DEPARTMENT OF SCIENCE AND TECHNOLOGY

TECHNOLOGY SYSTEMS DEVELOPMENT PROGRAM

PROJECT PROGRESS REPORT

DST File No : DST/ TSG/ TC/ 2007/ 39

Title: Rejuvenation of Traditional Pottery making by applying Advanced Biotechniques

Submitted by

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CONTENTS

PROJECT COMPLETION REPORT

1. DST File No : **DST/ TSG/ TC/ 2007/ 39**

2. Project Title : **Rejuvenation of traditional pottery making by applying advanced biotechniques**

3. Principal Investigator : Dr.A.J.A.Ranjit Singh

4. Date of commencement : 01.12.2008.

5. Planned date of completion : 01.12.2010.

6. Actual date of completion : 31.03.2011.

7. Implementing Institution : Sri Paramakalyani College

8. Objectives stated in the proposal and met:

Objectives	Objectives met
1. Development of different prototype models for zero energy cooling chambers, (EPCC) and other utensils.	✓
2. Evaluation of Organoleptic, biochemical analysis and shelf life period of consumables kept at the prototype EPCC.	✓
3. Analysis of various elements in the soil to test their qualities.	✓
4. Isolation of microbes in different soils to process soil and to make Varieties of pots.	✓ ✓
5. Incorporation of effective microbes in herbal product and pottery product, training to the artisans	

OBJECTIVES MET DETAILS

A. BRIEF ACCOUNT

Development of different prototype models for zero energy coolly chamber and other utensils

Low cost earthenware storage chambers	1. Zero energy cool chambers to store vegetables and fruits for kitchen use were developed. Five types of storage chambers were developed and their efficacy to store different fruits and vegetables were tested. 2. Organoleptic qualities, Biochemical qualities and shelf-life period were tested over time for the various stored products and these characteristics were compared with refrigeration. 3. Earthenware storage chamber that retained the expected results were promoted for bulk production by pottery artisans in the nearby places.
Production of value added kitchen utensils	By using a different methods for clay preparation • Micro-oven usable clay pottery products were developed so as to use them in modern kitchen. (Bowls, pots). The fuel efficiency was tested with other micro oven usable vessels. • Frying pans, idly pans, dosa taa, tea cups, attractive water storage bottles, mugs, table water pots (12 items) were prepared and their qualities were tested. To prepare these products black pottery technology was developed and used. As these products have good market value, we have trained the artisans to manufacture these products to earn a good income.
Ornamental / cosmetic products designing and development.	To earn a good income from a small amount of clay, technologies were developed to prepare several ornamental items like neck chain, ear studs, bracelets etc. The local women potters were trained. These products have a good demand and an avenue for bulk selling is looked into.
Alternative to conventional items – Novel products from clay were designed and developed so as to sell them for good price.	• Decorative bells-Vasthu bells making different sounds. • Clay distillation units. • Magic clay kettle. • Clay religious products. • Light shades. • Music instruments (Racho).

B. DETAIL OF ACHIEVEMENT OF OBJECTIVE – I

1. DESIGN AND DEVELOPMENT OF EARTHENWARE ZERO ENERGY STORAGE SYSTEM (EWSS)

1.B.1 INTRODUCTION

Storage of post-harvested products at a mass scale or home hold level till it decorates table, become necessary to avoid spoilage. Microbial spoilage paves way for much food-borne illness. Further deterioration of biochemical and Organoleptic qualities in fruits and vegetables due to improper preservation lead to poor taste and consumer's rejection. All home makers feel happy and get rid of kitchen stress if they get fruits and vegetables afresh every day. As getting time is difficult to go for shopping at every day morning for employed couples, weekly purchase and storage of fruits and vegetables has become an order of the day. To store the fruits and vegetables for a week, refrigerators or minicold storages are used. All these gadgets consume electricity and emit pollutants like climate change threatening chlorofluorocarbon (CFC).

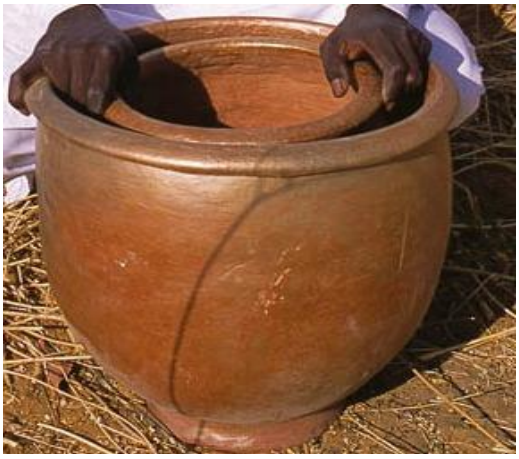
Hence it has become necessary to develop eco-friendly, economic and, none electrically operated system to store the products. With these concern efforts has been made to rejuvenate the dying art of pottery making by giving a new avenue to develop earthenware storage systems. Before the advent of electricity and refrigerator, people used traditional system of storage using pots. Hence in the present study a clay pottery making technologies are to be used to develop a earthenware storage systems /pots that can be used in lieu of refrigerators.

1.B.2 MODELS OF EARTHENWARE STORAGE SYSTEMS

These are simple designs of evaporative coolers developed by Abba, 2006. This can be used in the household storage. This ingenious technique that requires no external energy supply to preserve fruits and vegetables and other perishables in hot, arid climates. (Fig 2.3 a.)

This innovative cooling system consists of two earthenware pots of different diameters, one placed inside the other. The space between the two pots is filled with water and soil that is kept constantly moist, thereby keeping both pots damp. Fruits and vegetables and other items such as soft drinks are put in the smaller inner pot, which is covered with a lid with some holes for ventilation to the fruits and vegetables. The phenomenon that occurs is based on a simple principle of physics: The water contained

between the two pots evaporates towards the outer surface of the larger pot where the drier outside air is circulating. By virtue of the laws of thermodynamics, the evaporation process automatically causes a drop in temperature of several degrees, cooling the inner container, destroying harmful microorganisms and preserving the perishable foods inside. The inside of the smaller pot cools due to evaporation of the water and the temperature inside the pot is 5–6ºC compared to the ambient temperature outside during a dry hot day. The inner pot stores food that is kept cool.



We have developed a clay refrigerator.
This clay refrigerator is a lidded earthenware pot fitted inside a large pot with an insulating layer of sand in Between.
This sand layer is kept cool by adding water at regular intervals (twice a day). This ceramic refrigerator has proved very successful and it has been tested with a number of different vegetables. In this refrigerator tomatoes were kept fresh for 3 weeks

We have developed an evaporative cool chamber with the help of baked bricks and riverbed sand. Inside the chamber the temperature was about 10-15 0 C lower than outside temperature and inside humidity was about 30-40% higher than ambient condition. It has been recorded that weight loss of fruits and vegetables kept inside the chamber was lower than stored outside the chamber. The fruits and vegetables were fresh up to 3to5 days on the inside the chamber than outside.

Mitticool Model

Prajapathy (2009) of Gujarat, India has developed a mini refrigerator using clay. This unit is similar to modern clay fridge (Fig. 2.3.d.). Verma et al., (2001) studied the effectiveness of zero energy cool chamber to store the flower Chryanthemum and reported a 8.25 percent physiological loss of weight (PLW) in 73 h. and 7.18% PLW in 29 cold storage after 72h. After putting wax wrapper. According to Panhwar, (2006) post harvested fruits and vegetables of tropical origins must be stored above 120C. This is in contrast to plants which have evolved in temperate cooler climate which can be stored at 00C. In tropical countries the recommended temperature for storing grapes, banana, tomato, is 100C +. Bureau, (2009) had developed a technology for zero energy cool chambers as an alternative to refrigerator to store fresh fruits, vegetables and flowers to extend their marketability.

Earthenware storage system developed in the present study

In the present study new designs were conceived to create three types of Zero energy earthenware storage system (EWSS) that suits Indian environment and economic conditions. In these EWSS different types of tropical fruits and vegetables were stored. The shelf-life period within which the fruits and vegetables remain fresh, sustains physiological weight changes, biochemical and Organoleptic qualities were studied.

Designs of Earthenware storage system

For making earthenware storage systems, clay was collected from different ponds near Alwarkurichi. Dry clay was collected from the floor of the pond. Clay was collected from ponds in Vagaikulam, Achenkulam and Karunai river bed.

The chemical constituents in the clay used were given in chapter 5. The clay and sand collected from different sites and were dried in sun to make a powder form. The clays were then mixed in 80:20 (80 percent clay collected from Vagaikulam and Achenkulam and 20 percent Karunai river bed sand) proportions to get a homogenous mass. This is known to the potters as *Body.*

The mixture was charged into ball mills for the grinding up to the desired fineness. Water was added in the grinding process carefully. About 30 to 35 percent of water is first added on the basis of the materials put into the ball mill and 10 to 15

percent more water is added for proper flow of the ground slip. After the materials had been ground to their respective fineness, they were kept in separate tanks in the liquid or slip condition. The liquid clay mix was taken in a separate tank and it was left in it for 3 days to promote fermentation that makes the body soft to. The slip was then de-watered using filter press. The slip was made stiffer for further use.

The de-watered cakes of clay mass that come out of the filter press had the consistency of thick paste. The clay mass was put into kneading machine or a pug mill. The main function of these machine are to press the clay mass so as to squeeze out the air bubbles enclosed within the mass and to make the consistency of the body homogenous specially with regard to the water content. The workability of the clay mass or body was greatly improved by this operation.

After pugging the body was ready for throwing or jolleying. In throwing the claywares are shaped by hand on a rotating potter's wheel. The clay mass for throwing should be stiff enough for article not to lose the shape, under its own weight, yet it should be soft enough to yield easily to the pressure of the hand. Good throwing is of highest importance as the defects arising from any inequality of pressure of the thrower's hand do not show themselves before drying or firing. Throwing was followed by turning. It is a process of shaping on a lathe when the body is wet and is employed when accuracy of form is wanted. After truing and the properly shaped clayware were obtained, the clayware were dried. When the clayware got light colour after drying, it was taken to firing.

Modified Earthenware Storage System (EWSS2)

This unit is single pot structure. In this unit the exterior of the pot has two water holding ring like jackets. One at the rim and the other just a beneath the rim. To this ring like jackets 1 liter of water is added. The capacity of this unit is 8 liters. The water in the

ring like jackets provides coolness while the water moves by capillary action in the wall of chamber. Inside this modified unit fruits and vegetables can be stored. This unit occupies less space. The lid of the unit can be easily handled and it has air holes for air passage inside out or vice versa. Under the bottom of the unit an air hole of 2 cm diameter is present and this unit is placed on a hollow clay base. This permit air flow in to the system. Inside this unit the relative humidity was 90±3 % and temperature was 5 ± 2 o C less than ambient temperature.

Fig.2.5. Modified earthernware storage system (EWSS-2)

1.B.3 STRUCTURE OF EARTHERNWARE DESIGNED FOR STORAGE

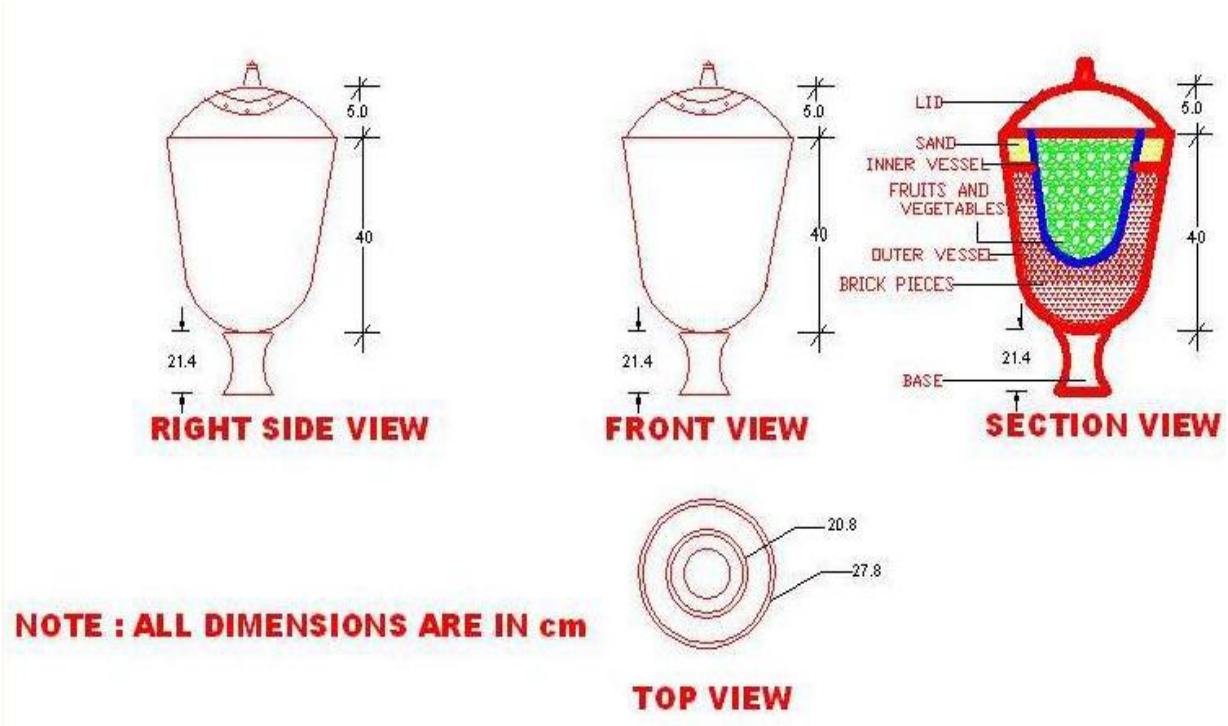
For the present study 3 models of clay wares were designed and designated as

1. Basic model Earthenware storage system (EWSS1)
2. Modified Earthenware storage system (EWSS2)
3. Pyramid type Earthenware storage system (EWSS3)

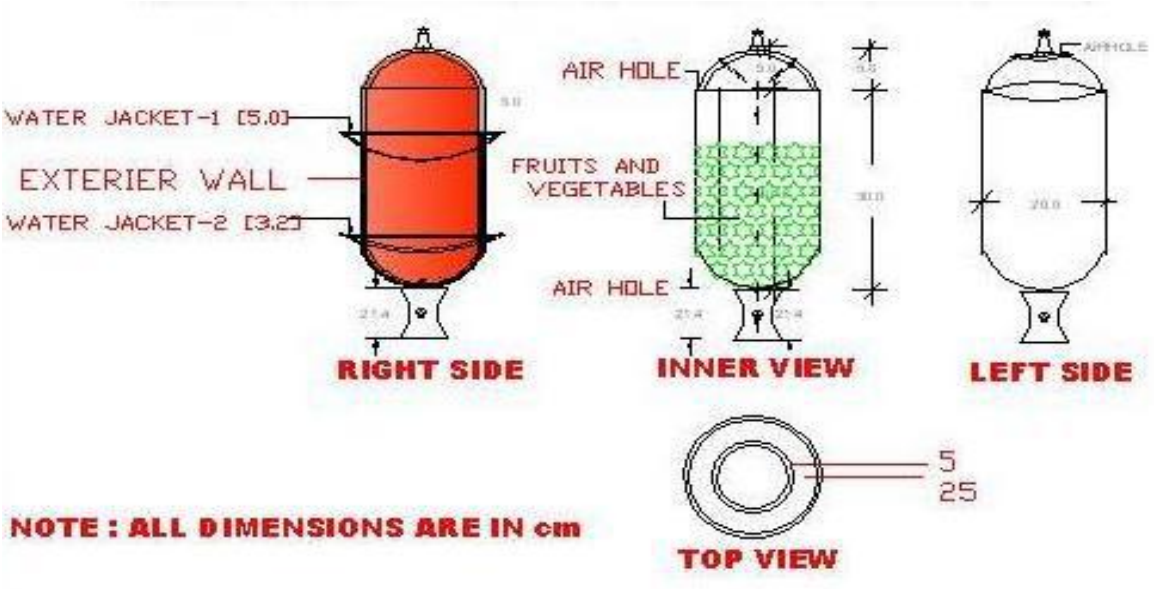
Basic Model Earthenware Storage System (EWSS1)

This unit is a double pot structure, having an inner pot and an outer pot. In between the inner and outer sides of the pots a narrow gap of 5 cm was left. At the bottom 15 cm gap is maintained. In the gap, broken and moist pieces of bricks and a top layer of river bed sand were kept to give cooling effect. The inner and outer chamber was covered with a common lid that had few holes so as to facilitate the air movement. In the inner chamber, vegetables and fruits are stored. The capacity of this chamber is 5 liters. Inside this chamber the relative humidity was in the range 80 ± 2 % and the temperature was normally 5 to 6 o C lower than the ambient temperature. As the capacity in this model is less and difficult to handle a modified model with less weight was designed.

MODIFIED EARTHENWARE STORAGE SYSTEM (EWSS1)



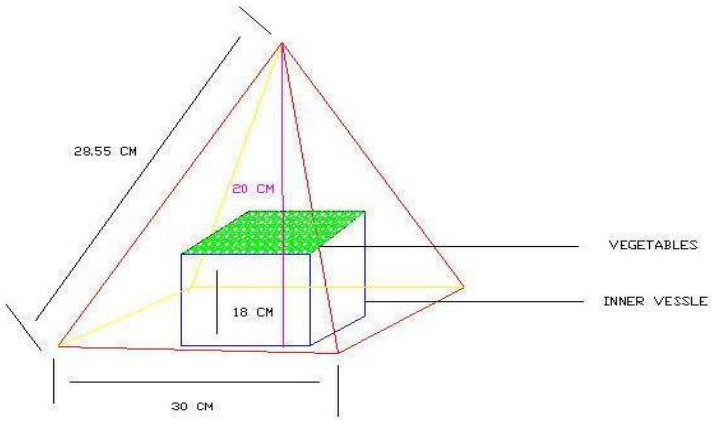
MODIFIED EARTHENWARE STORAGE SYSTEM (EWSS2)



Pyramid Type Earthenware Storage System (EWSS3)

In this unit the vegetables and fruits can be kept in a clay bowl of 3 liters capacity. The bowl was covered by a pyramid unit made of clay. The pyramidal unit covers the entire clay bowl. The bowl is kept at a height inside the pyramid where magnetic forces will be high. The pyramid shaped outer cover is provided with 0.5 cm diameter air holes (2 numbers on each side).

PYRAMID TYPE EARTHENWARE STORAGE SYSTEM (EWSS3)



In the present study different types of earthenware storage systems (EWSS) were tested for their efficiency to reduce microbial load/spoilage in household fruits and vegetables. The fruits and vegetables were also pretreated with disinfectants and stored in earthenware storage system. The microbial load in EWSS stored products were compared with other storage systems like refrigerator and ambient conditions.

