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How can increased access to diesel-free milk coolers improve efficiency and smallholder incomes in the dairy value chain?

Insights from Inficold's experience in India

Shell Foundation | 

Inficold 



Executive Summary

India has been a leading producer and consumer of dairy products across the globe for decades. The Indian dairy sector exhibits strong growth potential with the demand for milk and milk products in India expected to be 266.5 million metric tonnes in 2030¹. India has huge opportunities for processing and cold chain innovations as only 20% of the milk production is handled by the organised sector⁷.

More than 70% of India's 100-million-plus dairy farmers, hold only 2-3 dairy animals per person². The majority of the smallholder dairy farmers are in the interior regions of rural India, where it is difficult to set up cooling infrastructure, so the quality of milk deteriorates and spoilage rate increases, by the time it reaches the customer. The chilling infrastructure capacity of the country was 28 million MT in March 2016, only 18% of the year's national milk production³. The lack of cooling infrastructure is because of unreliable grid electricity and unavailability of cost-effective cooling solutions for small scale milk production.

Inficold bulk milk cooler with ice backup

Inficold's milk cooler addresses the shortcomings of existing diesel generator backed bulk milk coolers, which are not viable due to higher operational and maintenance costs. The 200 litre bulk milk cooler is powered by 1 kVA single phase grid connection and can provide cooling backup of a day with in-built ice during power outages. The system can handle up to 24 hours of continuous power outage without the need of diesel generators. It has one of the highest cooling performances as it can cool 100 litres of milk from 35 to 4 °C within an hour, which is three times faster than ISO 5708 Class 2 All standard of milk cooler.

This provides a cost-effective option to cool milk at the source, thereby enhancing the quality and shelf life of milk, improving profitability, reducing wastage risks, and optimising the overall milk value chain.

This report is based on the case study of a unit installed with a small-scale privately owned dairy, that sells organic milk in Puducherry, India. An assessment was conducted to understand the impact of a 200 litre bulk milk cooler integrated with thermal energy storage on this dairy farm.

Benefits of adopting the system

In a short span of five months since the installation of the bulk milk cooler, the dairy has increased their monthly revenues by 330% to INR 1,36,800 (~US\$1,824)⁴. This is attributed to higher milk quality, reduced milk spoilage and increased customer base. There is also an increase of 280% in milk sales to 76 litres per day and an increase of customer subscription by 369%. Customer acquisition has become easier due to the improved milk quality and availability of a larger customer base as the chilled milk can now be transported longer distances.

In addition, the dairy is efficiently managing the mismatch between demand and supply as the excess cold milk can now be stored in the milk cooler for a few days. The milk wastage, earlier at 9%, is now eliminated. At current revenue, the system payback is expected to be within two months. The dairy is expecting to increase the daily sales to 200 litres per day in the next six months, which will further reduce the payback period.

Challenges

The bulk milk cooler with in-built ice backup is a unique product. With a low number of installations and lack of service presence in India, the advantages of the system are not realised by the end user until a live demo is provided. More number of installations, enabling more demonstrations,

¹ <https://www.tpci.in/indiabusinessstrade/blogs/indian-dairy-sector-on-a-road-to-resilience/#:~:text=India%20has%20the%20largest%20bovine,%2D22%2C%20as%20per%20CRISIL>.

² <https://www.financialexpress.com/opinion/why-india-needs-to-protect-its-small-dairy-farmers/1700001/>

³ https://dahd.nic.in/sites/default/files/Vision%202022-Dairy%20Development%20English_0_0.pdf

⁴ Assuming exchange rate of 1 USD = 75 INR

are required to increase the adoption rate. With higher penetration of installations in a particular geography, existing service teams of traditional bulk milk coolers can also be trained to be a part of the support and service teams for milk coolers with ice backup.

Conclusion, recommendations and potential impact

The system payback is achieved within few months owing to improved milk quality, increased customer base and smooth demand-supply management without milk wastage. At present the bulk milk cooler is at 38% utilisation and the dairy is expanding its reach to more customers.

