The Pharma Innovation Journal 2022; SP-11(9): 3034-3040

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(9): 3034-3040

www.thepharmajournal.com
Received: 19-06-2022
Accepted: 23-07-2022

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Feasibility studies on mechanical formation of layers for mechanised production of *Malai Laccha*

Jetharam Panwar, RK Kohli, IK Sawhney, Rekha Rani and Banwari Lal

Abstract
Malai Laccha is a heat desiccated clotted cream shredded thin firm layers, pale yellow to light caramel colour and delicious tastes. *Malai Laccha* is using as a finishing material on top of the sweets to make it more attractive by garnishining especially on the Bengali sweets. It also adds delicious taste and nutritive value of products. Most of the sweets manufacturers are producing *Malai Laccha* traditionally. This method is laborious, time consuming and unhygienic. An attempt has been made to mechanise production of *Malai Laccha* by developing flat plate heat exchanger, having multiblade roller cutter, perforated trays and scrapper blade assembly. It is observed that having 0.25 cm diameter of holes and 1.5 cm rectangular pitch perforated tray was best suitable for a pass 30, 35, 40% TMS concentrated milk for uniform spreading over the flat plate heat exchanger. Process time for *Malai Laccha* layer was estimated as a function of milk concentration and steam pressure. Based on sensory evaluation milk crown *Malai Laccha* layer prepared from 35% TMS (3:1ratio of cow and buffalo milk) at 0.4 kg/cm^2 steam pressure has been judged for best quality. It was pale yellow to slight caramel colour thin shredded layer. However buffalo milk alone could not be successfully used for preparation of layers of *Malai Laccha.*

Keywords: Concentrated milk, compound pressure gauge, steam pressure, design and fabrication, plate heat exchanger, multiblade roller type cutter

1. Introduction
Traditional dairy products have significant role in the economic, social, religious and nutritional well being of our people since time immemorial. Deep-rooted tradition offers a considerable scope for organising and channeling the amount of milk going for conversion into traditional dairy products. The major strength of the traditional dairy products sector is the mass appeal enjoyed by such a wide variety of products. It is estimated that about 50-55 percent of milk produced is converted by the *halwais* into variety of Indigenous dairy products, Using processes such a heat and acid coagulation, heat desiccation and fermentation. This fact underlines the significance of traditional dairy products in our country in national economy. In spite of such a great importance of traditional dairy products in our country these products are still manufactured at the small scale (cottage industry) with variable quality depending on the skill of the *halwais.* There has been hardly any quality control and the shelf life is poor. The current methods of these products are primitive and based on techniques that essentially remained unchanged. The rural scale operations are associated with inefficient use of energy, poor hygienic and sanitation and non-uniform products quality. Most of the preparations are labour intensive and rely on local inputs.
There is rapid expansion of dairy industry in our country. The indigenous products are becoming very popular and tend to commercialization. Most of indigenous dairy products are still manufactured by using batch processes. The unit operations used for manufacture of these products including heating, evaporation and boiling. Due the growth of dairy industry, there is need to design and develop equipments for manufacture of these dairy products.
According to PFA (1955)" *Malai* is the of the product rich in butterfat prepared by boiling and cooling cow or buffalo milk or a combination thereof, it shall contain not less than 25 percent Milk fat". *Malai Laccha* is a heat desiccated clotted cream shredded thin firm layers, pale yellow to light caramel colour and delicious tastes. *Malai Laccha* is using as a finishing material on top of the sweets to make it more attractive by garnishining especially on the Bengali sweets. It also adds delicious taste and nutritive value of final products. *Milk Crown Laccha:* This is used in the following products such as Milk crown, Anorodh, Anarkali, Chines Rasogulla, Badam (Almond) Milk, Mutka kulfi, Indrani cup, Fruit cup.

