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SUPPLY CHAIN OPTIMIZATION AT MADURAI AAVIN MILK DAIRY

Anand had been working at the Madurai Aavin Milk Dairy (MAMD) for 25 years, and was in charge of the quality control department. The MAMD was one of the few profit-making milk dairies in Tamil Nadu, India. Anand's key responsibility was to ensure sufficient supply of milk and milk products to meet the demand, especially the demand for premium milk, and to ensure that the MAMD remained a profit-making entity.

According to Anand:

The gap between the demand and supply has increased over the last few years. In 2011, on an average, the MAMD supplied only about 2,50,000 liters of milk in a day, out of an estimated average market demand of 3,40,000 liters in Madurai district alone. The rest of the market was with the private sector milk producers. It is important for the MAMD to maintain market leadership to remain profitable.

Milk was considered one of the essential commodities in India, and its price was controlled by the state governments. The government-controlled milk cooperative societies were expected to meet the market demand for milk products. Muthiah, General Manager of the MAMD, had to make several supply chain decisions to ensure that they were able to meet the demand as much as possible while remaining a profitable dairy. With milk being a perishable product, there were several supply chain challenges, especially in a country such as India where the farmers might not have any cold storage facilities. India's recent economic growth had resulted in a substantial increase in the demand for milk and milk products; however, the milk production had not improved to match the increased demand. Muthiah's primary responsibility was to supply as much milk as possible to the market so that customers did not have to buy milk at a higher price from private milk suppliers. Muthiah said:

We charge INR 22 (USD 1 = INR 45)¹ per liter of milk, whereas the private companies charge as much as INR 31 per liter. Any reduction in the supply of milk from the MAMD is a concern for the common people, as they will have to buy milk at a higher price.

There were several reasons for the increasing gap between the demand and the supply of milk in India; many within the dairy industry believed that the increase in the purchasing power of the Indian middle class was one of them. Whatever the reasons, milk dairies such as the MAMD had to adopt several strategies to meet the increasing demand for milk in Madurai district. Milk could be prepared from other products such as skimmed milk powder (SMP) and butter. Since SMP and butter had a longer shelf life than milk, they could be easily converted into milk when required. However, the processing of milk from butter and SMP increased the production cost owing to the inventory carrying cost and the additional processing cost. Anand elaborated:

We try to meet the demand for milk through the recombination of SMP and butter whenever the supply of raw milk is less than the demand. Although the inventory carrying cost for SMP is not significant, the inventory cost for butter is high since it has to be stored at -20°C . We procure raw milk at INR 15 per liter

¹ The exchange rate between the Indian rupee (INR) and the US dollar was based on 2010 values.

from the farmers; to process raw milk into premium milk, it costs INR 4 per liter. The additional processing cost of converting butter into milk through recombination could wipe out the profit.

The demand for milk was seasonal, and the supply of raw milk from farmers was uncertain. The demand increased during festival months in India, such as October, November, and January, and decreased during the summer months of March and April. Butter and SMP were used to fill the gap between demand and supply during the high-demand season. Producing milk from SMP and butter required careful planning. Since the profit was very low, it was important to optimize the supply chain to ensure profitability.

THE INDIAN DAIRY INDUSTRY

In 2010,² India was one of the largest milk producing countries, producing about 114.4 million metric tons of milk, which was estimated to be 13% of the world's total milk production. The Indian dairy industry was valued at USD 70 billion in 2010,³ and it was growing at an annual growth rate of 7%. India was the world's largest consumer of dairy products, consuming almost 100% of its own milk production. The dairy sector in India could be classified into organized and unorganized sectors. The village cooperatives, milk unions, and government dairies formed the organized sector, and the proprietary milk dairies formed the unorganized sector. In the organized dairy industry, the cooperative milk processors had a market share of 60%. While the cooperative dairies processed and sold 90% of the milk that they collected as liquid milk, the proprietary dairies processed and sold only 20% of the milk collected as liquid milk; the remaining 80% was processed and sold as other value-added dairy products such as ghee, butter, cheese, yoghurt, condensed milk, paneer (Indian cheese), etc. The milk processing industry was small compared to the huge demand, which was increasing every year. Dairy cooperatives provided considerable employment opportunities in villages as well as cities, and around 13.9 million farmers were involved in the milk dairy farm. A significant proportion of India's rural population depended on the dairy process and the income generated through the dairy process.

