EFFECTS OF STORAGE CONDITIONS ON NUTRITIONAL COMPOSITIONS OF BANANA

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DECLARATION

I hereby declare that this project is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any University or Institution. Information derived from personal communications, published and unpublished works of others were duly referenced in the text.

Egbujor 17-02-2010
Egbujor, Eberechukwu Chikaodi .... Date

DEDICATION

This project work is specially dedicated to Almighty God, the Maker of Heaven and Earth, the Author and Finisher of life; He has been my source of wisdom and strength since I was admitted into this citadel of learning to acquire a bachelors degree in Agricultural and Bioresources Engineering and to my beloved parents Mr and Mrs. Chiedum Egbujor.

ABSTRACT

This project work was conducted to determine the effects of storage conditions and the nutritional composition of banana using three different storage methods: refrigerator, polythene bag and open air (shelf). The storage condition monitored here were temperature and relative humidity of the storage environment. Selected fresh green banana fruits were stored in a refrigerator, polythene bag and open air (shelf) for a period of seven days. Temperature, relative humidity and nutritional changes were monitored. The results obtained showed that temperature of banana in the refrigerator was between 4-5^{0}C at relative humidity of about 84%, for the polythene bag temperature ranges between 24-30^{o}C at 90-91% relative humidity, and for open air (shelf), the temperature used was between 23.5-26.0^{0}C at 90% relative humidity. All the storage methods experienced an increased and decreased in nutrients, but the refrigerator storage condition still ranked best in terms of quality preservations of banana compared to other storage methods. Storage in cold room can be used to store banana in large quantities.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

The word banana is a general term embracing a number of species or hybrids in the genus *Musa* of the family *Musaceae.* It is known to have originated from the tropical region of southern Asia. According to Lislie (1976), it is now cultivated throughout the tropics. Banana plants are cultivated primarily for its fruits and to a lesser extent for the production of fibres and as ornamental plants (Akinyosoye, 1991). As the banana plants are normally tall and fairly sturdy they are often mistaken for trees, but their main or upright stem is actually a pseudostem. For some species this pseudo stem can reach a height of up to 2–8 m, with leaves of up to 3.5 m in length. Each pseudostem can produce a bunch of yellow, green or even red bananas before dying and being replaced by another pseudostem.

The banana fruit grows in hanging clusters, with up to 20 fruits to a tier (called a hang, 3-20 tiers to a bunch). The total of the hanging clusters is known as a bunch, or commercially as a "banana stem", and can weigh from 30–50 kg. The fruit averages 125 g, of which approximately 75% is water and 25% dry matter content. Each individual fruit (known as a banana or 'finger') has a protective outer layer (a peel or skin) with a fleshy edible inner portion. Both skin and inner part can be eaten raw or cooked. Western cultures generally eat the inside raw and throw away the skin while some Asian cultures generally eat both the skin and inside cooked. Typically, the fruit has numerous strings (called 'phloem bundles') which run between the skin and inner part. Bananas are a valuable source of vitamin B_6, vitamin C, and potassium (FAO, 2005).

Bananas are grown in at least 107 countries. In popular culture and commerce, "banana" usually refers to soft, sweet "dessert" bananas. The bananas from a group of cultivars with firmer, starchier fruit are called plantains. Bananas may also be cut and dried and eaten as a type of chip. Dried bananas are also ground into banana flour. Although the wild species have fruits with numerous large, hard seeds, virtually all culinary bananas have seedless fruits. Bananas are classified either as dessert bananas (meaning they are yellow and fully ripe when eaten) or as green cooking bananas. Almost all export bananas are of the dessert types; however, only about 10-15% of all production is for export, with the United States and European Union being the dominant buyers (FAO, 2005).

After harvest, fruits are prone to deteriorate. The fruits having been harvested are severed from there source of water and nutrient, still continue to carry on metabolic activities. Nigerian fall within the tropical region of the world where the production of tropical fruits do not only has valuable social cultural significant but also represent an important source of income.

It is revealed that about 35% to 75% of the harvested fruits do not get to the consumer (Olorunda and Aworh, 1983). As production level is not marched by the provision of adequate storage facilities. Refrigerated storage an alternative method is considered inadequate due the problem of chilling injuries usually suffered by such products (Erinle and karikari, 1988). It is necessary to prolong the shelf life of banana fruit. In doing this the environment and atmospheric condition in which the products are kept are the determining factors. Low storage is the most effective means of prolonging the shelf life since it helps in reducing the respiration rate, retard maturity and ripening of fruits, and retard bioactivities.

The maintenance of the freshness of fruits and vegetables is one of the most difficult as aspects of fruits and vegetables production in the tropics (David and Adam, 1985; Bachmann and Earles, 2000). Mejia (2003) reported losses in fruits and vegetables of about 40 to 50% in the tropics and subtropics. He explained the reasons for the losses to be as a result of poverty, lack of appropriate technologies, insufficient or scarce access to information, poor storage and inadequate handling transportation. Physiological deterioration which results during storage due to natural reactions can lead to significant loss of nutritional value and in many cases, loss of the whole fruits or vegetable (William *et al.,* 1991). Deterioration may also arise from actions of biological or microbiological agents such as insects, rodents and other animals, bacteria, mould, yeast and viruses (William *et al.*, 1991). Temperature has been reported by Bachman and Earles (2000) to be the most important factor in maintaining quality of fruits and vegetables after harvest. They reported that the higher the storage temperature, the higher the rate of respiration and the greater the heat generated.

1.2 Statement of the Problem

Banana is an important staple food and crop, supplying about 25% of carbohydrate for approximately 70 million people in Africa (IITA, 1997). Major problem of banana is that the food is highly perishable. The difficulties associated with the short storage life of banana are made worst by the marketing system. The marketing system in Nigeria, usually involves several retailers. Buying and selling take time and this leads to increased crop damage. The environment within the market is also not suitable for long term storage. A combination of high perish ability, high ambient temperature, slow marketing system, and poor market system leads to losses in fruit quality, and ultimately to postharvest losses. To reduce or avoid physical, economic and nutritional losses in banana fruits, this research studies how to extend storage of banana fruits under identified storage conditions without compromising the nutritional qualities of the fruits.

1.3 Objectives of the Study

(a) To study the quality changes that occur in banana under three storage methods namely, storage in open air (shelf), storage in refrigerator, and storage in a polythene bag.

