PRESENTATION OF RIPE MANGO CHUNKS BY HURDLE TECHNOLOGY

By

REKHA RAVEENDRAN.R.S

THESIS
Submitted in partial fulfillment of the requirement
For the degree of
MASTER OF SCIENCE IN HOME SCIENCE
(Food Science & Nutrition)
Faculty of Agriculture
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF HOME SCIENCE
COLLEGE OF AGRICULTURE
VELLAYANI
THIRUVANANTHAPURAM

2009

DECLARATION

I hereby declare that this thesis entitled "preservation of ripe mango chunks by hurdle technology" 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, associate ship, fellowship or other similar title, of any other University or Society .

Vellayani

08.01.2010

Rekha Raveendran R.S.

CERTIFICATE

Certified that the thesis entitled "Preservation of ripe mango chunks by hurdle technology" is a record of research work done independently by Mrs. Rekha Raveendran R. S. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associate ship to her.

Dr. P.V. Nandini
Professor & Major Advisor
Dept. of Home Science
College of Agriculture
Vellayani

Vellayani
08 .12. 2009

APPROVED BY

Chairperson:

Dr. P.V. Nandini
Professor,
Department of Home Science
College of Agriculture
Vellayani
Thiruvananthapuram- 695 522

Members:

Dr. Mary Ukkuru. P.
Professor & Head
Department of Home Science
College of Agriculture
Vellayani
Thiruvananthapuram- 695 522

Dr. Philipose Joshua
Professor & Head (Retd)
Department of Processing Technology
College of Agriculture
Vellayani
Thiruvananthapuram- 695 522

Dr. Thomas George
Associate Professor
Department of Soil Science &
Agricultural Chemistry
College of Agriculture
Vellayani
Thiruvananthapuram- 695 522

External Examiner*:*

ACKNOWLEDGEMENT

I wish to place on record my heartfelt gratitude and indebtedness to ***Dr. P. V. Nandini****, Professor of Department of Home science and Chairperson of my Advisory Committee for her sincere guidance, constant encouragement, timely advice, pains taking effort and in-depth involvement in the preparation of this thesis.*

I express my sincere thanks to ***Dr. Mary Ukkuru****, Professor & Head, Department of Home Science for her skillful guidance, support, ever willing help and constructive criticisms in the preparation of the thesis.*

I am deeply obliged to my advisory committee members ***Dr.Philipose Joshua****, Professor & Head (Retd), Department of Processing Technology, College of Agriculture, Vellayani and* ***Dr. Thomas George****, Associate Professor, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani.*

I express my heartful gratitude to ***Dr. K.N. Anith****, Associate Professor, Department of Microbiology, College of Agriculture, Vellayani for the encouragement and sincere help extended to me during my research work.*

I express my deep concern and sincere thanks to Shri. ***Ajith Kumar, C.E****., Programmer, Department of Statistics, for his valuable advice and creative assistance during the period when statistical analysis was done.*

I wish to express my special thanks and love to my best friend Prem Pillai.

Let me place on record my heartfelt thanks to all my friends each who have contributed in some way or the other towards the completion of this work.

On a personal note I express my deep indebt ness and gratitude to my father, mother, Father in law, mother in law, brothers, sisters, grand mother for their moral support, constant prayers and sincere encouragement without which this task would not have been accomplished.

I express my heartfelt indebtedness to my husband Rajesh for his emotional support and continuous encouragement evinced during my study.

Above all, it would have been impossible for me to complete this research work successfully without the boundless blessings of the Almighty which were always there. I reverently bow my head before Him.

REKHA RAVEENDRAN. R .S.

LIST OF ABBREVIATIONS

C	Centigrade
G	gram
mg	milligram
µg	microgram
RH	Relative humidity
O_2	Oxygen
CO_2	Carbon dioxide
Hg	Mercury
PVC	Poly vinyl chloride
LDPE	Low density poly ethylene
AC	Ambient condition
RC	Refrigerated condition
Cfu	Colony forming unit
Cm	Centimeter
RTS	Ready to serve

B	Blanched
UB	Unblanched
T	Treatments
ml	millilitre
Kg	Kilogram
CD	Critical difference
KMS	Potassium metabisulphite
MA	Modified atmosphere
CA	Controlled atmosphere
ppm	parts per million
UV	Ultra violet

CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

1.INTRODUCTION

Mango (*Mangifera indica* L), popularly known as "King of Fruits" occupies a place in India as it is considered as the most delicious, exotic and nutritious fruit and has been cultivated for more than 4000 years. It is a native of Southern Asia, especially Burma and Eastern India. Mango is considered as "Fruit of excellence" and famous for its excellent flavour, attractive fragrance and plays an important role in balancing the diet of human beings by providing about 64-86 calories energy (Gandhi, 2005).

Mangoes are produced over 90 countries worldwide. Asia accounts for approximately 77 per cent of global mango production while America and Africa account for approximately 13 per cent and 9 per cent respectively (FAO, 2007). India is the largest producer and consumer of mangoes in the world and accounts for about 50 per cent of the world production of the fruits with an annul production of 12 million tonnes (Gandhi, 2005).

.

India exports about 49,000 metric tones of mangoes to 80 countries and the annual revenue earned from exporting mangoes and mango products reaches $85 million (http/newsbbc.co.uk). The total mango export from India during the year2007-08 was 54350.80 metric tones with the value of Rs.127.42 Crores (www.apeda.com).

Mango is cultivated in an area of 85,428 ha with a production of 3, 84,190 tonnes (FIB, 2006) in Kerala. Previously, there were vast areas of land under mango cultivation in Kerala. Vellari manga, Karpooram manga, Kottukonam varikka, Chandrakaran, Kalkanda manga and Kilichundan are some of the traditional mango

varieties of Kerala. The mango fruits form an important part of food preparations of Kerala and hence it finds place in all the homesteads. However due to the changes in socio-economic situation and land use pattern and the shrinking homesteads, the area under mango cultivation has been reduced.

Mango being a seasonal commodity creates glut during the season and becomes scarce during the off season usage. Due to mishandling inadequate storage or lack of post harvest technical know how mango producers and traders face about 20-30 per cent losses (Tahir et al., 2002). Losses of this perishable commodity are estimated up to 320.7 thousand tonnes annually with a value of Rs 3.0 billion in the country (Haq, 2002). Incompetent handling of mango fruits results in injury to the surface layer making them more susceptible to attack by spoilage organism with consequent reduction in consumer appeal in the market.

Post harvest loss can be considered as a social evil which eats up the grower's margin and pushes up the consumer's price. Percapita availability of fruits in India is 85g and that of vegetable is 75g which will still lower the recommended levels (Kapoor and Kaur, 2004).

Processing industry improves value addition of agriculture produce, generates mass employment, enhances income of farmers and rural poor and creates surplus for export growth.

The changing socio economic scenario in the country with hectic life styles and rise in disposable incomes, the ready to eat food market is growing at a rate of 35 per cent every year. Today, consumer demand foods that are more convenient to store and prepare good in quality and freshness, natural, nutritionally and medicinally sound. Strategies to meet these demands include modifications to

existing foods and the adoption of innovative and more sophisticated processing technologies.

There is always an intense need for some new and improved preservation technologies that effectively inactivate undesirable microorganisms in food, improve quality and meet the changing requirement of consumers. Most of the technologies are known for more than 60 years ago, but with the globalization, new technology is catching up.

Judicious synergism of the new technologies with traditional preservation procedures will hopefully meet the diversified demand of consumers, reduce post harvest losses, and margin the cost of production and vending.

Hurdle technology is based on combining low levels of two or more preservation factors (hurdles) to enhance the shelf life of the fruit. It produces minimal sensory changes, which makes the products more acceptable than those obtained by conventional methods (Aguilera and Chirife, 1994). Fruit preservation by hurdle technology is based on combinations of low levels of various antimicrobial factors (hurdles) acting synergistically resulting in a shelf stable high moisture, fresh like product.

Taking into account of the above factors, the present investigation was under taken to study the effect of mango chunks preserved using different combinations of hurdles on the microbial, chemical and organoleptic qualities of products under two different storage conditions.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The research work entitled “Preservation of ripe mango chunks by Hurdle Technology” is briefly reviewed under the following subtitles.

2.1 Mango- Origin, geographic distribution and production.
2.2 Nutritional & medicinal properties of mango
2.3 Need for mango processing
2.4 Post harvest handling practices of mango for enhancing shelf life
2.5 Application of Hurdle Technology for enhancing quality of mango

2.1 Mango- Origin, geographic distribution and production.

Mango is one of the oldest and most important tropical fruit and cultivated in almost all tropical and subtropical countries. It has originated in a tropical to subtropical monsoon area in the Himalayan foot hills especially Burma and Eastern India. Later on it spread to Africa, Caribbean and Central America (Lagtiani et al., 1998).

According to Stefan et al. (2003) mango contribute to nearly 50 per cent of the world production of tropical fruits.

The annual production of mango was over 24 million metric tonnes in 2004 with nearly 50 per cent produced in India followed by Mexico and Thailand .However about 98 per cent of production is consumed locally in the producing countries with very little participation in the global trade (FAO, 2005). In 2005, world production of mango was estimated at 28.51 million metric tonnes and the production grew at an average annual rate of 2.6 per cent between 1996 and 2005.

As of 2005, only six countries viz. India, China, Thailand, Mexico, Pakistan and Indonesia, accounted for over 75 per cent of the world production with India being the top producer almost 11 million tonnes annually (FAO, 2005).

According to Chadha (2005) mango, the king of fruits is grown in India in almost all states. India shares about 56 per cent of total mango production contributing 39.5 per cent of the total fruit production of India (Raj kumar et al., 2007). Andhrapradesh, Uttar Pradesh, Bihar, Karnataka, Maharashtra, West Bengal and Gujarat together contribute for about 82 per cent of the total production in India.

Sauco (2004) had opined that India is the largest producer of mangoes, accounting for 38.6 per cent of world production from 2003 to 2005. In Kerala, it is the second important fruit occupying an area of 75,911 hectares with an annual production of 323,517 tones (www.actahort.org).

Ravisankar et al. (2000) is of the opinion that the origin of commercial cultivars and the origin of the cultivation of the mango is collectively agreed to be India and India is still credited for having the most diverse collection of cultivated varieties of mango.

Mangoes make 15 per cent of the total fresh fruits exports from the country. During 2004-05, fresh fruit export totaled $ 181.12 million against $ 172 million in the previous year. In 2007, fresh fruit exports up to November totalled $130.25 million against $112.30 during the same period one year ago (Gandhi, 2005).

2.2 Nutritional and medicinal properties of mango

Fruits are no longer considered as a luxury since they belong to an important class of protective foods which provide adequate vitamins and minerals needed for the maintenance of health (Pruthi, 1992).

According to Bose and Mitra (1990) mango because of its great utility occupies a prominent place amongst the fruit crops grown in India and is acknowledged as the "King of fruits" of this country.

Giridhari et al. (1986) had pointed out that India is the "Home of mangoes" and a large number of varieties are found in almost all parts of the country. The author also reported that mango has earned a reputation of being the apple of the tropic, because it is so wide spread.

Singh (1990) identified that mango, due to its excellent taste, flavour and nutritive value is a favourite fruit in all parts of the country.

Mangoes are reported to be the most nutritious food (http://en.Wikipedia.org). Fresh fruits are considered as the integral part of any dietary system, since they are the rich source of minerals, vitamins and dietary fiber (Prasad and Singh, 1996).

During the ripening process the fruits are accumulates in the mesocarp. Free sugars including glucose, fructose and sucrose increase during ripening process giving the fruit a turpentive to sweet tasting flavour varying with species. (Haq, 2002).

According to Chakrabarthi et al. (2008) mango fruit comprises amino acids, carbohydrates, fatty acids, minerals, organic acids, proteins and vitamins. Ripe mangoes contain fair levels of vitamin C, but are rich in pro-vitamin A and vitamin B_1 and B_2.

According to Pal (1998) mangoes are very low in saturated fat, cholesterol and sodium. It also acts as a good source of dietary fiber.

Mukherjee (1997) pointed out that mangoes are packed with vitamins, minerals and antioxidants. Gowda and Ramanjaneya (1995) suggested that mango is an excellent source of β carotene and moderate in vitamin C and small amounts of vitamin B group.

Ascorbic acid, according to analysis in Central America, ranges from 41.8 to 172.0 mg/100g, whereas in India, ascorbic acid values may be as low as 13 mg/100g (Food Science, Food Technology and Nutrition, 1993).

Gopalan et al. (1977) reported that the riboflavin and niacin content of ripe mangoes were 0.08, 0.09mg/100g pulp respectively.

According to Pott et al. (2003) mango is a rich source of carotenoids and provides high vitamin content. Nanjudaswamy and Mahadeviah (1993) reported that 16 carotenoid pigments were identified in Alphonso mango of which 60 per cent is β carotene.Kaur and Khurdiya (1993) suggested that carotenoids in mango has great potential of improving the quality and nutrients of fruit beverage to which it is mixed. Byni (1997) reported that β carotene content of mangoes ranged between 829.03 to 1166.57µg/100g.

Studies found a positive effect of mango in improving vitamin A deficiency disorders (Bright et al., 2001).

Nutritionally, mangoes are wonderful sources of minerals such as Cu and K. It also contains traces of other minerals such as Mn, Se, Mg, Ca, Fe and P (www.brighthub.com).

Gopalan et al. (1977) reported that the Ca. P and Fe present in mango were equivalent to 14, 16 and 1.3 mg/100g pulp respectively.

Mangoes contain phenolic compounds and have powerful anti-oxidant and anti-cancer abilities. It is high in iron. Beyond being rich in vitamin, minerals and antioxidants, mangoes contain an enzyme with stomach soothing similar to papain (Stewart and Straus, 2000).

According to Wilhelmin (2005) the role of fruits and vegetables consumption can play in maintaining human health and reducing risk in growing disease. Mango fruit contain a compound called mangiferin, which has several medicinal properties and is a boon for anyone who wants to gain weight. All parts of mango plant from the seeds and flowers to the leaves and gum are used in traditional South Asian medicine, but the fruits are most important.

Ripe mango is excellent for toning up heart muscles, stimulating appetite and improving the skin texture and appearance (www.articlesbase.com).