MADURAI AAVIN MILK DAIRY: THE ORIGINS

The Madurai District Cooperative Milk Producers' Union Ltd., also known as the Madurai Aavin Milk Dairy (MAMD), was one of the largest dairies in the southern part of Tamil Nadu, India. The MAMD was started in 1967 as the Madurai Milk Project. The project and the dairy machineries were funded by the UNICEF under the New Zealand Freedom from Hunger Campaign Committee. In January 1974, the MAMD was brought under the control of the Tamil Nadu Dairy Development Corporation Ltd., Chennai. In 1982, the MAMD was converted into a district cooperative unit. The members of this cooperative unit constituted the Milk Producers' Cooperative Society (MPCS) at the village level, situated within a radius of 70 km. The MAMD was a cooperative organization statutorily controlled by the Commissioner for Milk Production and Dairy Development, Government of Tamil Nadu. The apex body of this unit was the Tamil Nadu Cooperative Milk Producers' Federation Ltd., Chennai. The objectives of the MAMD were: (1) to supply good quality milk to the consumers at a reasonable price; (2) to provide good remunerative price to the milk producing farmers; and (3) to assure year-round procurement of milk from the members of this union, i.e., the farmers. In 2011, the MAMD had more than 535 employees managing the complete supply chain associated with milk procurement, processing, storage, and distribution.

MILK PROCUREMENT AND OTHER INPUTS

The major activities in the supply chain were the procurement of milk from the farmers, and the provision of necessary technical input and facilities to them. The procurement was carried out by forming village-level Milk Producers' Cooperative Societies (MPCS). Each village could have only one MPCS, with at least 50 farmers as

² Source: <http://www.dairyindia.com/>

³ S. Chand, A. Saraiya, and V. Sridhar, "Public private partnership in Indian dairy industry: Initiating white revolution – II," CII Industry report, May 2010.

members. The procurement of milk from the members was based on the quality of milk. The procured milk was tested for its fat and solid non-fat (SNF) content. Raw milk was composed of 87.3% water, 8.8% SNF, and 3.9% fat. The quality of milk depended on the ratio of SNF and fat; the composition had to be 7.9–10.0% SNF, 2.4–5.5% fat, and 85.5–88.7% water. The farmers were remunerated based on the quantity and the quality of milk. One of the challenges in procurement was convincing the farmers to supply milk to the MAMD. About 80% of the Indian dairy industry was unorganized, and the raw milk market was dominated by the local milkman, which resulted in a complex supply chain. Cooperative milk dairies such as the MAMD also faced stiff competition from private milk dairies. Anand explained:

Private milk dairies pay the farmers in advance, whereas, as a policy, the MAMD pays after the milk is procured from the farmers. A few farmers obviously prefer advance payment, and the private milk dairies take advantage of this.

To motivate the farmers to supply milk to the MAMD, several schemes were developed. The MAMD provided veterinary healthcare support to farmers, and educated them about animal management. Training programs in cattle management were conducted regularly. Milk coolers were provided to farmers based on the need to store and increase the shelf life of milk. The farmers were also given equipment such as lactometers to analyze the quality of milk. Milk chilling centers were set up at all the milk collection centers that were more than 50 km away from the MAMD. The milk chilling centers also generated rural employment. Muthiah was confident that the farmers would appreciate the larger benefits they received by supplying milk to the MAMD. Muthiah elaborated:

We have a strong relationship with our farmers. The MAMD has employed 19 veterinary doctors who help farmers in disease control. The payments are made directly to the farmers' bank account once in 10 days. We also provide training on various dairy-related subjects for the benefit of the farmers.