(b) To study the effect of storage conditions on the nutritional contents of banana.

1.4 Justification of the Study

Agricultural products storage operations have been described as the only solution to the problem of adequate supply of highly nutritive food for the world (FAO, 1990). Banana has been observed to be a perishable crop. The vast majority of producers in Nigeria are the small scale farmers, growing the crop either for home consumption or for local market. Bumper harvest for farmers without adequate means of storage constitutes a waste of valuable nutrients. The outcome of this study will help in recommending optimum storage conditions and method that will lead to the least amount of nutritional losses of stored banana fruit in Nigeria. This will enhance food security and reduce postharvest losses.

1.5 Scope of the Study

The scope of this study is limited to the assessment of the effect of storage conditions on the nutritional contents of banana. The nutritional compositions to be assessed are moisture content, lipids, carbohydrate, crude fibre, ash, and crude protein.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Distribution of Banana

Edible bananas originated in the Indo-Malaysian region reaching to northern Australia. They were known only by hearsay in the Mediterranean region in the 3rd Century B.C., and are believed to have been first carried to Europe in the 10th Century A.D. Early in the 16th Century, Portuguese mariners transported the plant from the West African coast to South America. The types found in cultivation in the Pacific have been traced to eastern Indonesia from where they spread to the Marquesas and by stages to Hawaii (FAO, 2003).

Bananas are today grown in every humid tropical region and constitute the 4th largest fruit crop of the world, following the grape, citrus fruits and the apple. World production is estimated to be 28 million tonnes (65% from Latin America, 27 % from Southeast Asia, and 7 % from Africa). One-fifth of the crop is exported to Europe, Canada, the United States and Japan as fresh fruit. India is the leading banana producer in Asia. The crop from 161,878 ha is entirely for domestic consumption. Indonesia produces over 2 million tonnes annually, the Philippines about 0.5 million tonnes, exported mostly to Japan. Tropical Africa (principally the Ivory Coast and Somalia) grows nearly 9 million tonnes of bananas each year and exports large quantities to Europe (FAO, 2007).

2.1.1 Banana Cultivars

The antiquities of the banana and its tendency to produce mutations or sports have resulted in an extensive number of cultivars. Only the common ones grown are listed (Redmond, 2007).

(a) Apple, Silk, or Manzana

This is dessert type. It has a pleasant sub-acid apple flavour when fully ripe. The fruit is not ripe until some brownish spectacles appear on the skin

(b) Cavendish

Cavendish are resistant to Panama Wilt disease, clones of this variety are distinguished by the size of the pseudostem. The largest is Lacatan 3.7-5.5m followed by Robusta and Giant Cavendish 3-4.9m, and then smallest is the Dwarf Cavendish 1.2-2.1m.

(c) Gros Michel

Commercially, the most important and considered by many to be the most flavourful is the Gros Michel. Because of its susceptibility to Panama Wilt disease it is being replaced with resistant varieties. Although there is no Panama Wilt in California, it does poorly here as the plant seems to need more heat and it tends to grow more slowly than other varieties

(d) Lady Finger

Lady finger has an excellent-quality fruit, tolerant to cool conditions. It takes about 15 to 18 months from planting to harvest.

(e) Orinoco

It is commonly grown in California as a landscape plant, it takes 15 to 18 months from planting to harvest. Has s a nice flavour, texture is less than perfect, but when properly grown and cultivated it can produce enormous stalks of fruit.

Orinoco is excellent in banana bread and it is sometimes called horse, hog or burro banana, it can be purchased at most nurseries (Morton, 1999).

2.2 Harvesting of Banana

Banana bunches are harvested with a curved knife when the fruits are fully developed, that is, 75% mature, the angles are becoming less prominent and the fruits on the upper hands are changing to light green; and the flower remnants (styles) are easily rubbed off the tips. Generally, this stage is reached 75 to 80 days after the opening of the first hand. Cutters must leave attached to the bunch about 6 to 15-18 cm of stalk to serve as a handle for carrying. With tall cultivars, the pseudostem must be slashed partway through to cause it to bend and harvesters pull on the leaves to bring the bunch within reach. They must work in pairs to hold and remove the bunch without damaging it (Deborah, 2008).

Improved handling methods have greatly reduced bunch injuries. In modern plantations, the bunches are first rested on the padded shoulder of a harvester and then are hung on special racks or on cables operated by pulleys by means of which they can be easily conveyed to roads and by vehicle to nearby packing sheds. Where fields have been located in remote areas lacking adequate highways, transport out has been accomplished by hovercraft flying along riverbeds. Exposure to even moderate light after harvest initiates the ripening process. Therefore the fruits should be protected from light as much as possible until they reach the packing shed (Anderson, 2008).

2.3 Handling and Packing of Banana

Banana bunches were formerly padded with leaf trash which absorbed much of the sap and latex from the harvesting operation and the sites of broken off styles, each of which can leak at least 6 drops, especially if bunches are cut early in the morning. In the 1960's, when whole bunches were being exported from the Windward Islands and Jamaica to England, they were wrapped in wadding (paper backed layers of paper tissue) to absorb the latex, and then encased in plastic sleeves for shipment. Nowadays plastic sleeves left on the bunches help protect them during transport from the field to distant packing sheds and a cushion of banana trash on the floor and against the sides of the truck does much to reduce injury. But the plastic bags increase the problem of staining by the sap/latex which mingles with the condensation inside the bag, becomes more fluid, runs down the inside and stains the peel. When hands are cut off, additional sap/latex mixture oozes from the severed crown (Morton, 1999).

Banana growers and handlers know that this substance oxidizes and makes an indelible dark-brown stain on clothing. It similarly blemishes the fruits. At packing stations, the hands are floated through water tanks to wash it off. (Sodium hydrochloride is an effective solvent.) Some people maintain that the fruit should remain in the tank for 30 minutes until all oozing of latex ceases. At certain times of the year, up to 5% of the hands may sink to the bottom of the tank, become superficially scarred and no longer exportable (FAO, 2008).