4. OBJECTIVES – II

BIOCHEMICAL CHARACTERISTICS, ORGANOLEPTIC QUALITIES AND PHYSIOLOGICAL WEIGHT CHANGES IN FRUITS AND VEGETABLES STORED IN DIFFERENT STORAGE SYSTEMS

INTRODUCTION

Optimum health demands an adequate intake of all macro and micronutrients. Utilization of one nutrient is often dependent on the adequate supply of some other nutrient. Deficiency of any one of the nutrients, therefore, affects the entire metabolic machinery. Micronutrient malnutrition is a serious public health problem in the country. Food based approach, using foods naturally rich in micronutrients, is one of the strategies for combating micro nutritional deficiencies (Renuka Chowdhury, 2009). The consumption of foods that are important source of micronutrients, like fruits and vegetables, is low in Indian population, particularly among women and children. Enhancing consumption of fruits and vegetables and green leafy vegetables in daily dietary pattern, which are the rich source of micronutrients, dietary fibre and antioxidants, would contribute significantly in reducing the problem of micronutrient malnutrition among the masses.

Although India is the second largest producer of fruits and vegetables in the world, per capita consumption is less. Because of varied agroclimatic conditions. Some fruits and vegetables are available in glut in one season and disappear thereafter. The home scale preservations of these fruits and vegetables however, could make them available thought the year at the house-hold level. At least short term storage of fruits and vegetables in home will reduce the burden of cooking to a great extent.

When fruits and vegetables are stored in storage chambers like refrigerators or earthenware storage system or in ambient condition there should not be any loss in biochemical qualities and Organoleptic properties or at least such losses should be minimum to enhance consumers preference and their nutritional balance. Hence it is essential to evaluate the biochemical characteristics like protein, carbohydrates, lipids, sugars, vitamins minerals, fiber content etc, in the fruits and vegetables before and after the storage process. If any biochemical deterioration is noticed due to storage that can be reduced by using pretreatment of products before storage. Organoleptic characters like appearance of skin colour, flavour, texture and taste, etc provide consumer preference for

any products. Such qualities should be retained well during storage, lest their usage will be minimum after storage.

The taste, odor and appearance of a food are the ultimate criteria used by consumers to judge a foods acceptability. The Organoleptic quality of a food changes as its micro-flora bacteria, yeast, and mold-grow and metabolize available nutrients. The sensory changes at first might be subtle, but they eventually make the food unacceptable (Ghosh, 1993) Hence the storage system must be sterile or they should not enhance microbial growth fastly. Normally storage temperature and relative humidity determines the length of microbiological shelf-life of perishable foods.

Fruits and vegetables continue their physiological activities even after plucking and storage. If the storage fails to minimize the physiological weight loss, their consumer preference is limited. So a good storage system should reduce the physiological loss of weight during storage.

To make short term preservation of fruits and vegetables at domestic levels, economic, eco-friendly and efficient storage is needed. As fruits and vegetables get spoiled easily due to enzymatic changes and microbial growth, the storage system has a role to reduce such changes during storage. With this three objectives the efficiency of the earthenware storage system to minimize the loss of biochemical constituents, retention of Organoleptic properties and physiological weight was tested and it was compared with other methods of storage like refrigeration and ambient conditions.

Details collected from experiment – given in Table 4.1-4.24, Fig 4.1-4.5

Table 4. 1
BIOCHEMICAL CHANGES IN GRAPHS DURING DIFFERENT STORAGE PERIOD

S.No	Types of storage	Carbohydrate Concentration mg/g					Protein Concentration mg/g					Vitamin Concentration mg/g				
		Storage days					Storage days					Storage days				
		0	1	3	5	7	0	1	3	5	7	0	1	3	5	7
	Room temperature	180±3	165±3 (8.33)	160±2 (11.11)	153±2 (15.00)	148±1 (17.17)	6±1	4.5±.4 (25.00)	4.0±0.2 (33.33)	3.8±0.3 (36.66)	3.3±0.2 (45.00)	3±0.8	2.8±0.7 (6.66)	2.2±0.8 (23.33)	2.0±0.6 (33.33)	1.8±0.7 (40.0)
	Refrigerator	180±3	175±2 (2.77)	171±2 (5.00)	168±2 (6.66)	161±2 (10.55)	6±1	5.5±0.3 (8.33)	5.00±0.3 (16.66)	4.8±0.2 (20)	4.3±0.1 (28.33)	3±0.8	2.9±0.6 (3.33)	2.6±0.8 (6.66)	2.4±0.8 (10.00)	2.1±0.7 (30.00.)
	EWSS1	180±3	177±3 (1.66)	173±3 (3.88)	169±3 (6.11)	165±2 (8.33)	6±1	5.6±0.3 (6.6)	5.3±1 (11.6)	4.9±0.2 (1)	4.7±0.2 (21.66)	3±0.8	2.8±0.1 (2.22)	2.6±0.9 (6.66)	2.5±1 (16.66)	2.3±0.7 (23.33)
	EWSS2	180±3	176±1 (2.22)	174±2 (3.33)	171±2 (5.00)	168±3 (6.66)	6±1	5.8±0.2 (3.33)	5.6±0.4 (6.66)	5.2±0.2 (13.33)	4.9±0.2 (18.33)	3±0.8	2.9±0.8 (3.33)	2.9±0.6 (3.3)	2.7±0.8 (10.00)	2.5±0.4 (16.66)
	PEWSS	180±3	178±2 (1.11)	175±2 (2.77)	172±2 (4.44)	170±2 (5.5)	6±1	5.8±0.2 (1.66)	5.6±1 (6.66)	5.6±0.1 (6.66)	5.3±0.1 (11.66)	3±0.8	3±0.3 (0.00)	2.8±0.6 (6.66)	2.7±0.7 (10.00)	2.5±0.9 (16.66)

(Percentage changes over control is given in parenthesis)

Table 4. 2
BIOCHEMICAL CHANGES IN BANANA DURING DIFFERENT STORAGE PERIOD

S.No	Types of storage	Carbohydrate Concentration mg/g					Protein Concentration mg/g					Vitamin Concentration µg/g				
		Storage days					Storage days					Storage days				
		0	1	3	5	7	0	1	3	5	7	0	1	3	5	7
	Room temperature	790±3	765±3 (3.16)	653±2 (17.34)	642±3 (18.73)	602±3 (23.79)	40±2	35±1 (1.25)	31±2 (2.25)	24±1 (4.00)	19±1 (5.25)	70±3	67±2 (4.28)	63±1 (10.00)	58±2 (17.40)	53±1 (24.28)
	Refrigerator	790±3	783±2 (0.88)	7.68±3 (2.78)	753±2 (4..68)	7.31±2 (7.46)	40±2	36±1 (10.00)	33±1 (17.50)	29±2 (27.50)	2.6±1 (35.00)	70±3	69±2 (1.42)	60±1 (14.28)	53±3 (24.28)	50±1 (28.55)
	EWSS1	790±3	779±3 (1.39)	770±3 (2.53)	764±2 (3.29)	7.50±3 (5.06)	40±2	37±2 (7.50)	34±2 (15.00)	30±1 (25.00)	28±0.9 (30.00)	70±3	66±1 (5.7)	61±2 (12.85)	57±1 (18.57)	53±2 (24.28)
	EWSS2	790±3	782±4 (1.01)	778±3 (2.02)	768±3 (2.78)	743±2 (4.68)	40±2	38±1 (5.00)	36±2 (10.00)	34±1 (15.00)	32±0.8 (20.00)	70±3	67±2 (4.28)	63±1 (10.00)	59±2 (15.71)	56±3 (20.00)
	PEWSS	790±3	786±3 (0.50)	778±4 (1.51)	770±3 (2.53)	768±4 (2.73)	40±2	40±0.9 (0.00)	38±0.8 (5.00)	35±0.9 (12.50)	33±0.7 (17.50)	70±3	68±1 (2.85)	64±2 (8.57)	60±3 (14.28)	57±0.8 (18.57)

(Percentage changes over control is given in parenthesis)

Table 4. 3

BIOCHEMICAL CHANGES IN BRINJAL DURING DIFFERENT STORAGE PERIOD

S. No	Types of storage	Carbohydrate Concentration mg/g					Protein Concentration mg/g					Vitamin Concentration µg/g				
		Storage days					Storage days					Storage days				
		0	1	3	5	7	0	1	3	5	7	0	1	3	5	7
	Room temperature	3.11±0.3	2.98±0.4 (4.18)	2.80±0.3 (9.96)	2.70±0.4 (13.18)	2.60±.3 (16.39)	0.72±0.6	0.70±0.03 (2.77)	0.68±0.4 (5.55)	0.58±0.3 (19.44)	0.45±0.4 (37.5)	9.85±0.7	9.52±4 (3.35)	9.00±3 (8.62)	8.50±4 (13.70)	7.75±4 (19.28)
	Refrigerator	3.11±0.3	3.00±0.8 (3.53)	2.92±.5 (6.10)	2.89±0.4 (7.07)	2.75±0.4 (11.57)	0.72±0.6	0.69±0.04 (4.16)	0.66±0.05 (8.33)	0.62±0.06 (13.88)	0.55±0.05 (23.61)	9.85±0.7	9.71±4 (1.42)	9.40±3 (4.56)	8.80±3 (10.65)	8.11±4 (17.66)
	EWSS1	3.11±0.3	3.00±0.6 (3.53)	2.95±0.6 (5.14)	2.90±0.5 (6.75)	2.82±0.5 (9.32)	0.72±0.6	70±0.05 (2.77)	0.68±0.01 (9.72)	0.63±0.4 (12.50)	0.60±0.03 (16.66)	9.85±0.7	9.80±4 (0.50)	9.69±5 (1.62)	9.00±3 (8.62)	8.20±4 (16.75)
	EWSS2	3.11±0.3	3.06±0.7 (0.32)	3.05±0.4 (1.92)	2.98±0.5 (4.18)	2.80±0.5 (9.96)	0.72±0.6	0.72±0.4 (0.0)	0.68±0.2 (9.72)	0.61±0.3 (15.27)	0.63±0.4 (12.50)	9.85±0.7	9.79±5 (0.60)	9.40±4 (4.56)	8.10±5 (11.57)	8.27±3 (16.04)
	PEWSS	3.11±0.3	3.02±0.8 (2.89)	2.97±0.6 (4.50)	2.91±0.4 (6.43)	2.88±0.4 (7.39)	0.72±0.6	0.71±0.04 (1.38)	0.69±0.02 (4.10)	0.63±0.05 (12.50)	0.61±0.03 (13.8)	9.85±0.7	9.80±5 (0.50)	9.52±5 (3.35)	8.68±3 (11.87)	8.35±4 (15.22)

(Percentage changes over control is given in parenthesis)

Table 4. 4

BIOCHEMICAL CHANGES IN LADIES FINGER DURING DIFFERENT STORAGE PERIOD

S.No	Types of storage	Carbohydrate Concentration mg/g					Protein Concentration mg/g					Vitamin Concentration µg/g				
		Storage days					Storage days					Storage days				
		0	1	3	5	7	0	1	3	5	7	0	1	3	5	7
	Room temperature	4.02±0.6	3.90±0.4 (2.98)	3.79±.6 (5.72)	3.68±0.8 (8.45)	3.59±0.5 (10.69)	0.99±0.8	0.93±0.7 (6.06)	0.87±0.6 (12.32)	0.79±0.6 (20.20)	0.73±0.7 (27.27)	10.12±5	10.02±5 (1.98)	9.20±3 (9.09)	9.02±4 (10.86)	8.97±5 (11.36)
	Refrigerator	4.02±0.6	4.00±0.8 (0.50)	3.98±0.5 (0.99)	3.98±0.8 (0.99)	3.90±0.7 (2.98)	0.99±0.8	0.95±0.6 (4.04)	0.90±0.6 (9.90)	0.87±0.7 (12.12)	0.78±0.6 (21.21)	10.12±5	10.08±5 (0.39)	10.03±4 (0.88)	9.90±4 (2.11)	9.60±3 (5.13)
	EWSS1	4.02±0.6	4.00±0.5 (0.50)	3.97±0.6 (1.24)	3.95±0.4 (1.74)	3.93±0.5 (2.23)	0.99±0.8	0.95±0.5 (4.40)	0.92±0.6 (7.07)	0.90±0.4 (9.09)	0.81±0.4 (18.00)	10.12±5	10.08±5 (0.39)	10.05±7 (0.69)	9.98±6 (1.38)	9.83±6 (2.86)
	EWSS2	4.02±0.6	4.00±0.3 (0.50)	3.99±0.4 (0.74)	3.97±0.4 (1.24)	3.94±0.3 (8.00)	0.99±0.8	0.97±0.5 (2.02)	0.93±0.3 (6.06)	0.89±0.4 (10.10)	0.80±0.7 (9.19)	10.12±5	10.09±5 (0.29)	90.06±6 (0.59)	9.97±5 (1.48)	9.90±6 (2.11)
	PEWSS	4.02±0.6	4.02±0.4 (0.00)	4.01±0.7 (0.24)	3.98±0.6 (0.99)	3.96±0.4 (1.49)	0.99±0.8	0.98±0.3 (1.01)	0.95±0.7 (4.04)	0.93±0.6 (6.06)	0.90±0.5 (9.09)	10.12±5	10.08±6 (0.39)	10.05±7 (0.69)	10.00±4 (1.18)	9.98±4 (1.38)

(Percentage changes over control is given in parenthesis)

Table 4. 5

BIOCHEMICAL CHANGES IN TOMATO DURING DIFFERENT STORAGE PERIOD

S.No	Types of storage	Carbohydrate Concentration µg/g					Protein Concentration µg/g					Vitamin Concentration µg/g				
		Storage days					Storage days					Storage days				
		0	1	3	5	7	0	1	3	5	7	0	1	3	5	7
	Room temperature	17.22±3	17.18±1.5 (0.23)	17.12±1 (0.58)	16.30±0.9 (5.34)	15.00±0.6 (12.89)	12.44±2	9.16±0.9 (26.36)	8.11± 0.5 (36.80)	7.26±0.4 (41.63)	6.63±0.4 (46.70)	53.18±4	52.16±3 (1.91)	48.90±3 (8.04)	46.80±2 (11.99)	45.26±3 (14.89)
	Refrigerator	17.22±3	17.18±1 (0.23)	17.00±1 (1.27)	16.90±0.8 (1.85)	16.60± 1 (3.60)	12.44±2	11.13± 1 (10.53)	11.00±0.8 (11.57)	10.80±0.9 (13.18)	9.16±0.8 (26.36)	53.18±4	48.26±2 (9.36)	45.80±2 (13.87)	41.40±2 (23.01)	38.92±4 (26.81)
	EWSS1	17.22±3	17.10± 1 (0.69)	17.00±1 (1.27)	17.00±3 (1.27)	16.70± 2 (3.10)	12.44±2	12.15±0.9 (2.33)	12.00±0.6 (3.53)	11.80±0.9 (5.14)	11.35±0.8 (8.76)	53.18±4	52.08±3 (2.06)	48.35±4 (13.87)	46.10±3 (13.31)	47.35±2 (18.48)
	EWSS2	17.22±3	17.10±0.9 (0.69)	17.00±2 (1.27)	16.90±2 (1.85)	16.70± 2 (3.01)	12.44±2	12.05±0.8 (3.13)	11.90±0.7 (4.34)	11.70±0.6 (5.94)	11.50±1 (7.55)	53.18±4	50.00±4 (5.97)	48.000±3 (9.74)	47.10±4 (11.43)	46.00±3 (13.50)
	PEWSS	17.22±3	17.08± 3 (0.81)	16.95±2 (1.56)	16.85± 2 (2.14)	16.75± 3 (2.72)	12.44±2	12.00±1 (3.53)	11.80±0.8 (5.14)	17.75±0.7 (5.54)	11.65±0.7 (6.35)	53.18±4	49.80±2 (6.35)	49.10±3 (7.67)	48.80±3 (8.23)	48.20±4 9.36()

(Percentage changes over control is given in parenthesis)

Table 4. 6

BIOCHEMICAL CHANGES DURING IN CARROT DIFFERENT STORAGE PERIOD

S.No	Types of storage	Carbohydrate Concentration µg/g					Protein Concentration µg/g					Vitamin Concentration µg/g				
		Storage days					Storage days					Storage days				
		0	1	3	5	7	0	1	3	5	7	0	1	3	5	7
	Room temperature	1020±4	993±4 (2.64)	973±3 (4.60)	930±3 (8.82)	860±4 (15.68)	90±3	86±2 (4.44)	81±2 (10.00)	73±1 (18.88)	68±2 (24.44)	7.5±2	7.0±2 (6.66)	6.3±1 (16.00)	5.7±0.9 (24.00)	5.0±0.8 (33.33)
	Refrigerator	1020±4	990±4 (2.94)	950±2 (6.86)	910±3 (10.78)	880±3 (13.72)	90±3	87±1 (3.33)	83±3 (7.77)	75±4 (16.66)	71±4 (22.11)	7.5±2	6.9±1 (8.00)	6.5±2 (13.33)	5.9±0.7 (21.33)	5.4±0.5 (28.00)
	EWSS1	1020±4	1010±3 (0.98)	980±3 (3.92)	940±4 (7.84)	920±2 (9.80)	90±3	88±2 (2.22)	86±1 (4.44)	82±2 (8.88)	79±2 (12.22)	7.5±2	7.2±0.8 (4.00)	7.00±1 (6.66)	6.8±0.7 (9.33)	6.5±0.5 (13.33)
	EWSS2	1020±4	1008±3 (1.76)	980±4 (3.92)	960±4 (5.88)	940±4 (7.84)	90±3	88±4 (2.22)	85±2 (5.55)	83±3 (7.77)	81±2 (10.00)	7.5±2	7.1± 0.6 (5.33)	6.9±0.5 (8.00)	6.7±0.4 (10.66)	6.7±0.3 (10.66)
	PEWSS	1020±4	1012±3 (0.78)	1000±4 (1.96)	980±4 (3.92)	960±2 (5.88)	90±3	90±4 (0.00)	87±3 (3.33)	84±4 (6.66)	81±3 (10.00)	7.5±2	7.4±1 (1.33)	7.0±1 (6.66)	7.00±0.2 (6.66)	6.9±0.8 (8.00)

(Percentage changes over control is given in parenthesis)

Table 4. 7 Organoleptic qualities of Grapes sample in different storage system

S.No	Nature of storage	Characters of sample	Storage of Grapes in days					Overall acceptability
			Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	Skin colour appearance	10±1	8±0.7	6±0.4	4±0.2	4±0.2	5.50.3
		Flaour		8±0.6	5±0.3	3±0.1	3±0.3	5.25±0.4
		Texture		9±0.7	7±0.5	4±0.1	4±0.2	6.0±0.3
		Odour		8±0.5	3±0.1	2±0.2	1±0.1	3.5±0.2
2	Refrigerator	Skin colour appearance	10±1	8±0.6	7±0.5	4±0.3	4±0.2	5.75±0.3
		Flaour		8±0.7	6±0.4	5±0.2	4±0.4	5.75±0.5
		Texture		8±0.5	6±0.4	4±0.3	4±0.1	5.5±0.4
		Odour		7±0.4	5±0.3	5±0.5	4±0.3	5.25±0.3
3	EWSS1	Skin colour appearance	10±1	8±0.7	8±0.8	7±0.7	7±0.5	7.5±0.6
		Flaour		8±0.6	8±0.5	9±0.6	9±0.6	8.5±0.3
		Texture		8±0.7	9±0.4	8±0.7	8±0.5	8.25±0.5
		Odour		8±0.5	8±0.5	9±0.7	9±0.6	8.5±0.3
4	EWSS2	Skin colour appearance	10±1	9±0.1	8±0.8	8±0.6	7±0.5	8±0.6
		Flaour		9±0.8	9±0.7	8±0.5	8±0.6	8.5±0.5
		Texture		10±0.2	10±0.9	8±1	8±0.5	9.5±0.6
		Odour		10±0.3	10±0.3	10±0.5	9±0.7	9.75±0.5
5	PEWSS	Skin colour appearance	10±1	8±0.7	8±0.5	7±0.4	6±0.2	7.25±0.6
		Flaour		8±0.6	7±0.4	7±0.5	7±0.4	7.25±0.7
		Texture		8±0.5	8±0.7	7±0.3	6±0.8	7.25±0.6
		Odour		9±0.6	8±0.6	6±0.2	6±0.5	7.25±0.7

