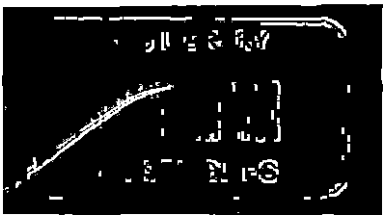
QUALITY EVALUATION OF ORGANIC RIPE BANANA

SREEDEVI L

Thesis submitted in partial fulfilment of the requirement for the degree of

Master of Science in Home Science

(Food Science and Nutrition)



Faculty of Agriculture

Kerala Agricultural University, Thrissur

Department of Home Science

COLLEGE OF AGRICULTURE

THIRUVANANTHAPURAM – 695 522

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DECLARATION

I here by declare that this thesis entitled **"Quality Evaluation of Organic ripe banana"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma. Associateship, fellowship or other similar title of any other university or society

Vellayani

Date 03- 07- 2013

Sreedevi. L

2011-16-105

Dr. Suma Divakar

Assistant Professor (S.S)

Department of Home Science

College of Agriculture

Vellayani, Thiruvananthapuram, Kerala

CERTIFICATE

Certified that this thesis entitled **"Quality Evaluation of Organic Ripe Banana"** is a record of research work done independently by Sreedevi. L(2011- 16- 105) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Vellayani

Date: 03-07-2013

Dr. Suma Divakar

(Chairman, Major Advisor)

Approved By

Chairperson

Dr. Suma Divakar

(Chairman, Major Advisor)

Assistant Professor(S.S)

Department of Home Science

College of Agriculture, Vellayani

Thiruvananthapuram, 695 522

Members:

Dr. P. V. Nandini

Professor and Head

Department of Home Science

College of Agriculture, Vellayani

Thiruvananthapuram, 695 522

Dr. V. L. Geetha Kumari

Professor and Head

Department of Agronomy

College of Agriculture, Vellayani

Thiruvananthapuram, 695 522

Dr. C. Nirmala

Assoc. Professor, Department of Home Science

College of Agriculture, Vellayani

Thiruvananthapuram, 695 522

EXTERNAL EXAMINER

Dr. P. BHANUMATHY, PROF (FOOD SCIENCE & NUTRITION)
POST HARVEST TECHNOLOGY CENTRE
AGRL. COLLEGE & RESEARCH INSTITUTE
TNAU, COIMBATORE - 641003.

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LIST OF ABBREVATIONS

Fig	-	Figure
g	-	gram
mg	-	milligram
mm	-	millimeter
µg	-	microgram
kg	-	kilogram
et.al	-	and others
ha	-	hectare
pop	-	package of practice
%	-	percentage
ppm	-	parts per million
cm	-	centimeter
GABA	-	Gamma Amino Butyric Acid

Introduction

Introduction

In the context of environmental pollution, consumers all over the world are becoming increasingly concerned about food safety The concern about pesticide residue in food, as well as pesticide damage to wild life, farm workers and the environment, contributed to the growing demand for Organic food (Byrne, 1992).

Due to increasing consumer demand for high quality, safe and ethical foods ,the production and consumption of organic foods have increased rapidly over past two decades (Cooper, 2003).

The demand for organic products has increased worldwide. This has been further boosted by the heightened awareness of the link between health and diet. This demand is also owed to recent series of highly publicized food scares, the debate over genetically modified foods and the perceived environmental hazards (Willer, 2002)

Globally, the concept of quality in the context of food has undergone a drastic change over the past few decades among importers and domestic retailers. It does not emphasise on the characteristic of the end product alone, but also the process and the method of production. Consumers have become health conscious and are willing to pay for clean healthy and natural foods (Sankaran, 2001).

Narayanan (2005) pointed out that consumers placed highest value in organic products for its 'credence', attribute or environment friendliness, whereas the most important reason given for not buying these products are attributes like price and availability.

Thompson, (1998) opined that organic farming is today's answer not only for higher and sustained productivity but also for safe and nutritious food. It is increasingly demanded by the enlightened consumers around the world. Organically grown agricultural produce fetches a higher premium in the market, thus favouring the farmer.

Dimitri and Greene (2002) pointed out that consumers are attracted to organic food because of it being pesticide free. In developed countries, increase in demand for organic food can be attributed to its increased availability which lowers the search costs, and increased selection of variety.

Researches proved that the amount of nitrogen content in certain fruits and vegetables has been found to be lower when grown organically as compared to conventionally grown ones. Elevated levels of nitrogen in fruit is regarded by most scientists as a public health hazard because of its potential for cancer causing nitrosamine compounds to form in the gastrointestinal tract. It is also proved that organic produce have lower arsenic and cadmium levels.

It is well known that among the foods, fruits play a significant role in human nutrition, especially as sources of vitamins, minerals and dietary fibre (Craid and Beck, 1999). Among the fruits bananas are most widely consumed fruits in the world, as they are available throughout the year (Zeller, 2005). They are rich in potassium and certain other minerals such as calcium, iron, magnesium and phosphorous. Bananas are also rich in fibre, vitamin C and B complex vitamins, making it all the more useful.

In the interest of the 'Organically and health conscious consumerism', a systematic and comprehensive study into the quality analysis of organic fruit, the banana, with respect to its physical, sensory, nutritional, shelf life and cooking characteristics is attempted, as it is lacking in this part of the country. This study has been carried out ,to get an overall scientific comparison of organically and conventionally cultivated common man's fruit- the banana.

Review of Literature

2. REVIEW OF LITERATURE

The literature reviewed related to the study on "Quality evaluation of organic ripe banana is organised under the following headings.

2.1 Concept of Organic farming

2.2 Need of Organic farming

2.3 Organic agriculture – The right approach

2.4 Controversies in Organic farming

2.5 Significance of Organic fruit consumption for health

2.6 Banana – The Poor man's fruit

2.7 Nutrient profile of banana

2.8 Banana as a source of antioxidants and biologically active compounds

2.9 Therapeutic importance of banana

2.10 The scope of banana peel

2.11 Banana – an economic crop of farmers as well!

2.1 Concept of organic farming

According to FAO, Organic Agriculture is a holistic production management system which promotes and enhances the health of agro eco-systems including the biodiversity, biological cycles and soil biological activity . It emphasizes the use of farm inputs, taking into account the regional conditions requiring locally adapted systems.

Lampkin (1990) defined Organic farming as a production system which avoids or largely excludes the use of synthetically compounded fertilizers, growth regulators and livestock feed additives, to the maximum extent feasible.

Broadly Organic farming systems relies on crop rotations, crop residues, animal manures , legumes green manures, off farm organic wastes and biological pest control. It also aims to maintain soil productivity by supply of nutrients and control of insect pest, diseases and weeds (GOI, 2000) .

USDA (2011) defined Organic farming as a system that is designed to produce agricultural products, by the use of methods and substances that maintain the integrity of organic agricultural products until they reach the consumers.

According to Funtilana (1990) Organic farming is giving back to the nature what is taken from it.

Organic agriculture sustains the health of soil, eco system and people. It relies on the ecological process, is adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationship and a good quality life for all involved (John, 2011).

Czyk and Knick (2006) reported that Organic farming was more environment friendly. Potential benefits from Organic production was aroused from improved soil fertility, higher organic matter content and biological activity, better soil structure and reduced susceptibility to erosion . In addition there was reduced pollution from nutrient leaching and pesticides, improved plant and animal diversity.

Organic Agriculture is not only a specific agricultural production system. It is also a system and encompassing approach to livelihood in general, where, due emphasis is given to relevant factors of influence for sustainable development (Eyhorn, 2001).

There are many terms that denote Organic farming, some notable ones are Ecological Agriculture (Gosling *et al.*, 2006) or Biodynamic Agriculture (Lampkin, 1990).

Boeling *et al.*, (2003) stated that conventional farming needs abundant, manmade resources, Organic farming makes use of functional integrity of the system, and it depends on the local environment (soil and water)

Nutrient management in organic farming systems is often based on soil fertility building, viz nitrogen fixation and nutrient recycling of organic materials such as farm yard manure and crop residues with limited synthetic inputs (Gosling and Shepherd, 2005)

Organic farming helps to maintain long term soil biological activity, ensure effective soil management by recycling wastes to return to the land

WHO (2001) defined Organic agriculture, also known as ecological or biological agriculture, as a holistic farm management system, which aims to optimise the health and productivity of interdependent communities of soil, life, plants, animals and people.

Organic farming emphasises on the use of organic matter for enhancing soil properties, minimizing food chain associated health hazards and helped in attaining closed nutrient cycles, the key factors for sustainable agriculture (Cardelli *et al.*, 2004).

According to Edwards (2005), Organic Agriculture is more than a system of production that excludes certain notable agro chemicals and genetically modified organisms.

Organic Agriculture may be defined as a diversified agriculture where crops and livestock are managed through use of integrated technologies with preference to resources available either at farm or in the locality (Anantharaj *et al.*, 2009)

According to the International Federation of Organic Agriculture Movement (Willer *et al.*, 2008) the major objectives of organic farming include

(1) Production of high quality food in sufficient quantity that is in harmony with natural systems and cycles.

(2) Enhancing biological cycles within the farming systems involving micro organisms, soil, flora, fauna, plants and animals.

(3) Maintaining soil fertility.

(4) Promoting healthy use and proper care of water resources.

(5) Creating harmonious balance between crop production and animal husbandry.

2.2 Need of Organic farming

Intensive Agriculture involved deforestation,overgrazing and widespread use of practices that resulted in soil degradation. These changes contributed considerably to global carbon dioxide emissions (Bengtsson *et al.*, 2005) . Agriculture had contributed to climate change, 10-12% of green house gas emissions were due to irrational use of resources in food production.

Modern agricultural practices, along with irrational use of chemical inputs over the past four decades resulted in not only the loss of natural habitat balance and soil health but have also caused many hazards like soil erosion, decreased ground water level , soil salinizations, pollution due to fertilizers and pesticides, genetic erosion, ill effects on environment, reduced food quality and increased cost of cultivation, which rendered the farmer poorer, year by year(Ram, 2003).

According to Intergovernmental Pattern of Climate Change (IPCC) the annual amount of green house gas emitted by the modern agricultural sector is estimated at between 5.1 and 6.1 giga tonnes, carbon dioxide equivalent in 2005 (Barker, 2007).

According to current projections, total green house gas emissions from modern agriculture is expected to reach 8.3 GT carbon dioxide equivalent

per year in 2030 compared to the current level of approximately 6GT carbon dioxide equivalents annually (Smith *et al.*, 2007).

The global warming potential of conventional agriculture is strongly said to be affected by the synthetic nitrogen fertilizers and by the high nitrogen concentration in soil (Cormack, 2000).

Methane accounts for about 14% of green house gas emissions two thirds of this is anthropogenic in origin which is mainly from agriculture (Kotschi and Muller, 2004).

2.3 Organic agriculture - The right approach

Organic Agriculture reduces the vulnerability of the farmers to climate change and variability. Firstly, because Organic agriculture comprises of highly diverse farming systems and this increases the diversity of income sources and the flexibility to cope with adverse effects of climate change and variability such as changed rainfall patterns. Hence this leads to higher economical and ecological stability through optimized ecological balance and risk (Eyhorn, 2007).

Modern Agriculture is the main emitter of nitrous oxide and methane (Beauchemin, 2005).Weiske *et al* (2006) reported that soil managed organically are more aerated and had significantly lower mobile nitrogen concentrations. Both factors reduced the emission of nitrous oxide.

Lotter *et al.*, (2003) pointed out that Organic Agriculture was a low risk farming strategy with reduced input costs and therefore, lower risks with partial or total crop failure due to extreme weather conditions, in the wake of climate change and variability.

Organic farming has expanded rapidly in the last ten years and is seen as a sustainable alternative to chemical based agricultural systems (Avery, 2007). Organic land management would help to stop soil erosion and convert carbon loses into gains (Reganold *et al.*, 1987).

Badgley *et al.*, (2007) stated that the global warming potential of organic farming system was considerably smaller than that of conventional or integrated farming systems.

Flessa et al (2002), reported reduced nitrous oxide emissions in organic farming. This was due to diversified crop rotation with green manure, improved soil structure, which diminished the emissions of nitrous oxide (Petersen *et al.*, 2006).

In Organic Agriculture, the ban of mineral nitrogen and the increased livestock units per hectare considerably reduced the concentration of easily available mineral nitrogen in soil and thus nitrous oxide emissions (Oleson *et al.*, 2006).

Hine and Pretty (2006) opined that Organic Agriculture could enhance productivity and improve access to food and income using locally available and appropriate technologies without causing environmental damage.

Potential hazards from synthetic input residues were prevented in organic agriculture to the greatest extent possible, reinforcing consumer expectations that organic food was healthier (Andover, 2011).

Edwards (2005) stated that through the mindful management of ecological and biological processes, organic farmers could optimise the use of locally or farm derived renewable resources, as it builds and enhances ecological management skills of farmers and social standards.

The economics of Organic farming is characterised by increased profits via reduced water use, lower expenditure of energy and increased retention of top soil (Bengstsson *et al.*, 2005)

Organic farming effectively addressed soil management of even damaged soil, subject to erosion and salinity. It could retain micro-nutrients via crop rotation, inter cropping techniques and extensive use of green manure. The absence of chemicals in organic farming did not kill microbes which increased the nourishment of the soil (Mangan *et al.*, 2011).

The Organic way enables farmers to get rid of irksome weeds without the use of any mechanical and chemical applications (Parton, 1997).

Organically grown plants were more drought tolerant. The soluble salts in the cells of fertilizer fed plants were unable to osmotically draw sufficient water to maintain safe dilution , thereby decreasing water content. Thus salt level reached toxic levels and resulted in the death of the plants (Sullivan, 2002).

The use of green pesticides such as neem, compost tea and spinosad were environment friendly and non-toxic. These pesticides helped in identifying and removing diseased and dying plants in time, and subsequently increased crop defence system (Cook, 1988).

Organic food had no harmful chemical residues such as herbicides, fungicides and herbicides (Pimental, 2005).

Naturally nourished organic plants showed better structural and metabolic integrity of their cellular structure than those conventionally grown (Peter, 2012). Thus Organic food stayed better longer. Insects were less attracted to organically grown crops, possibly because the plants did not contain high concentrations of elements such as nitrogen supplied in fertilizers (Gomiero, 2008).

Organic farming could protect crops against adverse temperature effects and improve seed germination. Increased water retention capacity of the soil created the right micro- climate for the development of beneficial soil microbes (Reddy, 2010).

Byrness (1998) assured that there were evidences of better nutritional content of organic produce. Organically grown food was higher in mineral content than those cultivated from modern conventional methods .

Florescu (1991) reported that the cucumber grown with urban waste compost had higher content of carbohydrate. Increased level of nitrogen fertilizers decreased the content of glucose and increased the quality of protein in vegetables.

Twenty five to thirty percent increase in lysine had been reported in organic wheat(Brandt et al., 2000). Organically grown amaranthus had increased level of protein(Kumar, 2000).

Sheeba (2004) reported that organic sources of plant nutrients recorded the highest value for beta carotene content. Auclair *et al.*, (1995) proved that organically grown tomato fruits had higher calcium, copper, iron, phosphorous, and zinc contents. Omar *et al.*, (2003) found that application of cattle compost increased freshness and vitamin C content in melon.

Thus the arguments in favour of organic approach were more in support of environmental friendliness and nutritional superiority.

2.4 Controversies in Organic Farming

There is an equally strong opposing approach to organic farming. Sanghi (2007) had argued that organic farming was an intensive process, limited mostly to resource rich farmers, and export market and depended heavily on external support system for pricing, market intelligence and certification of produce.

It has been pointed out that, an Organic farm cannot produce as much yield as a conventional or industrialised farm. A study conducted by the UN Environmental program(2008) concluded that, Organic methods of farming resulted in small yields even in developing areas, compared to conventional farming techniques.

Edwards(1987) pointed out that an organic farmer requires greater understanding of the crops and needs a close watch on the crops as there was no quick fixes involved like, pesticides or chemical fertilizers. Sometimes it could be hard to meet all the strenuous requirements to carry out organic farming.

Gundogmus (2006) observed that significant amounts of time and energy were required to execute the detailed methods and techniques that were required for a farm to be called an Organic farm .

An Organic farm would not produce as much food as a modern industrialised farm over a short period of time in the beginning stages (Chappel, 2007).

Wyen and Fritz (1987) argued that high levels of soil organic matter encouraged the growth of fungi that attacked the plant species and caused plant diseases

In Organic farming there was an inability to grow certain crops in some areas, particularly crops such as cotton and some legume crops because insects or weeds could not be controlled with out pesticides (Daivie, 2009).

In Organic farming there is a problem of competition for land. Because productivity per unit of land is lower in organic systems. More land is needed to produce same amount of food. This may lead to increased destruction of native forests particularly in developing countries where pressure on land and food supplies is the greatest(Adams, 1990)

2.5 Significance of Organic fruit consumption for health

Fruits play a significant role in human nutrition especially as sources of vitamins, such as ascorbic acid, thiamine, niacin, vitamin A, pyridoxine, folic acid, vitamin E, minerals and dietary fibre (Wargovich, 2000).

Fruits are important components of healthy diet and if consumed daily in sufficient amounts would help to prevent major diseases such as CVD, and certain cancers (Hyson, 2002).

Low fruit consumption was estimated to cause about 31% ischemic heart diseases and 11% stroke, worldwide. WHO recommends a minimum of five servings of fruits and vegetables per day. Low fruit and vegetable consumption increased the risk of obesity, coronary heart disease, type 2 diabetes, diverticulosis, hypertension. Low fruit consumption is an important modifiable risk factor that is contributing to the rising global burden of chronic diseases (WHO, 2009)

Lock (2000) estimated that 2.7 million deaths and 26.7 million disability were attributed to low fruit and vegetable intake globally.

Some components of fruits and vegetables called 'Phytochemicals' are strong antioxidants; they function to modify the metabolic actions and detoxification or disposition of carcinogens or even influences processes that alter the course of tumour cells (Prior, 2000). This antioxidant capacity varies greatly among fruits and vegetables and banana is a fruit which is rich in strong antioxidants (Kalt, 2002).

Fruits and vegetables contain a large variety of micro nutrients which are secondary metabolites in plants such as poly phenol, resveratrol and some carotenoids. Ren *et al.*, (2001) pointed out that organic fruits had higher levels of micronutrients especially in banana, peach, apple, pear, tomato etc.

Pieta (2000) reported that organically raised foods had typically higher levels of health promoting phyto nutrients and certain vitamins and minerals.

2.6 Banana – The Poor man's fruit

Banana is a tropical fruit, pre packaged by nature, featuring a firm and creamy flesh ,wrapped inside a thick peel(Randy,2007).Bananas belonging to the family *Musaceae* are one of the most important fruits in the world market. India is the home for bananas and plantain and was grown even before the Vedic times. All social, religious festivals and functions that are adorned with banana plants are considered auspicious. Besides providing beauty to the occasion, it is referred to as "Kalpatharu" (Plant of Virtue) due to its multi faceted uses.

