Post-Harvest Operations and Processing of Fruits, Vegetable, Spices and Plantation Crop Products

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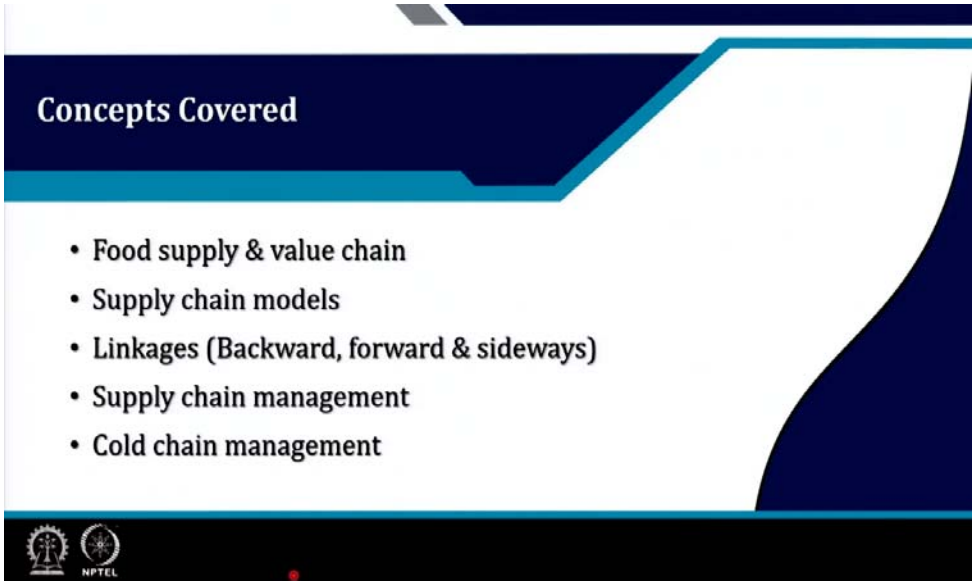
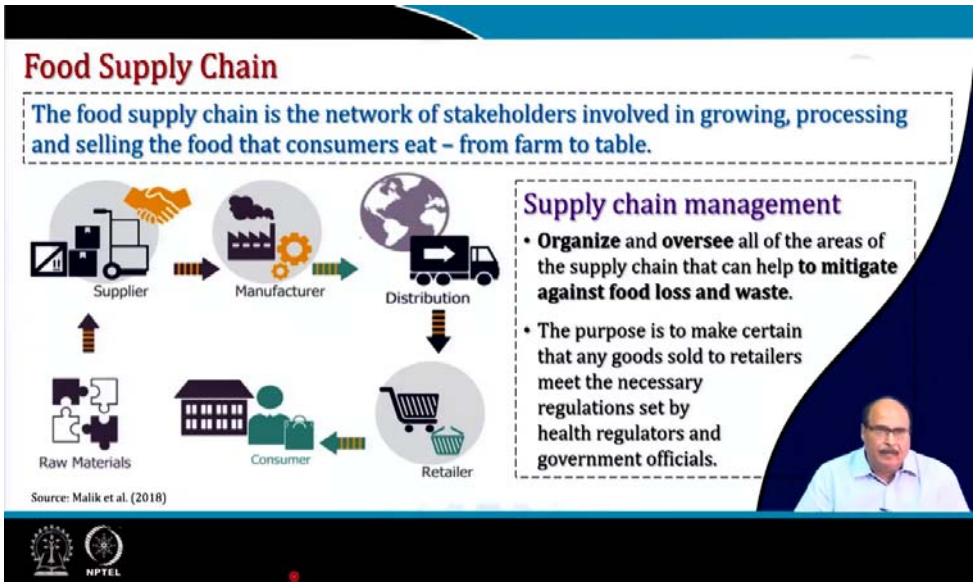
Lecture 09
Supply Chain Management and Storage

In this lecture supply chain management, and storage of fruits and vegetables will be covered. Various aspects of supply chain management, supply chain models, various linkages such as backward, forward, sideways, and cold chain management will be explained.

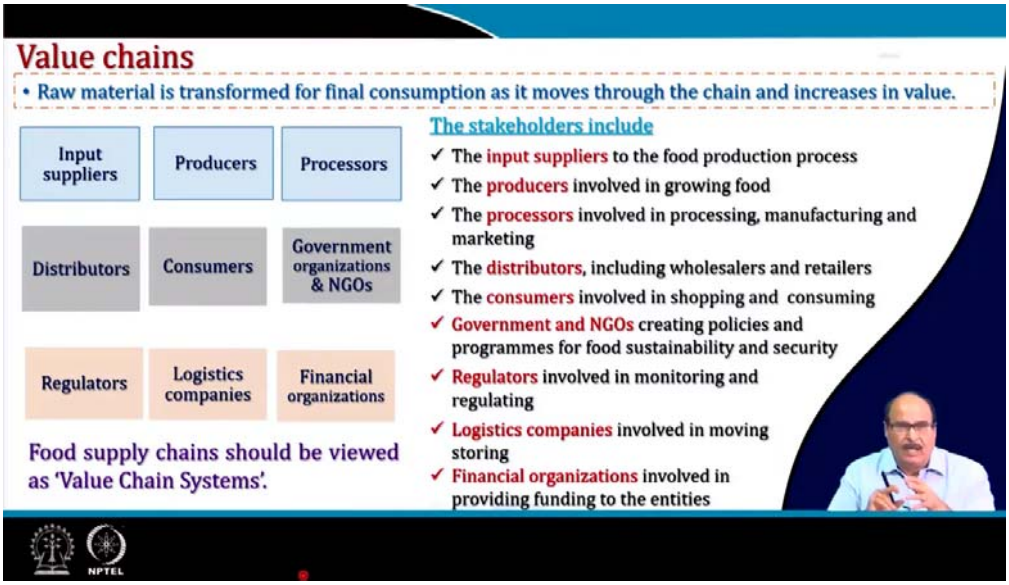




Food Supply Chain

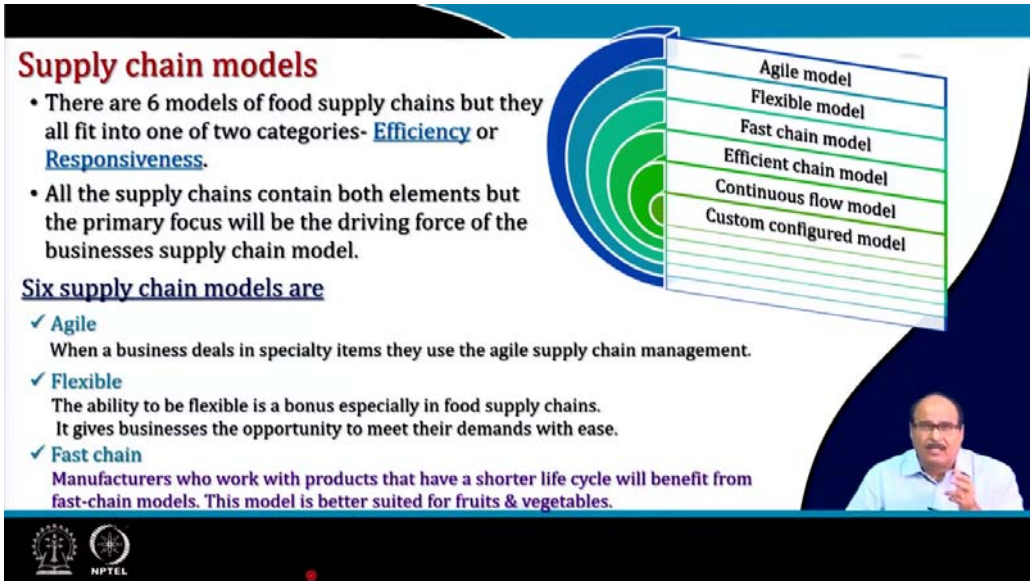
The food supply chain is the network of stakeholders which are involved in growing, processing and selling of the produce that the consumers eat. It includes all operations between from the farm to the table. It involves the raw materials, suppliers, manufacturer, distributor, retailers, and consumers.