Gallic acid present in mangoes, works as a wonderful disinfectant for the body. Mangoes work as blood cleansers. It is also supposed to reduce excessive heat in the body and prevent body odours (www.brighthub.com).

Unani physicians use mangoes for strengthening the nerves and blood systems. In Ayurveda, dried mango flowers are used to cure dysentery, diarrhea and inflammation of the urinary tract. In South Asian folk medicine, rheumatism and diphtheria is treated using the astringent bark of the mango tree. The leaf, bark, stem, green unripe and half ripe fruits are thought to inhibit the growth of bacteria particularly E.Coli. Ripe mangoes are having anti fungal properties (www.plantcultures.com).

Mango fruit is also beneficial in the treatment of nephritis as well as other kidney troubles (Islam, 1986).

Mangoes according to latest scientific research as well as of folk wisdom are known to increase the body resistance against dysentery, cholera and tuberculosis (www.kungfucancer.com).

Mango fruit is antiscorbutic, diuretic, laxative and invigorating. The fruit is also helpful for people who have liver disorders. Mangoes help to lower cholesterol (www.healthrecipes.com). Vitamin E present in mangoes helps in better functioning of hormonal system and it prevents internal haemorrhage (www.articlesbase.com).

2.3 Need for mango processing

Mango being a tropical climacteric fruit possesses a very short shelf life of 3-4 days at ambient conditions and accounts for 17-36 per cent loss in the total production (Puttaraju & Reddy, 1997). The maximum percentage loss occurs in local mango varieties which contributes a major chunk in the total production.

Eckert and Ogawa (1985) reported that ripe mango fruits have low intrinsic resistance to pathogen attack and hence get spoiled very easily.

Kalra et al. (1993) reported that India is the largest producer of mango fruit accounting for about 65 per cent share in the world produce. Hardly one per cent of the total mango production in India is processed and only a negligible proportion of our produce is exported as fresh fruit (Pruthi, 1992).

Processing of fruits and vegetables for both, food and non food uses will open up marketing alternatives to the sale of fresh produce, reduce post harvest losses, regulate prices during lean period and raise farm income and create employment (Dhankar, 2001).

Chadha (1995) stated that mango fruit is important from the processing point of view and contributes a share of 43-44 per cent in the total production of processed fruits and vegetables.

Mangoes are available for a short period each year and most varieties are alternate bearing, resulting in seasonal gluts and subsequent shortage. Processing overcomes many problems and offers the bonus of added value. Currently just 0.22 per cent of mangoes produced world wide are used for processing (http//spore.cta.int).

Singh (1990) opined that in a good fruiting year, market may be glutted with the produce, resulting in a lot of wastage as well as low price to the orchadist. Hence intensified effort to post harvest preservation of mango fruit is highly essential to ensure fair returns to the growers and to improve their economic conditions (Shaw et al., 1993).

Bourne (1986) has classified the cause of post harvest loss of perishable crops as primary loss due to insects, microbes and mechanical damages and secondary losses due to poor storage and inadequate transport facilities.

.

Mango with many versatile properties has naturally found application for processing in to various products unparalleled by any other fruit .Unripe mango is processed into pickles, brine stock, chutneys and used for making chutney powder; particularly in India (Beverage and Food World, 1994 and Hicks, 1990) while ripe mangoes are used for the preparation of canned slices, puree, nectar, juice concentrate , fruit bar, leather, mango cereal flakes ,strained baby foods and mango beverage in tetra pack(Neelima et al., 1993; www.fao.org).

2.4 Post harvest handling practices of mango for enhancing shelf life

According to FAO (2003) post harvest losses in mangoes have been estimated to be 25 to 40 per cent. Hence proper care and attention is needed to ensure the quality of the fruit preserved till the point of consumption.

Several practices and technologies are available to extend the shelf life and quality of mangoes. Storage is essential for extending the consumption period of fruits, regulating their supply to the market and also for transportation to long distance. There are several technologies like low temperature and other associated technologies such as controlled atmosphere (CA) / modified atmosphere (MA) storage, irradiated storage and storage using chemicals and by coatings (Rekha and Goswami, 2007).

2.4.1 Storage in low temperature

Low temperature to preserve foods work on the principle that low temperature slows microbial and enzyme action .The food is thus prevented from spoilage .The method of preservation at low temperature are refrigeration (4^0C to 7^0C), cold storage (1^0C to 4^0C) and freezing (-78^0C or below) (Bower et al., 2003).

Temperature greatly influences metabolic activity of plant tissues and organs, such as respiration and ethylene production, which are fundamental for fruit ripening, but harmful to fruit conservation (Bron et al., 2005).

According to Nair (2003) exposure of microorganism at low temperature reduces the rates of growth and reproduction. In refrigerator at 5^0C food remains unspoiled.

Since mango is a tropical fruit, it is highly susceptible to chilling injury.

A zero energy cool chamber, an on-farm rural oriented storage structure, which operates on the principle of evaporative cooling, was developed at IARI, New Delhi using locally available raw materials such as bricks, sand, bamboo, dry grass, jute cloth etc. (Roy and Pal, 1991).

Chaplin et al. (1991) and Nair (2003) had reported that exposure to extremely cold temperature can also lead to delayed ripening; poor flavour and water soaking in tissues after ripening.

Treatments to alleviate chilling injury include intermittent warming, high or low temperature, pre conditioning, chemical pretreatment and film packaging (Aguilar et al . (2000); Wang (1993) and Pesis et al. (1997).

2.4.2 Storage of mango at low pressure

Dilley (1982) had opined that as the total pressure within the sealed chamber is lowered, the partial pressure of each gaseous component within the chamber is proportionally reduced as per Dalton's law. Hence lower pressure implies a depleted O_2 composition of the chamber atmosphere and thus a reduced respiration rate and its ensuring benefits on the storage life of the fruit.

Insecticidal effect of this technology have been studied by Davenport et al. (2006) and found that when mangoes were stored under a low pressure of 15-20 mm of Hg at RH≥ 98 per cent and temperature of 13^0 C, a major proportion of the egg and larvae of Carribean fruit fly were killed.

However, there have been reports of loss of water and shriveling of mango at less than 50 mm of Hg (Wang, 1991).

2.4.3 Storage in controlled and modified atmosphere packaging

Controlled atmosphere (CA) and modified atmosphere (MA) storage involves altering and maintaining an atmospheric composition different from normal air composition. In CA and MA storage, the fruit is stored in a depleted O_2 and elevated CO_2 environment.

Fruits and vegetables are sometimes stored in sealed warehouse, were temperature and humidity are closely controlled and most importantly the composition of gases in the atmospheric is altered to minimize spoilage. Usually the concentration of O_2 is reduced, the concentration of O_2 is increased and ethylene, a gas naturally produced by plants that accelerate ripening is removed from the atmosphere. This controlled environment helps to slow the enzymatic reaction that eventually lead to decomposition and decay and may increase the time that produced that can be stored by several months. Ripening rooms, in which ethylene gas is added to the atmosphere, also helps to produce higher quality fruits and vegetables.

Increase in levels of O_2 and CO_2 delayed growth of aerobic and anaerobic microorganism (Amanatidou et al., 1999).

Controlled atmosphere storage of mango fruit was studied using two combinations of CO_2 (4 and 6 %) and three O_2 levels (4, 6 and 8 %). The fruits were evaluated at 5 day intervals for various quality attributes, incidence of pathogenic decay and sensory quality. All controlled atmosphere treatments showed the yellowing of both peel and flesh. After controlled atmosphere storage, fruit were stored at 13, 20 and 30 ^{0}C and the ripening periods were 7, 3 and 2 days respectively. The best storage was 4 per cent CO_2 and 6 per cent O_2 at 13^{0}C (Athpol and Nirat, 2007).

2.4.4 Storage using Irradiation

Irradiation is a process in which food is passed through a chamber where it is exposed to gama rays or X- rays. (Martha , 2008).

The use of ionizing radiation in the form of X-rays, r- rays or microwaves has been successfully studied for augmenting the shelf life of fresh mango fruit (Durigan et al., 2004 and Elsamahy et al., 2000).

The use of UV (100 to 290 nm) irradiation is an effective and rapid method to preserve post harvest life of ripe mango without adversely affecting quality attributes was reported by Aguilar et al. (2001).

According to Hagenmaier and Baker (1998) low doses irradiation significantly reduced microbial population and moderately increased respiration in fruits and vegetables.

2.4.5 Storage using chemical treatments

Chemical preservatives are used as antimicrobial agents or as disinfectants (Pirovani et al., 2001).

Chemical preservation must not impair wholesome of the minimally processed products .These may be categorized on the basis of their role (Garcia and Barrett, 2002).

Chemical treatment involves the use of either a dip in calcium salts, fungicides or ethylene inhibitors. Calcium treatment brings firmness in the fruit tissue and delays ripening (Santos et al., 2004; Singh et al., 2000 and Bringas et al., 2005).

The most commonly used chemical preservatives are the acids such as sorbic acid, benzoic acid and propionic acid. Sorbic acid is used for preservation of salads,

syrup, jellies and some cakes and benzoic acids is used for beverages , margarine, apples, cidar etc.(Sapers, 1993).

Growth regulators, naphthalene, acetic acid at 100-300 ppm and benzyladenine at 5-15 ppm have improved the colour and firmness of mango and prolonged the shelf life (Wavhal and Athale, 1989).

Parmar and Chundawat (1989) reported that gibberellic acid at 200 ppm gave a highly effective treatment for retarding rate of ripening in 'Kesar' variety of mango.

According to Jiang and Joyce (2000) gaseous fumes of methyl cyclopropene have been widely used as ethylene inhibitor in mango.

Malik et al. (2003) found that the post harvest application of polyamines such as putrescine, spermine and spermidine with 0.01 per cent ' Tween-20' as a surfactant on mango and have a positive influence on the shelf-life of the fruit with no adverse effect on quality.

Treatment of mature green mangoes of the variety 'Kensington pride' with ethephon at 250-2000 ppm resulted in reducing ripening times and improved the eating quality of the fruit (Singh and Janes, 2001).

2.4.6 Storage using wax coating and film wrapping

Waxing the fruit surface adds shine and reduces water loss and rate of respiration, thus improving external appearance and extending storage life. Carnauba wax, sugar cane wax, thermoplastic terpene resins, chitosan based coating and shellac are used commercially; however waxes of plant origin are preferred (Bringas

et al., 2005; Fonseca et al., 2004; Diazsobac et al., 2000; Ketsa and Prabhasavat, 1992; Bower et al ., 2003; Ketsa and Raksritong, 1992).

Benzalconic chloride in association with surface wax coating successfully controlled rot caused by colletotrichum gloeosporides in mango fruit (Fonseca et al., 2004).

Diazsobac et al. (2000) found that the effect of hydodispersion of malto dextrin, carboxylmethyl cellulose, and propylene glycol and sorbitan esters as coating helped in the reduction or prevention of spoilage in mango.

According to Castro et al. (2005) selective film wrappers like PVC and LDPE have increased the shelf life of mango.

Srinivasa et al. (2002) reported use of a chitosan coated film would be beneficial for extending the storage life of mangoes.

Use of edible coating in extending the shelf life of mangoes was also reported by Baldwin et al. (1999).

2.5 Application of Hurdle Technology for enhancing quality of mango

According to Gould and Grahame (2000) hurdle technology is the application of selected processing techniques in combination to preserve a product. Hurdle technology employs intentional use of combination of different factors or techniques to achieve reliable, safe, stable, nutritious, tasty and economical foods (Vink, 1994).

Gould, (1995), Leistner (2000), Leistner and Gould (2002) had opined that hurdle technology is the term applied when foods are preserved by hurdles or in combination. The concept of combinations of preservatives and treatments to preserve foods is frequently called the hurdle or barrier concept (Leistner and Gorris ,1995).

Hurdle technology is the preservation of fruits in a steeping solution consisting of permissible chemical preservatives and other food additives. It is one of the non thermal, low cost, alternate processing technologies having considerable scope for adoption in the developing countries like India (Khurdiya, 1995).

Hurdle technology is increasingly used for food design in industrialized and developing countries in many ways according to needs at various steps of the food distribution chain during storage, processing and packaging as a “back up” measure in existing minimally processed products with short shelf life to diminish microbial pathogenic risk or increase their shelf life (Alzamora et al., 1998).

The different treatments called as hurdles are used in preventing the chemical as well as microbial deterioration of the food product. A combination of these hurdles is very effective, while individually each hurdle is protecting food from deterioration (Leistner, 1994).

Hurdles have been classified as physical, physico-chemical, microbial, derived and miscellaneous as well, (Leistner and Gorris, 1995).

High temperature, low temperature, ultra violet radiation, electro magnetic radiation, ultra sonication, modified atmosphere packaging; high electric field pulses are physical hurdles. Physio-chemical hurdles include low water activity, organic

acids, low redox potential, low pH, sodium nitrite, sodium or potassium sulphites, smoking, spices, herbs etc.

Blanching is the physical hurdle of high temperature method. Blanching has been found to reduce the microbial load from 60 per cent to 99 per cent (Alzamora et al., 1995).

Water activity is one of the physico- chemical hurdles. It refers to the availability of water in a food or beverage and represents the amount of water that is available to microorganisms and is also a critical factor that determines shelf life.

Water activity is lowered by the removal of water, addition of solutes or binding of water when used, the solute selected influences the minimum aw for growth for particular organism. Reduction of water activity of product increased the stability of minimally processed fruits (Corry, 1978).

Microbial hurdles include antibiotics, competitive flora etc. Miscellaneous hurdles include moulaurin, chitosan and chlorine. Antimicrobials are microbial hurdles. Many naturally occurring antimicrobials have been explored for used as additives in food preservation (Conner, 1993 and Hoover, 2000).

Leistner (1999) opined that food products packaging is an important hurdle, since it contributes towards microbiological stability and safety and helps to preserve organoleptic quality.

Application of the hurdle concept for mango preservation may inhibit the growth of microorganism (Uyttendaele et al., 2001). These hurdles may be temperature, water activity, acidity, redox-potential, preservatives and others.

Ohlsson and Bengston (2000) reported that hurdle technology has arisen in response to a number of developments such as demand of healthier foods by consumers that retain their original and nutritional properties and the shift to ready to eat and convenience foods which require less processing.

