THE SUITABILITY OF A POTTERY DEVICE, JANATA REFRIGERATOR, FOR HOME STORAGE OF VEGETABLES

By

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I INTRODUCTION.

Food For The Family.

One of the chief responsibilities of the homemaker is to provide nutritious food to the family. This responsibility involves purchase, storage, preparation and service of foods, besides some amount of food production through the kitchen garden. Wise management will help the homemaker to carry out all these duties in an effective manner, with the minimum expenditure of the resources of the family.

The Importance of Proper Storage of Foods.

The proper storage of foods, particularly the perishables, such as vegetables and fruits, is an important aspect of food management, because it helps in obtaining maximum nutritive values from foods. Vegetables and fruits deteriorate rapidly if not stored under proper conditions. They lose their nutrients, especially vitamin C, if exposed to air and allowed to wilt. With a little more care in the storage of these perishables, the homemaker can improve the family diet considerably. Hence, a knowledge of good methods of storage of vegetables is essential for providing the family with nutritious food. Proper methods of storage are important from the economic standpoint as well. They reduce the wastages due to spoilage, and minimise the expenditure on shopping trips. In addition, they help to save time and energy spent on marketing. Hence, application of proper methods of storage of vegetables in the home, will ensure the procurement of maximum nutrients with the minimum expenditure of the resources of the family, such as money, time and energy. Thus there is better home management.

Need For an Inexpensive and Simple Storage Device.

Scientific studies have established the fact that refrigeration is an effective method of storage of perishables. Pentzer (1959)[1] asserts, "There is no substitute for refrigeration as a means of keeping fresh and frozen foods from losing quality". However, most of the Indian homes are not in a position to afford mechanical refrigerators.

The annual per capita income was Rs.291.50 for the year 1956-57[2], whereas the price of the mechanical refrigerator ranges from Rs.1,700/00 upwards. Even in families where the average income may permit the possession and use of the refrigerator, information about its advantages, care and maintenance is lacking, with the result that many persons are not yet convinced of its efficacy.

There is need therefore for introducing simpler and less expensive devices for storing perishables in the Indian home. The 'Janata' refrigerator is one such device made of pottery, being promoted in the rural areas by the 'Mukhya Sevikas' and 'Gram Sevikas' working in the Community Development Programmes. They claim that vegetables stored in the Janata refrigerator remain fresh for about three to four days. However, no scientific study has yet been made on the suitability and advantages of the Janata refrigerator. Hence, the present investigation was undertaken to study scientifically, the suitability, efficiency and economy of the Janata refrigerator, for storing perishable foods in Indian homes. It is hoped that the findings of the study will be of importance in promoting nutrition and better home management.

II REVIEW OF LITERATURE.

Causes of Food Spoilage.

One of the major problems that the homemaker faces in food storage, is the spoilage of foods due to various causes. A proper understanding of the nature and causes of food spoilage will help to prevent the losses due to spoilage.

Pennington and Tressler (1951)[3] state that the principal causes of food spoilage are -

(a) The growth of microorganisms, chiefly bacteria, yeasts and moulds;

(b) The action of enzymes which occur naturally in the foods;

(c) Chemical reaction, such as oxidation and hydrolysis;

and (d) Desiccation.

Spoilage of food materials may occur due to any one of these reasons, or a combination of two or three causes. Foods vary in their susceptibility to spoilage due to the above causes. For example, Frazier (1958)[4] points out that fats are more susceptible to chemical spoilage (such as oxidation and hydrolysis) than to microbial spoilage. According to Birkeland (1956)[5], the rotting of acid fruits such as orange and lemon, is largely due to the action of moulds and yeasts. Vegetables such as carrot, potato and cabbage, are non-acid, and subject to attack by bacteria and moulds. Krueger and Johansson (1959)[6] state that autolysis or spoilage due to the enzymes naturally present in them, is a more common occurrence in roots and tubers such as potatoes, carrots, beets and turnips, than in other green vegetables. Pennington and Tressler (1951)[5] remark that desiccation is often a cause of deterioration of fruits, vegetables and bakery goods, but it does not affect other types of foods.

a) Microbial Spoilage.

Halverson (1951)[7] explains that microorganisms cause spoilage by their direct action on the foods, and also indirectly by bringing about other changes such as the synthesis of toxins, that contribute to food spoilage. He further points out that the changes produced by the growth of microorganisms vary with the type or types of organisms concerned, and also with the decomposition of the foods involved.

i) Changes Involving Decomposition Due to the Direct Action of Microorganisms.

On Carbohydrates.

Halvorson (1951)[7] states that in foods which are rich in carbohydrates, bacteria will usually bring about fermentation, particularly of sugar. The different organisms break down the sugar in different ways, but in that reaction, aliphatic acids particularly lactic acid, are always produced, and carbon dioxide or a mixture of carbon dioxide, hydrogen and methane is liberated. In addition, alcohols, aldehydes and ketones are produced.

Saccharolytic organisms attack starch. They produce diastase, which is an enzyme that changes starch to sugar at first, and then the sugar to acid.

The starches are attacked also by another class of bacteria, which use starch for energy. They not only hydrolyse the starch, but also convert the hydrolysate to gum. Since sugar is thus removed from the sphere of action, acid formation is prevented. But proteolytic organisms (the action of which is inhibited in the presence of acid) begin to decompose the protein present in the food material along with the starch, giving rise to foul odours, as well as unsightly appearance. The production of ropy bread by Bacillus Mesentericus is an example of this type of change.

On Proteins.

The bacterial decomposition of proteins is due to the action of proteolytic enzymes produced by the bacteria. They cause changes that are more complex and undesirable than those that occur when carbohydrates are broken down. The end products of protein decomposition are also more varied, such as polypeptides, peptones and aminoacids. There is a further break down of amino acids. Usually, odoriferous compounds like hydrogen suphide, mercaptans, indoles, skatoles, putrescine and cadaverine are liberated. Pelczar and Reid (1958)[8] indicate that some species of the genus Clostridium, Bacillus Proteus and Bacillus Pseudomonas produce highly active proteolytic enzymes.

On Fats.

Although fats are less susceptible to microbial decomposition than carbohydrates and proteins, according to Halvorson (1951)[7], extensive changes can occur in fats also. There are many microorganisms which contain lipolytic and/or lipoxidative enzymes. The lipolytic enzymes hydrolyse the fats to free fatty acids and glycerol. The fatty acids liberated are further fermented in the same manner as in the case of carbohydrates. Aliphatic acids, aldehydes, ketones, alcohols, carbon dioxide, hydrogen and methane are produced. The lipoxidative enzymes, which are generally elaborated by moulds, bring about oxidative changes.

ii) Changes Involving Synthesis.

The microorganisms besides causing spoilage of foods by direct action as pointed out so far, also bring about other changes. Some synthesise compounds that alter the flavour, odour and colour of the foods on which they act, to an undesirable degree. For example, Pseudomonas Pyocyaneus, when it grows in milk, changes its flavour, because it produces pyocyanine. Similarly, Serratia Marcescens may produce a blood red pigment in bread.

Some bacteria, such as Clostridium Botulinum and

Staphylococcus, synthesise toxic products like botulism toxin and enterotoxin, and make the food unfit for human consumption. Even deaths due to such food poisoning will occur, if these foods are eaten.

b) Spoilage Due to Enzymes.

Spoilage of foods may occur due to the action of enzymes contained in the foods themselves. McDowall (1955)[8] defines an enzyme as "A colloidal organic catalyst". An enzyme being colloidal in nature, becomes coagulated and inactivated by heat; in other words, it is thermolabile. All plant products contain enzymes which become active when conditions are favourable. The changes caused by these enzymes are called autolytic ones.

Halvorson (1951)[7] describes the changes caused by food enzymes in the three major food constituents. Many food products contain diastatic enzymes, which can change starch to sugar. For example, when potatoes are stored at too high temperatures (above 80°F) they become sweet and soft. The proteolytic enzymes naturally occurring in milk, autolyse the casein in the milk if it is kept unheated. Such milk is considered as spoilt. Fat splitting enzymes are also present in plant and animal tissues. If the food (especially frying fats) is stored without first inactivating these enzymes by heating, the fats will be broken up into fatty acids, and the proportions of free fatty acids present in a fat will increase progressively on storage.

c) Oxidative Changes.

Oxidative changes occur usually in fatty foods, making them rancid. The first step in oxidative changes is the splitting of the fat into fatty acid and glycerol.

$(C_{17} H_{35} COO)_3 C_3 H_5 + 3 H_2 O \longrightarrow$
Stearin

$C_3 H_5 (OH)_3 + 3C_{17} H_{35} COOH$
Glycerol Stearic acid

The fatty acids undergo further disintegration, giving rise to peroxides, short chained acids, aldehydes and ketones. Concurrently there occur changes in flavour and taste, which generally make the food undesirable. According to Halvorson (1951)[7] "The rancid fats counteract or destory certain vitamins in the food. In addition, some of the by-products of oxidised fat may be toxic".

d) Desiccation.

Desiccation brings about a change in the turgor of the cells of perishables such as vegetables and fruits. Meyer (1960)[10] defines 'turgor' as the pressure of the cell-contents on the partially elastic wall of a cell, tending to produce rigidity. Under ordinary circumstances, this turgor is produced by a delicate balance of forces, which maintain the cell at a normal volume, and yet allow the exchange of substances. When there is a decrease in the volume of water in the cell during desiccation, the cell becomes soft and flabby. The vegetable becomes wilted and shrivelled.

Principles of Storage of Vegetables.

A knowledge of proper storage conditions is essential for minimising the deterioration of vegetables during storage. Watt and Leung (1959)[11] classify losses of nutrients which occur during storage of foods after harvest into two kinds - (1) the obvious physical loss that occurs when edible parts like the outer leaves of plants are removed, and (2) the chemical loss which follows the change in the structure of plant, because of the continuation of cell respiration and activity of enzymes. The texture and vitamin content of perishable foods deteriorate rapidly, especially if the temperature around them is not suitable for maintaining them in good condition.

Therefore these perishables need to be stored with care, to reduce the chemical loss. Work and Carew (1955)[12] list four conditions which need to be controlled for ensuring proper storage - (a) quality of produce; (b) temperature; (c) humidity, and (d) composition of the atmosphere.

a) Quality of Produce.

Successful storage depends on the quality of the vegetables to start with. The vegetables to be stored should be free from injuries - mechanical, and those due to insects or diseases. Beach and Tussing (1931)[13] point out that the stage of maturity is an important factor in storage. Root crops such as beets, carrots and turnips should not be allowed to mature fully before harvest, as they tend to get woody upon subsequent maturity in storage. On the other hand, cabbage, onion and pumpkin, should be allowed to mature properly before they are harvested. Unless they are mature to start with, they will not keep well even under the best of storage conditions.

b) Temperature.

The temperature at which vegetables are stored has a great influence on the chemical changes occurring in them, the action of microorganisms that may be present, and the loss of water from the cells. Therefore, vegetables have to be stored at optimum storage temperatures. The optimum storage temperatures required for the different vegetables vary. Pennington and Tressler (1951)[3] cite that some fruits and vegetables, such as banana, lemon, cucumber, tomato and potato, decay faster if they are held too long at even moderately low temperature.

It is very essential that the optimum temperature required by each food material is maintained constant during storage. The temperature of the place where vegetables are stored will rise due to the metabolic activities of the foods, as during the metabolic processes, heat is evolved by the plants, and carbon dioxide is liberated. Sinnott and Wilson (1955)[14] explain the production of heat during respiration as follows:- "Through the addition of oxygen, glucose is broken down into carbon dioxide and water, as shown by the reaction:-

$$C_6 H_{12} O_6 + 6 O_2 \longrightarrow 6 C O_2 + 6 H_2 O + \text{Heat.}$$

This, when expressed in terms of grams, means:

180 grams of sugar + 192 grams of oxygen $\longrightarrow$

264 grams of carbon dioxide + 108 grams of water + 674 calories of energy.

The quantity of heat evolved during metabolism by different plant products varies considerably. Prescott and Proctor (1937)[15] point out that Bartlett pears and cherries which have high respiration rates, require to be stored at lower temperatures than others, such as potatoes, apples and onions, which are comparatively low heat producers.

Wright, Rose and Whiteman (1954)[16] also point out the importance of maintaining constant temperatures in storage rooms. Variations in the storage temperature affect the quality of the vegetables. Potatoes are likely to begin to sprout if the temperature is too high, and usually becomes undesirably sweet if too low.

In addition, there is always the possibility that fluctuations in temperature will cause condensation of moisture on stored products. This is undesirable, because moisture favours the growth of mould and the development of decay.

i) Effect of Temperature on Chemical Changes.

High temperatures increase the rate of respiration and other chemical changes in food products. According to Vant Hoff's law (as quoted by Work and Carew (1955)[12]) "For every 10°C (18°F)rise in temperature, the rate of chemical reaction is approximately doubled". Pentzer (1959)[1] points out therefore that warm temperatures cause losses of vitamins. Among the vitamins, vitamin C is more easily destroyed by heat, than others. Most perishables lose their ascorbic acid (vitamin C) even at room temperature. Sweetman and Mackellar (1954)[18] state that the more perishable type of vegetables such as fresh spinach, lettuce, green peas, green corn, broccoli, cauliflower and green bananas, lose their anti-scorbutic value rapidly at room temperature. Spinach, when stored after harvest for three days, loses about half of its ascorbic acid, and all in seven days. Therefore, the loss of vitamin C in foods may be taken as an indication of spoilage.

ii) Effect of Temperature on Bacterial Action.

The control of storage temperature is necessary to restrict the action of microorganisms. According to Pennington and Tressler (1951)[3] spoilage by microorganisms is more likely to take place at high temperatures than at low ones, because bacteria, yeasts and moulds, grow less rapidly at high temperatures than at low temperatures.

iii) Effect of Temperature on Loss of Water.

Stearns (1956)[18] explains that the rate of evaporation of a liquid is accelerated at high temperatures. When the temperature is high, the molecules of the liquid which are in constant motion, move at a higher average speed and escape into the space above the liquid, and change into the vapour state more readily. Hence, the process of evaporation is speeded up at high temperatures. Therefore, when the temperature in the storage place is high, there is a greater loss of water from the cells of the vegetables.

The rising temperature also increases the capacity of air for holding water vapour. Therefore, if the temperature in the storage place fluctuates, increased evaporation of moisture will take place at high temperatures, and condensation at lower temperatures. In both cases, a great loss of water from the vegetables will result, leading to their shrivelling.

iv) Effect of Temperature on Flavour.

When after harvest, plant products are stored, the constructive synthetic process of carbohydrate formation in the product ceases, but due to the metabolic activities, the carbohydrates contained in them undergo changes. The temperature at which they are stored affects the transformation of carbohydrates, and consequently the flavour.

Sweetman and Mackellar (1954)[17] state that when vegetables containing a substantial amount of sugar, such as sweet corn, peas and asparagus are picked, photosynthesis, viz., the production of new carbohydrate is stopped. Part of the sugars present in them are also consumed in respiration, and part changed to other substances, particularly starch in corn and peas, and cellwall materials in asparagus.

Studies by Platenius (1939)[18] on the effect of increase in storage temperature on the sugar content of peas and corn show, that in general, loss of sugar is accelerated at higher temperature. When the loss reaches 30 per cent, sweetness decreases considerably, and the flavour is affected.

e) Humidity.

The humidity of the storage place is another important condition to be controlled. If the humidity is too low, wilting is likely to occur in most fruits and green leafy vegetables; if it is too high, it favours the development of decay. Leafy green vegetables which contain large amounts of moisture, need to be stored in places where the relative humidity is high. Otherwise, they rapidly lose their moisture and weight, deteriorate in texture, and become shrivelled.

d) Composition of the Atmosphere.

When there is a sufficient amount of oxygen in the storage place, aerobic respiration occurs in the plant products. The hexose sugars glucose and fructose, are oxidised completely to carbon dioxide and water. When the oxygen present in the storage atmosphere is not adequate, anaerobic respiration occurs. Fritsh and Salisbury (1955)[20] explain that during such anaerobic respiration, ethyl alcohol accumulates in the tissues, and causes 'off flavours.' The reaction may be expressed thus:-

$$C_6 H_{12} O_6 \longrightarrow 2\, C_2 H_5 OH + 2\, C O_2 + 26 \text{ Calories.}$$

According to Prescott and Proctor (1937)[16], an excess of carbon dioxide evolved during respiration produces 'brown hearts'* in apples. If there is proper circulation of air in the storage place, the accumulation of carbon dioxide is prevented.

Low Temperature Storage of Foods.

As low temperature is one of the conditions favourable for the storage of perishables, the use of low temperatures for the storage of food, its

* Chandler (1957)[21] explains that 'brown heart' is a name given to an internal breaking down of fruit, caused by injurious accumulation of carbon dioxide in the store room.

effect on the causative factors of food spoilage, and the different types of low temperature storage are reviewed here.

a) Use of Low Temperatures for the Storage of Food From Ancient Days.

