boghra and Mathur, 1996).

Carroll et al. (1971) have presented three phenomenon for increase in micelle size and their interaction during heating

(i) The interactions of whey proteins and other serum proteins with the casein micelles which are occur at either fore warming or sterilization temperature.

(ii) Precipitation of serum calcium as Ca$^{+2}$ or as less soluble form of Ca3 (Po4)2 on the casein micelles leading calcium bridging with concomitant increase in the micelles size and a virtual precipitation.

(iii) The disintegration of the micelles upon heating which results in formation of large aggregates.
**Overall acceptance:**

Over all acceptance scores reflect the combined effects on characteristics of a food product. Overall acceptance score of Kunda were, 7.3, 7.5, 8.2, 7.2 and 7.2, respectively in T-1, T-2, T-3, T-4, and T-5. Overall acceptance score significantly varied from 7.2 in pure cow milk to 8.2 in mixed milk (1:1) and there was significant increase (P>0.05), in overall acceptance. The similar trend was also noticed in, colour and appearance, body and texture score.

Cow milk Kunda was slightly bright in brown colour. Cow milk casein contains more sialic acid (glycopeptide) than buffalo milk. As glycopeptide contains carbohydrates; N-acetyl neuraminic acid: D-galactose: 2-acetamido-2-deoxy-D-galactose on the K-casein glycopeptides in 1:1:1 ratio released from k-casein (Hindle and Wheelock, 1970) by heat treatment at 100°C up to 8hours;

Sabarwal and Ganguli (1970) have found that faster sedimenting micelles (BM) have lower sialic acid content in k-casein than slower sedimenting micelles. Faster sedimenting micelles (BM) have higher calcium content than slower sedimenting micelles (CM). Similar observations were also made in Kunda.

Buffalo milk Kunda was found with abnormal sized grains (jowar size); with dull brown in colour and cow milk Kunda was bright brown in colour; but compact (caking) body. These defects were solved after mixing cow and buffalo milk in different proportions (Table 5 and 6).

**5.1.4 Effect of type of milk v/s extent of heating during Khoa making on physical properties of Kunda**
Heat treatment of cow milk and buffalo milk influences the products characters due to their compositional qualitative and quantitative differences.

The grains size in buffalo milk Kunda was abnormal (jowar size) with lumpiness and white specks. To prevent abnormal grain formation in buffalo milk; milk was not boiled during Khoa making. Abnormal grains formation in buffalo milk was due to aggregation of caseins; salts and sugars during boiling for Khoa making (Adhikari et al., 1993; Singh, 1988). Development of aggregates size with deposition of whey proteins may be the cause for abnormal size; Buffalo milk was slowly boiled (simmering 85° - 99°C) during Khoa making stage and vigorously boiled during Kunda making stages.

Similarly some defects were also found in cow milk Kunda. Cow milk Kunda was bright brown in colour but body and texture was compact (caking).

To solve the problem of caking in cow milk Kunda, which may be due to containing more glycopeptides (Hindle and Wheelock, 1970), standardized cow milk and buffalo milks were mixed in different proportions i.e. 25:75; 50:50, and 75:25; Kunda was prepared after simmering during Khoa making and boiling during Kunda making. The abnormal grains were not found. Grains sizes was uniform (mustard size) and there was no caking. The caking might be due to insufficient release of free fatty acids in Khoa due to low fat content and higher carbohydrate (sialic acid) content. (Ranganadham and Rajhoria, 1989). The observation on physical properties have been recorded and presented in Table 7.

5.1.5 Effect of steam pressure during Kunda making on properties of Kunda
Heat treatment of milk is one of the most commonly used operations in the manufacture of dairy products. Heat treatment temperatures range from thermization (50-65°C/10-20sec); pasteurization (75°-90°C) and sterilization (90°-140°C). Heat treatment <90°C is considered from the point of food safety. Heat treatment >90°C, or more than boiling of milk is considered from the point of changes taking place in milk and milk products (Singh, 1988). The changes that take place when milk is exposed to high temperatures for prolonged periods include acid production, transfer of casein, denaturation of whey proteins and their interaction with casein (Fox, 1981b and 1982).

Maillard reaction; is a complex chemical reactions between reducing sugars and proteins. Such reactions usually occur during processing and storage of foods; many factors influence the extent of the Maillard reaction, such as temperature, water activity; (Morales and van Boekel, 1998).

Kunda colour and flavour is basically from Maillard reaction. The temperature requirement for production of typical Kunda characteristics depends upon extent of heating. Boiling temperature of milk, during Khoa making is not enough to produce Kunda colour and flavours.

The development of brown colour is an extremely important and obvious feature of the advanced Maillard reaction, (Nursten, 1986). Maillard reaction is enhanced by the effect of temperature at 120-140°C. The food containing, proteins, sugars and fatty acids, produce appetizing flavours and colours when food is properly cooked, processed and stored; thus the Maillard reaction is very much desirable in making food more appetizing.
The steam pressure <1.0 kg/cm² produces a temperature of <100°C. Steam pressure 1.0 to 2.0 kg/cm² produces the temperature up to 120°C (steam table-appendix II). Steam pressure and temperature are directly related. An experiment was conducted to study the effect of heat treatment (steam pressure) on quality of kunda (Table 8 and 9).

5.1.5.1 Physico-chemical properties:

Moisture:

Moisture content in T-1 was 19.20% and in T-2 was 19.47%. There was no significant (P>0.05) difference between the two treatments; as the water is added at each desiccation and desiccated the actual difference was within the significant limit.

Total solids:

Total solids % in T-1 was 80.80%, and in T-2 was 80.53%. However there was slight significant difference (P≤0.05) between two treatments. This may be due to less browning in T-1 than T-2. The production of organic acids, volatile compounds is less in T-1 than T-2.

Yield:

The yield of T-1 was 249.67 gm/lit and T-2 was 252.50 gm/lit. The difference was statistically significant (P≤ 0.05). thus may be due to more moisture is absorbed due to more whey proteins aggregation and hydration of caseins at high temperature; Mohammed and Fox (1987) using electron microscope have shown that heating milk at 140°C for 10 min, causes an increase in the diameter of the casein micelles, due to deposition of denatured whey proteins on to the micellar surface and precipitation of calcium phosphate. Carroll et al. (1971) have observed that the increased level of calcium
in concentrated milk may lead to calcium bridging between micelles with a concomitant increase in micelles size.

**Water activity:**

Water activity is one of the influencing factors in Maillard reaction. Maillard reaction is maximum at intermediate moisture foods, with water activity values (IMF) of 0.60 to 0.80 and reduced at dry state and in high moisture food (Morales and van Boekel 1998). Aw exerts influence by controlling the viscosity of the liquid phase and by dissolution, concentration and dilution of reactants (Labuza, 1980).

Water activity in T-1 was 0.821 and in T-2 was 0.814, the difference was not significant (P>0.05). However higher water activity in T-1 may be due to less bound water in aggregates.

**5.1.5.2 Sensory properties:** Maillard reaction produced desirable flavour and colour; Maillard reaction products are sources of appetizing taste and colour (Namiki 1988).

The Maillard reaction is only one arriving many reactions which give flavour to a heated food stuff. Hundred of compounds are produced from interactions of carbohydrates, lipids and protein and protein components the reaction products often include N-heterocyclic, S-heterocyclic, furans, carbonyls and melanoidins, (Hurrell, 1982)

**Colour and appearance:**

Colour and appearance scores of T-1 was 6.3 and T-2 was 7.9. the difference between T-1 and T-2 treatment was statistically significant (P≤0.05). T-2 had higher
colour and appearance score, it was due to production of more (Maillard reaction) colour in Kunda prepared at steam pressure >1.0-2.0kg/cm^2 produces the temperature >100^0C which is requires for Maillard reaction (Lea and Hannan 1949; Labuza, 1980; Carroll, 1971). Maillard reaction is linearly proportional with temperature, especially>100^0C.

**Flavour:** Flavour of Kunda is typically pleasant, nutty flavour with sweet taste. Flavour scores in T-1 was 7.2 and in T-2 was 7.8. The difference between the treatments was significant (p<0.05). Flavour compounds are produced at higher temperature (>100^0C) (T-2) than at lower temperature (<100^0C). Maillard flavours are produce at higher temperature (Hodge, 1967). Ferretti *et al.* (1970) have identified about 40 Maillard reaction compounds such as acetic acid, acetol, 5-methyl-2-Furaldehyde, Furfuryl acetate, Furfuryl alcohol.

The rich pleasant flavour is also produced due to milk fat break down into acetyl, diacety, and carbonyls etc, nutty flavour are produced due to heating of proteins (nuts) and sweet taste is produced due to presence of sugar and their interactions with each other during desiccation.

**Body and texture:** Body and texture of Kunda is grainy texture, with loose body. Grainy texture is due to aggregation of casein and whey proteins at high temperature (Singh, 1988). The body and texture scores of T-1 was 8.0 and T-2 was 8.2. The difference was statistically significant (P≤0.05). T-2 was awarded higher score which may be due to development of uniforms grains at higher temperature (>100^0C).
Overall acceptance: the overall acceptance scores of Kunda were 7.1 in T-1 and 8.0 in T-2; the two treatments differed significantly (P≤0.05).

T-2 was awarded higher overall acceptance which may be due to higher heat treatment. Higher heat treatment (>100°C) produced better brown colours, flavours and grains during desiccation in Kunda, hence temperature range of 100-120°C is desirable (1.0-2.0 kg/cm² steam pressure) for Kunda manufacturing.