Part of the supply chain management is to organize and oversee all of the areas of the supply chain that can help to mitigate against food loss and waste starting from the raw material until it reaches the consumer. All possible efforts should be made for the material to reach in proper condition with minimum to no wastage. The purpose of the supply chain management is to make certain that any goods sold to retailers meet the necessary regulations set by the health regulators as well as the government officials.



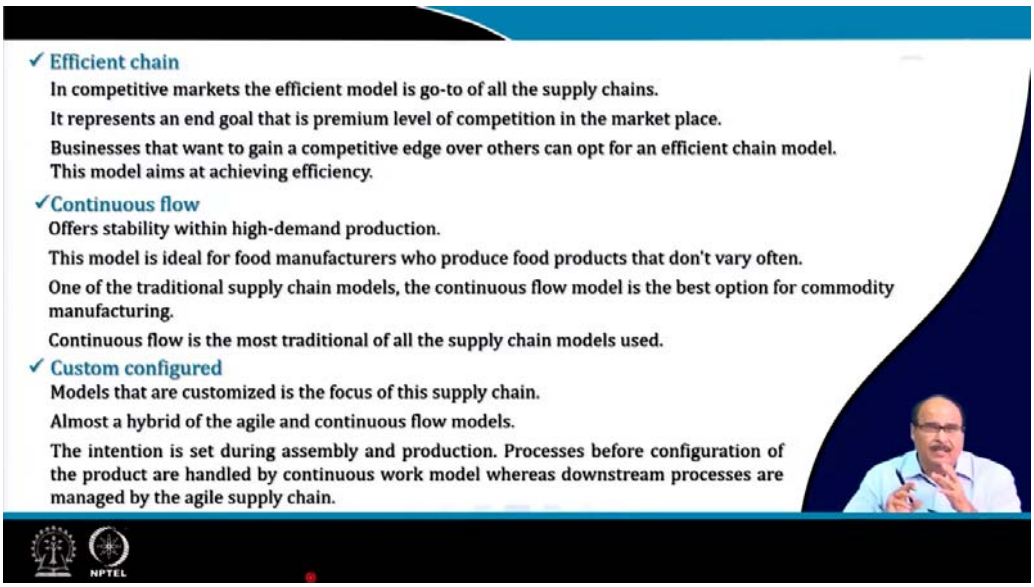
Value Chains

In the value chain, raw material is transformed for final consumption as it moves through the chain and increases in value. The stakeholders in the value chain include the input suppliers, producers, processors, distributors, consumers, government organizations and NGOs, regulators, logistics companies and functional organizations. The input suppliers supply raw material to the food production process. The producers are involved in growing and producing of the commodity in the field. The processors are involved in processing, manufacturing and marketing. The distributors include wholesalers and retailers, and the consumers are involved in shopping and consuming of the products. The government and NGOs create policies and programs for food sustainability and security. The regulators are involved in monitoring and regulating. Logistic companies are involved in moving and storing the material and the financial organizations are involved in providing funding to the entities. Thus, the food supply chain should be viewed as a value chain system.



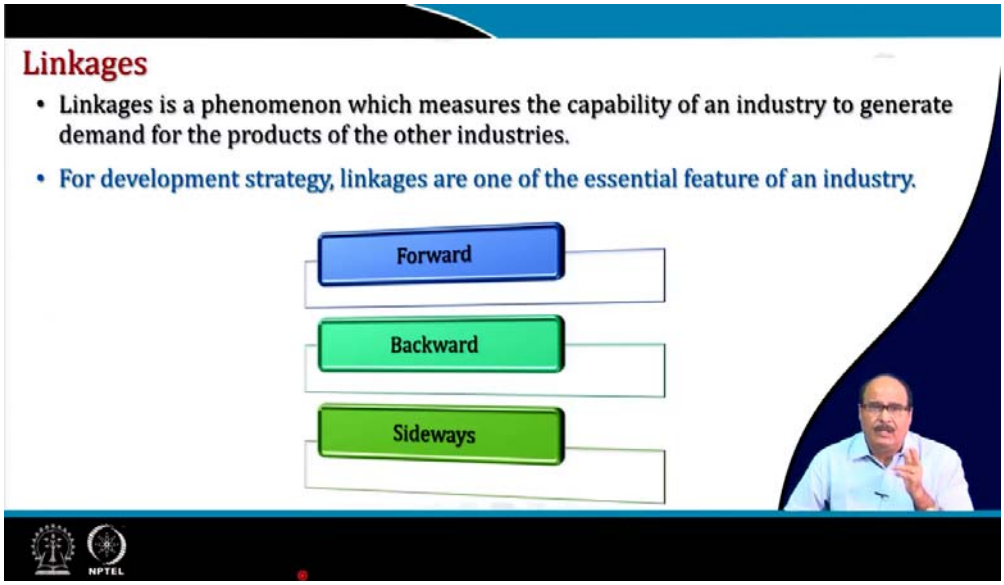
Supply Chain Models

There are 6 models of food supply chain, but they all fit into one of the two categories that is efficiency or responsiveness. All the supply chains contain both elements but the primary focus will be the driving force of the businesses supply chain model. The 6 supply chain models are agile model, flexible model, fast chain model, efficient chain model, continuous flow model, and custom configured model. When a business deals in specialty items they use the agile supply chain management. In flexible management, the supply chain has the ability to be flexible, which is a bonus especially in the food supply chain. It gives business the opportunity to meet their demands with ease. Manufacturers who work with products that have a shorter life cycle will benefit from fast chain models. This model is better suited for fruits and vegetables.



In competitive markets the efficient model is go-to of all the supply chains. It represents an end goal that is premium level of competition in the market place. Businesses that want to

gain a competitive edge over others can opt for an efficient chain model and this model aims at achieving efficiency. The continuous flow model offers stability with high demand production. This model is ideal for food manufacturer who produce food products that do not vary often that there is consistency in the product manufacturing line. So, the continuous flow model is one of the traditional supply chain models and is the best option for commodity manufacturing. Continuous flow model is most traditional of all the supply chain models used. Models that are customized is the focus of the custom configured supply chain model. Almost a hybrid of the agile and continuous flow models. The intention is set during assembly and production. Processes before configuration of the product are handled by continuous work model whereas downstream processes are managed by the agile supply chain.



Linkages

Linkages is a phenomenon which measures the capability of an industry to generate demand for the products of the other industries. For development strategy, linkages are one of the essential features of an industry. The linkages maybe forward linkage, backward linkage or sideways linkage.