Prescott and Proctor (1937)[15] point out that the storage and preservation of foods by the use of low temperatures have been recognised and appreciated by man for many centuries. In the very early days, men utilised natural resources such as wells, springs, streams and caves to keep food articles cool. Swank (1943)[22] while describing how the people in the past kept foods fresh, cool and sweet in the spring houses, says, "The small stone-house nestled low against a hill and there was a little stream of cool, clear water, seeping from the side of the hill, down to the spring-house below. Inside this house, the water ran along a shallow trough of wood or stone. And right there in the middle of the stream stood flat stoneware crocks and jugs, copper pans and tin pails, filled with milk and cream, lard and pats of yellow butter".

Lansing (1949)[23] also has shown that "On the island of Crete, in the Mediterranean Sea, there are ruins of an ancient palace dating from 1500 to 2000 B.C., with cool underground galleries, where are found, great earthenware jars. Food was stored in them and sealed from the air".

In the same manner, as the inhabitants of the Western countries, the people of the East also utilised nature's refrigerants such as ice and snow as cooling agents. Walley (1960)[24] refers to the fact that even before 1000 B.C. the Chinese used ice cellars. Davis and Sharpe (1947)[25] cite that "Alexander the Great had his serfs carry snow from the mountains and place it in deep trenches filled with hundreds of kegs of wine to keep them cool". Swank (1943)[20] points out that when Marco Polo returned from his famous travels in the East in 1295, he brought back reports of the use of ice for chilling. Peet and Thye (1955)[26] remark that "Nero, the Roman Emperor forced innumerable slaves to bring ice and snow from the higher mountains in Italy. This snow, placed in pits, insulated with sod and straw, was used in cooling wines, fruits and fish for his elaborate banquets."

Crowther (1955)[27] refers to the use of ice by the Britains in the eighteenth century, to store food, as can be seen from the following excerpt:- "Attached to many old mansions in England is an ice store. This consists of a thick-walled underground or semi-underground building generally located in a wood, and thickly thatched to keep out the warmth of the sun. Blocks of ice were cut during the winter frost, and stored in the underground building to be used during summer".

Crowther(1955)[27] further states that in the south of France, much ice from the glacier quarries of the Alps was used for preserving food.

Thus from the literature available, it is evident that snow and ice have been in use as cooling agents for storing foods at low temperatures in many parts of the world from ancient days.

b) Effect of Low Temperature on the Causative Factors of Food Spoilage.

Frazier (1958)[4] points out that when food articles are stored at low temperatures, the rate at which they deteriorate is reduced, because low temperatures retard spoilages due to the action of microorganisms, enzymes, chemical changes and desiccation.

(i) Effect of Low Temperature on Microorganisms

Prescott and Proctor (1937)[15] explain that cold affects microorganisms in two ways - it retards their growth, and restricts food supply.

Retardation of Growth.

Krueger and Johansson (1959)[6] have enumerated the factors which have an effect upon the growth and development of microorganisms as food supply, oxygen tension, moisture, temperature, hydrogen-ion concentration, oxidation-reduction potential, surface tension, osmotic pressure and light. Of these, temperature plays an important role. If the temperature is not favourable, the microorganisms stop growing or multiplying, and if the unfavourable condition continues, they die.

Based upon the temperature requirements, the micro-organisms are classified into three different groups - thermophiles, mesophiles and psychrophiles. The 'thermophilic' organisms grew best at temperatures above 40°C. Many of these will grow very well at temperatures around 65°C. The optimum temperature range for the growth of 'mesophilic' organisms is from 20°C to 40°C and these generally do not grow at temperatures above 40°C or below 10°C. The 'psychrophilic' organisms grow best at low temperatures, viz., below 15°C. According to Halverson (1951)[7] all the three types are concerned in food spoilage. Prescott and Proctor (1937)[15] are of the view, that organisms which can carry on their activities within the temperature limits of approximately 10°C to 38°C play the most important part in the commonly known types of food spoilage. Hence storage of foods at temperatures lower than 10°C restricts the growth of microorganisms in them.

Restriction of Food Supply.

Microorganisms require a moist environment for their normal metabolic activities. Their food materials must be in a liquid form in order to permeate their cell walls or membranes. If storage temperatures are sufficiently low, part of the water in the food articles will crystallize, leaving the constituents of the food concentrated in the remaining water left in the liquid state. The organisms may make use of them for some time. However, eventually the low concentration of water and the consequent high concentration of other materials in solution or colloidal suspension, will restrict the normal processes of microorganisms and retard their growth.

ii) Effect of Low Temperature on Enzymes.

Environment influences enzymes in about the same way as it does bacteria. Therefore, cold inhibits the action of enzymes also. Each enzyme has an 'optimum temperature' and a 'thermal inactivation point'. Referring to their activities, Mitchell (1950)[28] writes, "An enzyme - catalysed reaction tends to be increased in rate by the rise in temperatures as in any chemical reaction. At abnormally low temperatures, the effect of the enzyme is generally retarded. It practically disappears at 0°C and becomes nil when the enzyme is in a frozen condition. Therefore, the autolytic changes due to the action of enzymes are retarded by low temperatures. Pennington and Tressler (1951)[3] mention that most enzymes are still active at 0°C but the rate at which they act at 0°C is far below the rate at 20°C.

iii) Effect of Low Temperature on Chemical Changes.

Halvorson (1951)[7] indicates that oxidation and hydrolysis being chemical reactions, occur relatively slowly at cool storage temperatures.

iv) Effect of Low Temperature on Desiccation.

Water evaporates less slowly at low temperatures than at high temperatures. Consequently, the rate of food spoilage due to desiccation is markedly reduced when foods are stored at low temperatures.

e) Types of Low Temperature Storage.

According to Frasier (1958)[4] there are three different types of low temperature storage - (i) Common or cellar storage; (ii) Chilling, and (iii) Cold storage or freezing.

(i) Common or Cellar Storage.

From olden days the method of cellar storage is being used by farmers. They store their produce after harvest in cool outdoor storage cellars or underground cellars. In this type of 'common' or 'cellar' storage, the temperature is seldom lower than 15°C (60°F). The deterioration due to enzyme action and microorganisms is not prevented, but is reduced than that at atmospheric temperatures. Root crops, potatoes, cabbage, celery and apples can be stored in this way for limited periods.

(ii) Chilling.

Chilling is storage at temperature above freezing, but below the 'common' storage. Sweetman and Mackellar (1954)[17] mention that chilling may be produced by three methods - the so called ice-less refrigeration (cooling effected by the evaporation of water); ice-refrigeration, (making use of the latent heat of fusion of ice) and mechanical refrigeration (employing the latent heat of vaporization of liquids).

Frazier (1958)[4] writes that in ice-refrigeration, the temperature varies from 4.4°C to 12.8°C (40°F to 55°F) depending upon the amount of ice, its rate of melting, the amount of food, and the ice box used. Usually the temperature in the household (mechanical) refrigerator varies from 0°C to 10°C (32°F to 50°F). Most perishable foods including eggs, dairy produce, meats, sea foods, vegetables and fruits may be held in chilling storage for a limited time with little changes from the original conditions. In this type of storage, although the enzymatic and microbial changes in the food are not altogether prevented, they are reduced considerably.

iii) Freezing.

In freezing, food articles are stored at temperatures ranging below 10°F and the microbial growth is arrested entirely. Usually the foods are scalded or blanched before freezing to inactivate the action of enzymes. When such processed foods are frozen, tissue autolysis is stopped completely.

There are two main types of freezing - 'quick freezing' and 'slow freezing'. Carpenter (1961)[29] states that in quick freezing, the food article is frozen for 30 minutes or less at temperatures ranging from 0°F to -30°F (-18°C to -34°C). Slow freezing requires three to seventy-two hours and the temperature varies downward from 5°F (-15°C). Slow freezing produces large crystals of ice, which rupture cell walls and cause extensive 'drip' or loss of fluid upon thawing, whereas quick freezing produces smaller ice crystals and less damage to the food tissues.

Freezing is being increasingly employed in the west to store meat, fish and fish products.

Principles of Refrigeration.

As the present study is related to refrigeration, the basic principles of refrigeration are reviewed briefly in these pages.

Owens (1951)[30] defines 'refrigeration' as the "Science of producing temperatures below that of the surrounding atmosphere". Refrigeration makes use of two basic principles to produce low temperatures. As Haustrath and Harms (1951)[31] state, the first one is the flow of heat energy from a higher level to a lower level. The second is the absorption of heat when matter changes state.

Flow of Heat Energy From a Higher Level to a Lower Level.

Walley (1960)[24] explains that if two bodies at different temperatures are placed within an enclosed space, heat is transferred by radiation from one to another, until the two temperatures are equal. In the ice refrigerator, the heat removed from any substance placed inside it, is absorbed by the ice to change into water. In the mechanical refrigerator, heat is absorbed by the evaporator, which is kept at a lower temperature as described on page 26.

<u>Absorption of Heat During Change of State.</u>

Matter exists in three physical states - the solid, liquid and gaseous states. Energy is required to bring about a change in the state of matter. The body that is changing state, derives the energy required, in the form of heat by absorbing it from the space or other bodies nearby. The heat absorbed by a solid while melting to the liquid state, is known as the latent heat of fusion; and the heat absorbed by a liquid while changing to the gaseous state, is called the latent heat of vaporization. As during these processes of melting or vaporization, the body that is changing state absorbs heat from the immediate space or bodies, the space or neighbouring bodies are cooled.

The amount of heat absorbed when vaporization takes place is larger than that absorbed when melting occurs. One gram of water absorbs 540 calories of heat while changing from the liquid to the gaseous state at 100°C (212°F), whereas one gram of ice at 0°C absorbs only 80 calories of heat while changing to water. Thus vaporization of water is more than six times as efficient as melting of ice in producing cooling.

Hence, in modern refrigeration, the principle of vaporization is made use of, to produce low temperature in an area. The substance that is employed to absorb heat from the area is known as the refrigerant. It is always a gas to start with, and liquified under high pressure. The liquid is then allowed to vaporize. Some commonly used refrigerants are ammonia, sulphur dioxide, methylene chloride, dichlorofluoro methane, dichlorotetra fluoroethane and methyl formate.

Types of Refrigerators.

The various types of refrigerators in use may be grouped as follows:- (a) Mechanical refrigerators; (b) Ice refrigerators and (c) Iceless refrigerators.

a) Mechanical refrigerators.

Modern refrigerators have machinery to speed up the heat-absorbing process and therefore are designated 'mechanical refrigerators'. There are three different kinds of mechanical refrigerating systems:- (i) Compression; (ii) Absorption and (iii) Air system.

i) Compression System.

Haustrath and Harms (1951)[31] describe that in the compression system, the cooling mechanism consists chiefly of three distinct parts; a compressor, a condensor and an evaporator, as shown in Figure 1. The compressor compresses the refrigerating gas and delivers it to the coils of the condensor. The gas which becomes heated due to compression is cooled by means of a radiator. When the blades of the fan of the radiator rotate, the heat from the hot refrigerant is given off to the air. As the refrigerant cools, it changes to a liquid. This liquid is conducted to the evaporator through an expansion or reducing valve. Since the pressure is reduced, the gas expands and evaporates. In doing so, it absorbs heat from

COMPRESSION TYPE OF MECHANICAL REFRIGERATION

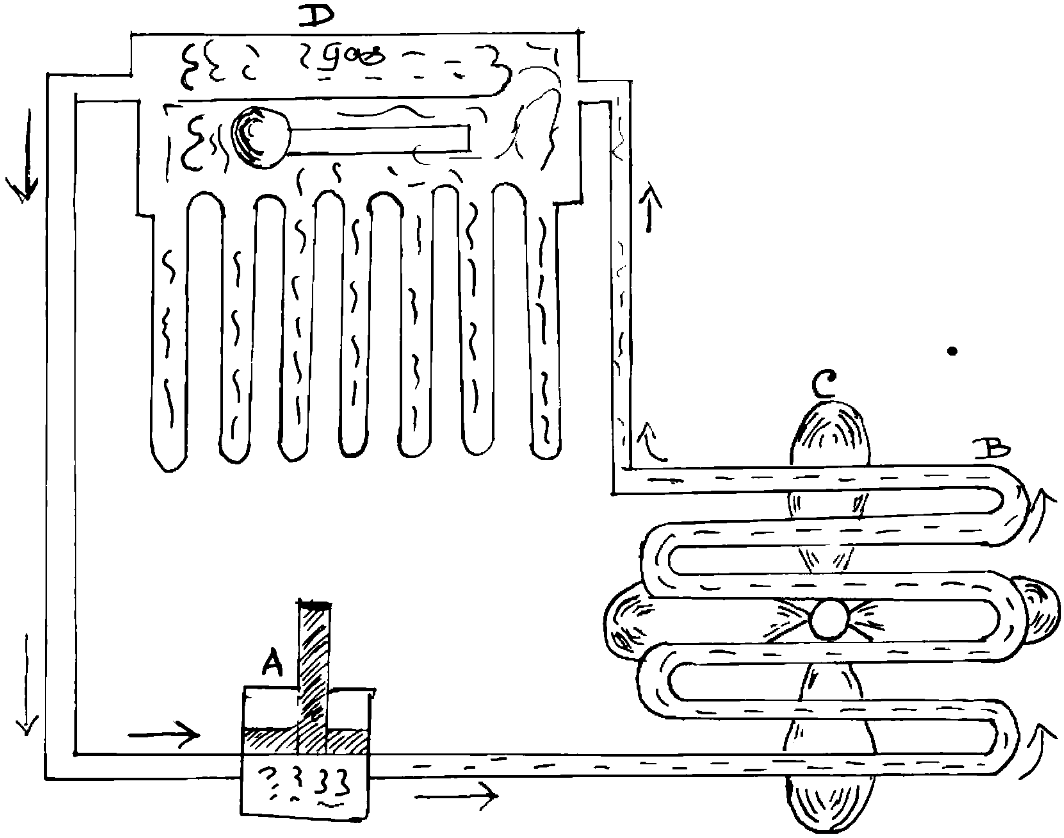


FIGURE 1

A. compressor C fan
B condensor D evaporator.

the surroundings. Thus, the evaporator is the actual cooling element of the refrigerator, and is placed inside the food compartment. After the gas has expanded in the evaporator, it is conducted back to the compressor and once again compressed, and the process is repeated continuously. Thus the system consists of repeated cycles of compression, condensation, expansion and evaporation.

ii) Absorption System.

Absorption refrigerating machines are heat-operated. Instead of a compressor, heat is used to compress the refrigerating gas, whih is usually ammonia. After condensation and evaporation, the gas is led into an absorber which contains a weak solution of the refrigerant. This weak solution absorbs the gas and becomes concentrated. The strong solution is then heated and thus the process continues.

iii) Air System.

In the air system, air is compressed to a high pressure by the compressor. It is then cooled by passing through coils over which cold water is run. The cooled, compressed air drives an air engine, and as it drives the engine, it expands and becomes very cold. The cold or refrigerated air is piped off for use in the refrigerating room.

b) Ice Refrigerators.

In the ice refrigerator, cooling is produced when ice melts. As Peet and Thye (1955)[26] point out, when food at room temperature is placed within the ice refrigerator, the warmth it contains, passes into the surrounding air which circulates towards the ice and then across the surface, melting the ice cake. As the ice melts, heat is absorbed and the air is cooled.

According to Peet and Thye (1955)[25], ice refrigerators of five to six cubic feet content, have a shelf area of about 10 square feet and an ice capacity of 75 to 100 pounds, with a re-icing capacity of approximately 50 pounds. Re-icing is necessary every four or five days on an average.

e) Iceless Refrigerators.

The United States Department of Agriculture (1958)[32] has evolved a simple type of iceless refrigerator as shown in Figure 2. It consists of a wooden cupboard, the sides of which are closed with screen wire. It is fitted with a cover of coarse cloth. The cupboard stands in a pan of water, into which the bottom of the cloth cover extends. Another pan filled with water is placed on the top of the cupboard. Four wicks sewed to the upper part of the cover dip into the pan on top.