Hurdle technology has also been used for the preservation of minimally processed fruit slices. A combination of mild treatment, reduction of water activity, lowering of pH and addition of potassium sorbate and sodium bisulphite for producing shelf stable pineapple slices was reported by Alzamora et al. (1989).

Storage life of pineapple, mango and papaya fruit chunk preserved by hurdle technology was studied by Vijayanand et al. (2001 using the hurdles pH, mild heat treatment, preservative and packaging.

High moisture products from peach, pine apple, mango, papaya, sapota and banana treated with a combination of mild heat treatment, water activity reduction, and addition of antimicrobials and packed in glass flasks or high density. Poly ethylene bags with syrup containing preservatives had a shelf stability ranging from 4 to 8 months (Alzamora et al., 1993).

The hurdle technology produces minimal sensory changes, which makes the products more acceptable than those obtained by conventional methods (Aguilera and Chirife, 1994).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The study on "Preservation of ripe mango chunks by Hurdle Technology" is a comprehensive study carried out with an objective to increase the shelf stability of the chunks through chemical, microbiological and organoleptic qualities.

The methodology followed in the study is presented under the following headings.

3.1 Selection of mango varieties
3.2 Physical characteristic of the selected mango varieties.
3.3 Selection of different pre-treatments.
3.4 Selection of storage media
3.5 Selection of storage condition
3.6 Storage of mango chunks.
3.7 Quality assessment of the stored mango chunks
3.7.1 Assessment of the chemical constituents of stored mango chunks
3.8 Organoleptic evaluation of mango chunks
3.8.1 Selection of judges.
3.8.2 Preparation of Score card.
3.9 Microbial examinations of mango chunks.
3.10 Cost benefit analysis of the chunks
3.11 Statistical analysis

3.1 Selection of mango varieties

Among the various fruits cultivated in Kerala, mango was selected for the study because of the following reasons.

Mango is relished for its succulence, exotic flavor and delicious taste and has considerable export potential both in its processed and raw forms (Indian Food Packer, 1995).

Out of the total production of mangoes 25 per cent is lost due to inadequate post harvest facilities and processing opportunities (CFTRI, 2002).

Mango fruit processing would not only avoid the huge wastage of the produce that would also go a long way in improving the employment potential for the local people and contribute to the over all progress of the region.

Local varieties contribute a major chunk in the total production of mangoes. Systematic data is not available at present on the processing of cut mangoes. Considering this facts, two popular local varieties such as Neelum and Kottukonam grown in an around Thiruvananthapuram district were selected for the present study (Plate1& 2).

3.2 Physical characteristics of the selected mango varieties

Physical characteristics like fruit length, fruit weight, peel weight, stone weight and flesh weight were recorded. The length of the fruit was measured using a thread and measuring scale. Peel weight, stone weight, fruit weight and flesh weight were recorded using an electronic balance. The length of fruits and fruit weight was determined by taking the length and weight of ten fruits drawn randomly.

NEELUM

KOTTUKKONAM

3.3 Selection of treatments

Pre-treatments are used to enhance the quality and shelf life of the product. The selected mango varieties were washed, peeled, cored and cut in to 2x2x1 inch dimension and divided in to two portions. For the present investigation half portion of the mango chunks were subjected to preliminary pre- treatments of blanching where as remaining half portion was kept unblanched. Both the blanched and unblanched mango chunks were subjected to further treatments with preservatives at different concentrations and combinations (Plates 3 to10).

For the present study citric acid, potassium metabisulphite, sodium benzoate and sugar were selected as preservatives. Following are the treatments selected for the study.

T_1	40^0 Brix sugar syrup +0.2 % citric acid + 0.035 % potassium metabisulphite
T_2	40^0 Brix sugar syrup +0.2% citric acid + 0.035 % potassium metabisulphite + 0.04%. sodium benzoate
T_3	50^0 Brix sugar syrup +0. 2 % citric acid + 0.035% potassium metabisulphite
T_4	50^0 Brix sugar syrup +0.2 % citric acid + 0.035 % potassium metabisulphite + 0.04 % sodium benzoate

A flow chart showing the preparation of mango chunks are given in Fig. 1.

3.4 Selection of storage media

Kalra et al. (1991) reported that mango varieties namely Totapuri, Benganappalli, Deshehari with papaya blends were preserved for one year in glass bottles under ambient condition.

According to Singh et al. (1995) glass bottles were found to be more suitable than PVC bottles from long time storage.

In the light of the above reports, for the present study glass containers were selected for the present study.

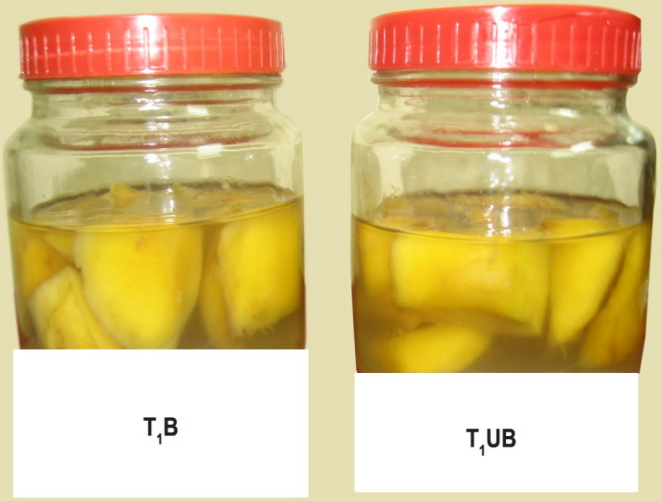
3.5 Selection of the storage condition

The mango chunks were stored under ambient and refrigerated condition for a period of 0, 15 and 30 days respectively.

3.6 Storage of mango chunks

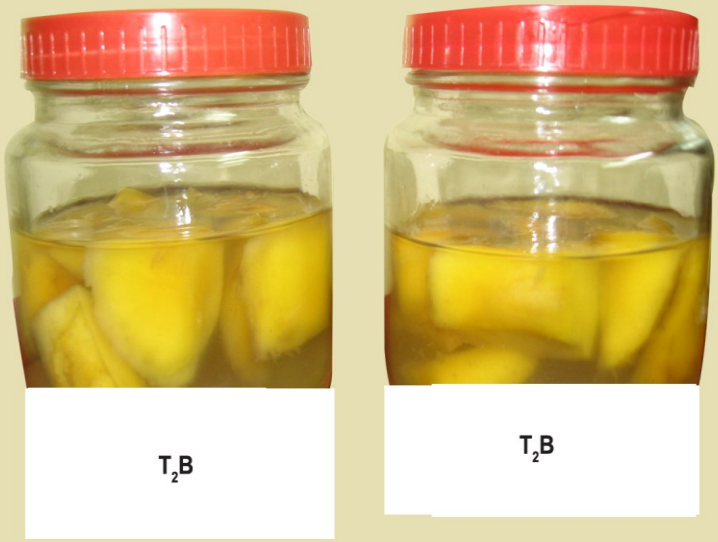
Both the blanched and un blanched fruit chunks were dipped in different treatments mentioned above and stored in sterilized glass containers at ambient and refrigerated conditions for the analysis of chemical, microbiological and organoleptic qualities.

TREATMENTS FOR VARIETY NEELUM



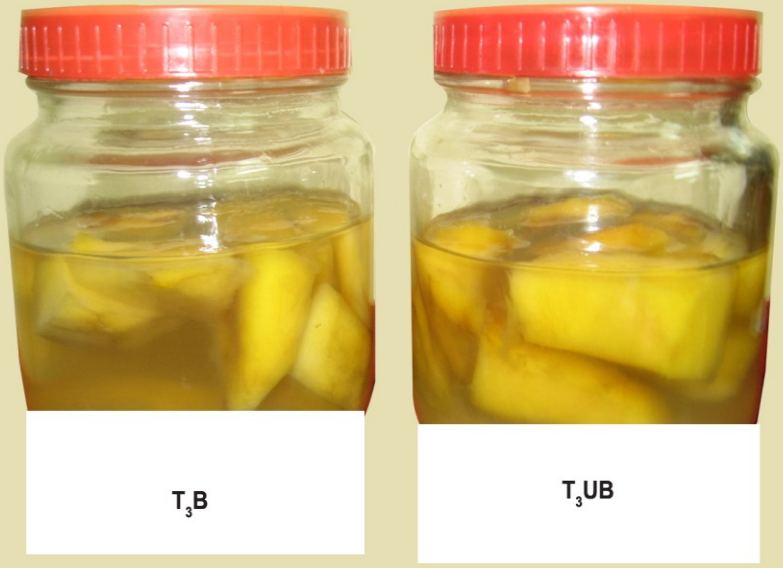
T_1B T_1UB

Plate - 3



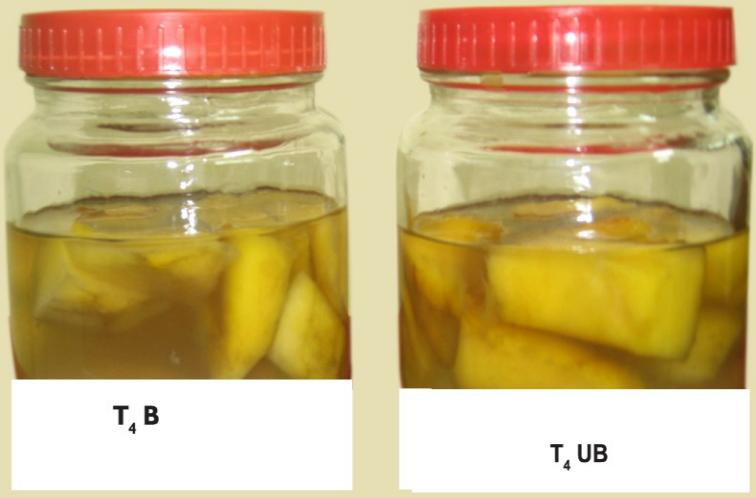
T_2B T_2B

Plate - 4



T_3B T_3UB

Plate - 5



T_4 B T_4 UB

Plate - 6

TREATMENTS FOR VARIETY KOTTUKONAM

T_1 B

T_1 UB

Plate - 7

T_2 B

T_2 UB

Plate - 8

T_3 B

T_3 UB

Plate - 9

T_4 B

T_4 UB

Plate - 10

3.7 Quality assessment of the selected mango varieties

Chemical qualities of the mango chunks were assessed followed by the microbial and organoleptic evaluation. Shelf stability of the mango chunks stored at ambient condition and refrigerated temperature were also assessed by evaluating the chemical, organoleptic and microbiological changes occurring during storage.

3.7.1 Assessment of the chemical constituents of stored mango chunks

Chemical composition is the major parameter influencing the quality of mango varieties from the point of view of nutritionist.

The different indicators ascertained under chemical composition are listed below.

Moisture Moisture content was determined by the method outlined by Sadasivam and Manikkam (1992)

pH pH was measured using pH meter Jackson (1973)

Acidity Acidity was estimated as per the procedure reported by Sathe (1999)

Total Sugar Total sugar was analyzed by the procedure suggested by A.O.A.C (1990)

Reducing Sugar Reducing Sugar was estimated as per the procedure reported by Renganna (2001)

Total Phenol Total Phenol was determined according to procedure outlined by Ranganna (2001)

The above indicators were assessed both in fresh as well as in stored mango chunks.

3.8 Organoleptic evaluation of stored chunks

Organoleptic qualities play an important role in the quality of food products. For judging consumer acceptability, organoleptic evaluation is essential.

Manay and Swamy (2002) opined that sensory evaluation plays a vital role in the food industry, because it represents a very unique technique that harness human behavioral instincts of perception, learning, cognition, psychophysics and psychometrics for the evaluation of food quality.

For conducting sensory evaluation, a panel of judges has to be selected, so as to ascertain consistent and accurate results.

3.8.1 Selection of judges

The panel members for sensory analysis at the laboratory level were selected from a group of P.G students. These judges were selected through triangle test as suggested by Mahony (1985). Details are given in Appendix 1.

3.8.2 Preparation of Score card

The score card used for the evaluation of stored mango chunks is given in Appendix 2.

The major quality attributes included in the score card were appearance, taste, colour, flavour, texture and taste. Scores for overall acceptability was obtained by determining the average mean score of each character. The quality attributes were assessed during 0, 15 and 30 days of storage at ambient and refrigerated conditions.

3.9 Microbial examination of stored chunks

Shelf stability of the mango chunks was conducted by plate count method (Dilliello, 1982) to assess the growth of bacteria, mould and yeast during 0, 15 and 30 days of storage at ambient and refrigerated conditions.

3.10 Costs benefit analysis of the chunks

The economics of the product depends much on the cost of the ingredients used for the preparation of products.

According to How (1990) accurate and up to date information on supply, demand and prices is essential for anybody directly involved in the business of food product industry. The cost of the product in this study was evaluated by taking in to account the expenses of raw materials, packaging accessories and cost of fuel.

Cost analysis of the each product standardized was computed taking into consideration of the pre market price of the ingredients used and cost involved in processing.

3.11 Statistical analysis

The data collected were analyzed applying the technique of Analysis of Variance (ANOVA) using five factor Completely Randomized Design (CRD) suggested by Panse and Sukhatme (1995). The factors selected were variety (two levels), storage condition (two levels), storage period (three levels), blanching (two levels) and treatments (four levels).

RESULT

4. RESULT

Result of the present investigation entitled "Preservation of ripe mango chunks by Hurdle technology" is presented under the following heads.

4.1 Physical characteristics of Neelum and Kottukonam mango cultivars
4.2 Chemical constituents in Neelum and Kottukonam mango cultivars
4.3 Chemical constituents in stored mango chunks
4.4 Organoleptic qualities of stored mango chunks
4.5 Microbial profile of stored mango chunks
4.6 Cost benefit analysis of mango chunks

4.1 Physical characteristics of Neelum and Kottukonam mango cultivars

Physical characteristics of the selected mango cultivars such as fruit length, fruit weight, peel weight, stone weight and flesh weight were recorded. The details are depicted in table 1.

