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Development of skid mounted improved butter churn suitable for small scale production

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SUMMARY :

A survey of traditional butter making in India would reveal that butter production in rural areas is still not technically advanced.To overcome this problem, a skid mounted improved frustum cone shaped insulated butter churn of small size was developed. In the present improved butter churn,the churning time required is reduced by providing internal stirring wing, thus, the process becomes more efficient with reduced labour requirements.With this churn cream from about 100 litres of milk could be processed daily into butter. In India small capacity skid mounted improved butter churn would prove to be economic and efficient.

KEY WORDS : Churning efficiency, Traditional butter making, Butter, Cream, Butter churn

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India is the largest milk producing country in the world. The FAO has reported that the present production of milk is about 140 Million Tonnes and 7 per cent is converted into butter (Anonymous, 2014). In India, about three-fourth of the population living in rural areas and about 38 per cent of them are poor. It is estimated that upto 60 - 65 per cent of the income of this group (marginal and small-scale farmers) now comes from dairying (Nargunde, 2013). The world annual butter production in 2010 was estimated to be 10 Million Tonnes. India is the world's largest butter producing country in the year 2014. Even then, the per capita consumption of butter in India is as low as 3.6 kg/year (NPCS, 2014). The demand of butter is so much that Chennigaraju *et al.* (2005) designed the conjugated intermeshing twin screw forming system (plasticizer) for continuous manufacture of butter from *Ghee* (clarified butter). Actually the screw system acted as butter worker. The recombined butter was produced

at a constant temperature of 6°C.

Women in poor rural areas play the key role in most of dairy activities. Quite commonly, the work load of rural women touches 16 hours in a day (World Bank, 2008). In most of cases, churning of butter is regarded as women's duty. One important reason for the low output of butter is women's lesser access to improved tools and equipment. A cheap, simple churning device would easily significantly lift their productivity. It would relieve them from tedious and time consuming traditional method of butter churning.Butter production at small scale level could be economic if a number of farmers pooled their milk. Cream from 100 l of milk could be processed daily into butter by combining manually operated cream separator (for removal of cream from milk) with improved skid mounted butter churn (for converting cream into butter).

In rural India, butter is extracted from the *Dahi* (fermented milk) rather than cream. However, local potters specifically prepare clayjars (*Matka*) for stirring of *Dahi*. A pedal bar type churn (*Mathani*) consistsof wooden shaft of maximum one meter length is specifically fabricated by local carpenters. Bladesare attached at the bottom end. The upper end has provision to attach ropes to rotate the *Mathani* clock wise and anti clock wise alternatively but continuously. The *Matka* is placed on wooden work station and having vertical shaft parallel to *Mathani* and both are connected by another rope for stability. *Dahi* is churned by continuous stirring and after adding appropriate quantity of chilled water butter granule appears. Preparation of butter from cream rather than whole milk is more efficient because of the high fat content (O'Mahony, 1988) present in the cream.

Deel (2013) developed a churning vessel which was removable and mountable to a motor-driven reciprocating drive. The motor drives the churning vessel in reciprocal motion, where by the reciprocal motion of the churning vessel agitates cream contained therein causing it to convert to butter. While Sevelle (2007) developed a compact butter maker having housing for use in the kitchen. The butter maker included a cream holding container in which cream is placed and also included drive assembly having a shaft rotatable along its vertical axis. The shaft included a dasher having a pair of spaced paddles for churning of butter. Clark and Terrell (1995) had invented an apparatus for serving the dual purposes of baking bread and for churning butter. In India, considered part of butter is transferred into *Ghee* through the process of melting. Solanki and Dodeja (2011) had successfully developed continuous butter melter for manufacture of *Ghee*.

EXPERIMENTAL METHODS

Traditional methods of processing generally give low yields of butter per unit of milk and require high labour inputs. In addition, the butter is hygienically inferior and of low stability. However, there is a market demand for these products.There is a need for development a simple butter churn on easy design mechanism made with non-expensive materials (Table A).

