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A SCIENTIFIC STUDY OF COLD STORAGES OF DISTRICT MUZAFFARNAGAR IN UTTAR PRADESH

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ABSTRACT

Preservation of non-living foods is more difficult since they are susceptible to spoilage. The problem is to preserve dead tissues from decay and putrefaction. This paper presents an overview of the main characteristics of cold storages. Cold Storage is a special kind of room, the temperature of, which is kept very low with the help of machines and precision instruments. India is having a unique geographical position and a wide range of soil thus producing variety of fruits and vegetables like apples, grapes, oranges, potatoes, chillies, ginger, etc. In this research paper, a study of cold storages has been carried out in the district Muzaffarnagar, Uttar Pradesh. The variables which are considered under this study are storage capacity, duration of storage, storage temperature, humidity, refrigerant, power consumption, number of employees, number of cold chamber and their respective areas, total cost, profit, devices used and their companies. Data about nine cold storages were collected. Five cold storages were used for storing the potato and sugar. Four cold storages were used for storing the bananas. It is observed from this study that maximum profit is earned by the Manohar cold storage and it is lowest for the Tyagi storage.

Keywords: *FAO, CPRS, CFTRI, IARI.*

I. INTRODUCTION

Cold Storage is a special kind of room, the temperature of, which is kept very low with the help of machines and precision instruments. India is having a unique geographical position and a wide range of soil thus producing variety of fruits and vegetables like apples,

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grapes, oranges, potatoes, chillies, ginger, etc. Marine products are also being produced in large quantities due to large coastal areas. The present production level of fruits and vegetables is more than 100 million MT and keeping in view the growth rate of population and demand, the production of perishable commodities is increasing every year. The cold storage facilities are the prime infrastructural component for such perishable commodities.

The potato is the most important food crop in the world after wheat, rice and maize. Over one billion people consume worldwide and potatoes are part of the diet of half a billion people in the developing counties. Potato ranks 4th in the world and third in India with respect to food production. In the year 1999- 2000, India produced 25 million tons of potatoes from an area of 1.34 million hectares with an average yield of 18.6 t/ha. Potato is a staple food in the colder regions of the world, while in other parts of the world it is generally used as a vegetable. In India 73% potatoes are consumed in different forms such as cooked, roasted, French-fried, chipped etc. Cooking often reduces mineral and vitamin constituents. In case of processed products it is possible to add missing or low ingredients in order to enhance overall nutritional value of the product [4].

The potato is a semi-perishable commodity. Appropriate and efficient post harvest technology and marketing are critical to the entire production-consumption system of potato because of its bulkiness and perishability. Unlike in temperate regions, in India the potato is harvested in the beginning of summer. Due to inadequate cold storage facilities to hold the produce for longer periods, prices plunge at harvest time and large quantities are spoiled before they could be disposed off. Consumers are also unable to develop a habit of consuming more potatoes because potato stocks disappear from the market within a few months of harvest and in later part of the year relative prices of potato are high. Per capita consumption of potatoes in India is 18.3 kg a year as against the world average of 52.7 kg, in spite of increase in production in recent years (FAO, 1991).

Egypt is one of the largest producers and exporters of potatoes in Africa. Potato is the second most important vegetable crop after tomato (El-Tobgy, 1974). In 1996, Egypt produced 2.6 million metric tons of potatoes and exported 411,000 metric tons valued at nearly US $80 million to Europe and the Arab countries. Small farmers grow 65% of these potatoes. In year 2000 Egypt produced 1.784 metric tons from an area of 83000 Ha with average yield of 21.49 t Ha-1 (FAO, 2000).

Our farmers continue to remain poor even though they take risk of cultivating high value fruits and vegetable crops year after year. A cold storage facility accessible to them will go a long way in removing the risk of distress sale to ensure better returns. This document endeavors to provide information on various broad technical and financial aspects of a cold storage unit to enable the financing banks and entrepreneurs in formulation and implementation such projects.