Still most of the sweets manufacturers are producing *Malai Laccha* traditionally. This method is laborious, time consuming and unhygienic process. An attempt has been made to mechanisation of *Malai Laccha* by developing and fabricating flat plate heat exchanger in Dairy Engineering Workshop, NDRI, and Karnal. This flat plate heat exchanger was used for improving the hygienic quality, increasing shelf life, producing value added products, reducing energy consumption, manpower and manufacturing time during production. By keeping these problems the present study was done to develop experimental set-up for mechanical formation of *Malai Laccha* layer, to check performances evaluation in relation to milk concentration and operating parameters.

2. Methods

2.1 Design and fabrication of experimental set-up

2.1.1 Flat Plate Heat Exchanger (FPHE)

A flat plate heat exchanger was fabricated at R&D workshop of Dairy Engineering Division, NDRI, Karnal. The top plate of FPHE is made of Stainless Steel (SS-304) sheet of 0.5 cm thickness; other five bounding plates are made of Mild Steel of 1cm thickness. The dimensions of flat plate heat exchanger are 106 cm long, 61 cm width and 5 cm height. Three baffles are attached to inner side of top plate of FPHE at equal partitions that increases thermal efficiency of heat exchanger and avoids the bulging of heat exchanger. The FPHE has four ports for steam inlet, two steam traps, one spring-loaded safety valve, a air vent and compound pressure gauge as shown in Figure 1and Plate No 1.

2.1.2 Experimental set-up Accessories

Steam control Valve (manual)/ steam control mechanism
Compound Pressure Gauge (-1 to 7 kg/cm^2)
Spring loaded safety valve (0.7 kg/cm^2)
Steam trap
Air vent

2.2 Multiblade roller type cutter

The fabrication of a multiblade roller cutter (shown in Figure 2 and Plate No 2) was developed and designed at R&D workshop of Dairy Engineering Division, NDRI, Karnal. This was designed to obtain the layers of *Malai Laccha* with 1.8 cm width. The multiblade roller cutter was 19 cm in length, 3.8 cm diameter and depth of blade 0.7 cm. Multiblade roller cutter has nine blades, which are 1.8 cm apart from each other. It was made of stainless steel –304.

2.3 Scrapper blade

Two scrapper blades (shown in Plate No-3.3) were fabricated at R&D workshop of Dairy Engineering Division, NDRI, Karnal. The blade was of 4.5 cm length, 3 cm width and 0.2cm thick. (Shown in Plate No.3.3).

2.4 Perforated trays

Perforated trays with following details were fabricated for equal distribution of concentrated milk to be spread over flat plate heat exchanger for production of *Malai Laccha* layers. Also to check the feasibility of passing through the different concentration of milk through different holes/slots.

2.4.1 Circular holes type (Plate No- 3.4)

Code
A1: 0.2 cm diameter and pitch 1.5 cm, square type pitch.
A2: 0.25 cm diameter and pitch 1.5 cm, square type pitch
A3: 0.5 cm diameter and pitch 1 cm, square type pitch
A4: 0.7 cm diameter and pitch 2 cm, square type pitch

2.4.2 Rectangular slots type (Plate No- 3.5)

B1: 5 cm length, 0.3 cm width and 0.5 cm pitch, rectangular type
B2: 5 cm length, 0.5 cm width and 2.5 cm pitch, rectangular type
B3: 5 cm length, 0.7 cm width and 2.5 cm pitch, rectangular type

2.5 Performance parameters

2.5.1 Constant parameters

Milk composition (5%fat and8.5%SNF),
Cow and buffalo milk in ratio of 3:1
Buffalo milk
Thickness of layers 0.01 cm for *Milk Crown Laccha*

2.5.2 Variable parameters

2.5.2.1 Feasibility of perforated tray in relation to % total milk solids of concentrated milk

Circular holes perforated trays: A1, A2, A3 and A4.
Rectangular slots perforated trays: B1, B2 and B3.