Table 1 Physical characteristics of Neelum and Kottukonam mango cultivars

Physical characteristics	Variety	
	Neelum	Kottukonam
Fruit length(cm)	11.20	10.35
Fruit weight(g)	249.0	187.0
Peel weight(g)	14.05	10.96
Stone weight(g)	16.06	22.01
Flesh weight(g)	190.0	138.35

The mean fruit length of mango cultivar Neelum was 11.20 cm while that of Kottukonam was 10.35 cm.

Fruit weight was recorded after thorough washing of the fruits .The fruit weight was noted to be 249 g and 187 g for Neelum and kottukonam mango cultivars, respectively.

Peel weight was recorded as 14.05 g and 10.96 g for Neelum and Kottukonam mango cultivars respectively.

The stone weight was recorded after washing the stone thoroughly and drying them at room temperature. The mean weight recorded was found to be 16.06 g and 22.01 g for Neelum and Kottukonam respectively.

The flesh weight was observed to be 190.0g for Neelum variety and 138.35 g for Kottukonam variety.

4.2 Chemical constituents of Neelum and Kottukonam mango cultivars

According to Ozdemir (2001) the knowledge of the constituents of the fruits and their properties forms the basis of understanding the quality of the product. In the present study the chemical compounds present in the fresh Neelum and Kottukonam mangoes were assessed with regard to its moisture, pH, acidity, total sugar, reducing sugar and total phenol. The results are presented in table 2.

Table 2. Chemical constituents of Neelum and Kottukonam mango cultivars

Chemical constituents	Variety Neelum	Variety Kottukonam
Moisture (%)	80.90	80.00
pH	4.06	4.24
Acidity (%)	0.23	0.27
Total sugar (%)	14.96	13.76
Reducing sugar (%)	6.26	6.43
Total phenol (µg /100 gm)	17.5	14.65

The moisture content of the mango variety Neelum was found to be 80.90 per cent as against 80.00 per cent in Kottukonam.

The pH of Neelum was recorded as 4.06 and that of Kottukonam was 4.24.

The variety Neelum recorded 0.23 per cent of acidity while that of Kottukonam was 0.27 per cent.

Total sugar content as found in the fruit Neelum and Kottukonam was 14.96 per cent and 13.76 per cent respectively. The reducing sugar content was found to be 6.26 per cent in Neelum and 6.43 per cent in Kottukonam.

The total phenol content of the variety Neelum was found to be 17.5µg / 100 g and in Kottukonam it was found to be 14.65 µg/100g.

4.3 Chemical constituents in stored mango chunks

4.3.1 Moisture

Changes in moisture content of Neelum and Kottukonam mango chunks stored at ambient and refrigerated condition is depicted in table 3(a) and 3(b) respectively.

As indicated in table, mean values of moisture content of Neelum and Kottukonam mango chunks was found to be significant statistically.

.

The variety Kottukonam chunks had higher moisture level (58.40 %) when compared to Neelum chunks (49.10 %).

A significant difference was also noticed in the moisture content of mango chunks as a result of blanching. The moisture content of blanched mango chunks was 54.49 while that of un blanched chunks was 53.01.The data revealed that moisture level was increased as a result of blanching.

Moisture content of chunks stored at ambient condition ranged between 29.50 to 61.50 per cent and 49.50 to 64.05 per cent in Neelum and Kottukonam varieties, respectively. The highest moisture content was noticed in Kottukonam T_4 UB (64.05 %) and the lowest in Neelum T_4UB (29.50 %).

A close observation on the various treatments on moisture level revealed that T_1 (50.90) and T_3 (57.21) are significantly different from other treatments. Mean values of treatment T_2 and T_4 (53.81 and 53.07) were on par with each other.

Table: 3 (a) Changes in moisture content of mango chunks stored at ambient condition (A.C) in percentage.

riety / Duration (days)	Treatments												
	T_1			T_2			T_3			T_4			Mean of treatments
	B	UB	Mean	B	UB	Mean	B	UB	Mean	B	UB	Mean	
Neelum (V_1)													
0	58.05	47.50	52.78	48.40	61.50	54.95	58.20	42.50	50.35	47.65	33.89	40.78	49.71
15	57.20	47.20	52.20	47.55	60.15	53.85	57.90	42.20	50.05	46.90	33.30	40.10	49.05
30	53.10	46.05	49.57	43.90	56.45	50.18	55.65	30.95	46.80	44.65	29.50	37.08	45.90
Mean	56.12	46.92	51.52	46.62	59.37	52.59	57.25	40.88	49.06	46.40	32.23	39.31	48.12
ottukonam (V_2)													
0	57.70	55.10	56.40	61.70	61.90	61.80	61.50	62.30	61.90	61.75	64.05	62.90	60.75
15	54.50	53.90	54.20	59.80	60.05	59.93	60.35	60.85	60.60	61.00	50.50	55.75	57.62
30	52.70	53.60	53.15	59.20	59.40	59.30	59.50	60.10	59.80	60.45	49.50	54.98	56.80
Mean	54.93	54.20	54.56	60.23	60.45	60.34	60.45	61.08	60.76	61.07	54.68	57.87	58.38

Table: 3(b) Changes in moisture content of mango chunks stored at Refrigerated condition (R.C) in percentage.

riety / Duration (days)	Treatments												
	T_1			T_2			T_3			T_4			Mean of treatments
	B	UB	Mean	B	UB	Mean	B	UB	Mean	B	UB	Mean	
Neelum (V_1)													
0	56.10	47.50	51.80	48.40	43.50	45.95	58.20	67.00	62.60	56.00	64.00	60.00	55.08
15	40.55	48.95	44.75	47.45	36.00	41.72	52.55	68.45	60.50	51.75	62.39	57.08	51.01
30	34.49	42.50	38.50	43.95	30.00	36.97	48.90	52.90	50.90	47.30	50.40	48.85	43.80
Mean	43.71	46.32	45.01	46.60	36.5	41.55	53.22	62.78	58	51.68	58.93	55.30	49.96
ottukonam (V_2)													
0	56.00	54.80	55.40	61.70	61.20	61.45	61.50	62.30	61.90	61.25	60.60	60.93	59.92
15	53.30	53.20	53.25	61.15	59.65	60.40	61.20	60.75	60.97	60.30	59.30	59.80	58.60
30	44.70	52.92	48.82	60.25	58.10	59.18	60.20	60.15	60.18	59.10	58.20	58.65	56.70
Mean	51.33	53.64	52.48	61.03	59.65	60.34	60.97	61.07	61.02	60.22	59.37	59.79	58.40

Mean Values :

Variety	**Condition**	**Duration**	**Blanching**	**Treatments**	
V_1 = 49.10	AC = 53.31	0 = 56.37	B = 54.49	T_1 = 50.90	T_2 = 53.81
V_2 = 58.40	RC = 54.19	15 = 54.07	UB = 53.01	T_3 = 57.21	T_4 = 53.07
		30 = 50.81			
$F_{1, 96}$=183.36**	$F_{1, 96}$=1.65	$F_{2\ , 96}$=22.05**	$F_{1, 96}$=4.68*	$F_{3, 96}$=14.51**	
CD =1.3469	CD = 1.3469	CD = 1.6496	CD=1.3469	CD = 1.9048	

* Denotes Significance of F at p = 0.05
** Denotes Significance of F at p = 0.01

Data regarding the storage period of mango chunks on moisture content also revealed a significant difference. Mean values of moisture content revealed that the initial moisture content of 56.37 per cent decreased to 54.07 per cent after 15 days of storage and 50.81 per cent after 30 days of storage .The study revealed that the moisture level is getting decreased as the storage period increased.

When the mango chunks were stored at refrigerated condition the moisture content ranged between 30.00 to 68.45 per cent and 44.70 to 62.30 per cent in Neelum and Kottukonam varieties respectively. Statistical analysis of the data revealed that there was no significant difference in the moisture content of two varieties when stored at ambient and refrigerated condition.

Significant interaction was also observed in moisture content between variety and storage period ($F_{2, 96}$= 3.57*), variety and treatments ($F_{3, 96}$=6.91**) treatment and condition ($F_{3, 96}$=26.35**).

4.3.2 pH

Changes in pH of Neelum and Kottukonam mango chunks stored at ambient and refrigerated condition are presented in Table 4(a) and 4(b) respectively.

pH of Neelum mango chunks stored at ambient condition ranged between 4.00 to 5.15 while it ranged between 4.10 to 4.86 in Kottukonam chunks.

In the case of mango chunks stored at refrigerated condition, the pH content ranged from 3.85 to 4.94 in Neelum variety while it ranged from 4.10 to 4.70 in Kottukonam variety. Initially the pH was found to be highest in T_1 (4.43) and lowest in T_2 (3.9).

Table: 4 (a) Changes in pH content of mango chunks stored at ambient condition (A.C)

riety / Duration (days)	Treatments												
	T_1		Mean	T_2		Mean	T_3		Mean	T_4		Mean	Mean of treatments
	B	UB		B	UB		B	UB		B	UB		
Neelum (V_1)													
0	4.22	4.60	4.41	4.00	3.80	3.90	3.95	4.85	4.40	4.10	4.00	4.05	4.19
15	4.25	4.60	4.43	4.00	3.80	3.90	3.95	4.85	4.40	4.10	4.00	4.05	4.19
30	4.65	5.00	4.83	4.15	4.10	4.13	4.20	5.15	4.67	4.20	4.10	4.15	4.44
Mean	4.37	4.73	4.55	4.05	3.90	3.97	4.03	4.95	4.49	4.13	4.03	4.08	4.27
ottukonam (V_2)													
0	4.40	4.45	4.43	4.25	4.15	4.20	4.10	4.10	4.10	4.30	4.30	4.30	4.25
15	4.40	4.45	4.43	4.25	4.15	4.20	4.10	4.10	4.10	4.30	4.30	4.30	4.25
30	4.60	4.65	4.63	4.50	4.65	4.58	4.86	4.75	4.80	4.65	4.65	4.65	4.66
Mean	4.47	4.45	4.46	4.33	4.32	4.32	4.35	4.32	4.33	4.42	4.42	4.42	4.38

Table: 4 (b) Changes in pH content of mango chunks stored at Refrigerated condition (R.C)

Variety / Duration (days)	Treatments												
	T_1			T_2			T_3			T_4			Mean of treatments
	B	UB	Mean	B	UB	Mean	B	UB	Mean	B	UB	Mean	
Neelum (V_1)													
0	4.25	4.60	4.43	4.00	3.85	3.93	3.90	4.85	4.37	4.10	4.00	4.05	4.19
15	4.25	4.65	4.45	4.06	4.00	4.03	4.45	4.88	4.67	4.70	4.60	4.65	4.45
30	4.21	4.69	4.45	4.15	4.07	4.11	4.55	4.94	4.75	4.70	4.75	4.73	4.51
Mean	4.24	4.65	4.44	4.07	3.97	4.02	4.30	4.88	4.59	4.50	4.45	4.47	4.38
Kottukonam (V_2)													
0	4.40	4.45	4.43	4.25	4.15	4.20	4.10	4.10	4.10	4.30	4.30	4.30	4.25
15	4.43	4.55	4.49	4.26	4.19	4.22	4.50	4.50	4.50	4.50	4.70	4.60	4.45
30	4.65	4.65	4.65	4.35	4.40	4.38	4.65	4.60	4.63	4.70	4.60	4.65	4.57
Mean	4.49	4.55	4.52	4.29	4.25	4.27	4.42	4.40	4.41	4.50	4.53	4.51	4.19

Mean Values

:

Variety	**Condition**	**Duration**	**Blanching**	**Treatments**	
V_1 = 4.33	AC = 4.33	0 = 4.22	B = 4.31	T_1 = 4.50	T_2 = 4.15
V_2 = 4.41	RC = 4.41	15 = 4.34	UB = 4.43	T_3 = 4.46	T_4 = 4.37
		30 = 4.55			
$F_{1, 96}$= 17.10**	$F_{1, 96}$= 13.69**	$F_{2, 96}$= 96.58**	$F_{1, 96}$= 38.31**	$F_{3, 96}$= 67.66**	
CD =0.0377	CD = 0.0377	CD = 0.0462	CD = 0.0377	CD = 0.0533	

* Denotes Significance of F at p =- 0.05
** Denotes Significance of F at p = 0.01

Data revealed that significant difference in pH was found to exist between the two varieties of mango chunks .The data proved that variety Kottukonam chunks had higher pH (4.41) when compared with variety Neelum (4.33).

Analysis of data pertaining to blanched and unblanched mango chunks observed that pH value decreased as a result of blanching and found to be highly significant. pH value of un blanched mango chunks was 4.43 while that of blanched chunks it was 4.31.

On comparing the mean values, pH of mango chunks stored at ambient and refrigerated condition differ significantly .The mango chunks stored at refrigerated condition were having higher values of pH (4.41) when compared with chunks stored at ambient condition (4.33).

Data regarding the various treatment levels on pH revealed that the treatments such as T_1, T_2, T_3 and T_4 differ significantly.

pH of mango chunks of both varieties was found to increase when stored under two conditions up to 30 days .

A significant difference was observed in pH of mango chunks during storage. pH of mango chunks showed a linear increase during storage. The initial pH of 4.22 for the mango chunks increased to 4.34 after 15 days of storage which again increased to 4.55 after 30 days of storage.

pH of Neelum chunks (4.19) stored at ambient condition during 0 days increased to 4.44 at the end of 30 days while it is increased from 4.25 to 4.66 in the case of Kottukonam chunks. In the case of refrigerated condition, the mean values increased from 4.19 to 4.51 and 4.25 to 4.57 in Neelum and Kottukonam chunks respectively. In general mango chunks stored at refrigerated condition recorded a higher pH as compared to chunks stored at ambient condition.

Significant interaction was observed in pH between variety and storage condition.

Significant interaction was also observed between variety and storage period, clearly indicating the significance of the fruit and storage period on the pH of mango chunks.

Interaction was also observed between variety and treatment ($F_{3, 96}$= 28.68**). The study revealed that the type of treatments and variety used affected the percentage of acidity in the mango chunks.

Significant interaction was also observed between variety and treatments ($F_{3,96}$ = 28.68**), treatment and storage period ($F_{6,96}$ = 4.27**), treatment and condition ($F_{3,96}$ = 11.27**) and storage period and condition ($F_{2, 96}$ = 16.09**).

4.3.3 Acidity

Table 5(a) and 5(b) details the changes in acidity of mango chunks stored at ambient and refrigerated condition and its interaction between varieties, storage condition, storage period, treatments and blanching.

