POLITECNICO DI MILANO

SCHOOL OF INDUSTRIAL AND INFORMATION ENGINEERING

MASTER OF SCIENCE IN MANAGEMENT ENGINEERING

STRATEGY FOR VALUE ADDITION IN DAIRY INDUSTRY

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ABSTRACT

In the fourth industrial revolution, most operations are moving to the digital space. The aim of this thesis is to examine how Internet of Things (IoT) will evolve the dairy industry. Dairy industry is the only competitive food industry with highest quality control limits, variable demand and supply, different customer needs in different forms of milk products. Increase in population increases the need for milk products with good quality. To supply the entire demand, the productivity of the farms should be improved by increasing lactation of an individual cow, and the waste across the entire supply chain must be minimised. This study answers how advances in automation and information technology will increase the quality and productivity of milk in farms, how these advancements will make an industry achieve competitive advantage and what are the changes to be followed to achieve it.

Benefits and needs of IoT in farms, upstream supply chain, milk processing industry and downstream supply chain is completely analysed, and further study has been made to improve the pasteurizer efficiency in which two products can be processed with one pasteurizer.

CHAPTER 1: INTRODUCTION

Over the span of three decades, India has transformed from a country of acute milk shortage to the world's leading milk producer, with production exceeding 150 million tonnes in 2017 representing sustained growth from 138 million tonnes in 2015. India accounts for 18.5 per cent of world milk production. This growth started from the program "Operation Flood" called as "the white revolution." It created a national milk grid linking producers throughout India with consumers in over 700 towns and cities, reducing seasonal and regional price variations while ensuring that the producer gets a major share of the price consumers pay, by cutting out middlemen.

Dairying has become an important secondary source of income for millions of rural households engaged in agriculture. The success of the dairy industry has resulted from the integrated co-operative system of milk collection, transportation, processing and distribution.

1.1 BACKGROUND

We analyse a leading dairy cooperative located in the southern part of India, which was launched in 1995 as a flagship brand won the trust of millions of consumers across the state.

The popularity of this industry is attributed to the fact that a whole eco-system has been built around the brand promise "Goodness with care, from our villages". Great care and hygiene goes into the procurement, processing and packaging of the Milk to ensure it's made available in a healthy way to the customer.

The dairy had an annual revenue of 5,50,235 euro (FY 2016-2017), which previously was 4.22.123 euro in the financial year 2015-2016. These major revenues are from milk categories like Standardised milk, Full cream milk, Toned milk.

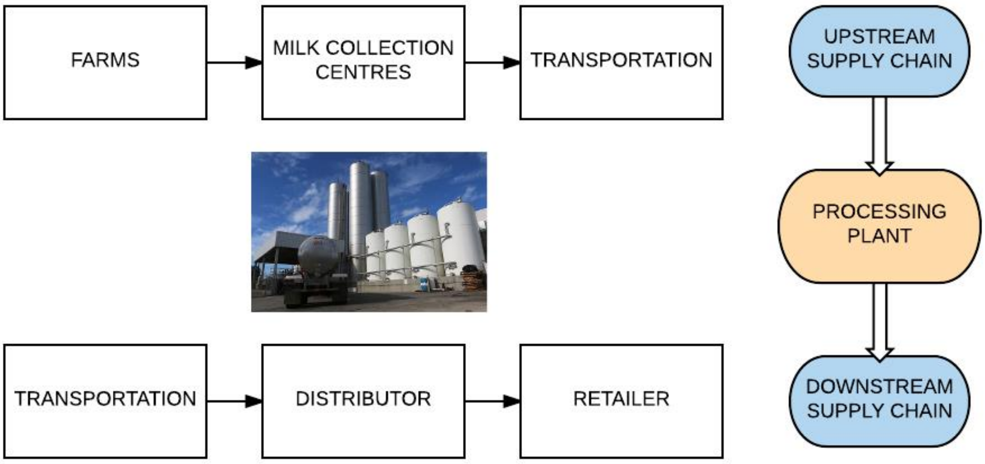


Figure 1: Supply chain of milk processing plant

The supply chain of a business process comprises mainly five activities Purchase of materials from suppliers, transportation of materials from suppliers to facilities, production of goods at facilities, transportation of goods from facilitates to warehouse and transportation of goods from ware houses to customers via distributors and retailers.

1.2 PROBLEM DESCRIPTION

In the process of analysing the industry for value addition, the following are considered as areas of improvement:

- Increasing demand vs constant supply: the dairy industries could not supply the milk for a constant price because of poor productivity. Also fluctuating the price of milk is against the constitutional law.
- Quality of the milk depends on the quality from its source, increasing cattle diseases, poor cattle feeding makes the quality of milk worse.
- Poor visibility in the supply chain is affecting the brand name as the industry must ensure freshness to customers.

CHAPTER 2: INTERNET OF THINGS

2.1 WHAT IS AN IoT

Technology made its way in many sectors but still the dairy industry needs revolution – IoT in the dairy industry. In the age of Industry 4.0 and the digital transformation of manufacturing, the food industry is the market where Industrial Internet of Things(IIoT) need to be realized and where most IIoT investments are to be made. Analysing the way to redefine the potential of dairy industry, Internet of Things (IoT) is a system of interrelated computing devices where digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human to human or human to computer interaction.

2.1.1 IoT IN DAIRY INDUSTRY: WHAT DO WE HAVE TODAY?

Proper Supply Chain Management (SCM) has proven essential for the competitiveness of organizations, since it ensures the effectiveness of supplies, and the proper coordination with suppliers, intermediaries and market needs [1]. The use of Information and Communication Technology (ICT) in the SCM has proven to have a positive impact in companies that have implemented it, particularly in relation to procurement, as it enhances collaboration, improving the quality of information shared between suppliers and buyers. With the presence of ICT 3.0 where the cloud architectures rule the industries, the dairy industry is upgrading for better performance and improved productivity.

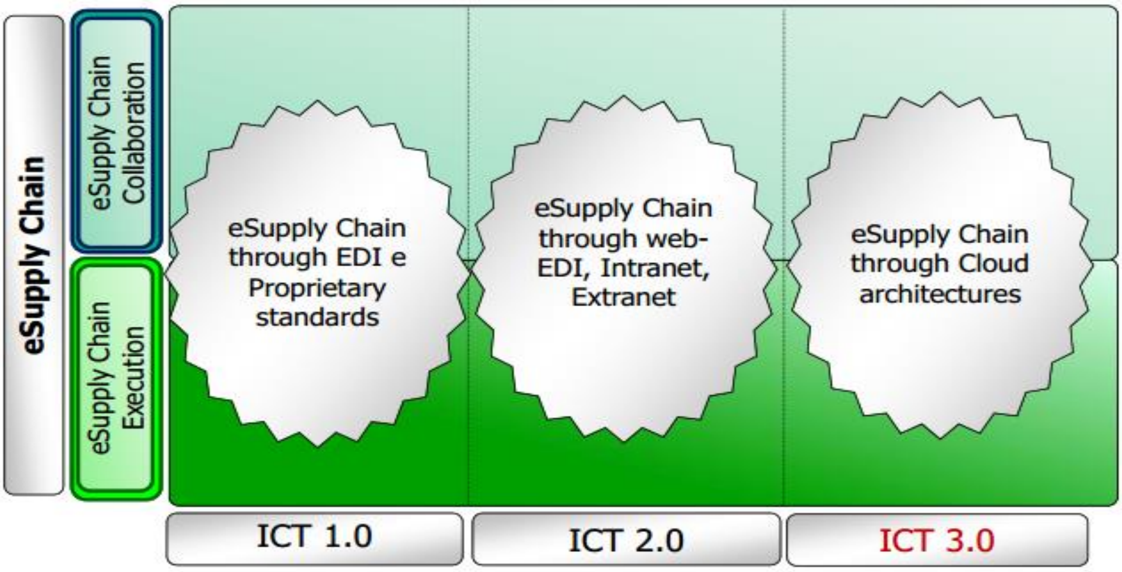


Figure 2: ICT development - Source: Osservatori

2.2 WHAT IoT DOES

By connecting people, process and data together, the software makes decision making easier and expedites the product to market process. IOT helps in i) Better productivity starting from cow to its various levels of milk processing, ii) It influences food safety, helping to spot pathogens before a potential outbreak or recall, iii) Increased operational efficiency by utilizing sensor technology to track temperature readings, analysing the bacterial conditions throughout the supply chain iv) Supply chain transparency and tracking making it easy for milk processors and consumers to track the entire supply chain [2]. The supply chain is the major area where dairies can benefit from real-time analysis. With multiple handovers in the process of creating a dairy product between different companies, real-time analysis can enable alterations if an issue appears anywhere along that supply chain.

CHAPTER 3: UPSTREAM SUPPLY CHAIN

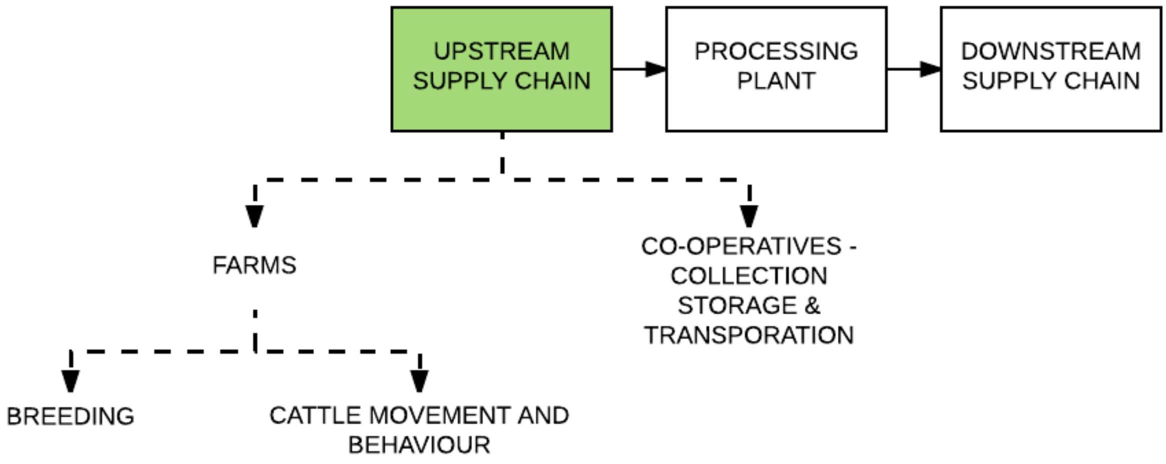


Figure 3: Key framework of analysis

3.1 IoT FOR CATTLE

Addressing the objective improving the quality and productivity from farms industries are required to adopt the supplier mentoring programme. with this programme they can improve quality, reliability, productivity through best supplier development practices.