The MAMD planned to increase milk production in the district by providing cattle loans to the farmers as well as technical knowledge regarding cattle management. This would help to increase milk procurement, reduce the price of milk by bridging the demand-supply gap, and would also increase the generation of self-employment in rural areas.

Inbound Logistics

The MAMD received milk from different places and from five chilling centers, transported by 16 vehicles. Milk was stored at 4 °C in the chilling centers in order to extend the shelf life, and tankers were used to deliver the milk to the MAMD. Every route had an MPCS to which the farmers supplied milk in cans; the milk was then transported to the MAMD in tankers. In outbound logistics, the packaged milk (consumer milk) was sent to milk parlors and retail stores. Other milk products were sent to the distribution centers, and these products reached the consumers through retail stores. **Exhibit 1** showed the inbound and outbound structures of the Madurai Aavin Milk Dairy.

DAIRY PROCESSING UNIT

The entire process of the dairy industry started with raw milk as the input, and ended with consumer milk as the output. Owing to the perishable nature of milk, the entire process was carried out in a controlled environment. Milk was processed in a stage-by-stage sequence, as shown in **Exhibit 2**. The types of consumer milk depended on the SNF and fat content, as shown in **Exhibit 3**. The most important product was premium milk that contained 4.5% fat and 9.0% SNF. Reconstitution was the process by which consumer milk was produced by mixing SMP and water in appropriate proportions. For instance, in the case of the premium milk sold by the MAMD, if the quantity of SNF and fat was less than 9% and 4.5%, respectively, SMP was added to the milk. The addition of SMP increased the volume of the milk; the additional cost incurred by this process was insignificant. The main purpose of reconstitution was to ensure quality, which was measured through the fat and SNF content in the processed milk.

The cost of reconstitution could be ignored since the farmers were paid based on the quality of the milk they supplied and the cost spent on reconstitution was indirectly recovered from the farmers. Recombination was the process in which butter, SMP, and water were combined in appropriate proportions to produce milk, in order to bridge the supply-demand gap. An inventory of SMP and butter was usually maintained for reconstitution and recombination.

Supply Chain Management Issues

Butter and SMP were produced using dedicated machines within the milk processing unit itself when excess raw milk was available. The process consisted of the removal of SNF and fat from milk, followed by the conversion of SNF into SMP, and the conversion of fat into butter. The conversion process involved the transformation of liquid to solid through evaporation. The SMP and butter were packaged and stored at a controlled temperature. During peak period, SMP had to be combined with butter to produce milk, which added to the production cost. The quantity of SMP and butter obtained after conversion could be illustrated with a sample calculation: 1000 liters of milk could be converted into either 93.45 kg (9.34%) of SMP or 54.87 kg (5.48%) of butter, and the water content would be evaporated in the process. In the process of recombination, 93.45 kg of SMP and 54.87 kg of butter would be used to produce 2000 liters of premium milk. In order to operate the machine that converted raw milk to SMP, a minimum of 40,000 liters of milk was required. Similarly, butter could be produced only when at least 20,000 liters of excess raw milk was available after meeting the demand for premium milk and the reserve stock requirement, which was 5% of the raw milk procured every day. It was important to note that raw milk could also be procured from other milk dairies at INR 16.5 per liter (inclusive of transportation costs). Butter and SMP were purchased from outside sources depending on the need. Raw milk, butter, and SMP were usually procured from milk dairies in the neighboring districts; further, SMP was imported if required. One of the major suppliers of SMP in India was Amul (the Gujarat Co-operative Milk Marketing Federation Ltd., Anand, Gujarat).

THE CHALLENGE

Milk was a perishable commodity, with a shelf life ranging from a few hours to a few days if preserved under suitably cold temperature. In 2011, the MAMD catered to only 70% of the demand; therefore, the challenge was to improve its ability to meet the total demand. It was found that the gap between supply and demand in 2010 was approximately between 8% and 10% for different months.