2.5.2.2 Concentration of milk

30, 35 and 40% total milk solids

2.5.2.3 Steam Pressures

0.3, 0.4 and 0.5 kg/cm^2

3. Material required

Milk, Steam jacketed kettle, Milk cans, Bucket, Scrapper, Beaker, Oven / Desiccator, Digital Thermometer, Strainer and Stopwatch etc.

3.1 Milk

Cow and buffalo milk was used in present investigation of research study obtained from experimental dairy of institute.

3.2 Steam Jacketed Kettle

A 20-liter capacity Stainless steel steam-jacketed round bottom open pan provided with steam control valve was used for concentration of milk.

3.3 Experimental procedure

3.3.1 The Preparation of test samples:

The cow and buffalo milk (12liters) was taken into steam-jacketed kettle in ratio of 3:1 (5%Fat and 8.5%SNF). The milk was heated at low pressure (0.5-0.7kg/cm^2) for 45 –55 minutes with continuous stirring by scrapper upto desired level of concentration of milk.

3.3.2 Spreading mechanism over Flat Plate Heat Exchanger (FPHE)

The concentrated milk was passed through the different perforated trays for uniformly spreading over flat plate heat exchanger.

3.3.3 Formation of *Malai Laccha* layer

A uniform *Malai Laccha* layer was formed over flat plate heat exchanger at low steam pressure (0.3-0.5 kg/cm^2) for 15-25 minute by evaporating moisture.

3.3.4 Cutting *of Malai Laccha* layers
A stainless steel multiblade roller cutter was used for uniform width (1.8cm) cutting of *Malai Laccha* layers on flat plate heat exchanger. (Shown in Plate No. 3.6 Cutting of *Milk Crown Laccha* Layers)

3.3.5 Scrapping of *Malai Laccha* layers
A stainless steel scrapper blade was used for scrapping of *malai laccha* layer, after desired level of moisture removed. The *malai laccha* layer was put into aluminum trays for chemical analysis and sensory evaluation of product. (Shown in Plate No.3.7 *Milk Crown Malai Laccha* Layers)

3.3.6 Experimental procedure flow diagram of *Milk Crown Laccha*

Receiving Cow and buffalo milk
(3:1 ratio, 5%fat and 8.5% SNF)
↓
Steam jacketed kettle (20liter capacity)
Heating at 0.5-0.7kg/cm^2 steam pressure for 45-55 Minutes
(Up to 30 –45% total solids)
↓
Concentrated milk transfer into bucket
↓
Pouring of concentrated through perforated trays on FPHE
↓
Formation of *Malai Laccha* layers over Flat Plate Heat Exchanger at (0.3-0.5 Kg/cm^2) steam pressure in 15-25 min.
↓
Cutting by multiblade roller cutter and scrapping by scraper blade
↓
Put in Aluminum trays (testing and judging)

3.4 Chemical analysis
3.4.1 Analysis of milk
The raw milk was tested for fat, SNF and total solids (TS) by using standard methodologies. Total solids (%) = SNF + fat the fat content was determined by Gerber method (IS: 1224, 1977) and the SNF content was ascertained by lactometer.

3.4.2 Moisture content of *Malai laccha*
Moisture content of malai laccha layers was determined by gravimetric method as suggested by A.O.A.C. (1985) [1].

3.5 Sensory evaluation of *malai laccha*
A selected panel of judges performed sensory evaluation of different samples of malai laccha at different variable parameters. They are using 100 point score card, which comprised of flavour (50), body and texture (35) and colour and appearance (15) as suggested by Rajorhia *et al*. (1990) [4].

4. Result and discussion
Result obtained and inferences drawn from the experiments carried out to meet the objectives. The observations have been presented in this chapter. Based on the trials, the necessary data have been recorded and tabulated. The results obtained from the proposed study have been analysed through graph and inference drawn from it. Mentioned as below:

4.1 Effect of perforated trays on concentrated milk (%tms)
Two types of trays with (slots/holes) have been used.

4.1.1 Effect of circular holes perforated trays on concentrated milk (%TMS)
The concentrated milk 30, 35, 40% Total Milk Solids was passed through using circular holes perforated trays with codes A1, A2, A3 and A4 for uniform spreading of concentrated milk over Flat Plate Heat Exchanger. In this case A2 (0.25 cm diameter and 1.5 cm pitch) circular holes perforated trays was best suitable for all concentrated milk.