2.4 Controlled Ripening and Storage

At times, markets may not be able to absorb all the bananas ready for harvest. Experiments have been conducted to determine the effect of applying gibberellic acid either by spraying, or by injection of a solution, powder or tablet into the stalk. In Israel, gibberellic A_4A_7 acid, applied by any of these methods about 2 months before time of normal ripening, had the effect of delaying ripening from 10 to 19 days. If applied too early, the gibberellic acid treatment has no effect (IITA, 1997)

Harvested bananas allowed to ripen naturally at room temperature do not become as sweet and flavourful as those ripened artificially. Postharvest ripening is expedited undesirably if bunches or hands are stored in unventilated polyethylene bags. As a substitute for expensive controlled-temperature storage rooms, researchers in Thailand have found that hands treated with fungicide can be stored or shipped over a period of 4 weeks in polyethylene bags, if ethylene absorbing vermiculite blocks (treated with a fresh solution of potassium permanganate) are included in the sack. The permanganate solution will be ineffective if exposed to light and oxygen. The blocks must be encased in small polyethylene bags perforated only on one side to avoid staining the fruits (IITA, 1997). Bananas are generally ripened in storage rooms with 90 to 95% relative humidity at the outset, later reduced to 85% by ventilation: and at temperatures ranging from 14.4-23.9°C, with two to three exposures to ethylene gas, at six hourly applications for one to four days, depending on the speed of ripening desired. The fruit must be kept cool at 13.3-15.6°C and 80 to 85% relative humidity after removal from storage and during delivery to markets to avoid rapid spoilage. Post-ripening storage at 21°C in air containing ethylene accelerates softening but the fruits will remain clear yellow and attractive with few or no superficial brown speck (Morton, 1999).

In the mid 1960's, fumigation by ethylene dibromide (EDB) against fruit fly infestation was authorized to permit export of Hawaiian bananas to the mainland USA. The treatment accelerated ripening and it could not be applied to 'Dwarf Cavendish' without covering the bunch with opaque or semi-opaque material for at least 2 months prior to harvest (Morton, 1999).

2.5 Uses of Banana

Bananas contain about 74% water, 23% carbohydrate, 1% protein, and 0.5% fat. A banana without the peel is a good source of vitamin B6, potassium, and fibre. Banana fruit may be eaten raw or as a cooked vegetable. The fruit can also be processed for a number of food products. Ripe fruits can be pulped for puree for use in a variety of products including ice cream, yogurt, cake, bread, nectar, and baby food. Ripe bananas can be dried and eaten, or sliced, canned with syrup, and used in bakery products, fruit salads, and toppings. Green bananas can be sliced and fried as chips. Whole green fruits can also be dried and ground into flour. Vinegar and alcoholic beverages can be made from fermented ripe bananas. Other parts of the banana plant are consumed besides the fruit. The banana leaves are not eaten but may be used for wrapping food in cooking. The banana foliage and pseudostem are used as cattle feed during dry periods in some banana producing areas. Culled bananas are used to feed cattle. Bananas are good energy sources but need to be supplemented with protein (Ikisan, 2000).

2.6 Proximate Compositions of Banana

2.6.1 Moisture

The amount of moisture or water present in a material or sample is known as moisture content. It is a very useful parameter in the determination of the quality and durability of food samples. Some food samples lose some of their food nutrient due to moisture/water loss and some food samples damage due to this.

Moisture content is the amount of moisture present per given weight of a sample. Its evaluation is useful in preservation of oil, promotion of self life of food products, prevention or reduction of microbial growth, infection, oxidation rancidity etc is made possible by removal of moisture content (www.answer.com).

2.6.2 Lipids

Lipids are a group name for organic substances called fats and oils. Lipids are diverse compounds that are grouped together because they are insoluble in water, but soluble in non-polar solvents such as ether. Common lipid types include fats, phospholipids and_steroids. These lipids have various functions in the body. Fats are composed of fatty acids and glycerol. They store energy, help to insulate the body, and cushion and protect organs. Phospholipids contain two fatty acids and are a major component of cell membranes. Steroids are cholesterol derived hormones that regulate various physiological functions in the body (Regina, 1997).

2.6.3 Carbohydrates

The name carbohydrate is derived from a French word hydrate d carbon. Chemically, carbohydrates are organic molecules in which carbon, hydrogen and oxygen are bonded together. Carbohydrates are found in foods either as sugar or as starches and glycogen. These later materials are long straight or branched chains of many sugar molecules, joined together. The chemical nature of the sugar determines their properties, their functions in living tissues and how starches are formed and broken down. All carbohydrates are made up of units of sugar called saccharide units. Carbohydrates that contain only one sugar unit are called monosaccharides, those with two sugar units are called disaccharides, while those with more than two sugars units are called polysaccharides. The disaccharides are referred to as the simple sugar. Simple sugars are sweet in taste and are broken down quickly in the body to release energy (Marv, 2007).

Two of the most common monosaccharides are glucose and fructose. Glucose is the primary form of sugar stored in the human body for energy. It is the key stone of metabolism in both plant and animals. Thus it is the main product of photosynthesis in green plants and occurs in starches of their main storage materials seed, roots and tubers. Glycogen is found in the liver and muscles of animals. Fructose is the main sugar found in most fruits, but galactose occurs only in combination as lactose in milk. Glucose and fructose are isomeric (FAO, 2009). Disaccharides have two sugar units bound together. Sucrose, lactose and maltose are examples. Sucrose is widely distributed in plant fruits and other tissues, such as sugar cane. Sucrose consists of glucose units bonded to a fructose unit. Maltose is found in starch of grain seeds when they begin to germinate (Worthington, 2007).

2.6.4 Crude Fibre

Crude fibre is that part of the food that goes undigested after being taken. It constitutes major part of some foods. It is important in the evaluation of the amount of fibre digested by the body and passed out (excreted) of a particular food sample. The carbohydrate of food is contained in two fractions, the crude fibre (CF) and the nitrogen free extractive (NFE). Crude fibre can also be defined as the residue left after successive extraction under closely specified conditions with petroleum ether, 1.25% sulphuric acid, and 1.25% sodium hydroxide, minus ash (Huv, 2007).

2.6.5 Ash

The ash content of banana is an analytical term for the inorganic residue that remains after the organic matter has been burnt off. The residue is ash which consists of the inorganic components in the form of their oxides. The ash not usually the same as inorganic matter present in the original food since there may be losses due to volatilization or chemical interaction between the constituents. Ash may contain materials of organic origin such as sulphur, phosphorus from proteins and losses of volatile materials in the form of sodium, chloride, potassium, phosphorus and sulphur will take place during ignition (Calvel *et al*, 2001).

