CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

Need for the study: In India, surplus milk in the rural areas where it is produced has been converted into a variety of traditional products primarily as a means of preservation. Traditional dairy products and sweets are an integral part of Indian heritage and have great social, religious, cultural, medicinal and economic importance [107]. Indian dairy sweets are largely made from two base materials Chhana and khoa [14]. Among these food items, jalebi is one such product prepared and consumed with much interest. It is mainly prepared by halwais and packaged in thin polyethylene pouches or paper boxes or plastic boxes and sold in retail market [102]. Government of India lays emphasis on promoting indigenous technologies and encourages patent protection lest these valuable technologies are stolen and projected as original in other parts of world. Jalebi preparation technology is well known and has undergone several changes and optimized over a period of time [10]. Though the market of variety of traditional dairy sweets is widespread in India, they have not been commercialized due to predominance of non standardized production procedures in unorganized sector and constraints regarding their shelf life [14]. Hence this study was successfully carried out by finalizing standardized procedure for Chhana jalebi production and shelf life was enhanced for the same by using preservatives, different packaging materials and techniques.

Optimized process of Chhana jalebi production: Chhana jalebi was manufactured based on the optimized specifications of individual processing parameters. The optimized process includes preparation of Chhana from 3% fat level milk, mixing of Chhana with equal quantity of hydrated maida, baking soda (0.25%), corn flour (4%) and water to form a smooth and uniform consistency batter. The well kneaded batter was extruded through an aperture of soft PET bottle to give a coiled shape. Extruded batter coils were fried in hot refined sunflower oil for deep frying at 160-170°C for 2 min. Sugar syrup was prepared by boiling 1:1 ratio (v/v) of sugar and water. The fried products were then soaked in sugar syrup with 68°Brix for 2 min at 60°C.
Characteristics studies of Chhana jalebi: After the production of optimized Chhana jalebi it was analyzed for various physical characteristics. It consists of 2 coils with diameter of each coil being 0.81±0.09. The diameter of each jalebi unit was 6.51±0.48. Weight of each Chhana jalebi unit before soaking in sugar syrup after frying was 5.1±0.22 g, whereas after soaking in sugar syrup each unit of Channa jalebi weighs 5.1±0.22g. Titratable acidity was found to be 0.310±0.01 expressed as % of lactic acid and pH of Chhana jalebi was 5.05±0.07. It shows that Chhana jalebi sample was acidic in nature.

The proximate composition values of total carbohydrate, protein, fat, moisture and ash content of jalebi were 67.11%, 5.71%, of 12.53%, 20.23% and 0.29% respectively. It shows it had high protein and fat content. The average water activity was 0.825±0.002. Though samples were deep fried and soaked in sugar syrup, this water activity level influences the growth of yeast and mold on the product. The mean value of L*, a* and b* were 51.04±1.47, 10.35±0.29 and 29.97±2.66 respectively. It indicates that the sample was bright golden yellow in colour. The average mean value of hardness, fracturabilty, cohesiveness, adhesiveness, springiness, chewiness and gumminess were 0.028 ± 0.003 N, 1.38±0.584, 0.438±0.109, -0.012 ± 0.008 Ns 0.694 ± 0.101, 0.008±0.003 and 15.82±1.416 respectively. The final product was crispy with porous core, slightly juicy with syrup oozing out when chewed and fracturability that is brittle in nature.

Sensory and microbial characteristics of standardized Chhana jalebi: Sensory characteristics such as color and appearance, flavor, body and texture, overall acceptability of standardized Chhana jalebi was ‘liked extremely’ since scores of all characteristics was 8.5 and above out of 9. The Chhana jalebi had a standard plate count (SPC) of 3.26 log_{10} cfu/g and yeast and mold (YM) count of 0.41 log_{10} cfu/g. Presently, there is no microbiological standard for the products like jalebi; however for Chhana (material used for Chhana jalebi preparation) standards are available. In this regard, the results obtained in this study may be helpful for the formulating microbiological standards for the jalebi in future.