India is the largest producer of milk and milk products. However, none of the major Indian dairy companies feature on the list of top 15 major dairy giants, while only one makes it to the list of top 20 dairy companies in the world⁷. Two structural shifts – customer preference of purchasing milk from the organised sector and increased demand of value-added dairy products instead of liquid milk – will provide long-term growth visibility to the dairy sector. The bulk milk cooler with ice backup is a viable and economic option for effective penetration of cooling infrastructure in the Indian dairy industry. The solution will assist in improving milk quality, reducing diesel emissions, reducing operational expenses and eliminating milk wastage with minimal expenditure.

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List of Abbreviations

NDDB	National Dairy Development Board
FY	Financial year
US	United States of America
LPD	Litre Per Day
GHG	Green House Gas
CO ₂	Carbon dioxide
ISO	International Organisation for Standardisation
INR	Indian Rupees
US\$/D	US Dollar

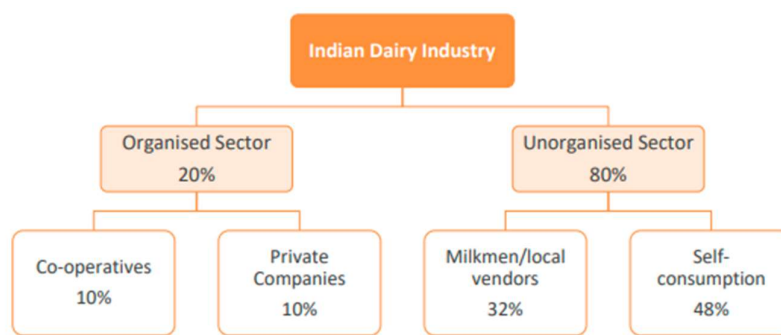
1 Introduction

1.1 Dairy value chain in India

The dairy sector in India has grown substantially over the years. According to NDDDB, India ranks first among the world's milk producing nations, achieving an annual output of 188 million tonnes during 2019, which is approximately twice that of the US and over five times that of China⁷. Dairy farming is one of the biggest agri businesses in India and the largest single agricultural commodity with ~4% share in the overall Indian economy⁵. It is also a significant contributor to farmers' income as approximately 70 million farmers are directly involved in dairy farming⁵. Dairy is the only agri product in which around ~70-80% of the final market value is shared with farmers, and accounts for approximately a third of rural household income in India⁵. It serves a wide range of consumer needs from protein supplements and health foods to indulgence foods such as yogurt and ice cream.

The Indian dairy industry is divided into the organised and unorganised segments. The unorganised segment consists of traditional milkmen, vendors and household consumption, and the organised segment consists of cooperatives and private dairies. The co-operatives and private dairies procure only about 20% of the milk produced in the country, while 32% is sold in the unorganised market and about 48% is consumed locally⁶. Unlike the unorganised segment, cooperatives and private dairies have a well-ordered channel of milk procurement and distribution. Milk is sourced from farmers through their collection centres at the village level. After the milk has been collected, it is processed/chilled, packed and then finally distributed.

Figure 1: Structure of Indian Dairy Industry



Source: Dept. of Animal Husbandry, dairying & fisheries, Ministry of Agriculture & Farmers Welfare, GOI⁷

The hygienic quality of fresh milk is determined by milk handling practices at the milk producer level and the cooling practices at the milk collection centres. Poor quality of milk at the collection level cannot be corrected further up the dairy value chain. Therefore, it is very important that cooling is done within an hour and a half of milking. The quality of the milk sold via the unorganised sector is not guaranteed. Largely sold in loose form, it is often adulterated with several additives to control milk spoilage.

⁵ <https://www.investindia.gov.in/team-india-blogs/indian-dairy-landscape#:~:text=Dairy%20is%20one%20of%20the,per%20cent%20share%20in%20economy.>

⁶ Annual Report 2019-20: Department of Animal Husbandry and Dairying Ministry of Fisheries, Animal Husbandry and Dairying Government of India - <https://dahd.nic.in/sites/default/files/Annual%20Report%202019-20.pdf>

⁷ <https://www.careratings.com/uploads/newsfiles/Indian%20Dairy%20%20Dairy%20Products%20Industry%20-%20June%202020.pdf>

India, in its quest to become a mature dairy industry, is aggressively transitioning from loose milk to value-added products and from unorganised/local to more of an organised and branded market. These two structural shifts will provide long-term growth visibility to the organised dairy sector. The transition will require capex in the initial phase and will improve the margins and return on investments over the long run for the companies in the sector. The demand for branded liquid milk via organised the sector and the value-added products will be driven by changes in macro-economic factors like increase in urbanisation, nuclear families, increasing number of dual income households with working women and improved per capita spending.