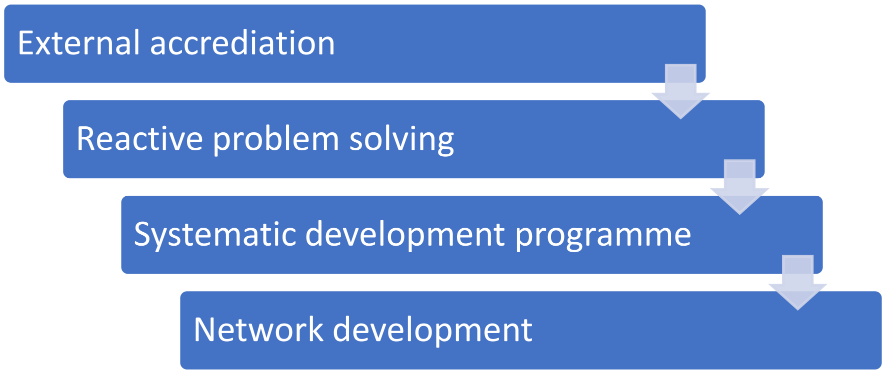


Figure 4: Stage of supplier development - Source: Hines et al. (2000)

According to *Hines et al. (2000) suggest that supplier development programmes typically progress through four steps, beginning with efforts to accredit suppliers, followed by reactive problem solving with suppliers, developing into a more systematic supplier development programme and ultimately into a process of ‘network development’. Where the third step focuses on knowledge flowing vertically from the focal company to its suppliers, the fourth step is characterized by mutual sharing of knowledge amongst buyers and suppliers both vertically and horizontally.

Best practices in supplier development:

- Create dedicated supply development teams.
- Teach a supplier how to develop itself after initial guidance from supplier development team.

- Focus on underlying causes of quality issues.
- Focus on wasteful activities.
- Provide training programmes and time.
- Provide education programmes.
- Provide improvement-focused seminars.
- Provide tooling and technical assistance .
- Provide supplier support centres.
- Provide feedback loop for suppliers to encourage efforts

How technology works in farms:

- Management of reproductive issues: poor reproductive performance increases the calving to calving interval and, therefore, the average length of lactation increases. As a direct effect, low reproductive performance can prevent the diet from being fully utilized.
- Control of health issues: the various diseases commonly encountered in dairy herds can reduce the efficiency of digestion (ketosis, acidosis, fatty liver, alkalosis ...) and cause disorders in eating behaviours (acidosis, lameness) as well as affect secretory tissues (mastitis ...).
- Housing conditions: housing must favour a better expression of the full potential of animals' behaviour. Animals should have permanent access to the feed bunk and drinking water. Appropriate housing must also prevent the emergence of diseases inherent to rearing contexts (the importance of ventilation, brightness, of bedding quality, of stalls setting...).

How the Farming industry can use the technology to increase productivity:

- Tracking cattle movement and locations to prevent potential loss or theft.
- Measuring fertility of cows to make better decisions on breeding.
- Monitoring or Tracking of cow's behaviour, eating habits, health conditions etc
- Lactation and the use of robots to increase milk production.

Beyond the diet, rearing conditions and herd management have a direct impact on the amount of milk produced per cow per day. A better herd management can be achieved by implementing the cloud based IoT [3]. The first step to be implemented consists of undertaking an audit. The conclusion drawn from this audit will help identify areas for improvement like fertility cattle movement and behaviour.

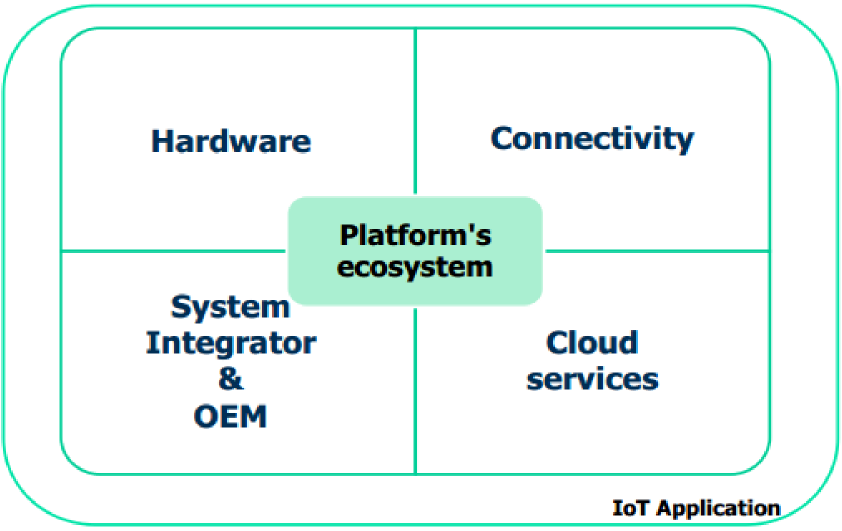


Figure 5: IoT in platform approach - Source: Osservatori

3.1.1 FERTILITY

Productivity can be improved by knowing the estrus period of the cow. Each cow has an estrus cycle spanning about 21 days in which the cows should be artificially inseminated so that it can produce milk in larger quantity and for longer time during its life span. The more the cow misses on getting fertilized during its estrus period, the usefulness of cow becomes lesser.

Figure 6: Pedometer - source: Fujitsu IoT

IOT helps in detecting the occurrence of estrus in the cow. During estrus period the walking pattern of the cow changes and is measured using the pedometer. Pedometer is a device that counts the number of steps taken. The pedometer is otherwise called as step counter. The pedometer measures the walking pattern and send to the cow's footstep count to the cloud in regular intervals of time. The pedometer is attached to the cow leg. When the estrus is detected the information is passed to the farmers. Hence farmers can fertilize the cows at the right time and make the cows more productive.

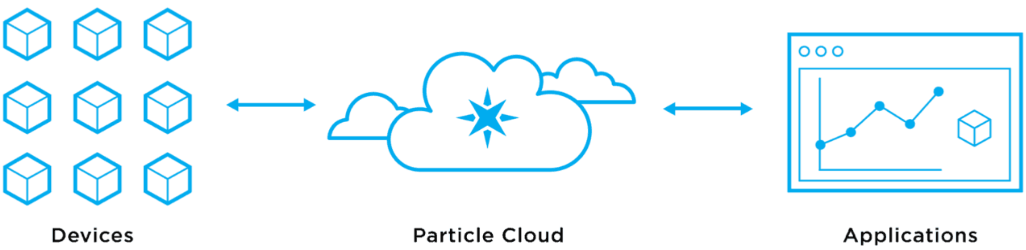


Figure 7: Cloud architecture

3.1.1.2 ANALYSING THE CASE

Fujitsu has manufactured a Pedometer, specifically designed for just this purpose. It has a battery life of at least 5 years and is connected through an antenna/receiver (with a range of up to 300 meters) over to a 3/4G router, which is connected to the main network (base station) from where the data is send over to the cloud. It is here where all data will be analysed (big data). As soon as an abnormality in the cow movement patterns has been detected an alert will be send to the (smart) phone, or PC/laptop etc. of the farmer. Next it will be up to him/her what to do with the received information. As easy and simple as it is efficient.

The use of these pedometers has successfully increased cattle production up to 70%. The earlier mentioned 50% accuracy around determining the upcoming Estrus cycle went up to 95%, and the success rate regarding pregnancies rose from 35% up to 65.

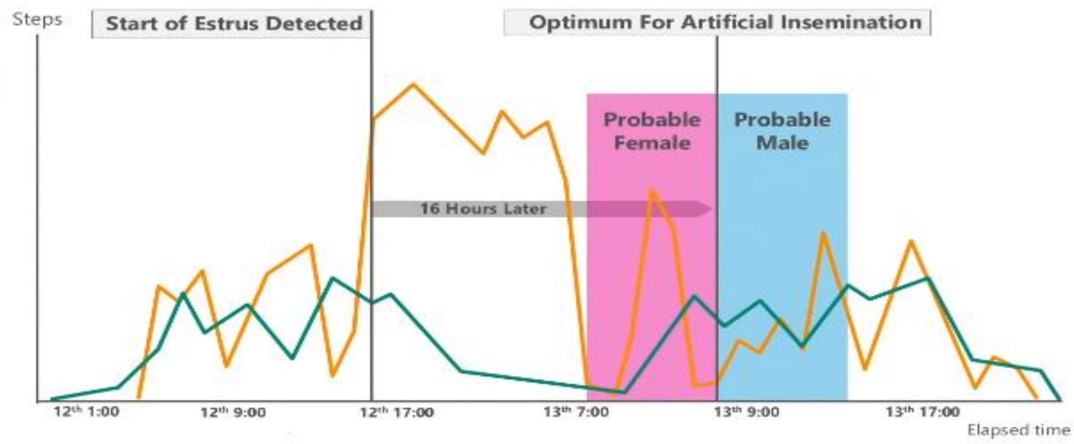


Figure 8: Estrus cycle - Source: Fujitsu

While studying the cow movement patterns in combination with the Estrus cycles Fujitsu found that there is a certain time window surrounding the optimal time a cow should receive AI, which comes around 16 hours after the first changes in movement have been detected. If they inseminate the cow in the first half of this window, in 70% of all cases she will get pregnant with a female. If the semen is inseminated during the second half of that window the cow will get pregnant with a male (mostly used for meat production) again in 70% of all cases.

3.1.2 CATTLE MOVEMENT AND BEHAVIOUR

The Internet of Things requires a few necessary components to enable communication between devices and objects. Objects are augmented with an Auto-ID technology, typically an RFID tag, so that the object is uniquely identifiable [4]. Also, an RFID tag allows to communicate wirelessly with certain type of information through which we can monitor the required data. If the cattle herder faces the issues like missing of cows, difficult in locating the cows, theft then an active RFID reader is suggested or else a passive RFID is sufficient.