The operation of this iceless refrigerator is simple. It is made to stand in a cool place, where there is good circulation of air in order to fadlitate the evaporation of water. This is because the circulating air carries away the water vapour that has formed during evaporation. Earle (1956)[33] explains that "if the evaporated molecules are allowed to remain near the surface, some of them in

ICELESS REFRIGERATOR

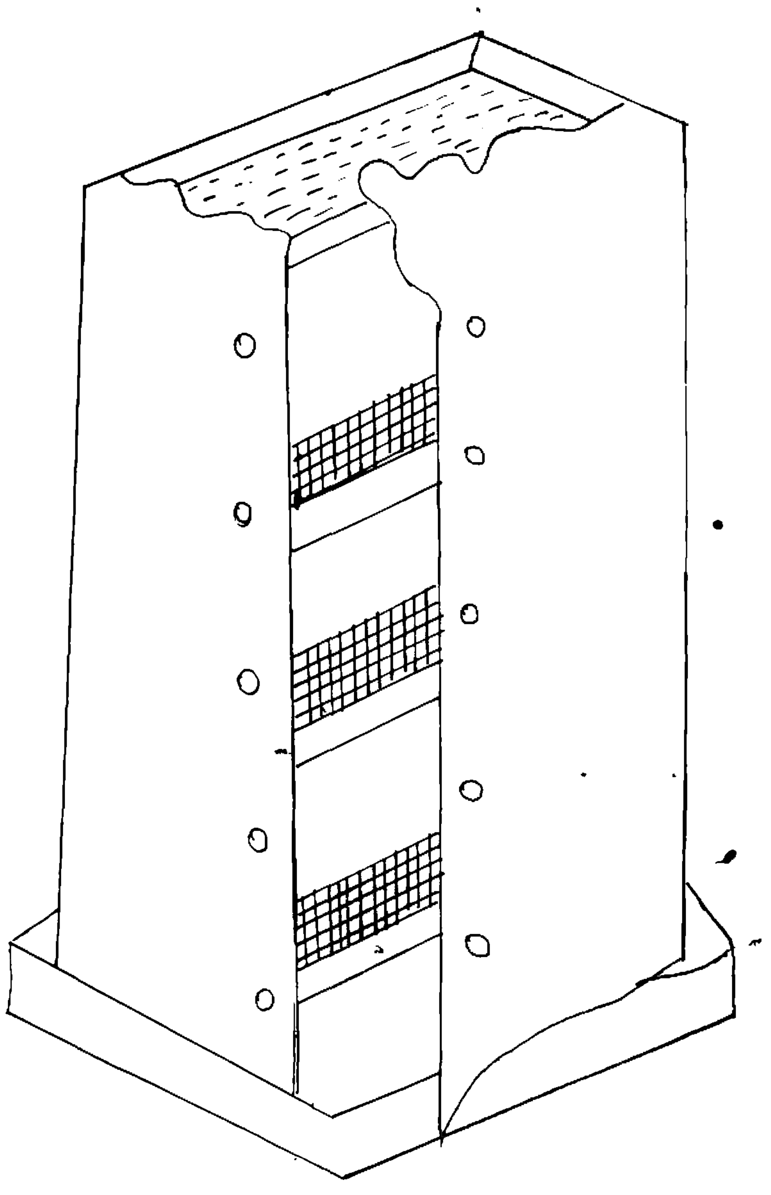


FIGURE 2

their random motions, strike the surface and are returned to the liquid state. Such backward transitions decrease the net rate of evaporation". The circulation of air avoids this return and consequently allows more rapid evaporation.

Whitman (1959)[34] points out that as the cooling effect is due entirely to evaporation, dry air and wind increase the efficiency. It is of little value in moist and stagnant air.

The Janata Refrigerator.

The Janata refrigerator, also known as the poor-man's refrigerator, is another type of iceless refrigerator. The origin of the name is not known. Perhaps the name has come into vogue, because the equipment is simple and inexpensive and hence can be afforded by the ordinary people.

The Janata refrigerator also works on the principle of the cooling effect produced by the evaporation of water. It consists of an outer earthenware trough for holding the water. The food articles which are to be kept cool, are placed inside an inner vessel. As the water in the outer trough evaporates, the temperature inside the inner vessel is lowered and the contents are thus kept at a temperature lower than that of the surrounding air. The equipment should be placed in a cool place, where there is good air circulation to facilitate rapid evaporation of water.

Some Types of Janata Refrigerators.

a) Usilampatty Janata Refrigerator.

The Pottery Training cum Production Centre at Usilampatty (1961)[35] produce out of red clay, three different sizes of Janata refrigerators, priced Rupees one, two and five respectively.

The Usilampatty Janata refrigerator consists of an outer vessel with a detachable perforated lid. There is another smaller vessel which is placed inside the outer vessel, shown in Figure 3. Water is poured inside the outer vessel through the water inlet on one side. Vegetables are placed in the inner vessel. As the water in the outer vessel evaporates slowly, the vegetables are kept cool.

The Block Development Officer at Usilampatty reported that this device is popular among flower vendors for keeping their flowers fresh, and the middle class families use this refrigerator for storing vegetables. It is not yet popular in the villages round about Usilampatty, because the villagers do not have adequate resources to purchase large quantities of vegetables necessitating storage.

b) T.Kallupatti Type.

Another type of Janata refrigerator is made at the Gandhi Niketan Ashram, T.Kallupatti, Madurai District. It is more or less similar to the Usilampatty type. There is a slight difference in the shape of the lid

USILAMPATTY JANATA REFRIGERATOR.

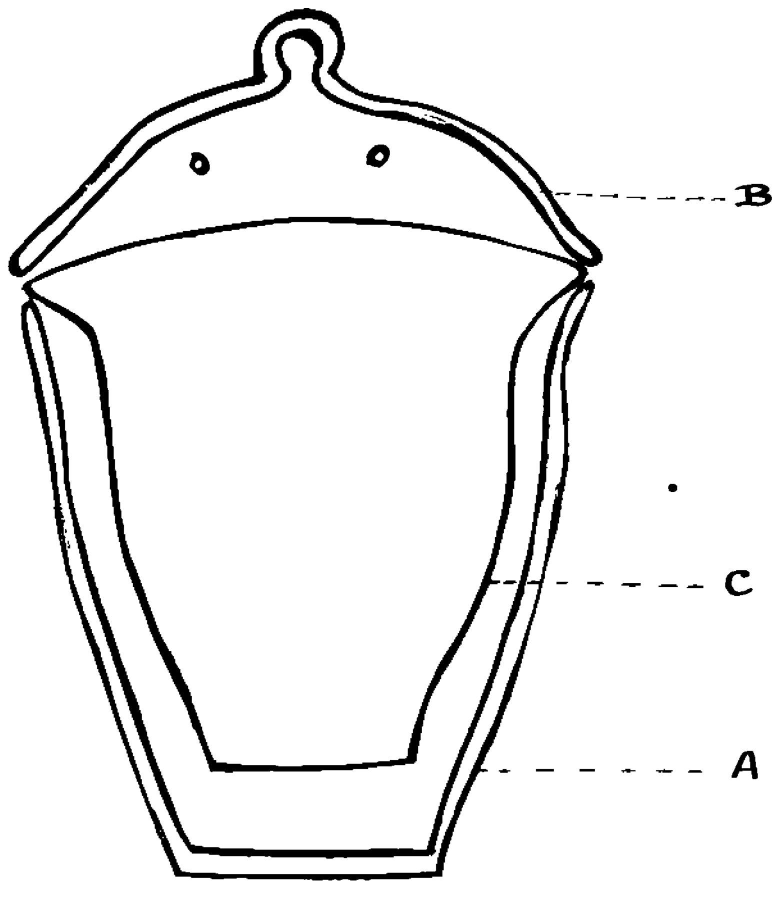


FIGURE-3

A-Outer Vessel B-Lid

C-inner vessel

T. Kallupatti Janata Refrigerator

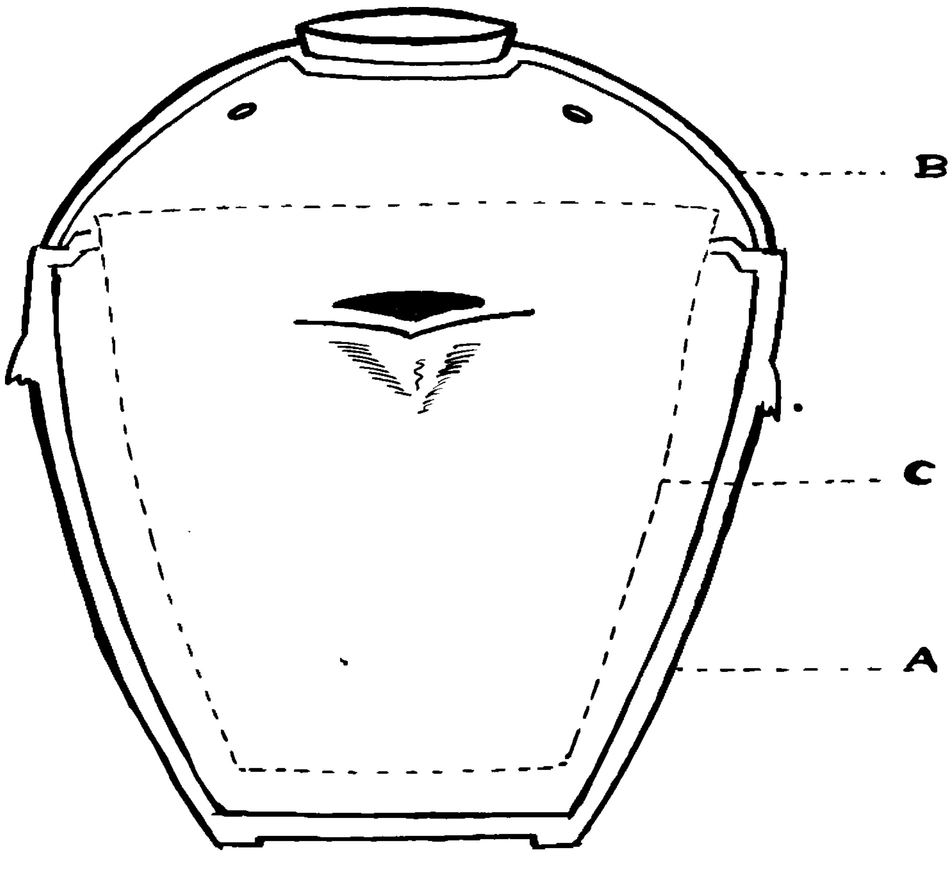


FIGURE-4

A - Outer Vessel B. lid

C - Inner Vessel

and the outer vessel, as illustrated in Figure 4.

e) <u>Shahpur Type.</u>

Figure 5 shows the Shahpur type of Janata refrigerator described by Nagori[36]. It consists of an earthen tub 1'-5" in diameter and 8" high. A small clay stand 6" in diameter and 2" high with a few holes on its surface is placed in the centre of the tub. This stand serves as the base for the wire cage, which holds articles for storage. There is another earthenware cylinder 1'-2" in height and 1'-2" in diameter, which is placed in the tub. The cylinder has a detachable dome-shaped lid with a central knob for lifting it. Around the knob there are eight or ten holes ⅛" in diameter. The foods to be stored are kept in a specially prepared wire cage 1' in diameter with two shelves, upper and lower, supported on a central rod. The wire cage is knit loosely in order to avoid creating air partitions within the cylinder as otherwise dampness may result. The inner cylinder is provided with a khadi petticoat having eight to ten vertically stitched lamp wicks and ¼" in width. These are so stitched that their ends at the bottom remain loose and free. The dome-shaped lid has a fine cloth cover.

The entire device is mounted on a tripod stand and kept in a cool, breezy spot of the house. The earthen tub is filled with water to a depth of about ⅛" (about ⅛" lower than the top of the central base). Periodical

SHAHPUR JANATA REFRIGERATOR

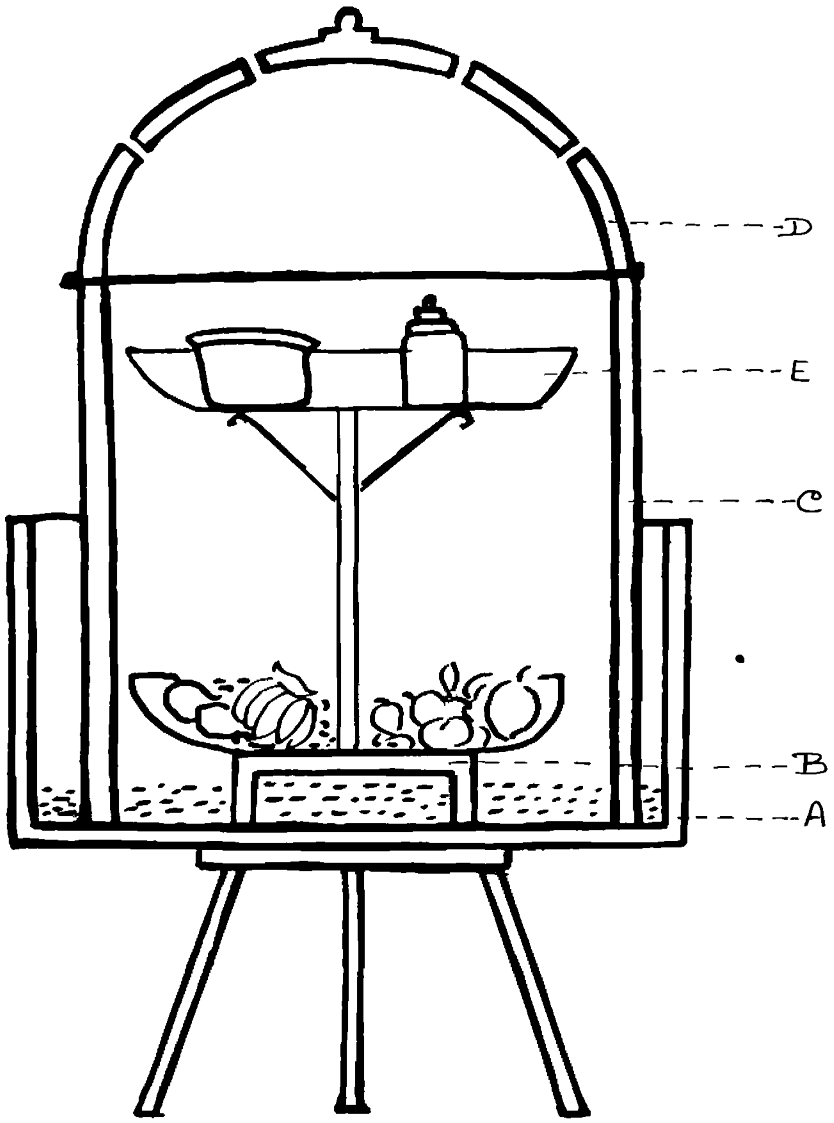


FIGURE 5

A. earthen tub C. earthenware cylinder
B. clay stand D. dome shaped lid
E. wire-cage

sprinkling of water on the cloth cover is necessary.

Report of Experiments Carried Out at Sarvodaya Ashram, Shahpur.

Nagori[36] gives a short report of the experiments carried out at Sarvodaya Ashram, Shahpur, with their Janata refrigerator. The experiments were conducted during the month of February and the first week of March. Vegetables like tomato and brinjals remained fresh for almost a week. Green coriander kept fresh for more than a week. An experiment with milk showed that it could remain in good condition for 36 hours. In a subsequent experiment on a very warm day in the last week of March, milk remained in good condition for nearly 27 hours. 'Neera' drink, which would ordinarily ferment within three hours, remained fresh and unfermented even after sunset, when kept in the refrigerator from early morning.

The porosity of the cylinder enhances its evaporating capacity. The porosity depends upon the composition of the material with which the cylinder is made. Hence with a view to increase the porosity of the cylinder, the Saurashtra Khadi Gramodyog Board added fibrous materials to the clay. These fibrous materials got burnt while the cylinder was baked, thus making the latter more porous.

d) Saurashtra Type.

This is slightly different from the types mentioned above. It is described in detail on page 44.

e) Home Science Wing Type.

Villagers are reluctant and are not in a position to buy a new equipment even when the cost may be within Rupees Five. Therefore, they need to be given guidance to make use of what they have in their houses and improvise a device for cold storage of foods. Therefore, the Home Science Wings training 'Gram Sevikas', are advocating an adaptation of the Janata refrigerator.

According to Puri (1961)[37] the type advocated by the Home Science Wings is simple and easy to construct. The articles needed are available in the village, namely, (1) a newly baked porous clay basin (size depending upon the needs of the family); (2) two shallow loosely knit bamboo baskets in the form of plates that can just fit into the basin; (3) a piece of old gunny; (4) a few bricks, and (5) rough sand (river), some mud and water.

First, a suitable place, as far away as possible from the chula (fire place) is selected to construct the Janata refrigerator. The clay basin is placed in the centre of that spot and one foot square of space is marked around it. A small brick wall about 1' high is built along the marking. This wall is smeared with a mud mixture, prepared by mixing clay steeped in water overnight, a little hay, and cow dung.

When the wall has dried thoroughly, the space enclosed by it is filled with coarse sand to about a fourth of the height of the wall. Then the clay basin is placed in the centre of the square and the remaining space is filled with more sand, so that the square is almost half full. Wateris sprinkled all over the basin and the sand, so that they are moderately wet. The water evaporates in course of time, making the inside of the basin cool. The moisture should be maintained constant.

One of the baskets is placed in the basin and the vegetables are placed in it. They are then covered with the other basket, over which is placed a wet gunny cloth, as depicted in Figure 6.

Thus, many types of Janata refrigerators have been developed. The Janata refrigerator seems to be an inexpensive and simple storage device for storing vegetables in the home. Therefore, an attempt was made to study the suitability of the Janata refrigerator for use in the Indian homes, with regard to efficiency, convenience and economy.