1.2 Inefficiencies in the milk value chain

Dairies currently use bulk cooling tanks to cool their milk to about 4°C at their procurement centres. These tanks, of 1,000-10,000 litres capacity, keep the milk chilled which is later transported to a processing plant nearby. These systems are designed as per ISO standards for cooling half of the rated bulk milk capacity to 4°C within 3 hours. Such standards work well for developed nations where milk production and cooling are co-located at the same vicinity. For India, such coolers have the following major drawbacks:

- Millions of small and marginal farmers in dairying who own two to three animals and produce an average of 5L comprise a critical portion of India's dairy industry⁸. Insufficient milk collection in a village to cater to a single bulk cooler, forces dairy companies to collect and transport uncooled milk from multiple villages. The milk is cooled at a centralised cooling centre. This entire process results in delayed arrival of milk at bulk cooler sites. Thus, milk is exposed to higher temperatures for a longer duration, which leads to increased bacteria count in the collected milk.
- Bulk coolers require electric back-up via diesel generator, as electric grid supply is not reliable. It results in increased operational expenses and environmental pollution. In addition, diesel generators associated with these coolers are oversized by up to five times the rated power of compressor just to handle the start-up surge requirements. It results in additional diesel consumption due to the part load operation of diesel generator.

The installed chilling infrastructure by cooperatives and private dairies was sufficient to handle only 18% of the total milk produced by the country in 2015-16³. The projected gap in installed chilling infrastructure capacity for the year 2023-24 is 127 million MT³. Despite large production of milk, the cold chain potential remains untapped due to the high cost of owning and operating a diesel generator with bulk milk cooler, risks involved in spoilage of milk due to irregular power supply, lack of awareness about quality, high initial investment for milk coolers, lack of enabling infrastructure like power and roads, lack of awareness for handling perishable produce and lapse of service either by the bulk milk cooling centre or the transporter leading to poor quality produce⁹.

Without availability of cold chain and processing infrastructure, the largely unorganised dairy sector resorts to milk adulteration for improving the shelf life and to increase the milk thickness. Water is the most common adulterant and reduces the nutritional value of the milk. If contaminated, water poses a health risk to the consumers. Other contaminants like urea, starch, glucose, formalin along with detergent are used as adulterants. These adulterants are hazardous and may even lead to cancer in long term usage¹⁰. To improve the milk quality and to eliminate the health risks posed by adulterated milk, it is essential to set up cold chain infrastructure at the production level and include smallholders in the organised sector – which not only improves the milk quality but also provides the households with constant income, guidance on animal health and breeding practices, and high quality milk production.

⁸ <https://www.fao.org/3/i0588e/i0588e05.htm>

⁹ <https://www.coolingindia.in/challenges-in-food-cold-chain/>

¹⁰ <https://economictimes.indiatimes.com/news/et-explains/is-the-milk-you-are-having-safe-heres-what-you-need-to-know/articleshow/66119023.cms>

1.3 Hypothesis – Need for Inficold solutions

Procurement of fresh milk is the most crucial element for dairy industry. Based on industry benchmarks, the fresh milk needs to be chilled within three hours of collection. If given an option, farmers prefer organised channels due to higher price realisation, but lack of infrastructure limits the participation of the majority of the smallholder farmers. To maximise the profit generated by farmers, retain milk quality and minimise wastage, it is essential to chill the milk near production level. The cold storage and supply chain infrastructure needs to be developed to penetrate tier-2 and tier-3 centres. If the traditional bulk milk coolers are used, the irregular supply of grid electricity at rural level is not reliable to provide the milk cooling and hence diesel generators are used as secondary source of power. The higher operation and maintenance costs involved in cooling of milk using diesel generators has largely prevented the penetration of organised sector in rural areas.