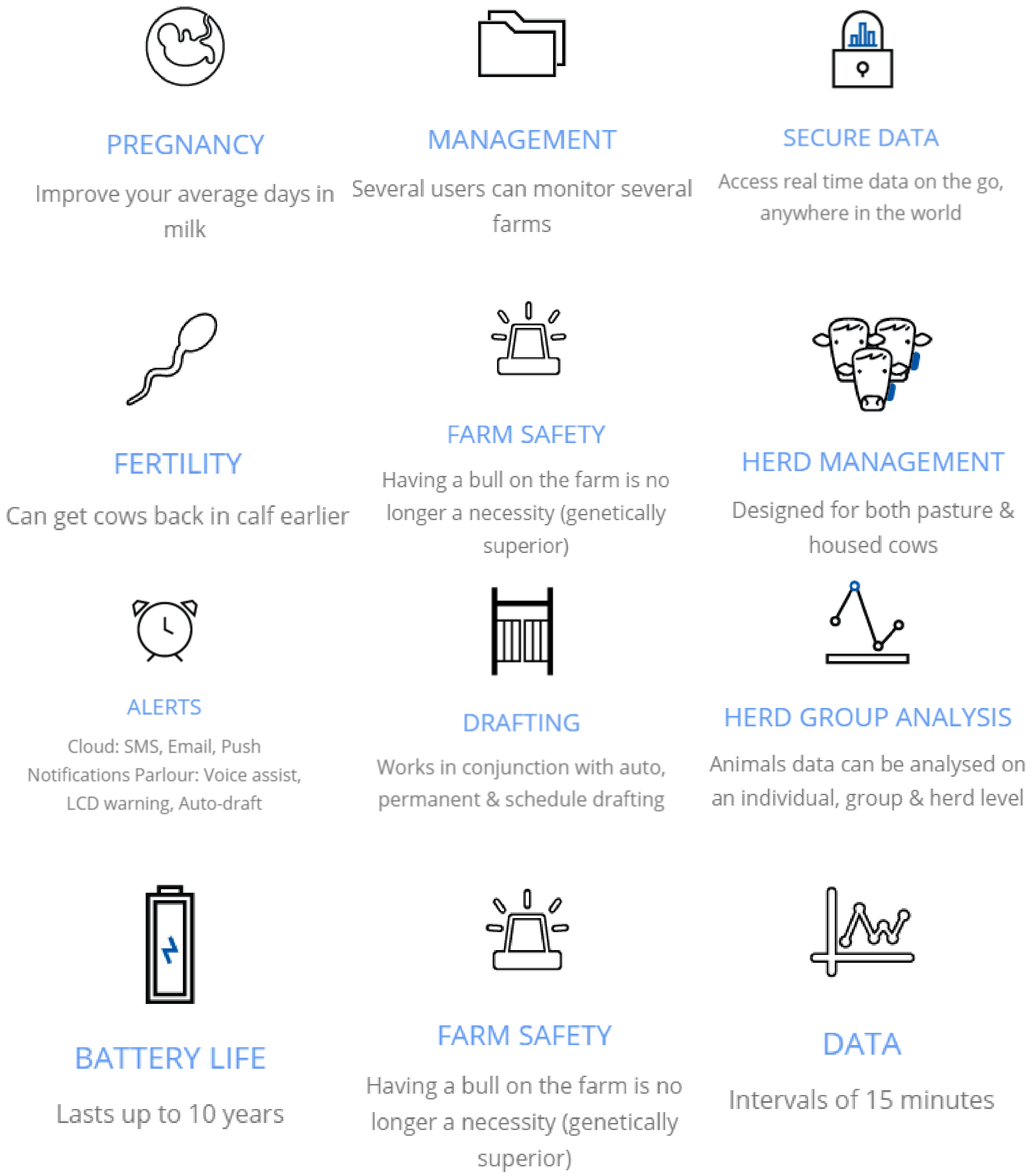


Figure 9: Functions of RFID tag - Source: Moo monitor

Wireless communication is a key important in cattle movement. The Active RFID in the form of belt is inserted on the cow's neck. Each cow has its own RFID number because of different species, weight, physical at different stages, environmental temperature, feeding method, the number of pregnancies, fatal weight and others determined distinct nutritional needs difference. If passive RFID is used when the cows pass through the reader antenna with goal posts, sending frequency followed by weighing or milking goal post, the reader will automatically read the collar-type radio frequency card information, at the same time through the pressure sensors the cow weight and milk weighing information, together with the acquisition time are sent to the site servers through a wireless local area network, the digital culture platform data were supplied [5]. Sensor node integrated sensor module, controller module, communication module and power supply modules, they are a wireless communication through the layered network communication protocols and distributed algorithms can quickly build self-organizing network system, with good collaboration.

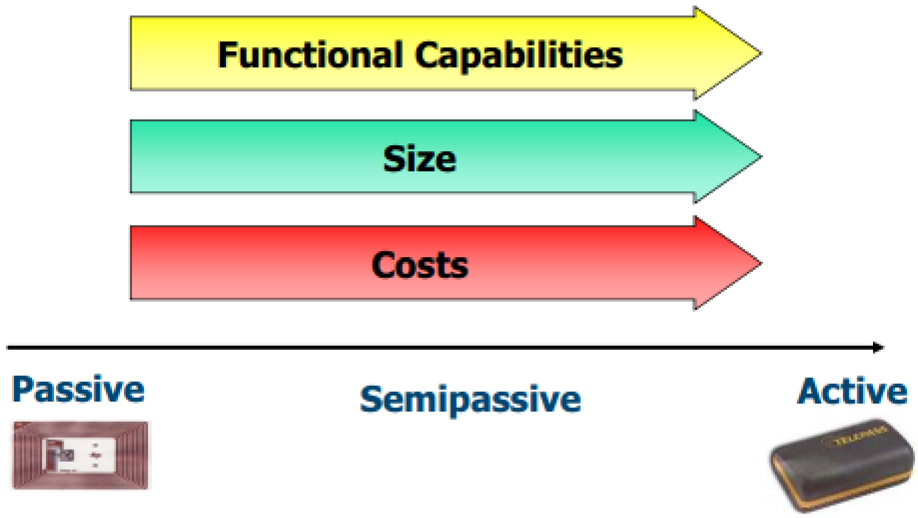


Figure 10: Active Vs Passive RFID tag

With help of Active RFID, it is easy to track the cow's real-time location with the help of signal that is transmitted by RFID. Also, both type of RFID and the sensor measure and sends the information on how many times the cows eat in a day, information on blood profiles and nutrition requirements of cows, such as whether the animals are getting the proper iron or calcium.

	ACTIVE RFID	PASSIVE RFID
1.	Extremely Long Read Range which is used for live location tracking of cows with the help of inbuilt power source.	Shorter Read Range which require an external power source.
2.	Increased tag abilities with partnered technologies like sensors, servers that can communicate with the inbuild power source.	Higher range of tag options with cheap rates.
3.	Extremely Rugged tag options and is expensive.	Tags can last a lifetime without a battery (depending on the wear and tear)

Table 1: Active Vs Passive RFID

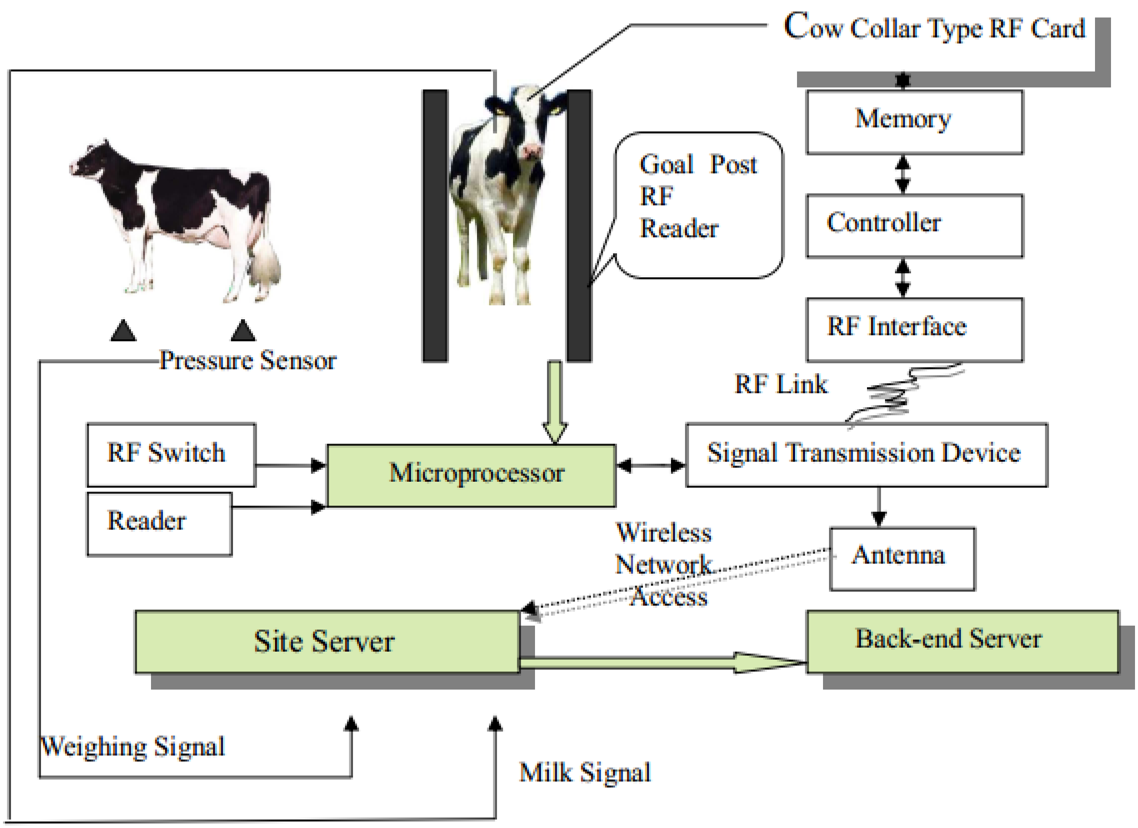


Figure 11: Cow individual identification and data transmission technology program

Analysing the data could lead to checking the health of a cow. With these measured and transmitted data, the farms can take earlier action if their cows are going to get sick. With the RFID tag it is possible to record and have complete life cycle of cows. In past, until milk production drops off it is difficult to find the sickness of cow. By earlier prediction and control it is possible to improve the cow's productivity in its life time.

3.2 TRANSPORTATION FROM COOPERATIVES

Milk is collected in various forms. From various villages through collection centres, directly from farms, which in turn is transported from collection centres to Milk Processing units.