Table: 5 (a) Changes in acidity of mango chunks stored at ambient condition (A.C) in percentage.

riety / Duration (days)	Treatments												
	T_1			T_2			T_3			T_4			Mean of treatments
	B	UB	Mean	B	UB	Mean	B	UB	Mean	B	UB	Mean	
Neelum (V1)													
0	0.86	0.85	0.85	0.89	0.93	0.91	0.79	0.84	0.81	0.89	0.68	0.78	0.83
15	0.88	0.89	0.88	0.95	0.96	0.96	0.82	0.89	0.85	0.96	0.70	0.83	0.88
30	1.02	1.02	1.02	1.27	1.28	1.28	1.28	0.89	1.08	1.07	0.82	0.94	1.08
Mean	0.92	0.91	0.92	1.04	1.06	1.05	0.96	0.87	0.92	0.97	0.73	0.85	0.93
ɔttukonam (V2)													
0	0.91	0.93	0.91	0.81	0.80	0.80	0.97	0.83	0.90	0.86	0.71	0.78	0.84
15	1.02	1.02	1.02	0.95	0.88	0.91	1.02	0.89	0.95	0.96	0.75	0.86	0.93
30	1.07	1.08	1.08	1.03	1.08	1.05	1.07	1.09	1.08	1.03	1.02	1.02	1.05
Mean	1.00	1.01	1.00	0.93	0.92	0.92	1.02	0.94	0.98	0.95	0.83	0.89	0.94

Acidity of Neelum mango chunks stored at ambient condition ranged between 0.68 to1.28 per cent while that of Kottukonam, it ranged between 0.71 to1.09 respectively.

While comparing the two varieties of mango chunks stored at ambient condition, it was observed that variety Kottukonam had higher acidity (0.95), while the variety Neelum had an acidity of 0.94 per cent. The results indicated negligible difference in acidity between the two varieties of mango chunks and the difference was not significant statistically. The maximum acidity was noticed in Neelum T_2UB and T_3B (1.28). It was observed that chunks formulated with variety Kottukonam were found to be more acidic when compared with chunks formulated with variety Neelum.

Significant difference was observed in the acidity of the mango chunks with various treatments tried out in the study .The highest acidity was observed for Neelum T_2 and T_3 (1.28). Treatment T_4 of Neelum and Kottukonam varieties were found to be less acidic (0.78).

Acidity of the mango chunks was found to be increased as a result of storage at ambient condition and it ranged between 0.68 to 1.28 per cent in Neelum mango chunks when compared with Kottukonam mango chunks (0.71 to1.09).

The acidity and storage period had direct impact on each other. A comparison of mean values revealed that acidity was found to be increased as storage period increased. Statistical analysis of the data revealed that the difference was found to be significant ($F_{2, 96} = 889.38^{**}$).

Data pertaining to acidity of mango chunks as a result of blanching revealed that blanched chunks had higher acidity when compared with unblanched chunks and was found to be significant statistically.

Significant interaction was also observed between condition and storage period ($F_{2,96}$ = 13.85**), variety and storage period ($F_{2,96}$ = 4.31*), condition and treatment ($F3_{,96}$ = 5.04**), variety and treatment ($F_{3,96}$ = 74. 05**) and storage period and treatment ($F_{6,96}$ = 10.18**).

4.3.4Total sugar

The total sugar in different fruits varies from 3 to 18 per cent and is composed of different proportions of mixture of sucrose, fructose and glucose (Boss and Mitra, 1990).

Table 6(a) and 6(b) depicts the changes in total sugar for Neelum and Kottukonam mango chunks stored at ambient and refrigerated conditions respectively.

Initial mean total sugar content of Neelum and Kottukonam mango chunks stored at ambient condition was recorded as 14.53 and 13.06 respectively. The highest total sugar content (17.29) was recorded in Neelum T_3UB while the lowest (12.30) in Kottukonam T_2 B .Comparison of mean values of two varieties of mango revealed that variety Neelum (14.93) had a higher total sugar content when compared with variety kottukonam (13.49) and the difference was found to be significant statistically.

Table: 6 (a) Changes in Total sugar of mango chunks stored at ambient condition (A.C) in percentage.

riety / Duration (days)	Treatments												
	T_1			T_2			T_3			T_4			Mean of treatments
	B	UB	Mean	B	UB	Mean	B	UB	Mean	B	UB	Mean	
Neelum (V_1)													
0	12.70	13.15	12.92	14.15	13.51	13.83	15.62	15.63	15.63	15.70	15.83	15.76	14.53
15	13.70	14.85	14.27	15.65	14.38	15.01	16.48	16.60	16.54	15.91	16.00	15.95	15.44
30	14.25	16.13	15.19	16.12	16.61	16.36	17.24	17.29	17.27	16.84	16.89	16.86	16.42
Mean	13.55	14.71	14.13	15.30	14.83	15.06	16.44	16.50	16.47	16.15	16.24	16.19	15.46
ottukonam (V_2)													
0	12.47	12.66	12.56	12.30	12.84	12.57	13.67	13.49	13.55	13.47	13.69	13.58	13.06
15	13.14	13.15	13.14	13.17	13.70	13.44	14.69	14.50	14.60	14.65	14.70	14.68	13.96
30	14.70	14.24	14.47	15.25	14.70	14.98	15.63	15.29	15.46	16.13	16.29	16.21	15.28
Mean	13.43	13.55	13.39	13.57	13.74	13.65	14.64	14.42	14.53	14.75	14.89	14.82	14.09

Table: 6 (b) Changes in Total sugar content of mango chunks stored at Refrigerated condition (R.C) in percentage.

riety / Duration (days)	Treatments												
	T_1			T_2			T_3			T_4			Mean of treatments
	B	UB	Mean	B	UB	Mean	B	UB	Mean	B	UB	Mean	
Neelum (V_1)													
0	12.55	13.05	12.80	13.88	13.51	13.70	15.12	15.53	15.32	15.70	15.76	15.73	14.38
15	12.66	13.18	12.92	13.97	13.65	13.81	15.23	15.64	15.44	14.28	15.83	15.06	14.30
30	12.75	13.34	13.05	14.25	13.79	14.02	15.36	15.76	15.55	14.66	15.91	15.27	14.47
Mean	12.65	13.19	12.92	14.03	13.65	13.84	15.23	15.65	15.44	14.87	15.83	15.35	14.38
ottukonam (V_2)													
0	12.22	12.32	12.27	12.08	12.06	12.07	13.27	13.45	13.36	13.47	13.51	13.49	12.79
15	12.26	12.43	12.35	11.77	12.16	11.96	13.37	13.67	13.52	13.55	13.63	13.59	12.85
30	12.36	12.56	12.46	11.90	12.30	12.10	13.48	13.77	13.62	13.63	13.75	13.69	12.96
Mean	12.28	12.43	12.35	11.91	12.17	12.04	13.37	13.63	13.5	13.55	13.63	13.59	12.87

Mean Values :

Variety	**Condition**	**Duration**	**Blanching**	**Treatments**	
V_1 = 14.93	AC = 14.78	0 = 13.70	B = 14.11	T_1 = 13.20	T_2 = 13.65
V_2 = 13.49	RC = 13.63	15 = 14.14	UB = 14.30	T_3 = 14.99	T_4 = 14.99
		30 = 14.78			
$F_{1, 96}$= 2439.28**	$F_{1, 96}$ = 1568.29**	$F_{2, 96}$ = 469.51**	$F_{1, 96}$ = 43.88**	$F_{3, 96}$= 997.49**	
CD =0.0580	CD = 0.0580	CD = 0.0710	CD = 0.0580	CD = 0.0820	

** Denotes Significance of F at p =0.01

Storage condition was found to have significant influence on the total sugar content of the mango chunks stored under study. The mango chunks stored under ambient condition depicted higher increase in total sugar content (14.78) when compared to chunks stored under refrigerated condition (13.63).

Storage period was also found to influence the total sugar content of the mango chunks. The total sugar content of mango chunks increased from 13.70 per cent to 14.78 per cent at the end of 30 days of storage. It was noticed that sugar content was getting increased significantly as the storage period increased.

Significant difference in total sugar content was observed with respect to various treatments. Treatment T_4 had experienced higher total sugar content (14.99) while treatment T_1 had the lowest value (13.20). Mean values revealed that treatments T_1, T_2 and T_3 differ significantly in sugar content during storage but there was no difference in total sugar content between T_3 and T_4.

The total sugar content of mango chunks decreased significantly as a result of blanching. The sugar content was found to be more in un blanched samples.

Significant interaction was observed between variety and treatment. The mean value of total sugar content of Neelum variety for various treatments were 14.13 per cent in T_1, 15.06 per cent in T_2,16.47 per cent inT_3 and16.19 per cent in T_4 where as the mean values of Kottukonam chunks were found to be 13.39 per cent in T_1, 13.65 per cent in T_2, 14.53 per cent in T_3 and 14.82 per cent in T_4, respectively. The study revealed that variety and treatments affected the total sugar content of mango chunks during storage.

Significant interaction was also observed between storage period and condition ($F_{2,96}$ = 362.49**), variety and storage period ($F_{2,96}$ = 4.65**), condition and treatment ($F_{3,96}$ = 10.06**), variety and treatment ($F_{3,96}$ = 90.16**) and treatment and storage period ($F_{6,96}$ = 6.13**).

4.3.5 Reducing sugar

Changes in reducing sugar content of mango chunks stored at ambient and refrigerated condition is detailed in Table 7(a) and 7(b) respectively.

As indicated in table, mean values of reducing sugar content of mango chunks stored at ambient condition ranged between 5.30 to 7.11 per cent while it ranged between 4.89 to 6.66 per cent when stored at refrigerated condition. The highest level of reducing sugar content was observed in Neelum at ambient condition T_3UB (7.11) and lowest in Kottukonam at refrigerated condition T_1 UB (4.89).

While comparing the mean values, a significant difference was observed between the varieties with respect to reducing sugar content. The variety Neelum had higher reducing sugar content (6.08) when compared to variety Kottukonam (5.78),

A significant difference was observed between blanched and un blanched mango chunks in the case of reducing sugar content.

The mean values of blanched mango chunks was 5.96 per cent while that of unblanched chunks, it was 5.90 per cent. The data revealed that reducing sugar content was increased as a result of blanching. Data regarding the storage period of mango chunks also revealed a significant difference. Mean values of reducing sugar content revealed that the initial sugar content of 5.81 per cent had increased to 5.92

Table: 7 (a) Changes in Reducing sugar content of mango chunks stored at ambient condition (A.C) in percentage.

riety / Duration (days)	Treatments												
	T_1			T_2			T_3			T_4			Mean of treatments
	B	UB	Mean	B	UB	Mean	B	UB	Mean	B	UB	Mean	
Neelum (V_1)													
0	5.44	5.30	5.37	5.90	6.00	5.95	6.60	5.99	6.29	6.50	6.56	6.53	6.03
15	5.58	5.37	5.47	6.01	6.14	6.07	6.94	6.16	6.55	6.62	6.97	6.79	6.22
30	5.77	5.43	5.61	6.11	6.23	6.17	7.05	6.25	6.65	6.84	7.11	6.97	6.35
Mean	5.69	5.36	5.48	6.00	6.12	6.06	6.86	6.13	6.49	6.65	6.88	6.76	6.19
ottukonam (V_2)													
0	5.30	5.41	6.97	6.14	5.61	5.67	5.77	5.77	5.77	6.15	6.07	6.11	6.13
15	5.37	5.48	6.11	6.23	5.67	5.73	5.82	5.89	5.85	6.25	6.18	6.21	5.97
30	5.89	5.94	6.00	6.12	6.87	6.46	6.15	6.33	6.24	6.41	6.28	6.34	6.26
Mean	5.52	5.61	5.56	5.86	6.05	5.95	5.91	5.99	5.95	6.27	6.17	6.22	5.92

Table: 7 (b) Changes in reducing sugar content of mango chunks stored at Refrigerated condition (R.C) in percentage.

riety / Duration (days)	Treatments												
	T_1			T_2			T_3			T_4			Mean of treatments
	B	UB	Mean	B	UB	Mean	B	UB	Mean	B	UB	Mean	
Neelum (V_1)													
0	5.36	5.23	5.30	5.71	5.77	5.74	5.95	6.03	5.99	6.51	6.53	6.51	5.88
15	5.41	5.35	5.38	5.75	5.84	5.80	6.06	6.12	6.09	6.57	6.60	6.58	5.96
30	5.49	5.41	5.45	5.86	5.91	5.88	6.10	6.27	6.19	6.63	6.66	6.64	6.03
Mean	5.42	5.33	5.37	5.77	5.84	5.80	6.03	6.14	6.08	6.57	6.59	6.58	5.95
ottukonam (V_2)													
0	5.30	4.89	5.09	5.59	5.50	5.54	5.61	5.65	5.63	6.05	6.22	6.13	5.59
15	5.40	4.90	5.15	5,66	5.57	5.61	5.69	5.71	5.70	6.16	6.30	6.23	5.62
30	5.44	5.07	5.26	5.72	5.63	5.67	5.79	5.76	5.77	6.20	6.36	6.28	5.74
Mean	5.38	4.95	5.16	5.65	5.56	5.60	5.70	5.70	5.70	6.09	6.21	6.15	5.65

Mean Values :

Variety	**Condition**	**Duration**	**Blanching**	**Treatments**	
V_1 = 6.08	AC = 6.04	0 = 5.81	B = 5.96	T_1 = 5.40	T_2 = 5.82
V_2 = 5.78	RC = 5.82	15 = 5.92	UB = 5.90	T_3 = 6.06	T_4 = 6.44
		30 = 6.06			
$F_{1, 96}$ = 177.41**	$F_{1, 96}$ = 96.99**	$F_{2, 96}$ = 40.36**	$F_{1, 96}$ = 6.08*	$F_{3, 96}$ = 367.51**	
CD =0.0456	CD = 0.0456	CD = 0.0559	CD =0.0456	CD = 0.0645	

* Denotes Significance of F at p = 0.05
** Denotes Significance of F at p = 0.01

per cent after15 days of storage and 6.06 per cent after 30 days of storage. It was observed that the reducing sugar content was found to be increased as the storage period increased.