5.1.6 Effect of levels of sugars on yield and composition of Kunda

Sugar is extensively used as sweetener in various Indian milk products. Sugar possessing multi-faceted functionality, is used as a bulking agent, stabilizer, preservative, texturiser, humactant, dispersing agent, stabilizer, fermentation substrate, flavour carrier, browning agent and decorative agent. The nutty, pleasant, sweet flavour of Kunda is due to carbohydrate-protein interaction during desiccation. Sugar which is a multi-functional, imparts the primary characteristics of sweetness to Kunda. The sweetness of Kunda decreases due to production of some organic acids and bitter compounds during heating. The pH also decreased from 6.8 to 6.0 and no detectable browning was produced at pH 6.0 (Ashoor and Zent, 1984).

5.1.6.1 physico-chemical properties:

Yield:

Yield of Kunda was 265, 270, and 285 gm/lit in 7.0 %, 9.0% and 11.0 % sugar. The increase in yield was significant (P≤0.05). This increase in yield is attributed to increased addition of sugar; Patel and Upadhyay (2003) observed that the contribution by sucrose to the total solids of Basundi (desiccated milk based indigenous product)
increased yield proportionally. This in turn decreased protein content significantly (P≤0.05) without reducing other milk constituents is evidenced that sugar has hydrolyzed and reacted in Maillard reaction.

**Total solids:**

Total solids in Kunda was 81.20 %, 80.67 %, and 80.48 % in 7.0, 9.0 and 11.0% sugar levels. The decrease in total solids per cent was significant (P≤0.05). The decrease in % total solids may be due to decrease in % protein and sugar, participating in Maillard reaction.

**Browning index:**

Browning index increased progressively. The browning index was 0.130, 0.185, and 0.212 in 7.0, 9.0 and 11.0 % sugar levels. The availability of excess sugar increased the Maillard colour which is evidenced by increased Browning index (Fahrettin Googos et al., 1998; Ashoor and Zent, 1984; O’ Brien and Morrissey, 1989a).

**Water activity:**

Water activity is reduces the sugar level. Sugar is a preservative and humectant. It absorbs the moisture from environment. The water activity values were 0.883, 0.890, and 0.870, in 8.0, 9.0, and 11.0 % sugar levels. However the change in water activity values was not significant (P>0.05).

5.1.6.2 Sensory characteristics:

**Sweetness**
Sweetness of sugar varies from sugar to sugar, with sucrose > glucose > fructose > lactose. Khoa based sweets all added with 7.0 sucrose (on milk basis w/v). Higher % in burfi (>25-30%) resulted in too sweetness.

Kunda was added with 7.0 %, 9.0% and 11.0 % sugar (on milk basis w/v) during desiccation. The sensory scores for sweetness were 7.1, 8.0, and 7.5 respectively on 9-point hedonic scale. The variation in sensory scores for sweetness was significant (P≤0.05). Patel and Upadyay (2003) found that the Basundi made using highest level of sugar caused significant decline in the flavours scores due to excessive sweetness. Hence 9.0 % has been selected as optimum level of sugar with maximum sensory scores (8.0) with more sensory scores for further trials.

**Colour and appearance:**

Colour and appearance scores of Kunda was 7.2, 7.7, and 6.2 in 7.0 %, 9.0 % and 11.0% level of sugars. Maximum score was awarded to 9.0% sugar level; there was no increase in colour and appearance score as the per cent of sugar increased to 11.0%. The difference was significant (P<0.05)

**Flavour:**

Flavour and colours of Kunda are produced during desiccations due to Maillard reaction. Flavours scores were 7.2, 8.8 and 7.5 in 7.0 %, 9.0 %, and 11.0 % respectively. The variation in flavour scores was significant (P≤0.05). The flavour scores significantly increased from 7.0 % to 9.0 % and then decreased from 9.0 % level to 11.0%. The
maximum score (8.8) was awarded to 9.0%. Therefore 9% sugar product was awarded optimum scores. Similar results were also reported by Patel and Upadhyay (2003) in basundi.

**Body and texture**

The body and texture scores of Kunda was 7.0, 8.0 and 6.9 in 7.0%, 9.0 % and 11.0 % respectively. The difference was not significant (P≥0.05). Hence the sugar levels has not any influence on body and texture of Kunda. The grainy texture of Kunda is not dependent on level of sugar where as other characteristics have been influenced significantly (P≤0.05).

**Overall acceptance:**

The overall acceptance scores which is final acceptance scores also significantly varied with each other (P≤0.05). The over-all acceptance scores was 7.0% in 7.0 %, 8.8 in 9.0 % and 7.1 in 11.0 % sugar levels. The overall acceptance scores were also in same trend as in other sensory score. Hence the over all acceptance score (8.8) of 9.0 % sugar level is accepted as optimum.

5.1.7 Effect of extent of desiccations on development of total carbonyl, browning Index vis-à-vis sensory properties during processing of Kunda

Kunda has typical nutty flavour developed during desiccations. The Maillard reaction which is the major contributor for Kunda flavour. The flavours are either volatile or non volatiles. The volatile flavours are either desirable or undesirable. Hundreds of compounds can arise from carbohydrates lipids, proteins, ascorbic acids either separately or in combination during Maillard reaction. These flavours compounds are broadly
classified into N-heterocycles, S-heterocycles, furans, carbonyls and melanoidins. The N-heterocycles which give corny, nutty roasted or broadly aromas (Hurrell, 1982).

The principal class of compounds responsible for the desirable flavour in milk and milk products are carbonyls. Flavour compounds (carbonyl) are produced during Strecker degradation. The dicarbonys are produced during oxidative degradation of Amino acid and sugar. Hodge et al. (1972) reported that different aromas are produced by the same reaction mixture heated at different temperatures.

Hemavathi and Prabhakar (1973) have reported that the major classes of carbonyl compounds identified in Burfi were methyl ketones, saturated aldehydes 2-enols, and 2, 4, dienols.

Kunda samples drawn during desiccations at 0, 2, 4, 6 and 8 desiccations were analyzed for pH, total carbonyls, Browning index (O.D.) and sensory characteristics. The results are presented in Table 13.

**pH:**

pH of Kunda was 6.43 in the beginning of desiccations. pH of Khoa has been reduced due to production of organic acids during Khoa making and Kunda making. Browning reduces the pH, due to production of organic acids up to pH 6.0. The decrease in pH from 6.43 in ‘0’ desiccations to 6.01 in ‘8’ desiccations is statistically significant (P≤0.05). It is also evident from the increase in total carbonyls and Browning index. The decrease in pH was due to production of organic acids during Kunda making.

**Total carbonyl:**
Total carbonyls obtained from 0,2,4,6 and 8 desiccations were 0.176, 0.576, 0.882, 1.403, and 1.797 (O.D) respectively. The increase in total carbonyls was significant (P≤0.05). The carbonyls produced during desiccation are mainly results of amino-carbonyl reactions. As the reaction increased with increased desiccation at higher temperature, for about 30-45 minutes (100-120° C), the carbonyls production increased. Hemavathi and Prabhakar (1973) have reported that the heat treatment during burfi making produced more carbonyls due to protein-sugar interaction.

**Browning index:**

Browning index measured from Kunda sample drawn at 0,2,4,6 and 8 desiccations were 0.263, 0.302, 0.308, 0.334 and 0.372. The brown pigment Melanoidin is produced during Maillard reaction is the main source of brown colour in Kunda. The increase in browning index was significant (P≤0.05) between the desiccations after 4 desiccation; however the browning was not significant (P≥0.05) up to 2,desiccation due to “ induction period” observed in Maillard reaction as discussed in earlier sections.

**5.1.7.2 Sensory characteristics :** The Sensory scores are awarded for kunda samples drawn during various stages of desiccation has been analysed statistically.

**Colour and appearance:**

Colour and appearance scores were 5.0, 5.6, 5.7, 6.67, 7.7 in 0,2,4,6 and 8 desiccations respectively. The increase in colour and appearance during desiccation was statistically significant (P≤0.05).The acceptable score increased only after 2, desiccations due to increase in browning.
**Flavour:**

Flavour scores in Kunda samples drawn at 0, 2, 4, 6 and 8 desiccations were 5.6, 5.6, 6.0, 7.07 and 7.8, respectively. The increase in flavour scores was significant (P≤0.05) after 4 desiccations due to productions of flavour compounds in advanced stage of Maillard reaction.

**Body and texture:**

Body and texture scores of Kunda increased from 5.8 at ‘0’ desiccation to 6.0, 6.4, 6.7, and 7.63 after 2, 4, 6 and 8 desiccations respectively. There was significant (P≤0.05) increase in body and texture score after 2, desiccation. It may be due to increase in aggregation of milk proteins after 2 desiccations. The aggregation of casein increases after heating at high temperature (100°-120°C) for long time. The grainy texture of Kunda has increased with increased desiccation.

**Overall acceptance:**

The overall acceptance scores increased significantly (P<0.05) from 5.5 at ‘0’ desiccation to 5.8, 6.2, 6.8 and 7.7 in 2, 4, 6 and 8 desiccations respectively. The overall acceptance score is a comprehensive evaluation of Kunda characteristics which also increased with increase in desiccations; due to increased production of brown colour, flavour compounds and grainy texture. Nine per cent sugar level was awarded highest overall acceptance scores.

**Process optimisation**

Manufacturing schedule has been developed after standarsisation of various factor such as extent of desiccation, type and composition of milk, steam pressure, level of
sugar to obtain standardized Kunda composition and characteristics. The optimized schedule has been discussed in sections 5.1.1 to 5.1.6. The standardized process of kunda manufacture is as follows (section 4.1.11)

“Mixing of standardized cow milk (5.0% fat and 8.5%SNF) with standardized buffalo milk (6.0% fat and 9.0%SNF) at 50:50 ratios. Simmering of mixed milk during Khoa making stage with scraping and agitation to obtain Khoa pat. Khoa pat was mixed with sugar @ 9.0% on milk basis and desiccate to Khoa consistency. Add 10 to 15% potable water to make slurry and desiccation is continued with scraping and agitation with steam pressure of 1.0 to 2.0 kg/sq.cm. The dilution and desiccations was repeated 8 times to obtain optimised Kunda with pleasant nutty flavour, brown colour and grainy texture. Kunda obtained by above method had standard composition of 80.42% total solids, 28.78% sucrose, 17.78% fat, 14.56% protein, 16.74% lactose and 2.56% of minerals”.