With the help of focused interventions and efficient cooling technologies, the value addition achieved by cooling of milk at the source can be initiated at the rural level, which is crucial to get better returns for the smallholder milk farmers. Inficold's bulk milk cooler with ice backup addresses the challenge directly. It bridges the gap of unreliable electricity by providing access to the highest cooling performance without the need of money consuming and emission spewing diesel generators. Moreover, traditional bulk milk coolers which are available in sizes of 500 litres and above are generally installed at a centralised location to cater for the cooling needs of a collection of villages, which results in sub-optimal quality due to higher transportation and chilling times. As the bulk milk cooler with ice backup is available in sizes of 200 to 500 litres per day cooling capacity, it is the most effective solution for value addition at the rural level which is characterised by small scale production.

The Inficold milk cooler price is at least 20% lower than the combined cost of the traditional bulk milk cooler and diesel generator. The value proposition by the Inficold bulk milk cooler with in-built ice back-up directly addresses the challenges of the current Indian dairy sector which has very limited penetration (~18%) of the cold chain³. The system holds the key to achieve this gargantuan task of increasing the reach of the organised dairy sector to the small dairy farms and individual farmers working in even the remotest areas of rural India.

1.4 Objective of the study

Inficold's milk cooling solutions are used by several dairy and horticulture service providers. It is necessary to understand whether these cold chain solutions are yielding positive benefits to the primary producers and service providers. Therefore, an assessment was conducted to study the following objectives:

- Assess to what extent diesel free and small sized milk coolers can add value to the farmers and the complete value chain;
- Identify challenges in scaling the technology and provide recommendations to accelerate adoption of the technology.

2 Methodology

2.1 Approach

This report is based on a case study of one unit of Inficold's diesel free Bulk Milk Cooler with ice back-up of 200 LPD milk chilling capacity – owned and operated by Lecolait dairy.

2.2 Data collection and analysis

A mixed method approach, using quantitative and qualitative data was used for the study. It included semi-structured interviews with the system owners which was used to understand the impact of Inficold services as compared to the traditional approach followed by them earlier.

Perspectives of the owner have been collected to understand their socio-economic conditions and their motivation to get the cold chain solution integrated in the supply chain.

3 Background

3.1 Inficold

Inficold is a National Technology Award winning company making farm level cooling systems efficient and inexpensive to own and operate. The diesel free cold storage and milk coolers are powered through grid electricity or solar photovoltaics, and the energy is stored in the form of ice. The ice provides round the clock cooling back-up which enables safe storage of perishable commodities, like, fruits, vegetables, poultry, flowers, milk, etc. It helps in reduction of post-harvest losses, improve quality, and increase profit margins across the entire supply chain of agriculture produce.

Diesel Free Bulk Milk Cooler with ice back-up

Inficold's Bulk Milk Cooler with 200-500 litres capacity is based on thermal storage technology. Thermal energy storage stores cooling in the form of ice, which provides cooling backup for milk. The inbuilt cooling backup is enough to cater to the cooling requirement of a dairy even with 8 hours/day of grid/solar availability, which eliminates the need for diesel genset during power outages.

Advantages of the Diesel free Bulk Milk Coolers with ice back-up

- Low capex (~20%)¹¹ and opex (~67%)¹² as the initial investment and further operational costs are lower compared to the traditional BMC backed with diesel generator;
- Automatic operations as there is no user intervention required during power outages;
- Eliminates usage of diesel generator, reduces GHG emissions (~38%)¹³ and operational expenditure;
- Off-grid solar model can be used in remote areas with no grid access to increase the reach of organised sector;
- Off-grid solar model also does not require large electric battery bank, which are hazardous, and have limited life cycle
- Enables dairy farmers to cool milk at the village level, which reduces the overall cooling time and improves the milk quality;
- Faster cooling than traditional milk coolers, resulting in better quality of milk.

The system is designed on a single skid which makes it easy to install and does not require any specialised installation at the site. Inficold's 200 litres bulk milk cooler can provide milk cooling backup of 200 litres of milk with in-built ice during power outages. It provides 24/7 cooling with eight hours of grid electricity any time of the day. This system has one of the highest cooling performance available in the world. It can cool 100 litres milk from 35 to 4°C within an hour, which is three times faster than ISO 5708 Class 2 All standard.