4.1.2 Effect of rectangular slots perforated trays on concentrated milk (%TMS)
The concentrated milk 30, 35, 40% Total Milk Solids was passed through using rectangular slots perforated trays B1, B2 and B3 for uniform spreading of concentrated milk over Flat Plate Heat Exchanger. In this case B1 (5 cm length, 0.3 cm width and 0.5 cm pitch) rectangular slots perforated trays was best suitable for 40% total milk solids concentrated milk and through other slots milk could not spread uniformly over flat plate heat exchanger.

4.2 Effect of concentrated milk (%tms) and steam pressure on process time
Figure 1 and Table 1 shows the effect of concentrated milk (%TMS) and steam pressure on the process time of 3:1 cow & buffalo milk and buffalo milk (35% TMS) for 0.1 cm thickness of *Malai Laccha* layers. It can be inferred from the graph that increase in the concentration of milk (%TMS) at constant steam pressures, process time is decreasing. It is also inferred from graph that increases the steam pressures at constant concentration of milk (%TMS), process time is decreasing the trend in graph. Ranjeet (2003) [5], manufactured *basundi* using conical vat process and two-stage film SSHE with standardized buffalo milk. *Basundi* prepared in conical vat process were good body and texture and appearance and overall acceptability for processing time 80 to 100 minute. Shah and Solanki (2004) [6] did mechanization of *Basund*i making using batch type stainless steel version of SSHE. Raghavarao (2007) [3] studied on the device designed and developed for various operations involved in *dosa* preparations such as batter spreading, cooking/baking, oiling, curry dispensing etc. Smeding *et al.* (2006) [7], reported a sandwich flat plate heat exchanger has been designed for application in a high temperature solid sorption heat pump.

4.3 The sensory evaluation of quality of *milk crown malai laccha* layers
The *Milk Crown* M*alai Laccha* layer so produced was sensory evaluated. The average sensory score of milk crown *Malai Laccha* layers produced at different operating conditions given in Table 3.

4.3.1 Effect of concentrated milk (%TMS) and steam pressure on Flavour
Figure 2 and Table 3 shows that the effect of concentration of milk (% TMS) and steam pressure of 3:1 (cow and buffalo milk) and buffalo milk for 0.1 Cm (~1 mm) thickness of *Malai Laccha* layers on flavour. It can be inferred from graph at 35% TMS and 0.4 kg/Cm^2 steam pressure carries highest sensory score 43.5, these values of % TMS and steam pressure are best suitable for *Malai Laccha* preparation.

Buffalo milk *Malai Laccha* layer carries lowest sensory score 37.4 (due to flat flavour) at 35% TMS and 0.5 kg/cm^2 steam pressure so buffalo milk is not suitable for malai laccha layers.

4.3.2 Effect of concentrated milk (%TMS) and steam pressure on Body and Texture

Figure 3 and Table 3 shows that the effect of concentration of milk (%TMS) and steam pressure of 3:1 (cow and buffalo milk) and buffalo milk for 0.1C m (~1 mm) thickness of M*alai Laccha* layers on body and texture. It can be inferred from graph at 35% TMS and 0.4 kg/Cm^2 steam pressure carriers highest sensory score 31 as *Malai Laccha* was soft homogeneous and thin shredded layers obtained. Buffalo milk *Malai Laccha* layer carries lowest sensory score 26.8 at 35% TMS and 0.5 kg/Cm^2 steam pressure because buffalo milk malai laccha layers was brittle, grainy texture and fat was separated.