The other challenges included:

- Fluctuation of supply owing to the spread of bovine diseases, lack of interest on the part of farmers towards improvements in cattle breeding, local consumption during festival seasons, and other climatic conditions;
- Fluctuation of demand owing to urbanization, increased consumption during festivals, and preference shown by farmers among different dairies to supply raw milk;
- Aggressive competition from other private milk dairies;
- Rising production costs and fierce competition in the local dairy market.

The demand for consumer milk was increasing at an annual rate of 10% (obtained from sales of the previous years, and shown in **Exhibit 4**). According to Anand, the challenge was to meet the demand in an optimal way by making use of the following data:

- i. Product demand profile
- ii. Manufacturing restrictions
- iii. Sourcing of milk from other dairies
- iv. Recombination of SMP and butter
- v. Inventory capacity

The following supply chain characteristics were observed at the firm level.

Product demand profile: The production requirement profile was represented by data from the previous year. About 10% increase in sales was assumed as demand for the year 2011. The monthly sales and average input per day were as shown in **Exhibits 4 and 5**, respectively.

Inventory capacity enhancement: The primary reason for maintaining inventories of SMP and butter was to reduce the gap between supply and demand, i.e., the supply of raw milk was less than the demand. In addition to meeting the demand-supply gap, the inventories of SMP and butter were required to meet the quality standards. The MAMD also had the option of procuring milk from other unions in neighboring districts; however, this increased the transportation cost. The costs of procuring SMP, butter, and milk from other unions were shown in **Exhibit 6**.

These factors had to be taken into account by the management while planning milk production. The market share of the MAMD fell to 62% in 2010 from more than 90% a decade earlier. The main challenge was to meet the demand for premium milk at a lower cost. The MAMD sold the entire stock of premium milk on the same day as it was processed. Anand reiterated:

Our main focus is the supply of premium milk to the market. We would like to meet at least 70% of the market demand. We produce other products (**Exhibit 3**) only when excess milk is available. Since the supply-demand gap was almost 40% in 2010, we rarely produced any other products apart from premium milk.

To achieve this target, the MAMD management was ready to compromise on all the other products sold by them. Since the demand for premium milk was higher than the supply of raw milk, the MAMD used recombination to meet the demand. Recombination increased the production cost by an average of INR 2 per liter; the total cost of milk produced through recombination was INR 21 per liter. Additional SMP could be purchased as required, at the cost of INR 163 per kg, while butter could be purchased at INR 112 per kg. The MAMD had the capacity to store 10,000 kg of butter. The cost of refrigerating butter was INR 2500 per day, irrespective of the amount of butter stored. However, if all the butter was used for recombination the same day as it was procured; there would be no inventory carrying cost. As a policy, 5% of the raw milk procured every day was always stored as reserve stock, and the remaining 95% of the procured milk was used to produce premium milk, SMP, and butter. The reserve stock would be utilized the next day. Further, the entire stock of premium milk produced was sold on the same day.

Anand had to optimize the short-term and the long-term production plans. His immediate concern was to forecast the monthly demand from April 2011 to September 2011, and to optimize the daily production plan for the month of April. On April 12, 2011, the MAMD had a stock of 12,110 liters of raw milk, 1200 kg of SMP, and 520 kg of butter. The SMP and butter inventory had remaining shelf life of 3 months and 6 months respectively.

