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Geo Thomas
Food Safety Officer, Ernakulam, Kerala, India

Adarsh M Kalla
Assistant Professor, Dairy Science College, Kalaburagi, Karnataka, India

Corresponding Author:
Geo Thomas
Food Safety Officer, Ernakulam, Kerala, India

Effect of storage on physico-chemical and textural characteristics of *malai*

Geo Thomas and Adarsh M Kalla

Abstract
Malai is an indigenous fat rich dairy product which is used in the manufacture of various products as well as for direct consumption. The present study was conducted with the aim to understand the physicochemical changes of *malai* during storage and its impact on the textural properties of *malai* by recording changes occurring during the storage period. The production process was standardized based on the quality and yield obtained; the maximum yield of *malai* was obtained at 90 °C temperature of heating the milk, holding at that temperature for 50 minutes and allowing *malai* formation till a cooling temperature of 30 °C was attained. The *malai* produced was evaluated for sensory and textural attributes. Based on the observations of the sensory panel members, it is stated that *malai* should have a typical yellowish colour, a rich nutty aroma and a soft, granular texture which imparts a flaky mouth feel. The *malai* prepared using the standardized conditions obtained highest sensory acceptance scores. It was observed that the *malai* could be stored at 5±1 °C for 18 days with satisfactory acceptance. Significant changes were observed on the physicochemical properties during storage and corresponding changes were observed in the textural attributes.

Keywords: *Malai*, physico chemical properties, textural attributes

Introduction

It is widely observed that when milk is heated and then cooled at lower temperatures, a layer known as milk skin forms on the surface. This milk skin is the fatty portion of the milk. The process of heating causes the whey proteins to denature, along with casein and some air, making them lighter and causing them to rise to the surface. The fat globules also rise to the surface and become trapped within the denatured proteins. As the surface layer comes into contact with cooler air, it solidifies, resulting in the formation of a layer known as "*malai*." In India, "*malai*" is a term used not only to describe the product itself but also as an adjective meaning "rich in fat and taste." While scientific research on this phenomenon is limited in India, other countries have conducted studies on a similar product known as clotted cream. *Malai* finds its application in numerous household culinary dishes, particularly in the creation of traditional Bengali sweets. It serves as a crucial ingredient in the making of various traditional Indian products like Basundi, Rabri, and Khurchan. Ideally, *malai* should possess a distinctive golden yellowish hue accompanied by a rich, nutty flavor. Additionally, it should exhibit a characteristic granular texture. *Malai* can be consumed directly, often with the addition of sugar, or incorporated into other sweet preparations as mentioned earlier. Some individuals also enjoy adding *malai* to their tea. Its popularity stems not only from its sumptuous taste but also from its firm yet soft and chewy consistency.

The production of *malai* is primarily carried out by the unorganized sector, specifically "halwais." Unfortunately, there is a lack of emphasis on hygienic practices during the manufacturing process and the proper packaging of the product. Another challenge faced in selling *malai* on a larger scale is its limited shelf life. Currently, there is no scientific data available regarding the phyisico chemical properties and textural characteristics of *malai*. In contrast, there is a wealth of scientific information available for its Western counterparts, such as clotted cream and kaymak, documented by researchers like Sadlep, (1917) [11]; Chapman, (1953) [3]; Dozet and Stanisic, (1983) [6]; Cakmakci and Hayaloglu (2011) [2].

Thus, a systematic technical study is needed to be carried out on this traditional product. Hence, this study has been taken up to understand about the physicochemical changes during storage and corresponding changes in the textural attributes of *malai*.

Materials and Methods
Materials
Fresh cow milk was obtained from Livestock Research Centre of ICAR-National Dairy Research Institute, Southern Regional Station, Bengaluru. Packaging material *viz.* polystyrene containers were obtained from local market in Bengaluru. Analytical grade (AR) chemicals were procured from firms like RANKEM, SD Fine Chemicals Ltd and NICE chemicals Pvt Ltd were used in the physico-chemical analysis.

Methods
Textural attributes changes during storage

To analyze the texture of *malai* samples, a Texture Analyser (TA-XT plus, Stable Micro Systems, Surrey, UK) was employed. The firmness and consistency of the samples were determined using force-time curves, where the force experienced by the probe was plotted on the Y-axis and time on the X-axis. An aluminum P/25 probe was used for the analysis. The *malai* sample, tempered at 20 °C, was placed in a 50 ml beaker positioned centrally over the platform. The probe penetrated the sample to a depth of 10 mm and then returned to its original position, generating a "Force-Time curve." The height of the force peak in Newton was measured as the firmness value of the sample. The area under the curve, measured in Newton-seconds, represented the consistency of the sample.

Physicochemical changes during storage

Polypropylene (PP) cups were used for the packaging of *malai*. This container was used because it is one of the most used low-cost containers in food industry. *Malai* prepared from optimised method was packed in this packaging container (100 g each) which were tightly closed and stored at 5±1 °C in a refrigerator. The product was analysed for changes in physico-chemical and textural properties during the storage.