Banana is one of the popular fruits in the world. Banana marketing is an organized and developed industry in India. It is reported to be the fourth important food crop in terms of economic value and is the second most important fruit crop in India, because of its year round availability, varietal range, taste, economic accessibility nutritive value and medicinal value (Shanmugha velu *et al.*, 1999).

It is the richest source of many nutrients. It is rich in easily digestible carbohydrate with a calorific value of 67-137Kcal/100g (Chada, 2010). It serves as an ideal low cost food for developing countries, hence called the " poor man's fruit".

2.7 Nutritient profile of banana

The nutrient profile of banana as evidenced in research reports are presented herewith. Banana is a high calorie tropical fruit providing 67-137Kcal/100g . Banana pulp is composed of soft, easily digestible simple sugars sucrose, fructose and glucose. Banana also contain oligosaccharides which act as food for good bacteria or act as a pre biotic in the digestive system. It improves absorption of nutrients such as calcium, hence improves bone health (Nieman,2012).

Banana fruit pulp is rich in vitamins especially vitamin A, B vitamins and vitamin C. Banana is a rich source of vitamin B6 (pyridoxine) providing 28% of RDA whose bioavailability is high.

Maier (2002) reported that Vitamin B6 in banana has a role in the treatment of neuritis and it also helps in the production of neuro transmitters namely serotonin and GABA. It also controls the production of homocystine, (a cumulative factor in coronory artery disease). Adults who consumed banana fruit daily showed an increase in vitamin B6 by 20%. (Morris, 2008).

Bananas are modest sources of folate. A small banana provides 5% of the daily requirement of folic acid . and a large banana can gives about 10% of the RDA which make the fruit ideal for younger women and also for maintaining health of the foetus. It also has a potential benefit in avoiding heart diseases (Jennings, 2000).

A medium banana will provides about a quarter of an adult's vitamin C requirements. vitamin C is well known as an anti oxidant and as an antiscorbutic agent. Regular consumption of banana ensures body resistance against infectious agents, scavenging of oxygen free radicals, and in collagen formation. (Ronnenberg and Venners, 2007).

The relative order of concentration of macro minerals both in pulp and peel are was K>Mg>Na>Ca and the decreasing order of micro mineral concentration was Mn>Fe>Zn>Cu(Yusoff, 2008).

Fresh banana is a very rich source of potassium, 100g fruit provides 358mg of potassium which is 10% of our daily requirement (Menton, 2004). Nowson (2006)reported that a high level of potassium in banana helps to keep blood pressure normal. Potassium in Banana can blunt the effect of sodium on blood pressure. Potassium is an important component in the cell and body fluids, that help to maintain heart rate, heartbeat, cell integrity ,fluid and electrolyte balance.

Fresh banana provides adequate levels of minerals like magnesium, manganese and copper. Magnesium is essential for bone strength and has a

cardio protective role as well. Manganese is used by the body as a co factor for the antioxidant enzyme, super oxide dismutase and Copper is required for the production of red blood cells.(Demighne *et al.*,2001).

Banana contain Resistant starch, which resists digestion and helps in the movement of the intestine (McClearly,2003).Raw banana contain resistant starch and amylase that are not digested in the small intestine and in the large intestine, thus preventing constipation (Cumming *et al*,1996).

Stephan (2007) reported that resistant starch in banana offers many benefits as it is used as a food by the friendly bacteria in the bowel, helping to protect bowel from becoming cancerous. It also increases stool weight : with every 1g increase in resistant starch , there is 1.68g increase in stool weight.

According to National Nutrition Survey, only around one in four people ate the recommended dietary intake for fibre. A medium banana will provide 2.7gm fibre which is 7% of RDA per 100gm that helps normal bowel movement ,there by reducing constipation problems (Faisent, 2000).

Banana pulp contains pectin (0.7-1.7%). During ripening ,insoluble protopectin is converted in to soluble pectin that cause loosening of cell wall and texture degradation leading to softening of fruit (Smith *et al.*, 2002). Gel forming ability of pectin has a varied uses like additives in jams, jellies and marmalades, thickeners, texturizers, emulsifiers, fat or sugar replacer.

2.8 Banana as a source of antioxidants and biologically active compounds

Antioxidants are bio molecules that reduce damage due to free radicals. Antioxidants include enzymes, vitamin C, Vitamin E, Beta carotene etc. Antioxidants in banana have a role in reducing the risk of lifestyle diseases such as heart diseases and some cancers; because antioxidants absorb and neutralise dangerous free radicals (Mann and Truswell, 2007).

Two research papers confirmed that bananas have significant antioxidant power due to two aspects. One study showed that bananas reduce oxidative stress in the blood, while the other study proved its ability to reduce LDL cholesterol. Oxidised LDL cholesterol plays a major role in the formation of plaques thus tending to clog the arteries and leading to heart diseases (Yin *et al.*, 2008).

Bioactive compounds in plants are compounds produced by plants, having pharmacological effects in man and animals (Frohne, 2004). Bioactive compounds in plants can also be defined as secondary plant metabolites diluting pharmacological or toxicological effects in man and animal(Copper *et al.*, 1995).

The protective capacities of fresh green bananas have been established against acute and chronic gastric mucosal lesions, due to the presence of its bioactive compounds such as phosphatidyl choline and pectin.(Dunjic *et al.*, 1993). The pulp of banana fruit *(M.Sapentium,var M.Cavendish)*)was confirmed for its cholesterol lowering effect(Lohnsonthorn, 2000).

Sanyal et al., (2006) reported that orally administered pulp powder of *M.sapientum* and *M.paradisiaca* showed a significant anti ulcerogenic activity in rats. According to them banana powder not only increased mucosal thickening but also significantly increased thymidine incorporation into mucosal DNA, which promoted healing by inducing proliferations.(Goel *et al.*, 2000).

Extracts of banana were studied to cause accumulation of eicosanoids in human gastric and colonic mucosa. The ethanolic extract of banana caused a concentration dependent increase in the eicosanoidal accumulation which increased the availability of arachidonate (an essential fatty acid derivative) (Goel *et al.*, 2000).

Banana peel is a major biproduct of pulp industry and it contains various bioactive compounds like poly phenols, carotenoids, pectins, proteases, lectins etc .Protective effects of peel extracts of unripe, ripe and leaky ripe

banana fruit on hydrogen peroxide induced haemolysis and also their antioxidant capacity were confirmed(Sundaram *et al.*, 2011)

Bananas contain Lectins, (bioactive protein) which have been strongly linked to a reduction in the risk of cancer and are potentially helpful in the treatment of cancer.(De meja, 2005).Prescaru (2005) also reported that banana lectins can affect growth and proliferation of cancer cells.

Someya and co-workers (2002) found that bananas were high in flavonoids with the peel being richer in total phenolics (907mg/100gm dry weight)compared to the pulp(232mg/100g dry weight) .This difference was reflected by the antioxidant activity of the peel extract being 22 times greater than the pulp. Several flavonoids were identified in banana including gallocatechin, catechin and epicatechin. Of these, gallocatechin exhibited the greatest antioxidant activity and was much higher in banana peel (158mg/100g dry weight)compared to pulp(29.6mg/100g dry weight) (Lima, 2005).

Heo(2008) reported that phenolic compounds in banana prevented oxidative stress induced neurotoxicity ,suggesting that the protection of nerve cells by the phenolics could reduce the risk of Alzheimer's disease.

2.9 Therapeutic importance of banana

According to a study reported in the, journal of Anaerobe (Mitson *et al.*, 2011) bananas can affect the number and type of microbes living in our digestive tract. Eating bananas appears to tilt the balance in favour of bacteria that promotes less bloating. Fibre rich bananas potentially helps to relieve constipation by helping to maintain peristalsis.

The anti diarrhoeal activity of banana was observed as early as in 1930's.This effect in the intestinal diseases was attributed to the pectin content of banana. Muhammed (2001) reported that banana diet was effective and advantageous in treating bacillary dysentery, in a study conducted on 127 patients of age 9 months to 48 years .

Banana flakes has also been tested and found effective in the treatment for diarrhoea in critically ill patients receiving enteral feeding (Emery *et al.*, 1999)

Goel *et al.*, (1999) reported that banana pulp powder showed significant anti- ulcerogenic activity. Ripe bananas are highly beneficial in the treatment of ulcerative colitis; being bland, smooth ,easily digestible and slightly laxative.

Pannangpetch *et al.*,(2001) reported that the anti ulcerative effect of banana may vary depending on different varieties of banana. The ethanolic extract of both *M. sapientum* and *M. paradisiaca* had significant protective effect, because it neutralized the over acidity of gastric juices and reduced irritation of the ulcer by coating the lining of stomach. A simple mixture of banana and milk thus significantly suppressed acid secretion.

Dunj (1999) conducted an animal study and reported that fresh bananas protected the animal's stomach from wounds. Bio active substances in banana activated the epithelial cells, so that they produced a thicker protective mucous barrier against stomach acids.

Whelton *et al.*, (2006) reported that bananas contained large amount of potassium which has a role in controlling blood pressure. Journal of American Medical association reported that daily consumption of banana could increase the potassium which was enough to lower systolic pressure by 3mm Hg and diastolic pressure by nearly 2mm Hg (Ascherio,*et al.*,2000)

A study published in the "Archives of Internal medicine showed that eating two bananas a day lowered blood pressure by 10%". (Sellmeyer, 2002).A study conducted at Deakin University revealed significant fall in blood pressure, when subjects ate more bananas and reduced their sodium intake (Fang, 2000). Saraswathy and Gownam(2000) reported that *Musa.paradisiaca* inhibited cholesterol crystallization in vitro which might have an effect on atherosclerosis plaque and gallstones. Hypo cholesterolaemic activity of *Musa paradisaca* was also reported by Usha *et al.*, (2004).

Hemicelluloses and other nautral dietary fibre (NDF)from the unripe *Musa paradisiaca* fruit showed lower absorption of glucose and cholesterol and triglycerides. The pulp of banana fruit (*M.sapientum Var M.cavendish*) was confirmed for its cholesterol lowering effects(Lohsonthorn, 2000).

The green fruit of *Musa.paradisiaca* has been reported to have hypo glycaemic activity due to stimulation of insulin production and glucose utilization.(Ojewole, 2003).The glycemic index of bananas is varied depending upon the type and ripeness. The bananas just before ripening had a glycaemic index of 52. Under ripe bananas had a higher starch content and a lower sugar content(Foster Powell, 2002).A glycaemic index of 52 is classified as low, making them a good fruit choice for people with diabetes.

Bananas could be helping to reduce the risk of kidney cancer. Research on 61,000 Swedish women aged 40-76 years revealed that , of all fruits eaten, bananas gave the greatest protection against renal cancer. Women who ate 5 bananas a week nearly halved their risk of renal cancer.(Rashid, 2005).

Researchers from the university of California found that the regular consumption of bananas in the first two years of life, consistently reduced risk of childhood leukaemia before the age of 15 years (Kwan, 2004). The protective role of resistant starch in the intestine, towards intestinal bacteria was proved to prevent intestinal cancer.

The water extract of pulp of the ripe *Musa.Sapientum* had been reported to have significant anti allergic activity (Tewtrakul *et al,*2008) Ash of the peel of *Musa sapientum* showed an increase in the urine volume (Jain *et al.*,2007).

Data reported in a study published in the Archives of Ophthalmology indicates that eating 3 or more servings of banana fruit per day lowered the risk of age related macular degeneration (Chois, 2004). The pulp of banana fruit *(M. sapientum var .M Cavendish*)was confirmed for its cholesterol lowering effects.(Lohsonthorn , 2000)

2.10 Scope of banana peel

Researches from the end of last century have highlighted the scope of banana peel, which was till then considered mostly as a cattle feed. Banana peel is a source of vitamin A which is good at rejuvenating, firming, softening and moisturizing the skin. It is also proved beneficial for the hair and scalp. It helps in softening, and adding volume to hair; it also makes hair shiny, and prevent dandruff, falling hair, split ends, and breakage. It also aids in pedicure

The peel can help relieve mosquito bites, burns and boils, by applying the inside of banana peel to the affected area for the healing effect. The peel is also a natural cure for warts. According to Japanese Scientific Research, full ripe banana with dark patches on yellow skin produces a substance called TNF (Tumor Necrosis Factor) which has the ability to combat abnormal cells. The more darker patches it has, the higher will be its immunity enhancement quality; Hence, the more ripe the banana the better the anti-cancer quality. Yellow skin banana with dark spots were more effective in enhancing the property of white blood cells (Deutscher, 1999).

Banana peel flour was revealed to be an important source of fiber (NDF), corresponding to about 32% of its dried weight (Ranzani *et al.*, 1996)

Archibald (1999) suggested that if the peels are properly processed, it could be a cheap and high-quality source of carbohydrates and minerals for livestock. Banana peel can be utilized for the extraction of banana oil (Amyl acetate) which is used as a food flavouring agent.

The journal of "Bioscience, Biotechnology and Biochemistry" reported that an extract of banana peel significantly suppressed prostate gland enlargement in mice treated with testosterone (Akamine, 2009)

During the production of banana products, banana peel accumulated in bulk posing serious environmental problems. To prevent this, it became necessary to develop alternative commercial applications for these agro-industrial wastes. The peel of banana represents about 40% of the total weight of fresh banana (Thobanoglous *et al.*, 1993) and has been underutilized. As a part of this endeavour, banana peel was used for the large scale production of

alcohol (Thevari *et al.*, 1986), enzymes such as lactases (Johann *et al.*, 2007) and amylases (Shaista *et al.*, 2003).

Various studies have been conducted to investigate the application of banana peel, including the production of banana peel flour(Ranzani *et al.*, 1996) ,the effects of ripeness stage on the dietary fibre components and pectin of banana peels (Emaga *et al.*, 2008). The chemical composition of banana peel, as influenced by the maturation stage and varieties of banana have also been exclusively studied. All these studies indicated a high content of dietary fibre in the peel, it would be possible to utilize the peel as a functional ingredient.

Banana peel amylases standout as a class of enzymes useful in the textiles as a textile detergent. It also has application in the brewing and pharmaceutical industries (Rosell *et al.*, 2001). They are also employed for starch liquefaction, production of maltose ,high oligosaccharide mixtures, high fructose syrup and maltotetrose syrup (Pandey *et al.*, 2000). They are also applied during detergent production to improve cleaning effect and also used for starch de-sizing in textile industry (Lonsane, 1990).

Mane (2012) reported that banana peel can be used as a remover of colour from waste effluent of textile industry. Thus banana peel can serve as a low cost natural adsorbent. Banana peel had been found to remove and concentrate Cr(III) from industrial waste water(Jamil *et al.*, 2008).

Hai-Yan-Sun (2011) reported that banana peel can be used as a potential substrate for cellulase production by *T.viride* GIM 3.0010 ,under solid state fermentation.

As the fruits of the banana trees are consumed at green, average ripe and ripe stages, the amount of fruit waste from the peels is expected to increase with the development of processing industries that utilize the green and ripe banana. Like the pulp flour, banana peel flour can also potentially offer new products with standardized composition for various industrial and domestic uses (Emaga *et al.*, 2008).

Banana can thus be promoted as a health food owing to its nutrient status, antioxidant profile and therapeutic properties. Since it has specific beneficial physiological effects that is beyond the conventional role of nutrients, it can be called an ideal functional food. Its preventive and curative effect has also been proved worldwide, thus raising it to the class of neutraceuticals.

2.11 Banana – an economic crop of farmers as well

Banana cultivation is also preferred among farmers due to its economic viability. It is of demand among all kinds of population in the world Banana fruit is grown in many countries in the sub-tropical areas and the big exporters are located in South East Asia, South America and the Caribbean. The Cavendish variety is widely produced by these countries. Banana takes the third place in the world's fruit volume production after citrus fruits and grapes. Green-mature banana fruits are transported to consumer countries and ripened in controlled conditions. Imported banana fruits are transported to airtight warehouses with ethylene gas control system and are ripened.

India is the home for bananas and plantains since Vedic times. It has also a good export potential. Banana serves as an ideal low cost food source for developing countries, where most of the population rely on bananas for food. Banana plant parts are also useful as insecticides, antioxidants, and colour adsorbents in preparation of various functional foods. It is also used in the manufacture of wine, alcohol, biogas, cattle feed etc.

The major banana growing states are Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Kerala, Tamilnadu, Madhyapradesh, Maharashtra, Orissa and West Bengal. Tamil Nadu has the largest area followed by Maharashtra and Karnataka.. Tamil Nadu ranks first in banana production followed by Karnataka. Highest productivity was recorded in Maharashtra followed by Gujarat, Tamil Nadu, Madhya Pradesh (FAO&NHB, 2009).

Banana and plantain are continuously exhibiting a spectacular growth worldwide. India alone produces 27.01 million tons. India is the largest producer of banana in the world and contributes 22.15 percent to global production from 7.4 percent of total area , followed by China and Philippines. Although Brazil has the second largest area under bananas, the country ranks only fourth in terms of production (NHB, 2009).

The banana industry has witnessed a significant growth during the last two decades. The area and production also witnessed a spectacular growth, indicating an overall 100 percent increase in area with 250 percent increase in banana production during the last two decades . The significant increase could be achieved due to adoption of improved production technologies.

The area of banana cultivation during 2010-2011 was 58,671ha, which was a 14 percent increase in area than 2009-2010 .Palakkad, Wayanad, and Malappuram district stands in the first three positions with areas 24 percent, 18 percent,13 percent respectively (NHB,2009).

Banana production was also highest in Palakkad District. Palakkad district occupies 19.84 percent of the total area of banana production in Kerala. Thiruvananthapuram has the seventh position in banana production in Kerala. Banana cultivation was least in Kasargod district and the contribution was only 0.6 percent.

Major banana varieties popular in this part of the countries are robusta(AAA), rasthali (Silk AAB), poovan (Mysore AAB), nendran (AAB), red banana (AAA), ney poovan(AB), virupakshi (AAB), pachanadan (AAB), monthan (AAB), Karpuravalli (ABB), safed velchi musa(AB) (Sathiamoorthy, 1992).

A qualitative comparison of banana, the "poor man's fruit", would be of interest to the food safety conscious common man.

Materials and Methods

3. Methodology

The experiment entitled "Quality evaluation of organic ripe banana" was conducted to study and compare the quality characteristics of selected banana varieties cultivated by organic and conventional farming techniques.

The methodology is discussed under the following heads

3.1. Selection of locale

3.2. Selection of fruits

3.3. Selection of treatments

3.4. Selection of quality parameters

3.5. Statistical analysis

3.1. Selection of locale

Organic samples of banana varieties were collected from the Organic farm, College of Agriculture, Vellayani and Conventionally cultivated varieties were collected from the instructional farm, College of Agriculture, Vellayani.