5.2.1 Energy conservation during manufacture of Kunda

Energy is defined as the ability of an agent to work and is measured by the total work done. Energy is the input of production of utilities like electrical, steam, heat, refrigeration, and mechanical energy.

Khoa and Khoa based products manufacturing requires high heat energy due to evaporation of about 85% to 87% water from milk. Kunda manufacturing requires more energy than Khoa making as repeated desiccation is required to get desired Kunda characteristics. Agrawala et al (1987) reported that 6.802 kg of steam energy is required per kg of Khoa as against 12.53 kg steam/kg of kunda. The energy requirement was
saved upto 26.91% (9.17 kg steam per kg of kunda) with addition of 40% caramelized sugar

Verma (1988) has reported that the heat losses during Khoa making was due to radiation (3.24%), condensate (14.3%). There was about 35.5%, total heat loss. About 8.32% of total energy can be gained by condensate reutilization.

Thermal energy leaves the system with product, with condensate, heat loses from product surface and heat loses by convection and radiation. The thermal energy balancing can be estimated as “Thermal energy input + thermal energy input with raw material = thermal energy output with product + thermal energy output with condensate + thermal energy loss from product surface + thermal energy loss due to convection and radiation.

Verma and Girirdhari Lal (1989) have estimated the amount of steam consumed for processing milk to Khoa varies from 1.2 to 1.35 kg/kg milk. About 12.35% of thermal energy was lost with condensate during Khoa making and total thermal energy losses during Khoa making had been estimated as 32.03%. The maximum thermal energy loss has been observed to be with condensate leaving the processing vat. Traditional Khoa manufacturing has following drawbacks:

(i) Batch -to-batch variation in product quality,

(ii) Small scale batch process not suitable for commercial adoption,

(iii) Energy inefficiency due to low heat transfer co-efficient.
Condensate leaving equipments normally used for manufacture of traditional dairy products is at very high temperature in the range of about 85° to 95°C. Hence energy can be saved.

The energy saving is the increase in efficiency without large investment, minimise losses. Thus the energy saving in Kunda manufacture was achieved with reduction in desiccation time by addition of partly caramelized sugar, so that browning could be advanced without affecting Kunda attributes.

5.2.1.1 Addition of different levels of caramelized sugar: Sugars are normally colorless and are generally sweet; however when they are heated above their melting point they darken yellow, brown, red/brown and finally to black. This process proceeds under acidic or alkaline conditions and is associated with a change in flavours as burnt, bitter and acid flavours. The pleasant caramel flavour is produced by carefully controlling the process. Sugar caramalization involving the heat degradation of sugars in the absence of amino acids or proteins. Baking, roasting and frying occur in the range 150° to 200° C e.g. roasting of coffee and cocoa beans.

Bryce and Greenwood (1963) showed that pyrolysis of sucrose, glucose and starch produce caramels of similar composition. Eskin et al (1971) found that volatile products are produced from difference group of sugars i.e. mono, di, and polysaccharides. In both the cases the caramels produced from different sugars, showed similar in composition. Hodge (1967) has reported that caramelisation takes place in acidic and alkaline degradation in 1, 2 enol derivative path ways with production of 5-HMF, Furans
over pH 6.0 -6.7. The main disadvantage of this reaction is the production of unpleasant, burned, bitter products which arise if this process is allowed to proceed uncontrolled.

The results pertaining to study the effect of different level of caramelisation on processing time and sensory characteristics are presented in Table 14.

**Processing time:**

Processing time drastically reduced from 68.33 min in control (T-1) treatment to 40, 35 and 50 min in 30%, 40% and 50% caramelisation levels respectively. The decrease in processing time was significant (P≤0.05) compared to control as well as between the different levels of caramel sugar. As the per cent of caramel sugar increased, the time requirement was significantly reduced (P≤0.05). This was due to increase in intensity of sugar caramelisation. Since the quantity of sugar used for caramelisation increased with increasing level of sugar caramelisation. The time required for desiccation was reduced because early browning was obtained in Kunda.

**Moisture:**

Moisture in Kunda ranged from 19.1%, in 30% caramelisation to 19.2% in control, 19.6% in 40% and 19.5% in 50% caramelisation. The variation of moisture was not significant (P≥0.05).

**5.2.1.1.2 Sensory characteristics:**

**Colour and appearance:**

Colour and appearance scores were 8.0, 7.8, 8.2 and 7.2 in T-1, T-2 T-3 and T-4, respectively. Only T-3 and T-4 treatments differed significantly (P≤ 0.05) in colour and
appearance scores as the per cent of caramelisation increased between 30% and 40%. Forty per cent caramel sugar level was almost same in colour and appearance as that of control.

**Flavour:**

Flavour score reduced from 8.5 in 40% caramelisation to 7.3 in 30% caramel and 6.5 in 50% caramel sugars. Caramelisation of sugar produces many flavour products which are acetic acids, furfural, Methyl furfural, levulinic acid, 5-HMF, Co2 and Co; acyclic compounds such as formic acid, acetic, diacetyl, maltol, isomaltol (Eskin et al, 1971). The flavour score significantly (P≤0.05) differed between 40% and 50% caramel sugar level; but not with other treatments. 40% caramel level sugar was not significant (P≥0.05) with control and 30% caramel sugar. However the processing time reduction was significant (P≤0.05).

**Body and texture:**

Body and texture scores varied significantly (P≤0.05) from 8.5 in 40% caramel, to 8.3 in control, 7.4 in 30% and 7.3 in 50% caramel sugar level. The body and texture scores significantly decreased in 30% and 50% but not in 40% caramelisation.

**Overall acceptance:**

The overall acceptance scores were 8.2, 7.4, 8.5 and 7.1 in control, 30%, 40% and 50% caramelisations respectively. The variation in overall acceptance scores was significant (P≤0.05). The difference between control and 40% caramel sugar was not significant (P≥0.05) 40% caramelisation was on par with control and was awarded highest scores in all sensory attributes with less processing time requirement.
5.2.1.2 Effect of caramelisation sugar (40%) on energy consumption of Kunda

Addition of 40% caramelized sugar solution was resulted in reduction in processing time compared to control with best sensory characteristics. 40% sugar caramelisation was rated better in all sensory characteristics compared to others (30 and 50%). Thus 40% caramelisation was selected for the experiment on energy consumption. Kunda was analysed for physico-chemical properties, yield, processing time, between control and treated (40%) sample and results are presented in Table 15.

Condensate from Khoa kettle was collected at each stage of Kunda making. The condensate collected in control (T-1) was 3.761 kg and T-2 (40% caramel) was 2.750 kg. The difference between the two treatments was significant (P≤0.05). The condensate temperature was about 95°C. The quantity of condensate released is equal to the quantity of steam utilized during processing of milk products.

There was significant (P≤0.05) savings in steam utilization (26.91%) compared to control (T-1). Addition of caramel sugar (40%) has reduced the desiccation time from 8 to 4 due to early browning. The steam utilization in control Kunda was 12.53 kg /kg of kunda as against 9.17 kg steam / kg of Kunda in 40% caramelisation Kunda.

Computation of energy:

Steam utilization has been computed by estimating heat energy content in condensate (Table 15). The net energy consumption (kj) was 8262.61 kJ in control and 6038.99 kJ in treated sample. There was significant (P≤0.05) difference between the two treatments. It is because of reduction in extent of desiccation due to addition of caramelized sugar (40%). Early browning reduced desiccation times so that the steam
utilization (condensate released) was significantly reduced. Hence, there was about 26.91% savings in energy by addition of 40% caramelisation compared to control (Table 16).

5.2.1.3 Effect of addition of caramelized sugar (40%) on processing time, yield and physico-chemical properties

Kunda with addition of 40% caramelisation sugar and control were prepared and analysed for its processing time, yield, moisture and acidity (Table 17).

Processing time:

The desiccation required and time in minutes for Kunda making in control was 8 and 68.33 min respectively. The desiccations and processing time required for 40% caramelisation sugar were 4 and 44 minutes respectively to produce Kunda similar to control. The difference was significant (P<0.05). This was due to reduction in desiccations which was reduced by addition of caramel solution.

Yield:

Yield obtained in control was 297.58gm/lit, whereas in 40% caramelisation was 295.gm/lit. The difference was not significant (P>0.05). There was no influence of caramelisation on yield of Kunda even there was reduction in desiccation required. Hence there was savings in energy consumption without affecting yield.

Moisture:
Moisture per cent in control was 19.81% and in treated sample was 20.2%. The difference between the two treatments was significant ($P \leq 0.05$). The caramel sugar addition in the form of solution has increased the moisture content.

**Acidity:**

Acidity produced in control was 0.47% lactic acid and in treated sample was 0.53%. The difference was not significant ($P \geq 0.05$). Acidity is produced both in Maillard reactions and caramalization due to production of organic acids (Hurrell, 1982; Eskin et al. 1971; Nursten, 1986; O’Brien and Morrissey, 1989). The acidity was almost same as in control.

**5.2.1.4 Sensory characteristics:** Kunda prepared with control and addition of caramel (40%) sugar was evaluated for sensory characteristics. (Table 18.)

**Colour and appearance:**

Colour and appearance scores in control was 7.17 and in 40% caramel was 7.70. There was significant ($P \leq 0.05$) difference between the two treatments. Higher scores was awarded to 40% caramel Kunda may be due to glassy appearance and more bright brown colour in treated than Kunda control.