The most important thing is what happens in the Milk collection centre than Milk Processing units, because the quality of the end milk depends on maintaining the quality of the milk at village level. Many co-operatives now use Milk Chillers at collection centres, in a way that solves the problem of milk contamination, but not quite enough. The problem with having just chiller is that, the Milk Processing plants will not know many important factors related to the process, like much milk is coming today, temperature of the milk and its Quality [6]. These parameters need to be monitored constantly to reduce the cost of quality which improves the ROI. This is where IoT in the milk industry can be a game changer by adopting a tracking system.

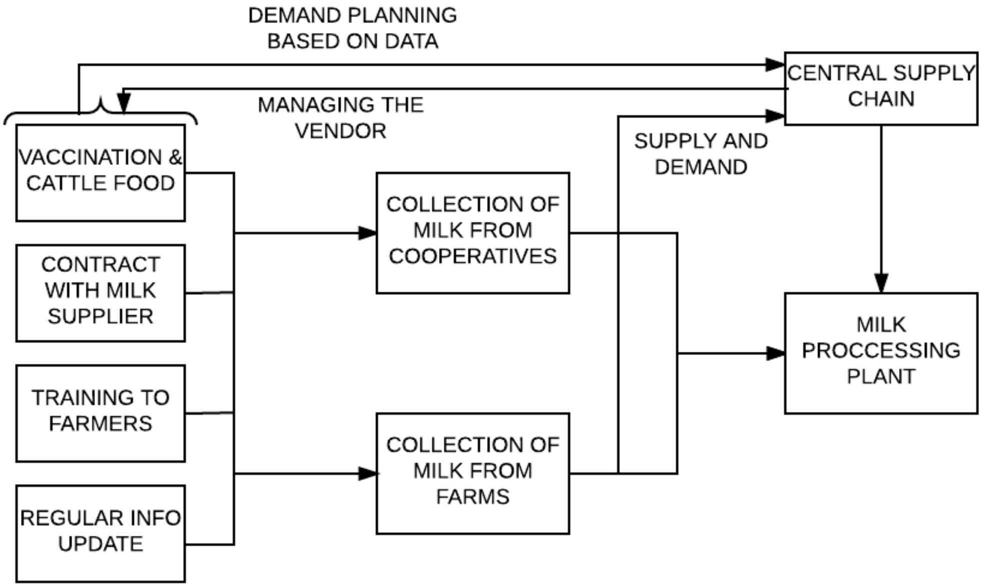


Figure 12: Upstream supply chain flow

By installing IoT devices at Collection centres it possible to track the quality, temperature, pH level and quantity of the milk from the processing plant. Also, the condition during transportation is recorded. For example, IoT can interface with pH sensors to measure the pH level of the milk and send data to cloud at the time of procurement itself or while transporting it to the chilling centres. This data will be transferred to the cloud and here, the recorded pH level is compared to the allowable range i.e. 6.5–6.7. In case the pH level of procured milk is deviated from this range, the dairy gets an alert message regarding the milk being unsuitable for processing. By analysing and controlling these data earlier before milk processing, it is possible to manage the required inventory, prevent the milk spoilage if the certain volume of milk has been having different properties (ex: because of improper cleaning the chiller). This way, the dairy can take necessary decisions at the earliest so that the cost of quality can be reduced. The result of these technology involvement will increase the ROI.

CHAPTER 4: PROCESSING PLANT

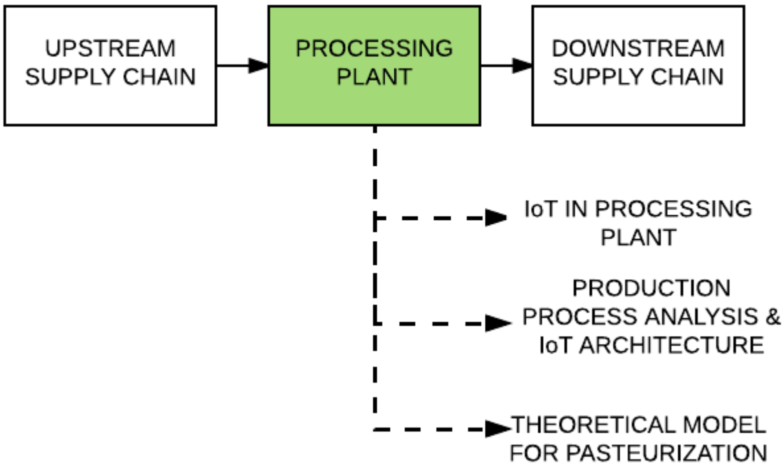


Figure 13: Key framework of analysis

Challenges posed by dairy companies by the complex regulatory from food safety corporations, made them update their technology when their existing technology and infrastructure limit them even further. Strict compliance measures, coupled with pressures from the consumer marketplace, inventory limitations and more make the dairy industry's infrastructure ripe for disruption with Industrial Internet of Things (IoT) technologies. To improve quality and to reduce losses, dairy companies must squeeze every ounce of speed, efficiency and responsiveness from their global supply chain. And doing this successfully means adopting automation technologies.

In dairy plant, connecting devices throughout the supply chain and production – pumps, refrigeration, equipment, etc. can allow for more rapid analysis of operational data, which allows for a range for powerful capabilities [7]**.** More automated, in-line analysis has begun to replace much of the hazard analysis that today is performed by manually collecting samples and sending them to a lab. Instead, with automation technologies, data can be made immediately available to centralized quality systems from samples tested at the edge of a dairy's network using chemical and spectroscopic analysis. A real-time approach accelerates the identification of potential problems, allowing dairy operators to make adjustments more quickly, reducing waste and costs associated with quality problems that go unchecked [8].

For example, an issue that causes the shutdown of a processing line or facility might benefit from real-time analysis telling a producer to redirect incoming supply. Similarly, an increase in demand for one product versus another may prompt changes to the production schedule.

IoT reduces manual and document-based processes and are digitized or delivering electronic insights to handheld devices on a plant floor (like capacity, outputs, temperature and more that can be analysed at the plant or data centre). Further capabilities can grow over time as dairy operators begin to see more value. This might lead them to transition to automatic data collection and analysis that will ultimately move them closer to a truly intelligent supply chain: one that shares analytics across many different boundaries (departmental, partner and even customer), creating efficiencies.

As the flow of data becomes more central to dairy operations, it also becomes more valuable. Given its ties to business-critical systems, it is essential to guarantee that any data directly impacting live processes always be available. Payments, compliance data, production analytics and more cannot be vulnerable to unplanned downtime.

4.1. ANALYSING THE PRODUCTION PROCESS

Operational units can run very lean when more business data is flowing through the network. So, it becomes necessary that dairy systems – homogenizers, pasteurizers, refrigerators, pumps and more can be easily (and even remotely) serviced. Dairy companies will be able to get complete view of the data, across the entire life of a product and strive to unify the flow from the farm all the way to the refrigerator.

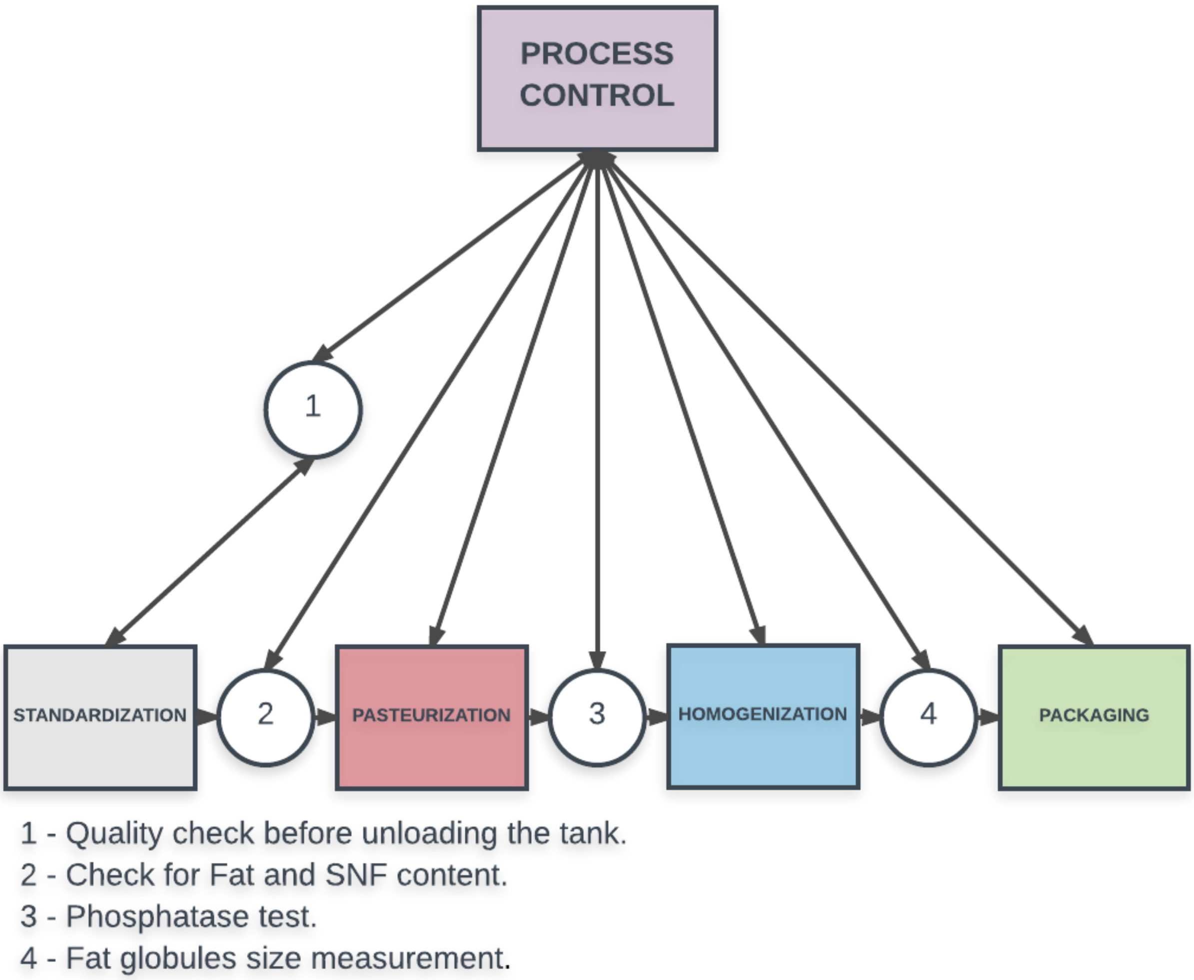


Figure 14: Stages of milk processing

4.1.1 RAW MILK QUALITY CHECKS

The raw milk is picked from the handler by various cooperative located in the villages. Before the milk is uploaded into the containers the milk is tested for antibiotic residues and somatic cells count. If the milk is free from antibiotics, then it is pumped into the tanks and transported to the processing units. During transportation the milk is maintained below 10°C.