3.2. Selection of fruits

Amongst all foods , fruits are nature's wonderful medicines packed with vitamins, minerals antioxidants and phyto nutrients. Among the wide variety of fruits, bananas are the most widely consumed fruits in the world, as they are available throughout the year and are affordable by common man. Banana also has high nutritive and medicinal value. Hence, it was felt apt to choose this common fruit for the quality analysis. Details of the banana varieties selected for the study are presented below.

A. Nendran(AAB)

B. Palayankodan (AAB)

C. Rasakadali (AA)

To reduce variations and obtain consistent data, measurements were limited to the fingers of the second hand of the freshly harvested physiologically matured bunches. The selected bananas were very clean, (free from defects such as scars, physical damage, insect injury and latex staining). The fruits were free from decay, had an adequate finger length and diameter and did not have an excess curvature upon ripening. They had the desired uniform yellow colour and aroma. Fruits which were in the fifth colour stage (matching with the banana colour chart of SH Pratt and company,2012) was selected.

3.3. Selection of treatments

Two types of farming practices were identified as the treatments for the study.

T1- Organic farming-

Fertilizers applied in organic plots were as recorded below-

FYM or compost or green leaves @ 10kg/ plant

500g of lime, vermi compost @ 2kg/ pit.

Ground nut cake/ neem cake @ of 1kg/ pit

N,P and K bio – fertilizer mixed with FYM and PGPR mix I @ 50 – 100g/ pit

These fertilizers were applied at the time of planting. Panchagavya 3% as foliar spray was also applied three times at the 3rd , 6th and 9th months after planting.

T2- Conventional farming

Fertilizers applied in conventionally cultivated banana plots were-

Compost, cattle manure or green leaves @ 10kg/ plant at the time of planting and N: P2O5: K2O were applied at the following rates.

Nendran – 190: 115: 300

Palayankodan – 100: 200: 400

Rasakadali – 100: 200: 400

The plant protection chemicals applied in the conventional farming were:-

To control pseudostem weevil chlorpyriphos (Radar) 20EC was applied at the rate of 3ml/litre water was sprayed on the plants.

To control sigatoka disease carbendazim (Bavistin) 50WP 1g/ litre was sprayed on the plant.

3.4. Quality parameters selected for the study were-

3.4.1 Physical characteristics

3.4.2 Sensory qualities of fruits

3.4.3 Shelf life

3.4.4 Nutrient / Chemical composition

3.4.5 Anti nutrients

3.4.6 Pesticide residue

Three samples of each variety and each treatment were taken for measuring the quality parameters.

3.4.1 Physical characteristics

With the ripening process ,many changes occur in physical properties of banana fruits. Knowledge of physical characteristics of banana fruit is essential for apt handling , sorting , processing, packaging ,thus for its total management system. These in turn affect the consumer acceptability. The physical quality of the fruit is discussed under the following heads.

3.4.1.1 Appearance

With ripening, peel colour changes from green to yellow, firmness decreases, banana softens, and starch is converted into sugar. These changes during ripening period occur as a result of breakdown of chlorophyll in the peel tissue. It often reported that appearance is more appropriate for predicting the level of ripeness of banana. Ripeness was assessed by comparing the colour of the peel with standardized colour chart that describe various stages of ripeness (Pratt and company, 2012)

3. 4. 1.2 Total number of hands per bunch

Total number of hands were obtained by counting the number of hands per bunch (Soltani , 2011).

3.4.1.3 Total number of fruits/hand

Total number of fruits/ hand were obtained by counting the number of fruits/each hand in each sample (Soltani, 2011).

3.4.1.4 Mean fruit weight

Fruit weight changes during maturation. Fruit weight is reported to increase when bunch age increases. The formula used for finding mean fruit weight was

Mean fruit weight= wt of bunch - wt of stalk / total number of fingers (Soltani, 2011).

3.4.1.5 Peel thickness

Each fruit from the samples were hand peeled after cutting transversely at the mid point , and thickness was measured with vernier calipers (Dadzie., 1994)

3.4.1.6 Pulp to peel ratio

Pulp and peel were separated , weighed individually and expressed as 'peel to pulp ratio' (ie , pulp weight divided by peel weight) (Brady, 1987).

3.4.2 Sensory qualities of food

Sensory evaluation is defined as a scientific discipline to evoke, measure, analyze and interpret results of those characteristics of foods, as they are perceived by the senses of smell , taste ,touch and hearing .The primary consideration for selecting and eating a food commodity subjectively, is after assessing the sensory qualities of fruit for its appearance ,colour ,flavour , taste and texture which is discussed below (Piggot, 1988).

Trained judges were selected for sensory evaluation, based on the following criteria, ie those who

1. had affinity for banana consumption
2. possessed the ability to identify basic tastes
3. were able to perceive smell and aroma
4. were non – smoking and pan chewing
5. had the ability to express their judgement (Plemmons and Resurrection, 1998).

3.4.2.1 Appearance

Surface characteristics of fruit contributes to the appearance. Quality of fruits can be ascertained to a great extent by its appearance. Score card was used to evaluate the appearance of each banana samples in the sensory evaluation by judges.

3.4.2.2 Colour

Consumer's fruit selection criteria is mainly based on the external appearance, which is strongly influenced by colour. Ripeness of fruits like banana can be assessed by colour . Moreover, colour is used as an index to the quality of fruits. Score card was used to evaluate the colour of samples.

3.4.2.3 Flavour

The flavour of food has three components namely, odour, taste and a composite sensation known as mouth feel. . Score card was used for the assessment of flavour of banana (Nieva *et al.,* 1968)

3.4.2.4 Texture

The texture or firmness of the pulp of banana, is an important post harvest quality attribute in the assessment of quality at harvest. It could be used as maturity ripening index also. Assessment of texture is important in the evaluation of fruit's susceptibility to physical or mechanical damage. Pulp firmness or texture reduce during ripening (Palmer, 1971). Score card was used as an index for assessing texture.

3.4.2.5 Taste

Food is valued mostly for its taste. Score card was used for assessing the taste of each banana sample. Taste is also an important feature for acceptability.

3.4.2. 6 Peeling condition

Ease of peeling depends on the peel thickness and degree of adhesiveness of the peel to pulp. Score card was used as an index for assessing peeling condition (INIDAP, 2001).

3.4.3 Shelf life

Shelf life is the period of time for which a product can be stored under specified conditions , retaining its optimum conditions and will remain suitable for consumption (Marriot , 1985).

Spoilage is the deterioration in the colour , flavour , odour or consistency of a food product. Food can deteriorate as a result of two factors; growth of micro organisms and action of enzymes. Fruits contain higher levels of sugar, mineral elements and low pH value making them particularly desirable for fungal decay (Singh and Sharma , 2007).

Shelf life study on banana varieties were done by assessing organoleptic properties on alternative days until spoilage. The moisture, acidity and TSS levels of the fruits were also analysed during alternate days of storage.

3.4.4 Nutrient /chemical composition

Nutrient content or nutrient density refers to the substances in foods that give energy and improve health. It also refers to the amount of nutrients for a given volume of food (Michel, 2005). The major nutrients /chemicals analysed in this experiments were Moisture, Acidity ,Vitamin C, TSS, Total minerals, Potassium , Sodium, Calcium and Iron.

3.4.4.1 Moisture content

Moisture content of each sample was determined by the method outlined by A.O.A.C (1990).

3.4.4.2 Acidity

Acidity of all the samples were estimated as per the procedure reported by A.O.A.C(1984).

3.4.4.3 Vitamin C

Vitamin C of the banana varieties were estimated by titrating using the dye 2, 6, dichlorophenol indophenol method (Sadasivam and Manikam, 1992).

3.4.4.4 Total Soluble Solids

TSS of each sample was determined by using the refractometer (0-20 Brix).

3.4.4.5 Total minerals

Total minerals were estimated by the method outlined by Raghuramalu *et al* (1983) for each sample.

3.4.4.5.1 Potassium

Potassium was estimated by the method suggested by Jackson (1973).

3.4.4.5.2 Sodium

Sodium was estimated by the method suggested by Jackson (1973).

3.4.4.5.3 Calcium

Calcium was estimated after wet digestion of the sample with triple acid . The triple acid digest was titrated by EDTA method (Jackson , 1973).

3.4.4.5.4 Iron

Iron was estimated by the method suggested by Jackson (1973)

3.4. 5 Anti nutrient Profile

Anti nutrients are substances which either by themselves or through their metabolic products, interfere with food utilisation and affect health of

animals (Dmello, 2000). But recently there is growing evidence that these secondary metabolites play a typical role in human health and may be important in terms of antioxidant activity, cardio protective role, neuro protective role and cancer protective role. Hence their content has become a source of interest, especially in fruit and vegetables (Lundedarh and Marlanson, 2003).

3.4.5.1 Phenol

Phenol content was determined by the procedure suggested by Sharma(2001)

3.4.5.2 Tannin

Tannin was estimated as per the procedure outlined by Ranganna(2001).

3.4.6 Pesticide Residue

Pesticide Residue was estimated using Schimatzu gas chromatograph (Anastassiades, 2003).

3.4.7 Statistical Analysis

Homogeneity of variances in the two treatments were tested using F – test. It was observed that there was similarity in variances Students t –test at 5% and 1% level of significance was adopted to compare significant differences in various parameters of the two treatments T_1 and T_2.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{S^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$S^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$$

Where

$\bar{X}_1$ = Mean of T_1

$\bar{X}_2$ = Mean of T_2

S_1= Variance of T_1

S_2 = Variance of T_2

n_1 = no of observations of T_1

n_2 = no of observations

Results

4.RESULT

The study entitled "Quality evaluation of Organic ripe banana" was conducted to ascertain the following quality parameters of bananas. The results of the study are discussed under the following heads:

4.1. Physical characteristics
4.2. Sensory qualities
4.3. Shelf life
4.4. Nutrient composition
4.5. Anti nutrient profile
4.6. Pesticide residue

4.1. Physical characteristics

In post harvest treatments, physical properties of fruits and vegetables are necessary data to design an agricultural system for handling, cleaning, sorting and related procedures. Besides the size of individual units of a products can significantly affect consumer appeal, , storage potential and market selection. Among the fruits and vegetables ,banana fruit has exclusive physical properties that make it different from other fruit and vegetables.

The physical characteristics of each variety of banana were assessed with respect to appearance, total number of hands/bunch, number of fruits/ hand, mean fruit weight, peel thickness, pulp to peel ratio and peeling condition. The results are depicted in the following tables.

4.1.1.Appearance

Since, the colour chart (Pratt and company, 2012),was used to select the varieties uniformly, the peel colour of all the varieties were rated against the colour chart as stage 6, ie., the stage when the peel colour was completely transformed to yellow from the pale green stage. This stage was purposefully

Appearance of Organically cultivated banana varieties

Nendran

Palayankodan

Rasakadali

selected, so as to ensure uniformity in all the other characteristics, for the favour of qualitative comparison.

4.1.2 .Total number of hands per bunch

Total number of hands/ bunch is one of the important physical characteristics for consumer acceptance. The higher number of hands/bunch was found in organic nendran and palayankodan varieties. However, the results revealed that there was no significant difference in the total number of hands/bunch among the treatments

Table: 1. Total number of hands/ bunch of selected banana varieties

Banana Varieties	Total number of hands/bunch		
	T1	T2	TSE
Nendran	5.00	5.00	1.00
Palayankodan	10.00	9.00	1.41
Rasakadali	10.00	10.00	0.00

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.1.3. Number of fruits per hand

There are many studies revealing an association of fertilizer application on number of fruits per bunch. Hence in this study also, this parameter was assessed for comparison among the treatments . The organic varieties were seen to have more number of fruits per hand. But only nendran variety showed significant difference at 1percent level.

Table: 2. Total number of fruits per hand of selected banana varieties

Banana Varieties	Total number of fruits/ hand		
	T1	T2	TSE
Nendran	8	7	8.45**
Palayankodan	19.00	19	1.00
Rasakadali	17	16.00	1.00

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.1.4. Mean fruit weight

Considering the fact that fertiliser application will increase or decrease fruit weight, fruit weight of the samples from each treatment were also assessed. Rasakadali and palayankodan were seen to have higher fruit weight in their organic treatments ,but the results revealed that, the difference was significant only in the case of rasakadali at 5 percent level.

Table: 3. Mean fruit weight of selected banana varieties

Banana Varieties	Mean fruit weight (g)		
	T1	T2	TSE
Nendran	234.94	235.45	0.327
Palayankodan	131.95	129.91	1.709
Rasakadali	124.56	121.56	3.250*

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.1.5.Peel thickness

Peel thickness is essential in terms of not only being a protection during post harvest stages, but also in terms increasing the weight of the marketable product. When peel thickness of organic and conventional palayankodan varieties were on par, Organically treated nendran and rasakadali had higher values for peel thickness. Organic nendran showed significant difference in peel thickness at 1 percent level.

Table: 4.Peel thickness of selected banana varieties

Banana Varieties	Peel thickness(cm)		
	T1	T2	TSE
Nendran	0.8	0.7	4.89**
Palayankodan	0.5	0.5	0.00
Rasakadali	0.36	0.3	2.00

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.1.6.Pulp to peel ratio

Pulp to peel ratio is considered as a co – efficient of ripeness and also as an indicator of bunch maturity (Dadzie, 1993). Conventionally cultivated varieties were found have higher values for pulp to peel ratio. This difference was proved to be significant in nendran and palayankodan variety.at1 percent level of significance.

Table: 5. Pulp to peel ratio of selected banana varieties.

Banana Varieties	Pulp to peel ratio		
	T1	T2	TSE
Nendran	1.68	1.89	6.19**
Palayankodan	2.02	4.17	6.43**
Rasakadali	2.04	4.84	1.70

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

To give an overall picture , physical parameters like total number of hands per bunch, total number of fruits per hand, mean fruit weight, Peel thickness and Pulp to peel ratio did not show uniform results among treatments.

4.2 . Sensory qualities

Consumers prefer food which is palatable and enjoyable. Palatability means quality of food should be appealing and appetizing. For a consumer, the primary consideration for selecting and eating a food commodity is the palatability or eating quality. Other quality parameters such as nutrition and wholesomeness are secondary. For consumers to prefer a food commodity ,the main quality attributes are appearance, colour, flavour, texture and taste . All these attributes were ascertained by sensory evaluation.

The sensory evaluation is very important for a food products, on account of the following advantages.

i) It is a simple analytical tool,

ii) It identifies the presence or absence of perceptible differences in terms of flavour, texture, colour and appearance,

iii) These important quality attributes are measured in a fast and quantifiable manner employing sensory techniques. The use of chemical and instrumental methods for examining sensory characteristics are time consuming, complicated and expensive,

iv) It enables identification of a particular problem or defect that cannot be detected by other analytical techniques,

v) Sensory evaluation techniques help in ensuring that the consumers get a non defective and enjoyable product.

The sensory qualities selected for the study were the following :- appearance, colour, texture, taste and overall acceptability. Beside this, peeling condition of bananas is also identified as a criteria in many studies ,for qualitative analysis. Results of sensory evaluation are presented as follows.

4.2.1. Appearance of banana varieties

Glaring colours formed in artificially ripened fruits, is a cause of concern among consumers in the recent years. Hence appearances of the fruits were evaluated by the sensory panel. Organic banana varieties in general scored higher with respect to appearance than the conventionally cultivated samples, as evidenced in the Table No 6. The scores for appearance of Organic rasakadali variety was found to be significantly differing at 1 percent level.

Table: 6. Appearance of selected banana varieties

Banana Varieties	Appearance		
	T1	T2	TSE
Nendran	4.3	4.2	0.39
Palayankodan	4.3	3.8	1.98
Rasakadali	3.9	3.3	3.28**

(t=2.10,at 5 % significance and t=2.87 ,at 1% significance)

4.2.2.Colour of the fruits

Yellowing or breaking down of chlorophyll along with softening is the best visible indicator of ripening in banana. When scores for colour were analysed, organic varieties had higher scores for colour .The difference of scores for colour of palayankodan variety proved to be significant at 1 percent level.

Table: 7. Colour of selected banana varieties

Banana Varieties	Colour		
	T1	T2	TSE
Nendran	4.1	3.8	1.8
Palayankodan	3.5	4.1	3.08**
Rasakadali	4.4	3.9	2.06

(t=2.10,at 5 % significance and t=2.87 ,at 1% significance)

4.2.3. Flavour of the fruits

Flavour is the combined impression perceived via the chemical stimuli from a product into the mouth. The consumer acceptance of fruits most often relies upon the inherent flavour and textural quality of the product. Organic palayankodan and rasakadali varieties showed higher values for flavour but there was no statistical significance among the score of both treatments.

Table: 8. Flavour of selected banana varieties

Banana Varieties	Flavour		
	T1	T2	TSE
Nendran	3.4	3.6	0.86
Palayankodan	3.8	3.6	0.94
Rasakadali	3.7	3.5	0.88

(t=2.10,at 5 % significance and t=2.87 ,at 1% significance)

4.2.4. Texture of the fruits

Texture means the sensory manifestation of the structure or inner make up of a food product. Organic nendran and palayankodan were observed to have higher scores for texture than the conventionally cultivated fruits. The difference in scores were found to be statistically significant at 1 percent level.

Table: 9. Texture of selected banana varieties

Banana Varieties	Texture		
	T1	T2	TSE
Nendran	4.0	3.5	3**
Palayankodan	3.9	3.3	3.28**
Rasakadali	3.6	3.7	0.44

(t=2.10,at 5 % significance and t=2.87 ,at 1% significance)

4.2.5 .Taste of the fruits

Bananas having multifarious varieties in different regions of the world ,is also identified with characteristic tastes .When the 3 varieties, were subjected to evaluation of taste ,in the 2 treatments, the taste of banana varieties were notably higher in organically treated samples and significant differences were observed in the scores between the treatments.

Table: 10. Taste of selected banana varieties

Banana Varieties	Taste		
	T1	T2	TSE
Nendran	4.5	3.9	4.2**
Palayankodan	4.4	3.6	4.0**
Rasakadali	5.0	4.3	4.7**

(t=2.10,at 5 % significance and t=2.87 ,at 1% significance)

On the whole, sensory qualities ,namely, appearance, colour, flavour, texture and taste of organic samples were rated better than conventionally cultivated samples.

4.3. Shelf life

Shelf life of a fruit can be defined as the time period within which the fruit is safe to consume or has an acceptable quality to consumers (Fu and Labuza, 1993).