Table 4.8 Organoleptic qualities of Banana sample in different storage system

S.No	Nature of storage	Characters of sample	Storage of Banana in days					Overall acceptability
			Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	Skin colour appearance	10±1	9±0.8	7±0.5	6±0.4	4±0.2	6.0±0.2
		Flaour		8±0.6	6±0.4	5±0.3	4±0.2	5.75±0.3
		Texture		8±0.7	5±0.2	4±0.1	3±0.1	5.0±0.4
		Odour		9±0.8	5±0.3	5±0.3	2±0.1	5.25±0.3
2	Refrigerator	Skin colour appearance	10±1	8±0.6	7±0.5	4±0.2	3±0.3	5.5±0.2
		Flaour		8±0.5	7±0.4	3±0.1	3±0.2	5.25±0.3
		Texture		7±0.5	6±0.4	4±0.2	3±0.1	5.0±0.2
		Odour		8±0.6	5±0.3	3±0.2	2±0.1	4.5±0.8
3	EWSS1	Skin colour appearance	10±1	10±0.1	10±0.2	9±1	9±0.8	9.5±0.5
		Flaour		8±0.9	9±0.7	10±1	8±0.5	8.75±0.7
		Texture		10±0.6	10±1	9±0.8	9±0.6	9.5±0.6
		Odour		8±0.5	10±0.9	9±0.5	9±0.7	9.0±0.8
4	EWSS2	Skin colour appearance	10±1	9± 1	10±0.8	10±1	9±0.7	9.0±0.7
		Flaour		9±0.7	8±0.6	9±0.7	8±0.6	9.0±0.9
		Texture		8±0.6	10±1	10±0.6	8±0.5	9.0±0.6
		Odour		10±0.5	10±1	9±0.6	9±0.7	9.5±0.3
5	PEWSS	Skin colour appearance	10±1	9±0.7	8±0.6	8±0.5	7±0.5	8.25±0.4
		Flaour		8±0..8	8±0.5	8±0.4	7±0.4	7.75±0.2
		Texture		8±0.7	7±0.6	6±0.4	7±0.6	7.0±0.1
		Odour		8±0.7	8±0.4	7±0.5	7±0.4	7.5±0.3

Table 4.9 Organoleptic qualities of Brinjal sample in different storage system

S.No	Nature of storage	Characters of sample	Storage of Brinjal in days					Overall acceptability
			Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	Skin colour appearance	10±1	10±1	9±0.5	7±0.5	6±0.4	8.0±0.3
		Flaour		8±0.7	7±0.4	7±0.4	7±0.3	7.3±0.2
		Texture		8±0.6	6±0.2	5±0.7	4±0.2	5.8±0.4
		Odour		9±0.8	7±0.4	6±0.4	5±0.3	6.7±0.3
2	Refrigerator	Skin colour appearance	10±1	10±1	8±0.6	7±0.5	6±0.4	7.8±0.4
		Flaour		8±0.6	6±0.4	5±0.3	4±0.3	5.8±0.3
		Texture		7±0.5	4±0.2	3±0.2	3±0.1	4.3±0.2
		Odour		8±0.4	7±0.5	6±0.5	6±0.4	6.8±0.3
3	EWSS1	Skin colour appearance	10±1	10±1	10±1	10±0.9	8±0.6	9.5±1
		Flaour		10±0.8	10±1	8±0.7	8±0.4	9.0±0.7
		Texture		10±1	10±0.9	10±0.8	10±0.6	10±0.8
		Odour		10±1	9±0.4	8±0.4	8±0.8	8.8±0.6
4	EWSS2	Skin colour appearance	10±1	10±1	10±0.8	10±1	9±0.6	9.8 ±0.3
		Flaour		10±0.9	10±0.7	10±0.9	9±0.7	9.8±0.4
		Texture		10±1	10±0.4	10±1	10±0.8	10±1
		Odour		10±1	9±0.7	9±0.8	8±1	9.0±0.2
5	PEWSS	Skin colour appearance	10±1	10±0.9	8±0.5	7±0.5	6±0.6	7.8±0.4
		Flaour		8±0.6	7±0.4	7±0.4	7±0.4	7.3±0.3
		Texture		9±0.7	8±0.7	7±0.5	4±0.5	7±0.5
		Odour		8±0.6	8±0.6	7±0.3	7±0.2	7.6±0.6

Table 4.10 Organoleptic qualities of Ladies finger sample in different storage system

S.No	Nature of storage	Characters of sample	Storage of Ladies finger in days					Overall acceptability
			Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	Skin colour appearance	10±1	8±0.7	4±0.3	3±0.2	1±0.2	4.0±0.2
		Flaour		8±0.6	8±0.7	8±0.5	6±0.3	7.5±0.3
		Texture		7±0.5	6±0.4	4±0.2	2±0.1	4.7±0.4
		Odour		8±0.6	8±0.6	7±0.5	6±0.4	6.7±0.6
2	Refrigerator	Skin colour appearance	10±1	9±0.5	7±0.6	6±0.4	5±0.3	6.7±0.4
		Flaour		9±0.4	8±0.5	8±0.5	6±0.3	7.8±0.3
		Texture		8±0.5	7±0.4	7±0.3	7±0.2	5.5±0.2
		Odour		7±0.3	6±0.4	6±0.4	5±0.5	5.0±0.1
3	EWSS1	Skin colour appearance	10±1	10±1	10±0.9	8±0.6	6±0.3	8.5±0.3
		Flaour		10±1	10±0.8	8±0.5	8±0.3	9.0±0.4
		Texture		9±0.8	9±0.7	9±0.7	8±0.6	8.8±0.5
		Odour		10±0.9	10±0.9	10±0.1	9±0.5	9.75±0.7
4	EWSS2	Skin colour appearance	10±1	10±1	10±1	9±0.7	8±0.6	9.2±0.2
		Flaour		10±1	10±0.8	9±0.5	8±0.7	9.2±0.4
		Texture		10±1	10±0.7	10±1	9±0.6	9.7±0.6
		Odour		10±0.9	10±0.8	10±0.9	10±0.9	10±0.4
5	PEWSS	Skin colour appearance	10±1	9±0.8	8±0.6	7±0.5	7±0.5	7.5±0.6
		Flaour		8±0.5	6±0.4	6±0.4	5±0.3	6.5±0.4
		Texture		9±0.7	7±0.5	5±0.2	5±0.2	6.5±0.3
		Odour		10±1	8±0.6	7±0.5	7±0.5	8.0±0.6

Table 4.11 Organoleptic qualities of Tomato sample in different storage system

S.No	Nature of storage	Characters of sample	Storage of Tomato in days					Overall acceptability
			Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	Skin colour appearance	10±1	9±1	7±0.9	5±0.2	5±0.4	6.5±0.4
		Flaour		8±0.4	4±0.5	3±0.3	2±0.3	4.25±0.3
		Texture		7±0.7	6±0.3	5±0.3	4±0.4	5.5±0.4
		Odour		8±0.6	5±0.4	4±0.2	4±0.3	5.25±0.3
2	Refrigerator	Skin colour appearance	10±1	8±0.6	7±0.4	6±0.5	5±0.3	6.5±0.4
		Flaour		7±0.7	7±0.5	4±0.3	3±0.1	5.25±0.4
		Texture		7±0.4	6±0.3	7±0.5	6±0.4	6.5±0.4
		Odour		8±0.5	8±0.6	6±0.4	6±0.3	7.0±0.3
3	EWSS1	Skin colour appearance	10±1	10±1	8±0.9	7±0.3	8±0.3	8.25±0.6
		Flaour		9±0.8	9±0.9	8±0.5	8±0.6	8.5±0.8
		Texture		8±0.6	9±0.5	8±0.4	9±0.7	8.25±0.3
		Odour		7±0.5	7±0.4	6±0.3	6±0.5	6.50±0.5
4	EWSS2	Skin colour appearance	10±1	10±0.6	10±0.4	10±1	9±0.5	9.75±0.2
		Flaour		10±0.7	10±0.9	9±0.6	8±0.9	9.25±0.4
		Texture		10±0.5	10±0.8	9±0.8	8±0.5	9.25±0.7
		Odour		10±0.6	9±0.7	8±0.6	8±0.7	8.75±0.6
5	PEWSS	Skin colour appearance	10±1	9±0.8	8±0.5	7±0.3	7±0.6	7.75±0.5
		Flaour		7±0.5	7±0.7	5±0.8	4±0.6	5.75±0.4
		Texture		9±0.7	8±0.5	6±0.4	5±0.2	7.0±0.3
		Odour		7±0.6	7±0.4	5±0.3	3±0.3	5.5±0.3

Table 4.12 Organoleptic qualities of carrot sample in different storage system

S.No	Nature of storage	Characters of sample	Storage of carrot in days					Overall acceptability
			Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	Skin colour appearance	10±1	10±1	06±0.4	04±0.4	03±0.2	5.75±0.6
		Flaour		10±1	07±0.3	04±0.3	02±0.2	5.75±0.4
		Texture		8±0.6	5±0.5	3±0.4	2±0.1	4.5±0.5
		Odour		8±0.7	5±0.4	4±0.2	1±0.1	4.5±0.3
2	Refrigerator	Skin colour appearance	10±1	10±1	10±1	4±0.2	3±0.1	6.7±0.6
		Flaour		10±0.9	08±0.2	06±0.4	06±0.4	7.5±0.4
		Texture		8±0.9	8±0.5	8±0.6	7±0.3	7.7±0.2
		Odour		8±0.8	7±0.3	7±0.5	6±0.2	7.0±0.3
3	EWSS1	Skin colour appearance	10±1	10±1	10±1	10±1	8±0.7	9.5±0.6
		Flaour		10±0.9	10±1	8±0.7	8.7±0.5	9.0±0.6
		Texture		10±1	10±0.9	10±0.9	10±0.8	10±0.7
		Odour		10±1	8±0.6	8±0.3	8±0.5	8.5±0.4
4	EWSS2	Skin colour appearance	10±1	10±0.9	10±0.4	10±0.3	10±0.9	10±0.6
		Flaour		10±0.8	10±0.8	8±0.5	8±0.5	9.0±0.5
		Texture		10±0.9	10±0.9	10±0.9	10±0.7	10±0.6
		Odour		10±1	10±1	10±0.7	10±0.7	10±0.8
5	PEWSS	Skin colour appearance	10±1	10±1	08±0.8	07±0.5	07±0.3	8.0±0.5
		Flaour		8±0.5	8±0.3	7±0.4	7±0.6	7.0±0.3
		Texture		8±0.6	7±0.4	7±0.3	6±0.2	7.0±0.5
		Odour		8±0.7	8±0.5	7±0.4	7±0.5	7.5±0.8

Table 4.13 Organoleptic qualities of Grapes sample in different storage system in pretreated with calcium hydroxide

S.No	Nature of storage	Characters of sample	Storage of Grapes in days					Overall acceptability
			Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	Skin colour appearance	10±1	9±0.8	8±0.7	4±0.5	4±0.5	6.25
		Flaour		6±0.4	5±0.3	3±0.1	2±0.2	4.00
		Texture		9±0.7	8±0.5	5±0.3	4±0.2	6.5
		Odour		8±0.5	3±0.2	2±0.1	1±0.1	3.5
2	Refrigerator	Skin colour appearance	10±1	8±0.7	5±0.3	4±0.2	4±0.2	5.25
		Flaour		8±0.6	4±0.2	3±0.1	2±0.1	4.25
		Texture		8±0.3	6±0.2	4±0.1	4±0.2	5.5
		Odour		7±0.4	4±0.2	3±0.2	3±0.1	4.25
3	EWSS2	Skin colour appearance	10±1	7±0.5	6±0.7	4±0.3	4±0.2	5.25
		Flaour		8±0.5	8±0.4	6±0.3	6±0.3	7.0
		Texture		8±0.4	9±0.4	8±0.5	8±0.4	8.25
		Odour		8±0.7	6±0.4	6±0.6	5±0.3	6.25

Table 4.14 Organoleptic qualities of Banana sample in different storage system in pretreated with calcium hydroxide

S.No	Nature of storage	Characters of sample	Storage of Banana in days					Overall acceptability
			Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	Skin colour appearance	10±1	7±0.4	6±0.3	6±0.2	4±0.1	5.75
		Flaour		8±0.5	6±0.2	5±0.3	4±0.1	5.75
		Texture		8±0.3	7±0.4	4±0.2	3±0.1	5.50
		Odour		8±0.6	6±0.4	5±0.3	2±0.2	5.25
2	Refrigerator	Skin colour appearance	10±1	8±0.5	6±0.3	4±0.1	2±0.1	5.00
		Flaour		8±0.4	7±0.5	3±0.1	3±0.1	5.25
		Texture		7±0.4	6±0.3	6±0.2	3±0.2	5.5
		Odour		8±0.5	6±0.3	3±0.2	3±0.2	5.00
3	EWSS2	Skin colour appearance	10±1	9±0.6	8±0.5	10±0.6	9±0.6	9.0
		Flaour		9±0.4	8±0.5	9±0.5	8±0.4	8.5
		Texture		9±0.7	9±0.6	9±0.5	8±0.7	8.75
		Odour		9±0.8	9±0.5	7±0.4	7±0.6	8.0

Table 4.15 Organoleptic qualities of Brinjal sample in different storage system pretreated with calcium hydroxide

S.No	Nature of storage	Characters of sample	Storage of Brinjal in days					Overall acceptability
			Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	Skin colour appearance	10±1	10±0.7	9±0.6	7±0.5	6±0.4	8.0
		Flaour		8±0.6	7±0.4	7±0.4	7±0.4	7.25
		Texture		8±0.5	6±0.2	6±0.3	5±0.3	6.25
		Odour		8±0.5	7±0.4	5±0.3	5±0.3	6.25
2	Refrigerator	Skin colour appearance	10±1	10±0.7	8±0.6	7±0.5	7±0.5	8.00
		Flaour		7±0.4	6±0.3	5±0.3	4±0.2	5.5
		Texture		8±0.5	6±0.2	4±0.4	3±0.1	5.25
		Odour		8±0.5	7±0.6	5±0.3	5±0.2	6.25
3	EWSS2	Skin colour appearance	10±1	10±0.7	9±0.5	8±0.4	8±0.4	8.75
		Flaour		10±0.8	8±0.5	7±0.4	7±0.4	8
		Texture		10±0.7	10±0.8	10±0.6	10±0.6	10
		Odour		10±0.8	9±0.7	7±0.4	7±0.3	8.25

Table 4.16 Organoleptic qualities of Ladies finger sample in different storage system pretreated with calcium hydroxide

S.No	Nature of storage	Characters of sample	Storage of Ladies finger in days					Overall acceptability
			Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	Skin colour appearance	10±1	8±0.6	6±0.5	5±0.4	3±0.2	5.5
		Flaour		8±0.8	8±0.5	7±0.4	6±0.3	7.25
		Texture		9±0.6	8±0.5	4±0.3	2±0.3	5.75
		Odour		8±0.5	6±0.4	5±0.3	5±0.4	6.0
2	Refrigerator	Skin colour appearance	10±1	9±0.6	8±0.4	7±0.3	5±0.3	7.25
		Flaour		9±0.5	8±0.4	6±0.2	6±0.3	7.25
		Texture		9±0.5	8±0.6	7±0.4	7±0.4	7.75
		Odour		7±0.4	6±0.2	4±0.2	4±0.3	5.
3	EWSS2	Skin colour appearance	10±1	10±0.7	10±0.6	8±0.4	7±0.3	8.75
		Flaour		10±0.5	8±0.4	7±0.3	6±0.4	7.75
		Texture		9±0.6	9±0.5	9±0.7	8±0.6	8.75
		Odour	10±1	10±0.8	10±0.6	8±0.3	8±0.5	9.00

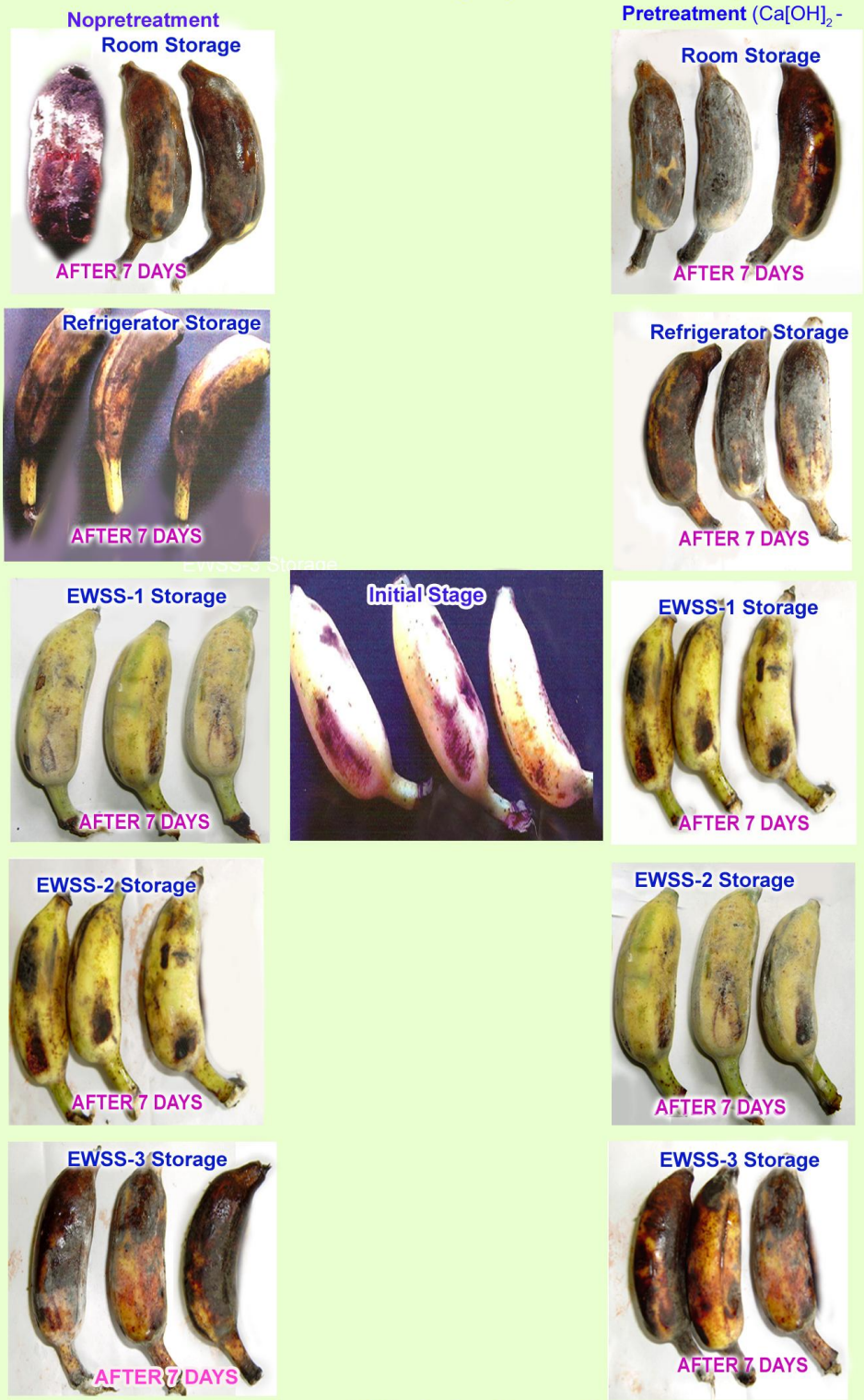
Table 4.17 Organoleptic qualities of Tomato sample in different storage system pretreated with calcium hydroxide