JANATA REFRIGERATOR – HOME SCIENCE WING TYPE

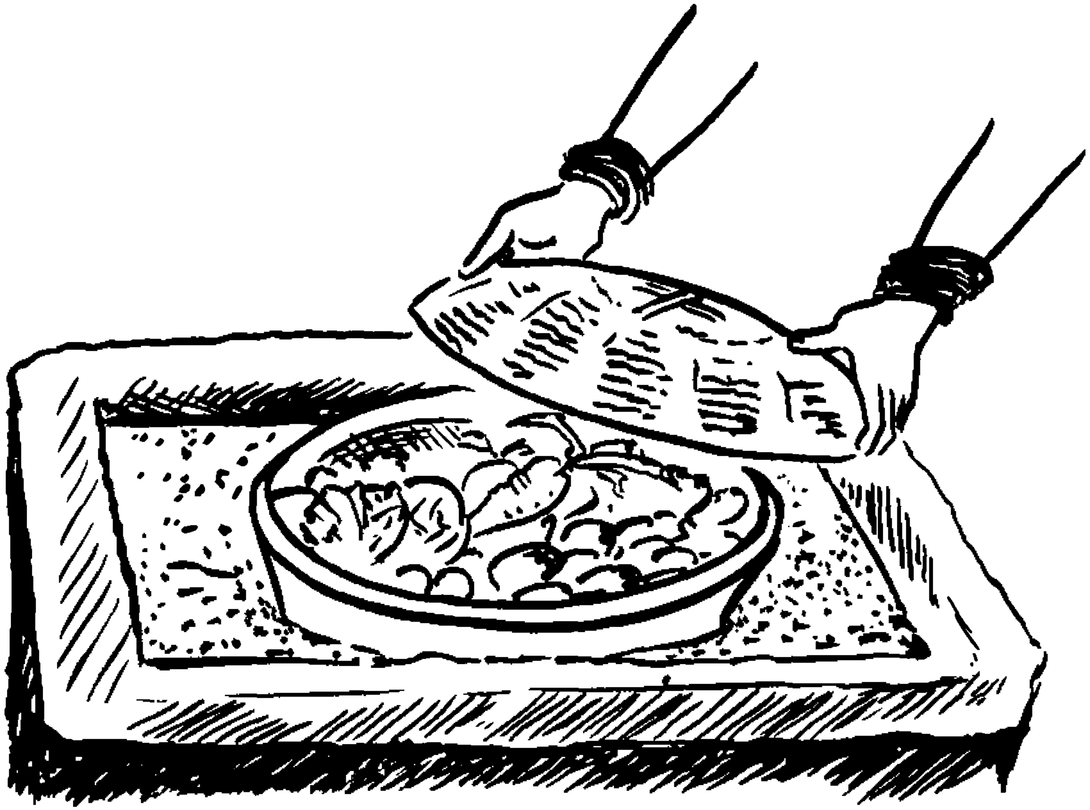


FIGURE - 6

III. EXPERIMENTAL PROCEDURE.

The value of any household equipment should be judged by three aspects from the management point of view. The equipment should give the maximum value with the minimum expenditure of resources such as time, energy and money. Accordingly, a good storage device should fulfil the following criteria:-

(a) Efficiency - The equipment should keep the stored articles in good condition;

(b) Convenience - The equipment should be convenient and easy to handle

and (c) Economy with reference to the initial cost and the cost of operation. In addition, there should be considerable saving in the expenditure on marketing trips by the use of the device.

Selection of Equipment.

These criteria were used in this study to judge the suitability of the Janata refrigerator for home storage of vegetables. As it was necessary to judge the pottery device against other storage devices used in our households, an attempt was first made to find out the common storage devices used by a selected group of families in Coimbatore city.

The population studied was the households of the 281 non-residential students of the Sri Avinashilingam Home Science College, since the students were easily accessible. The sample was chosen by selecting 100 households at random from the population. A form for collecting information on household practices regarding storage of vegetables, shown in Table I. was administered to the 100 households.

TABLE I.

FORM FOR COLLECTING INFORMATION ON HOUSEHOLD PRACTICES REGARDING STORAGE OF VEGETABLES.

(Issued to the non-resident students of Sri Avinashilingam Home Science College).

Name. Address.

Class. Monthly income of father or guardian.

Storage Method.	Vegetables Stored.
Cane basket (flat).	
Cane basket (tall).	
Wire basket.	
Vessel.	
Vessel covered with wet cloth.	
Cane basket covered with wet cloth.	
Earthenware.	
Wrapped in wet cloth.	
Keeping immersed in water.	
Open shelf.	
Cupboard with wiremesh doors.	
Janata refrigerator.	
Mechanical (electric) refrigerator.	
Keeping buried in sand.	

From the 80 forms filled and returned it was found that as many as fifteen devices were used in these households for the storage of vegetables. Table II shows the details.

TABLE II.

HOUSEHOLD DEVICES FOR STORAGE OF VEGETABLES.
(Total No. of Households=80)

S.No.	Storage device used.	No. of house-holds.	Percent.
1	Flat cane basket.	59	73.8
2	Tall cane basket.	49	61.3
3	Wire basket.	48	60.0
4	Cupboard with wiremeshed doors.	40	50.0
5	Open shelves.	35	43.8
6	Utensils.	35	43.8
7	Utensils covered with wet cloth.	31	38.8
8	Cane basket covered with wet cloth.	22	27.5
9	Earthenware.	16	20.0
10	Mechanical refrigerator.	5	6.3
11	Wooden box.	2	2.5
12	Janata refrigerator.	1	1.25
13	Cupboard with ordinary doors.	1	1.25
14	Floor in a ventilated area.	1	1.25
15	Floor with frequent sprinkling of water.	1	1.25

From Table II, it can be seen that storing in cane baskets is the most widely prevalent method, 73.8 per cent of households employing it. The devices which were next in the order of popularity were wire baskets, cupboard with wiremeshed doors, open shelves and utensils. Very few households, viz., only five used the mechanical refrigerator.

Out of these, the investigator chose a cupboard with wire-meshed doors and the mechanical refrigerator as the storage devices against which the performance of the Janata refrigerator of the Saurashtra type would be compared. The former was chosen because the cost is reasonable and it is hygienic, the latter because it is the most effective of the modern equipment for storing perishables. The Saurashtra type was chosen because it could be easily made by the local potter.

Description of Equipment.

Janata Refrigerator.

As shown in Figure 7, the Saurashtra type of Janata refrigerator consists of an outer tub (A) 1'-5½" in diameter and 3½" high, for holding water. There is an inner vessel (B) in the shape of an inverted flower pot, open at both ends. This measures 1'-3" in diameter at the base and 8¾" at the top. There is a short mud cylinder (C) 2" high and 3" in diameter, which is placed in the centre of the tub. This serves as the base for the mud plate (D) 9½" in diameter, on which the vegetables are placed. The plate is slightly shallow in the centre with five holes in its surface to facilitate aeration. The inner vessel is closed with a lid (E) 8¾" in diameter which has a handle. There are four holes ¼" in diameter on its surface.

PARTS OF SAURASHTRA JANATA REFRIGERATOR

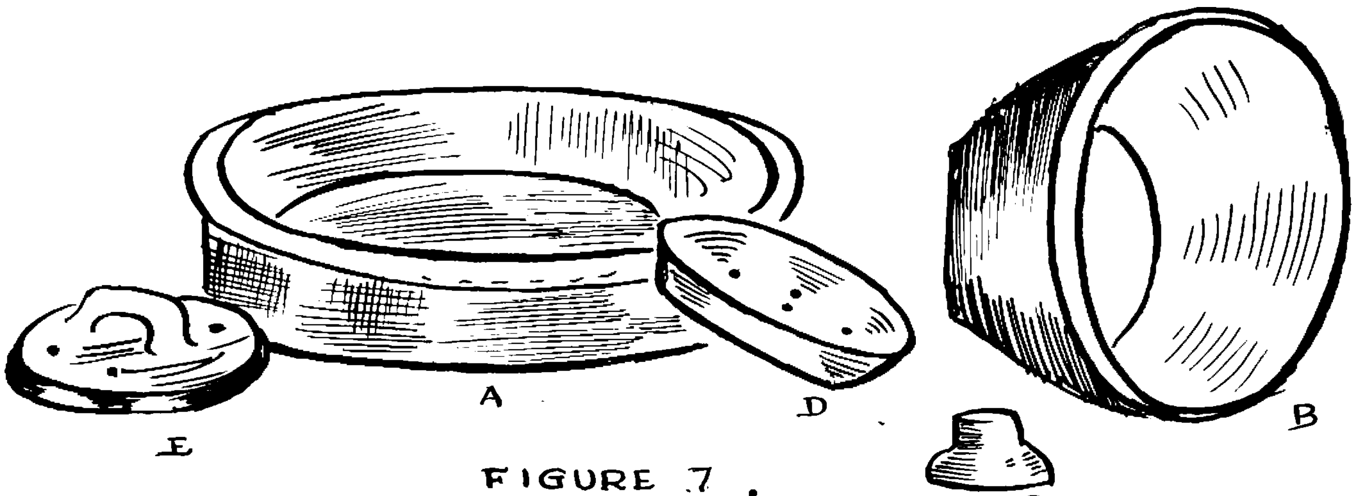


FIGURE 7.

A. Outer tub
B. Inner Vessel
C. Mud Cylinder
D. Mud plate
E. lid

The equipment was assembled as shown in Figure 8 and set up on a platform near a window, so that there was good circulation of air. Water was poured in the outer tub to a height of 1½". As the water evaporated through the porous material, cooling was produced. A fine cloth was wrapped round the inner vessel with its lower end dipping in the water in the tub. By capillary action, the cloth remained wet all through. The slow evaporation of water from the wet cloth also helped in producing cooling inside the vessel.

A Centigrade thermometer graduated from -10°C to 110°C was suspended inside the inner vessel through one of the holes in the lid.

Wire-meshed Cupboard.

This is a small cupboard 2'-3" tall, 1'-4½" wide and covered with wire-mesh on the two sides. It is fitted with a wire-meshed door. There are two shelves, which are 1' deep, as shown in Figure 9.

The shelves were lined with paper and vegetables placed inside. A Centigrade thermometer, graduated from -10°C to 110°C was also placed inside it.

Mechanical Refrigerator.

It is a 'Westinghouse' household refrigerator, model DL9 E, Style C42012 (Figure 10) dimensions 32" x 38" x 69" and capacity 9 cubic feet. The refrigerant used is Dichlorofluoromethane (CCl_2F_2). The control was adjusted so as to maintain a constant temperature of two degrees Centigrade.

JANATA REFRIGERATOR - ASSEMBLED

FIGURE 8.

WIRE-MESHED CUPBOARD

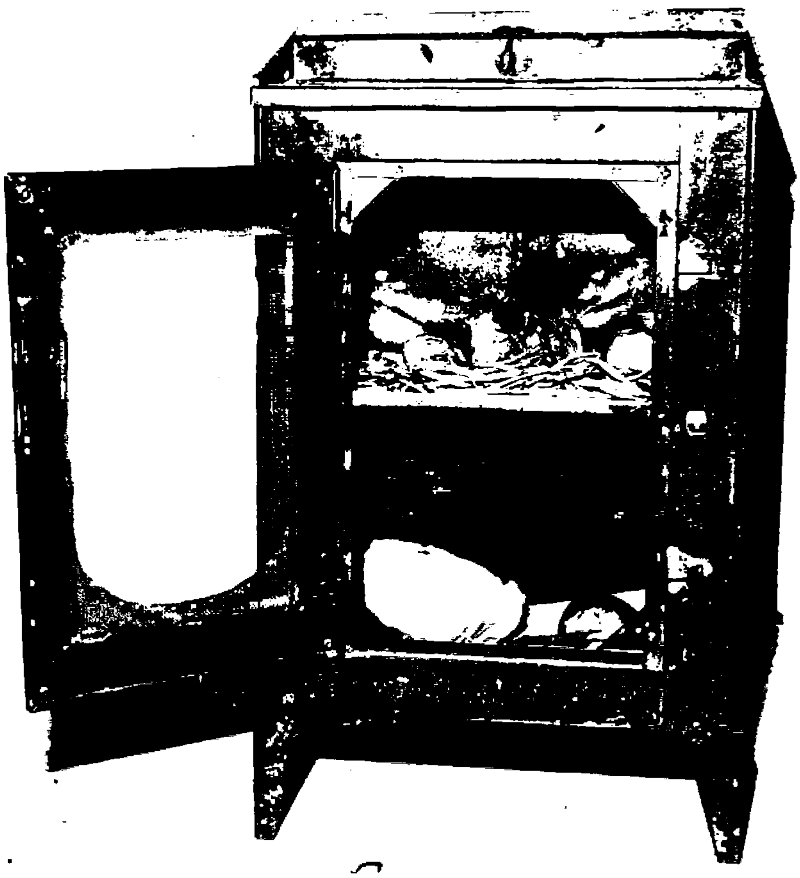


FIGURE 9.

MECHANICAL REFRIGERATOR

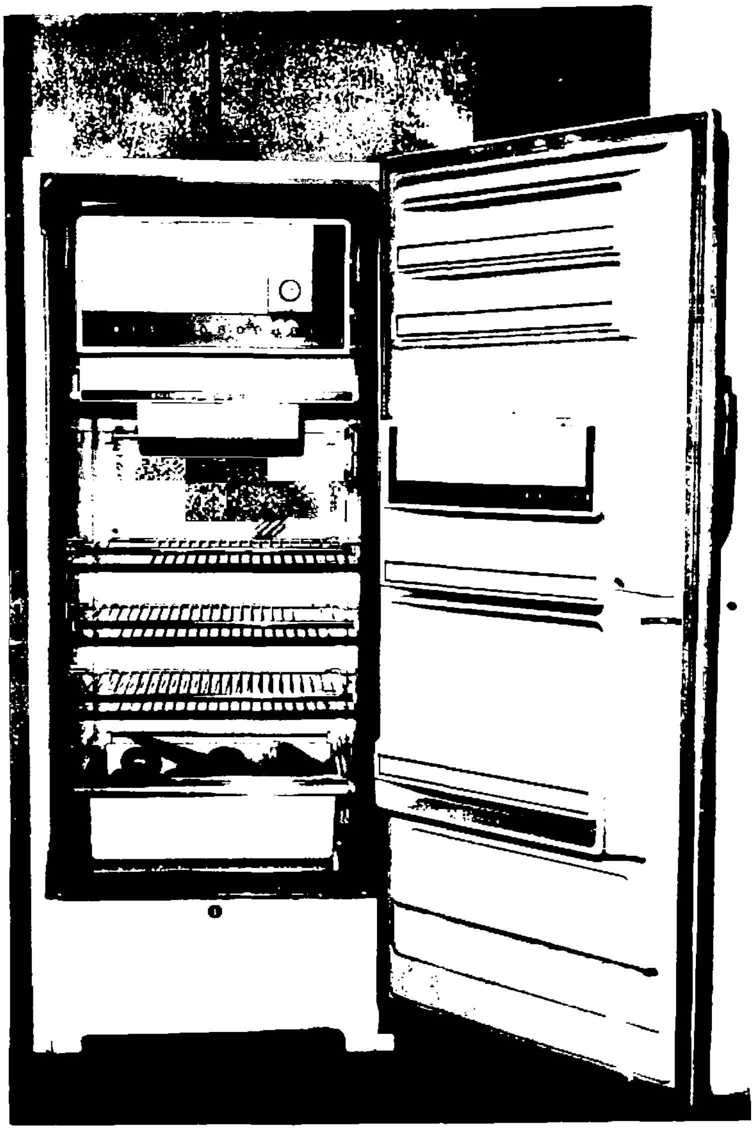


FIGURE 10

(a) Procedure For Assessing The Efficiency Of The Storage Devices.

One of the objectives of the study was to compare the three storage devices with regard to their efficiency. The term 'efficiency' is used in this study to mean 'the ability of doing what may be required of a thing'. It is expected of a storage device that it should maintain the articles stored in it in a fresh state. Hence a storage device is considered efficient if it keeps the vegetables fresh.

In order to judge the efficiency of the storage devices, two methods were used;

(i) Inspection of the appearance of the vegetables stored in the three devices by a specially evolved method

and (ii) Estimation of vitamin C in cabbage after storage in the three devices.

(i) Inspection of The Appearance of The Vegetables After Storage in The Three Devices.

Work and Carew (1955)[11] state that the quality of vegetables depends upon many characteristics - external, internal, physical and chemical. It is possible to observe some of the external and physical characteristics by inspection and judge the state of freshness of vegetables. According to Pentzer (1959)[1], conditions that keep fruits and vegetables fresh and attractive, usually help them to retain their nutritive value also. Therefore the state of freshness of the stored vegetables can be taken as an indication of the efficiency of the storage device used. Hence a method was especially evolved for the inspection of the appearance of the vegetables stored in the devices.

Determination of the Amount of Vegetables to be Stored.

In order to simulate home conditions, the amount of vegetables required everyday for a family of four members, consisting of father, mother and two children, a girl aged thirteen years and a boy of five years was determined, using the recommendations for the balanced diet by the Nutrition Advisory Committee of the Indian Council of Medical Research (1944)[38] and by Swaminathan and Bhagawan (1960)[39] as shown in Appendix I. The amount of the different types of vegetables required by the family for a week was calculated, as shown in detail in Appendix II.

Purchase of Vegetables.

In order to minimise the differences due to variety, handling and previous storage, the vegetables were obtained fresh once in four days from the same garden in the local jail, by the kind courtesy of the Superintendent.

Duration of Storage.

The duration of storage of vegetables was fixed for three days because, in an interview conducted in ten households in Coimbatore city, the data of which are given in Appendix III, it was observed that vegetables were stored for less than three days in these homes.

Method of Storage.

All the vegetables, shown in Appendix II except Cabbage and raw Plantain were used in this experiment, since in the preliminary experiments, Cabbage and raw Plantain did not show noticeable difference in the external appearance after storage for three days.