2.6.6 Proteins

The word protein is derived from Greek and means "holding the first place". Proteins literally hold the first place in the architecture and machinery of all living things. Without them no life can exit. Plant will not be able to grow and trap sunlight. Proteins are essential in everybody's diet they are complex substances found in many foods like banana and are made up of thousands of small units called amino acids. Proteins are the building blocks of the body. The different amino acids that make up proteins are important for growth, tissue repair and replacement of bones and muscles (Dietary Reference Values for Food Energy and Nutrients for the United Kingdom, 1999). When amino acids combine to form protein they do this through the NH_2 group of one amino acid reacting with the OH of another acid, splitting of water into H and OH in the process. Typical proximate compositions of banana are shown in Table 2.1

2.7 Storage Conditions of Banana

Physiological functions affecting the quality of banana during storage are the rate of respiration and transpiration. To extend storage life, respiration and transpiration should be reduced as much as possible. This is often done by controlling individually or in combination such as temperature, humidity, ventilation rate and atmospheric composition.

Table 2.1: Proximate Compositions of Banana

Nutrient(g)	Nutritional Value
Water	87.627
Protein	1.215
Total lipids (fat)	0.566
Carbohydrate	27.647
Total dietary fibre	2.832
Ash	0.944

Source: USDA, 1998.

2.7.1 Temperature

Temperature is one of the storage conditions that affect the nutritional compositions of banana. Reducing the temperature reduces the rate of transpiration which delays ripening and thus extends storage life. Optimum storage temperature for banana is 13-14°C. At this temperature, storage life of mature ripe fruit is 1-2 weeks. Bellow 11°C, stored fruit develops chilling injuries and peel turns gray (IITA, 1997).

Banana fruits should be harvested early in the day, when the temperature is low, because high temperature increases ripening. Immediately after harvest, fruits are cooled to the storage temperature. This is called pre-cooling. Banana is usually cooled with cold air to prevent temperature becoming too low which can cause chilling injury (IITA, 1997).

2.7.2 Relative Humidity

High relative humidity reduces water loss and increases storage life. However, high relative humidity encourages fungal growth. A relative humidity of 90% provides the best compromise for storing banana. Relative humidity can also be raised in a container or room by spraying water in a fine mist and can be reduced by venting.

Traditional methods for increasing the storage humidity include, spraying fruits intermittently with water, storing fruits on a wet sack, and storing fruits in boxes filled with sawdust. Although effective, these methods can cause excessive wetting, which leads to fruits splitting and reduces market quality (Neshashi, 2009).

2.7.3 Ventilation Rate

Air circulation is an effective method used to reduce temperature in storage rooms. However, ventilation also increases water loss from banana fruits, by removing the saturated layer of air that surrounds the fruit. If ventilation can be used to reduce temperature, water loss can be reduced by covering banana fruits with tarpaulins, packaging banana fruits into bags, boxes, or cartons and wrapping banana fruits in polyethylene bags or heat shrink plastic (IITA, 1997).

2.7.4 Atmospheric Compositions

Respiration can be reduced, and hence storage life increased, by modifying atmospheric compositions within storage areas. Normal atmospheric composition is approximately 21% oxygen, 78% nitrogen, and 0.03% carbon dioxide. By reducing the proportion of oxygen and raising the carbon dioxide, the rate of respiration is reduced and banana ripening is delayed. For example stored at 5% carbon dioxide and 3% oxygen at 20^{o}C, bananas have been stored for more than six months (Martha and Stephanie, 2007). A simple and cheaper method of storing banana is to seal fruit in polythene bags. Bananas sealed in polythene bags remain green for a long period than those stored in perforated polythene bags, and paper bags. As the banana fruits respire, the atmosphere within the bags decreases in oxygen and increases in carbon dioxide. Respiration is then inhibited because of the reduced oxygen.

In one study, storing banana in polythene bags at a temperature of about 20°C delayed ripening by up to six days. Also weight loss was reduced and there was less mechanical damage on the banana fruit. High relative humidity developed in the polythene bags, reduces water loss from fruit, and also has a lubricating effect which protects the bananas from physical damage. Polythene bags are now widely used in Australia to extend storage life of fruits like banana (IITA, 1997).

CHAPTER THREE

3.0 MATERIALS AND METHODS

The samples of banana used for this study were obtained from Minna Central Market in Niger State on 28th December, 2009. The samples of banana used for the experiment is shown in Plate 3.1

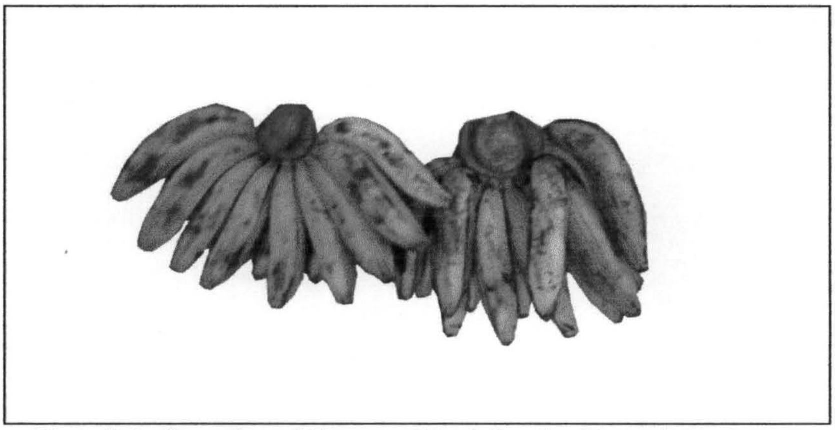

Plate 3.1: Samples of Banana Used for the Experiment

3.1.1 Reagents and Apparatuses

The reagents and apparatuses used are listed below.

3.1.2 Reagents

Tetraoxosulphate (VI) acid, H_2SO_4

Sodium Hydroxide, NaOH

Calcium Hydroxide, $Ca(OH)_2$

Ammonium sulphate, $(NH_4)_2SO_4$

Petroleum Ether

Methyl red indicator

Distilled water

Alcohol (Acetone Ethanol)

Alcohol (Acetone Ethanol)

3.1.3 Apparatuses

Air oven (UNISCOPE SM9053, Surgifriend Medicals England (50-300°C)

Petri dishes

Desiccators

Electronic weighing balance (SATRTURIUS, England Mark, Serial Number PT210, Capacity 1-200g, Sensitivity 0.01g)

Filter papers

Heating devices (Kieldatherm, Easy way Medical England, England Make, Serial Number 7731 408).