S.No	Nature of storage	Characters of sample	Storage of Tomato in days					Overall acceptability
			Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	Skin colour appearance	10±1	10±0.7	9±0.8	8±0.4	8±0.7	8.75
		Flaour		8±0.8	7±0.7	7±0.4	7±0.5	7.25
		Texture		8±0.5	8±0.4	7±0.7	7±0.4	7.5
		Odour		8±0.4	5±0.9	5±0.5	4±0.4	5.5
2	Refrigerator	Skin colour appearance	10±1	10±0.7	8±0.6	7±0.8	7±0.4	8.0
		Flaour		8±0.6	7±0.5	5±0.4	5±0.4	6.25
		Texture		10±0.7	9±0.6	8±0.6	8±0.4	8.75
		Odour		8±0.4	8±0.5	6±0.3	5±0.2	6.75
3	EWSS2	Skin colour appearance	10±1	10±0.7	10±0.4	8±0.7	8±0.8	9.0
		Flaour		9±0.8	9±0.5	8±0.4	8±0.3	9.0
		Texture		10±0.6	9±0.4	9±0.7	8±0.5	9.0
		Odour		8±0.5	7±0.6	6±0.4	6±0.5	6.75

Fig. 4.1 Organoleptic qualities retained in non treated and pretreated grapes stored in different storage systems for seven days

(overall acceptability is given in parenthesis)

Fig. 4.2 Organoleptic qualities retained in non treated and pretreated banana stored in different storage systems for seven days

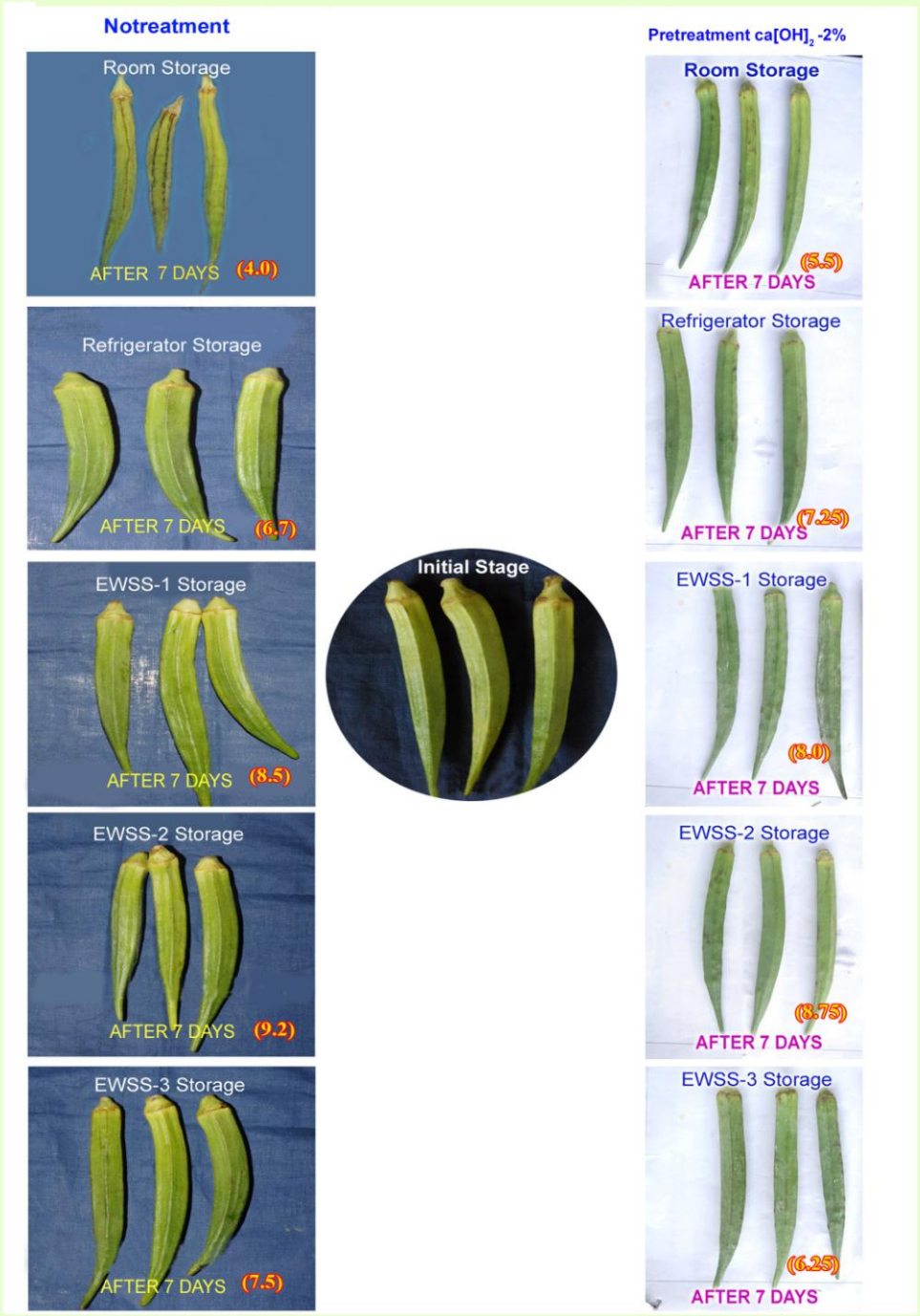


over all acceptability is given in parenthesis

Fig. 4.3 Organoleptic qualities retained in non treated and pretreated brinjal stored in different storage systems for seven days

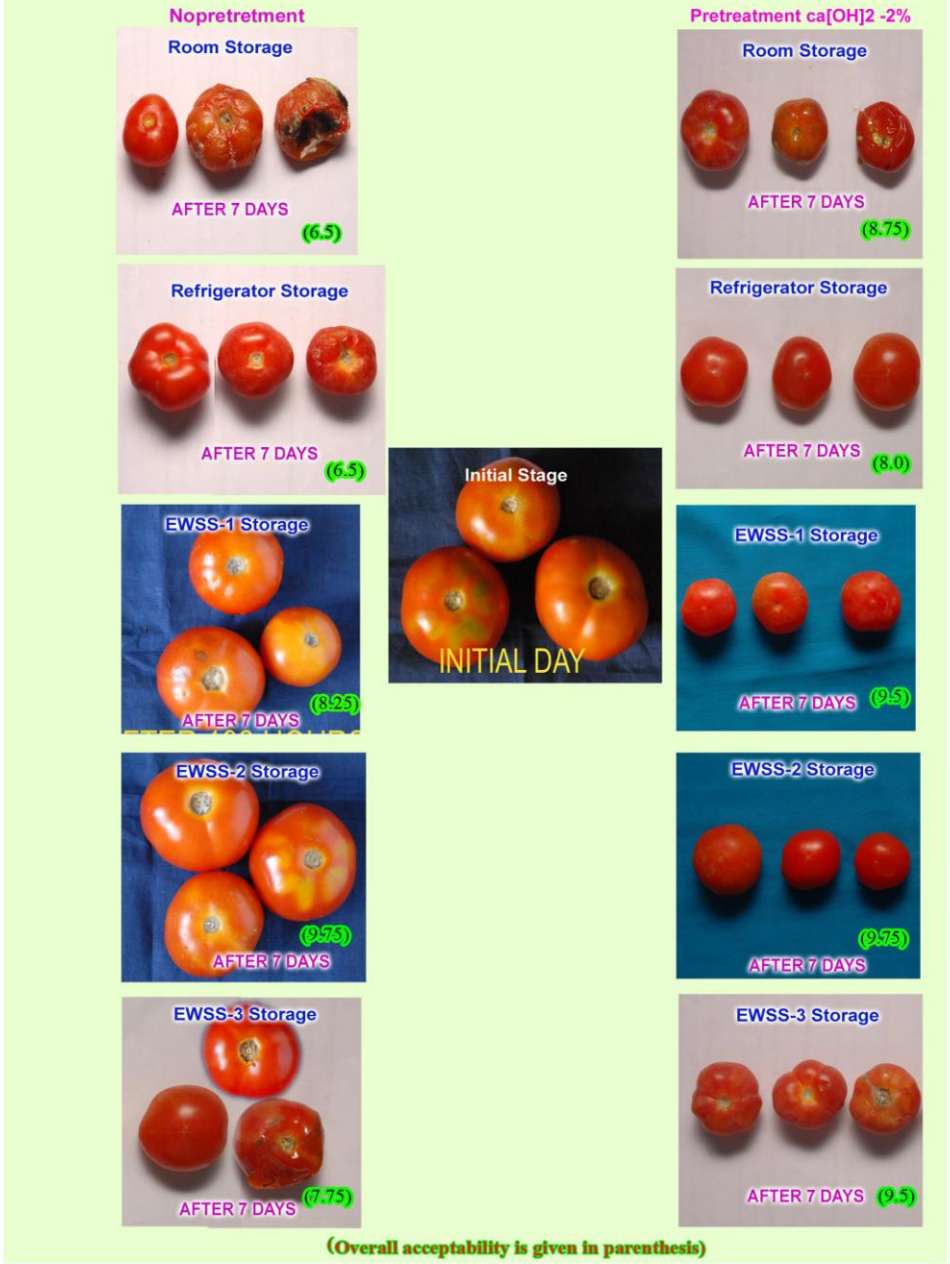
over all acceptability is given in parenthesis

Fig. 4.4 Organoleptic qualities retained in non treated and pretreated ladiesfinger stored in different storage systems for seven days



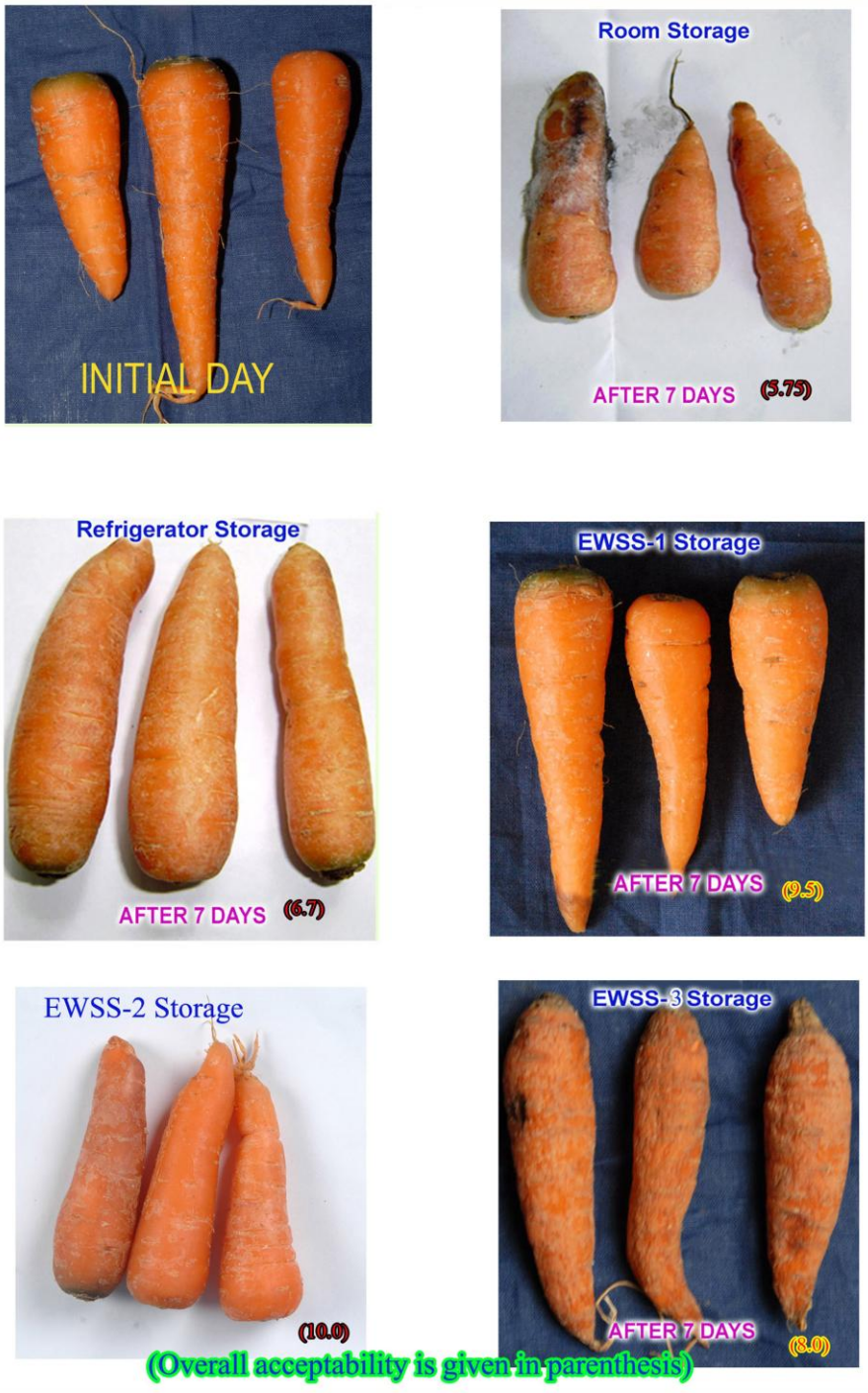
Over all acceptability is given in parenthesis

Fig. 4.5 Organoleptic qualities retained in non treated and pretreated tomato stored in different storage systems for seven days



(Overall acceptability is given in parenthesis)

Fig. 4.6 Organoleptic qualities retained in carrot stored in different storage systems for seven days



(Overall acceptability is given in parenthesis)

Table 5.18 Physiological Loss in weight of Grapes

S.No	Nature of storage	The percentage of physiological loss in weight (g) in different storage					Percentage of loss
		Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	14±1	13.8±1	13.0±0.3	12.5±0.4	12.1±0.3	13.57±2
2	Refrigerator	15±1	14.8±1	16.4±0.2	13.9±0.2	13.5±0.8	10.00±1
3	EWSS1	15±0.9	14.8±0.9	14.7±0.8	14.4±0.3	14.0±1	6.66±0.5
4	EWSS2	16±0.2	15.8±0.7	15.2±0.6	14.9±0.9	14.6±1	8.75±0.4
5	PEWSS	13±1	12.7±0.6	12.2±0.7	12.0±0.8	11.8±0.9	9.23±0.8

Table 4.19 Physiological Loss in weight of Banana

S.No	Nature of storage	The percentage of physiological loss in weight (g) in different storage					Percentage of loss
		Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	78.08±3	73.47±2	67.19±1	61.04±2	56.02±1	28.24±0.8
2	Refrigerator	85.13±2	84.38±2	82.07±2	78.91±3	75.59±2	11.19±0.7
3	EWSS1	85.27±3	84.73±2	83.97±3	80.41±2	76.20±1	10.05±0.8
4	EWSS2	79±1	78±1	77.7±1	76±1	74±1	7.59±0.5
5	PEWSS	80±1	78±2	77.2±2	76.3±2	73.5±1	8.12±0.6

Table 5.20 Physiological Loss in weight of Brinjal

S.No	Nature of storage	The percentage of physiological loss in weight (g) in different storage					Percentage of loss
		Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	313±2	308±1	300±2	285±1	275±1	12.14±0.8
2	Refrigerator	304±2	300.4±2	292±3	286.5±2	280±1	7.8±0.8
3	EWSS1	302±2	295±2	300.4±3	296.5±1	283±2	6.2±1
4	EWSS2	299.2±2	295.8±3	291±1	288±2	284.9±1	4.78±0.8
5	PEWSS	316±3	310±2	304±3	299±2	295±1	6.6±0.8

Table 5.21 Physiological Loss in weight of ladies finger

S.No	Nature of storage	The percentage of physiological loss in weight (g) in different storage					Percentage of loss
		Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	49.36±2	45.79±2	41.94±2.5	37.30±2	35.58±3	27.91±1
2	Refrigerator	46.59±1	46.39±2	45.52±2	44.74±2	42.84±1	8.04±1
3	EWSS1	43.58±1	39.5±1	39±1	38.3±0.9	37.4±0.8	5.87±0.5
4	EWSS2	41.3±2	41±2	40.9±1	40±2	39.6±2	4.11±0.7
5	PEWSS	40.3±1	39.5±1	39±2	38.5±1	37.8±1	6.20±0.3

Table 5.22 Physiological Loss in weight of Tomato

S.No	Nature of storage	The percentage of physiological loss in weight (g) in different storage					Percentage of loss
		Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	133±2	132.5±3	129.3±2	125.5±1	113±2	15.03±1
2	Refrigerator	122.3±1	121.3±1	117.3±2	115±2	112±1	9.23±0.9
3	EWSS1	133±1	132.5±2	129.3±1	125.5±1	123±2	7.52±1
4	EWSS2	146±2	144.3±2	142.6±1	140±1.5	138.3±3	5.2±0.8
5	PEWSS	113±1	112±2	111.3±2	110±0.8	106±0.9	6.19±0.9

Table 5.23 Physiological Loss in weight of Carrot

S.No	Nature of storage	The percentage of physiological loss in weight (g) in different storage					Percentage of loss
		Day 0	Day 1	Day 3	Day 5	Day 7	
1	Room temperature	133±2	132.5±2	129.3±2	125.5±1	113±2	15.03±1
2	Refrigerator	122.3±2	121.3±1	117.3±3	115±1	110±1	10.5±0.9
3	EWSS1	133±2	132.5±2	129.3±3	125.5±2	123±1	7.51±0.7
4	EWSS2	137±3	135.6±1	132.9±2	130.5±2	128±0.8	6.50±0.8
5	PEWSS	135±2	133±1	131±1	128±1	125±2	7.40±1