Storage studies of Chhana jalebi – shelf life enhancement by preservatives: Chhana jalebi was manufactured based on optimized process. It was observed that Chhana jalebi packed in LDPE pouch without preservative could stay with good
condition and quality up to 4 days at room temperature (28±2°C), whereas it was 15 days at refrigerated temperature (4±2°C). In order to enhance the shelf life, a commonly used and permitted class II preservative viz., potassium meta-bi-sulphate, sodium benzoate and potassium sorbate were used. They were dissolved in sugar syrup at different concentrations. Potassium meta-bi-sulphate was eliminated from further studies since it was shown less shelf life than other two preservatives. Sodium benzoate had shown minimum 10 days shelf life in 300 ppm concentration, whereas potassium sorbate shown 14 days in 800 ppm concentrations. However, sodium benzoate and potassium sorbate treated samples shown 28 days and 60 days respectively at refrigerated temperature (4±2°C) in the same concentrations. Hence, among these two preservatives, potassium sorbate was given high impact and selected for further investigation on the shelf life of Chhana jalebi.

**Effect of packaging materials on changes in sensory attributes of Chhana jalebi during storage:** Four different packaging materials such as polystyrene cups covered with aluminum foil, cardboard box lined with butter paper, low density polyethylene and metalized polyester were used to increase the further shelf life of product. These packaging materials were sterilized by exposing to UV light for 45 min before packaging Chhana jalebi. About 20 g Chhana jalebi was packed in each packaging materials and stored at both ambient (28±2°C) and refrigerated temperatures (4±2°C). At the interval of every alternate day the packets were cut opened and evaluated for sensory acceptance. Sensory scores were gradually decreased during storage irrespective of packaging material used. These scores remained within the acceptable range of 6.5 and above up to 4 days of storage at room temperatures (28±2°C) for all four packaging materials. However, scores of high barrier packaging materials such as LDPE and metalized polyester scores were high with compared to low barrier packaging materials. Hence it was understood that, high barrier packaging materials had shown less deteriorative effect on jalebi. Similarly it was observed 20 days of shelf life at refrigerated temperatures (4±2°C) for all four packaging materials.

**Effect of packaging material with preservative on quality attributes of Chhana jalebi during storage - Changes in physico-chemical characteristics:** There were changes in the physico-chemical characteristics of the jalebi during storage. Decreasing trend was observed in pH and water activity of the jalebi with increasing storage period. The rate of decrease in pH was more rapid in polystyrene cups covered
with aluminum foil packed samples followed by cardboard box lined with butter paper, LDPE pouch and metalized polyester. Similarly, the rate of decrease in water activity as more rapid in polystyrene cups covered with aluminum foil packed samples followed by metalized polyester, LDPE pouch and cardboard box lined with butter paper. End of 30\textsuperscript{th} day, the pH was observed not less than 5.10 and water activity was not less than 0.827 in all packaging materials packed samples.

Tyrosine and peroxide value showed a gradual increase during storage period. The rate of increase of tyrosine and peroxide value in polyester cup and cardboard box lined with butter paper was less as compared to LDPE pouch and metalized polyester sample. Tyrosine and peroxide value of polyester cup and cardboard box lined with butter paper samples varied from initial value of 3.00 and 0.35 to 35.40 mg /100 g of product and 2.80 ml / g of product respectively during 30 days of storage.

**Changes in microbial characteristics:** The total bacterial, yeast and mold count was found to increase with increase in storage time. End of 20\textsuperscript{th} day, metalized polyester packed samples (SPC - 4.62 \log_{10} \text{ cfu/ g}; YM - 0.88 \log_{10} \text{ cfu/ g}) had less bacterial, yeast and mold count followed by LDPE pouch, polystyrene cups covered with aluminum foil and cardboard box lined with butter paper (SPC - 6.51 \log_{10} \text{ cfu/ g}; YM - 1.67 \log_{10} \text{ cfu/ g}). During 30\textsuperscript{th} day, the bacterial, yeast and mold count was found high in all the samples and spoiled due to contamination from packaging system and environment.

**Changes in sensory score:** The sensory scores decreased during storage. The sensory scores of all packaging material samples remained acceptable up to a storage period of 20 days (overall acceptance score 6.5 – 6.69). After 20 days the overall acceptance scores were unacceptable limits because of off flavours caused by proteolysis and oxidation.