The other vegetables were divided into three approximately equal lots and placed in the three storage devices namely, the Janata refrigerator, wire-meshed cupboard and mechanical refrigerator. The room temperature in the first two devices were recorded every three hours. The control in the mechanical refrigerator was adjusted to maintain a constant temperature of 2°C since Crowther (1955)[20] recommends a temperature range of -0.9°C to 2.6°C for storage of vegetables.

Judging the Vegetables.

The freshness of appearance of the vegetables were judged in relation to certain criteria such as colour, absence of wrinkles, turgidity, and state of maturity, using a three-point scale score card as shown in Table III.

TABLE III.

SCORE CARD FOR JUDGING THE FRESHNESS OF VEGETABLES.

Quality.	Criteria.	Score.
Colour.	Natural green.	3
	Turning yellowish green.	2
	Turning more yellowish green.	1
Freshness.	Very fresh.	3
	Not so fresh.	2
	Wilted.	1
Tenderness.	Very tender.	3
	Not so tender.	2
	Hard.	1
Turgidity.	Very firm.	3
	Not so firm.	2
	Soft.	1

On this basis, individual score cards were developed for Cauliflower, Tomato, Beans, green Chillies, carrot bitter-gourd, Cluster beans, Beetroot, Brinjal, and Ladie's finger as shown in Appendices III to XIII.

A panel of five judges, consisting of a lecturer in Foods and Nutrition, a post-graduate student in Foods and Nutrition, two hostel assistants in charge of the preparation of foods in the hostel and a lady attender, who hails from a vegetable farm, was selected for the quality inspection of the vegetables using the Score Cards. The judges adjudged the freshness of vegetables immediately after purchase, and after storage for seventy two hours in the Janata refrigerator, wire-meshed cupboard and mechanical refrigerator respectively.

(ii) Estimation of Vitamin C in Cabbage After Storage in the Three Devices.

The efficiency of the storage device can be judged in relation to its capacity for conserving the vitamin C or preventing the loss of vitamin C from the vegetable stored because Watt and Leung (1959)[16] have pointed out that in research studies on changes in nutrient composition of food, the ascorbic acid content is taken as an indicator of the changes as it is the most easily destroyed among the nutrients.

Choice of the Vegetable for Study.

From among the vegetables included in the weekly menu, cabbage was selected for vitamin C assessment because cabbage is a rich source of vitamin C. Further, Watt and Leung (1959)[16] state that it is a more stable source of ascorbic acid than most other leafy vegetables. It is quite inexpensive, costing usually about 12 to 19 Naye Paise per pound in the Coimbatore market. Moreover, it is available throughout the year in Coimbatore.

Procedure for Taking Samples of Cabbage for Storage.

A fresh large sized cabbage was bought from the market every day. It was cut into four more or less equal wedge-shaped portions, from tip to base, as suggested by Adams (1943)[40], in order to include representative portions of the outer and inner leaves. One wedge was taken for vitamin C estimation. Each of the other three quarters was weighed and placed in the three storage devices, the Janata refrigerator, the wire-meshed cupboard and the mechanical refrigerator, respectively. After 72 hours of storage, they were again weighed and the loss in weight noted. The amount of vitamin C present in each quarter was determined.

Procedure for Ascorbic Acid Estimation.

For the ascorbic acid estimation 2:6 Dichlorophenol indophenol Visual Titration method as described by the Association of Vitamin Chemists (1947)[41] was followed. It consists of extracting the ascorbic acid from the food and measuring it by titration with 2:6 dichlorophenol indophenol.

(1) Preparation of Reagents.

6% Metaphosphoric Acid. The 6% metaphosphoric acid was prepared daily as follows: Without heating, 60 g. of metaphosphoric acid sticks were dissolved in 900 ml. of glass distilled water and the solution made up to one litre and stored at 3°C, when not in use. (On standing, metaphosphoric acid is slowly hydrolysed to orthophosphoric acid).

3% Metaphosphoric Acid Solution. The 6% metaphosphoric acid solution was diluted further with glass distilled water.

Ascorbic Acid Solution. The ascorbic acid solution required for standardising the 2:6 dichlorophenol indophenol dye was prepared by dissolving 20 mg. of ascorbic acid in 3% metaphosphoric acid solution and diluting to 100 ml. with the same solvent. As this solution is unstable, it was used immediately to standardise the dye.

2:6 Dichlorophenol Indophenol Solution. 100 mg. of the dye were dissolved in glass distilled water. This was filtered into a 100 ml. volumetric flask and the filter washed with small portions of glass distilled water. The volume was then made up with glass distilled water and mixed well. This was prepared fresh every day.

(2) Standardisation of the Dye (2:6 Dichlorophenol Indophenol Solution).

The standardisation of the dye was carried out daily by titrating the fresh dye solution against freshly prepared pure ascorbic acid solution.

A five ml. aliquot of the standard ascorbic acid solution (containing one mg. ascorbic acid) was diluted with five ml. of 3% metaphosphoric acid solution. It was then titrated with the dye solution to a pink colour which persisted for 15 seconds.

Dye Factor. Since this volume of dye represents one mg. of ascorbic acid, the ascorbic acid equivalent of one ml. of dye solution is equal to one divided by the volume in ml. of the dye solution used in this titration.

(3) Preparation of Extract for Analysis.

The cabbage piece to be analysed was weighed. It was then quickly cut into pieces (about ½" square) within one minute. The cabbage was then placed in the Waring blender and an equal amount by weight of 6% metaphosphoric acid solution was added. The cabbage was then blended for two minutes to yield a homogeneous slurry.

About 20 g. of this slurry was transferred to a beaker covered with a watch glass, which was weighed accurately in an analytical balance. The slurry was then transferred to a 100 ml. volumetric flask and diluted to 100 ml. with 3% metaphosphoric acid.

The diluted sample was then filtered through glass wool. The first few ml. of the filtrate were discarded.

(4) Titration.

A 0.01 c.c graduated burette was used. This was rinsed with the standardised dye solution and filled to the zero mark. Five ml. aliquots of the filtrate were pipetted into four small matched beakers. The dye was added in a fine stream to the extract, as long as the colour disappeared instantly, then drop by drop, with shaking after each drop, until a very faint pink colour appeared and persisted for about 15 seconds. The titration was repeated till concordant values were obtained. The estimation was repeated on four samples of the slurry and the mean value of the four replicates calculated.

(5) Calculations.

If, W_1 = Weight of the original material in grams.

W_2 = Weight of extracting acid used in grams.

W_3 = Weight of slurry taken for analysis in grams.

V_1 = Volume to which the slurry (W_3) is diluted in ml.

V_2 = Volume of filtrate taken for titration in ml.

V = Volume of dye in ml. required for ascorbic acid titration.

T = Ascorbic acid equivalent of the dye in mg. per ml. of dye.

This formula, $\frac{W_1 + W_2}{W_1 \times W_3} \times \frac{V_1}{V_2} \times 100\ (V \times T)$ will give the vitamin C content in milligrams per 100 grams sample.

(6) Precautions.

The four major precautions, namely, representative sampling, complete extraction, prevention of oxidation and rapid titration, suggested by Olliver (1942)[42] were strictly observed.

Representative Sampling. The cabbage was cut from tip to base into wedge-shaped sections in order to include representative portions of wrapper and inner leaves.

Complete Extraction. The cabbage was placed with an equal amount (by weight) of 6% metaphosphoric acid and ground for two minutes in the Waring blendor. After grinding for one minute, the blendor was stopped and any bits that might be sticking to the walls of the blendor pushed down and the material ground again for one minute more.

Prevention of Oxidation. Water redistilled in a glass-distillation apparatus was used for making up solutions and for rinsing all glassware. The extractant used was 6% metaphosphoric acid. The chopping of the cabbage as well as the preparation and weighing of the slurry were done as rapidly as possible.

Rapid Titration. The titration was completed in one to two minutes.

(b) Procedure For Assessing The Convenience Of The Storage Devices.

Two important factors which determine the convenience of a storage device are its storage capacity and the time involved in cleaning.

Hence first, the storage capacity of each of the three devices was assessed in relation to the quantities of vegetables required by the family for a week. Roots and tubers, such as potato, sweet potato, yam and colocasia were not placed in the storage devices, as they remain good even at room temperature. Secondly, the time taken to clean the three devices was recorded. For the wire-meshed cupboard, the outside and shelves were dusted and the lining papers renewed. The Janata refrigerator was dismantled, each part washed well and dried in the sun. The mechanical refrigerator was switched off and the door left open. The time taken for defrosting was noted. Then the outside was dusted well and the interior wiped well to remove all the moisture. The detachable shelves were taken out, washed and wiped dry. The freezer compartment trays were also cleaned and wiped dry. The frequency with which the mechanical refrigerator is cleaned in households was also taken into consideration.

(e) Procedure For Assessing The Cost Involved In The Use of The Three Storage Devices.

An equipment is considered economical when the initial outlay is reasonable and the operational cost nominal. Therefore the relative economy of the three storage devices was determined on the basis of the cost of purchase, cost of operation and the reduction in expenditure on marketing trips.

Initial Cost of Equipment and Operational Cost.

First, the cost of purchase of the three devices was noted. The Janata refrigerator and wire-meshed cupboard do not have any operational costs, whereas the mechanical refrigerator, running on electricity, involves some cost in operation. Therefore, in the case of the mechanical refrigerator, the operational cost was also taken into account.

Marketing Cost.

The duration for which the storage device keeps the articles in a fresh condition is of importance in determining the economy in its use. A device that keeps articles stored in a fresh condition for a long period saves the time and money that the homemaker has to spend on marketing trips.

It was found in the study that the vegetables stored in the Janata refrigerator stay fresh for three days. Vegetables can be kept fresh in the mechanical refrigerator for a week, whereas the vegetables stored in the wire-meshed cupboard start wilting by the second day of storage.

It was therefore assumed that a homemaker who possesses a mechanical refrigerator goes marketing once a week. This fact was confirmed by interviews. Households using a Janata refrigerator need to buy vegetables twice a week and those using wiremeshed cupboards daily. Therefore the expense on marketing for each trip and the total expense in a month was calculated.

IV. RESULTS AND DISCUSSIONS.

The results and discussions that follow cover the three criteria, viz., efficiency, convenience and economy, by which the suitability of the Janata refrigerator was studied.

(a) Efficiency of the Three Devices.

(i) Inspection of the Appearance of Vegetables After 72 Hours of Storage in the Three Devices.

The relative superiority of the three devices with regard to the appearance of the different vegetables stored in them is discussed below:-

Cauliflower.

Table IV shows the total scores given for cauliflower after 72 hours of storage in the three devices.

TABLE IV.

TOTAL SCORES FOR CAULIFLOWER AFTER STORAGE FOR 72 HOURS IN THE THREE DEVICES.

Replicates.	Mechanical Refrigerator.	Janata Refrigerator.	Wire-meshed cupboard.
1	43.0	35.0	32.00
2	40.0	36.1	34.40
3	43.0	35.0	32.00
4	43.0	35.0	30.00
5	40.0	35.0	30.00
Mean.	41.8	35.2	31.68
$F = 56.11$	$P < .01$		$D_{.01} = 3.00$

The results were statistically analysed to find the F ratio. {Snedecor (1956)[48] explains that F is a ratio of the variances between the experimental variables and within replicates. If P, the probability of its occurrence by chance, is less than 0.01, it indicates that the differences obtained in the experiment as a whole are very significant.} In order to find out which of the differences between the three means are significant, the 't' test was applied using the method suggested by Garrett (1958)[43]. In this method, the standard error for the data presented in each table was multiplied by the relevant 't' and the minimum difference required for significance was established.

As shown in Appendix XIVa, $D_{.01}$ for cauliflower is 3.00. Hence a difference greater than 3.00 between any two of the three means is statistically very significant.

It can be seen from Table IV given on page 62, that the mean of the scores given to cauliflower stored in the mechanical refrigerator is 6.6 more than the mean of the scores given to cauliflower stored in the Janata refrigerator, which in turn is 3.52 more than the mean score of the cauliflower stored in wire-meshed cupboard. All these differences are greater than 3.00, which is the minimum required for significance at one per cent level.

Hence the mechanical refrigerator is very significantly superior to the Janata refrigerator and wire-meshed cupboard; the Janata refrigerator is also very significantly superior to the wire-meshed cupboard as regards the appearance of cauliflower stored in it.

Table V shows the scores given to tomato after 72 hours of storage in the three devices.

TABLE V.

TOTAL SCORES FOR TOMATO AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Replicates.	Mechanical refrigerator.	Janata refrigerator.	Wire-meshed cupboard.
1	72.5	72.5	70
2	75.0	72.5	70
3	75.0	72.5	70
Mean.	74.16	72.5	70
$F = 20.46$	$P < 0.01$	$D_{.01} = 2.52$,	$D_{.05} = 1.66$

Analysis of variance (vide Appendix XLV) reveals a significant F ratio. Both the mechanical refrigerator and Janata refrigerator are significantly superior to the wire-meshed cupboard, as regards the appearance of the tomato; and the mechanical refrigerator is very significantly superior to the Janata refrigerator.

It was noticed that the tomato stored in the wire-meshed cupboard ripened earlier than those stored in the other two devices.

Beans.

Table VI shows the total scores given to beans after 72 hours of storage in the three devices.

TABLE VI.

TOTAL SCORES FOR BEANS AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Replicates.	Mechanical refrigerator.	Janata refrigerator.	Wire-meshed cupboard.
1	75	70	50
2	70	65	50
3	70	63	48
4	65	60	43
5	75	70	50
Mean.	71	65.6	48.2
$F = 46.31$	$P < 0.01$	$D_{.01} = 7.95$	$D_{.05} = 5.41$

On statistical analysis, the F ratio is found to be very significant, as shown in Appendix XVI. Both the mechanical refrigerator and Janata refrigerator are very significantly superior to the wire-meshed cupboard as regards the appearance of beans; while the mechanical refrigerator is significantly superior to the Janata refrigerator.

Green Chillies.

Table VII shows the total scores given to green chillies after 72 hours of storage in the three devices.

TABLE VII.

TOTAL SCORES FOR GREEN CHILLIES AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Replicates.	Mechanical refrigerator.	Janata refrigerator.	Wire-meshed cupboard.
1	40	38.3	28.3
2	42	38.3	33.3
3	44	41.3	38.8
4	45	41.5	33.0
5	45	41.5	33.0
Mean.	43.2	40.18	33.28
$F = 17.59$	$F < 0.01$	$D_{.01} = 5.17$	$D_{.05} = 3.68$

On statistical appraisal, the F ratio is found to be highly significant, as shown in Appendix XVII. The difference between the appearance of green chillies stored in the mechanical refrigerator and in the Janata refrigerator is not statistically significant. Both the mechanical refrigerator and the Janata refrigerator are found to be very significantly superior to the wire-meshed cupboard as regards the appearance of the green chillies stored in them.

It was observed that the green chillies placed in the wire-meshed cupboard ripened earlier (turning red) than those stored in the other two devices.

Carrot.

Table VIII shows the total scores given to carrot after 72 hours of storage in the three devices.

TABLE VIII.

TOTAL SCORES FOR CARROTS AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Replicates.	Mechanical refrigerator.	Janata refrigerator.	Wire-meshed cupboard.
1	45.0	38.3	30.0
2	40.0	39.4	28.3
3	43.8	39.4	25.0
4	45.0	35.0	25.0
5	45.0	44.4	29.4
Mean.	43.76	39.3	27.54
$F = 48.28$	$P < 0.01$	$D_{.01} = 5.23$	$D_{.05} = 3.71$

On statistical analysis, the F ratio is found to be very significant as is shown in Appendix XVIII. Both the mechanical refrigerator and the Janata refrigerator are found to be very significantly superior to the wire-meshed cupboard as regards the appearance of the carrot and the mechanical refrigerator is significantly superior to the Janata refrigerator.

Bitter Gourd.

Table IX shows the total scores given to bitter gourd after 72 hours of storage in the three devices.

TABLE IX.

TOTAL SCORES FOR BITTER GOURD AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Replicates.	Mechanical refrigerator.	Janata refrigerator.	Wire-meshed cupboard.
1	35.00	15.00	0
2	40.00	36.65	25.00
3	34.40	31.10	28.30
4	34.40	30.00	24.40
5	40.00	35.00	25.00
Mean.	36.72	29.55	20.54
$F = 4.55$	$P < .05$	$D_{.01} = 17.8$	$D_{.05} = 12.65$

On statistical analysis, the F ratio is found to be significant beyond five per cent level, as shown in Appendix XIX . The difference in appearance between the bitter gourd stored in the mechanical refrigerator and Janata refrigerator, and that between the bitter gourd stored in the Janata refrigerator and wire-meshed cupboard are not statistically significant. However it was noticed that the bitter gourd placed in the wire-meshed cupboard began to ripen on the second day, while that placed in the Janata refrigerator did not ripen. The mechanical refrigerator and the Janata refrigerator were found to be significantly superior to the wire-meshed cupboard as regards the appearance of bitter gourd.

Cluster Beans.

Table X shows the total scores given to cluster beans after 72 hours of storage in the three devices.

TABLE X.