Good storage should prevent excessive loss of moisture, development of rots, and excessive sprout growth. It should also prevent accumulation of high concentration sugars in potatoes, which results in dark-coloured processed products. Temperature, humidity, CO_2 and air movement are the most important factors during storage [7,8].

Varns et al. (1985) investigated the potato losses during the first three months of storage for processing. It was observed the sampling of three respondent groups includes a local storage region, the processing industry, and the federal inspection service (USDA). Questionnaires indicated that 64 to 150 thousand metric tons were annually lost during early storage from the total crop stored for processing. This constitutes a range of 5.6- 13.2 million dollars lost in production costs.

Out of 3443 cold storage units setup till 1988, 2012 units were for potato, 447 units were for multipurpose use, 198 units were for fruits and vegetables and the remaining were for products like meat, fish, milk, etc.

II. TRADITIONAL STORAGE DEVICES

Storage methods, which were in vogue in the warm plains of India till recently, are described by many authors and are as follows. (i) Storage in cool dry rooms with proper ventilation on the floor or on bamboo racks and (ii) Storage in pits. The former was generally followed in the plains for seed potatoes during the period from Feb.-March to Sept.-Oct. Storage in pits was adopted in the erstwhile Bombay state from Feb.- March till the onset of monsoon season in June [5].

In Egypt, the bulk of potato storage takes place in traditional structures or nawallas made of mud bricks. Nawallas are typically privately owned and are concentrated in the northern governorates with lower average temperatures. Walls are typically from 2.5 to 3.5 m high and 30 to 60 cm thick. Storage period is normally for 5 months, May to September. Roofs consist of bamboo matting, rice straw, and mud supported by wood or bamboo frames. Seed potatoes are dusted with SEVIN and CAPTAN (brand names) and arranged in piles 1.5 to 4 m across and 0.8 to 1.0 m high. The piles are sorted every two weeks and infested, diseased, or damaged tubers discarded. Rats and Tuber moth are major problems.

Temperatures within the nawallas are not much lower than the ambient temperatures in the shade outside, although within the heaps temperatures may as much as 10°C lower. Losses from tuber moth infestation, dehydration, excessive sprouting, and other causes average about 20-30%, although losses of up to 70% have been reported. The need for improving storage facilities and practices for warehouse as well as seed potatoes has been noted by several authors [3].

III. SCIENTIFIC STORAGE SYSTEM

A. Evaporatively Cooled Storage

Evaporative cooling is nature's very own method. The ancient Egyptians used a primitive form of evaporative cooling, dating back to about 2500 BC. Evaporation of water produces a considerable cooling effect and the faster the evaporation the greater is the cooling. Evaporative cooling (EC) occurs when air that is not already saturated with water vapour is blown across any wet surface. Thus evaporative coolers consisted of a wet porous bed through which air is drawn and cooled and humidified by evaporation of the water [9].

The farm level storage system, which is less capital intensive and extends the shelf life of fruits and vegetables sufficiently to realize better prices after the storage period was very much needed. EC storage was thus considered to meet the much-desired need and hence studies were initiated on this aspect in the early eighties at CFTRI, Mysore, CPRS, Jalandhar and IARI, New Delhi [10].

Chouksey reported the design aspects of a solar-cum-wind aspirator ventilated evaporative cooling structure of 20-ton capacity for potatoes and other semi perishables, which was constructed at the Central Potato Research Station (CPRS), Jalandhar. The structure maintained a temperature of 21-25°C with 80-90% RH at ventilation rate of 24 m^3/min when the outside temperature and RH were 40-42°C and 30-35%, respectively [11].

B. Forced Draught Cooling

In this system, the produce is stacked in the manner like in a cold store with a high refrigeration capacity. A sheet of canvas or other material is placed over the stacked produce and a powerful electric fan sucks cold air rapidly from the room through the packed produce.