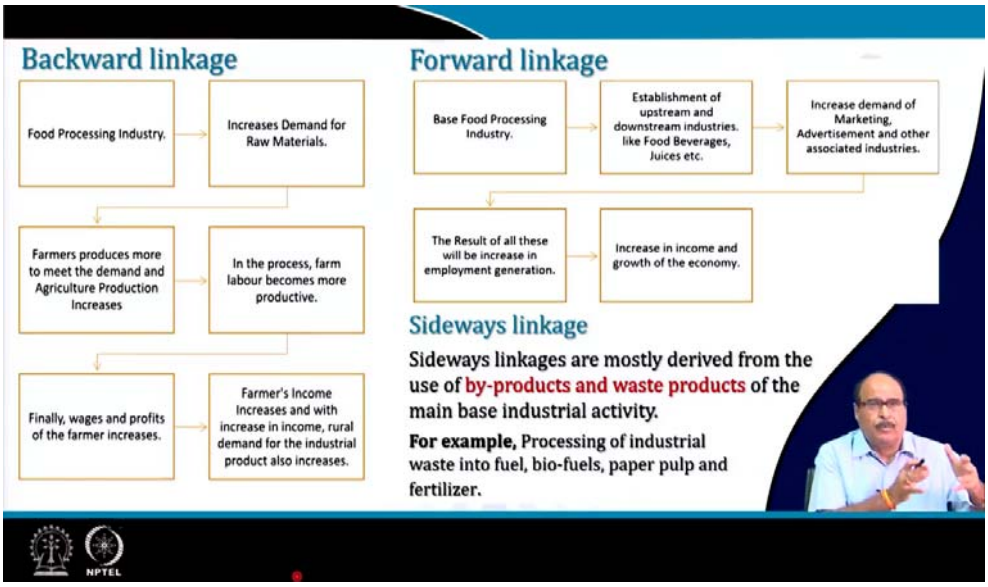
Backward Linkages

Food processing industry increases demand for raw materials. Farmers produce more to meet the demand and agricultural production increases. In the process, farm labor becomes more productive. Finally, wages and profits of the farmer increases. Farmer's income increases and with increase in income, rural demand of the industrial product also increases.

Forward Linkages

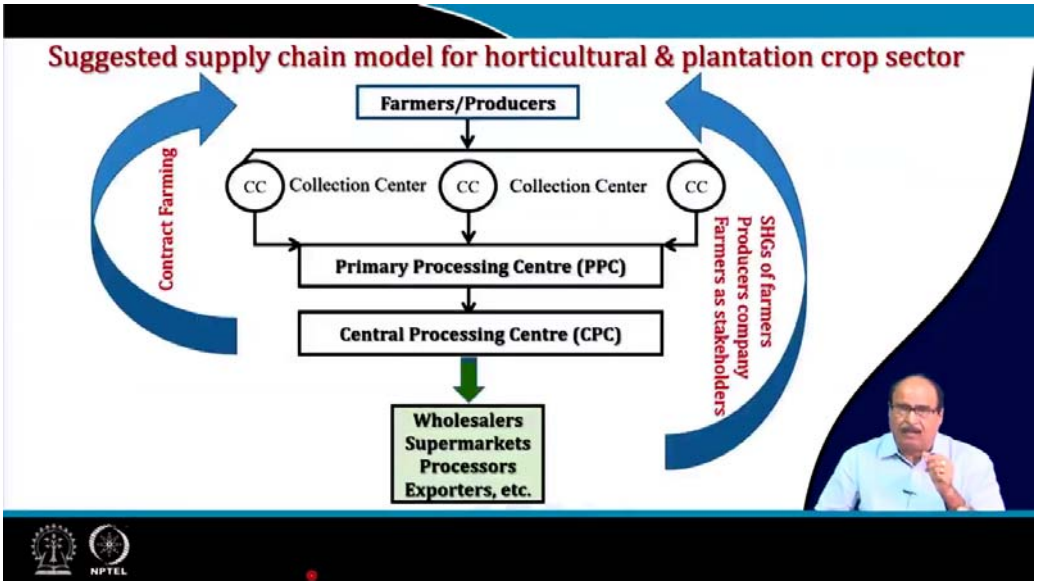
In case of forward linkages, when base food processing industry is established, there is establishment of upstream and downstream industries for food, beverage, juices, et cetera. There is increase in demand of marketing, advertisement and other associated industries. The

result of all these will be increase in employment generation and increase in income and growth of the economy of the country.



Sideways Linkages

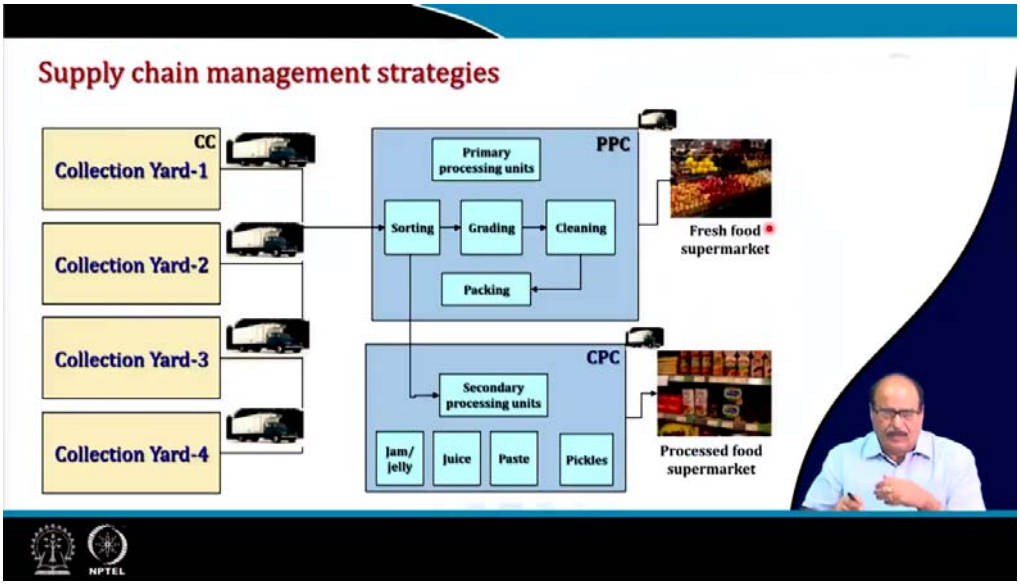
Sideways linkages are mostly delivered or derived from the use of byproducts and waste products of the main base industrial activity. For example, processing of industrial waste into fuel, biofuels, paper pulp and fertilizer. The wastes from fruit and vegetable processing industries can be used for extraction of bio-actives and various other purposes.



Supply Chain Model for Horticulture and Plantation Crop Sector

The supply chain model for horticulture and plantation crop sector is suggested where there are farmers and producers producing raw materials. There will be both backward and forward linkage by either a contact farming or by having a self-help group (SHGs) of the farmers, producers company with farmers as stakeholders. The model suggested is used in the dairy

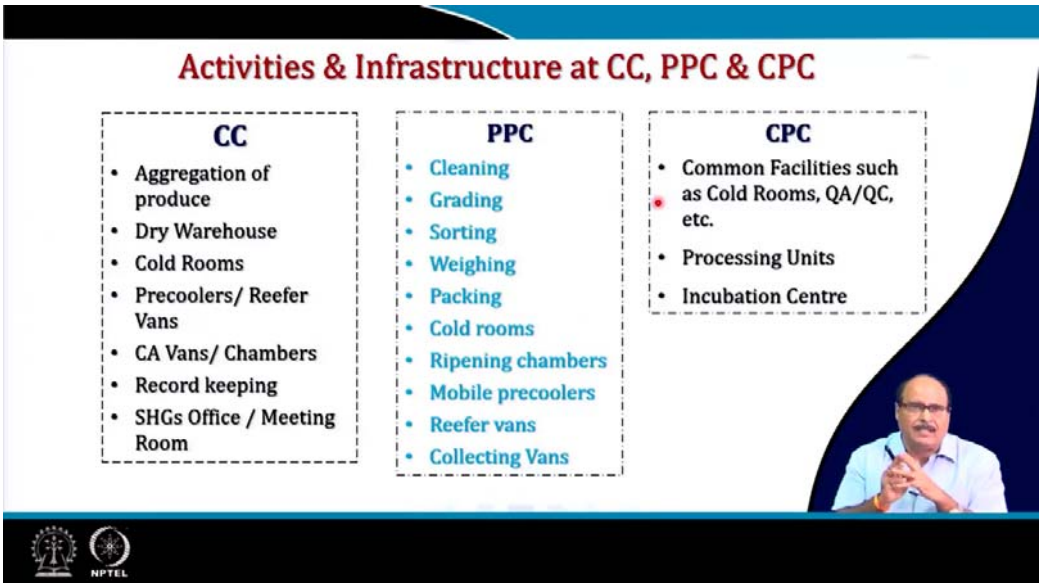
industry by Amul. That similar model can be done in the fruits and vegetables by collecting the commodities from farmers and producers in various collection centers. From the collection centers, the commodities can be routed to the primary processing center (PPC) and transferred to the Central Processing Center (CPC) from where it can be added value and distributed to wholesaler, supermarkets, processors, and exporters.