**Flavour:**

Flavour scores in control Kunda was 7.6 and in 40% caramel added Kunda it was 7.73. There was no statistical significant difference ($P \geq 0.05$) between the two treatments.
Flavour compounds produced both during Maillard reactions and caramelisation is same. Flavour produced in Maillard reaction may be Furan, Furfuraldehyde, acetone, acetic acid; N-heterocyclic, carbonyls and also in caramelisation (Namiki, 1988 and Eskin et al 1971).

**Body and texture:**

Body and texture scores were 7.53 in control and 7.43 in 40% caramel sugar added Kunda. There was only slight significant difference between the two treatments. It might be due to development of more grainy texture in control. The normal desiccation (8) is necessary for development of desirable grainy texture in Kunda. However control Kunda was awarded better body and texture scores than treated Kunda due to more heat treatment in control. There was less heat treatment in T-2, which reduced grain formation (Adhikari et al., 1993, Singh, 1988)

**Overall acceptance:**

The overall acceptance scores awarded to control Kunda were 7.13 and in 40% caramel Kunda was 7.73. There was significant (P≤0.05) difference between the two treatments (P≤0.05). 40% caramel Kunda was awarded higher sensory score in colour and appearance flavour even with less heat treatment. The caramelisation also produces pleasant flavours and colour due to control heat treatment. Thus 40% caramelisation was more beneficial without affecting quality.
5.2.2 Effect of additives added during processing on the physico-chemical properties of Kunda

Food additives are substances added to food in small quantities to improve its functional properties, freshness, sensory and nutritional qualities or as processing aids in the manufacturing of food. Food additives achieve some degree of uniformity needed for large scale production to enhance the flavour or improve the appearance or texture of a product.

Prasad et al. (1992) observed that the maximum increase in HCT in preheated / concentrated buffalo milk (120°C/12 min) when disodium hydrogen phosphate was added at 0.3%. Addition of tri-sodium citrate at some level was also found to increase HCT of concentrated milk to a lesser extent.

Kunda sample prepared with additives disodium phosphate and tri-sodium citrate at 0.05% and 0.10% were analysed for yield, moisture, Aw, pH and Browning index. Data is presented in Table 19.

Yield:

Yield obtained in control sample was 270gm and in treated sample was 245, 275, 280, and 278gm/lit respectively for 0.05% of DSP and TSC also at 0.10% of DSP and TSC.

The variation in yield was not significant (P≥0.05). There was no effect of DSP and TSC on yield of Kunda.
Moisture:

Moisture % increased from 19.3 % in control to 19.4 %, 19.5%, 19.8 % and 19.75 % in T-2, T-3, T-4 and T-5 respectively. There was no significant (P≥0.05) increase in moisture. The slight increase may be due to higher degree of dispersion and hydration of caseins particles (Ismail et al 1971b). Kunda obtained from above experiment was pasty in consistency, may be due to the dispersion effect of sodium.

Water activity:

Water activity values of Kunda changed from 0.890 in control to 0.886, 0.896, 0.910, and 0.907 respectively in T2, T3, T4 and T5 respectively. However the increase in water activity was not significant (P≥0.05).

Browning Index:

Browning index of Kunda prepared from addition of tri - sodium citrate and di - sodium phosphate at 0.05 and 0.10 % were estimated.

The browning index value increased from 0.185 to 0.190, 0.190, 0.195 and 0.195 in T-1, T-2, T-3, T-4 and T-5 respectively. There was significant increase in Browning index from T-1 to T-5 (P≤0.05) The increase in browning index may be because of increased availability of milk proteins due to dispersion action of these additives on proteins when the salts are added (TSC &DSP). Increased pH also enhanced the Maillard reaction.

pH:
pH of Kunda prepared from addition of Tri sodium citrate and Di sodium phosphate at 0.05% and 0.10% was not significantly changed (P$\geq$0.05). There was change in pH from normal pH of 6.6 - 6.8. The pH of control was 6.05; the drop in pH was due to production of inorganic acid during Maillard reaction.

5.2.2.2 Sensory characteristics: Kunda prepared from addition of tri - sodium citrate and bi - sodium phosphates at 0.05 % and 0.10 % was evaluated for sensory characteristics and results are presented in Table 20.

Colour and appearance:

Colour and appearance scores were 7.8, 7.8 7.6, 7.0, 7.0 in T-1, T-2, T-3, T-4 and T-5, respectively. The decrease in colour and appearance scores was not significant (P$\geq$0.05). The colour of Kunda was as brown as control sample. However the product was pasty in consistency. This may be due to dispersion of proteins by the TSC and DSP.

Flavour:

Flavour scores were 8.0, 7.9, 7.25, 7.2 and 7.1 respectively in T-1, T-2, T-3, T-4, and T-5. The decrease in flavour score was significant (P$\leq$0.05). There was no significant (P$\geq$0.05) difference between the two levels of additives.treated Kunda had less sensory scor due to saltyness.

Body and texture:

Body and Texture scores decreased from 8.0 in control to 7.77, 7.26, 7.6, 6.0 and 6.0 in T-2, T-3, T-4 and T-5, respectively. It was significant (P,0.05)
It was observed in our preliminary trial that Kunda was pasty and hard, at more than 0.1 levels there was no grainy texture. It may be attributed to dispersion action of sodium salts on proteins. The coagulation of proteins (both casein and whey protein) was not found. The citrate and phosphates competes with calcium and magnesium for formation of complex. The decrease in concentration of calcium and magnesium ions causes dispersion of the caseinate particles which are sensitive to divalent ions (Ismail et al 1971a). This may be reason for pasty consistency of Kunda. However, there was change in browning; slight reduction flavours score.

**Overall acceptance**

The sensory scores for overall acceptance scores decreased from 7.9 in control to 7.8, 7.4, 6.5 and 6.5 in T-2, T-3, T-4 and T-5. There was no significant (P≥0.05) difference. However at 0.10 % the overall acceptance score significantly decreased (p≥0.05) may be due to increased dispersion of proteins, desalting (no aggregation), pasty & caking consistency in Kunda. Treated Kunda was awarded less overall acceptance scores than control.
5.2.3 Effect of homogenization of milk on physico-chemical properties of Kunda

Homogenization of milk is the process of treatment applied to milk to ensure break-up of fat globules. Fat globules in milk are surrounded by a thin layer of surface active membrane materials. Milk fat globule membrane (MFGM) consists of a complex mixture of proteins, glycoproteins, triglycerides, phospholipids, cholesterol, enzymes, and other minor components.

Composition and properties of milk fat globule membrane in milk can be altered by various factors, such as animal, environmental and processing factors include cooling, drying, separation, agitation, heating and homogenization. Among these processing factors, heat treatment of milk causes whey protein to denature and complex with membrane components as well as k-casein in the micelles.

Homogenization causes significant compositional changes with milk fat globule membrane (MFGM) by disrupting fat globule, thus decreasing size while increasing the surface area; newly created MFGM surface area is covered by the adsorption of skim milk proteins, preferably casein micelles. (Anderson et al., 1977). Lee and Sherbon (2002) found that homogenization profoundly decreased the size of MFGM and increased the surface area of the fat globules, whereas heat treatment had no significant influence on the size and surface area of the fat globules.

Fox et al. (1960) have reported that the complex between protein and MFGM is formed through the operation of “Van der waals” forces between the hydrocarbon sites
on the fat and those of the casein which are exposed by distortion at the homogenization. Gramikov et al. (1962) have reported that the homogenization of whole milk increased the dispersion of the protein particles. It was 1075 Å in un homogenized whole milk and in milk homogenized at 50,100 atmosphere. The particle size increased to 5.95, 5.41 Å and 600 °A (about 1:500 times). The increase in the dispersion of the protein particles is proportional to the increase in the dispersion of the fat and caused by the adsorption forces of the fat globule. Henstras and Schdmit (1970) observed that caseins particles breaking down into small sub units which may adhere to the surface of the fat globules in homogenized milk.

Pynes and Heremans (1969) found that increased homogenization pressure brought about the conformation changes in casein micelles.

Hosteller and Im Hof (1953) have reported that structural changes in the casein particles of milk as a result of homogenization. Mulay and Ladhani (1973) found that homogenized milk Khoa was softer and lighter brown in colour and could not be “patted” together like the un homogenized milk Khoa. Ranganadham and Rajhoria (1989) reported that homogenization of milk reduced the free fat in Khoa samples to about one-half.

**Water activity:**

Water activity of Kunda ranged from 0.931 in skim milk; High pressure; without sugar addition (2:2:1) to 0.821 in whole milk: High pressure: sugar addition (1:2:2). The effect of homogenization has significantly influenced ($P \geq 0.05$) the increase in water activity on type of milk and addition of sugar but not on homogenization pressure. Skim milk homogenized Kunda had more water activity (0.908) than whole milk Kunda.
The significant difference was due to more skim milk protein surface area availability. Free casein grins formed during Kunda making from homogenized skim milk have absorbed more available with less complexing with milk fat globules.

Kunda prepared from milk homogenized in presence of sugar was significantly (P≤0.05) having less water activity (0.888) than sugar added after homogenization (0.902). It is also due to formation of sugar-protein complex. Some disrupted protein has been absorbed on fat globule membrane with increased surface area. Similar results are also obtained in moisture.

**pH:**

pH of Kunda ranged from 6.45 in (2:2:1) skim milk: high pressure: without sugar addition to 6.00 in skim milk: high pressure: with sugar addition (2:2:2). Addition of sugar significantly influenced (P≤0.05) the pH values of Kunda. None of the other treatments had significant effect. More acidity has been produced in Kunda produced from sugar added homogenized milk (pH 6.05). Homogenization before addition of sugar has formed more protein-fat complex than homogenization after addition of sugar. pH was reduced during homogenization without sugar addition due to formation of more break down products of sugar, fat and protein during desiccation rather than homogenization after addition of sugar.