Concept for proposed design:

When milk or cream is churned, the mechanical agitation to which fat globules are subjected causes the enclosing film to break and thus, the fat of individual globules combine to form into mass of butter and separate from buttermilk due to change in phase that occur during the churning period (Ananthkrishan and Sinha, 1987). In this process the oil in water emulsion of cream is converted by the process of churning into the water-in-oil emulsion of butter (Ahmed, 2006). The temperature control is the prominent step in manufacturing of butter. India is a subtropical country; the climate is dry and humid. Considering the point improved churn was made of

Table A : Guiding factors for designing of skid mounted improved butter churn

Sr. No.	Factors	Compliance on developed churn
1.	Technically feasible	Simple in construction and easy in operation and handling,
2.	Economically viable	Higher butter yield
3.	Acceptable	Low cost and easy to handle
4.	Replicable	Potential for commercialization and can be replicable for construction
5.	Adaptability	Operated by technical and non-technical operator
6.	Safety	Safe to use
7.	Affordability	Low cost with good returns

jacketed frustum cone filled with chilled water. The whole churn was insulated with low thermal conductive material *i.e.* foamed polyethylene for zeroing the effect of high ambient temperature.

In the present setup butter is to be obtained from cream. The design principle of the skid mounted churn is based on the centrifugal action where the drum rotates along the axis of rotation ensuring the cream to fall from top to bottom hence giving a sufficient turbulent and whipping action to the cream to separate the butter phase from butter milk. This churn is composed of easily available materials like SS and iron frustum cone drums, head, stirring wing, shaft, motor, stand and tray etc.

Construction of butter churn :

The butter churn was designed with a holding and working capacities of 10 and 5 litres of cream separately. The butter churn consisted of SS-304 inner and outer iron frustum cone shaped drums, respectively. The inner drum was provided with a single stirring wing extended from the bottom (closed end) to top (open end). The wing was obliquely positioned relative to the axis of drum to facilitate movement of chilled water from one end of the jacketed space to another. The SS 304 circular flange type head, 180 mm diameter, was designed with a thickness of 10 mm and it was fixed to the body for opening and closing the drum. A 26 mm diameter hole was drilled for fixing of sight glass. Thumb screws were provided to tighten the head. Nitrile rubber gasket (3 mm thick) was used to prevent the leakage during churning. The shaft (25 mm diameter) was made of low carbon steel by hot rolling, forging and turning. The shaft diameter was selected based on considerations of ability to sustain weight of churn and cream. The 0.5 hp single phase A.C motor was used with 1440 rpm and 50 Hz. The gear box of 1: 20 ratio was used to reduce the speed of motor to required churn speed. The body of churn and shaft rests on a square shaped stand which provided movability to the improved butter churn. Provision was made for unloading of butter into tray which was placed between the stand. In order to minimize gain of heat from ambient, the churn was designed with over lapping jacketed space for chilled water and then it was insulated with 3 mm thick foamed polyethylene (Fig A, B and C).