1) Samples from the bulk milk tanker are tested for antibiotic residues and temperature before the milk enters the factory processing area. Farm milk samples are tested for somatic cells count, milkfat, protein, bulk milk cell count and bacteria count [9]. Generally, bacterial count should be less than 10,000 per millilitre. If milk does not meet quality standards it is rejected. Most farmers are paid on the quality and composition of their milk. Reason for somatic cells: Mastitis infection is the inflation in udder which is a microbiological infection. Milk from these cows have more bacterial count and somatic cells count. If the milk with more somatic the quality of the milk is lower where it has less flavours and may undergo deterioration of milk fat and protein more quickly.

   A good quality of milk should be low bacterial count and should not have antibiotics if used to treat mastitis. Also, a good quality of milk is obtained if proper construction and maintaining facility, safe water supply, sanitary waste disposal, proper cleaning of milking equipment.

   General test carried out in this stage are: COB (Clot on Boiling), Alcohol test, The Alcohol-Alizarin test, Acidity test, etc... for example considering the output of Alcohol-Alizarin test is the PH level identified as 6.3, then the controller from control room monitor these data in real time and can take corresponding action immediately. The measured value by the sensor is automatically transmitted with the efficient ICT to the processing centre.

PARAMETER	NORMAL MILK	SLIGHTLY ACID	ACID MILK	ALKALINE MILK
PH	6.6 – 6.7	6.4 – 6.6	6.3 or lower	6.8 or higher
Colour	Red brown	Yellowish-brown	Yellowish	Lilac
Appearance of milk	No coagulation no lumps	No coagulation	Coagulation	No coagulation

Table 2: Milk characteristics for different PH levels

4.1.2 STANDARDIZATION

Standardization of milk refers to the adjustment which means raising or lowering of fat and solids not fat levels of milk. The standardization of milk is commonly done in case of market milk supply and in case of manufacture of milk products. e.g. condensed milk, milk powder, ice-cream and cheese etc. the standardization is mostly done to have a uniform milk fat content in the finished dairy product [10]. The milk is passed through the centrifugal separators to create a skim and cream portion of milk. The skim portion of milk is less than 0.01% fat and a cream portion are about 35% to 40% fat. Then cream portion is then added to the skim portion to yield a desired fat content. Generally, the common products are standardised milk with 4.5% fat, full cream milk with 6% fat, low fat milk with 3% fat and skim milk less than 0.1% fat.

2) After the standardization of the milk is carried out, the milk is checked for fat and SNF (solids not fat) contents. These can be measured using ultrasonic milk analysers. The Ultrasonic Electronic Milk Analyser works on the principle of Ultrasonic. The signals allowed to pass through the sample are measured digitally for accurate display [11]. These type of ultrasonic analysers is based on Microprocessor based state of art technology with features like sample reusable after test, lower power consumption, can able to transmit the measured data (%fat & SNF), can able to perform 55-60 tests per hour, operator friendly and easy to use.

4.1.3 PASTEURIZATION

The process that kills harmful bacteria by heating milk. The process of heating milk depends on the type of final product to be delivered. The below table [12, 13] shows the temperatures for different milk products based on different types of storage:

PASTEURIZATION TYPE	STORAGE AND LIFE TIME	PROCESSING TEMPERATURE	HOLDING TIME
Continuous high temperature short time (HTST)	Refrigerated and 4-7 days	75^0 C	8 seconds
Ultra-High Temperature (UHT)	Room temperature and 60 days	135^0C to 150^0C	5 seconds

Table 3: Pasteurization types

4.1.3.1 PROCESS OF PASTEURIZATION

It uses indirect hot-water heating system. When the milk enters the pasteurizer, the milk is heated up by conduction to a certain temperature for a certain time based on the type of product. After certain time of heating sudden cooling is carried out by condenser/refrigeration system (cold water circuit) where the milk is made to reach a temperature around 10^{0}C.

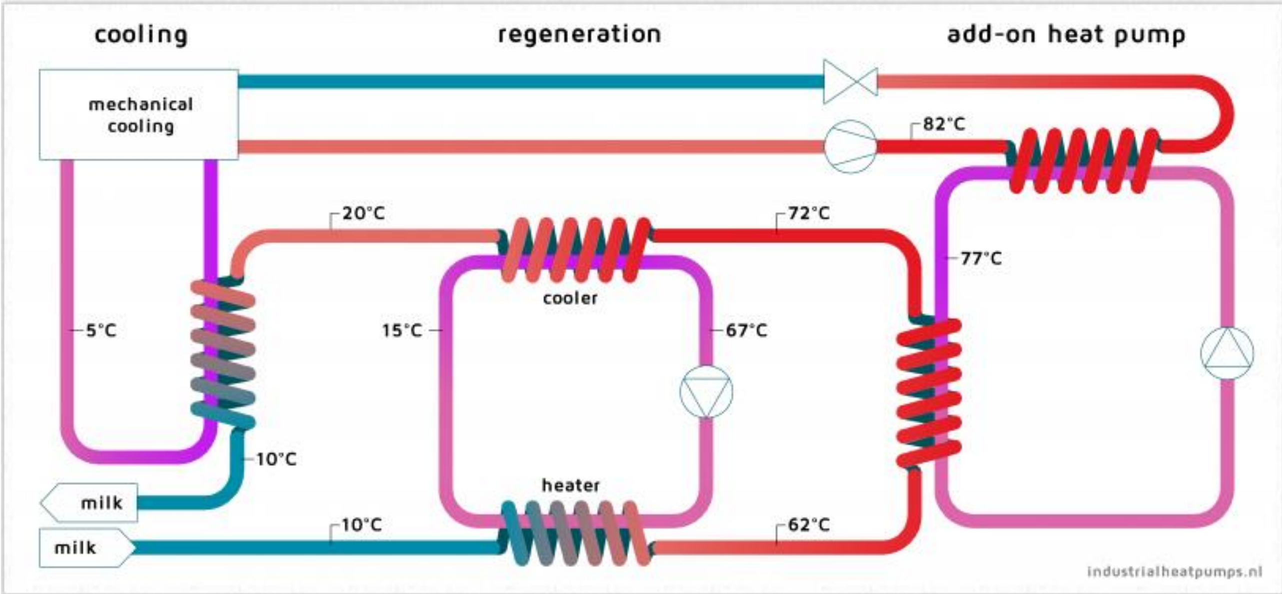


Figure 15: Typical Pasteurize - Source: Industrial hear pumps

3) Testing for alkaline phosphatase is the recognized method for confirming the completeness of pasteurization in dairy products. The Fluorophos ALP Test is so sensitive that it can help monitor pasteurizer performance and give early warning of the deterioration of heat exchanger plates [14]. Many times, more sensitive than other commercially available tests, Fluorophos ALP can detect as little as 0.003% raw milk contamination. Because the ALP Test is instrument-based, results are quantitative and not dependent on operator interpretation. On-board printer and computer interface is HACCP friendly. The Fluorophos Test System offers an instant digital display plus a hard copy for a permanent record. The computer interface allows connection to laboratory computers for analysis and reporting of data.

4.1.4 HOMOGENIZATION

To improve shelf-life, milk undergoes a homogenization process. This process makes fat globules of a uniform, small size. During the homogenization process the size range of the fat globules is reduced from 0.1-15 µm in unprocessed milk to 1-2 µm in homogenized milk [15]. These smaller globules cannot form large enough clusters for creaming to occur, increasing the shelf life of the milk. In this process the fat molecules are disrupted into smaller one by forcing the milk through a small passage at high velocity. The speed will increase until the static pressure is so low that the liquid starts to boil. When the liquid leaves the gap, the speed decreases and the pressure increase again. The liquid stops boiling, and the steam bubbles implode [16].

Milk also contains casein micelles, in the size range of 0.05-0.25 µm. The micelles play a role in stabilizing the fat globules, especially after the homogenization process.

4) The size of the fat globules and the proportion of free casein micelles are important parameters for monitoring the homogenization process and can be measured simultaneously by laser diffraction [17]. Laser granulometers works on the principle that particles scatter light from one or two laser beams with an angular pattern directly related to their size.

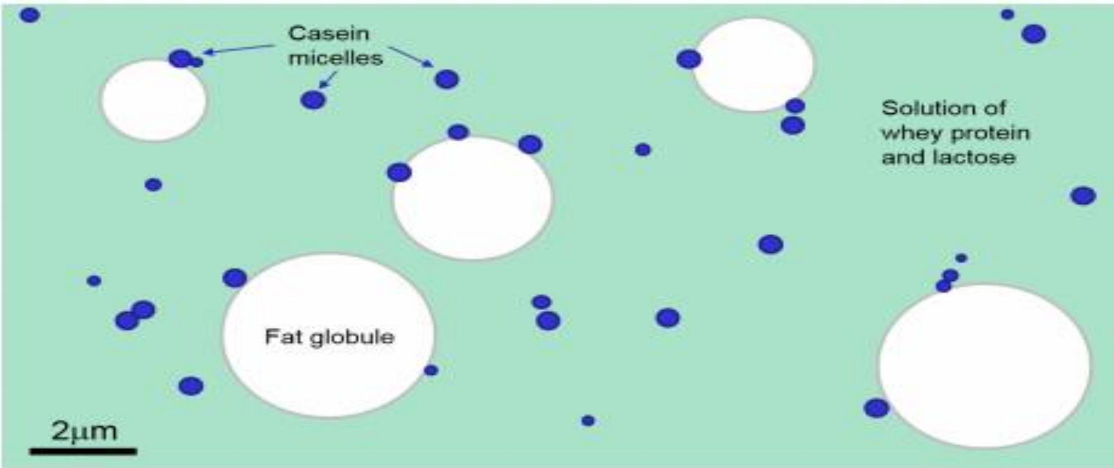
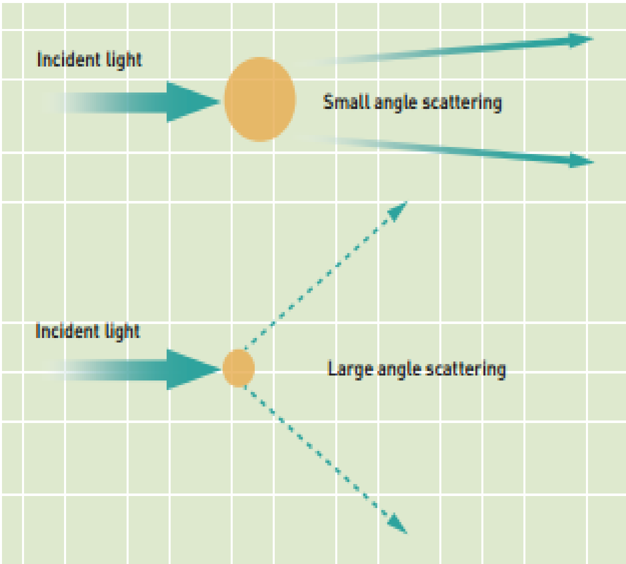


Figure 16: Laser diffraction perspective



In a laser diffraction measurement, a laser beam passes through a dispersed articulate sample and the angular variation in intensity of the scattered light is measured. Large particles scatter light at small angles relative to the laser beam and small particles scatter light at large angles. The angular scattering intensity data is then analyzed to calculate the size of the particles that created the scattering pattern using the Mie theory of light scattering. The particle size is reported as a volume equivalent sphere diameter [18 & 19]. With these data the analysis is made easier with the software which is readily available for analysis.