**Browning Index:**

Browning index of homogenized Kunda increased from 0.051 in whole milk: high pressure: without sugar addition (1:2:1) and skim milk: low pressure: without sugar addition (2:1:1) to 0.201 in whole milk: control: without sugar addition (1:3:1). However
none of the treatments were significant (P≥0.05) in increasing the browning index except control. (1:3:1)

Brown colour was observed only in control Kunda. None of the treatments were able to produce brown Kunda. Homogenization of either type of milk with or without addition of sugar at low pressure and high pressure did not produce brown colour Kunda. There was no Maillard reaction in such homogenized Kunda as the essential conditions for Maillard reaction were not met: v.i.z;

(i) Equimolar concentration of N-terminal ε-amino acid and free reducing sugar. Except this condition all other conditions were fulfilled during Kunda making from homogenized milk

(ii) Temperature requirement (100-120°C)

(iii) Moisture% 10-30%

(iv) pH normal 6.4-6.8

(v) Carbohydrates – sugar 9.0%

(vi) Desiccation duration 30 to 60 minutes.

Homogenisation resulted change in reactants concentration. This was altered due to homogenization. Homogenization of milk ruptures the fat globules to uniform fat globules of 2 µm. The milk protein especially casein is also disrupted into small granular (Henstras and Schmidt, 1970; Hosteller and Imhoff, 1953; Iwaida and Tsugo, 1961; Fox et al., 1960; Gravikov et al., 1962; Lee and Sherbon, 2002; O’Brien and Morrissey, 1989; Namiki, 1988; Eskin et al., 1971; Hurrell, 1982).
Homogenization of milk as it ruptures both fat and casein micelles. Casein micelles are absorbed on fat globule membranes and thus increase in surface area more than 1:500 times (Gravikov et al., 1962; Schmidt and Henstra, 1970). Caseins are attracted by surface active forces like van der Waals forces (Fox et al., 1960). Caseins and whey proteins also form complex and forms grains (Lee and Sherbon, 2002; Rose, 1963). With this it is inferred that the proteins are not available with N-terminal ε-amino acids to reducing sugar for Maillard reaction to occur or there was no browning in homogenized milk and skim milk.

Sharma et al. (1990) found that homogenization at 80 to 150 kg/sq.cm has decreased the colour of Khoa. Khoa prepared from homogenized milk Khoa had whiter colour and sticky body. Khoa homogenized at pressure of 150 kg/sq.cm was having greater loss of body, texture and flavour. Hence homogenization pressure of (70, 140 kg/sq.cm) is more suitable.

Walstra (1983) has reported that formation of fat cluster after homogenization depends upon fat/protein ratio, homogenisation pressure and protein load. Robson and Dalgleish (1984) suggested that there was less K-casein per unit area of absorbed casein micelles. Thus the amount of casein available for mutual interaction is larger than in case of non-adsorbed casein micelles.

5.2.3.2 Sensory characteristics of Kunda: Sensory characteristics of dairy products changes depending upon various factors such as animal, environmental, and processing factors. Homogenization is one of processing factors which decreases curd tension. It is
due to disruption of casein micelles. However, in Kunda sensory characteristics were affected due to homogenization. Results are presented in Tables 22, 24 and 26.

**Colour and appearance:**

Colour and appearance scores decreased from 7.90 in control (1:3:1) to 4.50 in whole milk: high pressure: with sugar addition (1:2:2). There was significant effect of homogenization ($P \leq 0.05$) on type of milk, homogenization pressure and addition of sugar. Skim milk homogenized Kunda was awarded higher colour and appearance score than homogenized whole milk. The difference was significant ($P \leq 0.05$), as the caseins are not adsorbed on fat globule due to homogenization of skim milk. The required fat was added after homogenization, fat globules were not ruptured.

Colour and appearance scores decreased significantly ($P \leq 0.05$), as the homogenization increased. Maximum score was awarded to control Kunda, followed by 5.36 in low pressure and 4.99 in high pressure homogenization. This was due to spreading of more ruptured caseins on homogenized milk fat globule surface as the pressure increased. There was only slight difference between colour and appearance scores of milk homogenized without addition of sugar (6.15) and with addition of sugar (5.96). It may be due to sugar-protein complex formation during homogenization (65 °C).

**Flavour:**

Flavour scores of Kunda decreased from 8.13 in control Kunda (1:3:1) to 5.13 in whole milk: high pressure: without sugar addition (1:2:1). All treatments were significant ($P \leq 0.05$) on variation of flavour scores. The flavour scores in homogenized whole milk was (6.62)significantly less than homogenized skim milk ($P \leq 0.05$)It may be due to more
protein-sugar interaction in skim milk; as ruptured proteins were free (without attachment to fat globules in skim milk). Control Kunda was awarded highest flavour scores (8.0) compared to low pressure (6.28) and high pressure (5.99) homogenized milk Kunda. The difference was significant (P≤0.05). In control Kunda flavour was produced due to more Maillard reaction as there was no rupture of caseins as well as absorption on fat globules. The flavour scores decreased due to high pressure. High pressure has increased the rupturing of caseins.

Kunda samples prepared from addition of sugar before homogenization has less flavour scores (6.65) than after homogenization (6.87). The sweetness has decreased in Kunda prepared from homogenization of milk with addition of sugar. The sugar-protein complexing has decreased the sweetness.

Body and texture:

Body and texture scores of Kunda decreased from 8.10 in control (1:3:1) to 5.17 in whole milk: low pressure: without addition of sugar (1:1:1). Homogenization pressure was significant (P≤0.05) in decreasing the body and texture scores. Type of milk used for homogenization was also slightly significant (P≤0.05). All interactions were nonsignificant (P≥0.05). Homogenized skim milk was having higher body and texture score (6.79) than homogenized whole milk (6.15). It may be due to less powdery texture in skim milk Kunda than whole milk Kunda. Homogenized milk ruptured casein has absorbed to fat globules more than homogenized skim milk; and there was more grainy texture in homogenized skim milk Kunda. It was due to formation of aggregates due to
complexing between serum proteins and caseins (Schmidt and Henstra, 1970; Henstra and Schmidt, 1970; Iwaida and Tsugo, 1961; Lee and Sherbom, 2002).

The body and texture scores of control Kunda was (8.10) which was higher than low pressure Kunda (6.07) and high pressure Kunda (5.82). There was development of uniform grainy texture (about mustard size) in control Kunda than powdery texture in homogenized whole milk Kunda. Homogenized milk Kunda was chalky in texture due to rupture of caseins during homogenisation. The chalky texture increased with increased pressure. Addition of sugar before homogenisation has reduced the body and texture scores (6.34) compared to after homogenisation (6.61). However, it was non-significant (P≥0.05).

**Overall acceptance** Overall acceptance scores decreased from 8.02 in control to 5.20 in Whole milk; low pressure: with addition of sugar (1:1:2). Homogenisation treatment was significant (P≤0.05) in decreasing the overall acceptance scores. Type of milk had slightly significant effect (P≤0.05). all other treatments and interactions were not significant(P≥0.05). As overall acceptance scores are complementary to other characteristics, the scores were similar to other characteristics. The overall acceptance scores in homogenized skim milk were 6.63, higher than homogenized whole milk (5.96). The free proteins surface area is less in homogenized skim milk due to less absorption of caseins on unhomogenised milk fat globules.

The overall acceptance scores decreased significantly from 8.07 in control (1:3:1) to other homogenized Kunda. The over all acceptance scores in low pressure homogenisation Kunda was (5.77); higher than high pressure homogenized Kunda. As
the pressure increased; proteins surface area also increased. Thus the overall acceptance scores were reduced. Similar results are also obtained in other characteristics. None of the interactions were significant (P≥0.05).

5.3.1 Effect of preservatives on physico-chemical and microbiological characteristics of Kunda

Food preservation technologies include heat processing, chilling, freezing, drying, currying, fermenting, acidifying, use of chemical preservatives and aseptic packaging. Microbial spoilage of dairy products are encountered in food products. Dairy products are not exception to the spoilage by bacteria and yeasts and moulds. Yeasts and moulds proliferate in Khoa based dairy products due to favourable medium with sufficient nutrients moisture, and pH.

Kunda is also a Khoa based sweet delicacy. The shelf-life of Kunda is reported to be about 15-28 days at 30 °C (Jayaraj Rao, 2000). Addition of preservative is one of the practices followed for preservation of food. Class-II preservatives are permitted as additives in food. Among the permitted preservatives Nisin: and potassium sorbate were studied on the shelf-life of Kunda. Results are presented in Tables 27, 28, 29, 30, 31 and 32.

5.3.1.1 Physico-chemical-chemical and microbiological characteristics

Moisture:

Moisture % in Kunda stored for varying period at two temperatures varied significantly (P≤0.05). The moisture% decreased from 20.05 in fresh samples to 17.90%
after end of storage period. Moisture 5% in fresh Kunda was 20.02 then decreased to 19.62, 19.34, 19.01, 18.67; 18.37 and 18.12 % after seven storage intervals respectively.

Moisture % in Kunda stored at 30°C was 18.98% and 19.06% at 5°C. Moisture % in control was 19.12% and in preservative-2 (Nisin ) was 18.95% and in potassium sorbate Pr-3) added Kunda was 19.00%. The difference was not significant (P≥0.05) between preservatives and their interactions.

**Water activity:**

Water activity is one of the important factors that govern the stability of food during storage. The relationship between moisture content and water activity is not linear, but it is sigmoid. It is the state of water free or bound water) rather than the total water content. It is important for microbial proliferation. Water activity controls microbial proteolysis, lipolysis, chemical reactions (browning, oxidation and physical / rheological characteristics. Different microorganisms have different water activity for their growth.

The traditional as well as modern methods of food preservation (drying, curing, and salting, freezing, addition of sugar) are practically based on reduction of water activity.

Addition of 30 %, 40% and 50 % sugar has significantly (P<0.05) reduced Aw from 0.92 in fresh Kunda to 0.83, 0.79 and 0.78 respectively (Prajapati et al., 1986).