Supply Chain Management Strategies

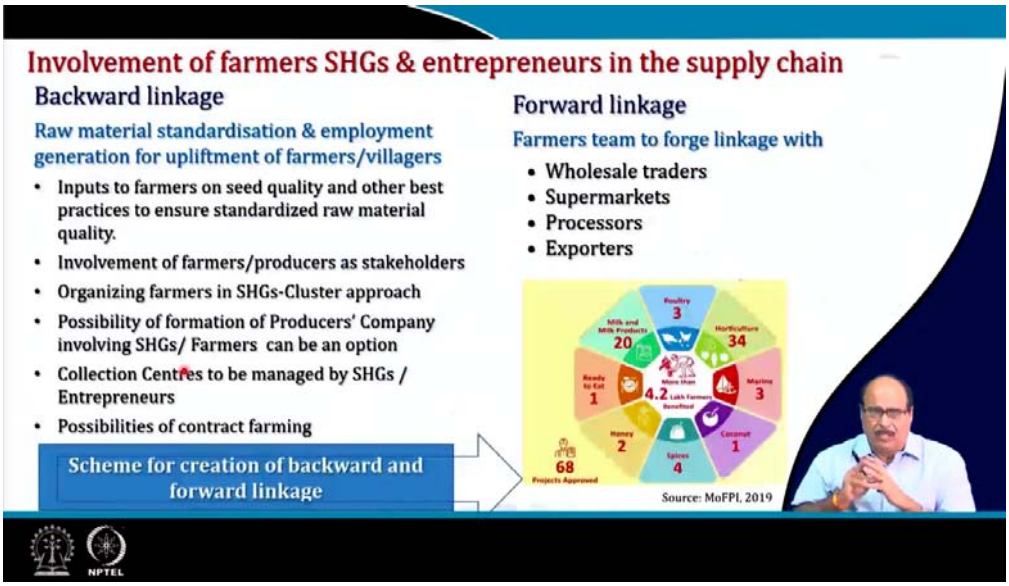
One of the major issues with the fruits and vegetables industries in India is the scattered production and high perishability of the materials. There is requirement for proper management system to collect the produces in different collection centers with proper refrigerated storage. The materials will be handled in a controlled environment and transferred to primary processing center, where various primary operations like sorting, grading, cleaning and packing can be done.

From primary processing centers, few of the materials can be directly channelized to fresh food supermarkets. Remaining materials can be sent to the secondary processing units where the fresh produce will be converted to value added products like jam, jelly, juices, paste, pickles, intermediate moisture food and high moisture fruit products. The value added products can be sent to the supermarkets or retails for sale.



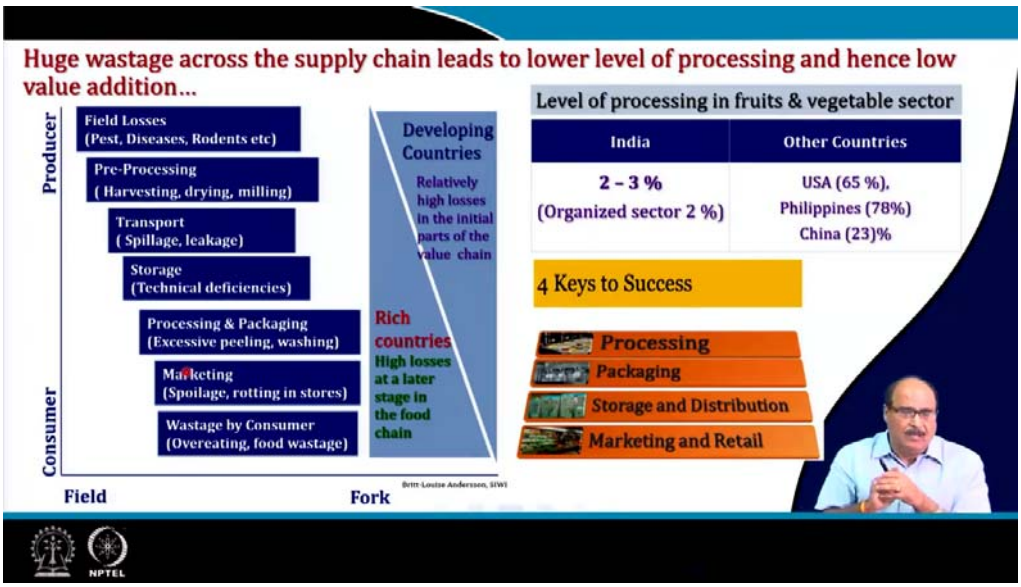
Activities and Infrastructure at CC, PPC and CPC

The collection centers should have facility for aggregation of produce for at least three days. It should also have infrastructures such as dry warehouse, cold rooms, precoolers or reefer vans, CA vans, and chambers. The collection centers should have proper arrangements for record keeping, SHGs office, and meeting rooms. The primary processing centers should be equipped with facilities to carry out activities like cleaning, grading, sorting, weighing, packing. It should also be provided with cold rooms, ripening chamber, mobile precoolers, reefer vans, and collecting vans. The central processing unit should have common facilities such as cold rooms, QA, QC settings, processing unit for value addition such as concentration, dehydration and drying. It should also have amenities for incubation center.



Involvement of farmers, SHGs & entrepreneurs in the supply chain

The backward linkage includes raw material standardization and employment generation for upliftment of farmers and villagers. It involves farmers by providing inputs to the farmers on seed quality and other best practices to ensure standardized raw material quality, involve farmers or producers as stakeholders and organizing farmers in SHGs cluster approach. The possibility of formation of the producer's company involving SHGs or farmers can be an option. Collection center can be managed even by the self-help groups and entrepreneurs and there are possibilities of contract farming. In the forward linkage, the farmers team should forge linkage with wholesale trader, supermarket, processors, and exporters. The ministry of food processing industry has created various schemes for creation of backward and forward linkages. It has approved about 68 projects including on ready to eat foods, honey, spices, coconut, marine products, horticulture products, poultry and milk and milk products. The schemes have benefited more than 4.2 lakh farmers.