Exhibit 1

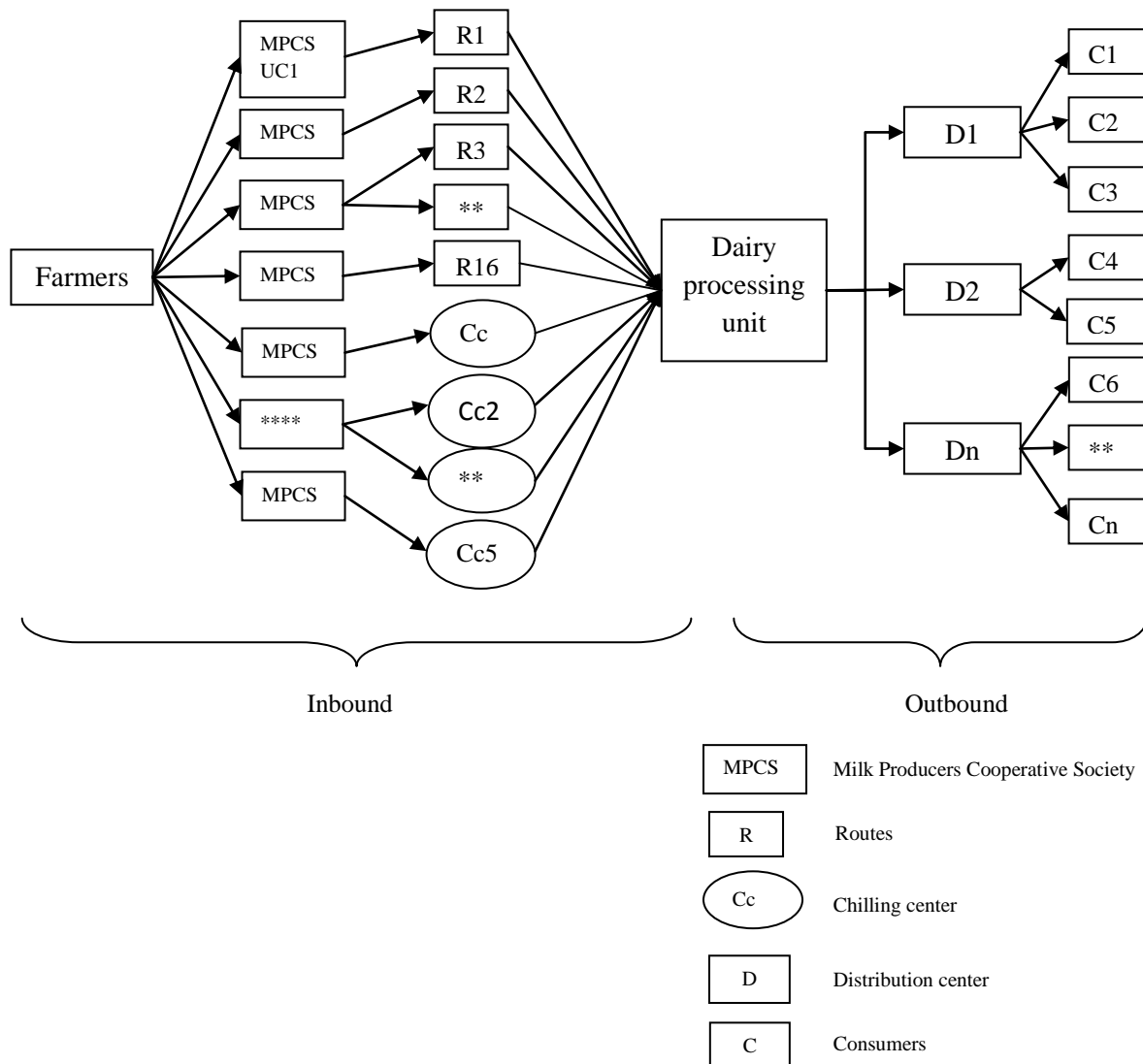
Inbound and outbound structures of Madurai Aavin Milk Dairy