Water activity values of Kunda ranged from 0.89 to 0.75 after storage period. The water activity influences by many factors such as temperature, oxygen, chemicals etc. however in Kunda the preservatives and heat treatment did not influence Aw; the effect of storage temperature as well as preservatives was not significant (P≥0.05) in affecting
the water activity only storage duration had significantly (P≥0.05) decreased the water activity. The interaction of preservatives and duration also not significant (P≥0.05).

There was significant decrease in water activity of Kunda from 0.89 to in fresh samples to 0.87, 0.86, 0.84, 0.83, 0.80, and 0.75 with respective intervals (Table 31). The water activity of control Kunda was 0.85, Nisin was 0.840 and in potassium sorbate Kunda was 0.80. The differences were statistically significant (P≤0.05). There was no significant difference between control and nisin, only potassium sorbate as reduced the Aw compared to control. This may be due to certain other inherent variables.

The Aw of Kunda samples stored at 30°C was 0.83 and at 5°C was 0.84; the difference was not significant (P≥0.05). The reduction in moisture percentage in Kunda stored at 30°C has not affected the water activity of Kunda, this is because water activity and moisture are not having linear relationship but sigmoidal. (Jayaraj Rao, 2000; Sawhney et al., 1997). It is the monolayer moisture content which accounts for the water activity; which influence the microbial growth. The bound water is not available to microbial growth. It is the state of water rather than total water content is important, which is related to vapour pressure of food. Hence there was no significant (P≥0.05) difference between Kunda stored at 30°C and 5°C.

**Titratable acidity:**

Acidity is expressed as % lactic acid. The acidity developed due to production of acids like formic acetic, lactic and other organic acids, free fatty acid. The acidity increases due to microbial action on lactose. Acidity is also produced during processing of Khoa and Khoa based products where heat treatment is higher. Acidity of Kunda is
same as Khoa. It slightly increases due to heat processing. Maillard reaction produces many organic acids, so that there will be increase in acidity.

Titrable acidity of Kunda increased from 0.55 in fresh samples to 0.81 % lactic acid. The increase in acidity of Kunda was significant ($P \leq 0.05$). All parameters and their interactions except addition of preservatives were significant. The acidity values increased from 0.55 % LA in fresh (‘0’ day) samples, to 0.57 %, 0.60 %, 0.61 %, 0.65 %, 0.69 %, and 0.81 % at the end of respective storage intervals. Similar results are also reported by Navajeevan and Jayaraj Rao (2005) in Kunda attributed to disappearance of basic amino acids. Titrable acidity of Khoa increased during storage (Kalra et al., 1973). Champak Palit and Dharam Pal (2005) reported that in acidity was more in Burfi samples stored at 30°C. They also reported that the rate of increase in acidity was slower in samples having potassium sorbate as preservative, irrespective of packaging conditions. It is attributed to slower microbial activity.

Prajapati et al. (1986) have reported that increase in acidity in Khoa stored after adding with 30 %, 40 % and 50 % sugar. The acidity in control sample was 0.62 %, LA, and in Nisin added Kunda was 0.62 % and in potassium sorbate added Kunda was 0.61 %. The difference was not statistically significant ($P \geq 0.05$). These preservatives have controlled the increase in acidity due to combined action of sugar and preservatives as Nisin: both bacteriostatic and bacteriocin. The acidity increased due to increase in storage period in control Kunda. The acidity increase in Kunda was statistically significant between storage temperatures of 30°C and 5°C ($P \leq 0.05$) with acidity values of 0.63 % found in 30°C storage and 0.62 % LA in Kunda stored at 5°C.
**Browning Index:**

Browning index is the indication of extent of Brown colour pigments produced during Maillard reaction expressed as optical density (O.D). Browning index is expressed as optical density/gm.

The first step in the Maillard reaction involves the nucleophillic attack by the nitrogen atom of an amino acid compound on the electrophillic carbonyl group of an aldehydes or ketone in food system predominantly between proteins and reducing sugars (Namiki, 1988).

Browning index in Kunda was also estimated during storage at regular intervals. The browning index values decreased from 0.380 to 0.310. the decrease in browning index was not significant (P≥0.05) in preservatives added, temperatures of stage and their interaction except the storage duration. The Browning index decreased significantly with the increase duration. The Browning index in fresh Kunda samples was 0.38, and then decreased to 0.36, 0.35, 0.34, 0.33, 0.32, and 0.30 after respective intervals of storage. The browning index values were 0.33, 0.34, 0.34 respectively in control, Nisin and potassium sorbate added Kunda. The browning index at 30°C and 5°C storage temperatures was 0.34 and 0.35 respectively. There were no significant (P≥0.05) differences between preservatives and storage temperatures are decrease in Browning index.

The decrease in Browning index is attributed to decrease in moisture and water activity. The Maillard reaction products have the ability to prevent peroxide formation. Hence they act as anti oxidants. Namiki (1988) had reported that the antioxidative
activity of Maillard reaction products (MRP) is the action of Melanoidins. Antioxidant activity has been found in selected amino acids. Barry and Marry (1991) have observed that the antioxidative activity was generally higher in casein-glucose than in casein-lactose systems. The relative ability of glucose and lactose to induce antioxidant activity in casein-sugar mixtures depends upon the ratio of casein to sugar with heating of mixture; but not otherwise. The increase in Browning index had been observed in Kunda retort sterilized Kunda stored 37°C and 55°C for about 3 weeks (Navajeevan and Jayaraj Rao, 2005). Gothwal and Bhavadasan (1992a) observed that the rate of increase in browning during storage of Khoa was more in Khoa prepared from cow milk than in Khoa prepared from Buffalo milk at 0, 5, 25 and 30°C storage.

**Bacterial counts (SPC):**

The SPC of Kunda samples stored ranged from 4.37 log10 cfu/gm to 3.74 cfu/gm. The SPC increased initially, and then decreased. The decrease in SPC was significant in all treatments and their interactions. (P ≥ 0.05).

The mean SPC in fresh Kunda was 4.36 log10 cfu/gm, then decreased to 4.30, 4.29, 4.22, 4.18, 4.05 and 3.96 log10 cfu/gm after 7 storage period intervals respectively. The decrease in SPC was significant (P ≤ 0.05). The decrease in SPC was due to increased osmotic pressure and decreased water activity.

When bacterial cells are exposed to high osmotic pressure cells are exposed to high ionic strength environment (low Aw) the water flows out of the cells to maintain
equilibrium increasing the ionic strength inside the cells. Thus the metabolic activity is reduced and at some level it is stopped. (Jayaraj Rao, 2000).

Prajapati et al. (1986) observed that during storage, addition of 40 % and 50 % sugar in Khoa practically prevented the bacterial and fungal growth. Rao et al. (1977) reported that the spore counts at 50°C was relatively linear than that at 300°C. Kalra et al. (1973) have reported that Khoa samples containing Nisin failed to show the presence of any bacteria. This is attributed to the combined bacteriostatic and bacterial properties of Nisin, without comparing characteristics. Champak Palit and Dharam Pal (2005) reported that potassium sorbate containing samples and vacuum packaged did not show any symptoms of spoilage up to 60 days at 30°C.

**Yeast and mold counts:**

Yeast and molds counts (YMC) were initially 4.70 log 10 cfu/gm, and then decreased to 3.0 log 10 cfu/gm after storage period. The decrease in yeast and molds counts was significant in all treatments and then interactions (P≤0.05). The yeast and molds counts in fresh samples were 4.7log 10 cfu/gm, which decreased to 4.70, 4.12, 3.83, 3.67, 3.40, 3.32 and 3.28 respectively after 7 storage intervals. Thus decrease in yeasts and molds counts was due to decrease in water activity. (Table 31)

The potassium sorbate which is an antifungal agent was decreased for counts the preservatives added Kunda had lower yeast and mold counts compared to control. Potassium sorbate Kunda showed 3.94 log 10 cfu/gm at the end of storage similar results are also reported by Rajarajan et al. (2006) who reported that potassium sorbate at 0.3 %
showed lower yeast and mold counts when stored both at 30°C and 5°C. Kunda samples stored at 30°C had significantly higher yeast and mold counts than Kunda stored at 5°C.

5.3.1.2 Sensory characteristics: Sensory evaluation plays critical role in product development. It is one of the simplest analytical tool for monitoring quality at all stages of food product processing, starting from the inspection of incoming raw materials to surveillance of their finished products (Dharam Pal et al., 1995). Texture is basically a sensory attribute received as a response to different kinds of physical and physico-chemical stimuli. Sensory methods are the basis for predicting acceptance by the consumers; but it is a time consuming and less reproducible. Hence the modern texture profile analysis (TPA) which is a combination of two or more texture profile parameters, could be useful in predicting various sensory texture descriptors particularly firmness, crumbliness and chewiness (Patil et al., 1990).

Sensory evaluation of Kunda was done by panel of experienced judges at regular intervals. Results are presented in Tables 28, 30 and 32.

**Colour and appearance:**

Colour and appearance scores ranged from 7.7 in fresh samples to 6.0 in Kunda stored at 30°C for 42 days. The decrease was significant (P≤0.05). The interaction mean of colour and appearance scores were 7.7, 7.55, 7.45, 7.44, 7.34, 7.19 and 7.02 respectively after seven storage intervals. The decrease was significant (P≤0.05). The decrease in browning index and slight decrease in moisture are the reasons attributed for decrease in colour and appearance scores. (Table 32)
The brown colour pigments melanoidins; acts as antioxidants. Namiki (1988) and Barry and Mary. (1991). The nitrogen component of melanoidin is involved, thus it may be decolorized.