4.3.1. Sensory qualities of bananas during storage

The sensory evaluation of the samples were conducted on first, third, fifth and seventh day ,while storing at room temperature The results of the scores ,as rated by the judges are presented in tables 11-15

Scores for appearance ,when analysed, showed similar trends in increase on the third day, followed by a decrease , later on. Scores for appearance among treatments, did not show significant difference till the fifth day. All the varieties revealed higher scores in organic treatments on the fifth day, and the difference was found to be significant. This trend, however was seen only in organic nendran on the seventh day,.

Table: 11. Change in appearance of bananas during storage for 7 days

Banana Varieties	Appearance											
	1st day			3rd day			5th day			7th day		
	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE
Nendran	4.0	4.2	0.3	5.0	4.0	1.5	4.2	3	2.5*	3	2.8	2.4*
Palayankodan	4.0	3.8	1.9	5.0	4.0	2.0	4.3	3	10**	2	2.8	0
Rasakadali	3.0	3.3	3.2	5.0	4.0	1.4	4.1	4	2.2*	2.7	2.7	0.4

(t=2.10,at 5 % significance and t=2.87 ,at 1% significance)

The scores for colour were observed to be uniform in both treatments, along the days of storage, Values increased on third day, following a decrease later on. When colour of the fruits were evaluated along the 7 days of storage, palayankodan showed significant difference among treatments on the first day, but this difference was not observed later on.

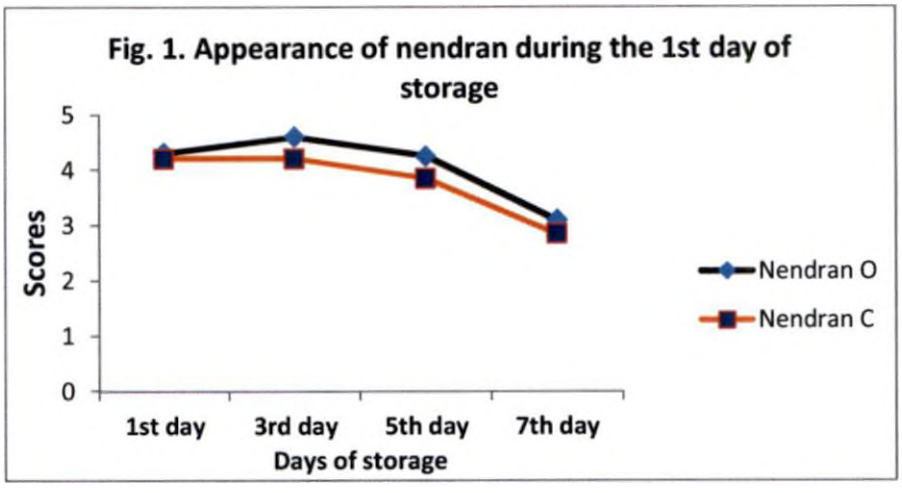
Table: 12. Change in colour of bananas during storage for 7 days

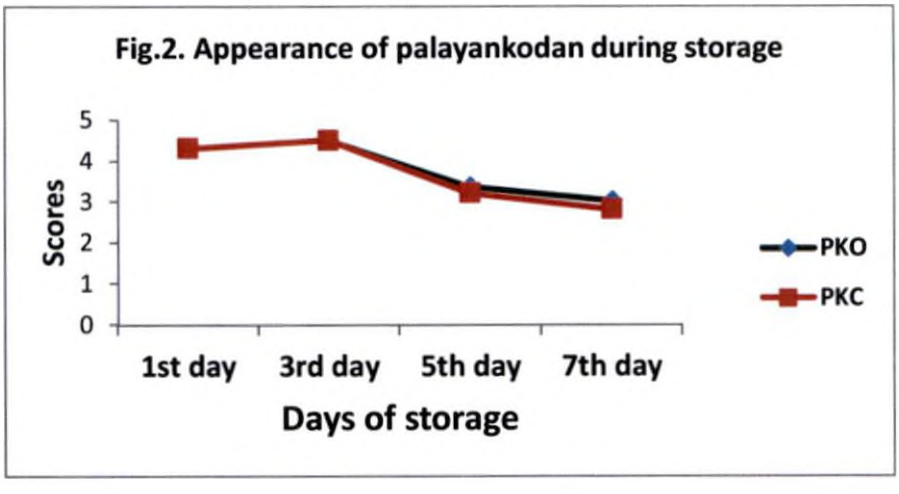
Banana Varieties	**Colour**											
	1st day			**3rd day**			**5th day**			**7th day**		
	T1	**T2**	**TSE**	**T1**	**T2**	**TSE**	**T1**	**T2**	**TSE**	**T1**	**T2**	**TSE**
Nendran	4.1	3.8	1.8	4.7	4.3	1.52	4.0	3.6	1.6	3.0	2.9	1.49
Palayankodan	3.5	4.1	3.08**	4.6	4.5	0.36	4.0	3.5	2.01	2.8	2.9	1.45
Rasakadali	4.4	3.9	2.06	4.8	4.6	0.94	4.3	3.9	1.98	2.65	2.5	1.96

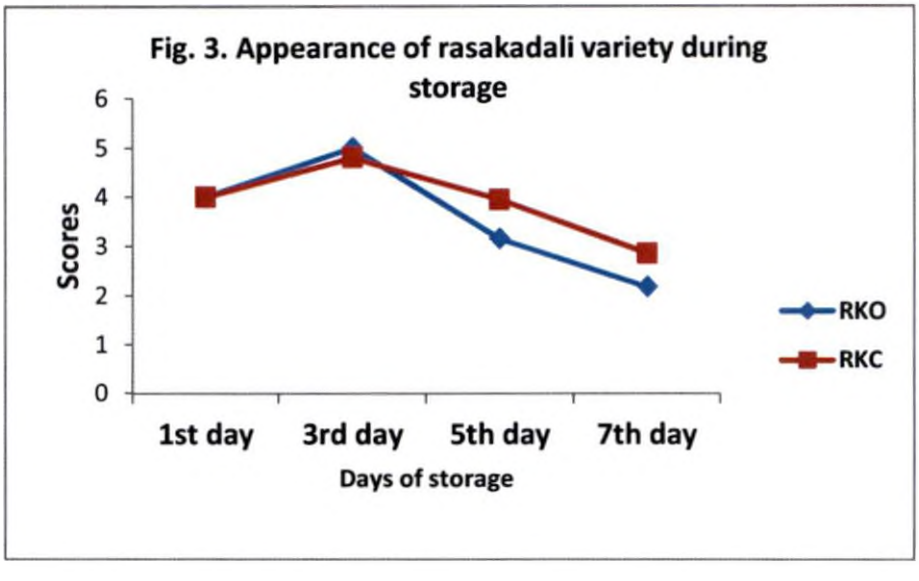
(t=2.10,at 5 % significance and t=2.87 ,at 1% significance)

Flavour was the next attribute analysed during the storage period on alternate days, by the sensory panel. The results are presented in table 13.There was striking difference in the scores of organic and conventional samples of nendran and rasakadali , on the third day ,this difference was not seen among treatments on the fifth day. On the fifth day, palayankodan treatments seemed to differ, which was again not visible on the seventh day. Significant difference was seen in the scores of rasakadali on the 7th day, being higher for organic rasakadali.

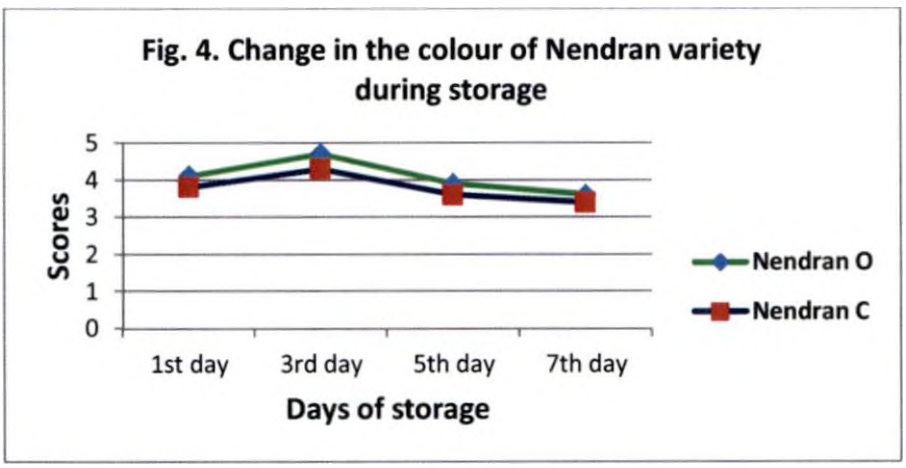
Change in the appearance of fruits during the 1st, 3rd,5th and 7th days of storage

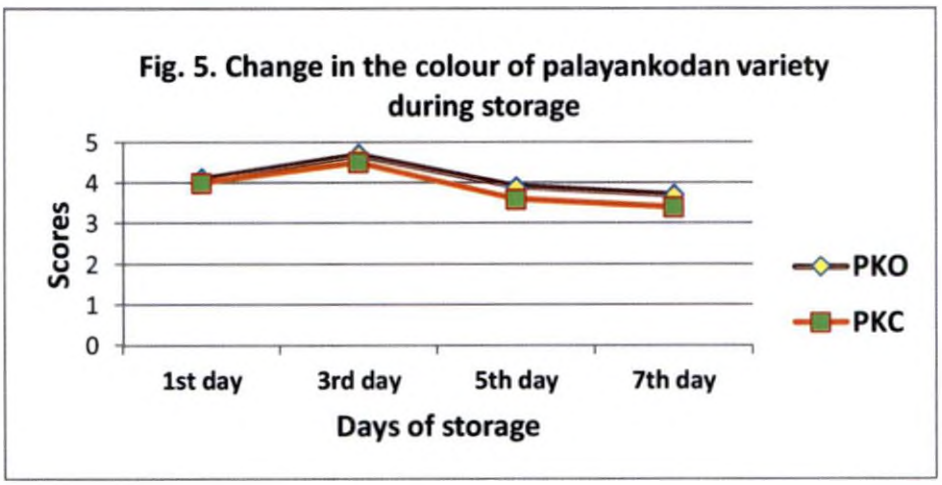


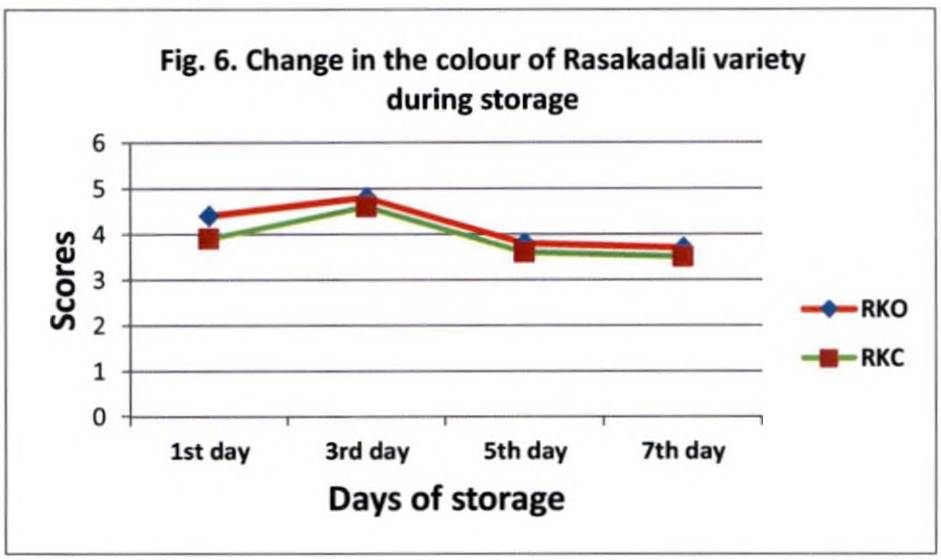




Change in the Colour of fruits during the 1st,3rd,5th and 7th days of storage







The trend of higher scores on third day and decreasing scores on following days were observed uniformly in both treatments.

Table: 13. Change in flavour of bananas during storage for 7 days

Banana Varieties	Flavour											
	1st day			3rd day			5th day			7th day		
	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE
Nendran	3.4	3.6	0.86	4.1	3.4	3.6**	3.62	3.36	0.94	3.0	2.9	1.49
Palayankodan	3.8	3.6	0.94	4.1	3.8	1.34	3.85	3.45	4.38**	3.0	2.9	1.45
Rasakadali	3.7	3.5	0.88	4.2	3.8	2.12*	4.05	3.85	1.26	2.7	2.5	6**

(t=2.10,at 5 % significance and t=2.87 ,at 1% significance)

Changes in texture along the days of storage was also assessed. There was significant difference in the ratings of nendran and palayankodan treatments on the first day and third days, but not obvious after that. Significant differences in the scores of palayankodan treatments were observed on the first and fifth days and not after that.

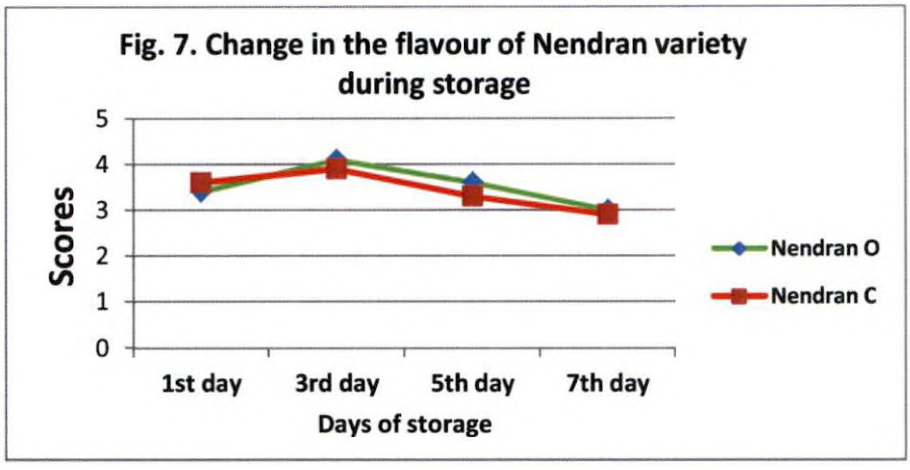
Table: 14. Change in texture of bananas during storage for 7 days

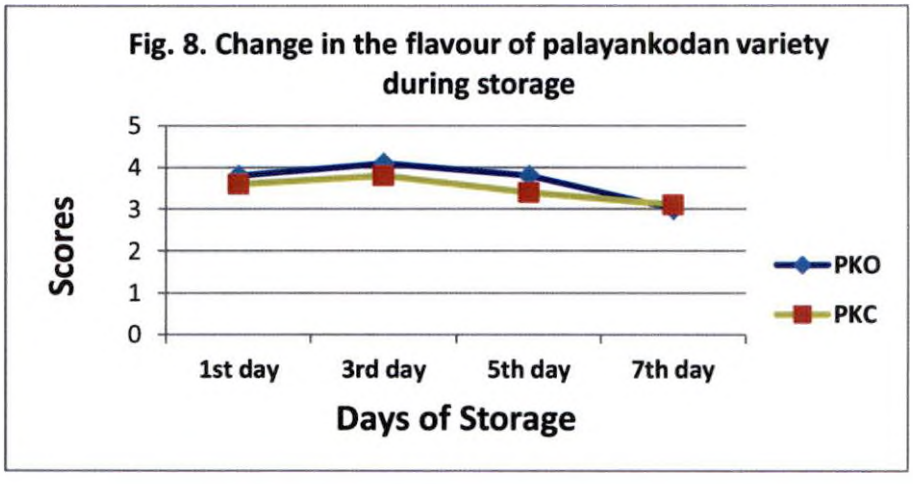
Banana Varieties	Texture											
	1st day			3rd day			5th day			7th day		
	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE
Nendran	4	3.5	3**	4	3.8	1.5	3.6	3.3	2.6*	3	3	1.49
Palayankodan	3.9	3.3	3.1**	4	4.5	1.6	3.5	3.2	3.7*	3	3	0
Rasakadali	3.6	3.7	0.4	5	3.8	3.**	4	3.9	1	3	3	6**

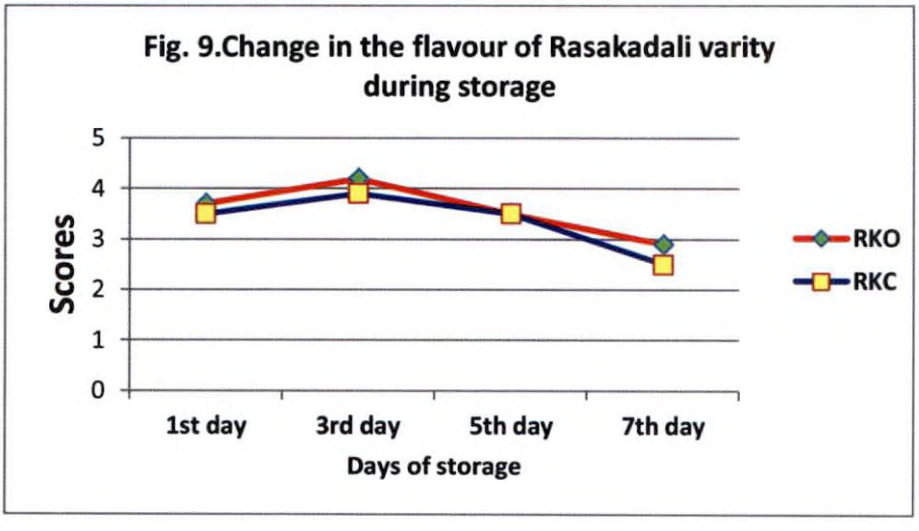
(t=2.10,at 5 % significance and t=2.87 ,at 1% significance)

Rasakadali treatments showed significant differences in values for taste on 3 days, namely, first, third and seventh days, .Organic nendran and palayankodan too showed significant difference in scores on first and third days. Nendran did not show this trend later on. while, palayankodan continued showing significant difference on the 5th day too.

