6.0 SUMMARY

Indigenous dairy products have not only served as a cultural link with the modern dairy industry, but also are providing technological base for diversification, export promotion and acting as value added products to make the modern dairy industry economically strong.

6.1 Kunda is one of the Khoa based traditional dairy products. The product has characteristic pleasant nutty flavour with brown colour and grainy texture. Kunda is prepared by Halwais under unhygienic conditions. There are no prescribed standard composition and manufacturing technology. Information collected from Belgaum region indicated that market Kunda samples has varied composition. Total solids content varied from 70-83 %, fat from 9-17 %, and sucrose from 26-51.2%. Many times, the product is kept in open tray and packaged in loose LDPE bags in the market. The shelf-life of Kunda is about 4 days at 30°C. The spoilage was observed to begin with visible growth of yeasts and moulds. Hence, there was a need for development of technology for method of manufacture with respect to composition and characteristics.

The manufacturing process was optimized in relation to type and composition of milk, sugar level, extent of heat treatment, effect of homogenized milk and use of caramelized sugar in manufacture of Kunda. Selection of suitable preservatives and packaging materials to extend the shelf life at 30 °C and 5°C was also studied.

6.2 Since Kunda making requires prolonged desiccation, influence of extent of desiccation on the product quality was studied. Khoa was prepared from fresh standardized cow milk (5.0 per cent fat and 8.5 per cent SNF) with addition of 9.0 per
cent sugar (on milk basis). Potable water was added @10 to 15 per cent to make slurry. The mixture was boiled vigorously to Khoa consistency. The dilution and desiccation was repeated for 8 times till typical brown colour Kunda was obtained.

Moisture percent in Kunda were 20.13, 19.49, 19.66, 19.32 and 20.36 per cent after 0, 2, 4, 6 and 8 desiccations respectively. Browning index significantly increased (P≤0.05) after 2nd desiccation. There was no visible browning in 0 and 2 desiccations due to “induction period “in Maillard reaction. Colour and appearance scores increased significantly (P≤0.05) as desiccations progressed, the values being 5.0, 5.7, 5.9, 6.8 and 7.6 after 0, 2, 4, 6 and 8 desiccations, respectively. Flavour, body and texture as well as overall acceptance scores also increased significantly as the desiccation progressed.

6.3 Effect of Cow milk and buffalo milk and their proportions on Kunda quality was studied. Kunda prepared from standardized buffalo milk (6.0% fat and 9.0% SNF) was found with abnormal grain size, and dull brown colour. Cow milk Kunda was brown in colour but had hard texture (caking). Grainy texture of Kunda is due to temperature-induced aggregation of caseins and whey proteins. Buffalo milk containing higher proportions of calcium, phosphorus and citrate than cow milk resulted in faster precipitation of calcium phosphate on to the casein micelles along with whey proteins and lactose, forming loose matrix. Cow milk formed comparatively compact smooth and pasty body.

To solve above defects in buffalo milk Kunda, milk was simmered during Khoa making stage itself; then vigorously boiled and desiccated 8 times to get optimum Kunda characteristics. Further to solve compact texture problem in cow milk Kunda,
standardized cow milk (5.0% fat and 8.5 % SNF) and buffalo milk (6.0 % and 9.0 % SNF) was admixed in different proportions (25:75, 50:50, and 75:25) and Kunda was prepared. Hence, simmering of standardized, mixed cow and buffalo milk (50:50) during Khoa making stage resulted in smooth textured, brown colored, nutty pleasant flavoured Kunda.

6.4 Temperature is one of the important factors influencing Maillard reaction. Manufacture of Kunda requires high heat treatment for long time for development of typical Kunda attributes. Temperature > 100°C has significant influence on browning than <100°C. Steam pressure > 1.0 to 2.0 kg/sq.cm is equivalent to 120°C. Kunda prepared at above steam pressure (Khoa to Kunda stage) was awarded better sensory scores in colour and appearance (7.9), flavour (7.8), body and texture (8.2) and overall acceptance (8.0). Therefore, steam pressure of 1.0 to 2.0 kg/sq.cm is recommended for manufacture of Kunda.

6.5 Sugar is the most important ingredient of sweet food products. Khoa based sweets are normally added with 7.0 per cent sugar on milk basis. However, Kunda requires higher amount of sugar to neutralize the acidity produced due to production of organic acids during desiccation. Kunda prepared with 9.0 per cent sugar obtained maximum sweetness score than the product prepared from milk with 7 or 11 per cent sugar.. However, higher amount of sugar was not significant in increasing browning index. Higher sensory scores was awarded to 9.0% sugar level with 8.0, 7.7, 8.8, 8.0 and 8.8 for sweetness, colour and appearance, flavour, body and texture and overall acceptance respectively.
6.6 Many factors influenced Kunda characteristics i.e. extent of desiccation, type and composition of milk, extent of heat treatment, moisture content and sugar levels. The optimized process for Kunda manufacturing was “simmering of mixed standardized cow and buffalo milk in 50:50 ratio in Khoa kettle with due scraping and agitation to obtain Khoa. Khoa is mixed with sugar @ 9.0 per cent on milk basis. Add 10-15 per cent potable water to make slurry. Then desiccate with scraping and agitation to ‘pat’ consistency at steam pressure of 1.0 to 2.0 kg/sq.cm. The dilution and desiccation was repeated 8 times to get typical Kunda.