TOTAL SCORES GIVEN TO CLUSTER BEANS AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Replicates.	Mechanical refrigerator.	Janata refrigerator.	Wire-meshed cupboard.
1	45.00	41.65	36.65
2	51.00	49.00	42.00
3	59.00	45.50	38.00
4	55.00	53.30	49.40
5	50.00	49.00	39.00
Mean.	52.00	47.69	41.01
$F = 6.32$	$P < 0.05$	$D_{.01} = 9.55$	$D_{.05} = 6.798$

On statistical analysis, the F ratio is found to be significant beyond five per cent level, as shown in Appendix X X. The difference in appearance between the cluster beans stored in the mechanical and Janata refrigerators, and the difference between the appearance of cluster beans stored in the Janata refrigerator and wire-meshed cupboard were not found to be statistically significant. The mechanical refrigerator was found to be very significantly superior to the wire-meshed cupboard as regards the appearance of cluster beans stored in it.

Beet Root.

Table XI shows the total scores given to beet root stored for 72 hours in the three storage devices.

TABLE XI.

TOTAL SCORES FOR BEET ROOT AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Replicates.	Mechanical refrigerator.	Janata refrigerator.	Wire-meshed cupboard.
1	40.4	39.0	25.0
2	44.4	43.3	33.3
3	44.4	42.2	38.3
4	44.4	43.3	33.3
5	38.0	36.0	31.0
Mean.	42.24	40.76	32.18
F = 10.45	P < 0.01	$D_{.01}$ = 7.28	$D_{.05}$ = 5.19

On statistical analysis, the F ratio is found to be significant at one per cent level, as shown in Appendix XXI. The difference in the appearance of beet root stored in the mechanical refrigerator and in the Janata refrigerator is not found to be significant. The mechanical refrigerator and the Janata refrigerator are very significantly superior to the wire-meshed cupboard as regards the appearance of beet root stored in them.

Brinjal.

The optimum storage temperature recommended by The Central Food Technological Research Institute, Mysore[45] for brinjals is 8.3°C to 10°C. But in this study the mechanical refrigerator was adjusted to maintain a temperature of 2°C. Therefore, that temperature was not suitable for storing brinjal. Consequently the brinjals stored in the mechanical refrigerator did not keep in good condition. The stalks became dry and there were black marks on the skin.

Hence, only the scores for the brinjals stored in the Janata refrigerator and wire-meshed cupboard, given in Table XII, were compared with each other.

TABLE XII.

TOTAL SCORES FOR BRINJALS STORED FOR 72 HOURS IN THE JANATA REFRIGERATOR AND WIRE-MESHED CUPBOARD.

Replicates.	Janata refrigerator.	Wire-meshed cupboard.
1	69.5	57.5
2	65.0	55.0
3	70.0	65.0
4	69.5	65.0
5	65.0	55.0
Mean.	67.8	59.5

$F = 10.49$ $P < 0.05$ $t = \sqrt{F} = 3.24$

On statistical analysis, the F ratio is found to be very significant, as is shown in Appendix XXII.

The Janata refrigerator is found to be significantly superior to the wire-meshed cupboard as regards the brinjal stored in it.

<u>Ladies Finger.</u>

The optimum storage temperature recommended by The

Central Food Technological Research Institute, Mysore[46] for ladies finger is 6°C to 10°C. So the ladies finger, when stored at 2°C in the mechanical refrigerator did not keep good. Therefore, only the scores given to the ladies finger stored in the Janata refrigerator and those stored in the wire-meshed cupboard, as shown in Table XIII, were compared.

TABLE XIII.

SCORES FOR LADIES FINGER AFTER 72 HOURS OF STORAGE IN THE JANATA REFRIGERATOR AND WIRE-MESHED CUPBOARD.

Replicates.	Janata refrigerator.	Wire-meshed cupboard.
1	46.65	35.00
2	46.00	32.00
3	45.00	30.00
4	46.00	32.00
5	46.00	32.00
Mean.	45.93	32.50
$F = 243.6$	$P < 0.01$	$t = \sqrt{F} = 3.36$

On statistical analysis, the F ratio is found to be very significant, as is shown in Appendix XXIII. The Janata refrigerator is found to be very significantly superior to the wire-meshed cupboard as regards the ladies finger stored in it.

To summarise, there is a difference in the appearance of the vegetables stored for 72 hours in the three devices. Table XIV shows the details.

TABLE XIV.

DIFFERENCE IN THE APPEARANCE OF VEGETABLES AFTER STORAGE IN THE THREE DEVICES FOR 72 HOURS.

Name of the vegetable.	Total scores after storage in:			Superiority of the devices.		
	Mechanical refrigerator.	Janata Refrigerator.	Wire-meshed cupboard.	Mechanical refrigerator versus Janata refrigerator.	Janata refrigerator versus wire-meshed cupboard.	Mechanical refrigerator versus wire-meshed cupboard.
Cauliflower.	41.80	35.20	31.68	**	**	**
Tomato.	74.16	72.50	70.00	*	**	**
Beans.	71.00	65.60	48.20	*	**	**
Green chillies.	43.20	40.18	33.28	—	**	**
Carrot.	43.76	39.3	27.54	*	**	**
Bitter gourd.	36.72	29.55	20.54	—	—	*
Cluster beans.	52.00	47.69	41.01	—	—	**
Beet root.	42.24	40.76	32.18	—	**	**
Brinjal.		67.80	59.50		*	
Ladies finger.		45.93	32.50		**	

Note:-

** Very significant.

* Significant.

— Not significant.

The panel of judges observed that, in general, the vegetables stored in the Janata refrigerator remained in a better condition than those stored in the wire-meshed cupboard.

(ii) Estimation of Ascorbic Acid in Cabbage After 72 Hours of Storage in the Three Devices.

Table XV shows the ascorbic acid content and the percentage loss of ascorbic acid in cabbage after 72 hours of storage in the three devices. Details of the calculations are given in Appendices XIV to XXVI.

TABLE XV.

ASCORBIC ACID IN CABBAGE AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Replicates.	Initial amount in mg.	Mechanical refrigerator.		Janata refrigerator.		Wire-meshed cupboard.	
		Ascorbic acid in mg.	Percentage loss.	Ascorbic acid in mg.	Percentage loss.	Ascorbic acid in mg.	Percentage loss.
1	44.50	41.51	6.72	40.00	10.11	36.10	18.88
2	49.98	47.17	5.62	42.34	15.30	37.31	25.40
3	53.97	49.76	7.80	44.63	17.30	39.53	26.80
4	50.00	46.38	7.24	42.41	15.18	37.75	24.50
5	47.99	44.39	7.50	38.99	18.75	32.63	32.01

As can be seen from the figures in Table XV, the piece of cabbage stored in the mechanical refrigerator showed the least loss ranging from 5.6 to 7.8 per cent, after 72 hours.

The piece of cabbage stored in the wiremeshed cupboard suffered the maximum loss, ranging from 18.9 to

32.0 per cent.

For the piece of cabbage stored in the Janata refrigerator, the loss of ascorbic acid ranged from 10.1 to 18.8 per cent, coming in between the losses suffered by the cabbages stored in the mechanical refrigerator and wiremeshed cupboard.

Table XVI shows the average percentage loss of ascorbic acid.

TABLE XVI.

MEAN PERCENTAGE LOSS OF ASCORBIC ACID IN CABBAGE AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Replicates.	Percent loss of Ascorbic Acid in cabbage stored in:		
	Mechanical refrigerator.	Janata refrigerator.	Wire-meshed cupboard.
1	6.72	10.11	18.88
2	5.62	15.30	25.40
3	7.80	17.30	26.80
4	7.24	15.18	24.50
5	7.50	18.75	32.01
Mean.	6.96	15.34	25.52
F = 37.89.			P < 0.01

This percentage loss of ascorbic acid is represented in Figure 11.

The results were statistically analysed as shown in Appendix XXVII. The F ratio is found to be highly significant. The 't' test for reliability of the differences between the means was applied, using the method suggested by Guilford (1956)[46]. It is found that the difference in the loss in ascorbic acid incurred by cabbage stored for

PERCENTAGE LOSS OF ASCORBIC ACID IN CABBAGE

FIGURE 11

M. Stored in mechanical refrigerator
J. Stored in Janata refrigerator
W - Stored in wire-meshed cupboard

72 hours in the three devices are very significant.

It is found that the retention of vitamin C is lowest in the cabbage stored in the wire-meshed cupboard, while it is the highest in the mechanical refrigerator. The retention of vitamin C in the cabbage stored in the Janata refrigerator is intermediate and there is a significant difference between this and the retention of vitamin C in the cabbage stored in the wire-meshed cupboard.

(iii) Loss of Moisture.

Table XVII shows the percentage loss of weight of cabbage stored in the three storage devices. The percentage of loss in weight is due to the loss of moisture, which is an indication of the amount of wilting undergone by the vegetables.

TABLE XVII.

PERCENTAGE LOSS IN WEIGHT OF CABBAGE STORED IN THE THREE DEVICES FOR 72 HOURS.

Replicates.	Mechanical refrigerator.	Janata refrigerator.	Wire-meshed cupboard.
1	14.4	10.3	29.1
2	11.3	8.2	26.0
3	10.8	9.6	47.7
4	10.9	6.8	23.4
5	11.1	8.3	22.5
Mean.	11.7	8.64	29.74

These results are represented in Figure 12.

From Table XVII it can be seen that the weight

PERCENTAGE LOSS OF WEIGHT IN CABBAGE

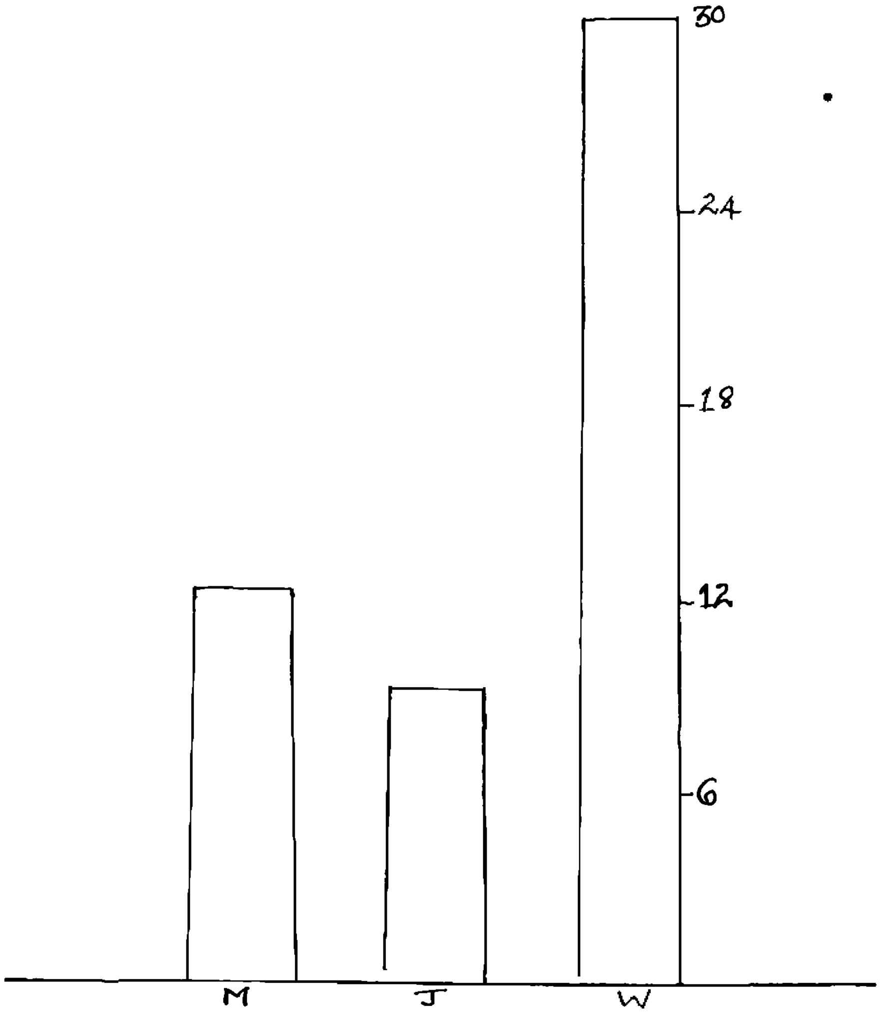


FIGURE 12.

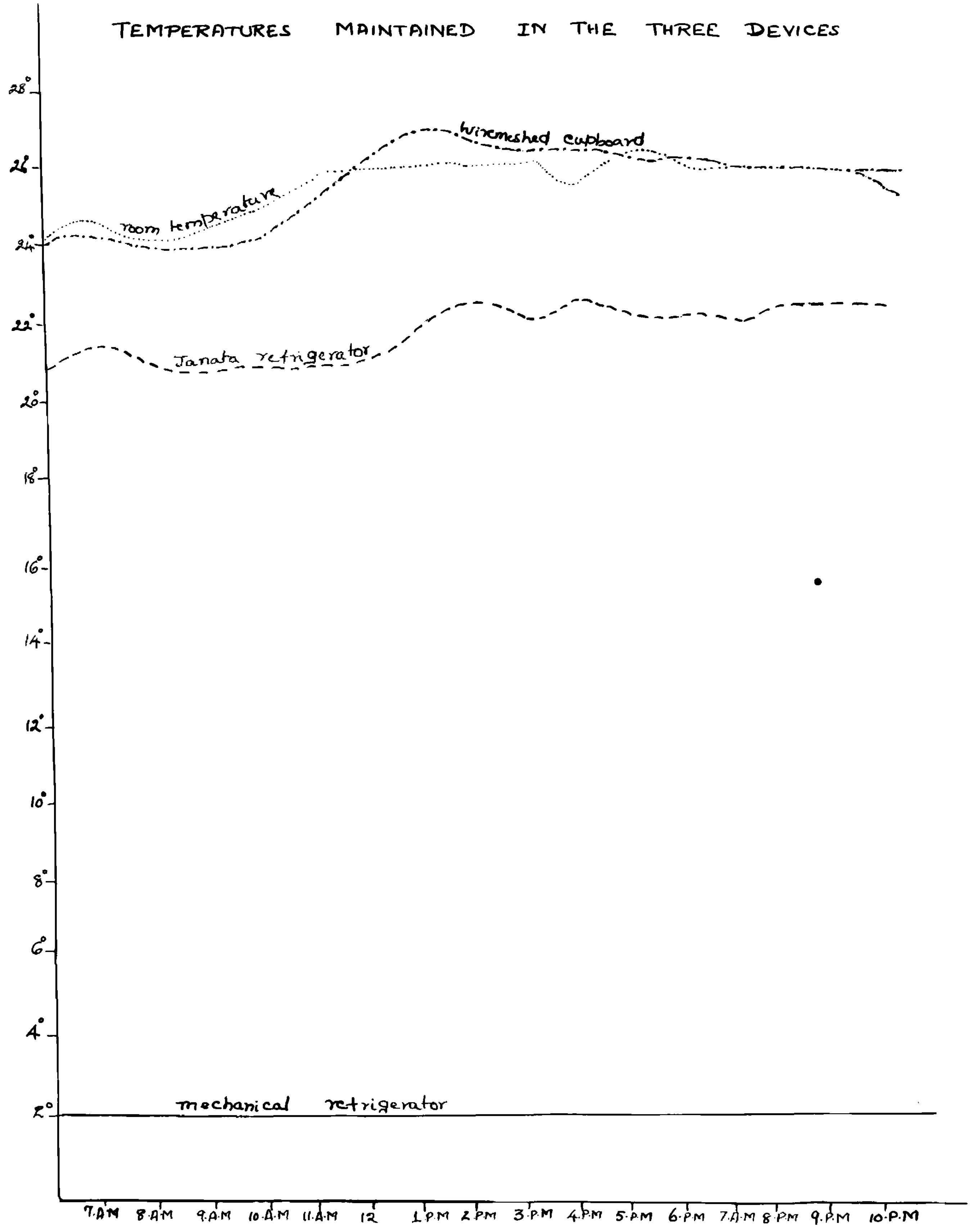
M, J and W refer to storage in mechanical refrigerator Janata refrigerator and wire-meshed cupboard respectively loss was maximum in the case of the piece of cabbage stored in the wire-meshed cupboard, varying from 22.5 per cent to 47.7 per cent.

Next in order comes the percentage loss in weight of cabbage stored in the mechanical refrigerator, the percentage loss in weight ranging from 10.8 to 14.4.

It is significant to note that the piece stored in the Janata refrigerator had incurred the least weight loss, the percentage loss in weight ranging from 6.8 to 10.3.

These differences in the loss of weight may be interpreted as bearing a relation to the temperature maintained in the three devices. Figure 13 shows the room temperature and the temperatures maintained in the three devices.

The differences between room temperature and temperature in the wire-meshed cupboard are shown in Table XVIII.



TEMPERATURES MAINTAINED IN THE THREE DEVICES
28°
26°
24°
22°
20°
18°
16°
14°
12°
10°
8°
6°
4°
2°
wiremeshed cupboard
room temperature
Janata refrigerator
mechanical refrigerator
7.AM
8.AM
9.AM
10.AM
11.AM
12
1.PM
2.PM
3.PM
4.PM
5.PM
6.PM
7.AM
8.PM
9.PM
10.P.M

FIGURE 13.