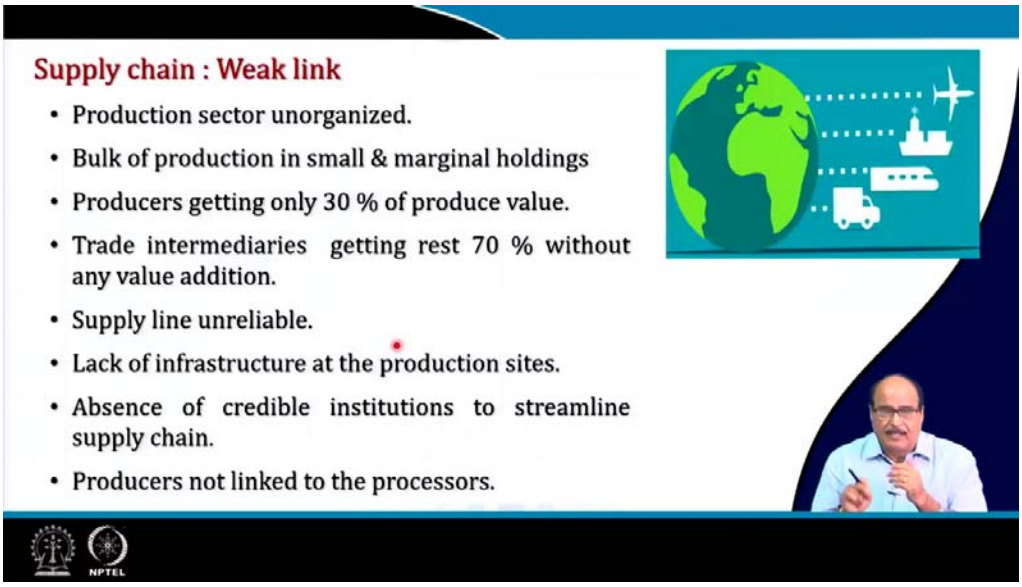


Wastage across Supply Chain

Huge wastage across the supply chain leads to lower level of processing and hence lower value addition. The losses incurred from field to fork are field losses due to pest, diseases and rodents, etc., pre-processing losses such as harvesting, drying and milling losses, transport losses such as spillage and leakage, storage losses such as technical deficiencies, processing and packaging losses such as excessive peeling and washing, marketing losses such as spoilage, rotting in stores, and wastage by consumers such as overeating and food wastage. Developing countries suffer higher losses in the initial stages of the value chain whereas, in rich countries incur high losses at the later stage in the food value chain.

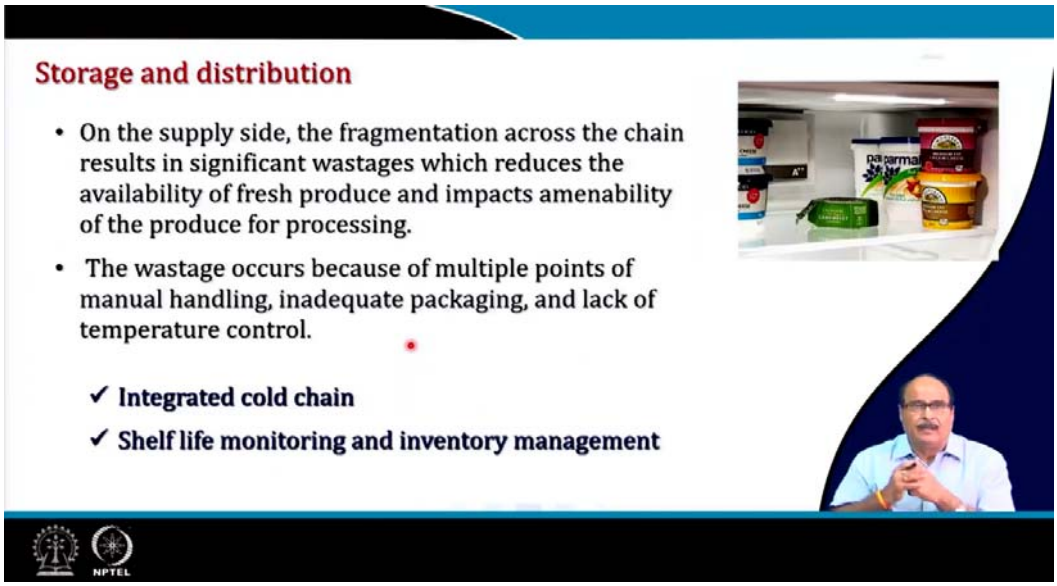
The level of processing in fruits and vegetables sectors is low in India due to poor processing, storage infrastructure and transport facilities. India processes about 2-3% of fruits and vegetables produces while other countries like USA, Philippines, and China processes about 63%, 78% and 23% of their produces, respectively. The four keys to success are proper

facilities and infrastructure for processing, packaging, storage, distribution, marketing and retail.



Supply Chain: Weak Link

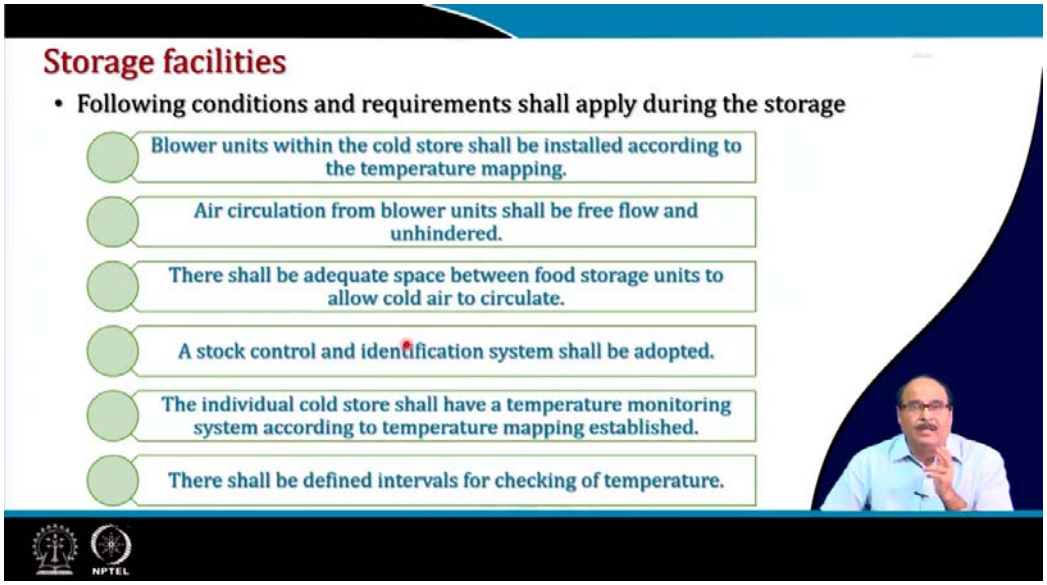
The weak links in the supply chain are unorganized production sector, bulk of production in small & marginal holdings, producers getting only 30 % of produce value, trade intermediaries getting rest 70 % without any value addition, supply line unreliability, lack of infrastructure at the production sites, absence of credible institutions to streamline supply chain and producers not linked to the processors.



Storage and Distribution

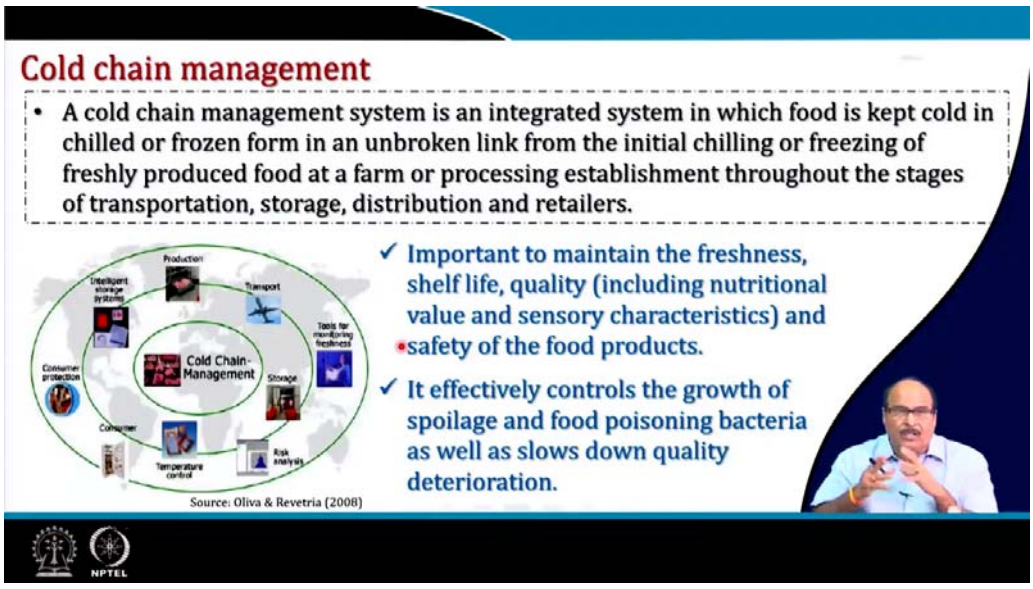
On the supply side, the fragmentation across the chain results in significant wastages which reduces the availability of fresh produce and impacts amenability of the produce for processing. The wastage occurs because of multiple points of manual handling, inadequate

packaging, and lack of temperature control. Integrated cold chain or shelf life monitoring and inventory management should be done to ensure the quality during transportation and storage.