Statistical analysis of the data on reducing sugar content revealed that both Neelum and Kottukonam mango chunks stored at ambient and refrigerated conditions were found to be significant. Mango chunks stored at ambient condition had a reducing sugar content of 6.04 per cent while that of chunks stored at refrigerated condition had reducing sugar content of 5.82 per cent. The data revealed that reducing sugar content was more when chunks stored at ambient condition.

Data on reducing sugar content of mango chunks stored with respect to various treatments revealed that T_1, T_2, T_3 and T_4 differ significantly.

Significant interaction was observed between treatments and storage period with respect to reducing sugar. The reducing sugar content was increased as storage period advanced. After a storage of 30 days the mean values of reducing sugar content of mango chunks stored at refrigerated condition for various treatments T_1, T_2, T_3 and T_4 were 5.37 per cent, 5.80 per cent, 6.08 per cent and 6.58 per cent in Neelum and 5.16 per cent, 5.60 per cent, 5.70 per cent and 6.15 per cent in Kottukonam chunks respectively.

Interaction was also observed between storage condition and treatment ($F_{3,96} = 4.51^{**}$), storage period and storage condition ($F_{2,96} = 6.64^{**}$), and variety and treatment ($F_{3,96} = 17.62^{**}$).

4.3.6 Total Phenol

Table 8(a) and 8(b) represents the changes in total phenol content of store mango chunks.

Significant difference was noticed in total phenol content of mango chunks of both the varieties. The variety Neelum had higher phenol content (13.49 µg/100g) as compared to variety Kottukonam (12.11 µg/100g) when stored for a period of 30 days.

Total phenol content of mango chunks of both varieties when stored under two different storage conditions was found to increase significantly. Phenol content ranged from 11.45 to 17.59 µg/100g in Neelum chunks and 9.83 to 15.32 µg/100g in Kottukonam chunks stored under ambient condition whereas it ranged from 10.41 to 15.60 µg/100g in Neelum and 10.00 to 15.13 µg/100g in Kottukonam chunks stored under refrigerated condition.

The mean values of phenol content revealed that phenol content was reduced when chunks were stored in refrigerated condition. Blanching of mango chunks with respect to phenol content revealed that unblanched chunks had higher phenol (13.00) content when compared with blanched chunks (12.61). Blanching of mango chunks decreased the phenol content significantly.

Significant difference was also observed in phenol content with respect to storage period. Phenol content of mango chunks decreased at the end of 15 days of storage to 12.89 µg from an initial value of 13.11µg (at 0 days) and again decreased to 12.41 µg/100g at the end of 30 days. The study revealed that phenol content is getting decreased as storage period increased.

Table: 8 (a) Changes in Total phenol of mango chunks stored at ambient condition (A.C)in microgram

riety / Duration (days)	Treatments												
	T_1			T_2			T_3			T_4			Mean of treatments
	B	UB	Mean	B	UB	Mean	B	UB	Mean	B	UB	Mean	
Neelum (V_1)													
0	16.40	15.40	15.90	13.40	12.90	13.15	17.59	13.81	15.70	14.38	12.61	13.50	14.56
15	16.06	14.98	15.52	13.61	12.80	13.20	17.40	13.51	15.45	14.10	12.10	13.10	14.31
30	15.75	14.33	15.04	12.98	12.05	12.51	16.98	13.07	15.02	13.70	11.45	12.58	13.78
Mean	16.07	14.90	15.48	13.33	12.58	12.95	17.32	13.46	15.39	14.06	12.05	13.06	14.21
ottukonam (V_2)													
0	10.57	13.91	12.24	11.10	15.32	13.20	13.00	12.38	12.69	11.10	12.41	11.75	12.47
15	10.41	13.80	12.11	10.79	15.05	12.92	12.78	12.06	12.42	10.80	12.08	11.44	12.22
30	9.83	12.75	11.29	10.00	14.49	12.24	12.41	11.70	12.05	10.07	11.92	11.00	11.64
Mean	10.27	13.48	11.88	10.63	14.95	12.78	12.73	12.04	12.38	10.65	12.13	11.39	12.11

Table: 8 (b) Changes in Total phenol of mango chunks stored at refrigerated condition (R.C) in microgram

Variety / Duration (days)	Treatments												
	T_1			T_2			T_3			T_4			Mean of treatments
	B	UB	Mean	B	UB	Mean	B	UB	Mean	B	UB	Mean	
Neelum (V_1)													
0	13.99	15.60	14.80	11.06	14.72	12.89	11.41	11.90	11.65	12.90	13.10	13.00	13.08
15	13.73	15.25	14.50	10.88	14.55	12.72	11.24	11.30	11.27	12.70	12.88	12.79	12.82
30	12.50	15.13	13.82	10.41	14.05	12.23	11.00	10.70	10.85	12.55	12.65	12.60	12.37
Mean	13.40	15.32	14.37	10.78	14.44	12.61	11.21	11.30	11.25	12.71	12.87	12.79	12.75
Kottukonam (V_2)													
0	12.50	10.56	11.53	10.80	15.13	12.96	11.81	10.99	11.40	14.51	12.33	13.42	12.32
15	12.35	10.50	11.43	10.50	15.11	12.81	11.80	10.75	11.27	14.21	12.25	13.23	12.18
30	12.10	10.15	11.13	10.00	15.00	12.50	11.00	10.35	10.68	14.09	12.05	13.07	11.84
Mean	12.31	10.40	11.36	10.43	15.08	12.75	11.53	10.69	11.11	14.27	12.21	13.24	12.11

Mean Values :

Variety	**Condition**	**Duration**	**Blanching**	**Treatments**	
V_1 = 13.49	AC = 13.17	0 = 13.11	B = 12.61	T_1= 13.27	T_2 = 12.78
V_2 = 12.11	RC = 12.44	15 = 12.89	UB = 13.00	T_3= 12.54	T_4 = 12.62
		30 = 12.41			
$F_{1, 96}$ = 3787.89**	$F_{1, 96}$ = 1061.29**	$F_{2, 96}$= 339.62**	$F_{1, 96}$ = 300.70**	$F_{3, 96}$ = 216.62**	
CD = 0.0445	CD = 0.0445	CD = 0.0545	CD = 0.0445	CD = 0.0629	

** Denotes Significance of F at p =0.01

Phenol content of mango chunks with respect to treatments revealed that all the four treatments of mango chunks T_1, T_2, T_3 and T_4 differ significantly each other. Treatment T_1 had observed maximum phenol content (13.27) while the lowest phenol content was observed in T_3 (12.54).

Significant interaction in phenol content was observed between variety and treatment ($F_{3,96}$ = 1039.71**), treatments and storage period ($F_{6,96}$ = 2.46*), treatment and storage condition ($F_{3,96}$ = 1084.39**), and condition and variety ($F_{1,96}$ = 1080.67**).

4.4 Organoleptic qualities of stored mango chunks

The overall quality of a food depends on the nutritional and other hidden attributes and sensory quality is assessed by means of human sensory organs. When the quality of a food product is assessed by means of human sensory organs, the evaluation is said to be sensory or organoleptic.

According to Cottet et al. (2007) sensory analysis is a technique that uses man as a measuring instrument. Numerical scoring test is used to evaluate particular characteristics of one or more samples indicating the rating as excellent, very good ,good, fair and poor (Manay and Swamy, 2002)).

Sensory quality is a combination of different senses of perception coming in to play in choosing and eating a food .The effective characteristic is not the property of the food, but the subject's reaction to the sensory qualities of foods (Srilakshmi, 2003).

4.4.1 Appearance

Table 9(a) and 9(b) depicts the mean score obtained for the quality attribute appearance.

The first impression of food is usually visual and major part of willingness to accept a food depends upon its appearance.

The mean score obtained for the quality attribute appearance ranged between 3.88 to 4.44 in Neelum mango chunks and 4.33to 4.64 in Kottukonam chunks respectively. A significant difference existed in the quality attribute appearance between the two varieties of mango ($F_{1, 384}$=27.73**).

Mean values of the two varieties revealed that Kottukonam mango chunks had bagged maximum score for appearance (4.48) as compared to Neelum chunks(4.22)

.

The study revealed that appearance of unblanched mango chunks was more acceptable (4.41).

Data on appearance of mango chunks with regard to treatments found that there was a significant difference in the mango chunks of Neelum and Kottukonam varieties in all the treatments ($F_{1,384}$=3.47*).

With regard to storage period of mango chunks, the study revealed a decrease in the quality attribute appearance at the end of 30 days storage.

Table : 9 (b) Appearance of mango chunks stored at refrigerated condition

Variety	Duration (days)	Treatments												
		T_1		Mean	T_2		Mean	T_3		Mean	T_4		Mean	Mean of treatments
		B	UB		B	UB		B	UB		B	UB		
Neelum	0	4.50	4.50	4.50	4.40	4.32	4.36	4.22	4.52	4.37	4.42	4.42	4.42	4.41
	15	4.50	4.50	4.50	4.40	4.32	4.36	4.22	4.52	4.37	4.42	4.42	4.42	4.41
	30	4.48	4.64	4.56	4.30	4.24	4.27	4.32	4.46	4.39	4.42	4.66	4.54	4.44
Mean		4.49	4.54	4.51	4.36	4.29	4.33	4.25	4.50	4.37	4.42	4.50	4.46	4.42
Kottukonam	0	4.66	4.66	4.66	4.52	4.48	4.50	4.74	4.54	4.64	4.78	4.74	4.76	4.64
	15	4.66	4.66	4.66	4.52	4.48	4.50	4.74	4.54	4.64	4.78	4.74	4.76	4.64
	30	4.66	4.66	4.66	4.52	4.48	4.50	4.74	4.54	4.64	4.78	4.74	4.76	4.64
Mean		4.66	4.66	4.66	4.52	4.48	4.50	4.74	4.54	4.64	4.78	4.74	4.76	4.64

Mean Values:

Variety	**Condition**	**Duration**	**Blanching**	**Treatments**	
V_1 = 4.22	AC = 4.18	0 =4.37	B = 4.30	T_1 = 4.32	T_2 = 4.24
V_2 = 4.48	RC = 4.53	15 = 4.37	UB =4.41	T_3 = 4.43	T_4 = 4.43
		30 =4.32			
$F_{1, 384}$ = 27.73**	$F_{1, 384}$ = 50.65**	$F_{2, 384}$ = 0.42	$F_{1384,}$ = 5.08*	$F_{3, 384}$ = 3.47*	
CD =0.0971	CD = 0.0971	CD = 0.1189	CD = 0.0971	CD = 0.1373	

* Denotes Significance of F at p= 0.05
** Denotes Significance of F at p = 0.01

The mango chunks stored at refrigerated condition was found to be more appealing (4.53) as compared to chunks stored at ambient condition (4.18) and was found to be significant statistically($F_{1,384}$ = 50.65**).

4.4.2 Colour

Colour of foods serves as a useful criterion for measurement of its quality. In addition to giving pleasure, the colour of food is associated with other attributes e.g. ripeness (red colour), sourness(green colour). Colour is also used as an index to the quality of a number of foods.

Table 10(a) and 10(b) shows mean score obtained for quality attribute colour. The score ranged between 3.93 to 4.44 in Neelum and 4.02 to 4.08 in Kottukonam mango chunks respectively. Neelum chunks had scored maximum mean score (4.15) as compared to Kottukonam chunks (4.03). The quality attributes colour differ significantly between the two variety of mango ($F_{1,384}$=9.45**).

Like appearance mean score of colour of unblanched mango chunks was more acceptable.

Data on attribute colour with respect to storage period revealed that colour score of mango chunks was decreased from an initial value of 4.11 to 4.08 during storage. There was no change in colour score during 15 and 30 days of storage.

Mango chunks stored at refrigerated condition bagged highest score (4.20) with respect to colour as compared to chunks stored at ambient condition (3.98). The study revealed a significant difference ($F_{1, 384}$ = 34.11**) in colour of the mango chunks during storage at ambient and refrigerated condition.

Table: 10 (a) Colour of mango chunks stored at ambient condition

Variety	Duration (days)	Treatments												
		T_1		Mean	T_2		Mean	T_3		Mean	T_4		Mean	Mean of treatments
		B	UB		B	UB		B	UB		B	UB		
Neelum	0	3.82	3.80	3.81	3.88	3.96	3.92	3.92	3.80	3.86	4.02	4.28	4.15	3.94
	15	3.82	3.78	3.80	3.86	4.00	3.93	3.90	3.78	3.84	4.04	4.28	4.16	3.93
	30	3.82	3.78	3.80	3.86	4.00	3.93	3.90	3.78	3.84	4.04	4.28	4.16	3.93
Mean		3.82	3.78	3.80	3.86	3.98	3.92	3.90	3.78	3.84	4.03	4.28	4.15	3.93
Kottukonam	0	4.14	3.96	4.05	4.24	3.90	4.07	4.14	4.08	4.11	4.00	4.02	4.01	4.06
	15	3.98	4.04	4.01	4.14	3.86	4.00	4.04	4.06	4.05	3.98	4.02	4.00	4.02
	30	3.98	4.04	4.01	4.14	3.86	4.00	4.04	4.06	4.05	3.98	4.02	4.00	4.02
Mean		4.03	4.01	4.02	4.17	3.87	4.02	4.07	4.06	4.07	3.98	4.02	4.00	4.03

Table : 10 (b) Colour of mango chunks stored at refrigerated condition

Variety	Duration (days)	Treatments												
		T_1		Mean	T_2		Mean	T_3		Mean	T_4		Mean	Mean of treatments
		B	UB		B	UB		B	UB		B	UB		
Neelum	0	4.30	4.46	4.38	4.16	4.30	4.23	4.40	4.28	4.54	4.26	4.32	4.29	4.36
	15	4.30	4.46	4.38	4.16	4.30	4.23	4.40	4.68	4.54	4.26	4.32	4.29	4.44
	30	4.30	4.46	4.38	4.16	4.30	4.23	4.40	4.28	4.54	4.26	4.32	4.29	4.36
Mean		4.30	4.60	4.38	4.36	4.30	4.33	4.40	4.41	4.54	4.26	4.32	4.29	4.38
Kottukonam	0	4.06	4.26	4.16	4.00	4.00	4.00	4.14	4.12	4.13	3.96	4.08	4.02	4.08
	15	3.98	4.04	4.01	4.14	3.86	4.00	4.04	4.06	4.05	3.98	4.02	4.00	4.02
	30	3.98	4.04	4.01	4.14	3.86	4.00	4.04	4.06	4.05	3.98	4.02	4.00	4.02
Mean		4.00	4.11	4.06	4.09	3.90	4.00	4.07	4.10	4.07	3.97	4.04	4.00	4.04

Mean Values:

Variety	**Condition**	**Duration**	**Blanching**	**Treatments**	
$V_1 = 4.15$	AC = 3.98	0 =4.11	B = 4.01	$T_1 = 4.07$	$T_2 = 4.05$
$V_2 = 4.03$	RC = 4.20	15 = 4.08	UB =4.11	$T_3 = 4.13$	$T_4 = 4.11$
		30 =4.08			
$F_{1, 384} = 9.45$**	$F_{1, 384} = 34.11$**	$F_{2, 384} = 0.25$	$F_{1, 384} = 0.88$	$F_{3, 384} = 1.22$	
CD =0.0726	CD = 0.0726	CD = 0.0889	CD = 0.0726	CD = 0.1026	

** Denotes Significance of F at p = 0.01

4.4.3 Flavour

The flavour of a food or beverage is not perceived in a single event, but rather as a series of events experienced as the food is consumed. (Piggot and Schaschke, 2001). Flavour is the combination of taste and smell. Taste includes sweet, salty, and sour characteristics in a product, while smell is identified as fragrant, acidic and burnt etc due to enzymatic, physiological or chemical changes. Odour preference is generalized by stimulation of the sensory cells by specific volatile compounds present in the food.