Table 5.24 PLW OF PRETREATED SAMPLES IN DIFFERENT SAMPLES WITH DIFFERENT STORAGE

S.No	Types of storage	Types of samples	Storage days									
			Control					Pretreated (2% sodium hydroxide)				
			O day	1	3	5	7	O day	1	3	5	7
1	Room	Graphs	38.7±1	36.2±2 (6.45)	34.9±5 (9.81)	33.5±4 (13.43)	32.2±3 (16.7)	38.3±4	37.2±3 (2.81)	36±3 (6.0)	35.1±2 (8.35)	34.0±1 (9.66)
	Refrigerator		27.7±2	27.0±3 (2.52)	26.2±3 (5.41)	25.0± 3 (9.74)	23.2±1 (12.6)	35.8±3	35.1±2 (1.95)	34.7±2 (3.07)	34.0±4 (5.02)	33.3±2 (7.14)
	EWSS2		36.3±3	35.8±3 (1.37)	35±2 (3.30)	34.6±2 (4.68)	34.1±1 (6.06)	27.3±1	27.1±1 (1.09)	26.8±1 (1.83)	26.1±3 (4.39)	25.8±2 (5.49)
2	Room	Banana	148±4	145±4 (2.O2)	142±2 (4.05)	130±4 (12.16)	126±3 (14.87)	150±2	147±3 (2.00)	140.5±4 (6.33)	137.5±2 (8.33)	133±2 (11.33)
	Refrigerator		146±2	142±2 (2.73)	137±1 (6.16)	134±2 (8.12)	130±3 (10.95)	143±3	141±4 (1.39)	138±3 (3.43)	136±4 (4.89)	132±3 (7.69)
	EWSS2		143±3	141±1 (1.39)	138±4 (3.49)	136±3 (4.89)	132±2 (7.69)	151±2	148±5 (1.98)	146±2 (2.64)	147±2 (3.31)	145±3 (3.97)
3	Room	Brinjol	103.2±4	99.3±3 (3.78)	95.3±5 (7.65)	94.4±4 (8.5)	87.6±4 (11.15)	111.8±4	107.8±4 (3.57)	102.3±1 (8.58)	98.2±5 (12.6)	96.7±2 (13.50)
	Refrigerator		130±3	127±4 (2.3)	125±3 (3.84)	124±3 (4.6)	122.6±3 (5.6)	169.8±3	167±2 (1.65)	165.8±2 (1.89)	164±2 (3.41)	163.7±4 (3.6)
	EWSS2		148±1	148±3 (0.40)	147.1±4 (0.67)	146 ±2 (1.74)	144.5±2 (2.75)	112.4±2	112.2±2 (0.17)	111.4±3 (0.88)	110±3 (2.13)	109.8±2 (2.3)
4	Room	Ladies finger	70.2±2	69.1±5 (1.56)	68.0±3 (3.13)	66.2±2 (5.69)	65.1±2 (7.26)	71.2±2	70.4±1 (1.12)	69.8±3 (1.96)	69±4 (3.08)	68.2±4 (4.21)
	Refrigerator		82.1±1	80.8±4 (1.58)	79.2±2 (3.53)	78.0±1 (4.99)	76.2±4 (7.1)	71.2±2	70.1±3 (1.54)	69.0±3 (3.08)	67.8±3 (4.77)	67.0±3 (5.8)
	EWSS2		78.5±2	78±3 (0.63)	77.2±1 (1.65)	76.9±4 (2.54)	75.9±3 (3.31)	74.8±4	74.5±5 (0.40)	74.0±2 (1.06)	73.3±4 (2.00)	72.7±4 (2.80)
5	Room	Tomato	106.6±2	105.0±3 (1.50)	102.1±3 (4.31)	100±3 (6.19)	97.2±2 (8.81)	162.8±3	159±4 (2.33)	156.7±4 (3.74)	153.2±2 (5.89)	149.2±2 (8.35)
	Refrigerator		114±3	112±1 (175)	111.1±2 (2.6)	109.6±3 (3.85)	108.2±2 (5.0)	140.3±1	139.7±2 (0.42)	138.5±4 (1.28)	136.2±1 (2.92)	134.2±3 (4.34)
	EWSS2		121.8±4	121.2±0.9 (0.49)	120.8±2 (0.82)	119.4±2 (1.97)	118.4±1 (2.79)	125.6±2	125±2 (0.48)	124.2±3 (1.11)	123.7±4 (1.51)	122.8±3 (2.2)

4.4 MICROBIOLOGICAL STUDIES IN FRUITS AND VEGETABLES STORED IN DIFFERENT STORAGE SYSTEMS WITHOUT PRETREATMENT

INTRODUCTION

Fruits and vegetables comprise a diverse range of plant products (leaves, roots, tubers, fruits and vegetables). The consumption of fruits and vegetables is increasing as consumer strives to eat healthy diets and benefit from the year-round availability of these products that up until recently were considered to be seasonal. Most of these products are generally eaten without further processing. Fruits and vegetables carry a natural non-pathogenic epiphytic microflora.

During growth, harvest, transportation and further processing and handling the produce can, however, be contaminated with pathogens from human of animal sources. Consumers are also increasingly concerned about the potential contamination of fruits and vegetables from the application of pesticides, chemical fertilizers and herbicides and there is a growing demand for organically grown products. Production practices, growth condition and the location of the edible part during growth (soil, soil surface, and aerial part) will in combination with intrinsic, extrinsic, harvesting and processing factors affect the microbial status at the time of consumption. (European Commission Report, 2002). Vegetables are tempting source of nutrient for spoilage organisms because of their neutral PH and high water activity. *Erwinia carotovora* is the most common spoilage bacteria (Tournas, 2005).

In the present study different types of earthenware storage systems (EWSS) were tested for their efficiency to reduce microbial load/spoilage in household fruits and vegetables. The fruits and vegetables were also pre-treated with disinfectants and stored in earthenware storage system. The microbial load in EWSS stored products were compared with other storage systems like refrigerator and ambient conditions.

RESULTS

Shelf-life of fruits and vegetables (time during which it remains stable and retain its desired qualities) gets affected unless they are stored properly after harvesting. In the present study the effectiveness of earthenware storage systems (EWSS) to inhibit microbial spoilage of fruits and vegetables was studied. The storage efficiencies of EWSS were compared with other storage system like refrigeration and ambient conditions.

Total viable bacterial load in the fruit, grapes was 4.5×105 CFU/g before storage. After 1st` day of storage the total viable count of bacteria had increased to 25.9, 24.8,

22.0, 12.0, and 8.0×105 CFU/g in grapes stored in room, refrigerators, EWSS1, EWSS2 and EWSS3 respectively. On the 7th day of storage the total viable count of bacteria in grapes was too numerable to count (TNTC) in room, 127×105CFU/g in refrigerator, 115×105 CFU/g in EWSS1, 82×105 CFU/g in EWSS2 and no detectable bacterial count in EWSS3. The total bacterial load in grapes stored in all EWSS did not get elevated as it was observed in refrigerator. But at room temperature grapes had gained a high microbial load.

EWSS is in no way inferior to refrigerator to store fruits and vegetables. The result of the present study has shed light on the microbial quality as well as on the effect of storage system. In order to minimize the microbial spoilage till the fruits and vegetables reaches the table, like refrigerator, low cost EWSS can be used for household purposes like grapes the total microbial load in banana did not show much difference in EWSS when compared to refrigerators. On the 7th day of storage the total viable count of bacteria in banana was too numerable to count (TNTC) in room, 87×105CFU/g in refrigerator, 79×105 CFU/g in EWSS1, 84×105 CFU/g in EWSS2 and 1 X 24×105 CFU/g in EWSS3.

The total viable bacterial load in the vegetable brinjal was 30.5×105 CFU/g on day 0. On the 7th day of storage the total viable count of bacteria in brinjal was too numerable to count (TNTC) in room, 280×105CFU/g in refrigerator, 209×105 CFU/g in EWSS1, 250×105 CFU/g in EWSS2 and 2 X 24×105 CFU/g in EWSS3.

The total viable bacterial count in ladies finger was 26, 4, 15, 12 and 20×105 CFU/g before putting them into different storage systems. After 7 days of storage, the total microbial load in ladies finger stored in refrigerator, EWSS and room got elevated. After 7th day of storage the total viable count of bacteria in ladies finger was too numerable to count (TNTC) in room. However it was 56×105CFU/g in refrigerator, 72×105 CFU/g in EWSS1, 52×105 CFU/g in EWSS2 and 6 X105 CFU/g in EWSS3. Between the two storage EWSS and fridge, the changes in Total viable count was less. This indicates that EWSS is also a good chamber like fridge to store ladies finger.

The total viable bacterial count in Tomato was 3.5, 1.0, 1.6, 0.7 and 7.4×105 CFU/g before putting them into different storage systems. After 7 days of storage, the analysis of total microbial load in tomato stored in refrigerator, EWSS and room got elevated. After 7 days of storage the total viable bacterial count (TVC) in tomato stored at room was too numerable to count (TNTC). However it was 90×105CFU/g in

refrigerator, 150×105 CFU/g in EWSS1, 130×105 CFU/g in EWSS2 and no detectable bacterial count in EWSS3.

The total viable bacterial count in carrot was 10, 3, 9, 5 and 6×105 CFU/g before putting them into different storage systems. After 7 days of storage, the analysis of total microbial load in carrot stored in refrigerator, EWSS and room got elevated. After 7 days of storage the total viable bacterial count (TVC) in carrot stored in room was too numerable to count (TNTC). However it was 59 and 50×105 CFU/g in EWSS1 and EWSS2 and 42×105CFU/g in fridge. In pyramidal storage the bacterial count was not detectable, this indicates that EWSS3 is very efficient in containing microbial load.

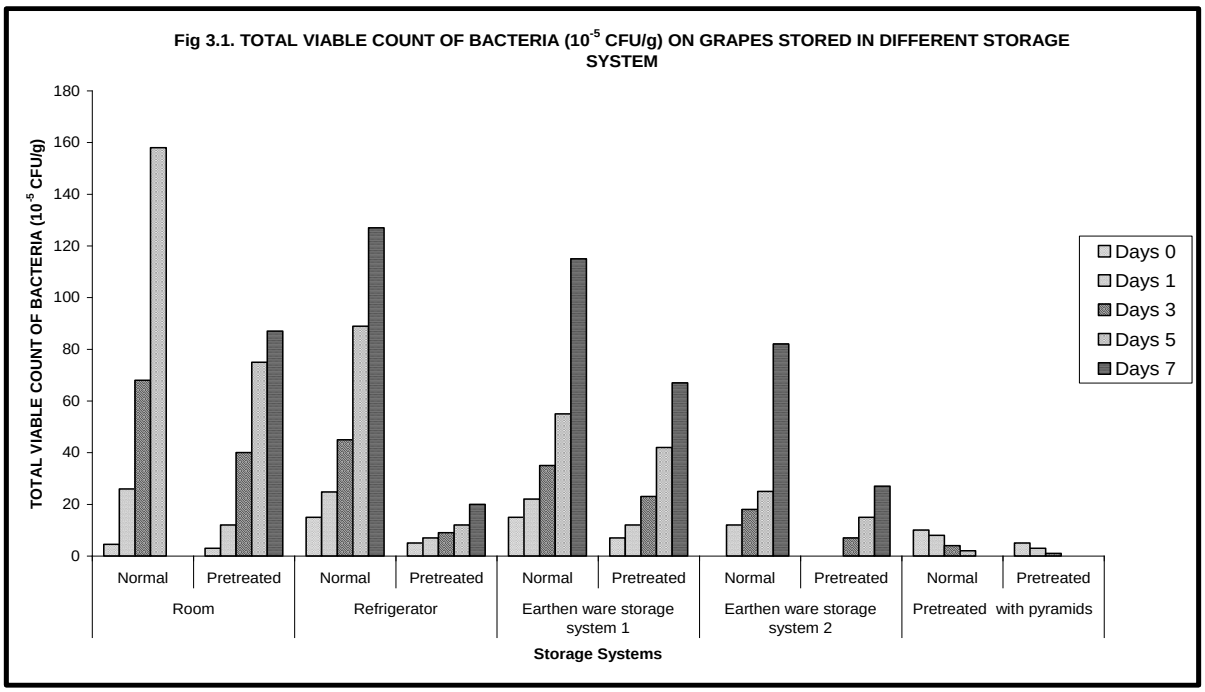
Total viable count of bacteria in fruits and vegetables stored after pre-treatment with calcium hydroxide

In this experiment two percent calcium hydroxide had been used to treat the samples (grapes, banana, brinjal, ladiesfinger, tomato and carrot) and results were recorded. Pre-treatment with calcium hydroxide reduced the microbial density to a greater extent. The microbial density of treated grapes sample after 7th day of storage was 87×105 CFU/g in room, 20×105 CFU/g in refrigerator, 67×105 CFU/g in EWSS1, 27×105 CFU/g in EWSS2 and no detectable bacterial load in EWSS3. Like grapes sample, all other samples had the same results. This reduction of microbial load may be due to antimicrobial property of calcium hydroxide. This study revealed that pre-treatment of fresh produce by calcium hydroxide decreases the density of microbial contaminant from the surface of the fresh produce.

Similar results were reported in hydrogen peroxide pretreatment (Ukuku, 2004). It was reported that hydrogen peroxide (2.5% and 5 %) treatments of fruits for 5 minutes caused a considerable reduction of the indigenous surface micro flora. Joshi et al., (2000) reported that samples rinsed with antimicrobial agents for five minutes showed 40-80% reduction in total number of organisms. Dhruba et al., (2006) reported that the maximum shelf-life was noticed in 1% calcium chloride treated fruits (16, 50 days) followed by 0.75% calcium chloride treated fruits (16, 17 days).

Calcium treatment could extend storage life and reduce the incidence of physiological disorders and storage rots. (Sharma et al., 1996). The calcium chloride had treatment significantly influenced the shelf-life of tomato fruits, Calcium treatment extended the storage life and reduced the incidence of physiological disorders and storage rots (Sharma et al., 1996) It was observed that samples kept in the room temperature, EWSS1, EWSS2 and refrigerator had high load of microbes when

compared with pyramid. The low number of total viable count bacteria in fruits and vegetables stored in pyramid was due to the influence of pyramid on both living and non living matter. This is attributed to the property of pyramid capturing cosmic energy from the surrounding, which is supposed to inhibit the growth of microorganisms by arresting or retarding the decay process (Ravikumar et al., 2005). To conclude pyramid could be used as a best eco-friendly, zero cost mechanisms to preserve fruits and vegetables without microbial spoilage