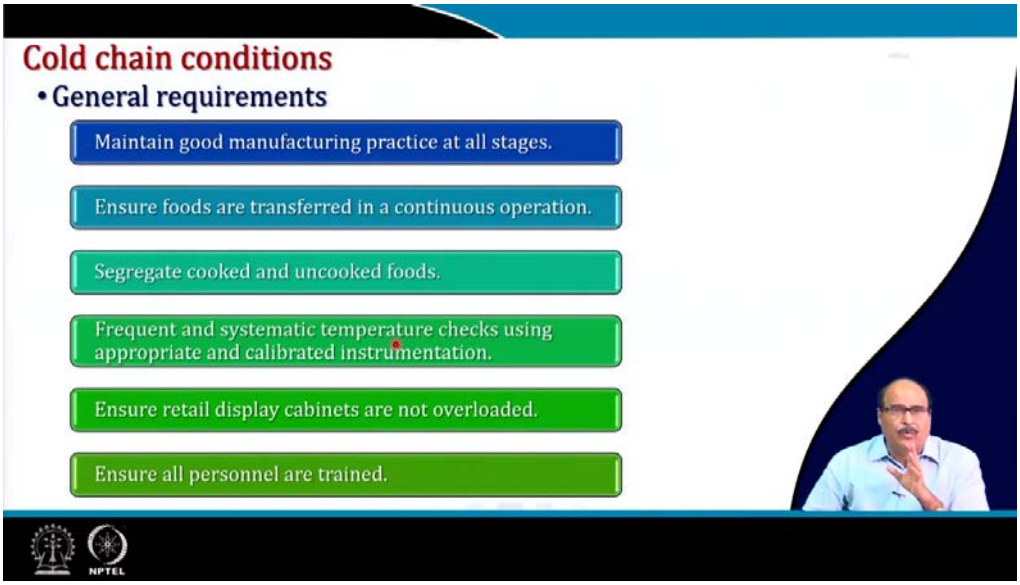
Storage Facilities

The following conditions and requirements should be applied during storage such as, blower units within the cold storage shall be installed according to the temperature mapping, air circulation from blower units shall be free flow and unhindered, there shall be adequate space between food storage units to allow cold air to circulate, stock control and identification system shall be adopted. The individual cold store shall have a temperature monitoring system according to the temperature mapping established. There shall be defined intervals for checking of temperature. Smart store houses uses inbuilt temperature sensors, IOTR, AIML, et cetera to routinely monitor and maintain the storage temperature.



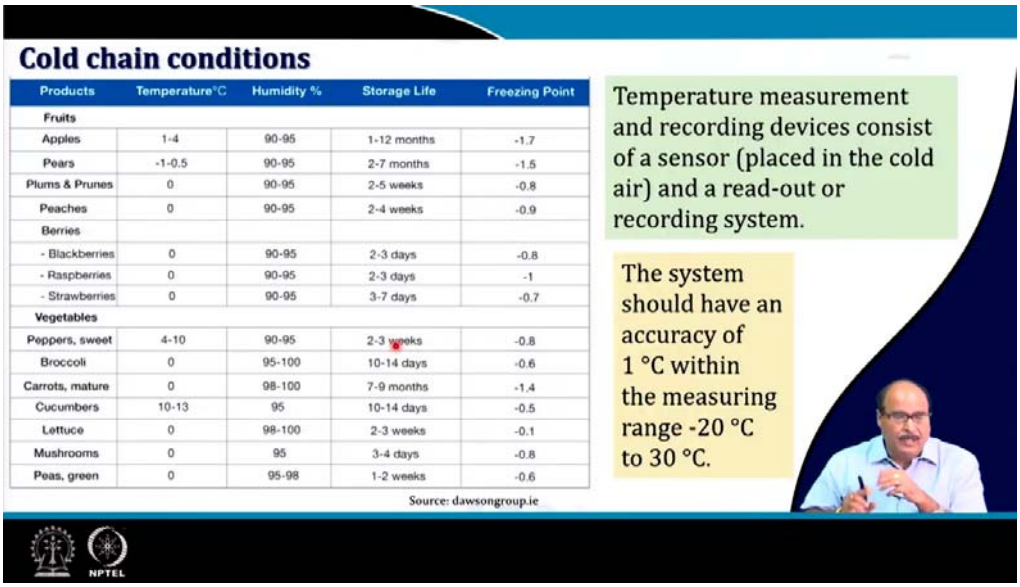
Cold Chain Management

A cold chain management system is an integrated system in which food is kept cold in chilled or frozen form in an unbroken link from the initial chilling or freezing of freshly produced food at a farm or processing establishment throughout the stages of transportation, storage, distribution and retailers. In case of fruits and vegetables, the produces should be precooled to remove the field heat before transportation. It is important to maintain the freshness, shelf life, quality including nutritional value and sensory characteristics, and safety of the food products. It effectively controls the growth of spoilage and food poisoning bacteria as well as slows down quality deterioration.



Cold Chain Conditions

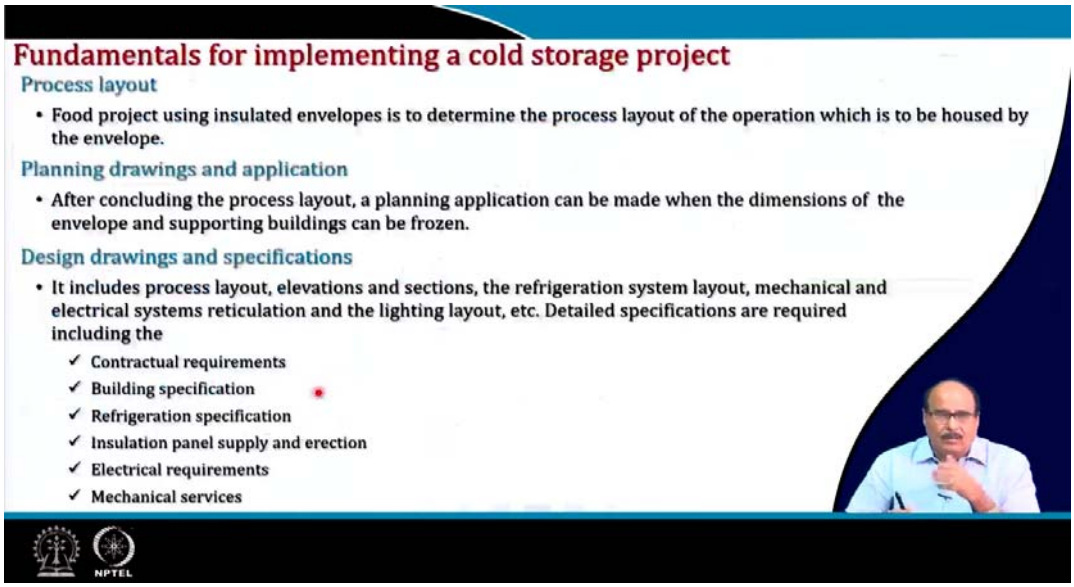
The general requirements for cold chain are to maintain good manufacturing practice at all stages, ensure foods are transferred in a continuous operations, segregate cooked and uncooked foods, frequent and systematic temperature checks using appropriate and calibrated instrumentation, ensure retail display cabinets are not overloaded and ensure that all personnel are trained and personal hygiene is maintained.