Mean values of the quality attribute flavour of the two varieties of mango chunks revealed that flavour was found to be more in Kottukonam chunks (3.99) as compared to Neelum chunks (3.92) as depicted in table 11(a) and 11(b) respectively.

Like colour and appearance, flavour was retained maximum in unblanched mango chunks (4.00) as compared to blanched ones (3.92) and found to be significant statistically($F_{1, 384}$=3.98*).

Data on quality attribute flavour with respect to treatments revealed that there was a significant difference in mango chunks in all the treatments ($F_{3, 384}$ = 4.62**). Treatments T_1 and T_2, T_1 and T_3 and T_2 and T_3 were on par with each other.

The study revealed that flavour of mango chunks decreased as storage period increased. The flavour was enhanced when chunks were stored at refrigerated condition (4.03) as compared to chunks stored at ambient condition (3.88).

Table : 11 (a) Flavour of mango chunks stored at ambient condition

Variety	Duration (days)	Treatments												
		T_1		Mean	T_2		Mean	T_3		Mean	T_4		Mean	Mean of treatments
		B	UB		B	UB		B	UB		B	UB		
Neelum	0	3.56	3.62	3.59	3.58	3.64	3.61	3.60	3.86	3.73	3.74	3.86	3.80	3.68
	15	3.58	3.60	3.59	3.62	3.60	3.61	3.64	3.84	3.74	4.02	3.92	3.97	3.72
	30	3.58	3.70	3.64	3.64	3.60	3.62	3.72	3.82	3.77	4.02	3.92	3.97	3.75
Mean		3.57	3.64	3.60	3.61	3.61	3.61	3.65	3.84	3.74	3.92	3.90	3.91	3.71
Kottukonam	0	4.10	4.00	4.05	4.14	4.04	4.09	4.16	4.14	4.15	4.02	4.18	4.10	4.09
	15	3.92	3.80	3.86	4.02	3.98	4.00	4.12	4.12	4.12	4.02	4.18	4.10	4.02
	30	3.92	3.80	3.86	4.02	3.98	4.00	4.12	4.12	4.12	4.02	4.18	4.10	4.02

Table : 11 (b) Flavour of mango chunks stored at refrigerated condition

Variety	Duration (days)	Treatments												
		T_1		Mean	T_2		Mean	T_3		Mean	T_4		Mean	Mean of treatments
		B	UB		B	UB		B	UB		B	UB		
Neelum	0	4.10	4.18	4.14	3.92	4.20	4.06	3.92	4.10	4.01	4.22	4.32	4.27	4.12
	15	4.10	4.18	4.14	3.92	4.20	4.06	3.92	4.10	4.01	4.22	4.32	4.27	4.12
	30	4.10	4.18	4.14	3.92	4.20	4.06	3.92	4.10	4.01	4.22	4.32	4.27	4.12
Mean		4.10	4.18	4.14	3.92	4.20	4.06	3.92	4.10	4.01	4.22	4.32	4.27	4.12
Kottukonam	0	3.94	4.10	4.02	4.02	4.10	4.06	4.04	4.04	4.04	4.02	4.20	4.11	4.05
	15	3.80	3.76	3.78	3.82	4.00	3.91	3.84	3.82	3.83	3.84	4.20	4.02	3.88
	30	3.80	3.76	3.78	3.82	4.00	3.91	3.84	3.82	3.83	3.84	4.20	4.02	3.88
Mean		3.84	3.87	3.86	3.88	4.03	3.96	3.90	3.89	3.90	3.90	4.20	4.05	3.93

Mean Values :

Variety	**Condition**	**Duration**	**Blanching**	**Treatments**	
$V_1 = 3.92$	AC = 3.88	0 = 3.99	B = 3.92	$T_1 = 3.88$	$T_2 = 3.92$
$V_2 = 3.99$	RC = 4.03	15 = 3.94	UB = 4.00	$T_3 = 3.95$	$T_4 = 4.08$
		30 = 3.94			
$F_{1, 384} = 3.32^*$	$F_{1, 384} = 13.15^{**}$	$F_{2, 384} = 0.65$	$F_{1, 384} = 3.98^*$	$F_{3, 384} = 4.62^{**}$	
CD =0.0804	CD = 0.0804	CD = 0.0984	CD = 0.0804	CD = 0.1137	

* Denotes Significance of F at p = 0.05
** Denotes Significance of F at p =0.01

4.4.4 Texture

Texture is a predisposing factor that determines the quality of the processed product.

Table 12(a) and 12(b) reveals mean score obtained for quality attribute texture.

Texture of Kottukonam chunks (3.98) was found to be good as compared to Neelum chunks (3.87).

The study revealed that there was no significant change in texture of mango chunks as the storage period increased from 0 to 30 days.

The texture of mango chunks stored at ambient condition was found to be better (3.93) as compared to chunks stored at refrigerated condition (3.91).

Statistical analysis revealed that a significant difference was noticed in quality attribute texture between the two varieties of mango ($F_{2, 384} = 8.66^{**}$).

`4.4.5 Taste

The mean score obtained for the quality attribute taste ranged between 3.58 to 4.47 in Neelum and 3.88 to 4.59 in Kottukonam chunks respectively as indicated in table 13(a) and 13(b).

Table: 12 (a) Texture of mango chunks stored at ambient condition

Variety	Duration (days)	Treatments												
		T_1		Mean	T_2		Mean	T_3		Mean	T_4		Mean	Mean of treatments
		B	UB		B	UB		B	UB		B	UB		
Neelum	0	3.82	3.98	3.90	3.70	3.96	3.83	3.96	3.74	3.85	3.78	4.02	3.90	3.77
	15	3.82	3.98	3.90	3.70	3.96	3.83	3.96	3.74	3.85	3.78	4.02	3.90	3.87
	30	3.82	3.98	3.90	3.70	3.96	3.83	3.96	3.74	3.85	3.78	4.02	3.90	3.87
Mean		3.55	3.98	3.76	3.70	3.96	3.83	3.96	3.74	3.85	3.78	4.02	3.90	3.83
Kottukonam	0	4.04	4.0	4.02	3.94	4.06	4.00	3.92	4.00	3.96	3.96	4.02	3.99	3.99
	15	4.04	4.0	4.02	3.94	4.06	4.00	3.92	4.00	3.96	3.96	4.02	3.99	3.99
	30	4.04	4.0	4.02	3.94	4.06	4.00	3.92	4.00	3.96	3.96	4.02	3.99	3.99
Mean		4.04	4.0	4.02	3.94	4.06	4.00	3.92	4.00	3.96	3.96	4.02	3.99	3.99

Table 12 (b) Texture of mango chunks stored at refrigerated condition

Variety	Duration (days)	Treatments												
		T_1		Mean	T_2		Mean	T_3		Mean	T_4		Mean	Mean of treatments
		B	UB		B	UB		B	UB		B	UB		
Neelum	0	3.74	3.88	3.81	3.64	3.92	3.78	3.92	3.92	3.92	3.86	4.04	3.95	3.86
	15	3.74	3.88	3.81	3.64	3.92	3.78	3.92	3.92	3.92	3.86	4.04	3.95	3.86
	30	3.74	3.88	3.81	3.62	3.84	3.73	3.92	4.00	3.96	3.90	4.04	3.97	3.87
Mean		3.74	3.88	3.81	3.65	3.89	3.77	3.92	3.94	3.93	3.87	4.04	3.95	3.86
Kottukonam	0	4.04	3.96	4.00	3.96	4.06	4.01	3.94	3.80	3.87	3.96	3.98	3.97	3.96
	15	4.04	3.96	4.00	3.96	4.06	4.01	3.94	3.80	3.87	3.96	3.98	3.97	3.96
	30	4.04	3.96	4.00	3.96	4.06	4.01	3.94	3.80	3.87	3.96	3.98	3.97	3.96
Mean		4.04	3,96	4.00	3,96	4.06	4.01	3.94	3.80	3.87	3.96	3.98	3.97	3.96

Mean Values:

Variety	**Condition**	**Duration**	**Blanching**	**Treatments**	
V_1 = 3.87	AC = 3.93	0 = 3.92	B = 3.89	T_1 = 3.93	T_2 = 3.90
V_2 = 3.98	RC = 3.91	15 = 3.92	UB = 3.96	T_3 = 3.90	T_4 = 3.95
		30 = 3.92			
$F_{1, 384}$ = 8.66**	$F_{1, 384}$ = 0.20	$F_{2, 384}$ = N.S	$F_{1, 384}$ = 3.74	$F_{3, 384}$ = 0.46	
CD =0.0729	CD = 0.0729	CD = -	CD = 0.0729	CD = 0.1031	

** Denotes Significance of F at p - 0.01

Table -13 (a) Taste of the mango chunks stored at ambient condition

Variety	Duration (days)	Treatments												
		T_1		Mean	T_2		Mean	T_3		Mean	T_4		Mean	Mean of
		B	UB		B	UB		B	UB		B	UB		
Neelum	0	3.70	3.34	3.52	3.58	3.34	3.46	3.52	3.80	3.66	3.54	3.88	3.71	3.58
	15	3.80	3.70	3.75	3.70	3.50	3.60	3.80	3.80	3.80	3.54	3.88	3.71	3.71
	30	3.84	3.70	3.77	3.74	3.64	3.69	3.76	3.68	3.72	3.74	3.80	3.77	3.73
Mean		3.78	3.58	3.68	3.67	3.49	3.58	3.69	3.76	3.72	3.60	3.85	3.73	3.67
Kottukonam	0	3.74	3.94	3.84	3.76	3.96	3.86	3.96	3.84	3.90	3.94	3.96	3.95	3.88
	15	3.74	3.78	3.76	3.84	3.96	3.90	4.04	3.98	4.01	4.02	4.14	4.08	3.93
	30	3.74	3.78	3.76	3.84	3.96	3.90	4.04	3.98	4.01	4.02	4.14	4.08	3.93
Mean		3.74	3.83	3.78	3.81	3.96	3.88	4.01	3.93	3.97	3.99	4.08	4.03	3.91

Table :13 (b) Taste of the mango chunks stored at refrigerated condition

Variety	Duration (days)	Treatments												
		T_1		Mean	T_2		Mean	T_3		Mean	T_4		Mean	Mean of treatments
		B	UB		B	UB		B	UB		B	UB		
Neelum	0	4.30	4.50	4.40	4.38	4.46	4.42	4.62	4.46	4.54	4.30	4.58	4.44	4.45
	15	4.30	4.50	4.40	4.38	4.46	4.42	4.62	4.46	4.54	4.30	4.58	4.44	4.45
	30	4.46	4.72	4.59	4.26	4.68	4.47	4.54	4.68	4.61	4.50	4.54	4.52	4.47
Mean		4.35	4.57	4.43	4.34	4.53	4.37	4.59	4.53	4.56	4.36	4.56	4.46	4.45
Kottukonam	0	4.30	4.44	4.37	4.66	4.76	4.71	4.76	4.60	4.68	4.60	4.60	4.63	4.59
	15	4.08	4.08	4.08	3.98	4.10	4.04	4.10	4.08	4.09	4.02	4.10	4.06	4.06
	30	4.08	4.08	4.08	3.98	4.10	4.04	4.01	4.08	4.09	4.02	4.10	4.06	4.06
Mean		4.15	4.20	4.17	4.20	4.32	4.26	4.29	4.25	4.28	4.21	4.26	4.25	4.23

Mean Values:

Variety	**Condition**	**Duration**	**Blanching**	**Treatments**	
$V_1 = 4.08$	AC = 3.80	0 = 4.13	B = 4.05	$T_1 = 4.03$	$T_2 = 4.04$
$V_2 = 4.08$	RC = 4.36	15 = 4.04	UB = 4.11	$T_3 = 4.14$	$T_4 = 4.12$
		30 = 4.07			
$F_{1, 384} = 1.78$	$F_{1, 384} = 211.73$**	$F_{2, 384} = 1.78$	$F_{1, 384} = 2.10$	$F_{3, 384} = 2.05$	
CD =0.0929	CD = 0.0758	CD = 0.1313	CD = 0.1072	CD =0.1516	

** Denotes Significance of F at p = 0.01

On comparing the taste of two varieties of mango chunks stored, there was not much difference in the taste of two varieties of mango chunks.

Significant difference ($F_{1, 384}$=211.73**) was observed in the taste of mango chunks stored at refrigerated and ambient condition. The chunks stored at refrigerated condition was found to be good (4.36) as compared to chunks stored at ambient condition (3.80).

The study revealed that taste of mango chunks decreased as the storage period increased and the taste was found to be better in unblanched chunks (4.11) as compared to blanched chunks (4.05).