TABLE XVIII.

DIFFERENCE BETWEEN ROOM TEMPERATURE (IN DEGREES CENTIGRADE) AND TEMPERATURE (IN DEGREES CENTIGRADE) IN THE WIRE-MESHED CUPBOARD.

Time.	Room temperature.	Temperature in wire-meshed cupboard.	Difference.
6 a.m.	24.25	24.00	- 0.25
7	24.50	24.00	- 0.50
8	24.00	23.75	- 0.25
9	24.50	23.75	- 0.75
10	24.75	24.25	- 0.50
11	25.75	25.75	0
12	26.00	26.25	+ 0.25
1 p.m.	26.00	27.00	+ 1.00
2	26.00	26.50	+ 0.50
3	26.25	26.25	+ 0.25
4	25.75	26.25	+ 0.50
5	26.50	26.50	0
6	26.00	26.25	+ 0.25
7	26.00	26.25	+ 0.25
8	26.00	26.00	0
9	26.00	26.00	0
10	25.50	25.50	0

An analysis of the storage temperature in the wire-meshed cupboard, as shown in Table XVIII, reveals that in the course of the day, it fluctuates slightly above and below the room temperature. This fluctuation may be attributed to the respiration taking place in the cabbage.

The control in the mechanical refrigerator was adjusted such, that it maintained a constant temperature of 2°C. Hence, the percentage loss is much lower in the piece stored in the mechanical refrigerator, than in that stored in the wire-meshed cupboard.

Table XIX shows the differences between room temperature and temperature in the Janata refrigerator.

TABLE XIX.

DIFFERENCE BETWEEN ROOM TEMPERATURE (IN DEGREES CENTIGRADE) AND TEMPERATURE (IN DEGREES CENTIGRADE) IN JANATA REFRIGERATOR.

Time.	Room temperature.	Temperature in Janata refrigerator.	Difference.
6 a.m.	24.25	21.00	- 3.25
7	24.50	21.50	- 3.0
8	24.00	21.00	- 3.0
9	24.50	20.75	- 3.75
10	24.75	21.00	- 3.75
11	25.75	21.00	- 4.75
12	26.00	21.25	- 5.75
1 p.m.	26.00	21.75	- 5.25
2	26.00	21.50	- 4.50
3	26.25	22.00	- 4.25
4	25.75	22.50	- 3.25
5	26.50	22.25	- 4.25
6	26.00	22.25	- 3.75
7	26.00	22.00	- 4.00
8	26.00	22.50	- 3.50
9	26.00	22.50	- 3.50
10	25.50	22.50	- 3.00

From Table XIX, it is found that the temperature in the Janata refrigerator has been on an average 3.9°C lower than that of the room temperature. It is observed that in the course of the day, the difference between the room temperature and the temperature in the Janata refrigerator is maximum when the relative humidity of the atmosphere in the room is low, usually from about 12 noon to 3 p.m. Appendices XXVIII to XXXIII show the variations in the relative humidity, room temperature, the corresponding variations in the Janata refrigerator and also the temperature in the wire-meshed cupboard.

It is interesting to note that the percentage loss in weight of the piece stored in the Janata refrigerator is lowest, in spite of the fact that the temperature in the Janata refrigerator is higher than that in the mechanical refrigerator. This can be explained as due to the high humidity built up inside the Janata refrigerator.

This percentage loss of weight incurred after three days of storage, was statistically analysed as shown in Appendix XXXIV.

The difference in the percentage loss of weight in cabbage stored in the three devices is found to be very significant. The 't' test for reliability of differences between the means were applied, as shown in Appendix XXXIV and found to be significant. Therefore, there is a significant difference between the loss in weight incurred by the cabbage when stored in the three devices.

(b) Convenience of the Three Devices.

Storage Capacity.

It was found that there is adequate space to store the vegetables required by the family for a week in the mechanical refrigerator and wire-meshed cupboard. The Janata refrigerator chosen for this study accommodates the vegetables required for three days, as shown in Tables XX(a) and XX(b).

TABLE XX(A)

AMOUNT OF VEGETABLES REQUIRED FOR THE FIRST THREE DAYS OF THE WEEK.

Name of vegetables.	Quantity.
Bitter gourd.	1 medium size.
Ladies finger.	6 "
Carrot.	3 "
Beet root.	1 "
Cluster beans.	1/8 Lb.
Tomato.	1 medium size.
Cauliflower.	1/4 Lb.
Brinjal.	6 medium size.
Cabbage.	7/8 Lb.

TABLE XX(b).

AMOUNT OF VEGETABLES REQUIRED FOR THE NEXT THREE DAYS.

Name of vegetables.	Quantity.
Beet root.	1 medium size.
Beans.	10.5 Oz.
Carrot.	1 medium.size.
Cabbage.	7/8 Lb.
Brinjal.	6 medium.size.
Ladies finger.	2 medium size
Tomato.	1/4 Lb.
Raw plantain.	1 medium size.

As pointed out earlier, the homemakers store vegetables for less than three days. Hence, this Janata refrigerator is adequate in size for a family of four members.

Cleaning Time.

Table XXI shows the time in minutes to clean the three storage devices.

TABLE XXI.

TIME (IN MINUTES) TAKEN TO CLEAN THE THREE STORAGE DEVICES.

Replicates.	Wire-meshed cupboard.	Janata refrigerator.	Mechanical refrigerator.
1	1.00	3.00	22.50
2	1.08	2.75	22.58
3	1.00	3.25	22.00
4	1.00	3.66	21.75
5	1.00	3.16	23.08
Mean.	1.02	3.06	22.38

From Table XXI it is found that of the three storage devices, cleaning the wiremeshed cupboard takes the least time, next in order comes the Janata refrigerator and then the mechanical refrigerator.

However, while calculating the time required to clean the devices, the frequency with which each device needs to be cleaned should also be taken into consideration. Hence the time required to clean the devices in one week was calculated.

Table XXII shows the time required in a week to clean the three devices.

TABLE XXII.

TIME REQUIRED IN A WEEK TO CLEAN THE THREE DEVICES.

Storage device.	Time in Min. for each cleaning.	Frequency of cleaning.	Time in Min. needed in a week.
Wire-meshed cupboard.	1.02	7	7.14
Janata refrigerator.	3.06	2	6.12
Mechanical refrigerator.	22.38	1	22.38

From Table XXII, it is seen that there is not much difference between the time taken for cleaning the wire-meshed cupboard and Janata refrigerator. However, the mechanical refrigerator requires more than thrice the time necessary to clean the Janata refrigerator.

Thus, in the course of a week, the cleaning time is the least with the Janata refrigerator. Since the time factor is important in home management, the Janata refrigerator is very suitable for the homemaker.

(e) Economy of the Three Devices.

Initial Cost of Equipment and Operational Cost.

The purchasing cost of the three devices, namely, wire-meshed cupboard, Janata refrigerator and mechanical refrigerator was noted. Table XXIII shows the purchasing costs of the three devices.

TABLE XXIII.

COST OF PURCHASE OF THE THREE STORAGE DEVICES.

..	Wire-meshed cupboard.	Janata refrigerator.	Mechanical refrigerator.
Cost in Rupees.	20.00	1.5	1298.64
Approximate ratio.	1	0.08	65.0

Thus, it is seen from Table XXIII that the Janata refrigerator is the least expensive of the three devices and within the means of the majority of people among the poorer classes.

Operational Cost.

There is no operational cost for the wire-meshed cupboard and the Janata refrigerator. The operational cost of the mechanical refrigerator was calculated as follows:-

The wattage of the equipment is 352. As the motor runs for ten hours in a day, the current consumption is 352 x 10 = 3520 watt hours or 3.52 units. Therefore, calculating at the rate of ten Naye Paise per unit, the operational cost amounts to 35.20 nP per day.

Expenditure on Marketing Trips.

Homemakers using wire-meshed cupboard have to buy vegetables daily, those using the Janata refrigerator need to buy twice a week and those using mechanical refrigerator once a week only.

From an interview of households in Perianaickenpalayam, a village, 11 miles from Coimbatore, it was gathered that the conveyance charges for each marketing trip amounts to Rupee one. On this basis, the expenditure on marketing trips for these households, if they were to use each one of the storage devices, was calculated as shown in Table XXIV.

TABLE XXIV.

EXPENDITURE ON MARKETING TRIPS.

Storage device used.	Frequency of marketing in a month.	Conveyance charges per month.
		Rs.
Wiremeshed cupboard.	30	30
Janata refrigerator.	8	8
Mechanical refrigerator.	4	4

It is seen from Table XXIV that the marketing cost is highest if the homemakers use wire-meshed cupboard and the lowest for those using mechanical refrigerators to store vegetables.

To sum up, the cost of purchase of the Janata refrigerator is the lowest of the three devices, and it does not involve any expense for maintenance and operation. If the homemaker uses the Janata refrigerator the expenditure on marketing trips would be less than that involved, if the homemaker were to use the wire-meshed cupboard.

V. SUMMARY AND CONCLUSION.

The homemaker needs a simple and inexpensive device for storing vegetables in the home. Therefore, the suitability of the Janata refrigerator as a simple device for home storage of vegetables was studied with reference to efficiency, convenience and economy. The results showed that -

1. In general, all vegetables remained in a better condition in the Janata refrigerator after 72 hours of storage, than when stored in the wire-meshed cupboard, as revealed by the scores awarded for the quality of the vegetables on inspection. The ripening of green chillies and bitter gourd was delayed when stored in the Janata refrigerator.
2. The loss of ascorbic acid was smaller in the cabbage stored in the Janata refrigerator than in that stored in the wire-meshed cupboard.
3. The Janata refrigerator used in this study is adequate in size to store the vegetables required by a family of four members for three days.
4. The cleaning procedure for the Janata refrigerator is simple. It involves only 6.16 minutes per week for cleaning it, twice a week.
5. The Janata refrigerator is inexpensive. No additional expense is required for maintenance and operation.

Thus from the data available, the conclusion is reached that the Janata refrigerator is more suitable for home storage of vegetables than the wire-meshed cupboard. The mechanical refrigerator is indeed superior to the Janata refrigerator, but since the initial cost is high and it requires the supply of gas or electricity for its operation, it cannot be used by many families and also in those parts of India, where gas and electricity are not available. Hence the Janata refrigerator is recommended for storing vegetables as an aid to better home management.

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A P P E N D I X

APPENDIX I

DAILY REQUIREMENTS OF VEGETABLES FOR A FAMILY CONSISTING OF THE FATHER, MOTHER AND TWO CHILDREN, A GIRL AGED THIRTEEN YEARS AND A BOY AGED FIVE YEARS.

Items	Requirements in ounces				Total
	Father*	Mother*	13 Yr. old girl**	5 Yr. Old boy**	
Green leafy vegetables.	4	4	4	2	14.0
Roots and tubers.	3	3	4	½	10.5
Other vegetables.	3	3	4	½	10.5

* Health Bulletin No.23, Page 16.

** Swaminathan and Bhagavan- 'Our Food', Page 71, 73.

APPENDIX III.

PRELIMINARY INTERVIEWS WITH TEN HOUSEHOLDS.

Duration of storage of vegetables.	No. of households.
One day.	7
Two days.	3
Three days.	0

APPENDIX IV

SCORE CARD FOR CAULIFLOWER

Quality	Criteria	Score
Colour of the head	White	3
	Turning creamish	2
	Brownish	1
Absence of decay	No decay	3
	Beginning to decay	2
	Decayed	1
Freshness	Fresh	3
	Slightly wilted	2
	Wilted	1

APPENDIX V

SCORE CARD FOR TOMATO

Quality	Criteria	Score
Skin	Very glossy	3
	Not so glossy	2
	Not at all glossy	1
	Intact	3
	Beginning to rupture	2
	Cracked	1
Colour	Green	3
	Turning red	2
	Red	1
Turgidity	Very firm	3
	Firm	2
	Not firm	1
Absence of decay	No decay	3
	A little	2
	Decayed	1

APPENDIX VI

SCORE CARD FOR BEANS

Quality	Criteria	Score
Colour	Green	3
	Turning yellowish green	2
	More yellowish green	1
Freshness	Fresh	3
	Not so fresh	2
	Wilted	1
Turgidity	Very firm	3
	Not so firm	2
	Soft	1
Tenderness	Very tender	3
	Not so tender	2
	Not tender (hard)	1
	End snaps readily	3
	Not so readily	2
	Does not snap	1

APPENDIX VII

SCORE CARD FOR GREEN CHILLIES

Quality	Criteria	Score
Freshness	Fresh	3
	Not so fresh	2
	Wilted	1
Colour	Natural green	3
	Beginning to ripen	2
	Ripened	1
Absence of decay	No decay	3
	Beginning to decay	2
	Decayed	1

APPENDIX VIII

SCORE CARD FOR CARROT

Quality	Criteria	Score
Freshness	Fresh	3
	Slightly wrinkled	2
	Wrinkled	1
Colour	Intense orange	3
	Not so bright	2
	Dull	1
Turgidity	Very firm	3
	Not so firm	2
	Not at all firm	1

APPENDIX IX

SCORE CARD FOR BITTER GOURD

Quality	Criteria	Score
Appearance	Fresh	3
	Not so fresh	2
	Not at all fresh	1
Colour	Green	3
	Turning yellowish green	2
	Turning yellowish	1
Turgidity	Very firm	3
	Not so firm	2
	Not firm	1

APPENDIX X

SCORE CARD FOR CLUSTER BEANS

Quality	Criteria	Score
Colour	Green	3
	Turning yellowish green	2
	More yellowish green	1
Freshness	Fresh	3
	Not so fresh	2
	Wilted	1
Turgidity	Very firm	3
	Not so firm	2
	Soft	1
Tenderness	Very tender	3
	Not so tender	2
	Not tender (hard)	1

APPENDIX XI

SCORE CARD FOR BEET ROOT

Quality	Criteria	Score
Appearance	Fresh	3
	Not so fresh	2
	Dull	1
Wrinkling	No wrinkles	3
	Starting to wrinkle	2
	Wrinkled	1
Turgidity	Very firm	3
	Not so firm	2
	Not firm	1

APPENDIX XII

SCORE CARD FOR BRINJAL

Quality	Criteria	Score
Appearance of skin	Very glossy	3
	Slightly glossy	2
	Not at all glossy	1
Colour	Natural	3
	Turning slightly yellowish	2
	More yellowish	1
Wrinkling	No wrinkles	3
	A few	2
	Many	1
Turgidity	Firm	3
	Turning slightly soft	2
	Completely soft	1
Absence of decay	No decay	3
	Beginning to decay	2
	Mostly decayed	1

APPENDIX XIII

SCORE CARD FOR LADIES FINGER

Quality	Criteria	Score
Appearance	Very fresh	3
	Not so fresh	2
	Dull	1
Turgidity	Firm	3
	Not so firm	2
	Not firm	1
Tenderness	End snaps readily	3
	Not so readily	2
	Does not snap	1
	Feels very tender	3
	Not so tender	2
	Hard and fibrous	1

APPENDIX XIV

ANALYSIS OF VARIANCE FOR TOTAL SCORES OF CAULIFLOWER AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Source of variation	Sum of squares.	Degree of freedom	Mean square
Between storage devices	263.94	2	131.97
Within replicates	28.30	12	2.35

For 2 and 12 df ; F at .01 = 6.93   F = 56.11
F at .05 = 3.88 $F < 0.01$

Significance of Mean Difference by Use of 't'

$S.D_W$ (Standard Deviation within = $\sqrt{\text{Within variance}}$

$S.E_D$ (Standard error of the difference between any two means) = $S.D \sqrt{\frac{1}{N} \times \frac{1}{N}}$

(N - Number of replicates) .

$D_{.01}$ (Minimum difference required for significance between any two means at 1% level) = $t_{.01} \times S.E_D$

$S.D_W$	$S.E_D$	$t_{.01}$	$D_{.01}$	M_m	M_j	M_w
1.53	0.97	3.06	3.00	41.30	35.20	31.58

M_m , M_j and M_w refer to the mean scores of cauliflower stored in the mechanical refrigerator, Janata refrigerator and wire-meshed cupboard, respectively.

Significance of mean Differences.	D_m and $_j$ = 6.6 $> D_{.01}$		$P < 0.01$
	D_j and $_w$ = 3.62 $> D_{.01}$		$P < 0.01$
	D_m and $_w$ = 10.12 $> D_{.01}$		$P < 0.01$

APPENDIX XV

ANALYSIS OF VARIANCE FOR THE TOTAL SCORES OF TOMATO AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES

Sources of variation.	Sum of squares.	Degree of freedom	Mean square
Between storage devise.	28.43	2	14.215
Within replicates	4.17	6	0.69
F: 20.46		P < 0.01	

Tests for significance of mean differences by use of 't'.