Among the preservatives; control samples scored lowest colour and appearance scores of 7.29, followed by 7.42 in Nisin and 7.46 in potassium sorbate preserved. The lowest values of control sample were significantly less (P ≤0.05) but this is not of much practical significance. There was significant decrease in Kunda stored at 30 °C than at 5°C. The storage at 30°C resulted in less moisture than at 5°C. The difference between the treatments was significant (P ≤0.05).

**Flavour:**

Flavour in Kunda is the flavour compounds released due to amino-carbonyl reaction. The typical pleasant rich, nutty flavour is developed due to protein-sugar reaction in suitable conditions. The released flavour compounds increase with the shearing pressure applied on the reactants to release the bound brown compounds( Morales and van Boekel,1991). It was evident that flavour in Kunda manufactured manually had better flavour than Kunda manufactured by machine (Khoa making machine). In Khoa making machine the flavour compounds are not regularly released.

Champak Palit and Dharam Pal (2005) have observed that addition of cardamom has increased flavour in Basundi. They also reported that effectiveness of potassium sorbate as a preservative was found to be more than that of cardamom. Navajeevan and Jayaraj Rao (2005) have observed that at the end of 3 weeks storage, the flavour scores of Kunda were below slightly. Rao *et al.* (1977) reported that acid values increased in Khoa
during storage. It was relatively slower at 5°C than at 30°C. The titrable acidity was related to flavour deterioration. Rajarajan et al. (2006) found that natamycin (0.05%) treated samples of Khoa showed lesser degree of proteolysis and lipolysis when compared to potassium sorbate (0.3%). These samples were acceptable up to 12 days at 30°C and up to 40 days at 5°C.

Flavour scores of Kunda ranged from 7.87 in fresh samples to 5.80 at the end of storage. All treatments and their interactions were significant in decreasing flavour score ($P \leq 0.05$). Flavour scores decreased from 7.87 in fresh Kunda to 7.77, 7.62, 7.54, 7.45, 7.33 and 7.05 after seven intervals of storage respectively. The decrease was significant ($P \leq 0.05$) with increased storage period. The flavour scores in Kunda with preservative Pr-1 was 7.42, in Pr-2 was 7.57 and in Pr-3 was 7.57 respectively. The variation was significant ($P \leq 0.05$). The control samples were having less flavour scores than the treated samples. This may be due to increase in acidity. There was significant ($P \leq 0.05$) difference between storage at 30°C and 5°C in flavour scores. The flavour scores in 30°C storage decreased due to increase in acidity and acid values as reported by Rao et al. (1977).

**Body and texture:**

Body and texture scores of Kundas ranged from 7.83 in fresh samples to 5.9 at the end of storage. The decrease in body and texture scores of Kunda was significant ($P \leq 0.05$). All treatments and their interactions were significant in reducing body and texture scores. Body and texture scores in fresh samples were 7.83, decreased to 7.63, 7.55, 7.45, 7.34, 7.23 and 6.90 after seven intervals of storage. The decrease was
significant (P≤0.05). This may be due to decrease in moisture as well as increased sugar crystallization. There was perceptible sugar saturation. However the samples were acceptable. Body and texture scores between 30°C and 5°C storage was significantly different. 30°C was having lower body and texture scores than at 5°C. This was due to more evaporation of moisture at 30°C during storage. This was in agreement with Rajarajan et al. (2006).

**Overall acceptance:**

Overall acceptance scores of Kunda decreased from 7.80 to 5.0. The decrease was significant (P≤0.05) all treatments and their interactions were significant (P≤0.05) in decreasing the over all acceptance scores of Kunda. Overall acceptance scores decreased from 7.80 in fresh sample to 7.66, 7.59, 7.42, 7.30 and 7.07 after seven storage intervals respectively. The decrease was significant (P≤0.05). This is attributed to decrease in colour or flavour and texture due to decrease in moisture, increased acidity and lactose crystallization.

The overall acceptance scores in Pr-1 was 7.33, , in Pr-2 was 7.55 and in Pr-3 was 7.54. The difference was statistically significant (P≤0.05). The control samples had lower overall acceptance scores due to increased acid values and acidity, lower moisture. The overall acceptability scores between 30°C and 5°C were 7.38, 7.58 respectively. Lowest overall acceptance scores at 30°C were due to more evaporation than at 5°C. This in agreement with Rajarajan et al. (2006) as observed during storage of Khoa.
5.3.2 Effect of packaging materials on characteristics of Kunda

Packaging forms an integral part of food production, marketing and distribution. Today an array of packaging materials and systems are available. Packaging being a means of ensuring safe delivery of milk and milk products in sound condition to the ultimate consumers. There is an intimate relationship between packaging system with product manufacture, storage, transport and marketing.

Traditional dairy products are produced and packaged unhygienically. Development of suitable packaging system is essential for modernization of the traditional dairy products industry. Already packaging systems have been developed for some indigenous dairy products.

Kunda is being produced under unhygienic conditions and packaged in loose LDPE bags. Hence the shelf life of Kunda is less than a week under existing market conditions. An experiment was conducted to check the suitability of LDPE, metalised polyester and aluminium tins for packaging of Kunda. Results are presented in Table-33, 34, 35, 36, 37 and 38 Kunda was packaged in LDPE pouch (P-1), metalised polyester (P-2) and aluminium cans (P-3).

5.3.2.1 Physico-chemical and microbiological characteristics:

Moisture:

Moisture% in Kunda stored for different intervals in different packaging materials ranged from 20.0% in fresh samples to 18.0 % at 30°C after 42 days. There was significant (P≤0.05) decrease in moisture %. The moisture % in Kunda stored for 42 days was 20.01 in fresh sample which decreased to 19.77 %, 19.61 %, 19.20 %, 18.91 %, 18.72 %, 18.53 %, 18.34 %, 18.15 %, 17.96 %, 17.77 %.
% and 18.5 % respectively. The decrease in moisture percent was significant as the duration is increased. Rao et al. (1977) have observed that the samples of Khoa wrapped in parchment paper exhibited an increasing hardness with increase in storage period this was accompanied by a decrease in moisture content.

The moisture % in P-1 was 19.15 %, in P-2 19.25 % and in P-3 it was 19.35 %. The difference in moisture was significant (P≤0.05). Goyal and Srinivasan (1988) reported that a greatest decrease in moisture content of Khoa sample occurred for packaging materials P-3, probably this material was most permeable to moisture vapours. Kumar et al (1975) and Goyal and Srinivasan (1988) have reported that laminates containing aluminium foil provide good protection against moisture losses because of their superior moisture barrier properties. More loss of moisture in P-1 (LDPE) than P-2 (utilized polyester) P-3 (aluminium cans) was observed in this study.

Moisture % in Kunda stored at 30°C was 18.99 % and at 5°C it was 19.50 %. The difference in moisture % was significant (P<0.05). More moisture evaporation at 30°C than 5°C is the cause for difference. Goyal and Srinivasan (1989) observed that Khoa samples packaged and stored at saturated humidity condition (5°C) decrease in moisture was not significant. There was significant effect on decrease in moisture of Kunda due to interaction effect of different packaging materials as well as durations.

**Water activity:**

Water activity of Kunda stored in different packaging materials for different duration decreased from 0.810 in fresh sample to 0.755 in Kunda stored at 30°C after 42 days. The decrease in water activity was significant (P≤0.05). Prajapati et al. (1986) have
observed decrease in water activity of Khoa added with different % of sugar during storage thus reduction in water activity of food products. There was significant decrease (P≤0.05) in water activity due to effect of packaging materials, temperature and duration. The interactions were not significant (P>0.05), P-3 was significantly superior (P≤0.05) to P-1 and P-2; and was least in loss of moisture. The water activity of Kunda stored for intervals decreased from 0.813 in fresh samples to 0.81, 0.807, 0.797, 0.790, 0.781 and 0.770, respectively. The decrease in water activity was significant (P≤0.05) as the duration increased. This is due to evaporation of available water in Kunda.

There was significant difference in water activity of Kunda stored at 30°C (0.788) with Kunda stored at 5°C (0.803). Goyal and Srinivasan (1989) have reported that the saturated relative humidity (100% RH) has not significantly reduce the moisture, irrespective of packaging hence 30°C storage was having less moisture than 5°C. This is in agreement with the observations of Goyal and Srinivasan (1988).

The interactions due to packaging and temperature, packaging and duration were not significant (P≥0.05). Only temperature and duration interactions were significant (P≤0.05). Similar results in Khoa storage has also been reported by Goyal and Srinivasan (1988a, 1989).

**Titrable acidity:**

Acidity of Kunda increased from 0.405 %( LA) in fresh samples to 0.676 %( LA) after 42 days at 30°C. The increase in acidity was significant due to packaging, storage temperatures, durations and their interactions (P≤0.05).
The acidity increased significantly from 0.41% LA in fresh samples to 0.46, 0.48, 0.50, 0.547 0.56 and 0.60 % after 7 intervals respectively. The increase in acidity was due to the action of microorganisms as well as production of organic acids during processing and storage. Similar results are also reported by Goyal and Srinivasan (1988, 1989). Rao et al. (1977) reported that the titrable acidity of Khoa increased upto 0.94 % after 4 days at 30°C, packaged in parchment paper, aluminium foil and polyethylene. Acidity as also increased in Kunda stored in retort pouch (Navajeevan and Jayaraj Rao, 2005).

The increase in acidity was observed in Kunda stored at 30°C (0.54 %LA) than at 5°C (0.49%). There was no significant development of acidity due to both chemical and microbiological changes at 5°C storage. The acidity developed between the packaging was significant. P-1 was having more acidity (0.54%) than P-2 (0.51) and P-3 (0.50). Khoa samples stored in tin cans were having least acidity (Goyal and Srinivasan, 1988).