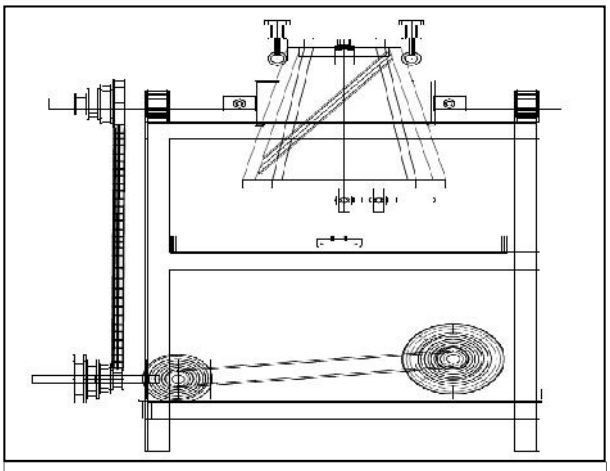

Fig. A : Auto-cad diagram of improved butter churn

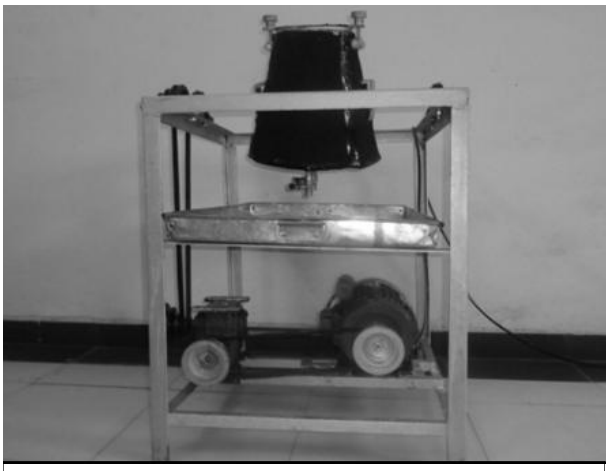

Fig. B : Skid mounted improved butter churn

Fig. C : View of worked and unloaded butter

EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Performance of the skid mounted improved butter churn :

For evaluating the butter churn, 40 per cent standardized cream was used. Experiment was conducted at three different speed levels of 35, 60 and 85 rpm and temperature parameters of 8, 10 and 12°C. Before churning, the churn was cleaned using hot water and then dried. Later chilled water was introduced in the jacketed space to maintain the churning temperature. The cooled cream was filled to 1/2 or 1/3 of the churn. Before operation, it was ensured that butter churn is locked properly by thumb screws.

After several experimental trials it was found that butter churn at churn speed of 60 rpm and churning temperature of 10°C, 40 min time was required to churn the cream. This butter was having 16 per cent moisture content with 19.5 per cent over run. This was the best possible combination of churn speed, operating temperature and time.

Techno economic feasibilities :

In order to determine cost economics of churning, the cost of operation was determined. The hourly cost of operation was calculated considering fixed and variable cost by taking the cost of improved butter churn development, annual use, salvage value, interest rate, maintenance cost and life of the churn. The cost of churning was calculated to be $ 0.21 and 0.33 per kg of butter obtained from churning of 5 and 3.3 kg of cream (1/2 and 1/3 loading), respectively. The churning of cream filled to 1/3 of churn has shown an increased cost of churning since the time required and machine used and operational costis same for less quality of product.

Break-even point calculation :

For churning of 5 kg of cream (1/2 loading) the fixed, variable and selling costs were calculated to be $ 41.39, 11.12, 11.34 per batch, respectively. The break-even point was estimated to be 191.4 number of batches per year for 2.4 kg of butter produced each time. For churning of 3.3 kg of cream (1/3 loading) the fixed, variable and selling costs were $ 41.39, 7.52, 7.57, respectively. In this case, the break-even point was estimated to be 876 numbers of batches per year for 1.5 kg of butter produced.

Pay-back period :

The initial investment on fabrication of skid mounted improved butter churn was estimated to be $ 320.33. For churning of 5 kg of cream (1/2 loading), total cost of production was estimated to be $ 8,399.06 per year while total return was expected to be $ 8712.22. Hence, the payback period was estimated to be 0.52 year. For churning of 3.3 kg (1/3 loading), the total cost of production was estimated to be $ 5566.05 per year and total return was expected to be $ 6021.46. Hence, the payback period was estimated to be 0.70 year.

Conclusion :

A skid mounted improved prototype of "butter churn" has been successfully developed and tested. Performance of this prototype was found excellent under the churning temperature of 10°C and churn speed of 60 rpm. This butter churn can be used for the butter production at cottage level. The cost of churning using this machine for 1/2 and 1/3 loading were estimated to be $ 0.21 and 0.33 per kg of butter, respectively.

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