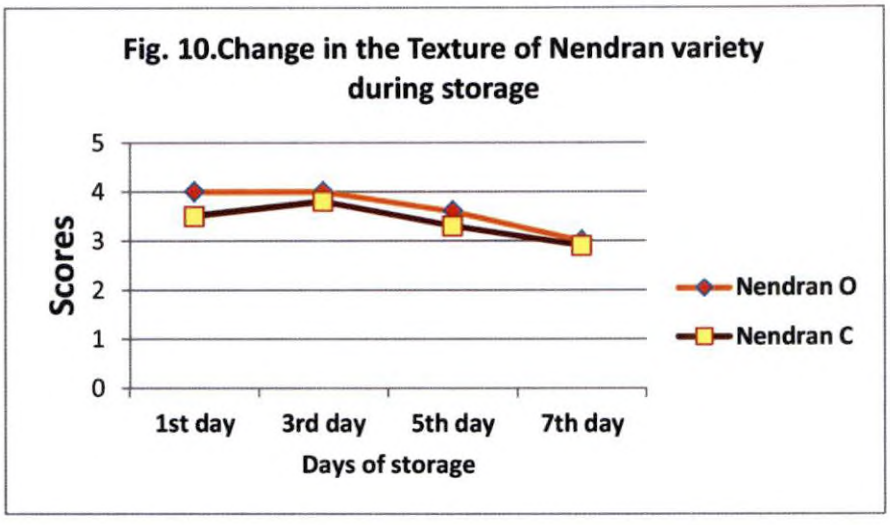
Change in the flavour of fruits during the 1st,3rd,5th and 7th days of storage

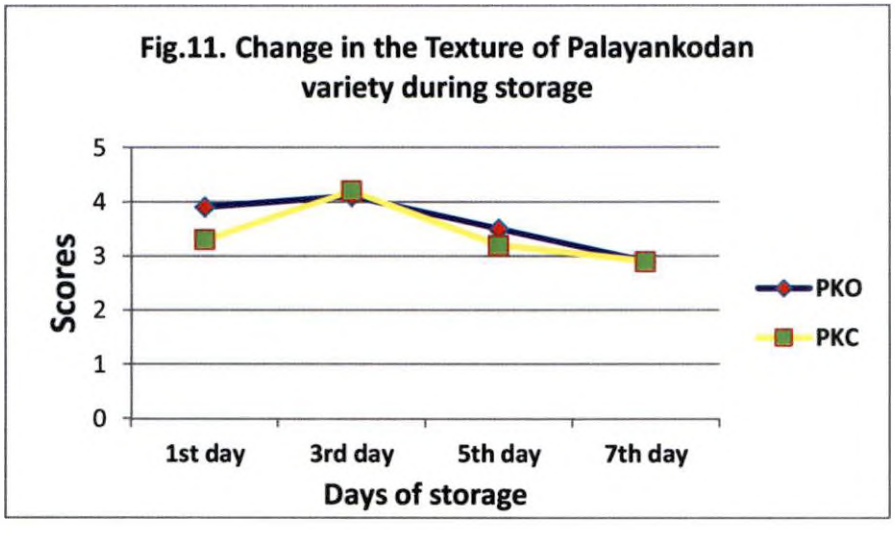






Change in the Texture of fruits during the 1st, 3rd, 5th and 7th days of storage





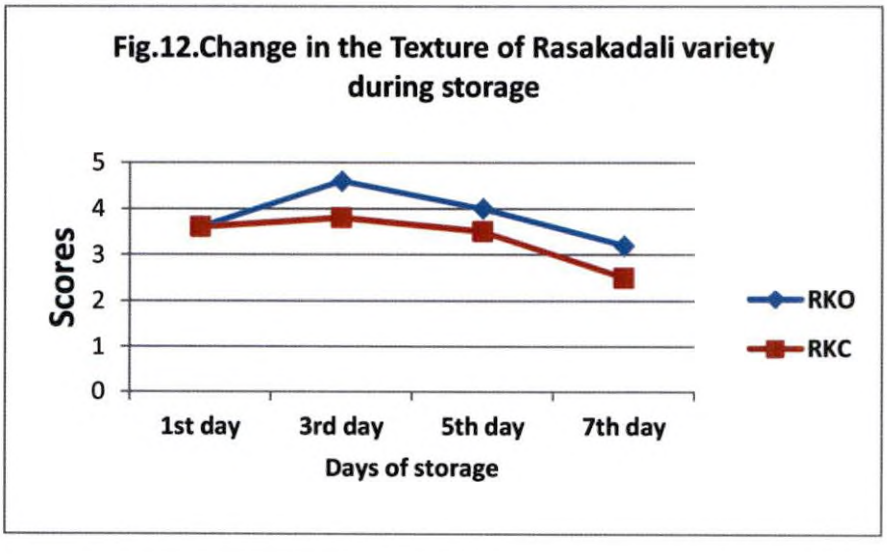


Table: 15 .Change in taste of bananas during storage for 7 days

Banana Varieties	Taste											
	1st day			3rd day			5th day			7th day		
	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE	T1	T 2	TSE
Nendran	4	3	3*	4	4	3**	3.7	3.7	0.4	3	3	1.49
Palayankodan	4	3	3*	4	3	3**	3.8	3.5	4**	2.9	3	1.49
Rasakadali	4	3	3**	5	4	4**	4.1	4.5	0.00	5	3	9**

(t=2.10,at 5 % significance and t=2.87 ,at 1% significance)

Changes in sensory parameters did show uniform trends, during the period of storage. Significant changes on a day was not reflected all throughout the period of storage

4.3.2. Change in chemical parameters of bananas during storage for 7 days

The critical factors affected during storage are, moisture, acidity and TSS. The trend in their changes were studied and the results obtained are presented in tables 16-18

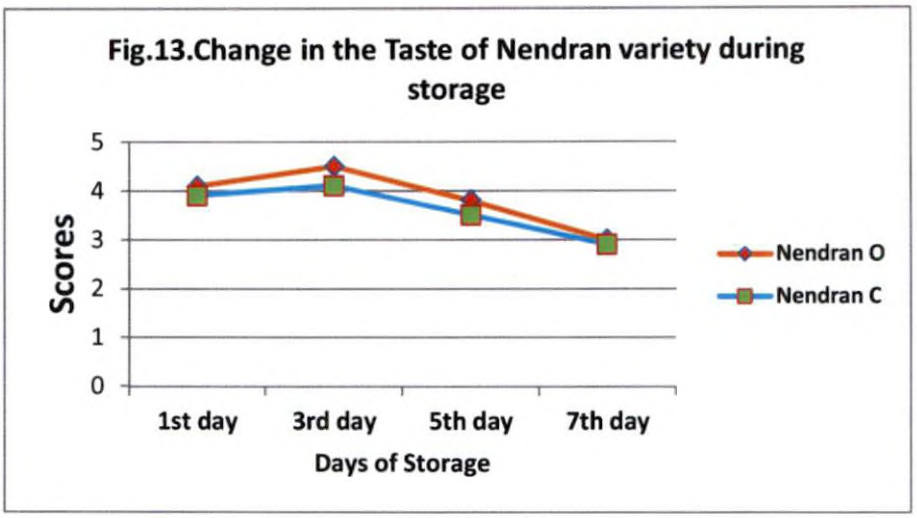
Moisture levels were increased more or less uniformly during the storage period in both type of treatments. Moisture levels showed significant differences among both treatments in rasakadali varieties on all days. In nendran this significant difference was observed on third and seventh days .In the case of palayankodan, there was significant difference among values on all days except on the seventh day, the values were higher for organic samples of all varieties.

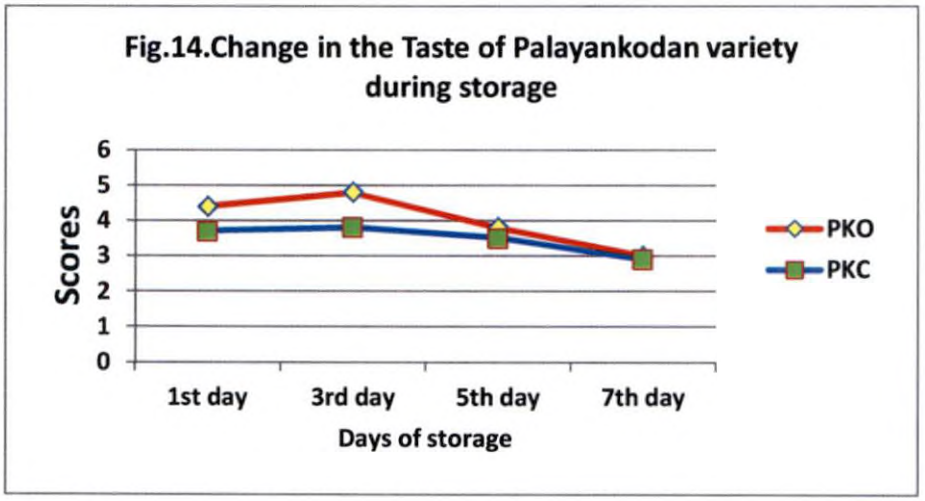
Table: 16. Change in moisture content of bananas during storage for 7 days

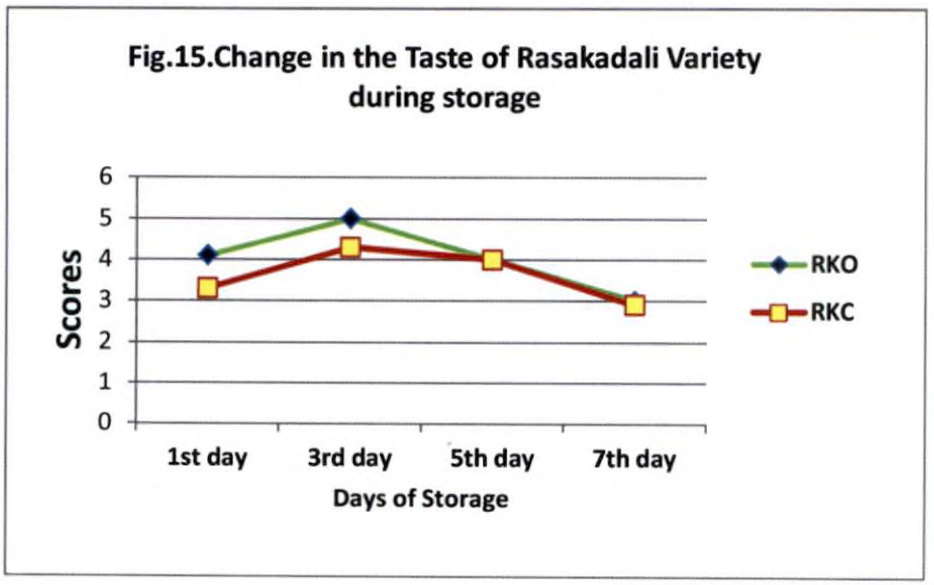
Banana Varieties	Moisture(%)											
	1st day			3rd day			5th day			7th day		
	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE
Nendran	68.1	62.4	2.62*	78.5	72.5	40**	79	78	0.7	81	80	6*
Palayankodan	80.4	77.8	13.2**	86.2	84.9	8**	87	86	4*	88	80	0
Rasakadali	80.7	75.1	21.7**	86.1	81.5	10**	87	85	5*	89	15	5*

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

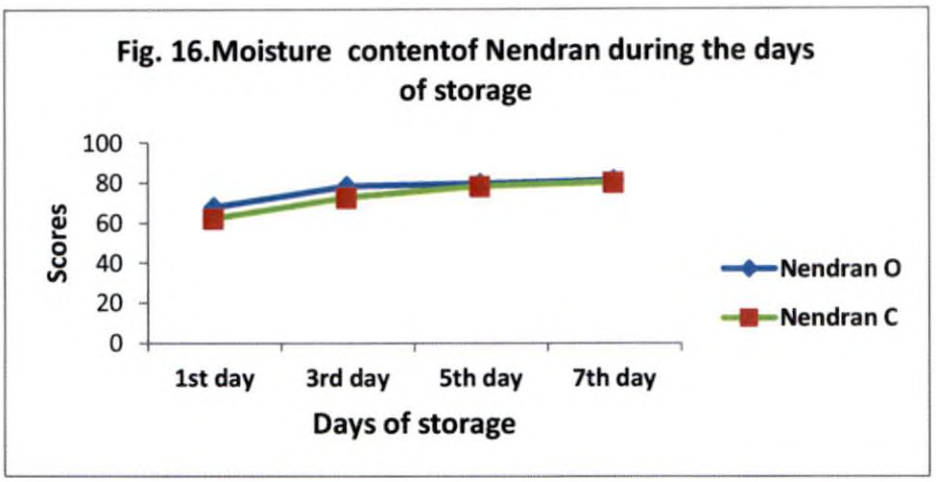
Change in the Taste of fruits during the 1st,3rd,5th and7th days of storage

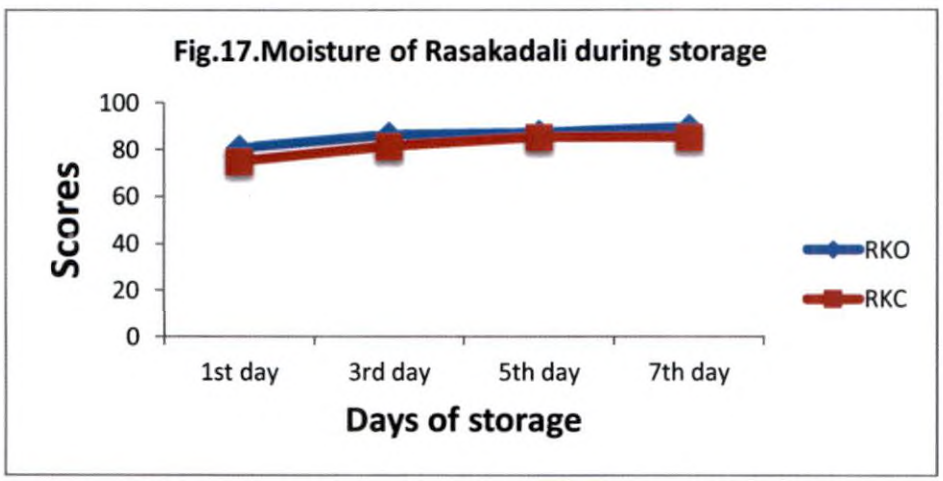


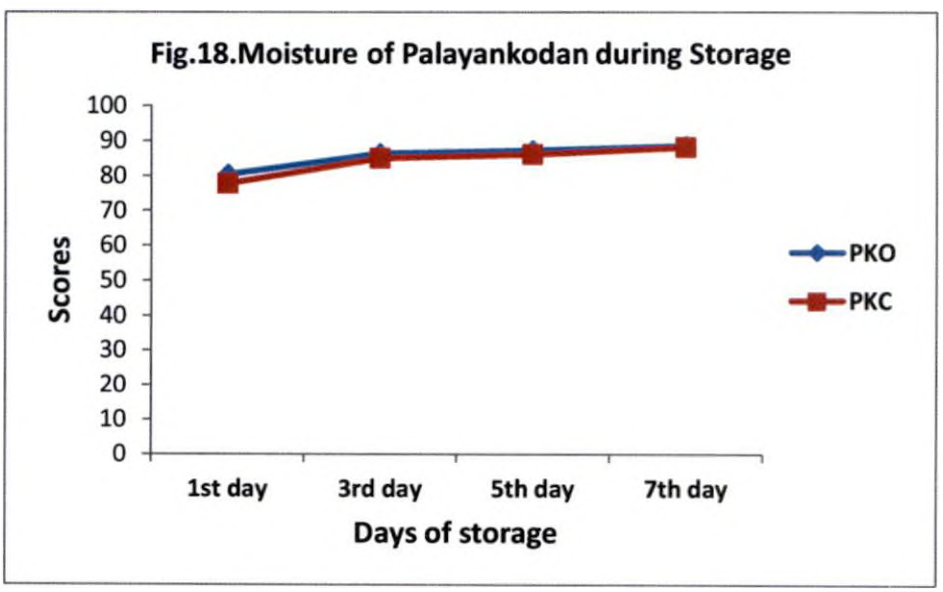




Change in the Moisture levels of selected banana varieties during the 1st,3rd,5th and 7th days of storage







Change in acidity of bananas during storage for 7 days

All varieties showed a uniform trend of an initial increase in acidity, followed by a slight decline. Rasakadali variety showed significant changes in acidity among treatments, on third, fifth and seventh days of the storage period. Palayankodan showed significant differences among treatments on third and fifth days. Nendran showed this difference among treatments on the third, fifth and seventh days only. Conventional samples retained higher level of moisture in all varieties.

Table: 17.Change in acidity of bananas during storage for 7 days

Banana Varieties	Acidity(%)											
	1st day			3rd day			5th day			7th day		
	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE
Nendran	1.06	1.06	0	1.34	1.67	27.7	1.18	1.42	11.2	1.15	1.39	36.5
Palayankodan	1.35	1.46	0.8	1.63	1.9	4.6	1.5	1.7	16.6	1.52	1.63	1.7
Rasakadali	1.13	1.27	3.02	1.32	1.6	19.6	1.19	1.38	20.5	1.17	1.37	34.6

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

Total soluble solids were higher in organically treated varieties and they were found to be increasing with storage

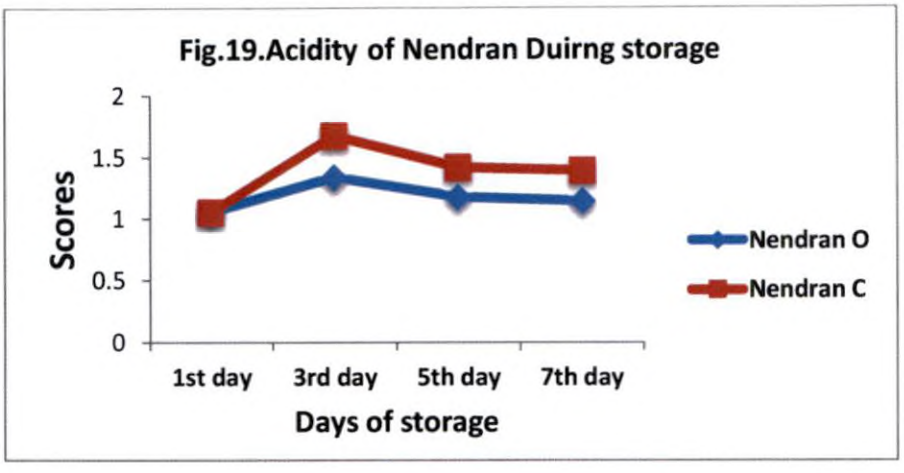
TSS values increased with storage in all treatments. Organically treated varieties maintained higher TSS all throughout. Nendran variety showed significant difference in TSS values, on first, fifth and seventh days of storage., while palayankodan showed this difference on third and seventh days Organic rasakadali showed higher and significant difference in values from third day of storage.