Bunsen burner (England Mark)

Round bottom flask (Pyrex)

Fume-cupboard (Gerhardt with Powerful Exhaust)

Porcelain crucible (Pyrex)

Flat bottom flask (Pyrex)

Pipette (Pyrex)

Furnace (Gallenkamp, Serial Number: 5096/03/094, Sensitivity of 1000°C)

Wet and dry bulb thermometer (0-50 ° C, Model TC WD-4, India Make)

Thermometer (0-100 ° C, Serial Number: 5525JI, England Make)

Refrigerator (Festech Make, Model BD-200, and Place of Manufacture: China)

Polythene bags (Thickness: 2.0mm)

3.2 Storage Methods

Three different storage methods were used.

(a) Storage in a refrigerator

(b) Storage in a polythene bag

(c) Open air storage on a shelf

3.3 Experimental Procedure/Methods

Storage Conditions and Measurements

Five banana fingers were selected from each storage method and numbered and these were weighed every day using an electronic weighing balance. Weighing commenced from the first day of storage, for a period of seven days and each measurement was taken once and the results were recorded.

Temperature and Humidity Measurements

The temperature was measured using a thermometer. The relative humidity was taken using a wet and dry bulb thermometer and the reading was measured on the humidity table (i.e. difference between the dry and wet bulb readings). The readings obtained were in degrees Celsius for temperature and percentages for relative humidity and were measured daily for seven days.

For storage using the refrigerator, storage conditions measured are temperature, relative humidity, oxygen consumption and carbon dioxide evolution. Another observation for banana stored in the refrigerator is chilling injury.

For storage using polythene bag, storage conditions measured are temperature, relative humidity, oxygen consumed and carbon dioxide evolved.

For the open air storage on a shelf, temperature, relative humidity, oxygen consumption and carbon dioxide liberation were measured.

Nutritional Analysis

The banana samples were analyzed for proximate compositions (moisture, lipid, carbohydrate, crude fibre, ash and crude protein) using AOAC (1980) nutritional guidelines see appendix A.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

The results of the analysis carried out on nutritional composition of banana stored in three different methods for a period of 7 days are shown in the table below:

Table 4.1: Effects of Storage Conditions (Temperature and Relative Humidity) on the Nutritional Composition of Banana using Three Different Storage Methods

Days	Storage Methods	Temperature °C	Relative Humidity %	Moisture content %	Crude Fibre %	Crude Protein %	Fat %	Ash %	Carbohydrate %
Day 0	Control	27.0	83	61.58	2.5	5.6	0.2	3.5	26.62
Day1	Refrigerator	4.0	83	64.16	1.3	5.4	4.5	4.0	20.62
	Polythene bag(2.0mm)	29.5	91	77.38	2.0	4.5	5.5	4.0	16.89
	Open air (shelf)	23.5	90	74.0	1.3	5.6	4	4.0	11.09
Day 2	Refrigerator	4.0	83	68.09	1.3	4.6	4.0	3.5	18.48
	Polythene bag(2.0mm)	29.0	90	75.05	1.3	4.2	3.0	3.0	17.0
	Open(shelf)	24.0	90	73.59	1.3	5.4	3.5	3.5	12.7

Day 3	Refrigerator	5.0	84	72.02	1.3	3.8	3.5	3.0	16.3
	Polythene bag(2.0mm)	29.5	91	72.72	0.6	3.9	3.5	2.0	17.2
	Open air (shelf)	24.2	90	73.17	1.3	4.8	3.0	3.0	14.3
Day 4	Refrigerator	4.5	83	67.46	0.9	3.6	3.0	2.5	22.4
	Polythene bag(2.0mm)	27.0	91	72.06	1.6	3.7	3.5	1.54	17.6
	Open air (shelf)	24.0	90	72.88	1.3	4.8	3.3	2.2	14.9
Day 5	Refrigerator	5.0	84	62.9	0.6	3.5	2.5	2.0	28.4
	Polythene bag(2.0mm)	24.0	90	71.4	2.6	3.5	3.5	1.1	17.9
	Open air (shelf)	26.0	91	72.6	2.6	4.4	3.5	1.5	15.48
Day 6	Refrigerator	4.5	83	68.34	0.6	3.0	2.4	1.7	23.9
	Polythene bag(2.0mm)	28.5	90	67.35	1.9	3.2	2.5	1.0	24.0
	Open air (shelf)	25.0	90	72.7	1.6	3.9	2.7	1.2	17.6
Day 7	Refrigerator	5.0	84	73.78	0.6	2.5	2.3	1.4	19.4
	Polythene bag(2.0mm)	30.0	91	63.30	1.3	2.9	1.5	0.9	30.1
	Open air (shelf)	26.0	91	72.99	0.6	3.5	2.0	1.0	19.85

4.2 Discussion of Results

Fresh banana samples were separated into three different storage methods refrigerator, polythene and open air(shelf) to know the effect of storage conditions (temperature and relative humidity)on the nutritional composition of banana for a period of seven days. Before storage the initial weight of banana was recorded and proximate analysis taken that served as the control. From the table above, it can be seen that there was minimal increase in moisture content of banana. Storage in the refrigerator from the first day to the third day, deceased from the 4^{th} and 5^{th} day of storage for banana stored in the polythene bag and on open air (shelf). There was a general decrease in moisture content from the 1^{st} to the 7^{th} day of storage; this decrease may be due to the respiratory act of the banana fruit as shown in figure 4.1 and 4.2.

Percentage crude protein from the three storage methods decreased daily, but refrigerator recorded the least in percentage crude protein compared to the other two storage methods. This shows that the nutritional content of banana differs in every storage component.

Percentage crude fibre content, ash content and lipid content increased daily throughout the experimental period (7day). This can be seen from the table above. This deceased in weight may be due to the respiratory rate of banana fruits that changes as the banana get ripped.

Percentage carbohydrate content of banana stored in a refrigerator reduced from the 1^{st} day to the 3^{rd} day, increased from the 4^{th} and 5^{th} day and deceased on the 6^{th} and 7^{th} day of the experiment.

Banana stored in polythene bag and open air (shelf) increased daily for 7day as shown in the table above (table 4.1). Refrigerator methods recorded the highest percentage of carbohydrate in banana.