**Browning index**

Browning index of Kunda ranges from 0.370 in fresh samples to 0.313 after storage. There was significant decrease in browning index during storage (P≤0.05). Browning index of fresh Kunda was 0.371 and it decrease to 0.363, 0.354, 0.348, 0.330, 0.323 and 0.316 after 7 storage intervals. Only storage duration was significant in decreasing the browning index. The brown compounds (melanoidins) are acting as antioxidants. They get oxidized so that the browning index reduced during storage. There was no significant effect on browning index of Kunda due to packaging materials, storage temperature and their interactions. Ravindrakumar et al. (1997) reported that peroxide values of peda package in different packaging techniques did not serve as a reliable
indicator of off flavours development in the multi component system such as peda that consists of protein, sugar and fat. They also reported that there was increase in browning index of peda during storage however the heat treatment in Khoa is less compared to Kunda.

**Bacterial counts**

Bacterial counts of Kunda decreased from 4.60 log$_{10}$ cfu/gm initially to 3.05 log$_{10}$ cfu/gm after storage. The decrease in bacterial counts was significant (P≤0.05) only due to increase in storage period. All other treatments and their interactions were not significant (P≥0.05).

The bacterial counts in P-1 was 4.24 log$_{10}$ cfu/gm, in P-2 was 4.19 and in P-3 was 4.15 log$_{10}$ cfu/gm respectively. The tin can was having less bacterial counts. Goyal and Srinivasan (1989) have reported that flexible packaging is the best in controlling minimum growth of Lipolytic, spores and yeast and molds at 4-5°C storage.

Rao *et al.* (1977) have reported that there was increase in total viable counts at 30°C packaged in different packaging materials. Spore counts of fresh Khoa increased during storage reaching 420/gm at 30°C. The spore count at 5°C was relatively lower than that at 30°C. However the packaging material did not differs significantly in their effect on spore count (P≥0.05). The bacterial counts in Kunda decreased significantly from 4.36 log$_{10}$ cfu/gm in fresh samples to 4.30,4.29,4.22,4.18,4.05 and 3.96 log$_{10}$ cfu/gm respectively after 7 storage intervals. The decrease in bacterial counts was due to decrease water activity where the water activity of Kunda was less than 0.90. The water activity of less than 0.90 is not suitable for growth of bacteria (Sawhney *et al.*, 1997;
Prajapati et al. (1986) have also reported that as the storage period increased, water activity values got decreased which restricted the growth of bacteria. It was found that in our preliminary trials there was no growth of either aerobic or anaerobic spores in Kunda.

The decrease in growth of bacterial was due to increased osmotic pressure. Kunda containing high % of sugar (about 30%). Ionic strength of cytoplasm in all microorganisms has maintained at a level which is optimum for their metabolic activity. This limits the osmotic pressure which determines the flow of water in and out of cell. When bacterial cells are exposed to high ionic strength environment (low water activity), the water flows out of the cells to maintain equilibrium increase in the ionic strength inside the cells. Thus the metabolic activity is reduced and at some level it is stopped (Jayaraj Rao, 2000).

Bacterial counts of Kunda in stored at $30^0C$ was $4.29 \log_{10} \text{ cfu/gm}$ and at $50^0C$ was 4.10. The difference was not significant ($P \geq 0.05$); as the osmotic pressure was limiting factor which is common to both temperatures. $50^0C$ is not having any significant effect on increasing the bacterial counts. The storage interactions were also significant.

**Yeast and molds counts (YMC):**

Yeast and molds are the organisms growing in intermediate moisture foods like Burfi, peda, kalakhand and Kunda suitable water activity for growth of yeast and molds is 0.87 to 0.80. yeast and molds count was higher compare to bacteria. As yeast and molds grow in low water activity than bacteria. Prajapati et al. (1986) have reported that as the storage period increase water activity values got decreased which restricted the growth of
bacteria. They also reported that addition of 40 % and 50 % sugar in Khoa practically prevented bacterial and fungal growth.

The yeast and mold counts of kunda decreased from $4.43 \log_{10} \text{cfu/gm}$ to $4.31, 4.23, 4.16, 4.03, 3.93$ and $3.80$ respectively after 7 storage intervals. The decrease was significant ($P \leq 0.05$). The reasons for this decrease are decrease in moisture per cent and water activity decrease which resulted in increase in osmotic pressure. However in Khoa no sugar is added hence yeast and mold count increased (Rao et al. 1977). Ravindrakumar et al. (1997) also observed that there was decrease in microorganisms population during storage of Khoa.

The yeast and mold counts in P-1 was $4.01 \log_{10} \text{cfu/gm}$, in P-2 was 4.18 and P-3 was $4.19 \log_{10} \text{cfu/gm}$. The difference was significant ($P \leq 0.05$). Goyal and Srinivasan (1988) have reported that the multilayered packaging materials consisting of poster paper / aluminium foil/ LDPE proved to be the best. The other multi layered laminates fared less in checking the growth of microorganisms for poor barrier properties of laminates.

Yeast and mold count at $30^\circ C$ was $4.32 \log_{10} \text{cfu/gm}$ and at $5^\circ C$ was $3.92 \text{cfu/gm}$. Rao et al. (1977) have reported that yeast and mold counts in Khoa increased at $30^\circ C$. The growth of yeast and mold count at $5^\circ C$ was relatively slower than that $30^\circ C$. All interaction of packaging materials, storage temperatures and duration of storage periods were significant ($P \leq 0.05$) in reducing the yeast and mold counts of Kunda.
Coliforms:

As Kunda was manufactured at high temperature for quite long time (more than 100\(^0\)C/45-60 min) there was no any growth of coliforms. Moreover Kunda was hot packaged in the sterilized packaging materials under sterilized conditions hence there was no coliforms count observed in Kunda during storage. Similar results are also reported by Ravindrakumar et al. (1997) in Khoa.

5.3.2.2 Effect of packaging materials on sensory characteristics of Kunda: Sensory evaluation of Kunda was conducted by experienced panel of judges and data is presented in Table 34, 36, and 38.

Colour and appearance:

Colour and appearance scores of Kunda packaged in different packaging materials ranged from 8.50 in fresh samples to 6.50 in after storage. The decrease in color and appearance scores was significant (P<0.05) due to increase in duration. Color and appearance scores in fresh samples was 8.10 which decrease to 7.88, 7.87, 7.81, 7.54, 7.30 and 7.11, respectively after 7 storage intervals. The decrease in colour and appearance was due to oxidation of brown compounds resulted in slight fading of colour. The product slightly dried up due to evaporation of moisture and decreased in colour and appearance scores.

The color and appearance scores of packaging were 7.63 in P-1, 7.70 in P-2 and 7.64 in P-3 respectively. However the difference was not significant (P>0.05). The estimated means color and appearance scores at 30\(^0\)C was 7.68 and at 5\(^0\)C it was 7.63.
The lower color and appearance scores was observed in storage temperatures at $5^\circ$C. The difference was not significant ($P\geq0.05$).

**Flavour**

Flavour of food products deteriorated during storage due to microbial activity and chemical reactions taking place during storage. There are many factors governing the changes in flavours.

Flavours scores of Kunda ranged from 8.50 in fresh samples to 6.10 after storage. The estimated flavour scores means decreased from 8.18 to 8.08, 8.10, 7.62, 7.46, 7.43 and 6.04, respectively after storage intervals. The decrease was significant the decrease was due to production of acidity and other organic acids during storage. Flavour score at $30^\circ$C was 7.77 and at $5^\circ$C it was 7.65. The difference was significant ($P\leq0.05$), it can be attributed to production of flavour compounds at higher temperature ($30^\circ$C) than at lower temperature ($5^\circ$C).

The flavour score of Kunda stored in P-1 was 7.66, in P-2 it was 7.73 and in P-3 it was 7.68 respectively. Flavour score was maximum in metallised polyester packaging (P-2). It has better barrier properties moisture and other flavour compounds. In aluminium cans the available oxygen content might have contributed to growth of aerobes. Similar results were also observed by Goyal and Srinivasan (1989) and Ravinrakumar et al. (1997) in Khoa. The interactions were also significant in reducing the flavour scores of Kunda ($P<0.05$)
**Body and texture:**

Body and texture scores of Kunda ranged from 8.50 in fresh samples to 6.03 at the end of storage. Body and Texture scores decreased significantly as the duration increased. Estimated body and texture scores means were 8.10, 7.92, 7.80, 7.66, 7.45, 7.33 and 6.81, respectively after storage intervals. The reason for decrease in body and texture score was due to loss of moisture and crystallization of sugar. Thus the body and texture score decreased.

Body and texture score at 30°C was 7.87 and at 5°C it was 7.49. The difference was significant (P≤0.05). However lower body and texture score was been awarded to 5°C due to hardening of Kunda during storage.

Body and texture scores of Kunda packaged in P-1 was 7.46, in P-2, it was 7.62 and in P-3, it was 7.67 respectively. The difference was significant (P0.05). Lowest body and texture scores was awarded to P-1has there was more loss of moisture. There is no significance difference in body and texture scores of other packagings (P≥0.05).

**Overall aceptatance:**

Overall acceptance scores of Kunda stored ranged from 8.5 in fresh samples to 6.4 at the end of the storage. The decrease in overall acceptance score was significant (P≤0.05). The overall acceptance score decreased from 8.5 in fresh samples to 8.43, 8.02, 7.82, 7.25, 7.08 and 7.26, respectively after storage intervals. The difference was significance. The reasons are due to decrease in colour and appearance, flavour and body and texture characteristics.
The overall acceptance scores of Kunda stored at 30°C was 7.66 and at 5°C it was 7.42. The difference was significant. The refrigerated storage has decreased the sensory properties was due to hardening and sugar crystallization.

The overall acceptance scores in P-1 was 7.49, in P-2 it was 7.63 and in P-3 it was 7.73. The difference was significant. The lowest overall acceptance scores was awarded to P-1 where there was loss of moisture comparatively more than other packagings. There was not much loss of flavour texture in P-3. Hence, the same has been considered superior because it has better barrier properties than other packaging materials.