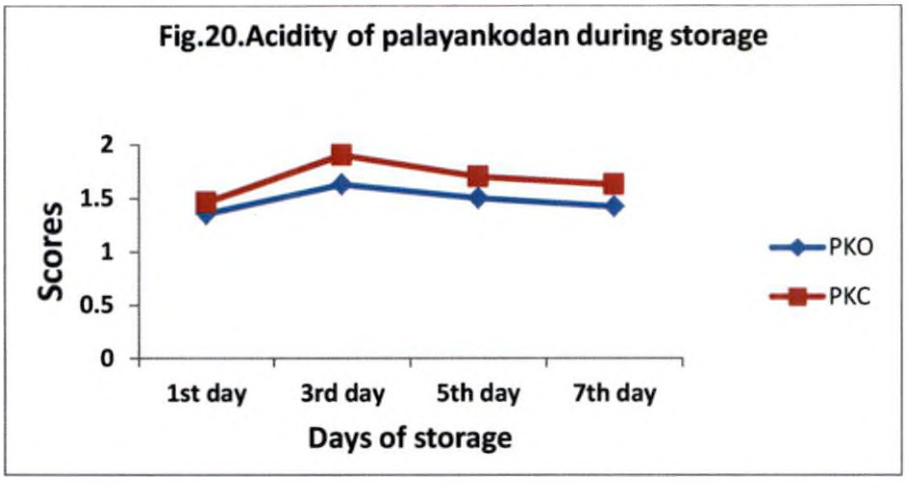
Table: 18 .Change of TSS in bananas during storage for 7 days

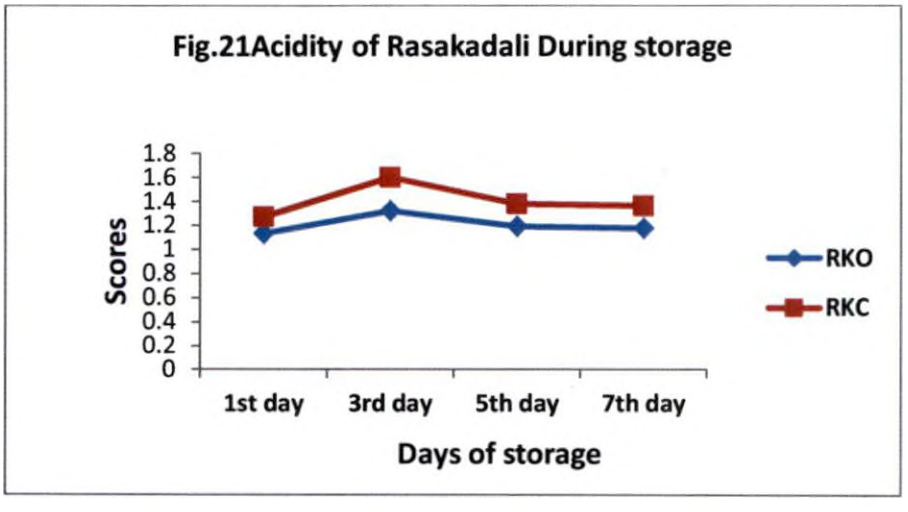
Banana Varieties	TSS (%)											
	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE	T1	T2	TSE
Nendran	17.	15	5.65	19.4	18.6	2.58	19.8	19	3.13	21	19	3
Palayankodan	18.	17	1.7	19.8	18.6	5.62	21.2	20	16.9	23	20	2
Rasakadali	17	17	0.9	20.5	20.1	3.13	20.6	20	3.59	22.	21	84**

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

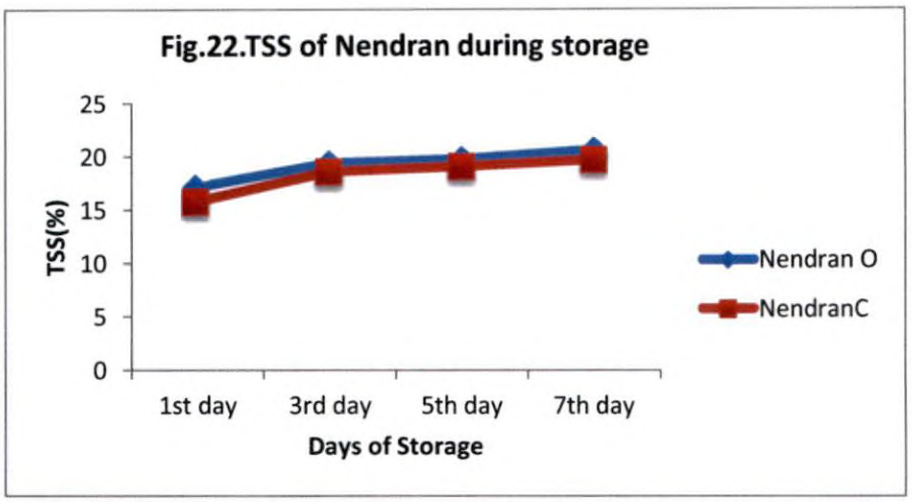
Change in Acidity levels of selected banana varieties during the 1st,3rd,5th and 7th days of storage

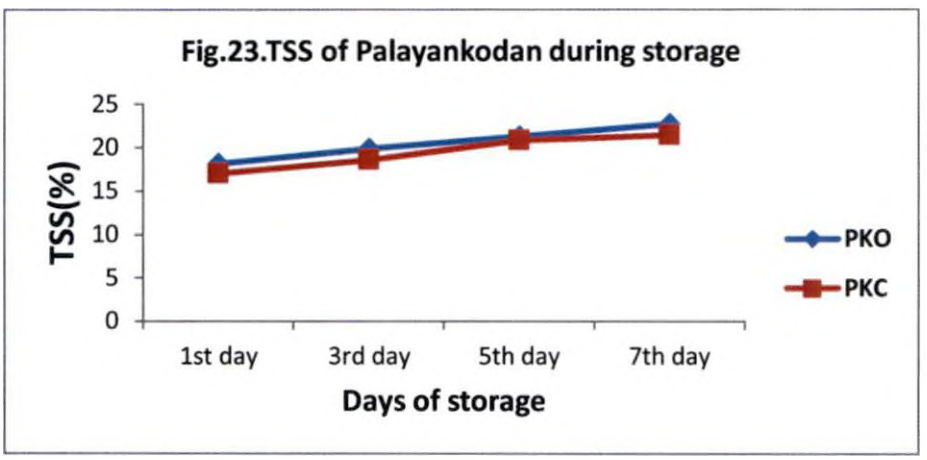


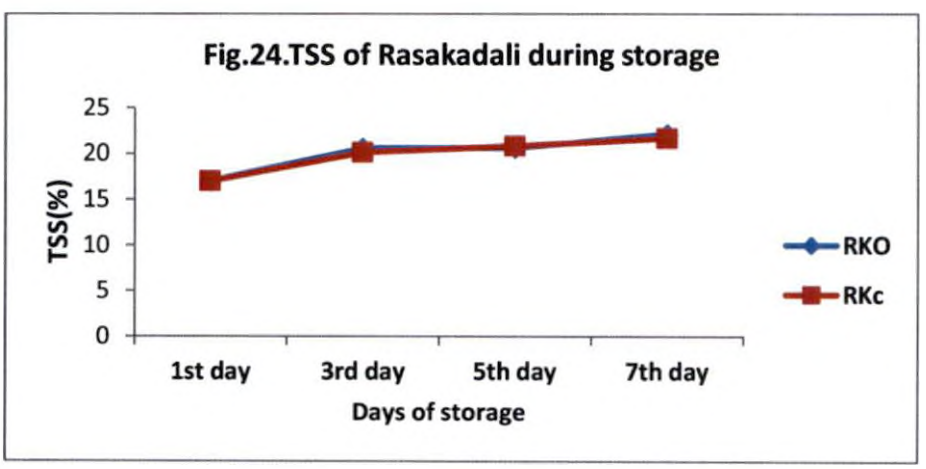




Change TSS levels of selected banana varieties during the 1st,3rd,5th and 7th days of storage







STAGES OF STORAGE OF ORGANICALLY CULTIVATED NENDRAN

FIRST DAY

THIRD DAY

FIFTH DAY

SEVENTH DAY

STAGES OF STORAGE OF CONVENTIONALLY CULTIVATED NENDRAN

FIRST DAY

THIRD DAY

FIFTH DAY

SEVENTH DAY

STAGES OF STORAGE OF ORGANICALLY CULTIVATED PALAYANKODAN

FIRST DAY

THIRD DAY

FIFTH DAY

SEVENTH DAY

STAGES OF STORAGE OF CONVENTIONALLY CULTIVATED PALAYANKODAN

FIRST DAY

THIRD DAY

FIFTH DAY

SEVENTH DAY

STAGES OF STORAGE OF ORGANICALLY CULTIVATED RASAKADALI

FIRST DAY

THIRD DAY

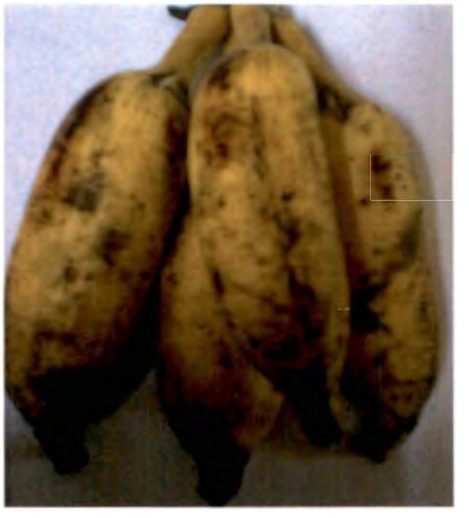
FIFTH DAY

SEVENTH DAY

STAGES OF STORAGE OF CONVENTONALLY CULTIVATED RASKADALI

FIRST DAY

THIRD DAY



FIFTH DAY

SEVENTH DAY

The rate of change in TSS, moisture and acidity, were not different among treatments ,as depicted in the graphs.

4.4. Chemical/nutrient composition

The concept of nutrient density or nutrient composition is built around the amount of key nutrients contained in 100g of a given food (Hansen, 1991). Nutrients analysed under the experiment were moisture content, acidity, total soluble solids, vitamin C ,total minerals and minerals like calcium, iron, potassium and sodium. The results are presented in the following tables.

4.4.1 .Moisture content of banana varieties

High moisture content of bananas is a matter of concern , making it more susceptible to post harvest losses. Therefore ,it is an essential parameter to be assessed. Higher level of moisture was found in organic nendran, palayankodan and rasakadali. Statistical analysis revealed that the difference in moisture content of palayankodan and rasakadali varieties were significantly different at 1percent level of significance .

Table: 19. Moisture content of the selected banana varieties

Banana Varieties	Moisture(%)		
	T1	T2	TSE
Nendran	68.08	62.41	2.62
Palayankodan	80.4	77.8	13.2**
Rasakadali	80.7	75.1	21.7**

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.4.2 .Acidity of selected banana varieties

Acidity of banana is primarily used to estimate consumption quality. It is also considered as the indicator of fruit maturity or ripeness. The acid content was on par in nendran variety among the treatments ,but higher in conventionally cultivated palayankodan and rasakadali varieties .But the

difference was observed to be significant only in rasakadali variety at 5 percent level of significance

Table: 20. Acidity of selected banana varieties

Banana Varieties	Acidity(%)		
	T1	T2	TSE
Nendran	1.06	1.06	0.00
Palayankodan	1.35	1.46	0.80
Rasakadali	1.13	1.27	3.02*

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.4.3. Vitamin C content of banana varieties

Vitamin C, which includes ascorbic acid and de hydro ascorbic acid, is one of the most important of the nutritional factors in horticultural crops that has many significant biological activities in human beings.

The content of Vitamin C in fruits and vegetables is affected by various factors such as genotype difference, pre harvest climatic condition and cultural practices, maturity level, harvesting methods and post harvest processing (Lee and Kader, 2000).

Vitamin C level was high in organically cultivated banana varieties and nendran and rasakadali varieties showed significant difference in vitamin C values among the treatments at 1 percent level

Table:21. Vitamin C content of selected banana varieties

Banana Varieties	Vitamin C(mg)		
	T1	T2	TSE
Nendran	6.4	4.8	16.9**
Palayankodan	3.33	3.23	00.62
Rasakadali	6.46	4.86	16.97**

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.4.4. TSS level of selected banana varieties

Sugar content of fruit is measured as Total Soluble Solids or Soluble Sugar Content. It is influenced by factors such as irrigation, the nutritional status of plant, weather condition and the position of fruit on the tree. It is partially influenced by fruit maturity. Data on total soluble solids does not help in deciding when to harvest ,but it provides an indicator of when the fruit has an appropriate level of sweetness.

Table: 22. Total Soluble Solids content of selected banana varieties

Banana Varieties	Total Soluble Solids (%)		
	T1	T2	TSE
Nendran	17.16	15.8	5.65**
Palayankodan	18.13	17	1.70
Rasakadali	17.1	17	0.90

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

Organically treated nendran and palayankodan varieties were higher in total soluble solids, TSS values of rasakadali variety were seen to be on par. Difference in TSS values of nendran variety was found to be significant at 1 percent level of significance.

4.4.5. Total mineral content of selected banana varieties

Total mineral content or ash content refers to the inorganic residue remaining after either ignition or complete oxidation of organic matter in food stuffs. It represents the total mineral content in that food. This analysis is an essential part of proximate analysis for nutrient evaluation (Marshall, 2000).

Organically cultivated nendran, palayankodan, rasakadali showed higher values of total mineral content and these differences were also observed to be significant at 1 percent level.

Table: 23 .Total minerals content of selected banana varieties

Banana Varieties	Total minerals (mg)		
	T1	T2	TSE
Nendran	0.833	0.59	6.99**
Palayankodan	0.72	0.51	7.59**
Rasakadali	0.74	0.59	5.74**

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.4.6.Potassium content of selected banana varieties

Among fruits, bananas are valued more for their potassium content, because of this mineral's role in maintaining the body's blood pressure. Potassium content of organically cultivated samples of nendran, palayankodan and rasakadali were higher in comparison to their conventional counterparts ,but the difference was statistically significant only in rasakadali(at 1 percent level of significance).

Table: 24. Potassium content of selected banana varieties

Banana Varieties	Potassium(mg)		
	T1	T2	TSE
Nendran	86.5	84.9	1.75
Palayankodan	80.76	79.76	2.00
Rasakadali	79.4	78.4	4.06**

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.4.7. Sodium content of selected banana varieties

Fruits and vegetables low in sodium are generally valued from the health point of view. An assessment of sodium profile would thus be helpful. Organic nendran and palayankodan revealed significantly higher values of sodium content at 1 percent level of significance while the values of rasakadali varieties were on par.

Table: 25. Sodium content of selected banana varieties

Banana Varieties	Sodium(mg)		
	T1	T2	TSE
Nendran	32.46	30.7	5.416**
Palayankodan	28.68	27.55	2.94*
Rasakadali	27.91	27.02	1.15

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.4.8. Calcium content of selected banana varieties

It is undisputable that, natural food sources of calcium are anytime healthier than synthetic supplements. With the increasing number of population suffering from bone defects, the awareness of calcium levels is felt needed.

The calcium contained in all the organic samples of nendran, rasakadali (at 1 percent level) and palayankodan (at 5 percent level) were higher than the conventionally cultivated respective counterparts, and the difference in values were statistically significant too.

Table: 26. Calcium content of selected banana varieties

Banana Varieties	Calcium (mg)		
	T1	T2	TSE
Nendran	16.03	13.89	11.71**
Palayankodan	13.33	12.50	2.41*
Rasakadali	12.62	11.99	8.55**

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.4.9.Iron content of selected banana varieties

Iron has an important place in the health of a human beings, mainly owing to its role in haemoglobin formation. Its availability in foodstuffs is of concern to plan protective diets. Though all organic varieties revealed higher values, the difference in values in comparison to conventional varieties were significantly different in nendran and rasakadali at 1 percent level.

Table: 27. Iron content of selected banana varieties

Banana Varieties	Iron (mg)		
	T1	T2	TSE
Nendran	0.33	0.296	3.16**
Palayankodan	0.28	0.27	0.45
Rasakadali	0.28	0.27	2.27*

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.5. Anti nutrient profile

Anti nutrients analysed under this experiment were phenol and tannin.

4.5.1. Phenol content of selected banana varieties

Though phenol levels decrease with ripening, their role as phyto chemicals, is gaining ground in the field of medicine. The phenol content of palayankodan and rasakadali were observed to be on par. However the phenol content was higher in conventionally cultivated nendran variety and the difference was observed to be significant at 5 percent level.

Table:28. Phenol content of selected banana varieties

Banana Varieties	Phenol (mg)		
	T1	T2	TSE
Nendran	3.24	3.4	4.00*
Palayankodan	4.6	4.6	1.00
Rasakadali	4.8	4.81	0.99

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.5.2. Tannin content of selected banana varieties

Tannins are responsible for the astringent taste in bananas. Hence, the knowledge of the effect of cultural practices on their presence would be worthwhile. Tannin content was higher in organic nendran, palayankodan and

rasakadali. However only rasakadali variety showed significant difference among treatments at 5 percent level.

Table: 29. Tannin content of selected banana varieties

Banana Varieties	Tannin (mg)		
	T1	T2	TSE
Nendran	4.3	4.2	0.39
Palayankodan	4.3	3.8	1.98
Rasakadali	3.9	3.3	3.28*

(t=2.776, at 5 % significance and t=4.604, at 1% significance)

4.6. Pesticide residue

"Pesticide" means any substance intended for preventing, destroying, attracting, repelling, or controlling any pest including unwanted species of plants or animals during the production, storage, transport, distribution and processing of food. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant, fruit thinning agent, or sprouting inhibitor and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport. The results of the Pesticide analysis report is as follows-

Each banana samples were subjected to pesticide residue analysis. The pesticides tested for were organochlorines, organophosphorous and synthetic pyrethroids. The results revealed that there was no pesticide residue in banana varieties

The qualitative comparison on the whole, depicts a better nutrient and sensory profile of organic varieties. The physical characteristics, shelf life and safety aspects were found to be on par among the treatments.

Discussion

5. Discussion

Banana is the common name for herbaceous plants of the genus Musa and the fruits they produce. It is one of the oldest of cultivated plants. It is the most important fruit consumed worldwide. Its year round availability affordability, varietal range, taste, nutritive value and medicinal value, makes it the favourite fruit among all classes of people. India is the second largest producer of fruits in the world. There has been significant increase in the export of fresh fruits during the past few years. Banana is the most important of the fruit crops in India ,having great socio economic significance. It also has good export potential. It is the second most important crop in India next to mango. It contributed to 31% of the total food production(NHB,.2009).

During the recent decades, consumers have started to look for safer and better controlled foods, produced in more environmentally friendly, authentic and local systems. Organically produced foods are widely believed to satisfy the above needs. In the context of organic revolution, a comparison of qualities of the organic and conventionally cultivated popular fruit – banana was felt apt.

This chapter encompasses a critical appraisal of the salient findings of the study " Quality evaluation of organic ripe banana " and the discussion is presented under the following headings.

5.1 Physical characteristics

5.2 Sensory qualities

5.3 Shelf life

5.4 Nutrient Composition

5.5 Anti nutrient profile

5.6 Pesticide residue

5.1 Physical characteristics

In the present study physical characteristics studied for bananas were appearance, total number of hands/ bunch, number of fruits/ hand, mean fruit weight, peel thickness, pulp to peel ratio and peeling condition.

5.1.1 Appearance

Uniform scores were obtained for this attribute. This was because they were selected in the sixth stage of the standardised colour chart (Pratt and Company, 2012). Hence there was no obvious difference in physical appearance noted among the treatments. Tapre and Jain (2012) have stated that, in the uniform stage of colour chart, fruits are in the same maturity conditions, where in they will only reveal uniform physical characteristics.