Banana stored in open air (on a shelf), ripened at 90-91% relative humidity and temperature ranging from 23.5-26.0^{0}C, and this agrees with the finding of the work carried out by (Morton, 1999). Banana stored in the polythene delayed in ripping due to the thickness of the polythene bag and has a temperature of about 24-30^{0}C at 90-91% relative humidity. High relative gave a minimal reduction in moisture content of banana stored in the polythene bag compared to the three storage methods.

Graphical representation of Weight Loss and Moisture Content of Banana for a Period of 7days for Three Different Storage Periods is shown in fig4. 1 and 4. 2.

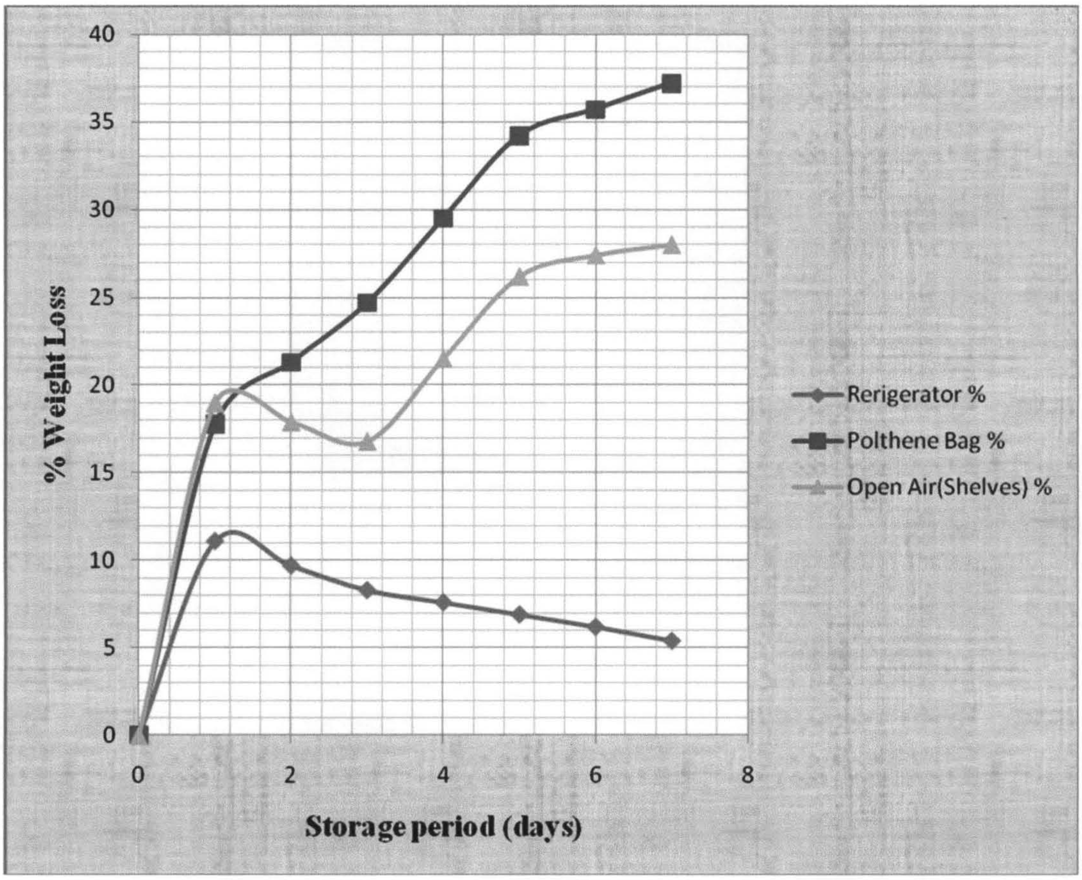

Fig4. 1: Percentage Weight Loss against Storage Periods (Measured and Calculated Values)

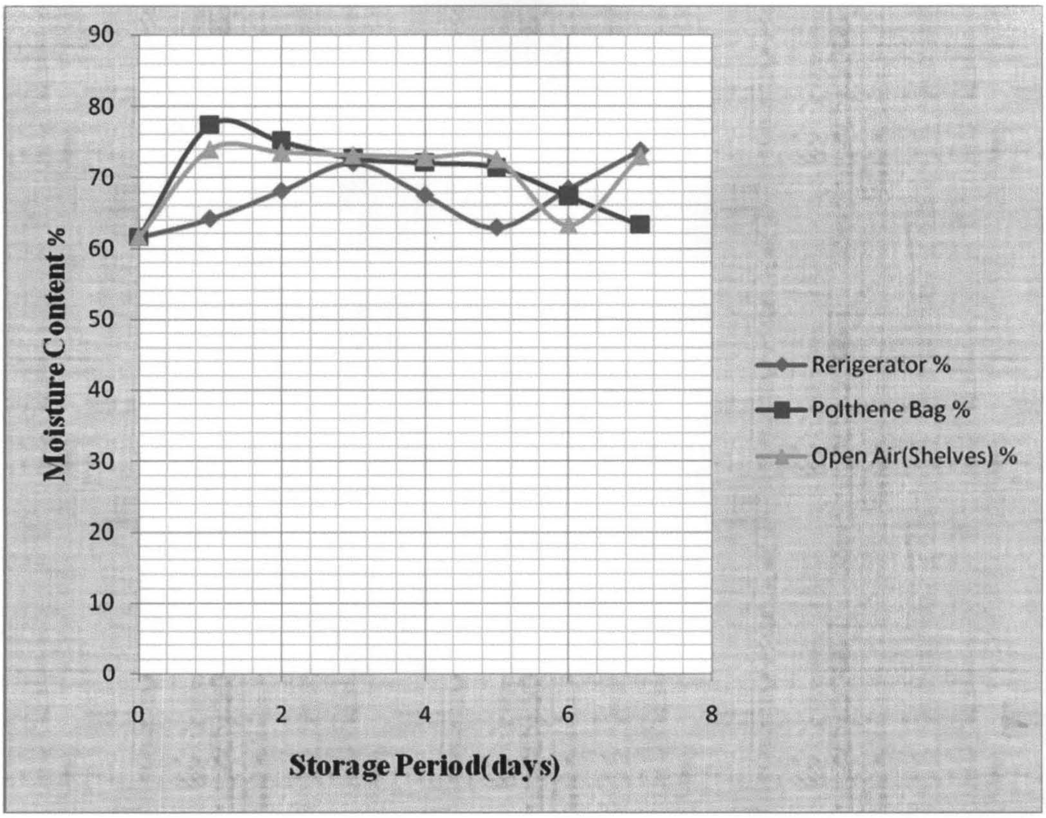

Fig4. 2: Percentage Moisture Content against Storage Periods (days)

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This project focused on the effect of storage conditions of storage Banana fruits in the refrigerator, polythene bag and open air (shelves). This was done to compare their results so as to know the best condition to store the banana for them to loss very little of their qualities.