Kunda obtained by above method had standard composition of 80.42 per cent total solids, 28.78 per cent sucrose, 17.78 per cent fat, 14.56 per cent proteins, 16.74 per cent of lactose and 2.56 per cent of minerals. Kunda prepared from optimized process was having pleasant nutty flavour, brown colour and grainy texture.

6.7 Flavour of Kunda is developed during desiccation of protein-sugar mixture under suitable conditions. Many flavours are developed due to Maillard reaction: carbonyls are prominent among volatile flavours produced due to break down of fat, proteins and sugars during desiccations. Total carbonyls production expressed as O.D. significantly increased with increasing desiccations.

6.8 Kunda manufacturing requires lot of heat energy. Significant amount of heat energy is also lost during Kunda making. About 35.50 per cent of total energy is lost during Khoa making. In this regard energy saving is important without large investment.
Addition of caramel sugar reduced the desiccation from 8 to 4 times, during Kunda making. Careful controlled caramelisation produces pleasant flavours with browning in caramelized sugar. Addition of sugar @ 40 per cent in caramelized form (T-2) had resulted in reduction of processing time from 68.33 min in control to 35 min. The best sensory scores colour and appearance (8.2), flavour (8.5), body and texture (8.5) and overall acceptance (8.5) were awarded to this product.

Addition of caramelized sugar had reduced the heat energy required for desiccations. Heat energy lost in condensate was estimated. The quantity of condensate collected was 3.761 kg/kg of Kunda in T-1 and 2.750 kg/kg in T-2 respectively. The net energy consumption (kJ/kg) has been estimated as 8262.61 kJ in T-1 and 6038.99 kJ in T-2. The number of desiccations required in T-2 has been reduced to 4 from 8 in control (T-1). There was 26.91 per cent saving in heat energy requirement in caramelized sugar added Kunda. Forty per cent caramelisation produced best Kunda with better sensory attributes.

6.9 Additives are added during processing for improvement in functionality; freshness or as a processing aid. Phosphates and citrates originally exert an opposite action to that of calcium and magnesium decreasing the effect of coagulation by calcium and magnesium ions. Therefore there was dispersion and hydration of proteins. Thus, Kunda prepared from disodium phosphate and trisodium citrate was pasty in consistency. Increase in pH from I.E.P of protein increases the browning during Maillard reaction. There was significant differences between treated (0.10 per cent additive) and control Kunda samples (P≤0.05). The browning index was 0.185, 0.190, 0.190, 0.195 and 0.195 at 0.05.
and 0.10 % of DSP and TSC respectively. Treated Kunda was awarded significantly lower sensory scores (P≤0.05). Hence, addition of DSP and TSC was not suitable for Kunda making.

6.10 Homogenisation of milk is the process of treatment applied to milk to ensure break-up of fat globules. Homogenization causes significant changes in milk fat globules, whereby surface area is increased enormously. Homogenization of whole milk increased the dispersion of casein (1:500) with changes in caseins attachment. Caseins are attracted on milk fat globule membrane by “Van der waal” forces.

There was adverse effect of homogenization of milk on attributes of Kunda. There was little brown colour formation in Kunda made from homogenized milk. The texture was powdery (chalky). All sensory characteristics were changed due to homogenization. Browning index decreased to 0.05 in Kunda prepared from whole milk homogenized at high pressure in absence of sugar, from 0.3 in control. Homogenisation of either type of milk (whole and skim milk) with or without addition of sugar at low or high pressure did not produce enough brown colour. There was little Maillard reaction in homogenized milk Kunda as the essential conditions were not met (equimolar concentration of n-terminal ε-amino acids and free reducing sugar due to changes in ruptured casein attachment in homogenized milk).

Colour and appearance scores of Kunda decreased from 7.80 in control to 4.5 in Kunda made from whole milk; high pressure: with sugar addition. This was due to lack of sufficient non-enzymatic browning in homogenized milk Kunda. Flavour scores of Kunda decreased from 8.03 in control Kunda to 5.13 in whole milk; high pressure:
without sugar addition. This was also due to non-production of casein-carbohydrate reaction flavours during desiccations.

Body and texture scores of Kunda decreased from 7.00 in control Kunda to 5.17 in whole milk: low pressure: without addition of sugar. Homogenized milk Kunda was chalky in texture due to rupture of casein during homogenization. The chalky texture increased with increased pressure. Addition of sugar before homogenization had reduced the body and texture scores (6.34) compared to after homogenization (6.61). Overall acceptance scores decreased from 8.02 in control to 5.20 in whole milk; low pressure: with addition of sugar.