4.3.3 Effect of concentrated milk (%TMS) and steam pressure on Colour and Appearance

Figure 4 and Table 3 shows that the effect of concentration of milk (%TMS) and steam pressure of 3:1 cow and buffalo milk, buffalo milk for ~1 mm thickness of *Malai Laccha* layers on colour and appearance. It can be inferred from graph at 35% TMS and 0.4 kg/cm^2 steam pressure carries highest sensory score 13.6 because in cow and buffalo milk (3:1 mixed), milk was pale yellow colour more attractive due to carotene content of cow milk. Buffalo milk *Malai Laccha* layer carries lowest sensory score 10.7 at 35% TMS and 0.4 kg/cm^2 steam pressure because buffalo milk *Malai Laccha* layers was in whitish colour and fat was separated.

4.3.4 Effect of % TMS and steam pressure on Overall Acceptability

Figure 5 and Table 3 shows that the effect of concentration of milk (%TMS) and steam pressure on overall acceptability of 3:1 cow and buffalo milk at 35% TMS and 0.4 kg/Cm^2 steam pressure carries highest sensory score 88.5, because pale yellow colour and soft more attractive thin firm shredded layers.

The effect of concentration of milk (%TMS) and steam pressure on over all acceptability of buffalo milk *Malai Laccha* layers at 35% TMS and 0.4 kg/cm^2 steam pressure carries lowest sensory score 77 due to whites colour and breathe structure of shredded layers.

Table 1: Effect of Concentrated Milk (% TMS) and Steam Pressure on Process Time

Concentrated Milk	30%TMS			35% TMS			40% TMS			35% TMS (BM)	
Pressure	0.3	0.4	0.5	0.3	0.4	0.5	0.3	0.4	0.5	0.3	0.4	0.5
Heating Time(min.)	25	23	20	23	21	18	20	18	15	22	20	19

Table 2: Chemical Composition o*f Milk crown Malai Laccha*

Concentrated Milk	30%TMS			35% TMS			40% TMS			35% TMS(BM)		
Steam Pressure (kg/sq.cm)	0.3	0.4	0.5	0.3	0.4	0.5	0.3	0.4	0.5	0.3	0.4	0.5
Fat (%)	28.2	31.4	27.5	26.2	27.3	26.7	28.2	31.4	27.5	29.1	27.6	28.4
Moisture (%)	19.6	17.7	20.3	25.54	23.14	24.6	19.8	17.7	20.3	19.6	21.3	20.8

Table 3: Sensory Evaluation of Malai laccha

Concentrated Milk	30% TMS			35% TMS			40% TMS			35% TMS(BM)		
Steam Pressure(kg/sq.cm)	0.3	0.4	0.5	0.3	0.4	0.5	0.3	0.4	0.5	0.3	0.4	0.5
Flavour (50)	43.1	38.6	38	39.4	43.5	41.5	41.6	43	41.7	40.1	38.2	37.4
Body & Texture(35)	30.4	28.6	28.6	28.8	31	30.2	29	30.1	29.5	28.4	28.1	26.8
Colour & Appearance(15)	12.3	12	12	12	13.6	13.3	13.3	13.4	12.5	11.3	10.7	10.9
Overall Acceptibility(100)	85.8	78.6	78.6	80.2	88.5	84.8	83.9	86.5	83.5	79.8	77	75.1