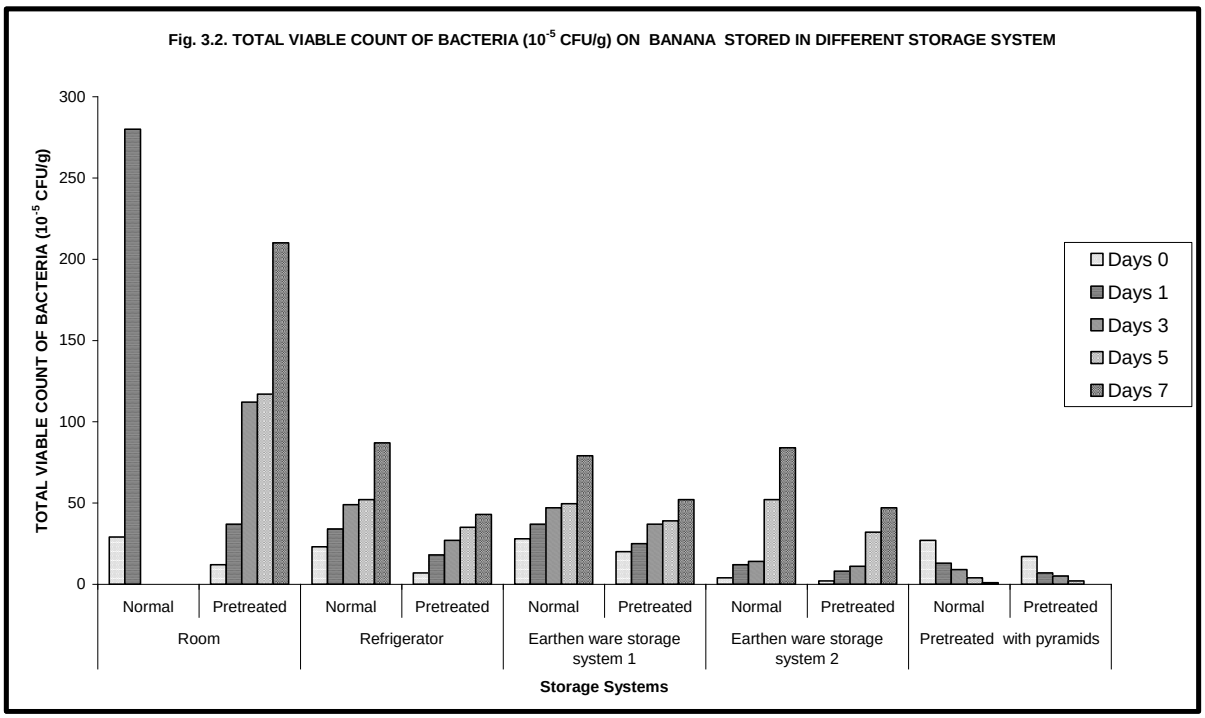


Fig. 3.3 TOTAL VIABLE COUNT OF BACTERIA (10^{-5} CFU/g) ON BRINJAL STORED IN DIFFERENT STORAGE SYSTEM

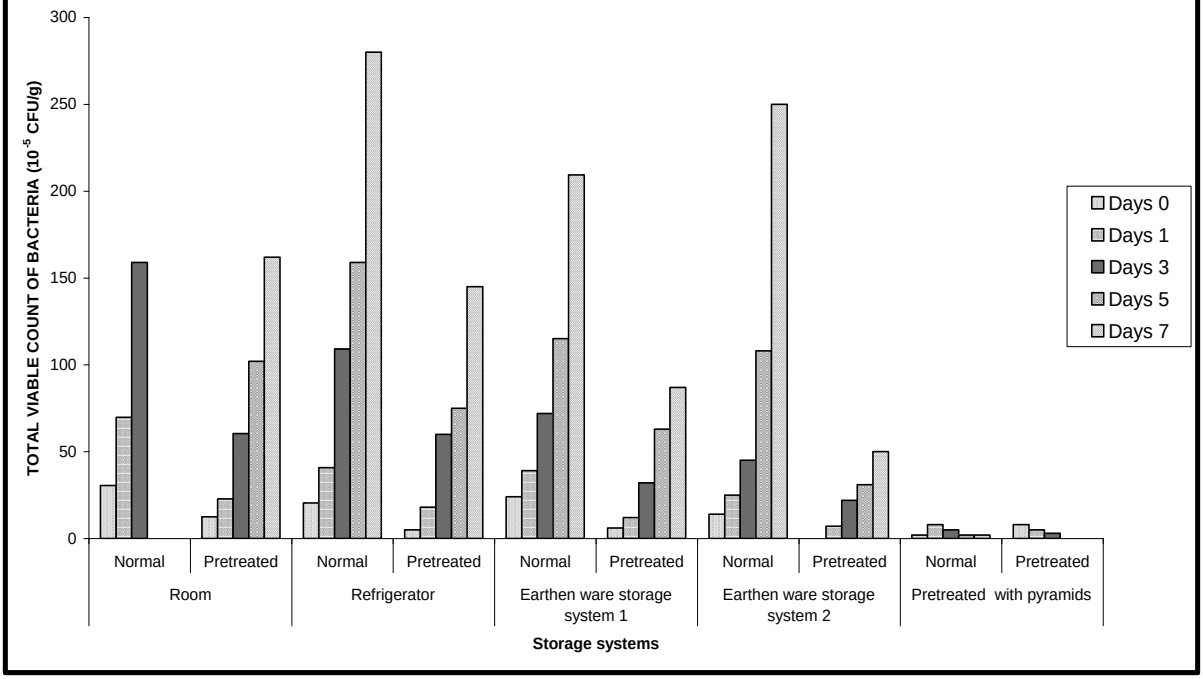


Fig. 3.4 TOTAL VIABLE COUNT OF BACTERIA (10^{-5} CFU/g) ON LADIES FINGER STORED IN DIFFERENT STORAGE SYSTEM

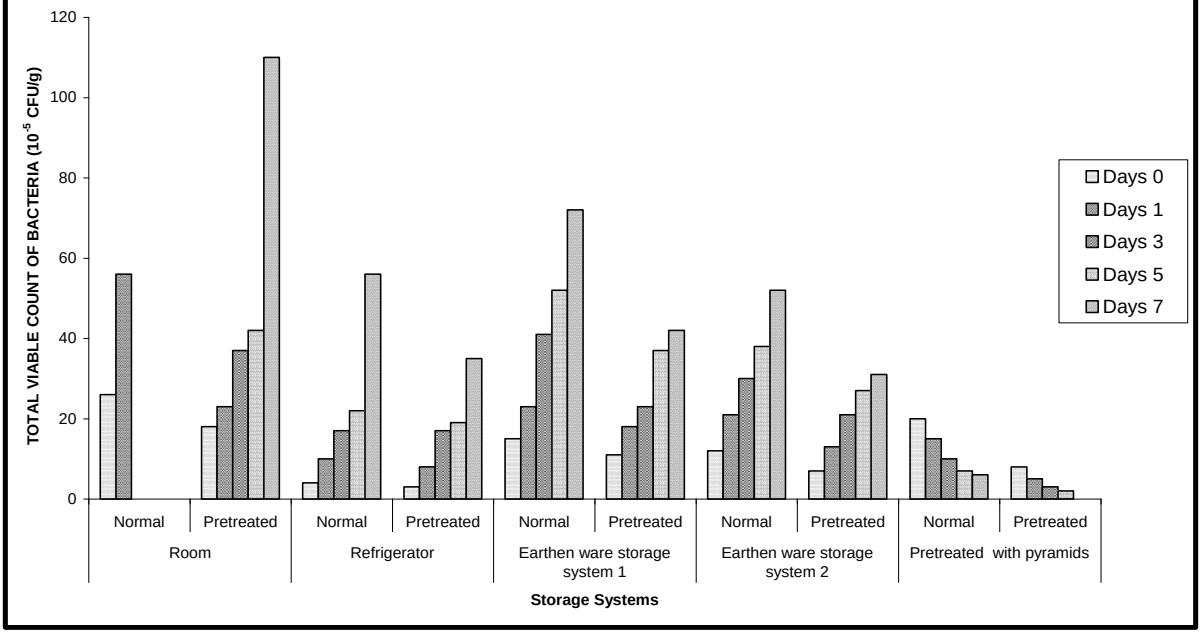


Fig. 3.5. TOTAL VIABLE COUNT OF BACTERIA (10-5 CFU/g) ON TOMATO STORED IN DIFFERENT STORAGE SYSTEM

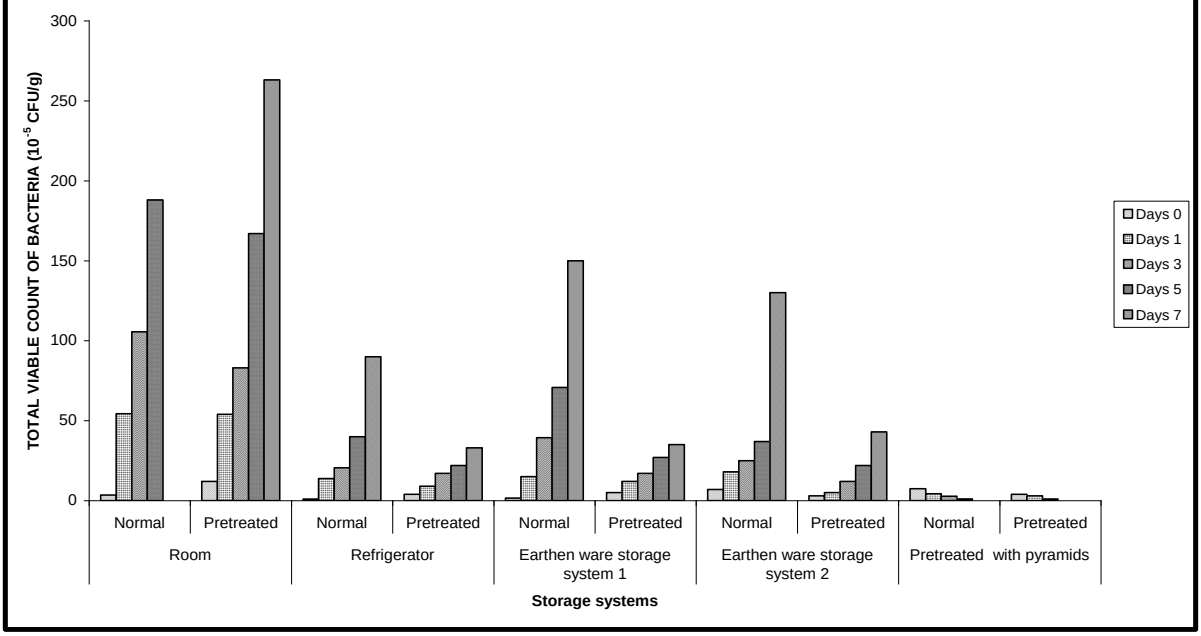
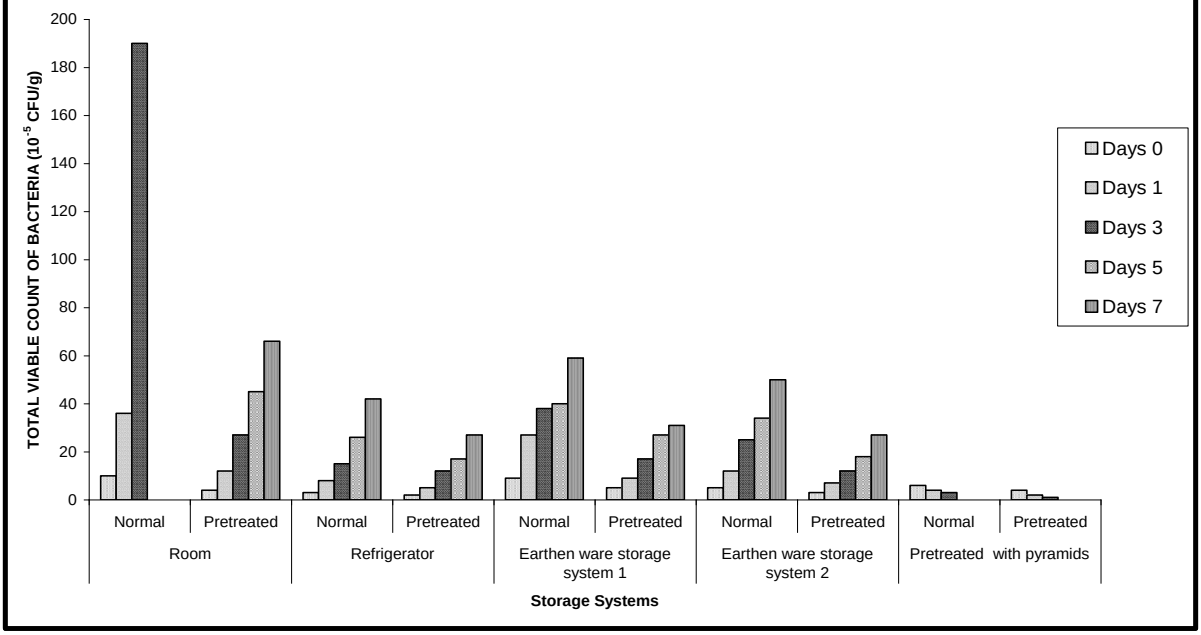


Fig. 3.6. TOTAL VIABLE COUNT OF BACTERIA (10^{-5} CFU/g) ON CARROT STORED IN DIFFERENT STORAGE SYSTEM



5. OBJECTIVE – III
ANALYSIS OF VARIOUS ELEMENTS IN THE SOIL USED TO PREPARE EARTHERNWARE

5.1 Introduction

In South India, particularly in Tamil Nadu earthenwares are used for all domestic purposes. To prepare some Siddha and Ayurvedic medicine, the traditional healers use only clay products. Even for distillation, earthenware distillation units are used. It is also believed that pickles, curd, buttermilk etc, can be stored for a long time with a good taste and flavour in earthenware. Further in Kerala and Kanyakumari districts of Tamilnadu, people still use earthenwares to cook fish curry. Today earthenware that can be used in microoven are also available for cooking.

Hence it has become interesting to study the utility value of earthenwares. In this context, in the present study it has been planned to find out whether earthenwares like pots and other earthenware debris can filter the toxic arsenic in the drinking water?.

Further the earthenware products developed from the clay collected from different areas soil have different qualities like, colour, appearance, flexibility etc. So an interest has been developed to find out the various chemical components present in different soils and these components are useful to enhance consumer attraction are studied. Also microbes associated with soil fermentation and bacteria were studied

MINERAL COMPOSITION IN THE CLAY SAMPLES USED TO PREPARE EARTHENWARE STORAGE SYSTEMS

ENERGY DISPERSIVE X-RAY ANALYSIS (EDAX)

Clay used for earthenware products contains varieties of minerals. The minerals present in the clay gives plasticity, strength, colour and other qualities to the product (Banerjea, 1942) In the present study it was observed that the potters collect clay from different regions and mix them in a particular proportion to prepare their products. For example to make a cooling pot, the potters mix clay taken from, Vakaikulam, Achankulam, and Karunai river bed soil. It is believed that each clay has different mineral constituents. So it is essential to analyse the mineral composition in the clay that are used for earthenware storage system.

Hence in the present study the clay samples collected from selected places like Vagaikulam, Achenkulam and river bed soil were subjected to energy dispersive X-ray analysis to find out the mineral composition.

RESULTS

Vagaikulam (Pond) Sample

The energy dispersive X-ray analysis pattern of the caly sample taken from the village Vagaikulam has shown the presence of several minerals. The peak value, atomic weight, and weight of the minerals are present in the table 5.1.

The figure1. showed peak for the presence of silicon, aluminum, magnesium, manganese and oxygen. From the fig. (5 b) and the table (5 a.) it is clear that silicon is in the highest proportion (23.38 percentage by weight, Atomic weight percentage is 17.86. Next to silicon, the percentage weight of aluminum in the sample was 15.20 and manganese was 12.35%. In the sample, the amount of magnesium percentage was trace (01.30 percent by weight). The particle size of minerals (SEM analysis) (Fig 5 b) also indicated the presence of silicon particles in a dominant proportion.

Achenkulam (Pond) Sample

The EDAX analysis of the yellow clay taken from Achenkulam showed the presence of silicon, aluminum, barium and ferrous (Fig. 5.2a and 5.2b and Table 5.2) . The amount of aluminium present in this clay was higher (19.68 percent by weight) than silicon (19.20 percent by weight), and ferrous content was 7.41 percent by weight). The amount of barium was traced. The SEM analysis also indicated that particle size of aluminium, silicon that were dominating the clay.

Karunai River Bed Sample

Energy dispersive X-ray analysis of the river bed sand sample that was mixed with the above two samples for preparing the clay products showed the presence more number of elements (Fig 5.3a). In this sample 7 elements were found to be present viz. silicon, aluminium, ferrous, titanium, calcium, potassium and manganese. Silicon was dominating the minerals composition (23.19 percentages by weight), next to silicon, ferrous was found in higher proportion (12.26 percentage by weight). The amount of aluminium was (11.13 percentages by weight). In this sample it is very interesting to observe the presence of titanium oxide (0.83 percentages by weight). Potassium and magnesium were also present in trace amount. The SEM analysis of the particles showed the higher amount of silica. From the study it is clear that the chemical composition present in the soil plays an important role in the creation of an earthenware. Although the various component present in the sample whether unknown to potters from the time

immorial they knew the importance of composition by practice and hence they have mixed different clay to prepare good quality earthenwares

Fig. 5.1 Scanning electron microscope and x-ray diffracto meter

Fig. 5.1a : EDAX analysis of soil samples taken from Vagaikulam pond

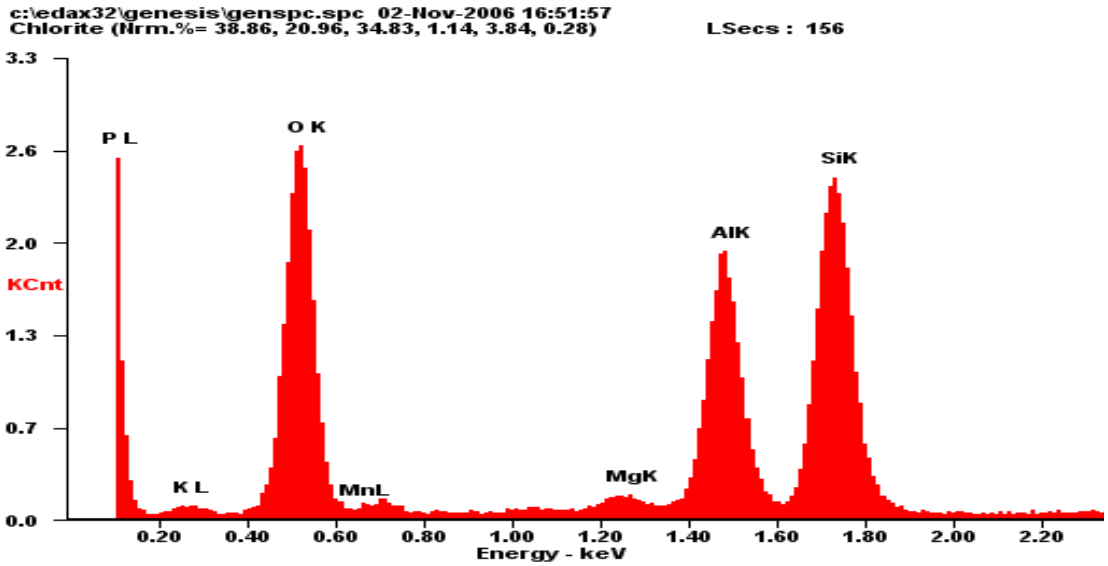


Table-5.1a Table showing the percentage comparison of various elements present Vagaikulam pond.

Element	Wt %	At %
O K	47.77	64.08
MnL	12.35	04.83
MgK	01.30	01.15
AlK	15.20	12.09
SiK	23.38	17.86

Fig. 5.1b SEM analysis of sample taken from Vagaikulam pond

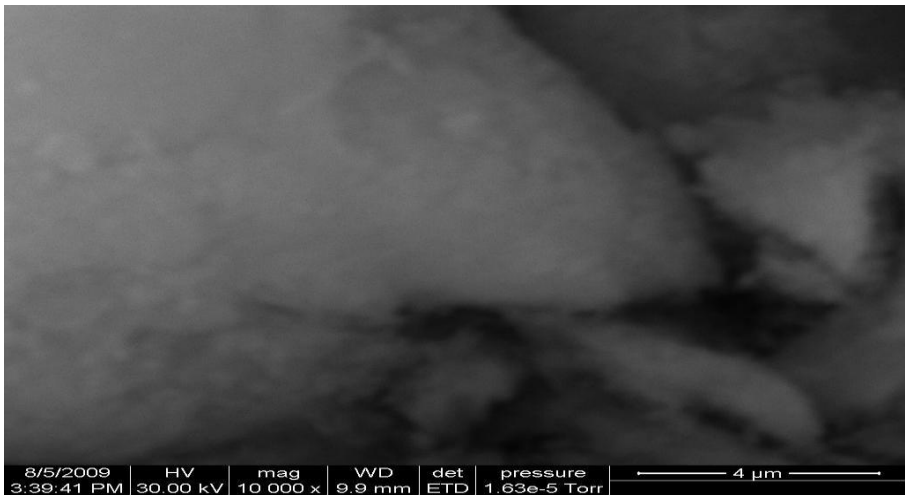


Fig. 5.2a : EDAX analysis of soil samples taken from achankulam

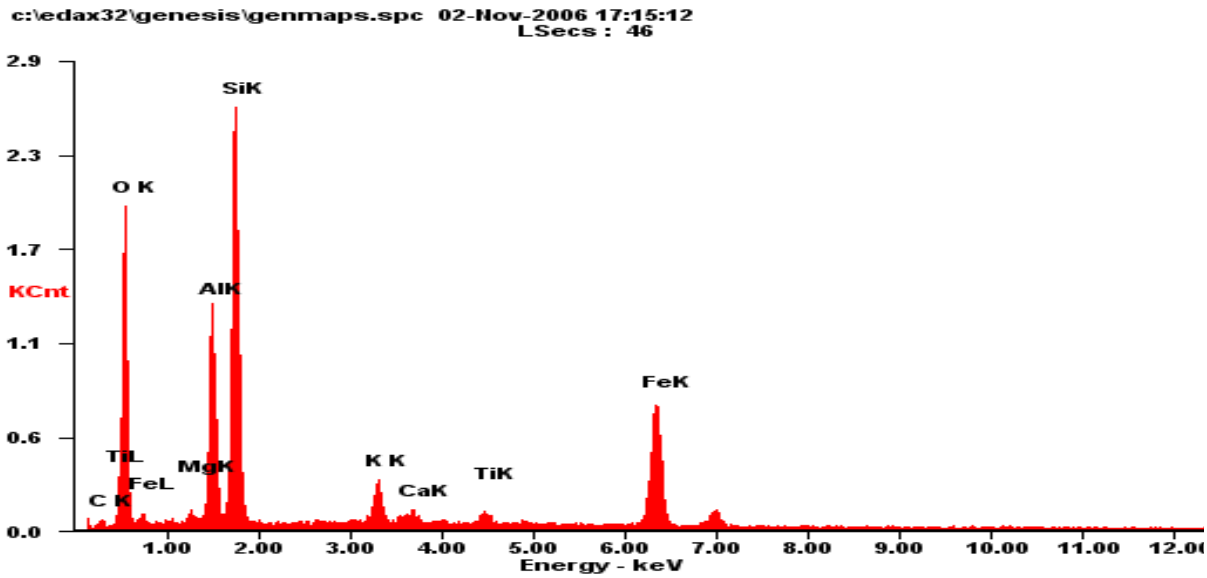


Table showing the percentage comparison of various element present Achankulam pond.

Element	Wt %	At %
O K	47.77	64.08
MnL	12.35	04.83
MgK	01.30	01.15
AlK	15.20	12.09
SiK	23.38	17.86

Fig. 5.2b SEM analysis of sample taken from Achankulam pond.