Although the rapid air movement creates more water loss from the produce, cooling is much more rapid than otherwise and the respiration rate is reduced very quickly. As soon as the produce has been cooled down to close to the optimum storage temperature, it can be transferred to an ordinary cold store for the rest of its storage life. There are many different types of forced draught cooling systems and most depend upon the produce being in appropriate containers – often fiberboard cartons. Ships and containers adapted especially for refrigeration and carriage of fresh produce use a variation of this system.

C. Ice-bank Cooling

This is a relatively recent development in which heat is removed by melting a large block of ice, which has been built up over a period of days by a small refrigeration unit. The heat is removed from air in the store by passing it through sprays of ice-cold melt water in a chamber separate from the store. In this way cool air of very high relative humidity can rapidly cool the store and the produce.

Temperature of ventilating air is reduced at the rate of –17.5°C per day until holding conditions is reached. This is first done by measuring the return air temperature (although measuring the bulb temperatures at the top of the pile will be more accurate). If the return air temperature is within -16.7°C of the set temperature, it will be necessary to lower the set temperature at the rate mentioned above. The best time to measure the return air is during early morning hours because the pile would have gone through an extended period of cooling through the night. Ventilation should always be provided during cool down. Once the conditions inside the storage are stabilized, daily ventilation carried out should be long enough to maintain a –17.2 to –16.7°C differential between the bottom and the top of the pile. Increasingly, fans are being run in shorter cycles (at the rate of 2 to 4 hours per run with a break of at least 2 hours). The shorter cycles tends to reduce extreme pile temperature difference between the top and the bottom. The point to remember is that if the fans are stopped for long periods, the pile tends to get warmer; therefore, it will require more time to cool down. This recommendation is fairly new and therefore storage managers are advised to check the efficiency of the air system before making any changes.

IV. IMPORTANCE IN INDIA

Preservation of non-living foods is more difficult since they are susceptible to spoilage. The problem is to preserve dead tissues from decay and putrefaction. Long term storage of meat and fish product can only be achieved by freezing and then by storing it at temperature below -15°C. Only certain fruits and vegetables can benefit from freezing. However, for fruits and vegetables one should be very careful about the recommended storage temperature and humidity a deviation from which will have adverse effect on the stored product leading to even loss of the entire commodity.

India is one of the world's largest consumers of food and the third largest producer of agriculture, according to 2015 Top Markets Report on Cold Chain by International Trade Administration [2]. India also holds the distinction of being the largest producer of milk in the world and boats of having the largest livestock population. Food processing refers to value addition to agricultural or horticultural produce. The food processing sector comprises two segments- Primary (packaged fruits and vegetables, milk, etc., constituting around 62% in value) and Value added (processed fruits and vegetables, juices, jam & jelly etc constituting around 38% share in the total processed food [6].

V. COMMODITY STORAGE CONDITIONS

For designing a cold storage, product storage conditions must be defined in terms of critical storage conditions of temperature, relative humidity, presence of CO_2, ethylene, air circulation, light etc. In absence of research data for Indian conditions, it is recommended to adopt commodity storage conditions as prescribed by Commodity Storage Manual of WFLO.

(a) **Temperature range:** The temperature in the multi commodity cold store chambers should be kept within +1°C of the recommend temperature of the produce being stored. For storing at temperatures close to freezing point of the commodity, for increasing storage life, even a narrow range may be needed.

(b) **Humidity range:** The humidity (RH) is again dependent on the produce storage requirements and may vary from 95% to 98% RH in case of fresh fruits and vegetables like grapes, kiwi fruit, carrots, cabbage etc and lower in the range of 65% - 75% RH in case of onion and garlic.

(c) **CO_2 level:** Not more than 4000 PPM during loading and 2000 PPM during holding. (Source – Industry). However, if the cold store chambers are being used for Modified Atmosphere Storage for selective commodities like apples etc, the levels of CO_2 and O_2 should be maintained and regulated as recommended in the Commodity Storage Manual of WFLO.