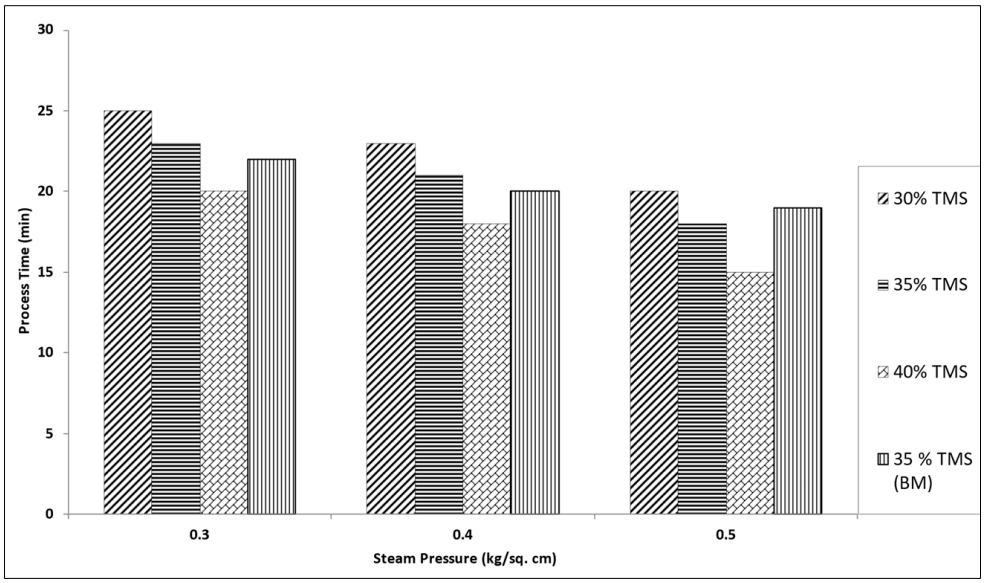

Fig 1: Effect of concentrated milk (% TMS) and Steam pressure on process time

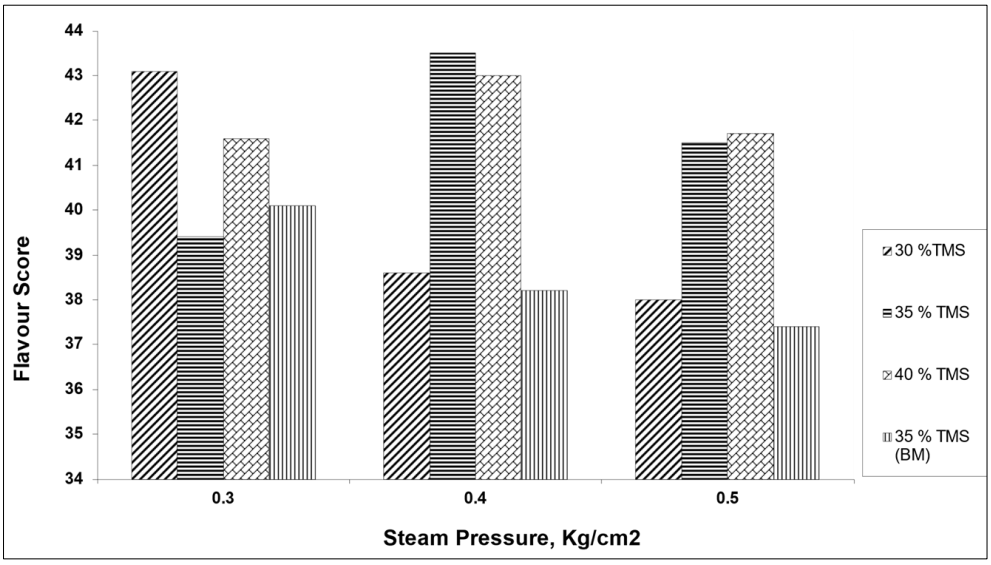

Fig 2: Effect of concentrated milk (% TMS) and Steam pressure on Flavour