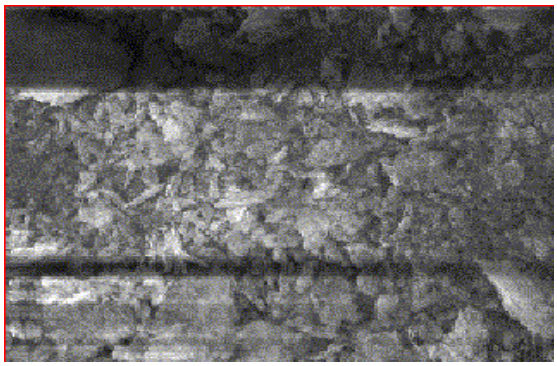


Fig. 5.3a : EDAX analysis soil samples taken from Karunai river bed soil

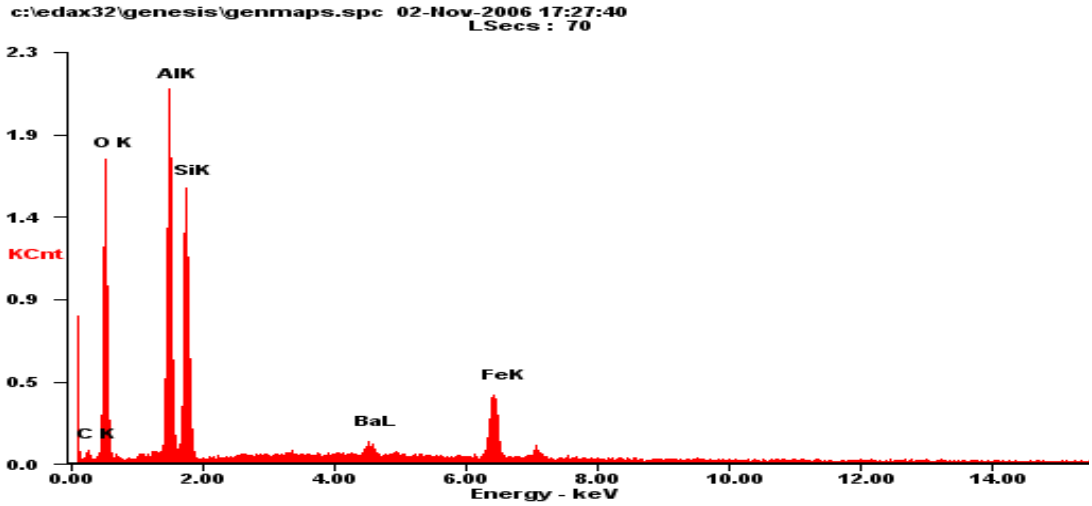
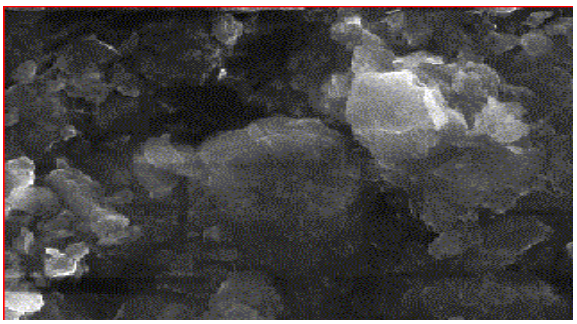


Table- 5.3a Table showing the percentage comparison of various element present karunai river bed

Element	Wt%	At%
CK	08.00	13.52
OK	43.11	54.72
AlK	19.68	14.81
SiK	19.20	13.88
BaL	02.61	00.39
FeK	07.41	02.69
Matrix	Correction	ZAF

Fig. 5.3b SEM analysis of soil sample taken from Karunai river bed.



6. OBJECTIVES – IV

ISOLATION AND IDENTIFICATION OF MICROBES IN SOIL AND TO MAKE POTTERY PRODUCTS

In pottery making, raw clay pots / or other clay wares are fired at high temperature (above 5000C). The higher the temperature, the greater the clayware get colour and appearance. During the firing process, it was surprise to find certain microbes in the very hot clay wares. The heat tolerant microbes or thermophiles in clayware shed lights on the role of this microbe to give some strength or other properties to the clayware. This area needs a great attention. With this curiosity clay ware samples from red hot kiln were collected aseptically and the microbe (bacteria) was isolated. As this is a peculiar microbe, the gene sequence of this microbe was studied. This will be valuable information for further studies.

MATERIAL AND METHODS

From a clayware manufacturing unit an unfired pot sample was taken. This small pot was covered by a cotton cloth and mud paste was applied over the covering cloth. This was fired in a muffle furnace at 9000C for 2 h. After firing the clay pot was aseptically removed and powdered. From the powdered clayware, sample was collected using a sterile loop and transferred to thermal agar broth. The plates were incubated for 24 h at 600c (Elnasser et al., 2007). After 24 h the bacterial colonies formed on the plates were isolated and pelletized. The microbial pellets were subjected to 16sRNA studies using PCR. The genomic DNA was isolated and amplified in HELINI Biomolecules, Chennai.

16S rRNA amplification

The 16S rRNA was amplified using the bacterial specific primer pairs. The reaction mixture for PCR amplification was prepared in a total volume of 50 µl with 25 µl Master mix (10 x Taq buffer, 2mM Mgcl2, 0.4 mM dNTP mix and 2U proofreading Taq DNA polymerase), 2 µl bacterial genomic DNA, 1 µl forward and 1 µl reverse (10 pmoles/ µl) primers, 21 µl water and nuclease. The amplifications were performed in a DNA thermal cycler 480 (Perkin Elorer, USA). The PCR reaction details were as follows: 3 min at 94ºC for initial denaturation, 1 min at 94ºC for denaturation, 1 min at 65ºC for annealing, 1 min at 72ºC for extension with total 30 cycles of amplification and 5 min at 72ºC final extension. The 16S rRNA of PK strain was purified using

GenEluteTM Gel Extraction Kit (Sigma Aldrich, USA) and sequencing of 16S rRNA gene was done in an automated ABI-3100 Genetic Analyser (GeNei, India).

Phylogenetic analysis

BLASTN (optimized for megablast) searches were manipulated with the sequences of PK. (my sample) The corresponding sequence of representative species was used for phylogenetic analyses. MEGA 4.1 software programme was started with a set of aligned sequences using Clustal W, and searches for phylogenetic trees that are optimal according Neighbor-Joining (NJ) and Maximum Parsimony (MP) algorithms (Tamura et al. 2007).

RESULTS

Phylogenetic analysis

A 729 (PK) bp sequence was amplified from the genomic DNA with specific primers and it was submitted to GenBank. As shown in Table 1, strain PK 16S rRNA sequence was used for identity search, which was made using BLASTN algorithm 79 (optimized for megablast). The 16S rRNA gene showed high similarity with 16S rRNA genes deposited in the GenBank (Table 1). PK strain 16S rRNA had 93% identity (E value 0.0) with 16S rRNA gene of *Exiguobacterium sp.* (GQ503330) followed by 93% identity (E value 0.0) with 16S rRNA gene of *Bacillales bacterium* (AB491820), *Exiguobacterium aestuarii* (FJ462716), *Exiguobacterium arabatum* (FM203124), *Exiguobacterium panipatensis* (EF519705), *Exiguobacterium profundum* (AY818050), *Exiguobacterium homiense* (FJ999945) *and Exiguobacterium aurantiacum* (FJ460165). In this study, 16S rRNA gene of different *Exiguobacterium* species (different strains of a species) was obtained by BLASTN search, however 8 strains of *Exiguobacterium* species were selected on the basis of high identity (%) with good E value for phylogenetic analysis. As shown in Fig. 1A, 1B, 2A and 2B, two strains belonging to Bacillales Family XIII. Incertae Sedis were relatively closely related to *Exiguobacterium*; strain PK had a clade supported with *E. aestuarii* (FJ462716).

The cumulative results from a limited number of studies to date suggest that 16S rRNA gene sequencing provides genus identification in most cases (>90%) but less so with regard to species (65-83%), with regard to species from 1-14% of the isolates remaining unidentified after testing (Drancourt et al., 2000; Mignard and Flandrosis, 2006; Woo et al., 2003). Michael and Sharon (2007) reported that, the minimum 500-525 bp essential for phylogenetic analysis, and also for species identification minimum >99% similarity and ideal >99.5% similarity should be desirable. <0.5% similarity and other

properties such as phenotype should be considered to final species identification. E value is related to the probability that the observed degree of similarity could have arisen by change: E is the number of sequences that would be expected to match as well or better than the one being considered, if the same database were probed with random sequences. Values of E below about 0.05 would be considered significant; at least they 80 might be worth considering (Arthur, 2005). According to Michael and Sharon (2007) and Arthur (2005) reports, in this study, isolate PK (729 bp) had (93%) which was ideal less than 99.5% similarity and E value (0.0) <0.05 with *Exiguobacterium* sp., *Bacillales bacterium, Exiguobacterium aestuarii, Exiguobacterium arabatum, Exiguobacterium panipatensis, Exiguobacterium profundum, Exiguobacterium homiense and Exiguobacterium aurantiacum.* According to the suggestion of Drancourt et al., 2000; Mignard and Flandrosis, 2006; Woo et al., 2003 our PK had 93% with 0.0 E-value; it is reveals strain PK belongs to the genus *Exiguobacterium*.

Comparison of 16S rRNA sequences has become the „gold standard" for the elucidation of phylogenetic relationships among microorganisms. As the number of sequences available for analysis continues to grow, the structure of phylogenetic trees derived from these sequences becomes both more intricate and more accurate (O"Connor et al., 1991). Pernodet et al. (1989), Chang et al. (1997) and Fukushima et al. (2002) reported that 16S rRNA, *gyrB* and 23S rRNA of various bacterial species were partially sequenced and used for defining all members of the genus, groups of species or individual species. In the present investigation, phylogenetic tree were constructed that are optimal for NJ with topology and MP with topology.

As shown in Fig. 1A, 1B, 2A and 2B, two strains belonging to Bacillales Family XIII. Incertae Sedis were relatively closely related to Exoguobacterium; strain PK had a branch supported with *Exiguobacterium aestuarii* (FJ462716) where other species had separate branch. The results supported that the phylogenic position of strain PK in the genus *Exiguobacterium* might belong to the family Bacillales Family XIII. Incertae Sedis. The results of a BLASTN analysis and phylogenetic analysis based on the 16S rRNA sequences can be suggested strain PK should be positioned in the genus *Exiguobacterium aestuarii*. In 81 addition, the special characteristics mentioned in the study suggest that novel strain PK belong to the species *Exiguobacterium aestuarii* with high identity.

Table 1. Results of similarity searches between 16S rRNA gene (PK) isolated in the present investigation and GenBank accessions using BLASTN Algorithm (optimized for megablast).

Highest Identical Species	Matched Sequence Accession number	Sequence Identity (%)	E-value
Exiguobacterium sp	GQ503330	93	0.0
Bacillales bacterium	AB491820	93	0.0
Exiguobacterium aestuarii	FJ462716	93	0.0
Exiguobacterium arabatum	FM203124	93	0.0
Exiguobacterium panipatensis	EF519705	93	0.0
Exiguobacterium profundum	AY818050	93	0.0
Exiguobacterium homiense	FJ999945	93	0.0
Exiguobacterium aurantiacum	FJ460165	93	0.0

Fig. 1 - Phylogenetic trees are based on the nucleotide sequence of 16S rRNA genes. The trees were constructed by using MEGA 4.1 software. (A) Neighbor-Joining algorithm was used for tree construction. (B) Neighbor-Joining algorithm with topology was used for tree construction.

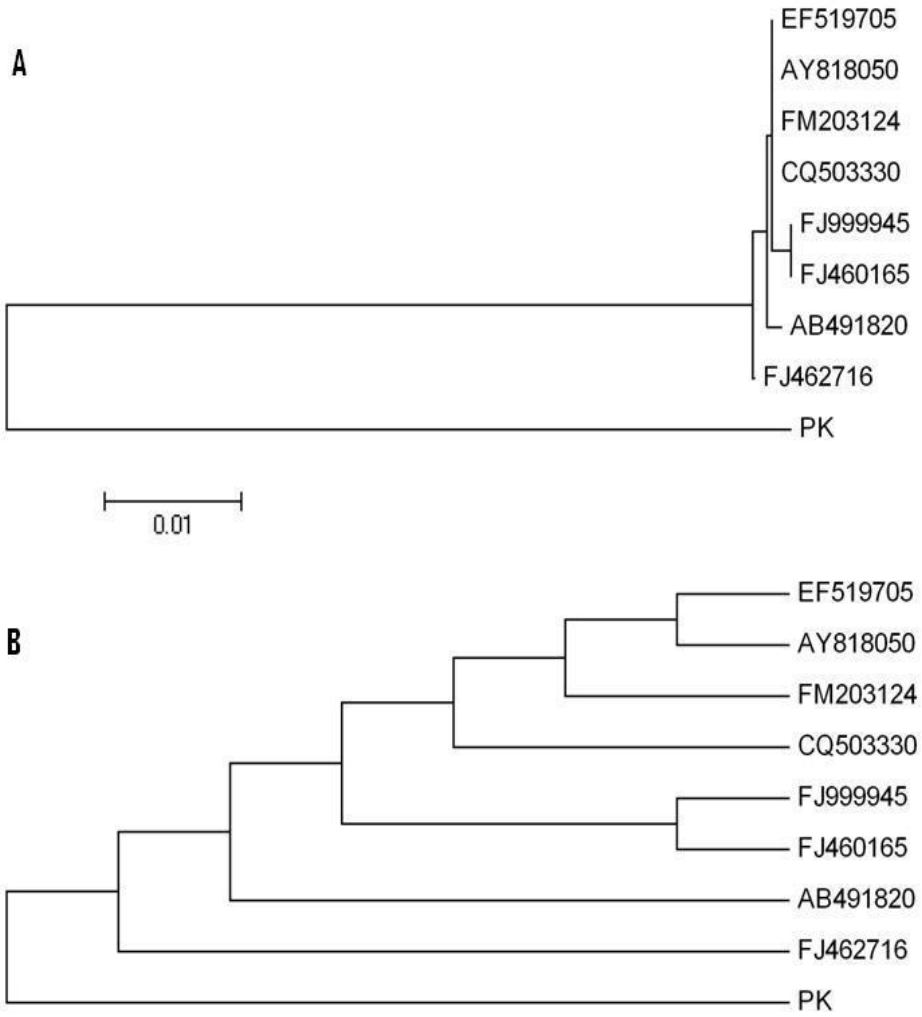
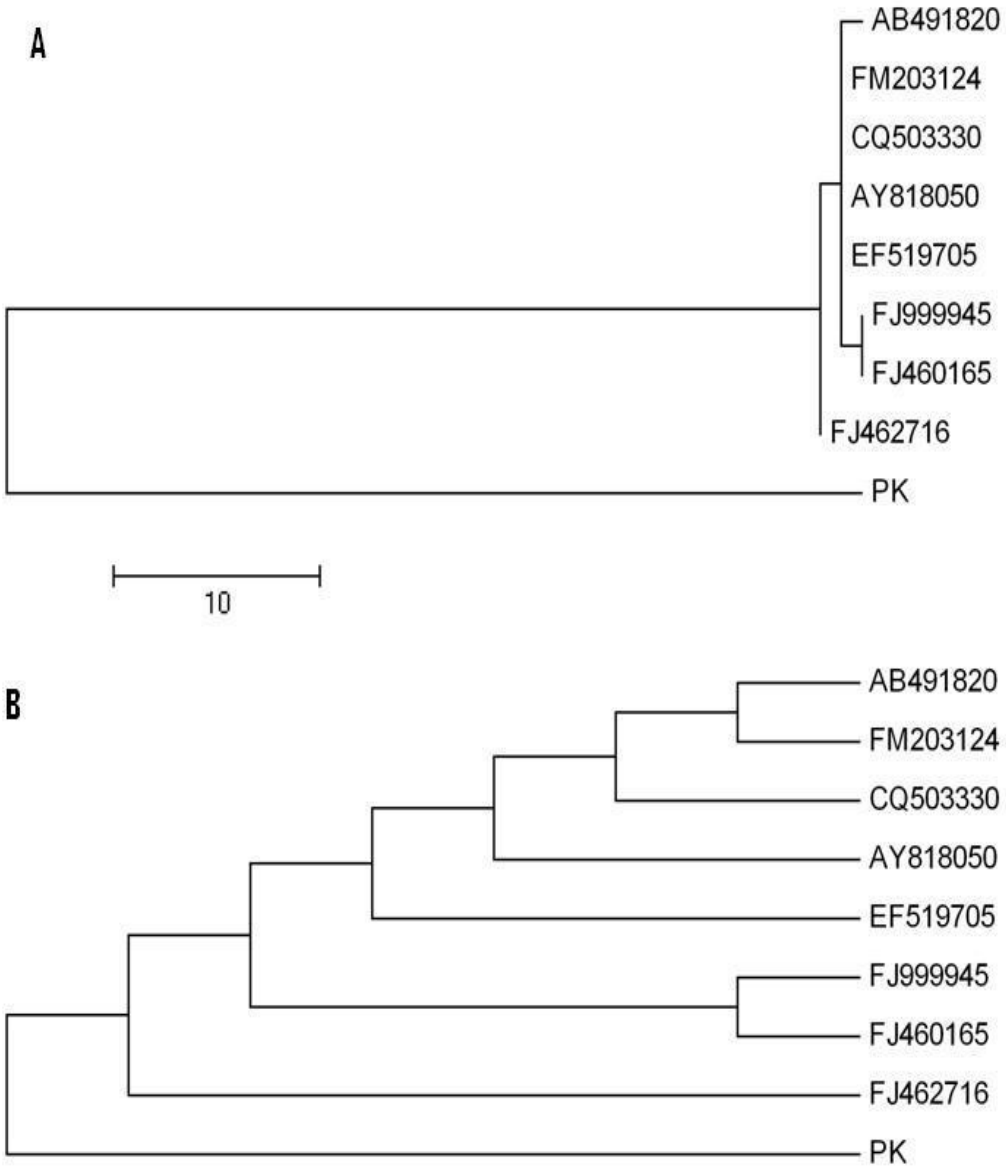


Fig. 2 - Phylogenetic trees are based on the nucleotide sequence of 16S rRNA genes. The trees were constructed by using MEGA 4.1 software. (A) Maximum Parsimony algorithm was used for tree construction. (B) Maximum Parsimony with topology was used for tree construction.



7. OBJECTIVE – V
INCORPORATION OF HERBAL POWDER IN TO POT

In India, purified potable water is not available in many rural villages. In many villages in Tamil Nadu and West Bengal rural people depend on ground water sources to meet their water need. Ground water is taken out through bore wells and wells. Ground water is polluted by many pollutants like toxic metals, pesticides etc. In many parts of Tirunelveli district, drinking water sources in many villages is contaminated with a variety of chemicals of which fluoride and Arsenics are common. Water contaminated with fluoride and arsenics cause many health problems. Arsenic in water causes hyperkeratosis, cancers in bladder, skin and other internal organs (Andrews, 1980). WHO has given a standard value of 0.01 mg/l arsenic in drinking water as a permissible level.