**Effect of modified atmosphere and vacuum packaging with preservative on quality attributes of Chhana jalebi packed in LDPE pouch during storage:** Modified atmosphere packaging techniques was carried out by using two gases namely N\textsubscript{2} and CO\textsubscript{2} in three different conditions such as 100\% N\textsubscript{2}, 100\% CO\textsubscript{2} and 50\% N\textsubscript{2} with 50\% CO\textsubscript{2}. Vacuum packaging technique was also done for LDPE.
Changes in physico-chemical characteristics: Decreasing trend was observed in the pH and water activity while storage period increases. The rate of decrease in pH was more rapid in 50% N₂ with 50% CO₂ followed by 100% N₂, 100% CO₂ and vacuum packaging techniques. The sample pH was decreased not less than 5.01 and water activity was 0.725 for all the samples during storage period of 40 days at 28±2°C. The rate of decrease in water activity was more rapid in 100% CO₂ followed by 50% N₂ with 50% CO₂, 100% N₂ and vacuum packaging techniques.

Increasing trend was observed in the peroxide and tyrosine value while storage period increases. Rate of increase was higher in 50% N₂ with 50% CO₂ followed by 100% N₂, 100% CO₂ and vacuum and packaging techniques. Peroxide and tyrosine values were increased not more than 0.59 ml/g and 10.7 mg/100g respectively for all the samples during 40 days of storage at 28±2°C.

Changes in microbial characteristics: The total bacterial, yeast and mold count was found to increase with increase in storage time. End of 40th day, 50% N₂ with 50% CO₂ (SPC – 4.92 \log_{10} \text{ cfu/g}; YM – 1.05 \log_{10} \text{ cfu/g}) 100% N₂, 100% CO₂ and vacuum and packaging techniques stored at 28±2°C.

Changes in sensory characteristics: There was gradual declining trend in sensory scores as indicated by the statistical means of the storage periods (P<0.05). The sensory scores of the product were retained well (6.5 and above) up to 30 days of storage irrespective of the packaging techniques without any preservatives whereas 800 ppm potassium sorbate treated samples had given 40 days in LDPE. The effect of the gas flushing and the interval of storage on overall acceptability of Chhana jalebi were found significant (P<0.05).

Changes in textural characteristics of Chhana jalebi packed in LDPE with MAP during storage: In the present study, a gradual increase in hardness of all Chhana jalebi samples irrespective of the packaging techniques was observed. The increase in hardness of all Chhana jalebi samples during storage could be attributed to the decrease in moisture content. The adhesiveness values of 100 % N₂ samples showed rapid increase from initial value of -5.65 to -4.38 Ns after 50 days storage. It was found that the samples packaged in LDPE with showed rapid increase in cohesiveness from initial value of 0.53 to 0.61 towards the end of 50 days storage followed by 50% N₂ + 50% CO₂. This increasing trend in gumminess and chewiness in all jalebi samples during
storage could be attributed to increase in hardness and cohesiveness and gumminess and springiness values respectively. All the LDPE packed jalebi samples showed an increasing trend in hardness, springiness, cohesiveness, and chewiness during storage but the rate of increase varied in all packaging techniques. The rate of increase was more rapid in LDPE with 100% CO₂ compared to 100% N₂ at 50 days of storage.

**Effect of modified atmosphere packaging with preservative on quality attributes of Chhana jalebi packed in metalized polyester during storage:** Modified atmosphere packaging techniques was carried out by using two gases namely N₂ and CO₂ in three different conditions such as 100% N₂, 100% CO₂ and 50% N₂ with 50% CO₂. Vacuum packaging technique was also done for metalized polyester.

**Changes in physico-chemical characteristics:** Decreasing trend was observed in the pH and water activity while storage period increases. The rate of decrease in pH was more rapid in 50% N₂ with 50% CO₂ followed 100% N₂, 100% CO₂ and vacuum packaging techniques. The sample pH was decreased not less than 4.81. In case of water activity 100% CO₂ packed samples was observed more rapid decrease followed by 50% N₂ with 50% CO₂ and 100% N₂. Water activity was decreased not less than 0.634 for all the samples during storage period of 60 days at 28±2°C.

Increasing trend was observed in the peroxide and tyrosine value while storage period increases. Rate of increase was higher in vacuum followed by 100% CO₂, 100% N₂ and 50% N₂ with 50% CO₂ packaging techniques. Peroxide and tyrosine values were increased not more than 0.7 ml/g and 12.5 mg/100g respectively for all the samples during 60 days of storage at 28±2°C.