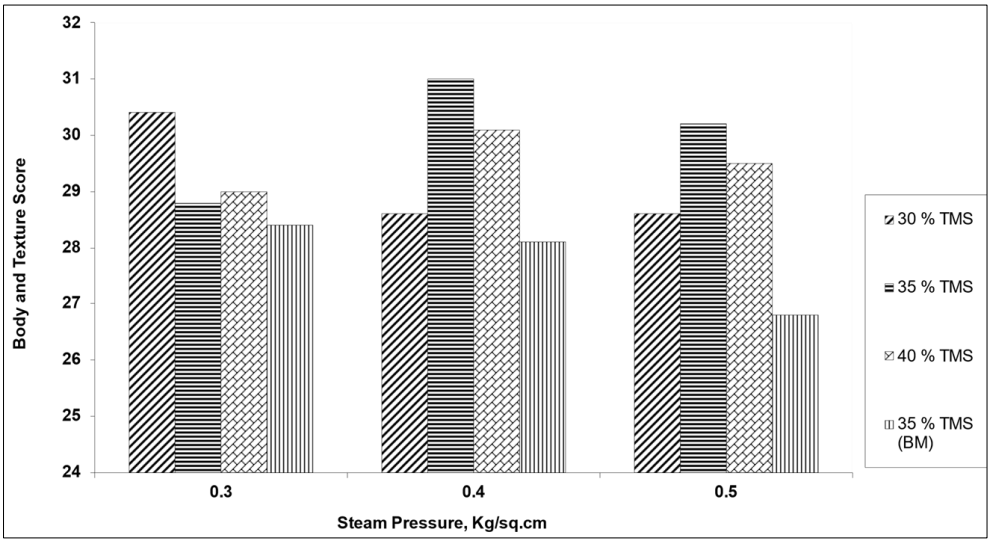

Fig 3: Effect of concentrated milk (% TMS) and Steam pressure on Body and texture

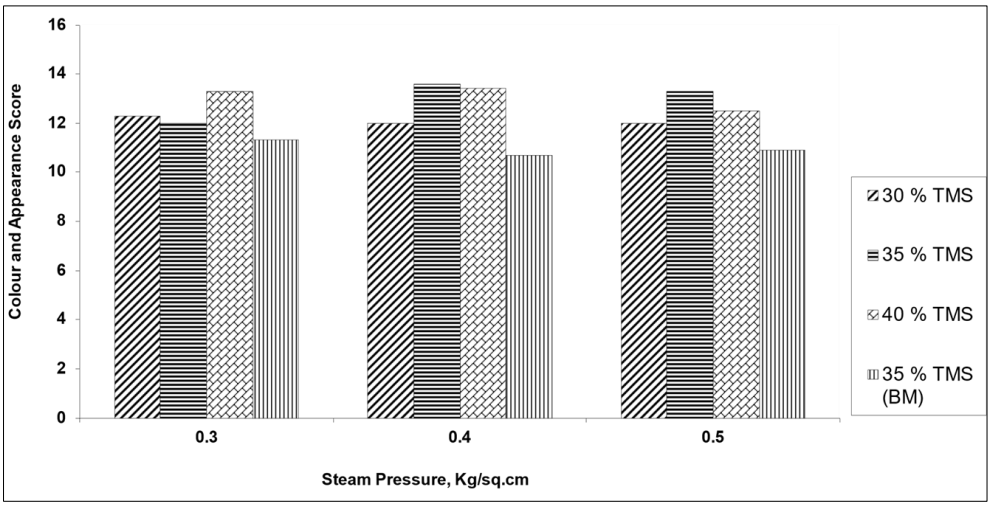

Fig 4: Effect of concentrated milk (% TMS) and Steam pressure on Colour and Appearance