$S.D_W$	$S.E_D$	$t_{.01}$	$D_{.01}$	$t_{.05}$	$D_{.05}$	M_m	M_j	M_v
0.83	0.68	3.71	2.52	2.45	1.66	74.16	72.50	70.00

D_m and $_j$ = 1.66 $= D_{.05}$ P = 0.05

D_j and $_v$ = 2.50 $> D_{.05}$ P < 0.05

D_m and $_v$ = 4.16 $> D_{.01}$ P < 0.01

APPENDIX XVI

ANALYSIS OF VARIANCE FOR TOTAL SCORES OF BEANS AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES

Sources of variation.	Sum of squares.	Degree of freedom	Mean square
Between storage device	1419.76	2	709.88
Within replicates	184.00	12	15.33
$F = 46.31$		$P < 0.01$	

Tests for significance of mean differences by use of 't'

$S.D_W$	$S.E_D$	$t_{.01}$	$D_{.01}$	$t_{.05}$	$D_{.05}$	M_m	M_j	M_w
3.90	2.48	3-06	7.95	2.18	5.40	71.0	65.60	48.20

D_m and $_j$ = 5.4 = $D_{.05}$ $P = 0.05$

D_j and $_w$ = 17.4 $>$ $D_{.01}$ $P < 0.01$

D_m and $_w$ = 22.8 $>$ D $P < 0.01$

APPENDIX XVII

ANALYSIS OF VARIANCE FOR TOTAL SCORES OF GREEN CHILLIES AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Sources of variation	Sum of squares.	Degree of freedom	Mean square
Between storage devices	251.96	2	125.98
Within replicates	85.68	12	7.14

$F = 17.59$ $\qquad P < 0.01$

Tests of significance of mean differences by use of 't'.

$S.D_W$	$S.E_D$	$t_{.01}$	$D_{.01}$	$t_{.05}$	$D_{.05}$	M_m	M_j	M_w
2.67	1.69	3.06	5.17	2.18	3.68	43.20	40.18	33.28

D_m and $_j$ = 3.02 $\quad D_{.05}$ $\quad$ not significant

D_j and $_w$ = 6.90 $\quad D_{.01}$ $\quad$ P 0.01

D_m and $_w$ = 9.92 $\quad D_{.01}$ $\quad$ P 0.01

APPENDIX XVIII

ANALYSIS OF VARIANCE FOR TOTAL SCORES OF CARROT AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES

Sources of variation.	Sum of squares	Degree of freedom	Mean square
Between storage devices	702.15	2	351.08
Within replicates.	87.26	12	7.27
	F = 48.28	P < 0.01	

<u>Tests of significance of mean differences by use of 't'.</u>

$S.D_W$	$S.E_D$	$t_{.01}$	$D_{.01}$	$t_{.05}$	$D_{.05}$	M_m	M_j	M_w
2.[illegible]97	1.[illegible]	3.06	5.23	2.18	3.71	43.76	39.3	27.54

D_m and $_j$ = 4.46 > $D_{.05}$ $P < 0.05$

D_j and $_w$ = 11.76 > $D_{.01}$ $P < 0.01$

D_m and $_w$ = 16.22 > $D_{.01}$ $P < 0.01$

APPENDIX XIX

ANALYSIS OF VARIANCE FOR TOTAL SCORES OF BITTER GOURD AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Sources of variation	Sum of squares.	Degree of freedom	Mean square
Between storage devices	657.3	2	328.65
Within replicates	867.70	12	72.31
$F = 4.55$		$P < 0.05$	

Tests of significance of mean differences by use of 't'.

$S.D_W$	$S.E_D$	$t_{.01}$	$D_{.01}$	$t_{.05}$	$D_{.05}$	M_m	M_j	M_v
8.50	5.80	3.06	17.8	2.18	12.65	36.72	29.55	20.54

D_m and $_j$ = 7.17 $< D_{.05}$ not significant

D_j and $_v$ = 9.01 $< D_{.05}$ not significant

D_m and $_v$ = 16.18 $> D_{.05}$ $P < 0.05$

APPENDIX XX

ANALYSIS OF VARIANCE FOR TOTAL SCORES OF CLUSTER BEANS AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES

Sources of variation	Sum of squares.	Degree of freedom	Mean square.
Between storage devices	306.56	2	153.28
Within replicates	291.67	12	24.31
$F = 6.32$		$P < 0.05$	

Tests for significances of mean differences by use of 't'.

$S.D_W$	$S.E_D$	$t_{.01}$	$D_{.01}$	$t_{.05}$	$D_{.05}$	M_m	M_j	M_w
4.93	3.12	3.06	9.55	2.18	6.798	52.00	47.69	41.01

D_m and $_j$ = 4.31 $<$ $D_{.05}$ not significant

D_j and $_w$ = 6.68 $<$ $D_{.05}$ not significant

D_m and $_w$ = 10.99 $>$ $D_{.01}$ $P < 0.01$

APPENDIX XXI

ANALYSIS OF VARIANCE FOR TOTAL SCORES OF BEETROOT AFTER 72 HOURS OF STORAGE IN THE THREE DEVICES.

Sources of variation.	Sum of squares	Degree of freedom	Mean Square
Between storage devices	295.71	2	148.35
Within replicates	170.63	12	14.22
$F = 10.43$		$P < 0.01$	

Tests for significance of mean differences by use of 't'

$S.D_W$	$S.E_D$	$t_{.01}$	$D_{.01}$	$t_{.05}$	$D_{.05}$	M_m	M_j	M_w
3.73	2.38	3.05	7.28	2.18	5.19	42.24	40.76	32.18

D_m and D_j = 1.48 $< D_{.05}$ not significant

D_j and D_w = 8.58 $> D_{.01}$ $P < 0.01$

D_m and $_w$ = 10.06 $> D_{.01}$ $P < 0.01$

APPENDIX XXII

ANALYSIS OF VARIANCE FOR TOTAL SCORES OF BRINJALS AFTER 72 HOURS OF STORAGE IN THE JANATA REFRIGERATOR AND IN THE WIRE MESHED CUPBOARD.

Sources of variation	Sum of squares.	Degree of freedom	Mean square
Between storage device	172.23	1	172.23
Within replicates	131.3	8	16.41

$F = 10.49$ $\quad P < 0.05$

<u>Test for significance of difference by use of 't'</u>

$t = \sqrt{F} = 3.24$ $\quad P < 0.05$

$t_{.01} = 3.36$ $\quad t_{.05} = 2.31$

APPENDIX XXIII

ANALYSIS OF VARIANCE FOR TOTAL SCORES OF LADIES FINGER AFTER 72 HOURS OF STORAGE IN THE JANATA REFRIGERATOR AND IN THE WIREMESHED CUPBOARD.

Sources of variation	Sum of squares.	Degree of freedom	Mean square
Between storage device	445.75	1	445.75
Within replicates	14.65	8	1.83

$F = 243.5$ $\quad P < 0.01$

$t_{.01} = 3.35$ $\quad t = \sqrt{F} = 15.5$[illegible] $\quad P < 0.01$

APPENDI

ASCORBIC ACID CONTE
72 HOURS OF STORAGE IN

Repli- cates.	Initial content of ascorbic acid in mg/100 g	Weight Initial
1	44.5	99.50

APPENDIX XXV

ASCORBIC ACID CONTENT OF CABBAGE AFTER 72 HOURS OF STORAGE IN JANATA REFRIGERATOR.

Replicates	Initial content of ascorbic acid in mg.	Weight of Cabbage		Ascorbic acid content in mg.		Mean
		Initial	After 72 hours	Apparent	actual (After correction)	
1	44.5	125.1	119.2	45.51 45.50 43.33 44.24	40.83 40.36 39.13 39.68	40.0
2	49.98	118.25	108.6	47.10 46.74 45.52 46.20	43.24 42.91 41.79 42.42	42.34
3	53.97	120	108.5	49.11 49.91 46.68 48.7	44.41 45.13 44.93 4[illegible].03	44.63
4	50.00	196.6	183.1	45.57 44.83 46.04 45.67	42.44 41.76 42.88 42.54	42.41
5	47.99	136.6	125.3	43.60 43.30 41.51 41.59	40.00 39.73 38.07 38.14	38.99

APPENDIX XXVI

ASCORBIC ACID CONTENT OF CABBAGE AFTER 72 HOURS OF STORAGE IN WIRE-MASHED CUPBOARD.

Replicates	Initial content of ascorbic acid in mg	Weight of Cabbage in g		Ascorbic acid content in mg		Mean
		initial	after 72 hours	apparent	actual after correction	
1	44.5	124.5	88.2	50.79	36.01	36.1
				51.58	[illegible]	
				52.74	35.11	
				50.59	35.86	
2	49.98	147.7	109.25	50.55	37.40	37.31
				53.93	39.90	
				47.22	34.93	
				50.03	37.03	
3	53.97	124	76.35	64.10	39.48	39.53
				64.21	39.58	
				62.56	38.62	
				65.85	40.54	
4	50.00	175.2	134.2	50.72	38.85	37.75
				48.17	36.90	
				49.62	38.00	
				48.63	37.25	
5	47.99	114.1	88.4	41.82	32.41	32.53
				41.72	32.32	
				42.20	32.70	
				42.71	33.09	

APPENDIX XXVII

ANALYSIS OF VARIANCE FOR PERCENTAGE LOSS OF ASCORBIC ACID IN CABBAGE ON STORAGE FOR 72 HOURS IN THE THREE STORAGE DEVICES

Source of variation	Sum of squares.	Degree of freedom	Mean of squares
Between storage devices	863.90	2	431.95
Within replicates (error)	136.47	12	11.37
F = 38.00			P < 0.01

Test for significance of differences by use of 't'.

$$t = \frac{M_I - M_{II}}{\sqrt{\frac{\Sigma x_1^2 + \Sigma x_2^2}{N (n-1)}}}$$

M_I	M_{II}	M_{III}	Σx_1^2	Σx_2^2	Σx_3^2	$t_{.01}$
6.96	15.34	25.89	4.11	43.73	88.93	3.36

For mean differences $d_f = N_1 + N_2 - 2 = 8$; $t_{.01} = 3.36$

t_I and t_{II} = 12.52 > 3.36

t_{II} and t_{III} = 12.70 > 3.36

t_I and t_{III} = 27.38 > 3.36

M_I = mean percentage loss of ascorbic acid in cabbage stored in mechanical refrigerator.

M_{II} = mean percentage loss of ascorbic acid in cabbage stored in the Janata refrigerator.

M_{III} = mean percentage loss of ascorbic acid in cabbage stored in wire-meshed wire-meshed cupboard.

APPENDIX XXVIII

VARIATIONS IN THE RELATIVE HUMIDITY, ROOM TEMPERATURE AND TEMPERATURE IN THE JANATA REFRIGERATOR AND WIRE-MESHED CUPBOARD IN THE COURSE OF THE DAY.

(Temperature in degree Centigrade)

Time	Relative humidity	Room temperature.	Temperature in Janata refrigerator	Deviation from room temperature	Temperature in wiremeshed cupboard.	Deviation from room temperature
12 Noon	57.5	23.75	19.75	- 4.00	23.50	- 0.25
1 p.m.	53.0	23.75	19.25	- 4.50	23.75	..
2	57.5	24.00	20.25	- 3.75	24.00	..
3	57.5	24.25	20.50	- 3.75	24.50	+ 0.25
4	57.5	24.75	21.00	- 3.25	25.00	+ 0.75
5	57.5	24.25	20.50	- 3.75	24.50	+ 0.25
6	63.0	24.00	20.50	- 3.50	24.00	..
7.	53.0	24.00	20.50	- 3.50	24.00	..
8.	63.0	23.75	20.50	- 3.25	23.50	- 0.25
9.	64.5	23.75	20.00	- 3.50	23.25	- 0.50
10.	64.5	23.75	20.25	- 3.50	23.75	..

APPENDIX XXIX

VARIATIONS IN THE RELATIVE HUMIDITY, ROOM TEMPERAT[illegible] TEMPERATURE IN THE JANATA REFRIGERATOR AND WIRE-MESHED CUPBOARD IN THE COURSE OF THE DAY.

Time	Relative humidity	Room temperature.	Temperature in Janata Refrigerator	Deviation from room temperature	Temperature in wire-meshed cupboard	Deviation from room temperature.
6 a.m.	76	22	18.75	- 3.25	21.5	- .5
7	76	22	19.0	- 3.0	21.5	- .5
8	76	22	19.0	- 3.0	21.5	- .5
9	76	22	19.75	...	22	...
10	70	32.5	19	- 3	22	- .5
11	72	23	19	- 3.75	22.75	- .25
12	59.5	23.75	19.75	- 3.75	23.5	- .25
1 p.m.	60.5	23.75	19.25	- 4.5	23.75	...
2	63	24.00	20.25	- 3.75	24.00	...
3	63	24.25	20.50	- 3.75	24.5	+ .25
4	53.5	24.25	21.00	- 3.25	25.[illegible]	+ .75
5	53.5	24.25	20.5	- 3.75	24.5	+ .25
6	45	24.25	21.0	- 3.25	24.5	+ .25
7	65	24.25	21.0	- 3.25	24.0	- .25
8	71	24.25	21.0	- 3.25	24.0	- .25
9	39	24.25	21.0	- 3.25	24.0	- .25
10	72.5	23.5	21.0	- 2.5	23.5	...

APPENDIX XXX

VARIATIONS IN THE RELATIVE HUMIDITY, ROOM TEMPERATURE AND THE TEMPERATURES IN THE JANATA REFRIGERATOR AND WIREMESHED CUPBOARD IN THE COURSE OF THE DAY.

Time	Relative humidity	Room temperature	Temperature in the Janata Refrigerator	Deviation from the room temperature	Temperature in the wire-meshed cupboard.	Deviation from the room temperature.
7 a.m.	78	23	20.25	- 2.75	23	...
8	77	23	20.25	- 2.75	22.5	- .5
9	77	23.25	20.5	- 2.75	22.75	- .5
10	69	24.50	20.5	- 4.0	23.75	- .75
11	70	23.25	21.75	- 2.5	24.25	-1.0
12	68	25.0	21.5	- 3.5	24.25	- .75
1 p.m.	63	26	21.5	- 4.5	24.75	-1.25
2	63	25	22	- 3.0	24.75	- .25
4	64.25	25	22.25	- 2.25	25.25	+ .25
5	64	25.25	22.25	- 3.0	24.75	-1.0
6	64.25	25.25	22.25	- 3.0	24.75	- .5
8	74	25	22.25	- 2.75	24.5	-0.5
9	76	25	22.25	- 2.75	24	-1.0
10	75.75	25	22.75	- 2.25	24	-1.0

APPENDIX XXXI

VARIATIONS IN THE RELATIVE HUMIDITY, ROOM TEMPERATURE AND THE TEMPERATURES IN THE JANATA REFRIGERATOR AND WIRE-MESHED CUPBOARD IN THE COURSE OF THE DAY.

Time	Relative Humidity	Room Temperature	Temperature in the Janata Refri-gerator.	Deviation from room temper-ature	Temperat-ure in the wire-meshed cupboard	Deviation from the room tempera-ture
6.00	86	24	22	- 2.0	23	- 1.0
7	86	24	22	- 2.0	23	- 1.0
8	86	24	22	- 2.0	23.25	- .75
9	86	24.25	22.25	- 2.0	23	- 1.25
10	82	24.25	22.50	- 2.0	23.25	- 1.00
11	78	25.25	22.75	- 1.75	24	- 0.5
12	68	25.25	21.50	- 3.75	25	- .25
1.00	68	24.50	22.75	- 2.5	25	- .5
2	70	25.75	22.50	- 2.0	25.50	+ 1.0
3	66	25.75	22.75	- 3.0	25.75	..
4	68	25.50	22	- 3.5	25.25	- .25
5	68	25.50	22	- 3.25	25.00	- .50
6	72	25.25	22	- 3.25	25.00	- .25
7	74	25	22	- 3.0	24.50	- .50
8	78	25	22	- 3.0	24.25	- .75
9	71	25	22	- 3.0	24.25	- .75
10	80	24.25	22	- 2.75	23.75	- 0.50

APPENDIX XXXII

VARIATIONS IN THE RELATIVE HUMIDITY, ROOM TEMPERATURE AND THE TEMPERATURE IN THE JANATA REFRIGERATOR AND WIRE-MESHED CUPBOARD IN THE COURSE OF THE DAY.

Time	Relative Humidity	Room Temperature	Temperature in the Janata refrigerator.	Deviation from the room temperature.	Temperature in the wire-meshed cupboard.	Deviation from the room temperature
6.00	84	23.5	21.5	- 2.0	23.0	- .5
7	83.5	23.5	21	- 2.5	23.0	- .5
8	83	23.5	21.00	- 2.5	23.0	- .5
9	90	24	21.25	- 2.75	23.5	- .5
10	90	24	21.00	- 3.0	23.5	- .5
11	95	24.5	21.25	- 2.25	24	- 0.5
12	74	25	21.75	- 3.75	24	- 1.0
1.00	55.5	25.25	21.75	- 3.5	24.75	- .50
2	56	25.75	22.50	- 3.25	25	- .75
3	52	26.0	24.0	- 4.0	25.25	- .75
4	57.5	25.75	22.25	- 3.5	25	- .75
5	57	26	22.25	- 3.75	25.25	- .75
6	62.5	25.5	22.25	- 3.25	25	- .5
7	70	23.5	22	- 3.5	25	- .5
8	64	26	22.5	- 3.5	25	- 1.0
9	56	25.75	22.5	- 3.25	25	- .75
10	70	25.5	22	- 3.5	25	- .5