Exhibit 2

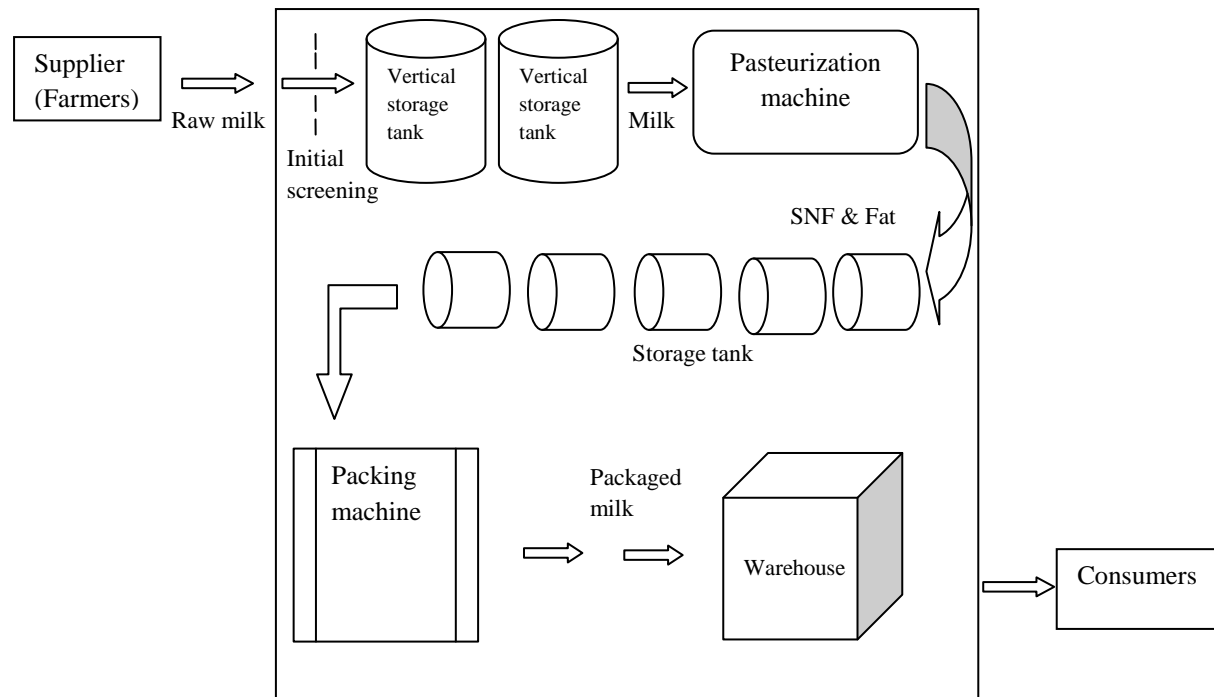
Schematic representation of Madurai Aavin Milk Dairy processing unit

Exhibit 3

Types of milk sold

Type of Milk	Fat (%)	SNF (%)
Toned milk	3.0	8.5
Standardized milk	4.5	8.5
Premium milk	4.5	9.0
Full-cream milk	6.0	9.0
Double-toned milk	1.5	9.0

Exhibit 4

**Estimated sale of packaged milk (in liters) in Madurai region between 2008 and 2011
(including neighboring districts)**

Month	Year		
	2008–2009	2009–2010	2010–2011
April	6436977	8168753	8727300
May	8038673	9042377	9936678
June	7699105	8535593	9777312
July	7446966	9159860	10408932
August	6893954	8660746	9666011
September	7266777	7985469	8922312
October	9577732	10287574	11038170
November	6959258	8865297	9234684
December	9196648	10106207	10751284
January	7703373	8763792	9737546
February	6337111	6573767	7068566
March	6661873	7012498	7622280

Exhibit 5

Estimated daily demand (in liters) for April 2011

Day	Demand	Supply	Day	Demand	Supply	Day	Demand	Supply
1	286387	232031	11	269299	218186	21	272493	220774
2	307453	249099	12	275672	223350	22	298470	241821
3	288095	233415	13	308182	249689	23	318493	258043
4	267987	217123	14	287419	232867	24	304744	246904
5	288652	233866	15	307718	249313	25	285709	231482
6	327752	265545	16	316682	256576	26	308121	249640
7	260029	210676	17	330245	267565	27	316298	256265
8	278243	225433	18	335029	271441	28	257257	208430
9	299058	242297	19	342925	277838	29	314569	254864
10	323536	262129	20	309399	250675	30	272352	220660

Exhibit 6

Procurement costs

Skimmed milk powder	INR 163 per kg
Butter cost	INR 112 per kg
Raw milk from other unions	INR 16.5 per liter