It was observed that a lot of losses in weight occurred in polythene bags and the open air (shelves) method, while a least percentage mean loss was recorded in the refrigerator. Considering only the weight losses, it is better to store banana in the refrigerator for about a period of seven days than any of the other two methods.

The nutritional charges in the three storage methods used were monitored periodically up to seven days. The moisture content in the refrigerator was found to have increased for the first three days, decreased in the fifth day and increased on the seventh day. Moisture content for other two methods decreases from the first day to the last day of storage which is the seventh day. Crude protein, Ash and Fat content decreased in the three storage methods through the experimental period. Storage conditions (temperature and relative humidity) affect the three storage methods. High humidity about 91% gave a minimal reduction in moisture content of banana stored in the polythene bag, reduction in crude protein and fat content.

5.2 RECOMMEDATIONS

Based on the findings of this project, the following are recommended:

1. Further study should be done to improve the ventilation rate of banana stored in the polythene bag.
2. Further study should be recommended to know the nutritional qualities contained in varieties of banana to know which of them is good for consumption.
3. Cold room should be used to store banana in large quantities.

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APPENDIX A

AOAC (1980) STANDARD/PROCEDURE

Sample was analysed chemically according to the official methods of analysis described by AOAC (1980).

Determination of Moisture Content

Moisture content was determined as described in AOAC (1980). Air oven method is used based on weight loose as a result of drying the sample of banana sample to an acceptable weight in an air oven at a specific temperature and time.

Procedure:

5g of the banana sample was weighed into a previously weighed crucible. The crucible plus sample taken was then transferred into the oven set at 100^0C to dry to a constant weight for 24hours overnight. At the end of the 24hours, the crucible plus the sample was removed from the oven and transferred to desiccators, cooled for ten minutes and weighed.

If the weight of the empty crucible is W_1

Weight of the crucible plus sample is W_2

Weight of crucible plus oven-dried sample is W_3

$$\%\ Total\ Solid\ or\ \%\ Dry\ Matter = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

$$\%\ Moisture = \frac{Loss\ in\ Weight}{Weight\ of\ Sample\ before\ drying} \times 100$$

Or % Moisture = 100 - % DM (Dry Matter)

Determination of Ash Content

The organic component of food is burnt off in air. The residue is ash which consists of the inorganic components in the form of their oxides.

Procedure:

Crucible was cleaned, dried and cooled in desiccators and weighed. 5g of the sample was weighed into the crucible. The sample was charred on a hot plate in a fume-cupboard until no more soot was given off. The crucible was cooled in a desiccators and weight of crucible and ash were taken.

$$Ash = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

W_1= Weight (g) of crucible

W_2 = Weight (g) of crucible + sample

W_3 = Weight (g) of crucible + ash

Determination of Crude Fibre

This was determined by the procedure outlined in AOAC (1980)

Procedure:

Conical flasks were weighed (W_1), 5g sample was put in the conical flasks and weighed (W_2), and then content was boiled in 200ml hydrocholoric acid (%) for 30 minutes. The suspension was filtered and the residue was washed vigorously with boiling water until it was no longer acidic.

The banana sample residue was then boiled again in a 200ml sodium hydroxide solution for 30 minutes, filtered through filter paper and the residue obtained was transferred into a crucible in an air oven for 30 minutes. The dried residue was then cooled in a desiccators and weigh. The weighed sample residue was removed from furnace when it temperature was 200^0C. It was cooled in desiccators and weighed (W_3). The loss in weight of the incinerated residue before and at incineration was taken as the crude fibre content.

Percentage Crude Fibre was calculated as:

$$\frac{Total\ weight\ of\ fibre}{Weight\ of\ sample} \times 100$$

$$Crude\ FibreContent\ (\%) = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Determination of Fat/Lipid

Fat content was determined using Soxhlet solvent extraction method outlined in AOAC (1980).

Procedure:

5g of the sample were weighed and the weight of the round bottomed flask was taken with the extractor mounted on it. The thimble was held half way into the extractor and the weighed sample carefully transferred into thimble. Extraction was carried out using petroleum ether (boiling point $40\text{-}60^0C$), the thimble plugged with cotton wool was fully dropped into the extractor and the extraction was continuously done for 8hours. At the completion of extraction, the solvent was removed by evaporation in the water bath and the remaining in the flask dried at 80^0C for 30 minutes in the air oven to dry the solvent and was cooled in a desiccators. The flask was re-weighed and percentage fat was calculated as:

$$\% Fat = \frac{Weight\ of\ extracted\ fat}{Weight\ of\ Sample} \times 100$$

$$= \frac{W_4 - W_3}{W_2 - W_1} \times 100$$

W_1 = Weight thimble

W_2 = Sample plus thimble

W_3 = Weigh the 500ml round bottom flask (fat free)

W_4 = Sample cool in desiccators

Determination of Nitrogen/Crude Protein

The crude protein in the sample was determined by routine semi-micro kjeldahl, procedure.

Procedure:

5g of banana sample was taken 5ml of NaOH solution and 0.5M H_2SO_4 were added to the sample. The sample and the reagents were mixed thoroughly and allow settle for 15minutes. This was then filtered using filter paper. 5ml of filtrate was put into clean conical flask, and 5ml of distilled water was added and shaken. 2 drops of methyl orange indicator was added and shaken. This was titrated against 0.5M H_2SO_4. The titres values for the sample is 2.07

Equation of reactions

$$2NaOH + H_2SO_4 \longrightarrow (Na)_2SO_4 + 2H_20$$

$$Nitrogen\,(\%)\,in\,the\,sample = \frac{Corrected\,titre\,(ml) \times 14 \times 5 \times 100}{1000 \times 70 \times weight\,of\,sample\,(g)}$$

$$= \frac{Corrected\,titre\,(ml)}{10 \times weight\,of\,the\,sample\,(g)}$$

Crude Protein Content (%) = 6.25 x Nitrogen (%)

Determination of Carbohydrate Content

The procedure outlined in AOAC (1980) was used in determining the carbohydrate content in sample.