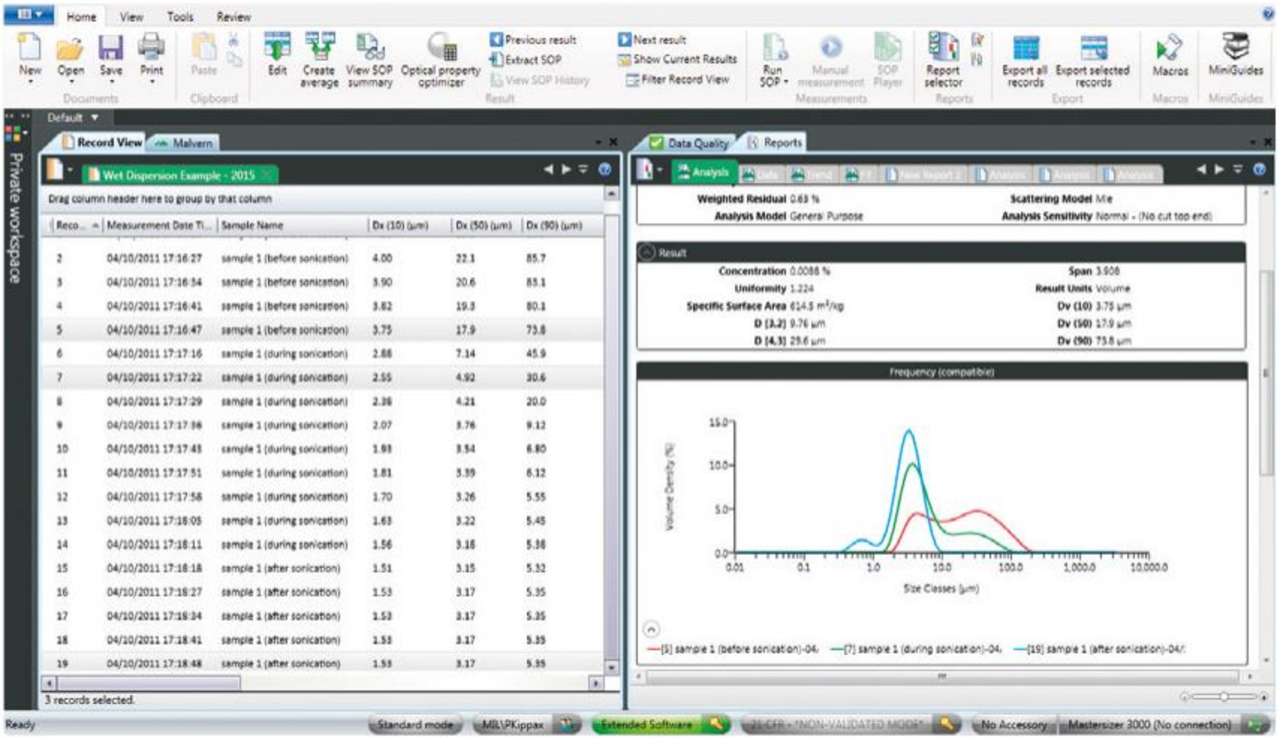


Figure 17: Real time laser data - Source: Peter Domonkos, Victor Venema and Olivier Mestre, 'EFFICIENCIES OF HOMOGENISATION METHODS'.

CHAPTER 5: THEORETICALLY SUGGESTED MODEL FOR PASTEURIZATION

Hybrid pasteurizer which can process two varieties of simultaneously at the same time. The suggested model:

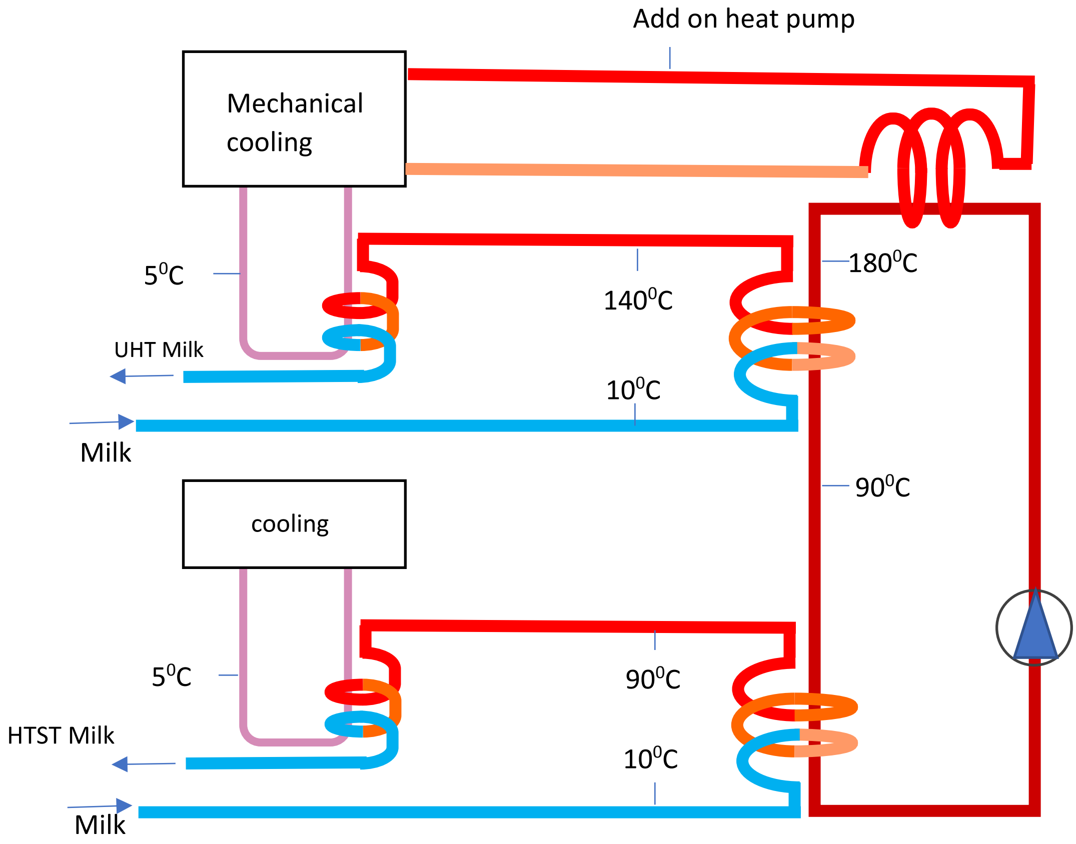


Figure 18: Hybrid pasteurizer

Temperature changes calculations:

Assumptions:

Milk to be heated from 10^0C to 140^0C (V1): 20,000 l/h.

Density (ρ) and specific heat (C_p) of milk is 1,020 kg/m^3 and 3.95 KJ/kg.

Water used at 180^0C to heat the milk(V2): 30,000 l/h.

Density (ρ) and specific heat (C_p) of water is 950 kg/m^3 and 4.18 KJ/kg.

$$V_1 * \rho_1 * C_{P1} * \Delta t_1 = V_2 * \rho_2 * C_{P2} * \Delta t_2$$

20,000 l/h*1,020 Kg/m^3*3.95 KJ/kg*(140^0C – 10^0C) = 30,000 l/h*950 Kg/m^3*4.18 KJ/kg* Δt_2

Δt_2 = 88^0C

The temperature of the hot water will drop by 88^0C from 180^0C to 92^0C.

The outcome of the water at 92^0C is suitable to produce a normal pasteurized milk which should be get heated to about 70^0C.

PRODUCTION MIX CALCULATIONS:

Figure 1: only one product and one production rate

Figure 2: Multi Production Mix where 2 products at different production rates are produced.

CP = Production Mix*utilization*Efficiency………………………… (1)

Production Mix calculation:

Assumptions 1:

Time Required to pasteurize the 1 litre of HTST milk = 8s

Time required to pasteurize 1 litre U.H.T milk = 5s

Utilization = 0.95

Efficiency = 0.98

Therefore, Pmix = $\frac{1+1}{8+5}$ = 0.154 ………………………………… (2)

(2) in (1)

CP = 0.154*0.95*0.98 = 0.143……………………………………… (3)

Assumption 2:

Time Required to pasteurize the 1 litre of milk = 7s

Time required to pasteurize 1 litre U.H.T milk = 2s

Therefore, Pmix = $\frac{1+1}{7+2}$ = 0.223 ………………………………… (4)

(4) in (1)

CP = 0.223*0.95*0.98 = 0.2 ………………………………………… (5)

Analysing the equation 3 and 5, decrease in production time of certain variety of milk increase the CP.

5.1 IoT ARCHITECTURE IN PROCESSING PLANT

The data measured at different levels of milk processing (DATA SENSE LAYER) are transmitted through cloud (ICT) to the data integration layer. Many communication technologies are well known such as Wi-Fi, Bluetooth, ZigBee and 2G/3G/4G cellular, but there are also several new emerging networking options such as Thread as an alternative for home automation applications, and Whitespace TV technologies being implemented in major cities for wider area IoT-based use cases [20]. Depending on the application, factors such as range, data requirements, security, power demands and battery life will dictate the choice of one or some form of combination of technologies. One the data is received to the data integration layer the collected raw data are integrated to a consolidated data; that is, data that has been combined into a single version. In the diagnosis layer the data analysed according to the defined quality principles and algorithm. The result of the diagnosis layer is then transmitted to the application service layer where the alarm is raised if there is an issue or the data is used by the management team for certain improvement [21]. The control actions can be taken in the application service layer and the control is implemented through these layers.