(d) **Loading Rate:** Generally the refrigeration system capacity is based on 4% to 5% loading rates of the total cold store capacity. The loading pattern is also a design consideration for sizing the storage chamber capacity for optimal utilization and performance.

In case separate pre-cooling chambers are provided in the multi commodity storage facility, the load per batch is to be considered along-with initial and final desired product temperature, pull down rate etc while sizing the pre-cooling chambers and the refrigeration requirements.

(e) **Pre-cooling Time:** 4-6 hours for pre-cooling to 7/8th cooling time as recommended for majority of fresh fruits and vegetables. However, in case of fresh produce like carrots, apples etc meant for long/medium term storage, which are directly cooled and stored in the cold rooms, the cooling period, can be up-to 20 hrs per day and should meet the requirements specified in the commodity storage manuals.

(f) **Air Circulation:** Multi Commodity stores should be design to provide an air flow of 170 CMH per metric ton of product, based on maximum amount of product that can be stored in each chamber. This is essential for rapid cooling of the produce. However, the system should be designed to reduce air flow to 34 to 68 CMH per metric ton of product after the produce has reached the storage temperature. This is achieved by variable frequency drive and control system to automatically maintain the temperature variation within each chamber at less than + 1°C throughout the storage period. In case the fresh produce is pre-cooled in a separate pre-cooling chamber before loading and storage in the main cold store chambers, the air flow requirements may range.

(g) **Stacking:** During room cooling, cold air from the coils flows past the produce stored in crates/pallet racks/bins thereby removing the product heat. For best result the pallets/crates/ boxes/bins should be stacked so that the moving air can contact all the container surfaces for adequate5and rapid cooling. Well ventilated boxes/crates with vent alignment should be considered as they great speed-up the cooling rate by allowing the cooling air to uniformly flow. It is recommended that the storage pallets must be stacked to form air channels 4 to 6 inches wide to direct air movement. They should also be space between the product and walls to allow refrigerated air to absorb the heat of conduction through the walls. Since, air takes the path of least resistant, in proper stacking in hips or partly filled rooms have poor air distribution and effect the cooling rate. from 67 CMH to 100 CMH.

It is therefore recommended that such multi commodity cold store chambers / facility are designed for storage in PVC crates, bins and ventilated card board boxes stacked in pallet frames. However commodities which do not require rapid cooling like onion, garlic, potatoes etc may be stored in jute / nylon net bags, stacked in pallet frame. The pallets are required to be handled with fork lift /

stackers. Generally steel pallet frame are of size 1200mm x 1000 mm x 1600 mm high suitable for holding crates and boxes and can be easily stacked up to 4 high. Sometimes pallets frame of size 1300mm x 1000mm x 1800mm are preferred for storing in 50 kgs bag of potatoes / onion/ garlic for optimal utilization. Generally, each pallet frame can hold upto 1000 kg produce.

(g) **Ventilation requirements in the cold store chambers:** It may range between 2 to 6 air changes per day to maintain CO_2 less than 4000 ppm.

(h) **Lighting Condition-Dark**

(i) **Application of Smart Fresh**

VI. COMPATIBILITY GROUPS FOR STORAGE OF FRUITS AND VEGETABLES

In absence of our own R & D data in this regard, we adopt recommendations made by USDA office of transportation and fresh fruits and vegetables are grouped in seven distinct groups (Source: McGregor, B. M. 1989. Tropical Products Transport Handbook. USDA Office of Transportation, Agricultural Handbook 668).