5.1.2 Total number of hands/ bunch

Here the effect of organic treatment is seen to be on par with conventional treatments, which indicates that it is in no way inferior to conventional approaches. . A study conducted by Blake (1971) on physical properties of banana and reported that the total number of hands/bunch ranged from8 – 12 in musa varieties. Evidences proved that integrated approach of cultivation gives better results for better values of hands per bunch.How ever, Barket et al., (2011) observed in their studies on effects of various kinds of cultivation practices that , banana plant fertilized by organic fertilizers using 1.5 strength of chemical dose with EM produced the highest hands per bunch. This was also in accordance with the findings of Naby (2000) that, the best hands per bunch in banana plants cv Magrati, were obtained when treated with banana compost with 25% chemical fertilizers and sulphur in the early maturity stage. Balerao et al., (2009) too concluded the same from his studies that use of organic manure was beneficial for getting higher hands/ bunch. Ndukewe *et al.*, (2011) had observed that, cultivars that had high biomass yield might produce many fruits which resulted in heavier bunches. The higher utilisation of organic inputs could be the reason for this outcome.

5.1.3 Total number of fruits/hand

The results here indicate that ,organic and conventional treatments affect such physical parameters in a similar way. But, organic nendran was observed to have more fruits per hand , than conventionally treated ones and this difference was statistically significant at 1% level. . Alfredo et al.,(2012) reported that bio fertilizer application in Grand naine plantain resulted in more number of fruits per bunch. Adriano et al., (2012) also reported that the application of compost in the physical properties of fruit. The compost made with co – products generated in the same field (pseudostems, banana rachis, leaves) mixed in 1:1 ratio with palm fibre ,when added in the field resulted in more number of fruits per bunch.

Baiyeri (2008) had suggested that number of fruits per hand could have increased due to the higher potential of nutrients in manure which increased dry matter accumulation to the economic part of the plant.

5.1.4 Mean fruit weight

In this study the effect of both cultivation practices were seen to be the same on fruit weight. Organic and mineral fertilizer have more or less equal role in affecting fruit quality. The mean fruit weight of organic palayankodan (131.95) and and organic rasakadali (124.56) were observed to be higher than the conventionally cultivated fruits and the difference in rasakadali was observed to be statistically significant at 5% level. Branson (1972) reported that manure applied soil increased the yield by increasing the fruit weight. Papanikoleau (1988) also reported that the combined effect of manure and foliar also increased the mean fruit weight. Baiyeri (2002) has pointed out that inorganic fertilizer promotes vegetative growth mostly to the disadvantage of the harvested product.

5.1.5 Peel thickness

Peel thickness is a factor affected by cultivation practices, though here ,effect of organic and inorganic inputs did not show much difference in their effects. Kader (2012) concluded from his studies that use of chemicals may not directly affect fruit composition, but may indirectly affect by delayed or accelerated fruit maturity. Peel thickness values were high on par in rasakadali and palayankodan varieties, but organic nendran revealed higher values that were statistically different at one percent level. Dadzie (1994) reported from his study that the peel thickness of banana varieties ranged from 0.3 – 1.0. Akhter et al (2012) also reported that the peel thickness of rasakadali variety ranged from 0.1 – 0.38. Obreza (1995) reported that applying manure (an organic fertilizer) at the rate of 20kg/ hectare/ year resulted in thick peeled fruits. Huang et al (1996) reported that applying urea in the soil helped to increase peel thickness of fruits.

5.1.6 Pulp to peel ratio

The pulp to peel ratio was higher in inorganic varieties of nendran, palayankodan and rasakadali. The difference in these values among treatments were significant in nendran and palayankodan at 1 percent level of significance. Chemical inputs were seen to affect pulp to peel ratio significantly. High potassium fertilizers favours the action of enzymes – starch synthase which promotes starch storage. This could be the reason for higher pulp to peel ratio in conventionally cultivated fruits. Saratha et al., 2001 reported pulp to peel ratio of conventional variety as 1.8. Stover and Simmonds(1987) reported that during ripening sugar concentration increases more rapidly in the pulp than in the peel, prompting a differential change in osmotic pressure. The peel losses water both by transpiration to the atmosphere and by osmosis to the pulp, leading to the increase in the fresh weight of the pulp as the fruit ripens. This results in an increase in the pulp to peel ratio during ripening and it also reported that it ranged between 1.5 – 6 in different varieties.

5.2 Sensory Qualities

"Quality" is a composite of product characteristics that impart value to the buyer or consumer. Consumer considers good quality fruits and vegetables as those that look good, are firm and offer good flavour and nutritive value. Although consumers buy on the basis of appearance and textural quality, their satisfaction and repeat purchases are dependant upon good eating quality. Producers and handlers are first concerned with appearance and textural quality along with long post harvest life (Kader, 2012).

Hence. sensory evaluation of the three varieties namely nendran, palayankodan and rasakadali , which belonged to two treatments – conventionally cultivated and organically cultivated was conducted.. Ten members formed the expert panel. Their assessment of sensory parameters namely appearance, colour, flavour , texture and discussed here with

5.2.1 Appearance

All organic samples irrespective of variety scored significantly higher values than their inorganic counterparts. Rasakadali showed significant difference in scores at 1 percent level of significance. Organic fertilizers are seen to increase TSS of fruits which could be affecting the firmness and appearance of fruits (Aguyoh *et al.*, 2004).

5.2.2 Colour

Analysis of sensory evaluation report of the judges revealed higher scores for organically cultivated nendran and rasakadali varieties. However in the case of palayankodan, scores were higher for inorganic varieties, the difference in values were significant at 1 percent level. Various studies have revealed the influence of fertilizers on the colour of fruits. Sulphur applied in the

form of different fertilizers with ammonium, sodium, potassium and cadmium, significantly increased red colour of tomatoes (Zekhna *et al.*, 2009). Increased use of nitrogen fertilizers led to quality of fruits in terms of colour and keeping quality (Murthy *et al.*, 2011).

5.2.3 Flavour

Scores of flavour among treatments were observed to be on par.. Human perception of flavour is exceedingly complex. During ripening components that cause flavour development are accumulated in fruits. Early harvesting leads to less flavour . higher NPK treated tomatoes scored lower in sensory analysis due to increased volatiles (Wright and Marris, 1985) . Mite control measures affected the flavour of strawberries as compared to those which did not receive any treatment (Podoski *et al.*, 1997). Kader (2008) has observed that the influence of cultural practices on precursors of esters that determine the ultimate level of volatile esters in fresh fruits which in turn affect flavour.

5.2.4 Texture

Organic nendran and palayankodan showed higher scores than the conventionally cultivated ones. The difference in scores was significant at 1 per cent level of significance. Fruit texture is influenced by environmental, cultural, physiological and genetic factors (Sams, 1999). Decrease in flesh texture has been reported due to excessive fertilization in many fruit crops (Blampced *et al.*, 1998). High fertilizer application level impaired the early solubilisation of polyuronides resulting in the accumulation of low molecular weight water soluble polyuronides, which ultimately causes inferior texture of fruits (Jia *et al.*, 2006).

5.2.5 Taste

Organically cultivated banana varieties had significantly higher value for taste as compared to conventionally cultivated banana varieties. Vasquez et al., (2012) concluded from their study that bio fertilization did not have any

negative influence in the sensory qualities of banana fruit grand naine it improved the sweetness and ascorbic acid content. Smith *et al.,* (2002) after reviewing several studies and reported that organic fruit and vegetables are claimed to be better tasting and fresher. There have been many comparative studies of organoleptic quality of organic and conventional fruit and vegetables. The result consistently shows enhanced organoleptic quality in organic produce. ECROPOLIS report (2010) points out that popularity of organic fruits and vegetables was due to their better taste. Poelman (2008) reported that Organic foods had greater nutritional and sensory qualities than conventional foods. Michael (2010) conducted a study in lettuce to study the effect of organic fertilizers on growth, yield quality and sensory evaluation of red lettuce and reported that organic fertilizers such as compost, cattle manure and chicken manure were applied in the field resulted lettuce with better taste and appearance.

Analysis of scores of taste of panel members revealed higher scores for all organic varieties. The difference in scores among treatments were significant at 1 per cent level.

Wang *et al.,* (2002) reported that tomato fruits were sweeter when fertilized with chick manure and less sweeter in chemically fertilized plots. While, increased potassium was proved to increase sweetness of peaches (Javana *et al.*, 2002). The increase in sweetness could be due to the participation of potassium in bio synthesis and transfer of sugars as concluded by Karam *et al.*, (2003).

5.2.6 Peeling condition

Peeling condition showed uniform scores, as all the varieties and treatments were selected from the same maturity stages. Cohesiveness of the peel is essentially affected by the stage of maturity, which in turn affects the peeling condition. Thompson (1996) has stated that , with ripening water moves from peel to pulp , which makes the banana more peelable.

5.3 Shelf life

Change in sensory attributes with storage

Colour, appearance and firmness of fruits were seen to improve with foliar application of potassium (Wajak, 2005)Firmness was reduced by nitrogen application, as confirmed by Miner et al., (1999). Sadaf et al., (2012) reported that chemical constituents in higher doses negatively affected firmness of tomato fruits. Vazquez et al., (2012) in their study on storage of banana fruits , however observed that aroma did not show much differences with fertilizers. Caussiol (2001) too did not observe significant difference between bananas of conventional and organic treatments on storage. It can be concluded that organic and conventional production system do not create major sensory differences during storage in foods.

Changes in moisture, TSS, acidity with storage

Moisture content generally increased with storage. John (1995) has reported that the increase in the moisture content was due to movement of moisture from peel in to the pulp. Percentage of moisture content increased rapidly during the first days of storage due to respiratory breakdown, carbohydrate breakdown, osmotic transfer from peel to pulp. Rise in moisture content was almost same in both varieties on alternate days of analysis. Idah and Abdullah (2000) explained that it is the physiological activities in fruit rather than cultivation practices which affect the moisture content.

Similar trends in TSS change was observed by Ibom and Asiegbu (2007). Increasing TSS reflects hydrolysis of starch in to sugar as banana ripens (Stover and Simmonds, 1987). Probably starch content of conventionally cultivated bananas were higher, which showed the initial increase.

The change in acidity showed uniform trends in organic and inorganic varieties. This change is more affected by post harvest physiological processes especially respiration, which increases at first and then decrease.

5.4 Nutrient/ Chemical Composition

Nutrients analysed under the experiments were moisture content, Acidity, vitamin C, total soluble solids, total minerals and minerals like potassium, sodium, calcium and iron.

5.4.1 Moisture

Moisture content was seen to be higher in organically cultivated bananas and they were seen to be significantly affected by cultivation practices. A study conducted by Syamala et al., (2011) reported that moisture content of banana varieties such as nendran, palayankodan, rasakadali are 69.9, 82, 80, and the moisture content was highest in palayankodan variety. Gopalan *et al.,* (2010) reported that the moisture content was 70.1 in his sample of banana. Vincente (2012) had pointed out that cultivation conditions influence structural differentiation which will have a marked effect on moisture content. Idah and Abdullah (2000) had observed that physiological activities like respiration led to increase in moisture.

5.4.2 Acidity

The acidity content of inorganic rasakadali was higher, while that of nendran in both treatments were seen to be on par. This could be because most of the chemical fertilizers have high acid content (Rupiasih and Vidyasagar, 2009).

5.4.3 Vitamin C

Vitamin C content was higher for organically cultivated samples. Many studies suggest that oxidative stress induced by organic inputs, diverts carbon skeleton to antioxidant and phyto chemical synthesis rather than for the synthesis of proteins (Carlson *et al.,* 2004 and Olsson *et al.*, 2006).

5.4.4 Total Soluble Solids

Total Soluble Solids is higher in organically cultivated banana varieties and was found to be statistically significant. Total Soluble Solids increased on ripening. This increased Total Soluble Solids is due to the increased movement of water into the flesh and the degradation of starch to soluble sugar within the cell (Palmer, 1984). Thus we can assume that organic treatment could facilitate to more movement of water into the cell. Huang et al., (1996) reported that fruits of manured plants increased the total soluble solids which may be attributed to the different types of manure and different rates of application and decomposition.

5.4.5 Total mineral content

Mineral content was higher in organically cultivated nendran, palayankodan and rasakadali samples. Ibrahim and Fadni (2013) has indicated that organic manure decreased soil pH values and increase the nutrient uptake by plants. It has been reported by Foster *et al.,* (2010) mineral content of soil seem to have a major influence on the mineral content of bananas. Vazqnez *et al.,* (2012) observed that application of organic fertilizer provides tremendous benefit to the plants by providing better availability of nutrients.

5.4.6 Potassium content

Organically cultivated nendran, palayankodan and rasakadali were high in potassium content than the conventionally cultivated varieties and the difference was statistically significant in the case of rasakadali (4.06**). This fact was also stated by Hang et al., (2008) who found that organic fertilizer application increased phosphorous and potassium in soil and makes it more available.

5.4.7 Sodium content

Sodium content was higher in organic samples of banana than inorganic samples. Akoe *et al.,* observed that general intake of all nutrients were improved with organic manure application – probably due to slow and effective release of nutrients in comparison to chemical fertilizers.

5.4.8 Calcium content

The higher level of calcium in organic samples agrees to the fact that organic inputs supply nutrients more effectively to the plants. Moreover higher calcium and vitamin C in organic food suggest a correlation of calcium and vitamin C (Bargash, 1976).

5.4.9 Iron content

Iron content of organic samples of nendran, palayankodan and rasakadali were superior to their respective inorganic counterparts. Thus, in no way organic treatments lag behind ,chemical fertilizer in improving nutrient quality of plant produce.

Iron content of banana varieties

5.5 Anti nutrient profile

The anti nutritional factors may be defined as those substances generated in natural food stuffs by the normal metabolism of species by different mechanisms which mostly exerts effects contrary to optimum nutrition (Checke, 1985). Tannins are phenolic compounds with a molecular weight greater than 500 and has the ability to precipitate proteins from aqueous solution (Kumar, 1990).

5.5.1 Phenol content

Phenol content was found to be on par among the treatments for palayankodan and rasakadali. However, inorganic nendran showed higher values, and this difference was found to be significant at 1% level. In a similar study

organic tomatoes showed lower levels of phenol. The slight differences may be due to the difference in management practices , variety and soil preparation etc.

5.5.2 Tannin content

Tannin content was higher in organically cultivated banana varieties. (Kondakova *et al (* 2009) has pointed out that, chemical constituents of foods are not only affected by cultivation practices but also variety, species, region and weather.

5.6 Pesticide residue

Pesticide residue refers to the pesticides that may remain on or in food after they are applied to food crops (Crinnion, 2009). The results revealed that pesticide content in each banana sample were even below the minimum limit of quantification. Paranthaman *et al.*, (2012) conducted a study on the determination of pesticide residues in banana (nendran and rasakadali) and reported that the residue level was not exceeded the FAO/WHO codex alimentarius standards for minimum residue limit values. The absence of residues of pesticides of banana during harvest could be due to :-

Long time gap between pesticide application and harvest (nearly 4 months). Generally pesticide application is done during planting and three months after planting with systemic pesticides like furadan cartap hydrochloride or swabbing with chlorpyrifos. So, a huge gap between application and harvest during which the pesticide got metabolised and lost.

The absorption mechanism of banana is such that the compounds absorbed from roots will be translocated to leaves via sheath. So pesticides absorbed are likely to be present in leaves and sheath and not in the inner core. The bunch is as an extension of inner core which is free of pesticides.