The cold chain conditions for storage of apple are 1-4 °C, humidity 90 to 95 percent and storage life ranges from 1 to 12 months. Its freezing point is -1.7. Similarly, berries like blackberries, raspberries and strawberries, have a storage temperature of 0°C and relative humidity of 90 to 95 %. In case of strawberries, it can be kept for 3 to 7 days while raspberry and blackberry for 2 to 3 days. Vegetables like cucumber should be stored at 10 to 13°C, and peppers at 4-10°C. Other vegetables like broccoli, lettuce, mushroom, and peas green require 0°C and 95-96% RH. The temperature, relative humidity, storage life and freezing point of common fruits and vegetables are provided in the table given. Temperature measurement and recording devices consist of a sensor (placed in the cold air) and a read-out or recording system. The system should have an accuracy of 1 °C within the measuring range -20 °C to 30 °C.

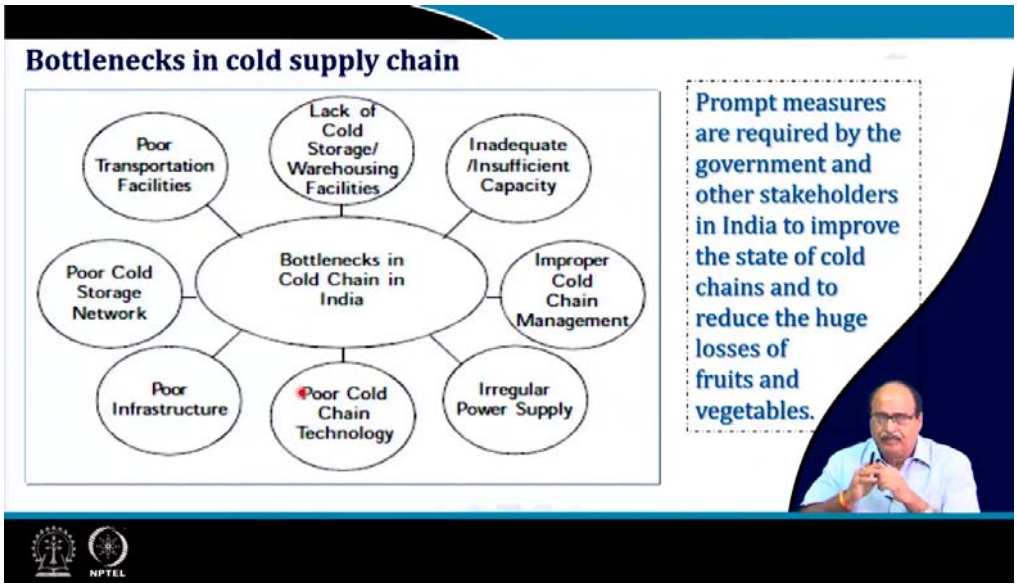
Classification of Cold Stores

The classification of cold stores are bulk cold rooms, controlled atmosphere stores, multipurpose cold stores, small cold stores, frozen food stores and mini units or walk in cold stores. Bulk cold stores are for storage of a single commodity on a seasonal basis like stores for potatoes, chillies and apples, etc. The controlled atmosphere stores are is designed for certain fruits and vegetables. Multipurpose cold stores are for storage of variety of commodities, which operate practically throughout the year. Small cold stores with the pre-cooling facilities are for fresh fruits and vegetables, mainly for export-oriented items like grape et cetera. Frozen food stores are designed for with or without processing and freezing facilities for processed fruits and vegetable. Mini units/ walk in cold stores are located at distribution center. Not sensitive to cold produces like vegetables are stored at 0-4°C, moderately sensitive to cold produces such as mangoes, oranges, potatoes and tomatoes are stored at 4-8°C, and cold sensitive produces like pineapple, banana and pumpkins, are stored at more than 8°C.



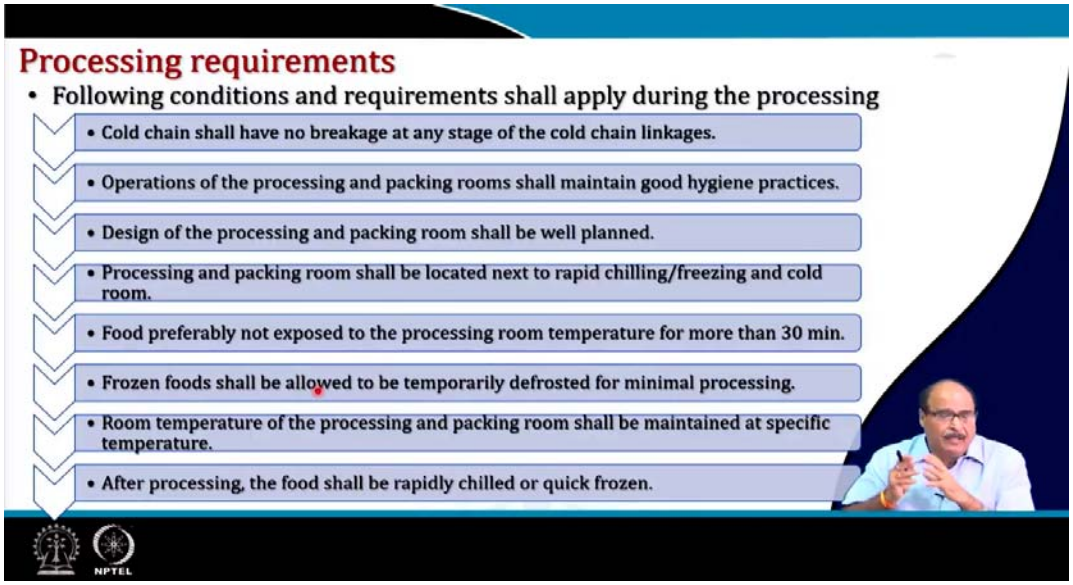
Fundamentals for implementing a cold storage project

The fundamentals for implementing a cold storage project are process layout, planning drawings and application, design drawings and specifications. Food project using insulated envelopes is to determine the process layout of the operation which is to be housed by the envelope. After conducting the process layout, a planning application can be made when the dimensions of the envelope and the supporting buildings can be frozen. The design drawings and specifications, includes process layout, elevations and selections, the refrigeration system layout, mechanical and electrical system reticulation and lighting layout, et cetera. Detailed specifications are required including the contractual requirements, building specification, refrigeration specification, insulation panel supply and erection, electrical requirements, mechanical services et cetera.



Bottlenecks in Cold Supply Chain

The bottlenecks in the cold supply chain include the lack of cold storage warehousing facilities, inadequate or insufficient capacity, improper cold chain management, irregular power supply, poor cold chain technology, poor infrastructure, poor cold storage network, and poor transportation facilities. Prompt measures are required by the government and other stakeholders in India to improve the state of cold chain and to reduce the huge losses of the fruits and vegetables.



Processing Requirements

The conditions and requirements for processing are cold chain shall have no breakage at any stage of the cold chain linkages, operations of the processing and packaging rooms shall maintain good hygienic practices, design of the processing and packaging rooms shall be well planned. Processing and packaging rooms shall be located next to rapid chilling or freezing

and cold rooms. Food preferably shall not be exposed to the processing room temperature for more than 30 minutes and frozen foods shall be allowed to be temporarily defrosted for minimal processing. Room temperature of the processing and packing room shall be maintained at specific temperature. After processing the food shall be rapidly chilled or quickly frozen.