The free fatty acid content was analysed by the method of Deeth and Fitz-Gerald (1976) [5]. Titratable acidity of *malai* was estimated by BIS (1981) [1] method.

Acidity

Titratable acidity of *malai* was estimated by BIS (1981) [1] method. 10 g of sample was weighed into 250 ml beaker and 100 ml of hot distilled water was added to it followed by addition of few drops of 0.5% phenolphthalein indicator. The contents were titrated against 0.1 N NaOH with continuous stirring till a faint pink colour persisted for 30 sec.

$$\text{Acidity} = v/w \times 0.9$$

Where, v = volume of 0.1 N NaOH required for titration w = weight of the sample (g)

FFA

Method described by Deeth and Fitz-Gerald (1976) [5] was used. Five g of finely dispersed *malai* sample was mixed with 37.5 ml of 2% sodium citrate in a hundred ml conical flask and kept in the water bath at 50-60ºC for 5 min to mix it properly. Bureau of Dairy Industry (BDI) reagent of 10 ml was added into the flask and was kept in gentle boiling water bath for 20 min (BDI reagent: Triton X-100 of 30 g of and 70 g of sodium hexametaphosphate was dissolved distilled water and volume made up to 1 litre). Sample was shaken intermittently till a clear fat separation was obtained. Contents were transferred to a butter butyrometer and centrifuged for 1 minute. Enough methyl alcohol was added to bring the fat column well within the graduated portion and further centrifuged for 1 min. The butyrometer was then placed in a water bath (57±3 ºC) for 5 min. About 0.2-0.4g fat was transferred at 57 ºC from the butyrometer to previously weighed 100 ml Erlenmeyer flask using 1 ml micropipette. Fat was dissolved in 5 ml of fat solvent and 5 drops of phenolphthalein was added as indicator. The mix was titrated with standardized alcoholic potassium hydroxide solution to faint pink colour. Blank titration was performed on fat solvent (in absence of fat) using 5 drops of phenolphthalein indicator.

Calculation

$$\text{FFA} = \frac{(\text{ml of KOH solution for sample} - \text{ml of KOH solution for blank}) \times \text{N} \times 100}{\text{Weight of fat taken for titration (g)}}$$

Where, N= normality of alcoholic KOH solution (0.02)

In this study, FFA was expressed as m.eq of KOH per 100 g fat.

Statistical analysis

Statistical analysis of data for effects of the various factors on physico-chemical and textural properties was performed by single factor completely randomized design using SPSS software (version 23.0) in three replications and analysis of variance was done with Duncan's multiple range test at $p<0.05$.

Results and Discussions
Physicochemical properties
Physico-chemical changes are one of the important methods to judge the quality of food. The physico-chemical changes of *Malai* during the storage period were evaluated. Acidity and free fatty acid content of *malai* were the parameters evaluated. The data on the acidity of *malai* packed in polypropylene container during the storage period is represented in Fig.1,

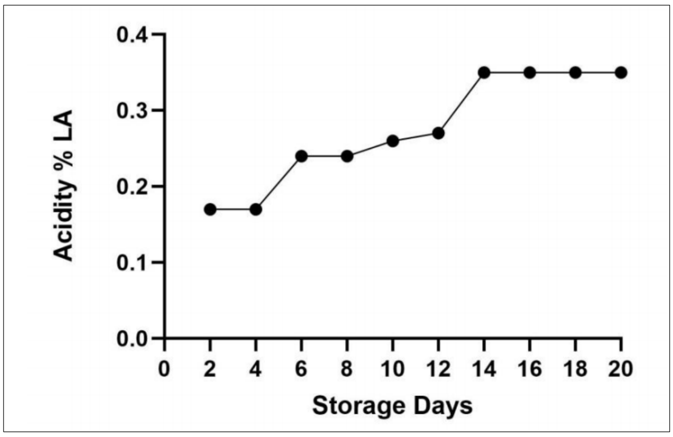

Fig 1: Changes in acidity with storage

On the 0th day, the *malai* exhibited an acidity level of 0.17±0.005% LA. Subsequently, on the 4th day, there was a gradual and statistically significant ($p<0.05$) increase in the acidity level. As the days progressed from the 4th to the 10th, the acidity of the product continued to increase gradually. The highest acidity was recorded on the 20th day, measuring 0.35±0.003% LA. Parmar *et al.*, (2018) [10] observed significant increase in acidity of *basundi* samples during storage. Similar observation was reported by Gayen and Pal (1991) [7] in case of *rabri* samples.

To monitor the lipolytic changes that occurred during the storage period, the free fatty acid content of *malai* was analyzed. The results depicting the changes in free fatty acid content of *malai*, packed in polypropylene containers, during the storage period, is presented in Fig. 2.