6.11 Food additives that are added specifically to prevent the deterioration or decomposition of food products have been referred as chemical preservatives. Preservatives may inhibit microorganisms by interfering with their cell membranes, their genetic mechanism and metabolite activity. Potassium sorbate and nisin were added to hot Kunda @ 2000ppm and packaged in LDPE pouches by electric impulse sealing machine. These samples were stored at 30°C for 0, 7, 14, 21, 28, 35 and 42 days and also at 5°C for 0, 15, 30, 45, 60, 75 and 90 days. It was observed that there was decrease in moisture content of Kunda during storage irrespective of storage temperature. Moisture per cent of Kunda decreased from an initial value of 20.02 to minimum of 17.90% after 42 days of storage at 30°C and 18.0% at 5°C after 90 days. It was due to evaporation of moisture during storage.

Titrable acidity in fresh Kunda was 0.55% lactic acid. It increased significantly to 0.81% after storage at 30°C for 42 days in control Kunda and 0.69 at 5°C after 90 days.
(P≤0.05). It was due to production of organic acids during desiccation. The pH of milk also decreases on heating due to release of H\(^+\) ions consequent upon the precipitation of calcium phosphate and formation of acids from lactose. The preservatives had no significant effect on reduction of acidity of Kunda during storage. The browning index decreased from 0.376 OD in fresh samples to 0.310 OD in stored samples at the end of storage. It may be due to antioxidant activity of Maillard reaction products (melanoidins).

Kunda contains high percent of sugar, which acts as natural preservative and also increases osmotic pressure so that microbial growth is controlled. In Kunda samples stored with nisin, the bacterial counts decreased. SPC was 4.37 log\(_{10}\) cfu/gm in the beginning and it decreased to 3.74 log\(_{10}\) cfu/gm after 42 days at 30°C. The decrease in bacterial counts was due to increased osmotic pressure. Yeast and mould counts decreased from 4.60 log\(_{10}\) cfu/gm in the beginning to lowest 4.01 log\(_{10}\) cfu/gm in samples stored with potassium sorbate at 30°C.

Colour and appearance scores of Kunda decreased from 7.70 to 6.0 at the end of storage due to loss of moisture. Flavour scores also decreased from 7.85 in fresh sample to 5.8 in Kunda stored at 30°C after 42 days. Control Kunda was awarded less flavour scores due to microbial activity. Body and texture scores decreased due loss
moisture during storage. Overall acceptance scores also decreased during storage.

6.12 Kunda is produced under unhygienic conditions by halwais. No suitable packaging system has been developed. Market Kunda has shelf-life of <1 week under ambient conditions. There was decrease in moisture in LDPE stored Kunda due to water vapour permeability. Titrable acidity increased from 0.41 to 0.68 % during storage. There was significant decrease in bacterial counts during storage (P≤0.05). Similar decrease in SPC and YMC was observed in these studies also. The reason was also due to increased osmotic pressure.

There was no growth of coliforms found in products with respect to both preservative and packaging materials studies. High temperature treatment during manufacturing and packaging under sterile conditions are the reasons for the same.

The sensory scores also decreased due to loss of moisture and development of acidity during storage. Colour and appearance score decreased because of slight fading off of colour due to antioxidant action of browning compounds. However, Kunda was acceptable at the end of storage period studied both at 30º C and at 5º C.
CONCLUSION

Brown colour is the desirable characteristic of Kunda. Development of brown colour depends upon extent of desiccations. Brown colour in Kunda is produced during desiccations due to Maillard reactions. Depending upon intensity of heating, the browning index increased significantly after “4” desiccations. It was found that ‘8’ desiccations are necessary to produce desirable light colour. Slow boiling of buffalo milk (simmering) during Khoa making and vigorous boiling during Kunda making reduced abnormal grains size. Mixing of standardized cow milk and buffalo milk in equal proportions produced uniform grainy texture, sweet nutty favour Kunda.

The development of brown colour is an obvious feature of advanced Maillard reaction. Maillard is linearly proportional with increase desiccation temperature (>100° C), which produce appetizing flavours and appealing colour. Steam pressure of 1.0 to 2.0
kg.sq. Produced Kunda with optimised characteristics. Nine per cent sugar level was adjudged as best for Kunda sweetness.

Kunda manufacturing requires lots of heat energy due to repeated desiccations. 26.91% of steam utilization was saved by using 40% caramel sugar. The number of desiccations was reduced from ‘8’ in control kunda to ‘4’ in 40% caramel sugar Kunda. The steam utilization was reduced to 9.17 kg/kg of Kunda in 40% caramel sugar as against 12.53 kg/kg of product in control. Addition of TSC and DSP > 0.05% attributed to pasty texture Kunda.

Homogenisation of milk with or without fat and sugar did not produce brown colour as there was no maillard reaction. The essential requirement for maillard reaction was not met, necessary equimolar concentration of ε-amino acids and free reducing sugars were not available. Homogenisation of milk produced chalky (powdery) texture Kunda.

There was decrease in bacterial counts as well as yeasts and molds counts significantly during storage due to increase in osmotic pressure of organisms. The bacterial population decreased in nisin added Kunda as well yeasts and molds counts in potassium sorbate added Kunda. Kunda could be stored safely for > 42 days at 30°C. Aluminum cans and metalised polyester packaging are the best suitable for their barrier properties. Coliforms counts were not observed in Kunda as the product was warm packed under sterile conditions.