¹¹ Comparison made for 500 litre per day milk cooler.

¹² 0.25 INR/L for bulk milk cooler with ice backup against 0.75 INR/L for traditional 500L bulk milk cooler with 7.5kVA diesel generator assuming only 30% power outage in a day.

¹³ 3MT CO₂ emission from bulk milk cooler with ice backup against 5MT CO₂ emission from traditional 500L bulk milk cooler with 7.5kVA diesel generator assuming only 30% power outage in a day.

Figure 2: Schematic of 200 litres Bulk Milk Cooler with ice backup



3.2 Lecolait Dairy

Established in April 2021, Lecolait Dairy is a privately owned dairy situated in the union territory of Pondicherry. Owned and managed by Mr. Netha, the milk is produced and procured from the self-managed farm of 30 cows, which graze on organic pastures and are free from Genetically Modified Organisms (GMO). The vision of the founder is to provide organic milk and other dairy products.

Dairy operation prior to the installation of milk cooler

The dairy farm is located 40 kms from the main city and it was taking around two hours to transport the uncooled milk from the dairy farm to the distribution center. From the distribution center, it takes another hour to reach the end consumer. The average quantity of milk handled by the dairy was around 20 litres per day. In the absence of availability of a small size bulk milk cooling solution, the dairy farmer was using a 45L capacity residential refrigerator to cool the milk. Cooling through refrigerator is inefficient as it takes around 6-8 hours for milk to attain a temperature of 7°C. It is very important that cooling milk up to 4 °C is completed within three hours of milking to prevent the wastage of milk by souring. At times when the delivery is delayed due to external factors, or when the ambient temperature is high during the summer season – the dairy receives customer complaints on milk spoilage. The inadequacy to reduce the cooling time increases the risk of milk spoilage, diminishes the brand value and limits the reach to customers.

Sales and revenue prior to the installation of milk cooler

The milk production, sales and revenue data of the dairy was collected for a period of six months before the installation of bulk milk cooler in October 2021. The average milk production by the dairy is around 20 litres per day and the client list of the dairy includes 23 families. On an average, 18 litres of milk was sold directly to the consumers at the price of INR 60 per litre. Two litres of milk per day which remained unsold was sold to traders at a price of INR 40 per litre. The total liquid milk supplied by the dairy in the last six months was 3600 litres. As recorded in the complaint register, around 300 litres of milk (~9%) got spoiled within the last six months after it was received by the customer. The dairy refunded the charges for spoiled milk. The total revenue for the last six months from dairy operations was INR 1,90,800.

4 Findings

4.1 Benefits of bulk milk cooler with ice backup

The dairy has been using a residential refrigerator for its cooling operation since its inception. From October 2021, Inficold's bulk milk cooler with 200 LPD milk cooling capacity was installed at their distribution centre. The following advantages have been identified:

- The five months of data post the installation of the bulk milk cooler suggests that the time required to cool the milk has reduced by three times and the milk is now cooled to 4°C as compared to 6-8 hours it took earlier to reach 7°C with the help of the refrigerator. The faster cooling has reduced the chance of milk spoilage, improved milk quality and the milk delivery is much faster than earlier. The improved delivery timings, chilled milk supply at the doorstep and zero complaints from customers on the milk spoilage has improved the brand perception and helped the dairy to scale up its business.
- As the milk cooling became faster reducing the chances of milk spoilage, the dairy was able to take on more customers for its milk services from around the city. With availability of increased cooling capacity, the daily quantity of liquid milk supplied to the consumers by the dairy distribution centre has increased from 20 to 76 litres (280% growth) gradually after the installation of the bulk milk cooler. The customer list of the dairy has also increased to 108 customers (369% growth) and the dairy is in a continuous mode of expansion further adding customers. The customer acquisition has become easier due to improved brand perception owing to chilled milk being supplied by the dairy.
- The customers procure milk from the dairy on a subscription basis, where customer is given flexibility to modify the quantity of milk required or pause the subscription completely. The uneven demand generated by the subscription model is better handled with availability of the bulk milk cooler. Without the bulk milk cooler, the extra milk was processed to produce curd. Whereas with the bulk milk cooler, the extra milk can be stored for another 24 hours which gives dairy farmers a buffer period to process or sell the remaining milk without the risk of spoiling or degradation in quality.
- There have been no complaints from the customers regarding spoilage of the milk in the last five months. The earlier wastage of ~9% milk has been completely prevented using the bulk milk cooler, which will result in savings of greenhouse gas equivalent of 23.6 MT CO₂¹⁴ assuming 100% capacity utilisation of the bulk milk cooler.
- The dairy was able to increase sales with the help of bulk milk cooler and is now generating revenue of INR 1,36,800 per month. As compared to pre installation revenue of INR 31,800 earlier, the revenue has increased by 330%. The cost of the system is INR 1,80,000 (USD 2,400)⁴ and the operational cost is INR 1,000 per month, which translates to a simple payback period of less than two months.
- With a completely automatic cooling operation, the owner of the dairy did not have to hire additional staff to oversee the cooling operation. Moreover, the unsold milk is left safely in the bulk milk cooler tank until new milk is bought in the next shift. The bulk milk cooler has provided the owner with peace of mind and added scope for new business opportunities. The dairy's business is growing at a rapid pace and will further increase to utilise the bulk milk cooler to its full capacity of 200 litres per day by the year end of 2022.