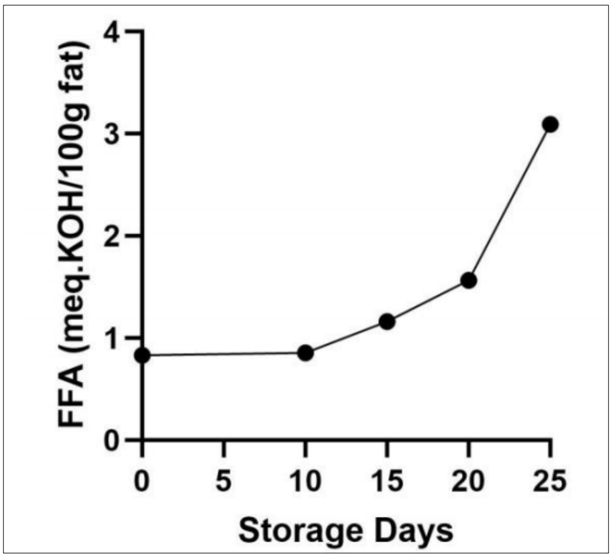

Fig 2: Changes in FFA with storage

The initial average free fatty acid (FFA) content of *malai* was 0.833±0.003 meq. KOH/100 g fat. During the 5th day of storage, there was a slight increase in the FFA content of *malai*. On the 10th day, the lipolytic activity continued to increase. The highest value of FFA content was observed on the 20th day, reaching 3.092±0.01 meq. KOH/100 g fat in polypropylene containers. The rate of increase was gradual up until the 15th day, but it accelerated from the 15th to the 20th day. Due to its higher fat content compared to liquid milk, *malai* is prone to fat breakdown. The degradation of fat can be assessed by measuring the presence of free fatty acids (FFA). An increase in FFA indicates an escalating breakdown of fat, which can be attributed to the growth of microorganisms and enzymatic hydrolysis of fat (Deeth *et al*., 1979) [5].

Textural properties

Firmness of a product refers to the force required to deform the product. Higher value of firmness indicates that product is firmer and a lower value indicates that product is soft. Consistency is a significant textural characteristic that reflects the flow ability of a product on a surface. A higher consistency value suggests that the product is less flow able, while a lower value indicates easy flow. The textural analysis was conducted at 25±1 °C. The changes in firmness and consistency of *malai* packed in polypropylene container during the storage period are tabulated in Table. 1 and Table. 2.

Table 1: Changes in firmness (N) value of *Malai* during storage

Days	Packaging Container
0	1.711±0.05
5	2.431±0.35
10	3.345±0.28
15	1.452±0.06
20	0.980±0.122

Note: Results are expressed as Mean ± S.D.

Table 2: Changes in consistency value (Ns) of *Malai* during storage

Days	Packaging Container
0	10.494±0.89
5	16.416±0.97
10	12.690±1.08
15	7.680±0.82
20	6.04±.54

Note: Results are expressed as Mean ± S.D.

The initial mean firmness of *malai* on the 0th day was 1.711±0.05 N. By the 5th day, it increased to 2.431±0.35 N in polypropylene containers. The maximum firmness was observed on the 10th day, measuring 3.345±0.28 N in polypropylene containers. However, by the 15th day, there was a decrease in firmness for both containers, with values dropping to 1.452±0.06 N in polypropylene containers. On the 20th day, the firmness further declined to 0.980±0.122 N in polypropylene containers. On the 0th day, the mean consistency value of *malai* was 10.494±0.89 Ns. A significant (p<0.05) increase in consistency was observed during the 5th day of storage. The values rose to 16.416±0.97 Ns in polypropylene container. However, by the 10th day, the consistency decreased to 12.690±1.08 Ns in polypropylene container. By the 15th day, the consistency further decreased to 7.680±0.82 Ns in polypropylene container. On the 20th day, the consistency value reduced to 6.04±0.54 Ns in polypropylene containers. The rate of increase in consistency from 0 to the 5th day was higher, while the decline in consistency from the 5th to the 20th day followed a gradual trend. The gradual increase in firmness and consistency from 0 to the 10th day can be attributed to moisture loss during refrigerated storage, while the decline in firmness and consistency after the 10th day can be attributed to increased acidity the release of free fat from the product. The decrease in consistency from the 10th day onwards is due to and the release of free fat from the product. It as reported by Lucey, J. A. (2004) [8] that at high acidic levels firmness decreases due to excessive charge repulsion. Madadlou *et al*. 2007 [9] stated the plasticising impact of free fat can influence the textural attributes of dairy products.

Conclusion

The study conducted and the results obtained imply the correlation between textural attributes and physicochemical properties. The changes in the firmness and consistency of *malai* is corresponding to the changes the acidity and FFA level. The physicochemical properties have a definite influence on the textural attribute of the product and controlling the physicochemical changes will help in maintaining the textural properties of the product during storage.

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