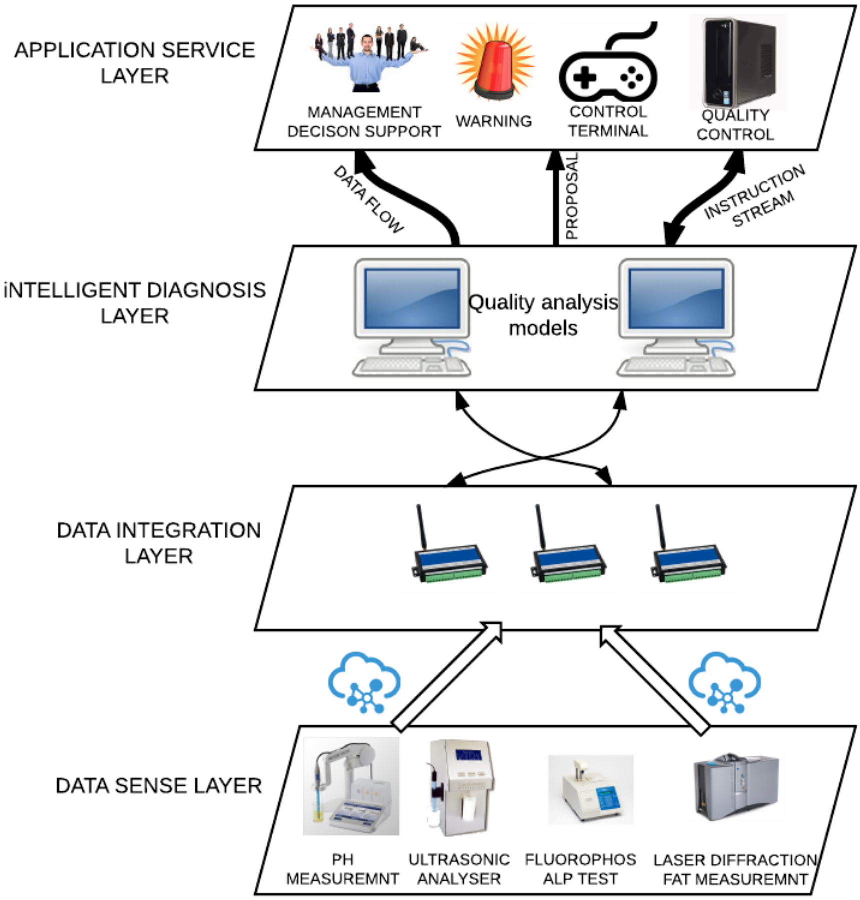


Figure 19: IoT architecture

CHAPTER 6: DOWNSTREAM SUPPLY CHAIN

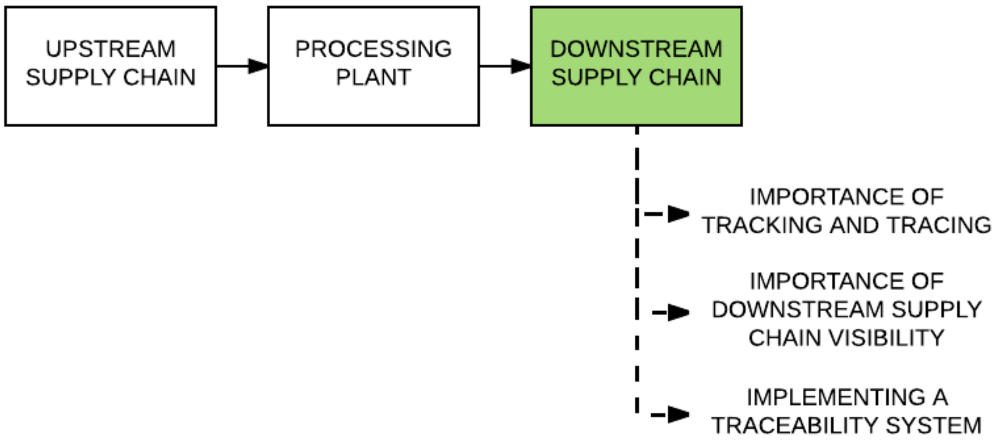


Figure 20: Key framework of analysis

After the milk is processed the milk is passed into the packaging section where the milk is packed into different volumes. Once packed it is taken to the warehouse and stored at required temperature. From the warehouse the milk is transported to various distribution centres based on the available demand.

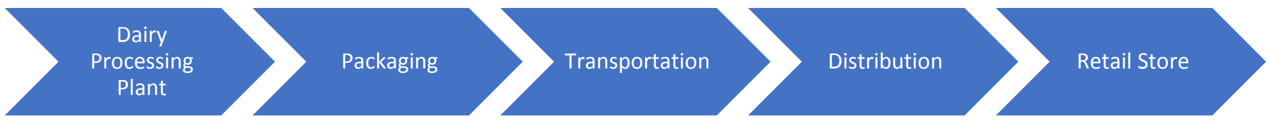


Figure 21: Downstream supply chain

Major Problem with downstream supply chain is poor visibility of supply chain in terms of product movement, product recall and withdrawal.

Product Recall:

Measure aimed at achieving the return of a dangerous product that has already been supplied or made available to consumers by the producer or distributor. Recall is the procedure implemented when the product may have already reached the consumer.

Product withdrawal:

Any measure aimed at preventing the distribution, display and offer of a product dangerous to the consumer. The withdrawal procedure concerns every business operator who has reason to believe that the product he has imported, produced, processed, manufactured or distributed is not compliant with the safety requirements.

Tracking: Tracking is the capability to locate a product based on specific criteria wherever it is in the supply chain, in order to be able to withdraw it, or recall it, whenever necessary.

Tracing: Tracing is the capability to identify the origin and characteristics of a product based on criteria determined at each point of the supply chain, in order to be able to determine the identity and source of products received whenever necessary.

6.1 WHY ARE TRACEABILITY AND TRACKABILITY IMPORTANT

- For public safety, it's about reducing incidences of food fraud as well as unintentional or intentional adulteration; disease management; and environmental emergencies.
- And for stake holders, it's about access to markets; and enhancing or strengthening brand confidence.
- For businesses, it's all about risk management and mitigation—lowering the impact of recalls and lowering liability costs.
- For the supply chain, efficiencies relate to productivity; cash flow improvements; innovation; and reducing waste.

6.2 IMPLEMENTING A TRACEABILITY SYSTEM

Implementation of traceability system is difficult because the complexity in the supply chain, knowing what to record and who should record and how the recorded data are shared are major challenges in implanting traceability in the milk supply chain [22].

Upstream supply chain:

- When receiving raw milk, the receiving facility access and stores the cooperative names from which milk is received. Only the route information is recorded by the receiver because the load is comingled by a cooperative. In this case, the cooperative will have the farm information for each load, and would be involved in the traceability effort if a recall were required.
- The Milk Hauler record the farm pickups which is paramount to making a recall work and are the first step in creating a successful traceability program. Accurate identification of the farm, quantity, CIP records, and sample of milk is recorded and transmitted to the processing plant. Using Farm ID is often used as the identifier for the farm load. This can be helpful to trace the loads, usually the number is issued by the state milk cooperative officials which is used in inspections and for other records. However, many cooperatives and other dairy businesses assign their own farm ID as well [23]. It is important that your haulers and receivers in plant to record consistent and accurate information.
- The industry also maintains the record of ingredients, products, and packaging materials that are used. After the packaging is done the lot identifying mark is created for a batch and recorded & printed to the final product using the barcode technology.

- When the final product with barcode is ready it is taken to the warehouse and maintained below 8^0C. Then product from warehouse are loaded into the trucks based on the demand from the distributors. To avoid wrong loading of the trucks the industry uses the passive RFID technology on their wheels which is separated from the metals for proper reading and are washable [24, 25]. The reader used here is a short-read range and can be further adjusted based on the truck position in the warehouses. The RFID attached to the trolley is recorded by the recorder each time when the loading is done which helps in loading the requested order [26].
- After this process the responsibility of the industry is completed, and no proper visibility is available to the downstream supply chain in the industry. Moreover, Upstream Competitive advantage are no more applicable almost every companies have good control on upstream supply chain as it lies within the industry.

6.3 IMPORATNCE OF DOWNSTREAM SUPPLY CHAIN VISIBILITY

- Having a full control in its supply chain the industry will achieve a competitive advantage in terms of delivery, and differentiation advantage. Further explanations have been given how these competitive advantages can be achieved.
- Brand positioning: A brand reputation is not located inside the walls of the company, but resides in the minds of consumers. Its effects are felt in the marketplace and are evident in the behaviour of customers.
- Reduce product recall & product withdraw.
- Better visibility in the downstream supply chain help the industries to be more agile in this case. If contaminated milk in certain truck is identified earlier (during movement) then a replacement truck with new load can be sent to the destination. This helps in maintaining the brand image by delivering the product at perfect quality at correct time and avoid loss of sales from that region due to stock out. Further tracing is done to prevent the occurrence of the issue in future [27].

CHAPTER 7: HOW DOWNSTREAM SUPPLY CHAIN VISIBILITY IMPROVED

- Tracking should be initiated immediately once the loaded truck leaves the industry. Further frequent update of internal temperature of the truck is updated to the server of production plant and kept in record for tracing.
- In addition to the temperature of the truck, number of hours processed milk is continuously monitored in order to ensure freshness to the customers.