Group 1: Fruits and vegetables, 0 to 2°C (32 to 36°F), 90-95% relative humidity. Many products in this group produce ethylene

Apples	Grapes (without sulphur dioxide)	Parsnips
Apricots	Horseradish	Peaches
Asian pears	Kohlrabi	Pears
Barbados cherry	Leeks	Persimmons
beets, topped	Longan	Plums
berries (except cranberries)	Loquat	Pomegranates
cashew apple	Lychee	prunes
Cherries	Mushrooms	quinces
Coconuts	Nectarines	Radishes
figs (not with apples)	oranges* (Florida and Texas)	rutabagas turnips

(**Source:** ASHRAE handbook)

Group 2: Fruits and vegetables, 13 to 15°C (55 to 60°F), 85-90% relative humidity. Many of these products produce ethylene. These products are also sensitive to chilling injury.

Atemoya	granadilla	Papayas
avocados	grapefruit	Passionfruit
Babaco	guava	Pineapple
Bananas	Jaboticaba	Plantain
bitter melon	jackfruit	potatoes, new
black sapote	Langsat	Pumpkin
Boniato	lemons*	Rambutan
breadfruit	limes*	Santol
Canistel	mamey	Soursop
Carambola	mangoes	sugar apple
Cherimoya	mangosteen	squash, winter (hard shell)
coconuts	melons (except cantaloupes)	Tomatillos
Feijoa		tomatoes, ripe
ginger root		

Group 3: Fruits and vegetables, 0 to 2°C (32 to 36°F), 95-100% relative humidity. Many products in this group are sensitive to ethylene.

Amaranth*	cherries	parsley*
anise	daikon*	parsnips*
artichokes*	endive*	peas*
Asparagus	escarole*	Pomegranate
bean sprouts	grapes (without sulfur dioxide)	Raddichio
beets*	horseradish	radishes*
Belgian endive	Jerusalem artichoke	Rhubarb
berries (except cranberries)	kiwifruit	rutabagas*
Bokchoy	Kohlrabi	Salsify
broccoli*	leafy greens	Scorzonera
brussels sprouts	leeks' (not with figs or grapes)	snow peas
Cabbage	lettuce	lettuce
carrots*	lo bok	Sweet corn*

cauliflower	mushrooms	turnips*
celeriac*	celeriac* onions, green* (not with figs, grapes, water chestnut	water chestnut
celery*		watercress*

Source: International Institute of Ammonia Refrigeration(IIAR)

Group 4: Fruits and vegetables, 4.5°C (40°F), 90-95% relative humidity.

cactus leaves	lemons*	Tamarillo
Cactus pears	lychees	tangelos*
Caimito	kumquat	tangerines*
cantaloupes**	mandarin*	ugli fruit*
clementine	oranges (Calif. and Arizona)	yucca root
cranberries	Pepino	

Source: International Institute of Ammonia Refrigeration (IIAR)

Group 5: Fruits and vegetables, 10°C (50°F), 85-90% relative humidity. Many of these products are sensitive to ethylene. These products also are sensitive to chilling injury

beans	kiwano	Pummel
Calamondin	malanga	squash, summer (soft shell)
chayote	okra	Tamarind
cucumber	olive	taro root
eggplant	Peppers	
haricot vert (fine beans)	potatoes, storage	

Source: International Institute of Ammonia Refrigeration(IIAR)

Group 6: Fruits and vegetables, 18 to 21°C (65 to 70°F), 85-90% relative humidity

jicama	sweetpotatoes*	watermelon*	yams*
Pears (for ripening)	tomatoes, mature green	white sapote	

Group 7: Fruits and vegetables, 0 to 2°C (32 to 36°F), 65-7 5% relative humidity. Moisture will damage these products.

garlic	onions, dry

VIII. DETAILS OF COLD STORAGES OF MUZAFFARNAGAR

Table 1 : Muntazir Ali Cold Storage

Storage	Banana
Capacity	1300 Carat
Duration	4-6 days
Temperature	55°F
Air Conditioner	3-4
No. of Employees	4
Sources of raw banana	Andhra Pradesh, Bihar, Gorakhpur, Gujarat
Supply	Jansath , khatauli, shahpur,Budhana