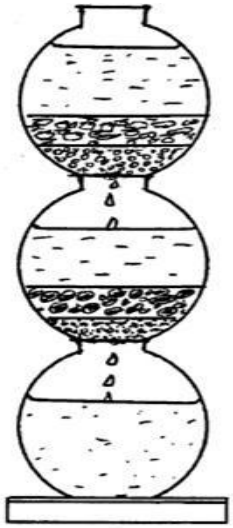
In rural village people can't afford to install sophisticated water purifier to remove arsenic. Hence if some indigenous technologies are developed, it will be a great boon to thousands of poor villagers who are use arsenic contaminated water innocently. So in the present study a novel method of removing arsenic in drinking water was tried. For the removal of such contaminant earthen pots with earthenware pieces and naturally occurring material were used.

MATERIALS AND METHODS

To test the efficacy of earthen pots to remove arsenic in drinking water, earthen pots were used. To carry out the study three earthen pots of uniform capacity (20 liters) were developed at Alwarkurichi potters society. The pots were piled one above the other. Three types of pot systems were used. In type 1 pot system the top pot was (Fig 5.4 & 5.5) filled with 1 litter of broken pieces of clay tiles and bricks, and one liter of stone pebble pieces. In the centre of the pot a hole of 5 cm was made and a circle of 100% polyester batting was placed over it. So that water can flow slowly from the hole in the bottom of the pot.

This pot 1 is placed over another pot that contained 1 litter wood charcoal and 1 litter fine sand. In the middle of the bottom 5 mm hole was made and this was covered with a circle of 100% polyester batting as provided in the above mentioned pot. In the third pot filtered water was collected. To hold the pots, erect wooden stands were given for support. This setup is a control system. For the experiments few modifications were made in this setup. In the setup 2 in the second pot of the set up one liter of dried pieces of the plant "sivanar vembu (Indigofera aspalathoides)" was kept above wood charcoal.

CONTROL POT SYSTEM

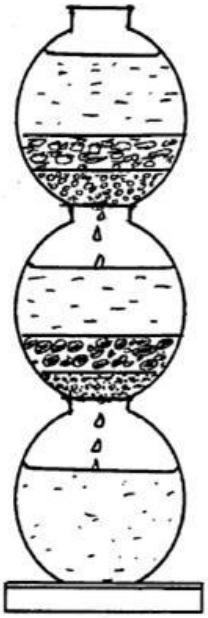


Pot 2 1 litter wood charcoal and 1 litter fine sand

Pot 1 1 litre of broken pieces of clay tiles, stone pebble and bricks

Pot 3 contains filtered water

TEST POT SYSTEM



Pot 3 contains filtered water

Pot 2. 1 litter of dried pieces of Sivanar vembu

Pot 1. 1 litre of broken pieces of clay tiles, stone pebble and bricks

Preparation of Arsenic Water

For preparing experimental standard arsenic water 1.320 g arsenic trioxide was dissolved in 25 ml (20% w/v) of potassium hydroxide and neutralized with 20% (v/v) nitric acid

Experiment

Before passing arsenic contained water, 5 liters of tap water was passed through each pot to flush out materials that may have become dislodged with the water flow, ending up in the resulting water. Then 2.5 liter of arsenic contained water was allowed to pass through the pot system 1 and 2 separately. For arsenic removal 2 separate sets of experiments were conducted. Arsenic content in the water before introduction in to the pot system and in the filtered water at last compartment was estimated. For testing arsenic atomic absorption spectrophotometer was used. (APHA, 2005)

RESULTS

To provide safe drinking water to the rural villages, a cheap method of water purification is developed by using earthenware storage chamber. The earthen pots and the ingredients added inside are cheap plant products. This filtering unit does not require energy/power. This is a natural method of water purification to save the life of several thousand villagers who suffer with arsinosis. Several experiments were conducted to find out the efficacy of the systems.

The amount of arsenic before the filtration was 145µg/lit. It was reduced to 1.6µg/lit. After allowing to pass the water through the claywares system 1. In the clayware system two (claywares with the plant) the arsenic content was less than detectable level. Clayware with the plant **"**Sivanar Vembu (*Indigofera aspalathoides*)" functions as a very effective agent to absorb the toxic arsenics.

8.MILE STONES FIXED AS PER AGREEMENT:

S.No	Milestone	Target Achieved
1	➢ Models of Earthernware storage system ➢ Structure of Earthernware designed for storage	✓
2	➢ Biochemical characteristics Organoleptic qualities Physiological weight changes and microbiological studies	✓
3	➢ Analysis of various elements in the soil used to prepare pottery products	✓
4	➢ Isolation and identification of microbes in soil used to make pottery products	✓ ✓
5	➢ Incorporation of herbal powder and microbes in pottery products	✓
6	➢ Capacity building Training market ability.	

9. **Deviation made from objectives if any: -NIL-**

10. Conclusion summarizing the achievements and indications of scope for future work

For a healthy life, good nutritional food consumption is essential. To get minerals, vitamins and other nutrients, people consume fruits and vegetables. The demand for fruits and vegetables increasing day by day. As fruits and vegetables are grown mostly by applying chemical fertilizers and pesticides, their shelf-life period is poor, unless they are preserved in good storage systems like refrigerators. To consume fresh and unperished fruits and vegetables, every house needs a storage system. If fruits and vegetables are not properly cared before consumption, they not only get perished but also inflict food-borne illness. Hence proper storage of fruits and vegetables is imperative in each kitchen. Preserving the fruits and vegetables, for domestic use by using refrigerators or deep freezers not only pollutants to the atmosphere but also consumes electricity. In order to avoid pollutional discharge from home hold storage chambers and to minimize poor people's expenditure on maintenance and electricity to keep to storage chambers, attempts had been made to design develop a "poor man's storage system".

In the present study eco-friendly, economic, effective, earthenware storage systems were created to store fruits and vegetables. Three designs were created and based on the design, three types of home hold storage chambers were developed. For making the storage chambers, the skills of pottery artisans were applied. Using clay pottery techniques the

storage systems were developed. The utilization of clay pottery for making poor man's fridge has many objectives. It helps to rejuvenate the dying art of day pottery and give life to thousands of pottery artisan's family whom are suffering because of the poor market demand for pottery products in this era of metal culture. Besides clay pottery products are eco-friendly, degradable, low-cost and no maintenance expenditure. Rural people can afford to purchase this low-cost storage system. This natural way of storing the perishable fruits and vegetables provide good nutrients supply and good health.

In the present study, three types of earthenware storage systems, viz: Basic model of earthenware storage system ($EWSS_1$), Modified model of earthenware storage system ($EWSS_2$) and pyramidal type earthenware storage system ($EWSS_3$) were developed. For making these units clay material were collected from local Ponds and mixed them is proper ration. Using modern scientific knowledge the clay materials were processed and three types of poor man's fridges were developed.

After developing the eco-friendly storage systems the utility value and efficiency to store fruits and vegetables were studied in detail by applying various testing procedures. Microbial contamination easily occurs in fruits and vegetables, if they are not stored properly. The storage systems should inhibit the microbial growth on the stored products. So in the present study microbial load in the following food products, grapes, banana, brinjal, ladiesfinger, and carrot was enumerated before putting them in to the earthenware storage systems. After a periodic intervals of 3rd day, 5th day and 7th day, the microbial load in each stored item was tested and the results were compared with the same fruits and vegetables stored in refrigerator and in ambient condition. To the surprise it was observed that the pyramidal type earthenware storage system significantly minimized the microbial load more than the modern refrigerator and ambient condition.

Retention of biochemical constituents (carbohydrates, proteins, and vitamins) in fruits and vegetables were studied. The fruits and vegetables stored at earthenware storage systems retained all the nutrients at an astonishing level when compared with the products stored in refrigerators.

Highly significant differences were recorded in the physiological loss of weight among the different storage systems. The maximum weight loss was observed in all fruits and vegetables in the ambient conditions followed by refrigeration whereas PLW was low in fruits and vegetables stored in $EWSS_2$ followed by $EWSS_1$ and $EWSS_3$. The result indicated that $EWSS_2$ is a good storage unit to reduce the loss of weight for stored fruits and vegetables.

Organoleptic quality of the fruits and vegetables were quantified before putting them into the earthenware storage system. After 7 days of storage Organoleptic properties (skin colour appearance, texture, and flavour and taste) were estimated in the fruits and vegetables stored in earthenware storage systems and refrigerator and at room. The study revealed the efficiency of the earthenware to retain Organoleptic qualities more than the refrigerator.

For preparing clay wares, clay soil was collected from 3 major sources in the study area. In the present study the day sample collected from the study areas were tested for mineral constituents advanced instruments XRD and EDAX with SEM were used. The study provided information on the different minerals in each day. The clay contained silicon, Alumina, manganese, ferrous, barium, titanium, calcium, and potassium. Such mineral components give strength to the pots, promote evaporation, provide flexibility create the pot colour and appearance to the products. Further, to promote the importance of clay products to use as filters, attempts were made to test the efficiency of the products to remove arsenic from potable water. Two types to earthen pots were used. In one of the types a plant material "Sivanarvembu" (*Indigofera aspalathoides*) was placed to enhance filtering. In this unit, the filtered water contained arsenic content below detectable level. From these experiments it is inferred that the clay pot can be used to remove toxic arsenic in drinking water.

Along with the newly designed clayware storage systems that are to be obtained patent rights, other kitchen wares are to be developed shortly. It has been planned to develop micro-oven usable claywares, dosa pan, cookers, etc. and to provide training to the poor potters to develop the novel products. This could help them to sustain their lively hood and prevent the extinction of this great art of pottery making.

11. S & T benefit accrued.

1. Journal publication during the period.

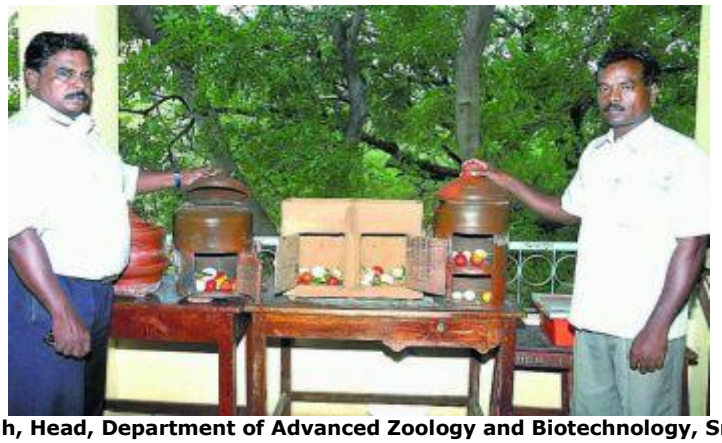
Title of the paper	Journal issue	Authors
Evaluation of shelf life and organoleptic aspects of fruits stored in a modified traditional earthern pot cool chamber	Indian Journal of Traditional Knowledge (NISCAIR). 2011. 10(2); 375 – 379.	A.J.A.Ranjit Singh, A.M.Murugan and S.Vidhya

2. Presentation in Symposia / Conference during the period.

Title of the paper	Symposium	Date of Symposium	Authors
1.Efficiency of modified rural based post harvesting technology to preserve biochemical	International colloquium on Emerging Biotechniques in agriculture animal health and productivity. Alagappa	23.04.2009 – 26.02.2009	A.J.A.Ranjit Singh and A.M.Murugan

and organoleptic value of vegetables and fruits.	University, Karaikudi.		
2.Modified earthen pot cool chambers for vegetable storage.	Application of Biotechnology in medicine and in law. S.P.College, Courtallum.	06.03.2009	A.J.A.Ranjit Singh and A.M.Murugan
3.Eco-friendly pyramidal type earthen were storage system for rural house hold system.	98th Indian Science Congress, SRM University, Chennai	03.01.2011- 07.01.2011	A.J.A.Ranjit Singh and A.M.Murugan

Biologically treated clay developed



A.J.A. Ranjit Singh, Head, Department of Advanced Zoology and Biotechnology, Sri Paramakalyani College, Alwarkurichi, (left) with the zero energy cool chamber and A.M. Murugan, a reasearch scholar in pottery.

TIRUNELVELI: The Department of Advanced Zoology and Biotechnology of Sri Paramakalyani College, Alwarkurichi, in the district has revived art of pottery in this region by supplying to the traditional potters four bacteria and three fungi varieties, which add more plasticity to the clay being used for making pots and other value added products of clay like zero energy cool chambers, kitchen utensils, ornamental products, light shades, musical instruments, religious products etc.

After being funded by the Department of Science and Technology, Government of India, a team of researchers headed by A.J.A. Ranjit Singh, Head, Department of Advanced Zoology and Biotechnology of Sri Paramakalyani College commenced their research on December 1, 2008 on isolating the beneficial bacteria and the fungi from different types of soil to process the clay and to make a range of value added utensils.

Zero energy cool chamberThe zero energy cool chamber, made with the bacteria-treated clay, can keep the vegetables and fruits for up to nine days and no shrink can be seen on the skin of the veggies as temperature prevailing in this specialized chamber that does not need any power is as low as 21 degree Celsius.

While the specially-treated earthen frying pans, idly pans, dosa tava etc. need only a small quantity of oil, the clay bowl used in the microwave oven does not develop any crack or spoil the food. Another interesting aspect is that these clay utensils do not consume more fuel.

For preparing the non-stick clayware, Dr. Ranjit Singh's team has developed 'black pottery technology'. To enhance the quality of water being stored in these clayware, the team has used imported 'super cera', a pro-biotic microbial chip from the United States of America.

"As part of giving a new lease of life to the artisans, we've succeeded in our attempt of isolating four beneficial bacterium and three fungi to soften the clay being used for pottery. Subsequently, we trained the local potters in using the isolated micro organisms in the clay to make it soft and add more plasticity.

Moreover, we've replaced the conventional flower pots, cooking pot and the household clay furnace with eco-friendly, economical, efficient and attractive clayware that consumes less fuel," Dr. Ranjit Singh told The Hindu.

As the cost of all these products so cheap (the zero energy cool chamber carries a price tag of just Rs. 500), it is expected that the clayware made with specially treated clay will rock the market, Dr. Ranjit Singh noted.

91. Eco-friendly Pyramidal Type Earthenware Storage System for Rural House hold Storage of Vegetables

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Keywords : *Pyramid, storage, vegetables, nutritive value, organoleptic value*

With view to investigate the influence of pyramidal structure for vegetable storage experiments were conducted for a period of 9 days and it was compared with other storage systems including refrigerator and ambient conditions. Parameters like physiological loss of weight, heterotrophic microbial count, carbohydrate and protein content and organoleptic qualities were analyzed for the stored products like carrot, tomato and ladies finger. The results indicated that the vegetables stored in pyramidal storage system minimized the physiological loss of weight, reduced microbial numbers and prevented spoilage, retained nutritive value much greater than, when compared to refrigerator storage and ambient storage. In the pyramidal system, organoleptic value has also unchanged.

3. Patented during the period.

1. Clay made percussion musical instrument - 1036/CHE/2011.

2. Low cost high capacity indigenous anaerobic chamber
   For the culture of anaerobic microbes - 1037/CHE/2011.

3. Zero-energy earthen were cool chamber for house hold
   fruits and vegetables storage - 601/CHE/2011.

(12) PATENT APPLICATION PUBLICATION (21) Application No.1037/CHE/2011 A

(19) INDIA

(22) Date of filing of Application :31/03/2011 (43) Publication Date : 08/04/2011

(54) Title of the invention : LOW COST, HIGH CAPACITY, INDIGENOUS ANAEROBIC CHAMBER FOR THE CULTURE OF ANAEROBIC MICROBES

(51) International classification	:C12M1/00
(31) Priority Document No	:NA
(32) Priority Date	:NA
(33) Name of priority country	:NA
(86) International Application No	:NA
Filing Date	:NA
(87) International Publication No	: NA
(61) Patent of Addition to Application Number	:NA
Filing Date	:NA
(62) Divisional to Application Number	:NA
Filing Date	:NA

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(57) Abstract :
Anaerobic chamber is used for the culture of anaerobic microorganisms. The anaerobic chamber available in the market is expensive. In many anaerobic chambers absorbents are placed inside the chamber to remove air. To overcome this problem a low cost, high capacity, high effective anaerobic chamber has been developed by using locally available materials. The capacity of the chamber can be increased or decreased according to our need. A thrown out compressor in a refrigerator, a pressure cooker are used with modifications. The parts for the of instruments are available easily. The capacity of the chamber is increased by placing the lid on a high capacity pressure cooker. Further the complete evacuation of air inside the chamber is easily monitored.

No. of Pages : 11 No. of Claims : 6

(12) PATENT APPLICATION PUBLICATION (21) Application No.1036/CHE/2011 A

(19) INDIA

(22) Date of filing of Application :31/03/2011 (43) Publication Date : 08/04/2011

(54) Title of the invention : CLAY MADE PERCUSSION MUSICAL INSTRUMENT-GHADAM

(51) International classification	:G10D, C04B33/00
(31) Priority Document No	:NA
(32) Priority Date	:NA
(33) Name of priority country	:NA
(86) International Application No	:NA
Filing Date	:NA
(87) International Publication No	: NA
(61) Patent of Addition to Application Number	:NA
Filing Date	:NA
(62) Divisional to Application Number	:NA
Filing Date	:NA

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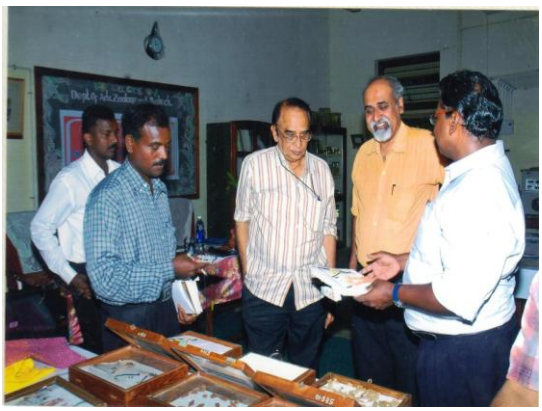
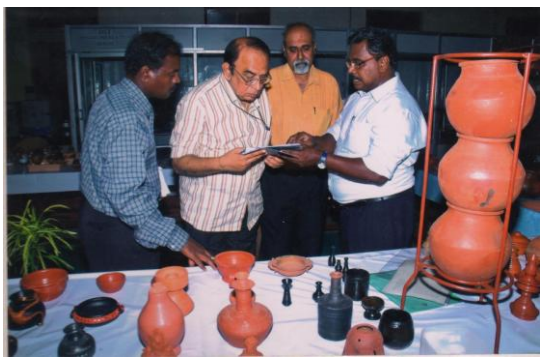
(57) Abstract :
In the present invention, three types of clay, fine sand, nano sized metal particles are incorporated to design the earthenware, the Ghadam; which is developed for South Indian Classical music performances. The proportion in which the clay was mixed and metal particles are added and firing decides the sound. The tone of the pot has to be good. To achieve that, nano sized metal particles are mixed with clay. The wall of the Ghatam is of even thickness, to produce an even tone. These clay Ghadams are tuned to the taste of a musician.

No. of Pages : 12 No. of Claims : 1

4.Man power trained





5. **Replication potential**

In the present study the potters in Tirunelveli districts were trained in their villages. Except the microbial culture handling, all the other techniques we followed by the trainees and earn money.

5. Linkages developed

Linkages with 17 potters society hamlets and also with national centre.

Date :

Place

Signature of Principal Investigator