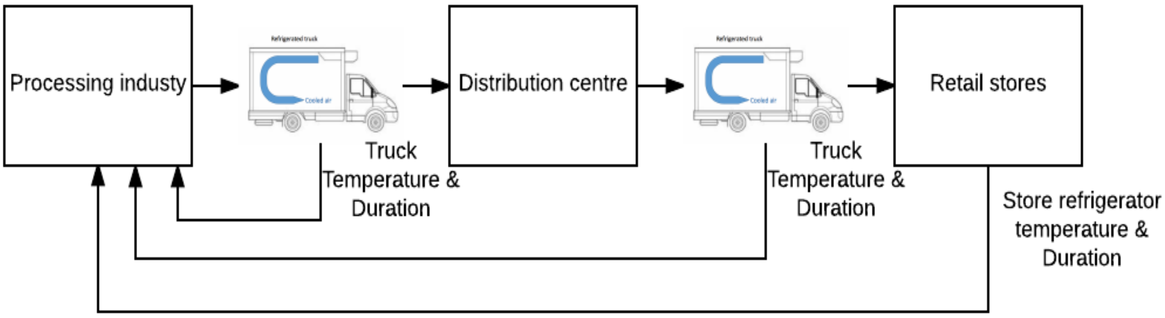


Figure 22: Downstream supply chain control

- Once the truck reaches the distribution centre further distribution to the retailer stores by small trucks also to be monitored. Further separate refrigerators to every retail stores are provided, and its internal temperature are continuously recorded and transmitted to the processing industry for tracing purpose if any recall is occurred.
- The batch dispatched from industry to distribution centre and further to retail stores are fully monitored in order to determine number of days in the retailer shelfs for ensuring freshness to the customers.

7.1 SIMULATION OF A TRACK AND TRACE FACILITY

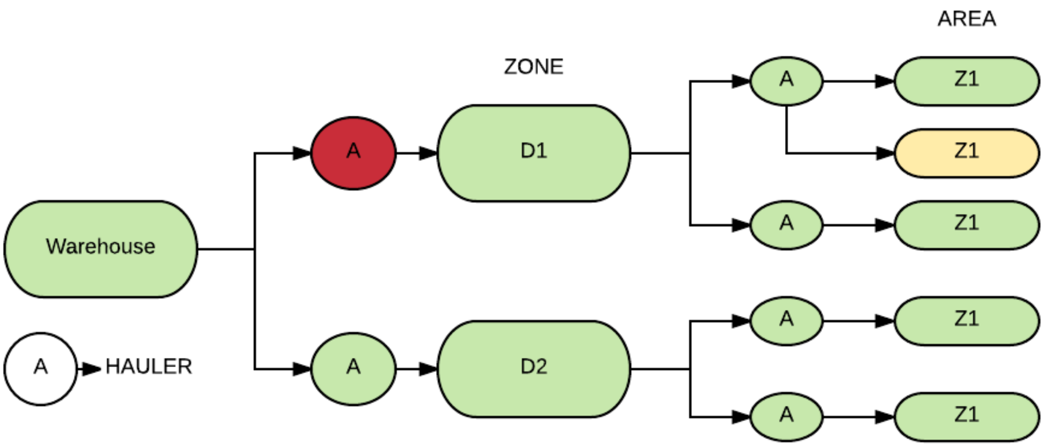


Figure 23: Track and Trace simulation

Red – Possibly contaminated due to high temperature for a long period of time or life cycle of the milk is ended.

Yellow – Higher risk of contamination due to gradual increase in temperature or life cycle of the milk is about to end.

Green – Free of possible contamination.

These measured and transmitted data are recorded at the plant [28]. Usually this type of system can be implemented by SCADA (Supervisory Control and Data Acquisition System).

Usually the record should contain:

- A traceability record should enable you to find a Lot Identifying mark.
- A prime traceability record should contain up to date information about temperature changes, route path which contains information about distributor information, details of retailer with lot and their refrigeration temperature.
- Having access to quick and accurate data regarding the movement of lot will help for better traceability and reduce recall impact.

Specific record should contain information about:

- Farm identification in load.
- Time at which load left the warehouse
- Truck route & temperature.
- Distributor information.
- Mini truck route & temperature.
- Retail store refrigerator temperature & time at which the lot enters for final sale.

CHAPTER 8: CONCLUSION

The dairy industry is one particularly focused on ROI, given its narrow margins and intense competition. Considering the overall perspective of the industry, below graph of strategic product positioning shows the 'As is' situation Vs 'To be' situation of a dairy company in India.

The important variables like freshness, quality, and production need to be improved followed by decreasing product recall which can be achieved by extracting and leveraging intelligence across the supply chain (streams) with industrial automation and IoT technologies as discussed in the study. There is a huge potential here, if more intelligent supply chain is established which results in improved production processes and better efficiency.

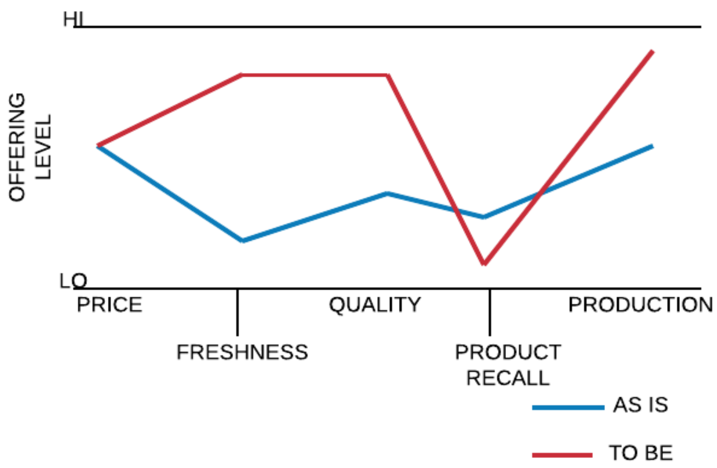


Figure 24: Value curve of 'As is' Vs 'To be'

First and foremost is to invest in IoT. Improvements across the spectrum of organizational functions will directly increase key performance indicators of the organization such as productivity and efficiency, that could indirectly lead to return of investment.

India with its growing population and changing food preferences, the demand for milk and milk products will grow to at least 210 million tonnes by 2021–22, a rise of 36% over five years, according to government estimates. To meet this demand, production must grow by 5.5% per annum, according to the State of India's Livelihood (SOIL) report.

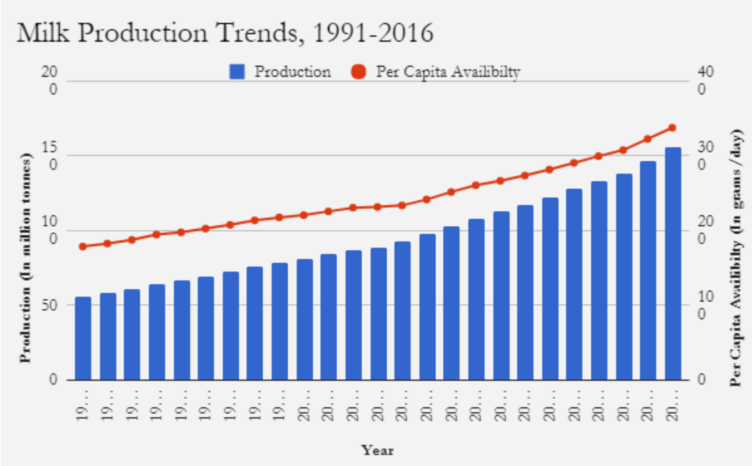


Figure 25: Milk production trends - Source: Hindustan Times

Productivity is improved starting from farms by implementing the best fertility method followed by monitoring the cattle movement as discussed in the study through which it is possible to improve the milk productivity of the individual cow in India. Implementation of this technique could reduce the risk of milk import in 2021 in order to satisfy the demand.

Secondly, the efficiency of the pasteurizer is increased. This could be in the form of energy efficiency/cost efficiency, analysing which requires massive data which could not be collected due to confidentiality in the dairy industry.

Finally increasing the productivity is not the only way to supply the demand. Reducing the waste across the entire supply chain will have an impact in managing the demand. Moreover, IoT has the ability to reduce risk by avoiding food quality or safety issues. Real-time quality analysis starting from farms to final retail storage can protect a dairy industry from catastrophic product recall. Companies should view IoT as critical to the future success of their organization. IoT can produce measurable results, and the top performers who are seeing the greatest results treat their IoT initiatives as business projects, not IT purchases.

Dairy industry needs to be leaner and more agile than before as it continues to face increasing pressure from both statutory regulators and consumers. Similar to the food business, dairy companies operate on tight margins and must meet stringent quality and safety regulations. Digital record keeping to track and trace the entire history and flow of product can lead to better planning and tighter execution.

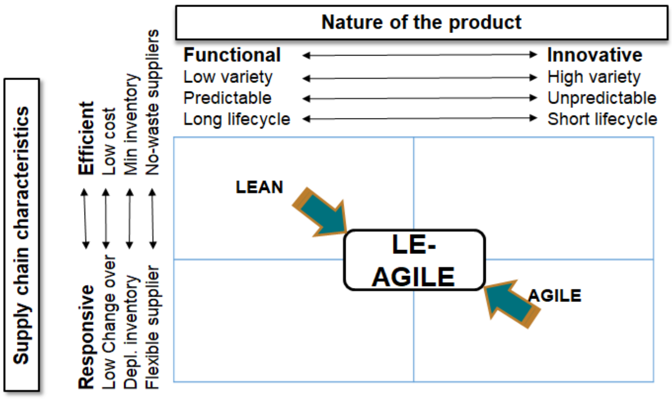


Figure 26: Le-agile

Adopting to these technologies and solution will make themselves achieve point of difference with the other dairy industries located across the country. This will greatly determine how the dairy companies can overcome the challenges they face as they try to keep pace with their ever-changing industry.

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APPENDIX

Latheesh1983 Jun 1, 2014

Not serving chilled milk products

Dear Sir/Madam,

We are not getting chilled products from your outlet at gopalapuram (near M.V. Diabetic center). When ever we ask they say that there is chilled items available. Hence we are unable to enjoy the quality milk products. Kindly address this issue asap.

Thanks,

Consumer complaints and reviews about milk

IyappanP Feb 11, 2017

Strong detergent smell

I bought 500ml Nice milk on 6th Feb 2017 at SVS Super Market, Palavakkam. I smelled strong detergent odour in the milk when boiled it. The sample milk and cover are preserved for investigation. I request the authorities to look into this and take necessary action.

Deekshithkumar May 25, 2016

MILK SOLD MORE THAN MRP PRICE

milk is being sold more than MRP price (i.e., half litter orange milk pocket is being sold out for Rs.25/- instead of its original retail price of Rs.22.5/-) at in all shops. Kindly Please take necessary action against the retailer.

jameemtaj Nov 4, 2015

spoilage of milk

Respected Sir,

Last week Two time the milk was spoiled while heating. It happen Weekly once.
Not only for me. It happen in our flat neighbour.
Our depo number is 74. (near William school, royapettah, chennai 14)
So kindly see and sent the milk sir.