**Changes in microbial characteristics:** The total bacterial, yeast and mold count was found to increase with increase in storage time. End of 60th day, vacuum (SPC – 6.26 log₁₀ cfu/g; YM – 1.54 log₁₀ cfu/g) followed by 100% CO₂, 100% N₂, 50% N₂ with 50% CO₂ stored at 28±2°C.

**Changes in sensory characteristics:** There was gradual declining trend in sensory scores as indicated by the statistical means of the storage periods (P<0.05). The sensory scores of the product were retained well (6.5 and above) up to 30 days of storage irrespective of the packaging techniques in metalized polyester without addition of preservative whereas 800 ppm potassium sorbate treated samples had given 60 days.
The effect of the gas flushing and the interval of storage on overall acceptability of Chhana jalebi were found significant (P<0.05).

**Changes in textural characteristics of Chhana jalebi packed in metalized polyester with MAP during storage:** An increasing trend in textural characteristics of Chhana jalebi samples packed in metalized polyester with MAP during storage was observed. The hardness was increased from 1.41 to 2.24, 2.45 and 2.16 respectively for 100% N\textsubscript{2}, 100% CO\textsubscript{2} and 50% N\textsubscript{2} + 50% CO\textsubscript{2} at 60 days of storage. This increasing trend in gumminess and chewiness in all jalebi samples during storage could be attributed to increase in hardness and cohesiveness and gumminess and springiness values respectively. All the samples showed an increasing trend in hardness, springiness, cohesiveness, and chewiness during storage but the rate of increase varied in all packaging techniques. All textural characteristics were shown increasing trend in metalized polyester packed with 100% CO\textsubscript{2}, 100% N\textsubscript{2} followed by 50% N\textsubscript{2} + 50% CO\textsubscript{2} at 60 days of storage.

**Shelf life of all packaging materials:** Based on observations, it was concluded that Chhana jalebi treated with 800 ppm of potassium sorbate packed in LDPE pouch, metalized polyester, polyester cups and cardboard box lined with butter paper and stored at ambient temperature (28 ±2°C) showed 20 days of shelf life. Similarly, LDPE and metalized polyester pack filled with 100% N\textsubscript{2}, 100% CO\textsubscript{2}, 50% N\textsubscript{2} and 50% CO\textsubscript{2} and vacuum treated samples had shown shelf life of 40 and 60 days respectively at ambient temperatures (28±2°C). Based on the chemical and microbial analyses, metalized polyester with 50% N\textsubscript{2} & 50% CO\textsubscript{2} was found as more suitable for packing Chhana jalebi samples to store at ambient temperatures. Vacuum packed samples became crumpled and after cutting open the packets Chhana jalebi samples were found with compressed appearance, ruptured the coils and oozed out sugar syrup. Hence, it is concluded that vacuum packaging treatment was not suitable for Chhana jalebi though it shows higher shelf life.

**Cost analysis study:** Cost of production of Chhana jalebi per kg was calculated as Rs. 534/-. 
6.2 CONCLUSION

Chhana jalebi production process was standardized based on optimized parameters. This study confirmed that, the standardized product was suitable for human consumption through physico-chemical, microbial, textural and sensory characteristics. This study also attempted to improve shelf life of the product with the interventions of preservatives, packaging materials and techniques. This study reveals that, potassium sorbate was the best suitable preservative for Chhana jalebi. Similarly, metalized polyester with 50% N₂ and 50% CO₂ gas combination packaging method along with preservative was given best improved shelf life i.e. minimum 60 days for the product. Cost of the product was achieved as Rs. 534 per kg which is on par with other milk sweet products in the market. Hence it is concluded that, standardized Chhana jalebi was suitable in all the ways for commercialization through industrial mass production.

6.3 RECOMMENDATIONS FOR FUTURE STUDY

There are varieties of cultural based indigenous products available in India and other countries in the world. Since there is very limited standardized method of production procedure and shelf life enhancement technologies, they have started disappearing from the new generation families and new markets. Hence it is suggested that, research on such products could be undertaken to standardize them with improved shelf life so as to carry them to the new generation families. Moreover, automated machineries could also be developed in order to increase the volume of production, through which cost of production could be reduced.