Fig. 25. Total Soluble Solids of Selected Banana Varieties

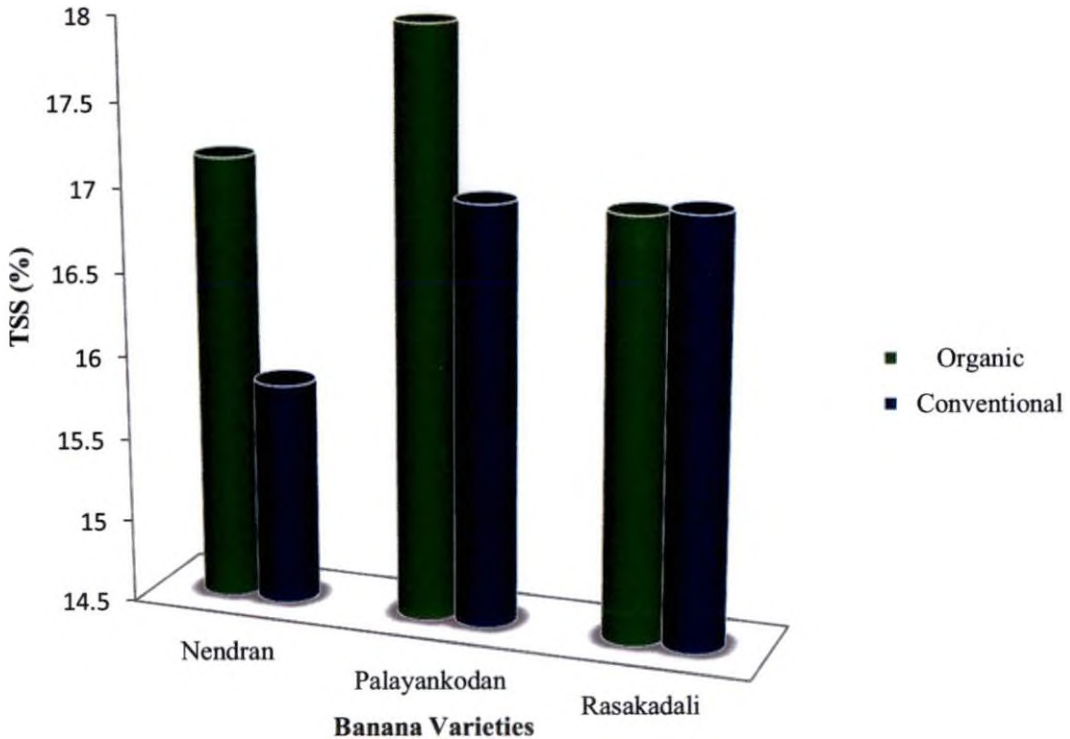


Fig. 26 Total minerals content of Selected Banana Varieties

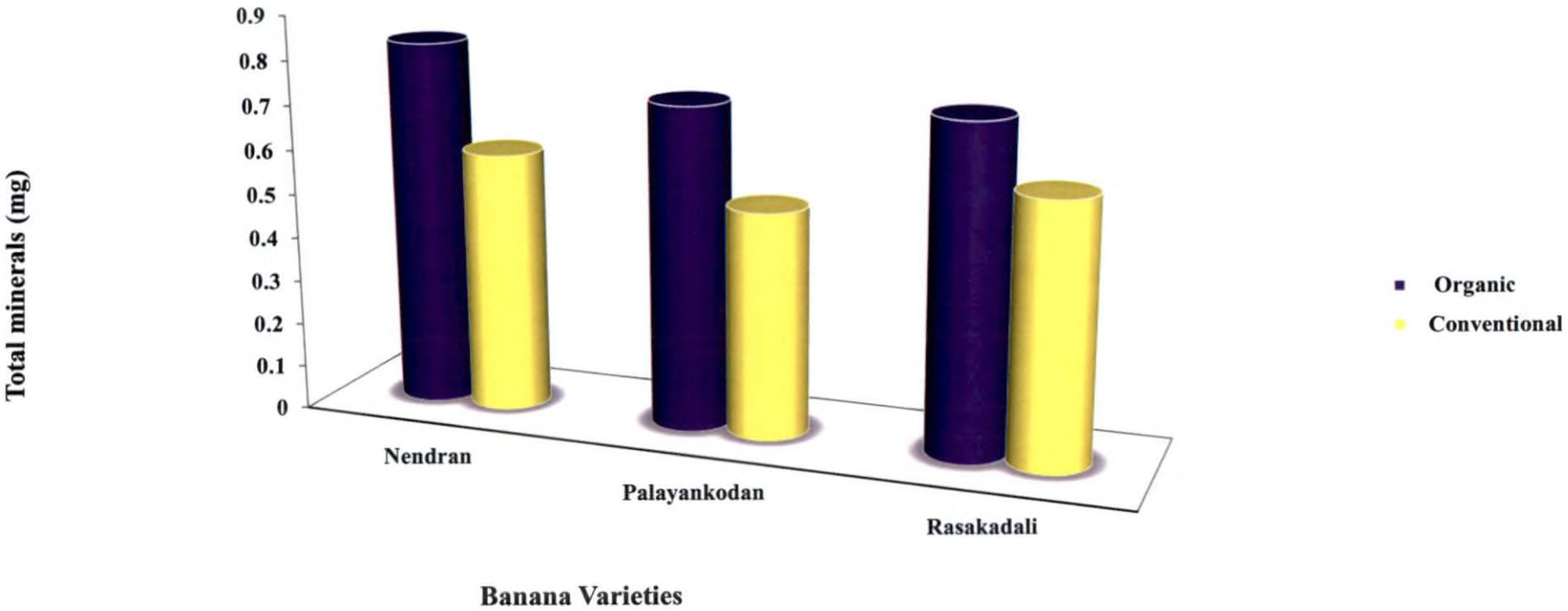


Fig. 27. Vitamin C content of selected Banana Varieties

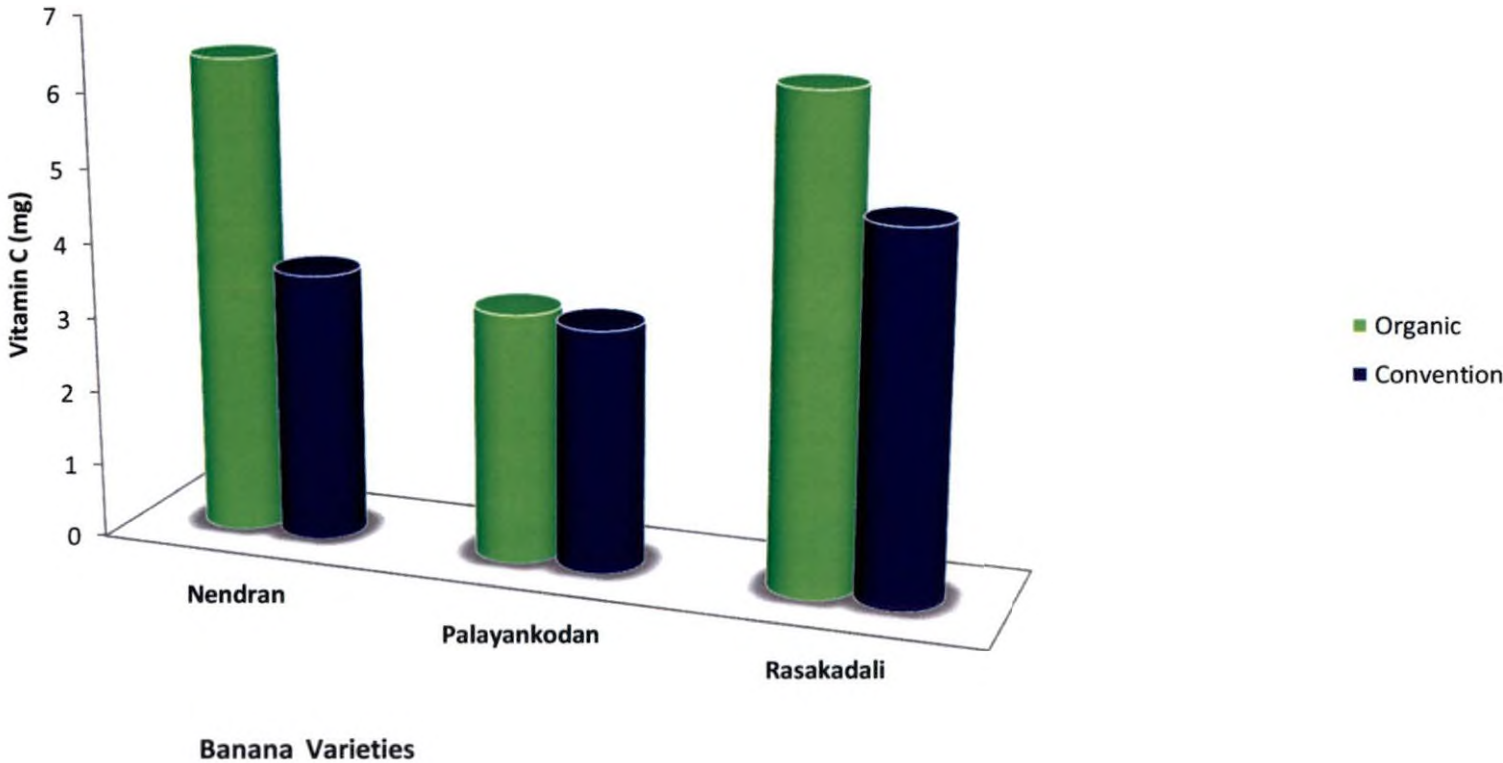


Fig. 28 Calcium Content of Selected Banana Varieties

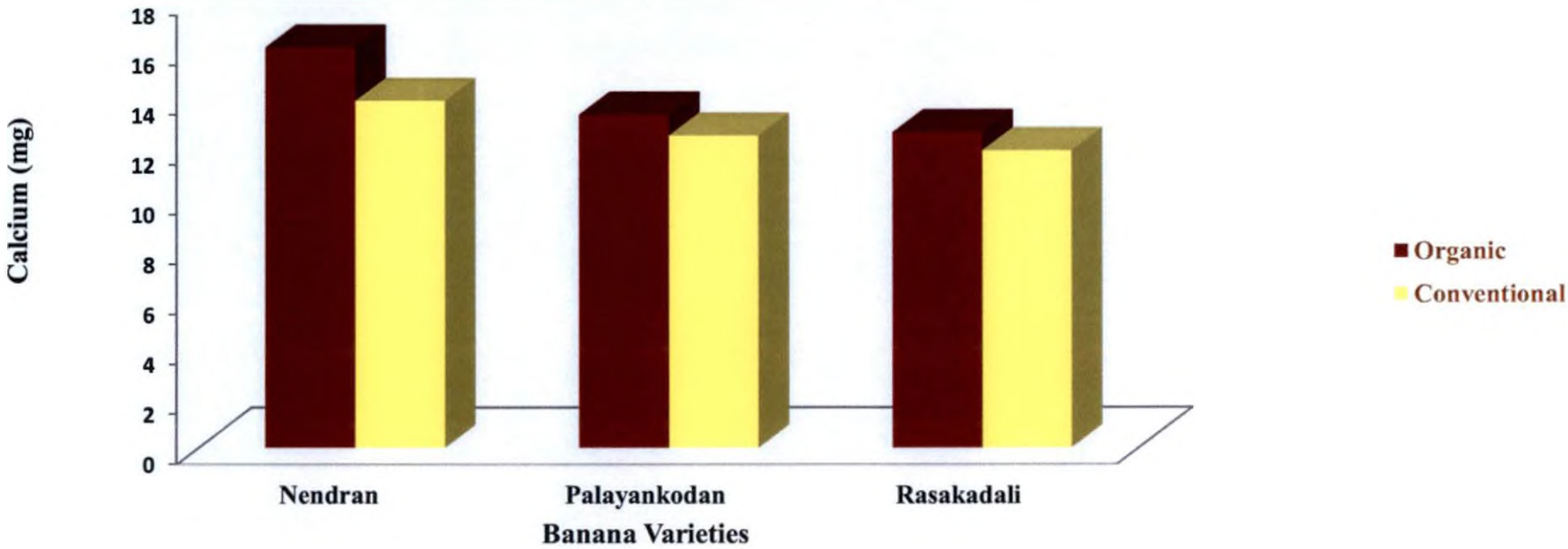
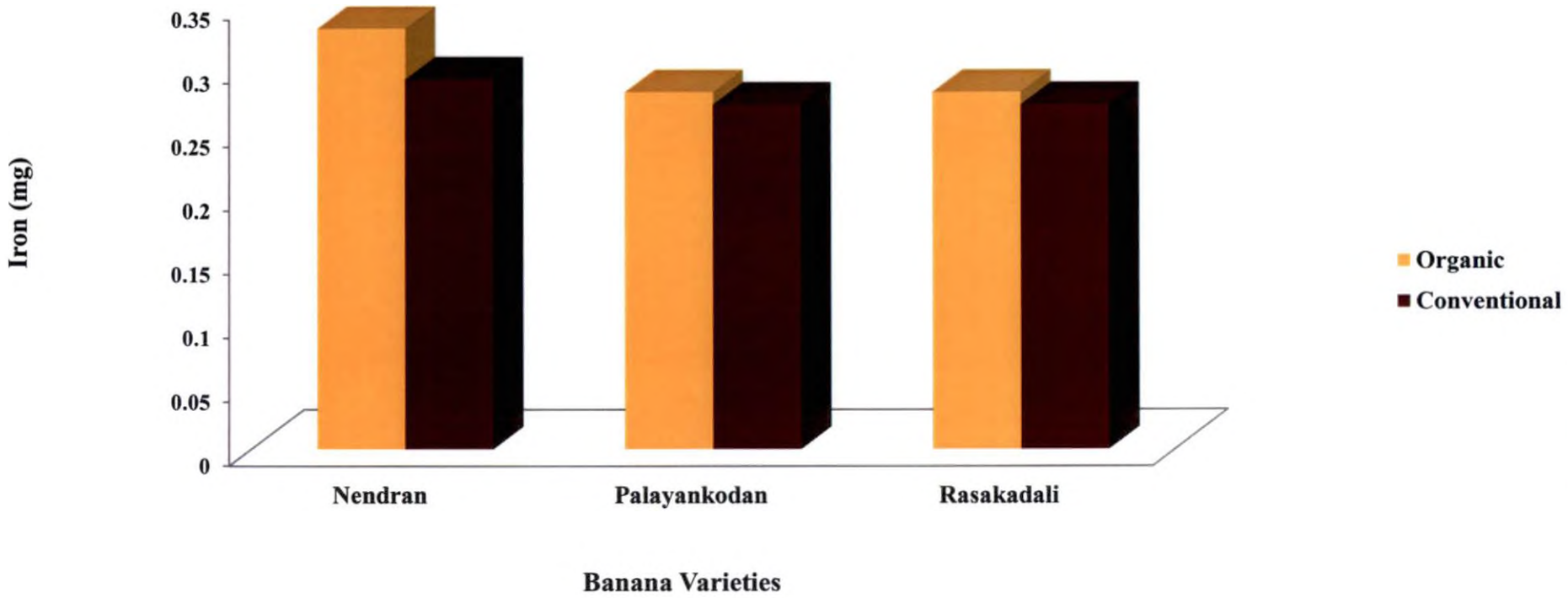


Fig. 29 Iron Content of Selected Banana Varieties



Summary

Summary

The study entitled "Quality evaluation of organic ripe banana" was conducted to compare the quality parameters of organically and conventionally cultivated bananas. The varieties selected were 'nendran', 'palayankodan' and 'rasakadali'. The main quality parameters assessed were physical characteristics, sensory qualities, shelf life, nutrient composition, anti nutrient profile and pesticide residue.

Fruits of uniform appearance in each variety were selected using the standardised colour chart of S H Pratt and company. Total number of hands/ bunch was on par among the treatments. Organic cultivation practices were found to be significantly affecting the number of fruits per hand, as evidenced in the case of organically cultivated nendran. Organically cultivated palayankodan showed significantly higher fruit weight than their counter parts. When peel thickness was higher for organic varieties, pulp to peel ratio was higher for conventionally cultivated varieties.

With respect to sensory qualities, appearance, colour, flavour, texture and taste was found to be superior in organically cultivated fruits than the conventionally cultivated ones. Peeling condition gave uniform scores owing to the identical stage of maturity selected for each treatment.

Shelf life of the fruits were assessed with respect to change in sensory attributes namely appearance, colour, flavour, texture and taste in periodic intervals. Change in moisture TSS and acidity were also assessed on periodic intervals – 1st day, 3rd day, 5th day and 7th day. The changes in sensory attributes were observed to take an uniform pattern in both treatments. There was no drastic difference in the changes noted in the fruits with respect to moisture, TSS and acidity.

The chemical and nutritional profile of the fruits were assessed with respect to moisture, acidity, vitamin C, TSS, total minerals, potassium, sodium, calcium and iron content. Moisture, vitamin C, TSS, total minerals, potassium, sodium, calcium and iron were significantly higher in organically cultivated varieties. The anti nutrients analysed were phenol and tannin. The phenol content

was higher in conventionally cultivated fruits whereas tannin content was higher in organically cultivated varieties. Pesticide residue analysis did not reveal any positive results.

Organically cultivated banana varieties were on par with conventionally cultivated varieties with respect to physical characteristics. Organically cultivated banana varieties were seen to have more acceptability with respect to colour, flavour, texture and taste. Nutrient wise also they were superior with respect to vitamin C, minerals, potassium, sodium, calcium and iron. Shelf life results were also on par when the treatments were compared. On the whole, organically cultivated bananas are environment friendly and preferable from the safety point of view.

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QUALITY EVALUATION OF ORGANIC RIPE BANANA

By

Sreedevi. L

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Abstract of the

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Kerala Agricultural University, Thrissur

Department of Home Science

COLLEGE OF AGRICULTURE

THIRUVANANTHAPURAM – 695 522

KERALA, INDIA

2013

ABSTRACT

The project entitled "Quality evaluation of organic ripe banana" was carried out with the objective to study and compare the quality characteristics of the selected banana varieties cultivated by conventional and organic farming techniques.

Nendran, palayankodan and rasakadali were the selected varieties. Physical characteristics, sensory qualities of fruit, shelf life, nutrient/chemical composition, anti nutrients and pesticide residue were the parameters investigated in the present study.

With respect to physical characteristics- appearance and total number of hands/bunch were on par among the treatments. Number of fruits/ hand and peel thickness were significantly higher in organically cultivated nendran variety, whereas pulp to peel ratio was higher in conventionally cultivated nendran variety. Pulp to peel ratio was higher in conventionally cultivated palayankodan also and this difference was statistically significant. Only rasakadali revealed significantly higher fruit weight for organic produce compared to conventional produce.

As far as sensory qualities were concerned organic treatment depicted higher values. Especially significant values were obtained in the case of colour, appearance, texture and taste.

Storage studies revealed uniform trends in the increase and decrease in ratings, throughout the period of storage in both treatments with respect to sensory qualities and acidity.

Moisture content of organic produce was significantly higher. Inorganic rasakadali recorded significantly higher acidity. TSS, total minerals, calcium, iron, potassium and sodium were significantly higher in organically cultivated varieties. Inorganically cultivated nendran variety registered significantly higher values in phenol content whereas organic rasakadali was significantly higher in tannin content. However pesticide residue analysis showed nil results.

Hence it can be concluded that organic produce were higher in sensory qualities (appearance. colour, texture and taste) and nutritional qualities (moisture, TSS, Vitamin C and minerals), with respect to physical characteristics the values were on par compared to the conventional produce. Shelf life studies revealed similar trends in both organic and conventional produce.

APPENDIX – I

Score card for organoleptic qualities of organic Banana

Tested by:

Age:

Date:

PARTICULARS	CRITERIA	SCORE	A1	A2	B1	B2	C1	C2
Appearance	Excellent							
	Very Good							
	Good							
	Fair							
	Poor							
Colour	Excellent							
	Very Good							
	Good							
	Fair							
	Poor							
Flavour	Excellent							
	Very Good							
	Good							
	Fair							
	Poor							
Texture	Excellent							
	Very Good							
	Good							
	Fair							
	Poor							
Taste	Excellent							
	Very Good							
	Good							
	Fair							
	Poor							

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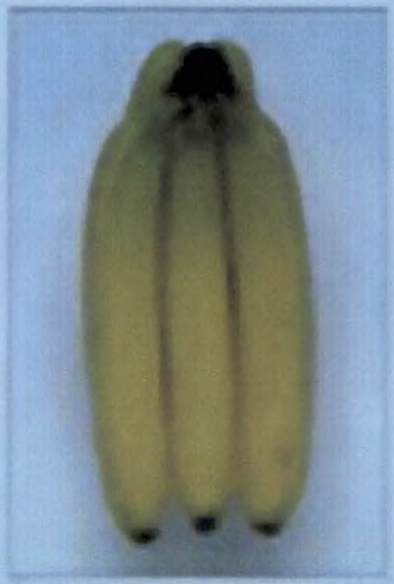
1. ALL GREEN

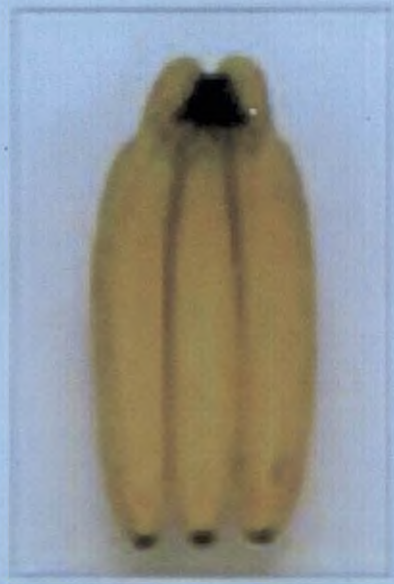
2. GREEN WITH A TRACE OF YELLOW

3. MORE GREEN THAN YELLOW

4. MORE YELLOW THAN GREEN



5. YELLOW WITH A TRACE OF GREEN



6. ALL YELLOW

7. ALL YELLOW WITH BROWN SPECKLES