Table 2 : H.M Cold Storage

Storage	Potato, Raw sugar
Capacity (potato)	70000 bag (1 bag=50kg) =3500000 kg =3500 tonne
Capacity (Raw sugar)	150000 bag (1 bag=40kg) =6000000 kg =6000 tonne
Duration	March – October
Temperature (potato) Temperature (Raw sugar)	38°F (sugar free) 44°F (sugar) 57°F
Humidity	95%
Refrigerant	Ammonia (R-717)
Power consumption	150 KVA
No of employees	15
No. of cold chamber	5
Area of cold chamber 1 Area of cold chamber 2 Area of cold chamber 3 Area of cold chamber 4 Area of cold chamber 5	144x85 sq.ft 60x55 sq.ft 133x86 sq.ft 125x72 sq.ft 82x77 sq.ft

Total cost	1.23 – 1.30 crores
Profit	24 -33 lakhs
Compressor	Reciprocating type Company – kirloskar
Condenser	Vibrating type Company – kirloskar
Evaporator	Tube type Company - kirlosker
Expansion valve	Company – supermany

Table 3 : Bhushan Cold Storage

Storage	Banana
Capacity	1500 Carat
Duration	4-5 days
Temperature	57°F
Air Conditioner	4
No. of Employees	5
Sources of raw banana	Andhra Pradesh, Bihar, Gorakhpur
Supply	Jansath , Bhopa, Morna

Table 4 : Gupta Cold Storage

Storage	Potato, Raw sugar
Capacity (potato)	50000 bag (1 bag=50kg) =2500000 kg =2500 tonne
Capacity (Raw sugar)	100000 bag (1 bag=40kg) =4000000 kg =4000 tonne
Duration	March – October
Temperature (potato) Temperature (Raw sugar)	35°F (sugar free) 43°F (sugar) 55°F
Humidity	95%
Refrigerant	Ammonia (R-717)
Power consumption	135 KVA

No of employees	13
No. of cold chamber	4
Area of cold chamber 1 Area of cold chamber 2 Area of cold chamber 3 Area of cold chamber 4	140x75 sq.ft 80x45 sq.ft 130x76 sq.ft 110x62 sq.ft
Total cost	75 – 80 lakhs
Profit	15-20 lakhs
Compressor	Reciprocating type Company – kirloskar
Condenser	Vibrating type Company – kirloskar
Evaporator	Tube type Company - kirlosker
Expansion valve	Company – supermany

Table 5 : Shadab Cold Storage

Storage	Banana
Capacity	1200 Crate
Duration	3-5 days
Temperature	57°F
Air Conditioner	4-6
No. of Employees	4
Sources of raw banana	Andhra Pradesh, Bihar, Gorakhpur, Gujarat
Supply	Morna, Bhopa, , shahpur,Budhana

Table 6 : Manohar Cold Storage

Storage	Potato, Raw sugar
Capacity (potato)	40000 bag (1 bag=50kg) =2000000 kg =2000 tonne
Capacity (Raw sugar)	300000 bag (1 bag=40kg) =12000000 kg =12000 tonne

Duration	March – October
Temperature (potato) Temperature (Raw sugar)	37°F (sugar free) 44°F (sugar) 57°F
Humidity	95%
Refrigerant	Ammonia (R-717)
Power consumption	215 KVA
No of employees	18
No. of cold chamber	6
Area of cold chamber 1 Area of cold chamber 2 Area of cold chamber 3 Area of cold chamber 4 Area of cold chamber 5 Area of cold chamber 6	156x86 sq.ft 90x72 sq.ft 138x76 sq.ft 125x72 sq.ft 78x60 sq.ft 92x68 sq.ft
Total cost	1.90-2 crores
Profit	40-60 lakh
Compressor	Reciprocating type Company – kirloskar
Condenser	Vibrating type Company – kirloskar
Evaporator	Tube type Company – kirloskar