4.2 Challenges

Inficold's bulk milk cooler with in-built ice back-up was developed recently and has very few installations as compared to the traditional bulk milk coolers which have extensive presence throughout the country. Moreover, Inficold service centres are only situated in a few cities such as Delhi, Bangalore, Guwahati, and Raipur. The system malfunction is addressed by the service representative from the nearest service centre. A smaller installation base and no presence of local service centre in some cases, becomes a big impediment to selling the system for Inficold. Even though the system is technologically superior, the biggest questions which create a doubt in the mind of the buyer are long term system performance, reliability, unknown/less known brand name

¹⁴ 3.6 kg CO₂ emission per kg of milk wastage * 9% of 200L * 365 days = 23.6 MT CO₂ equivalent
<https://www.independent.co.uk/climate-change/news/drink-your-milk-waste-is-equal-to-gas-emissions-from-20-000-cars-7743521.html> - 3.6

and long-term service capabilities. The initial system sold to Lecolait Dairy and few other dairies were provided at discounted rates to increase the adoption rate of the new product. Once a greater number of systems become available on the ground and the service presence increases, the gap between the technology and market will be bridged to a greater extent as the brand perception will improve and people will have more trust and confidence in the performance superiority of bulk milk coolers with in-built ice back-up. With higher penetration of installations in a particular geography, the existing service team of the traditional bulk milk coolers can be trained to be a part of the support and service team for milk coolers with ice back-up. However, to accelerate the process of increasing the reach of the organised sector in dairy and to improve the presence of cold chain to a greater extent, higher participation is required from government agencies and NGOs to proactively engage in promotion and assimilation of innovative technologies by the dairy producers and small dairy owners. There is a need to develop awareness about the product and the related benefits, especially in tier-3,4 and tier-5 centres.

5 Conclusion

The diesel-free milk coolers with ice back-up have multiple advantages and have the potential to improve milk quality and provide better profit margins for smallholder farmers, small to mid-sized private dairies, and milk collection centres of the dairy cooperatives at village society level. Some of the advantages of the diesel free bulk milk cooler include:

- Fast cooling leading to improved milk quality that fetches a higher value for the produce ;
- Elimination of diesel generators, leading to cost competitiveness and reduced CO₂ emissions;
- Off-grid solar model can be used in remote areas with no grid access, increasing the reach of the organised sector.

Based on the National Action Plan for Dairy Development, Vision – 2022, there is a requirement to set up chilling infrastructure to handle 426 million litres of milk per day by 2023-24³. The Inficold technology, if implemented at scale, has the potential to improve the socio-economic status of smallholder dairy farmers, spur the local economy, reduce CO₂ emissions and increase the reach of the organised sector to every corner of India. There is a significant opportunity to bring smallholder farmers on board with the organised milk cooperative ecosystem in India, which calls for the need to generate more awareness at cooperative level around the adoption of sustainable cooling solutions.