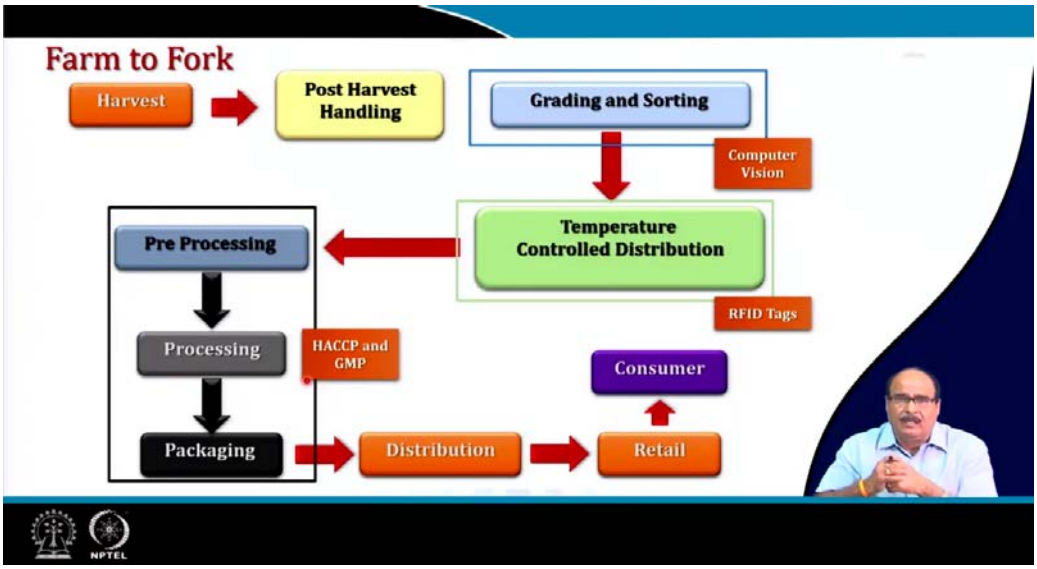
Export

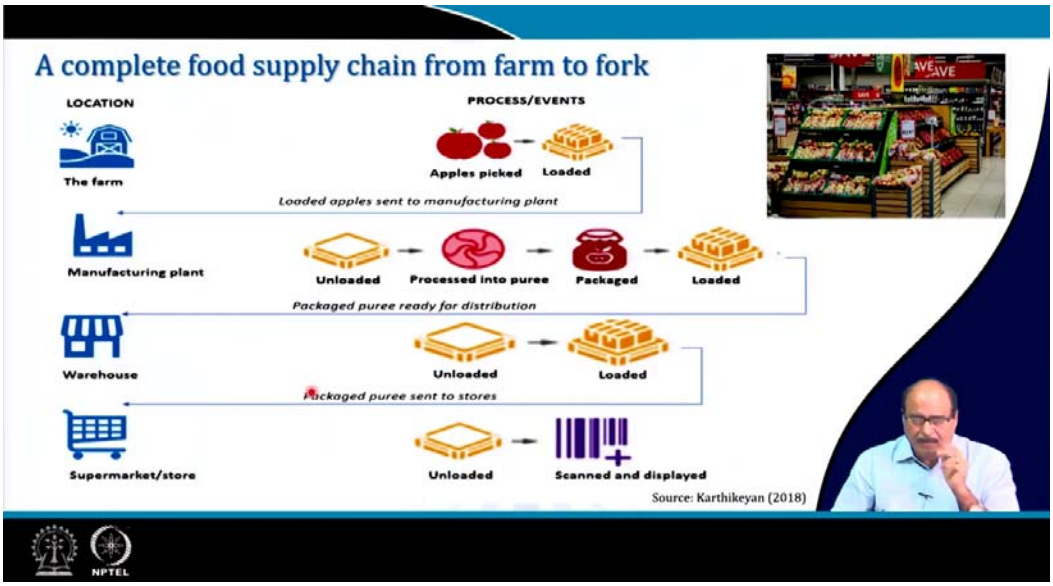
Strategies to improve export are ongoing export promotion program should be strengthened, marketing intelligence should be streamlined, marketing research should be strengthened, standards development, testing facilities and enforcement mechanism should be in place. Training programs for farmers and entrepreneurs should be undertaken.

Quality aspects of the export to be considered are increase in health consciousness increasing the demand for quality produce. International standards such as Codex Alimentarius Commission, WHO, FAO, WTO, UN, European Union and Indian organizations such FSSAI, AGMARK and other relevant necessarily standards should be properly implemented. There is need for popularization of the standards among growers and processors as well as need for better infrastructure for quality testing.

Farm to Fork

Good harvesting practices should be followed while harvesting the produce, followed by better post-harvest handling. The produces are subjected to grading and sorting using techniques such as computer vision. RFID tags are used during transportation to ensure temperature-controlled distribution. The produces are pre-processed, processed and packaged. HACCP and GMP should be implemented during processing to ensure hygienic and safe production of the food products. The produced products are then distributed to retails to reach the consumers. At every in the value chain proper care must be implemented.



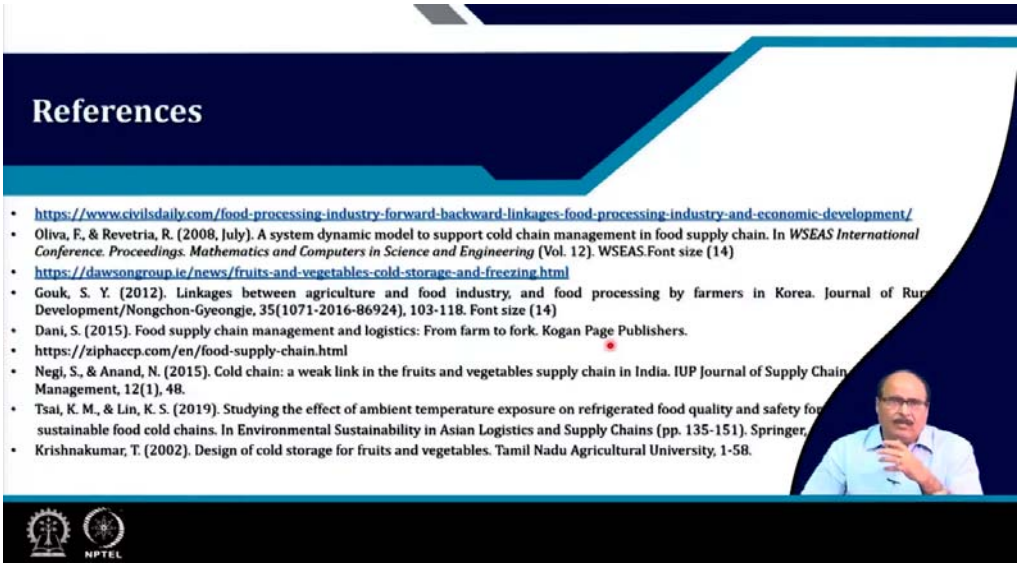


A complete food supply chain from farm to fork is explained using the value chain of apple from farm to fork. Apple after harvesting is loaded and sent to the manufacturing plant, where they are unloaded, processed into value added products like juice, puree and packaged.

The packaged product is ready for distribution to warehouse. From the warehouse the products will be distributed to retail stores and supermarkets to be scanned and displayed. Similarly, the value chain is specific and complex for each commodity.

Summary

The food supply management organize and oversee all of the areas of the supply chain that helps to mitigate against food losses and food wastage. There are six models of food supply chain including agile, flexible, fast chain, efficient chain, continuous flow and custom configured. For development strategy, linkages are one of the essential features of an industry. A cold chain is a temperature-controlled supply chain comprising of refrigerated production, storage and distribution facilities supported by equipment that can constantly maintain the required low-temperature range.



These are the references for further study. Thank you.