Procedure:

This was calculated by difference. The sum of the moisture, fat protein and ash contents were subtracted from 100.

Carbohydrate Content = 100 – (%protein + % moisture + %fat + %ash).

APPENDIX B

Tables of Results of the Experiment Carried out on Banana

Table 1: Effect of Storage Periods on Moisture Content of Banana

Storage Period (days)	Refrigerator %	Polythene bag %(2.0mm)	Open air(shelf)%
0	61.58	61.58	61.58
1	64.16	77.38	74.01
2	68.09	75.05	73.59
3	72.02	72.72	73.17
4	67.46	72.06	72.88
5	62.90	71.40	72.60
6	68.34	67.35	72.7
7	73.78	63.30	72.99

Table 2: Effects of Storage Period on Lipid/Fat Content of Banana for Three Different Storage Methods

Storage Period (Days)	Refrigerator %	Polythene bag %(2.0mm)	Open air(Shelf) %
0	0.2	0.2	0.2
1	4.5	5.5	4
2	4.0	3.0	3.5
3	3.5	3.5	3.0
4	3.0	3.5	3.3
5	2.5	3.5	3.5
6	2.4	2.5	2.7
7	2.3	1.5	2.0

Table 3: Effects of Storage period on Carbohydrate Content of Banana for Three Different Storage Methods

StoragePeriod (Days)	Refrigerator %	Polythene bag %(2.0mm)	Open air(Shelf) %
0	26.62	26.62	26.62
1	20.6	16.89	11.1
2	18.48	17.0	12.7
3	16.3	17.27	14.3
4	22.4	17.6	14.9
5	28.4	17.92	15.48
6	23.9	24.0	17.6
7	19.4	30.1	19.85

Table 4: Effects of Storage Period on Crude Fibre Content of Banana for Three Storage Methods

Storage Period (Days)	Refrigerator %	Polythene bag %(2.0mm)	Open air(Shelf) %
0	2.0	2.0	2.0
1	1.3	2.0	1.3
2	1.3	1.3	1.3
3	1.3	0.6	1.3
4	0.9	2.6	1.9
5	0.6	2.6	2.6
6	0.6	1.9	1.6
7	0.6	1.3	0.6

Table 5: Effects of Storage Period on Ash Content of Banana for Three Different Storage Methods

Storage Period (Days)	Refrigerator %	Polythene bag %(2.0mm)	Open air(Shelf) %
0	3.5	3.5	3.5
1	4.0	4.0	4.0
2	3.5	3.0	3.5
3	3.0	2.0	3.0
4	2.5	1.5	2.2
5	2.0	1.1	1.5
6	1.7	1.0	1.2
7	1.4	0.9	1.0

Table 6: Effects of Storage Period on Crude Protein of Banana for Three Different Storage Methods

Storage Period (Days)	Refrigerator %	Polythene bag %(2.0mm)	Open air(Shelf) %
0	5.6	5.6	5.6
1	5.4	4.5	5.6
2	4.6	4.2	5.4
3	3.8	3.9	5.2
4	3.6	3.7	4.8
5	3.5	3.5	4.4
6	3.0	3.2	3.9
7	2.5	2.9	3.5

Table 7: Percentage Weight Loss for each Storage Method

Storage Period (Days)	Refrigerator %	Polythene bag %(2.0mm)	Open air(Shelf) %
0	0	0	0
1	11.1	17.8	19
2	9.7	21.3	17.9
3	8.3	24.7	16.8
4	7.6	29.5	21.5
5	6.9	34.2	26.2
6	6.2	35.7	27.4
7	5.4	37.2	28

Table 8: Effects of Storage Conditions (Temperature and Relative Humidity) on the Nutritional Composition of Banana using Three Different Storage Methods

Days	Storage Methods	Temperature °C	Relative Humidity %	Moisture Content %	Crude Fibre %	Crude Protein %	Fat %	Ash %	Carbohydrate %
Day 0	Control	27.0	83	61.58	2.5	5.6	0.2	3.5	26.62
Day1	Refrigerator	4.0	83	64.16	1.3	5.4	4.5	4.0	20.62
	Polythene bag(2.0mm)	29.5	91	77.38	2.0	4.5	5.5	4.0	16.89
	Open air (shelf)	23.5	90	74.0	1.3	5.6	4	4.0	11.09
Day 2	Refrigerator	4.0	83	68.09	1.3	4.6	4.0	3.5	18.48
	Polythene bag(2.0mm)	29.0	90	75.05	1.3	4.2	3.0	3.0	17.0
	Open air (shelf)	24.0	90	73.59	1.3	5.4	3.5	3.5	12.7
Day 3	Refrigerator	5.0	84	72.02	1.3	3.8	3.5	3.0	16.3
	Polythene bag(2.0mm)	29.5	91	72.72	0.6	3.9	3.5	2.0	17.2
	Open air (shelf)	24.2	90	73.17	1.3	4.8	3.0	3.0	14.3
Day 4	Refrigerator	4.5	83	67.46	0.9	3.6	3.0	2.5	22.4
	Polythene bag(2.0mm)	27.0	91	72.06	1.6	3.7	3.5	1.54	17.6

	Open air (shelf)	24.0	90	72.88	1.3	4.8	3.3	2.2	14.9
	Refrigerator	5.0	84	62.9	0.6	3.5	2.5	2.0	28.4
	Polythene bag(2.0mm)	24.0	90	71.4	2.6	3.5	3.5	1.1	17.9
	Open air (shelf)	26.0	91	72.6	2.6	4.4	3.5	1.5	15.48
Day 6	Refrigerator	4.5	83	68.34	0.6	3.0	2.4	1.7	23.9
	Polythene bag(2.0mm)	28.5	90	67.35	1.9	3.2	2.5	1.0	24.0
	Open air (shelf)	25.0	90	72.7	1.6	3.9	2.7	1.2	17.6
Day 7	Refrigerator	5.0	84	73.78	0.6	2.5	2.3	1.4	19.4
	Polythene bag(2.0mm)	30.0	91	63.30	1.3	2.9	1.5	0.9	30.1
	Open air (shelf)	26.0	91	72.99	0.6	3.5	2.0	1.0	19.85