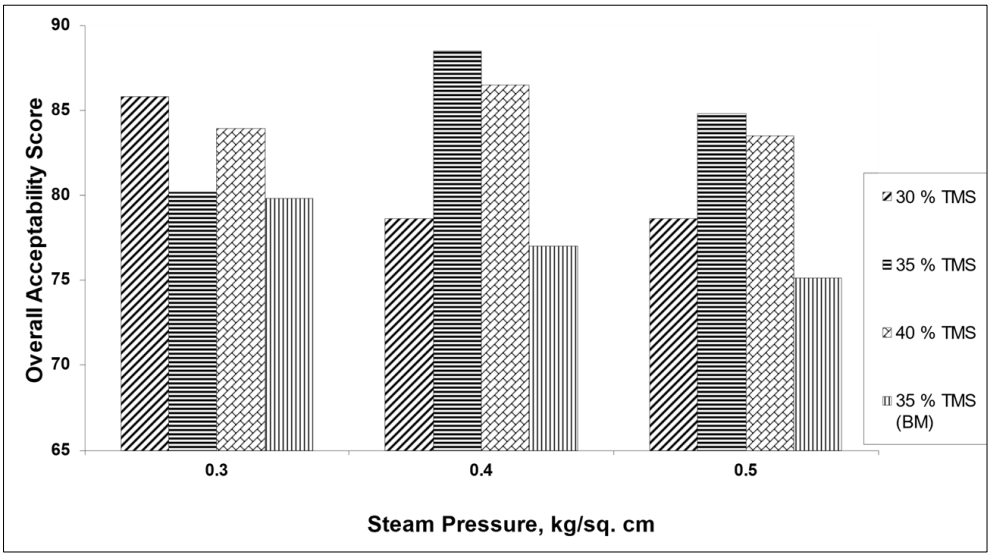

Fig 5: Effect of concentrated milk (% TMS) and Steam pressure on overall acceptability

Plate 1: Experimental set up of Flat Plate Heat Exchanger

Plate 2: Multiblade roller cutter

Plate 3: Scrapper Blade

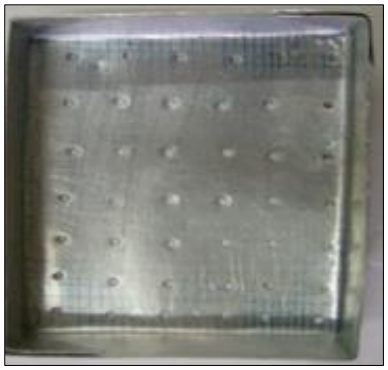

Plate 4: Circular holes perforated tray

Plate 5: Rectangular slots perforated tray

Plate 6: Cutting of *Milk Crown Malai Laccha* layer

Plate 7: *Milk Crown Malai Laccha* layer

5. Conclusions

It includes development and fabrications of Flat Plate Heat Exchanger and multiblade roller cutter, perforated trays and scrapper blades etc. The feasibility of perforated trays A1, A2, A3 and A4, circular holes types and B1, B2 and B3 rectangular slots types has been found the uniform spreading of concentrated milk on flat plate heat exchanger A2 tray (0.25 cm diameter and 1.5 cm rectangular pitch) is the best suitable in respect to different concentrations of milks (%TMS). In case of rectangular slots perforated B1 tray (0.3 cm width and 0.5 cm pitch.) is only for 40% TMS concentrated milk. The Milk *Crown Laccha* layer was prepared from 35% TMS concentrated milk (cow and buffalo milk in 3:1) at 0.4 kg/cm^2 steam pressure for 21minutes process time at found best sensory quality. The buffalo milk to preparation of *Malai Laccha* layers was found not acceptable (sensory attributes) at any combination, because of broken layer formation being less soft. The sensory characteristics of final products were found to be best in case of 35% TMS concentrated milk (cow and buffalo milk in ratio of 3:1)and 0.4 kg/cm^2 steam pressure among the all combinations, with the sensory score flavour 43.5, body and texture 31, colour and appearance 13.6 and overall acceptability 88.5. The cow and buffalo milk (3:1 ratio) from formation of *malai laccha* layer was soft shredded pale yellow to slight brownish colour good attractive surface, but buffalo milk *malai laccha* layers was highly brittle, whitish colour and stale flat flavour.

The problems encountered production of *Malai laccha* has been mentioned below:

1. The flat plate heat exchanger requires, refabrication with more smooth surface for uniform *Malai laccha* layer formation.
2. Studies can be initiated for other two types of *Malai Laccha* layers.
3. Spreading of concentrated milk on the flat plate can be further mechanized.

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