Table 7 : Arjun Cold Storage

Storage	Banana
Capacity	1000 Crate
Duration	4-5 days
Temperature	56°F
Air Conditioner	3-5
No. of Employees	3
Sources of raw banana	Andhra Pradesh, Bihar, Gorakhpur, Gujarat
Supply	Charthawal, Jansath , shahpur,Budhana

Table 8 : Tyagi Cold Storage

Storage	Potato
Capacity	100000 bag (1 bag = 50kg) =5000000kg =5000 tonne
Duration	March – October
Temperature	40 F (sugar free) 46 F(sugar)
Humidity	95%
Refrigerant	Ammonia (R-717)
Power consumption	100 KVA
No of employees	12
No of cold chamber	3
Area of cold chamber 1 Area of cold chamber 2 Area of cold chamber3	120x45 sq.ft 36x74 sq.ft 60x78 sq.ft
Total cost	50-60 lakhs/season
Profit	10-15 lakhs/season
Compressor	Reciprocating type (Company – Kirloskar)
Condenser	Vibrating type (company – Kirloskar)
Evaporator	Company –Kirloskar
Expansion valve	Company - supermany

Table 9 : Manoranzan Cold Storage

Storage	Raw sugar
Capacity	250000 bag (1 bag = 40 kg) = 10000000kg = 10000 tonne
Duration	March-October
Temperature	54°F = 12°C
Humidity	95%
Refrigerant	Ammonia (R-717)

Power consumption	150 KVA
No of employees	15
No of cold chamber	4
Area of cold chamber 1 Area of cold chamber 2 Area of cold chamber 3 Area of cold chamber 4	175x100 sq.ft 150x90 sq.ft 96x62 sq.ft 112x84 sq.ft
Total cost	1.25-1.35 crores
Profit	25-35 lakhs
Compressor	Reciprocating type (company –kirloskar)
Condenser	Vibrating type (company – kirloskar)
Evaporator	Tube type (company – kirloskar)
Expansion valve	(Company – kirloskar)

VIII. RESULTS AND DISCUSSIONS

Capacity V/S No. of Employees

The data has been collected from nine cold storage plants of Muzaffarnagar. Five cold storages named Gupta, Manohar, HM, Tyagi and Manoranzan were using the cold storage facility for storing the potatao and sugar. Cold storage plant was set up. The details of plants are given in Table 2, Table 4 and Table 6, table 8 and Table 9. It is also observed from the tables that nearly 35–40°F temperature is required for the sugar free potato and 43–46°F is required for the potato with sugar. Raw sugar is used at a temperature of 55–57°F. Ammonia as a refrigerant was used in all the cold storages and 95% relative humidity was maintained. The period used for the storage is March to October. The highest temperature was maintained by the Tyagi cold storages. The potato is in group 5 for which temperature requirement is 50°F and relative humidity 85 to 90%.

The four cold storages (Muntazir Ali, Bhusan, Arjun and Shadab) were used in for storing the bananas. The details of cold storages are given in table 1, 3, 6 and 7. It is observed from the tables that temperature for cold storage was maintained at 55°F and duration was 3-6 days. 3-4 air conditioners were used. The bananas were supplied locally. The babana is in group 2 for which temperature requirement is 55°F and relative humidity is 85 to 90%. Fig. 3 shows that there is a maximum profit for the Manohar storage and it is lowest for the Tyagi storage and it is because of the reason that Tyagi storage was maintained at a little higher temperature than other storages.

IX. CONCLUSION

From this study, following recommendations may be followed for better management of storage.

- Ammonia was used as a refrigerant for the bigger plants and more profit is earned by bigger plants.
- The ideal atmosphere for optimum storage conditions should be maintained for the different cultivars (of potatoes) grown in different soils.
- Irradiation technique that can significantly improve the storage life of commodities should be adopted.
- It is concluded that there is a scarcity of cold storages in Muzaffarnagar.
- No cold storage is available for storing the fruits and other vegetables.
- Potato, Raw sugar and bananas cold storages are the only cold storages available in Muzaffarnagar.

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