4.4.6 Overall acceptability

The overall acceptability of Neelum and Kottukonam chunks during storage at ambient and refrigerated condition is depicted in table 14(a) and 14(b) respectively.

Analysis of data revealed that there was a significant difference ($F_{3,384}$ =11.70**) in the overall acceptability of Neelum and Kottukonam mango chunks during storage. Kottukonam mango chunks had bagged maximum score (4.11) as compared to Neelum mango chunks (4.04).

Significant difference was noticed in the overall acceptability of mango chunks with respect to blanching ($F_{3,384}$ =7.50**) .Overall acceptability of unblanched mango chunks was more acceptable for the judges (4.11) when compared with blanched mango chunks (4.05).

Table: 14 (a) Over all acceptability of mango chunks stored at ambient condition

Variety/ Condition	Storage period (days)	Treatments												
		T_1		Mean	T_2		Mean	T_3		Mean	T_4		Mean	Mean of treatments
		B	UB		B	UB		B	UB		B	UB		
Neelum	0	3.78	3.73	3.75	3.71	3.76	3.73	3.80	3.86	3.83	3.80	4.01	3.90	3.80
	15	3.80	3.79	3.80	3.74	3.79	3.76	3.86	3.85	3.85	3.86	4.02	3.94	3.83
	30	3.82	3.80	3.81	3.76	3.80	3.78	3.83	3.78	3.80	3.89	4.00	3.95	3.83
Mean		3.78	3.77	3.78	3.73	3.78	3.75	3.83	3.83	3.82	3.85	4.01	3.93	3.82
ottukonam	0	4.04	4.00	4.02	4.02	4.11	4.06	4.12	4.06	4.09	4.04	4.19	4.12	4.07
	15	3.97	3.95	3.96	3.99	4.09	4.04	4.11	4.08	4.10	4.06	4.23	4.14	4.06
	30	3.97	3.95	3.96	3.99	4.09	4.04	4.11	4.08	4.10	4.06	4.23	4.14	4.06
Mean		3.87	3.85	3.86	3.84	3.91	3.88	3.95	3.93	3.94	3.93	4.09	4.01	3.92

Table: 14 (b) Overall acceptability of mango chunks stored at refrigerated condition

Variety	Storage period(days)	Treatments												
		T_1		Mean	T_2		Mean	T_3		Mean	T_4		Mean	Mean of treatments
		B	UB		B	UB		B	UB		B	UB		
Neelum	0	4.19	4.30	4.25	4.10	4.24	4.17	4.22	4.34	4.28	4.21	4.34	4.27	4.24
	15	4.19	4.30	4.25	4.10	4.24	4.17	4.22	4.34	4.28	4.21	4.34	4.27	4.24
	30	4.22	4.38	4.30	4.05	4.25	4.15	4.22	4.38	4.30	4.26	4.38	4.32	4.26
Mean		4.2	4.32	4.26	4.08	4.24	4.16	4.22	4.35	4.28	4.22	4.35	4.28	4.25
Kottukonam	0	4.20	4.28	4.24	4.23	4.28	4.26	4.32	4.22	4.27	4.26	4.33	4.30	4.26
	15	4.11	4.10	4.11	4.08	4.10	4.09	4.13	4.06	4.10	4.12	4.21	4.16	4.11
	30	4.11	4.10	4.11	4.08	4.10	4.09	4.13	4.06	4.10	4.12	4.21	4.16	4.11
Mean		4.17	4.25	4.21	4.10	4.20	4.15	4.20	4.25	4.23	4.20	4.30	4.25	4.21

Mean values:

Variety	**Condition**	**Duration**	**Blanching**	**Treatments**	
$V_1 = 4.04$	AC = 3.94	0 = 4.10	B = 4.05	$T_1 = 4.05$	$T_2 = 4.03$
$V_2 = 4.11$	RC = 4.21	15 = 4.06	UB = 4.11	$T_3 = 4.09$	$T_4 = 4.14$
		30 = 4.07			
$F_{1, 384} = 11.70$**	$F_{1, 384} = 138.23$**	$F_{2, 384} = 0.86$	$F_{1, 384} = 7.50$**	$F_{3, 384} = 4.99$**	
CD =0.0438	CD = 0.0438	CD = 0.0536	CD = 0.0438	CD = 0.0619	

** Denotes Significance of F at p = 0.01

Data on storage days of mango chunks also revealed a significant difference with respect to overall acceptability .The study revealed that overall acceptability of mango chunks decreased when the storage period increased.

Mean score of mango chunks stored at ambient and refrigerated condition revealed that there was a significant difference in the overall acceptability ($F_{1,384}$ =138.23**) .Overall acceptability was found to be higher in mango chunks stored at refrigerated condition (4.21) as compared to mango chunks stored at ambient condition (3.94).

A significant difference was also experienced in the in the overall acceptability of mango chunks with regard to treatments given ($F_{3,384}$ =4.19**). On comparing with CD values, treatments T_1, T_2, T_3 and T_4 differ significantly while treatments T_1 and T_2 and treatments T_1 and T_3 were on par.

4.5 Assessment of microbial profile of the stored mango chunks:

Microbial population in the processed foods is an important factor which determines the quality and safety of the product .When foods are processed, there are chances of contamination through various means and during the storage of the product, these microbes multiply and cause spoilage in the products. Hence assessment of microbial population of the products is an essential step in the development of new products.

Processing methods and addition of preservatives will reduce the microbial load of the products, which would enhance the keeping quality of the products.

Mango chunks formulated from the two varieties of mango were assessed for microbial contamination soon after it was prepared and were stored at ambient and refrigerated condition for a period of 30 days. At the end of 15 and 30 days they were again assessed for the changes in microbial load. The chunks were analyzed for bacteria, mould and yeast. The media used for the determination of bacteria, mould and yeast were nutrient agar and potato dextrose agar respectively.

Table 15(a) and 15(b) gives an account of microbes present in stored mango chunks.

Table-15(a) Microbial quality of mango chunks stored at ambient temperature

Variety	Treatments	No: of yeast and Mould colonies(cfu/g)	
		15 days Storage	30 days Storage
Neelum	T_1 B	02	04
	T_1 UB	04	06
	T_2 B	02	04
	T_2 UB	03	05
	T_3 B	04	08
	T_3 UB	05	07
	T_4 B	04	08
	T_4 UB	05	09
Kottukonam	T_1 B	02	04
	T_1 UB	02	06
	T_2 B	02	08
	T_2 UB	03	04
	T_3 B	02	06
	T_3 UB	03	04
	T_4 B	02	04
	T_4 UB	02	08

Table-15(b) Microbial quality of mango chunks stored at refrigerated condition

Variety	Treatments	No: of yeast and Mould colonies(cfu/g)	
		15 days Storage	30 days Storage
Neelum	T_1 B	Nil	02
	T_1 UB	Nil	04
	T_2 B	Nil	02
	T_2 UB	Nil	03
	T_3 B	Nil	02
	T_3 UB	Nil	04
	T_4 B	Nil	03
	T_4 UB	Nil	04
Kottukonam	T_1 B	Nil	02
	T_1 UB	Nil	Nil
	T_2 B	Nil	02
	T_2 UB	Nil	Nil
	T_3 B	Nil	Nil
	T_3 UB	Nil	Nil
	T_4 B	Nil	Nil
	T_4 UB	Nil	Nil

The results revealed that bacterial contamination was not detected in any of the samples stored at ambient and refrigerated condition up to a period of 30 days. However when samples were analyzed for yeast and mould, negligible contamination was observed at the end of 15 days and 30 days storage both in Neelum and Kottukonam varieties. The mean values of yeast and mould count of Neelum mango chunks increased from 02 to 05 cfu/g at the end of 15 days and 04 to 10 cfu/g at the end of 30 days.

In the case of Kottukonam chunks stored at ambient condition, the yeast and mould count ranged between 0 2 to 3 cfu/g and 04 to 08 cfu/g at the end of 15 and 30 days of storage respectively. Yeast and mould count was found to be less in

Kottukonam chunks as compared to Neelum chunks when stored at ambient condition.

Data on mango chunks stored at refrigerated condition revealed that yeast and mould count was not detected in any of the samples up to a period of 15 days. But at the end of 30 days, negligible contamination was noticed in variety Neelum in different treatments. Maximum contamination was noticed in Neelum T_1UB, T_3UB and T_4 UB (4cfu/g). Microbial contamination was found to be less in blanched chunks as compared to unblanched chunks.

The result of microbial analysis among the two varieties of mango chunks, revealed that variety Kottukonam was least affected by microbial attack as compared to variety Neelum.

4.6 Cost benefit analysis of mango chunks

Economic feasibility is the important factor in the development of new products.

The factors that determine the cost of the finished product is the turn over of the finished product obtained from the raw materials used. Knowledge of the product yield of any product developed is essential in deciding the economic feasibility of the product.

Table 16 depicts the cost of production of mango chunks for 1 kg fruits.

Table 16 : Cost of production of mango chunks developed

Sl No	Variety and Treatments	Cost/Kg
1	Neelum mango chunks (T_1 & T_2)	61.00
2	Neelum mango chunks (T_3& T_4)	62.00
3	Kottukonam mango chunks (T_1 & T_2)	71.00
4	Kottukonam mango chunks (T_3 & T_4)	72.00

The cost was worked out after adding the cost of fruit, sugar, preservatives, fuel and bottles. The cost of production of 1 kg of chunks ranged between Rs.61 to 72.00 .Cost of production was found to be highest for the mango chunks developed from Kottukonam (Rs.72.00) and lowest for Neelum (Rs 61.00)

DISCUSSION

5. DISCUSSION

The results of the study entitled "Preservation of ripe mango chunks by hurdle technology are" discussed under the following heads.

5.1 Assessment of physical constituents of Neelum and Kottukonam mango cultivars.
5.2 Assessment of chemical constituents of Neelum and Kottukonam mango cultivars
5.3 Chemical constituents of stored Neelum and Kottukonam mango chunks.
5.4 Organoleptic qualities of mango chunks.
5.5 Microbial assessment of mango chunks
5.6 Cost benefit analysis of mango chunks

5.1 Assessment of physical constituents of Neelum and Kottukonam mango cultivars:

The physical constituents of mango varieties were assessed in order to study the major characteristics of two varieties of mango. The major characteristics assessed in the present study were fruit length, fruit weight, peel weight, stone weight and flesh weight.

5.1.2 Fruit length

A physical characteristic refers according to the particular cultivars. The fruit length of variety Neelum was observed as 11.20 cm while that of Kottukonam was 10.35 cm.

The average fruit length of mango varieties ranged between 9 and 16.15 cm as reported by Byni (1997).

5.1.3 Fruit weight

Average fruit weight of Neelum and Kottukonam mango varieties was 249 and 187 cm respectively.

The average fruit weight of the superior variety Alphonso under Kerala conditions has been reported as 230 g. Out of the fifty accessions, twenty five had fruit weight of 200g and above, which is comparable to that of the best commercial variety (Radha and Manjula, 2000). The fruit weight ranged from 17.43g in variety Kanappe to 191.75g in variety Gaddalalli Appe (Vasugi et al., 2008). According to Singh and Yadav (1992) Banashan, Fazli, Bangalora, Sunderjan and Mallika had high fruit weight

5.1.4 Peel weight

The peel weight of Neelum variety was 14.05 g while that of Kottukonam was 10.96. Byni (1997) had reported that, average peel weight of mango cultivars ranged between 5.18 and 18.46g. According to Gowda and Ramanjaneya(1995), the lowest peel weight was noticed in Suvarnarekha.

5.1.5 Stone weight

The stone weight of Neelum variety was found to be 16.00 g as against 22.0 g in Kottukonam. Minhas et al. (1991) reported the stone weight of different mango cultivars ranged from 15.4 gm to 48.4 g.

5.1.6 Flesh weight

In the present study the flesh weight of Neelum and Kottukonam varieties was found to be 191.0g and 138.35g respectively.

Minhas et al. (1991) reported that the flesh weight of different mango cultivars ranged between 94.7 g and 117.4g

According to Byny (1997), flesh weight of different mango cultivars ranged between 92.5g and 432.5g.

5.2 Assessment of chemical constituents of Neelum and Kottukonam mango cultivars

Bose and Mitra (1990) reported that the composition of fruit in general differs with cultivar and stage of maturity. In the present study the chemical components present in Neelum and Kottukonam variety were assessed with regard to the moisture, pH, acidity, total sugar, reducing sugar and total phenol contents.

As indicated in table 2, the moisture content of Neelum and Kottukonam mango varieties were 80.90 per cent and 80.00 per cent respectively. According to (Jayaraman, 1995) the moisture content of mango ranged between 79 to 89 per cent. The moisture content shows a decreasing trend with increase ripening period as reported by Vijayanand (2001).

Byni (1997) studied the pH of 20 varieties of mango and ranged between3.40 to 4.65. The authors also reported that the highest pH was observed in variety Mulgoa (4.65) and lowest in variety Rumani (3.40). According to Irene (1997), the pH of the different mango varieties ranged between 3.80 to 4.60.Vijayanand (2001) analysed the pH of mango varieties and it ranged from 3.56 to 5.55. According to Hussain et

al. (2005) the mean values for pH were 2.44, 2.28, 2.24, 2.56 and 2.15 for squash samples prepared from the Fajri, Desi, Ting, Chausa and Totapuri respectively. A increasing trend of pH during storage of apple was reported by Hayat et al. (2005).

The titrable acidity of the fresh Neelum and Kottukonam mango varieties was 0.21 per cent and 0.26 per cent respectively.

Byni (1997) observed the titrable acidity of the Neelum and Kottukonam mango varieties as 0.21 and 0.26 per cent respectively.

Irene (1997) reported the titrable acidity of the Kottukonam mango was 0.22 per cent.

A decrease in acidity in mango fruit was observed during ripening. (Srinivasa et al., 2002). During ripening the titrable acidity of the fruit decreased to as low as 0.1 to 0.2 per cent. The reduction of acidity during ripening takes place as a result of change in acid – sugar balance and consequently influences the taste and flavour of the fruit.

The total sugar content of mangoes ranged between 12.50 – 15.25 per cent as reported by Irene (1997).Our study revealed that total sugar content of Neelum and Kottukonam mango varieties were 14.98 and 13.76 per cent respectively.

The major portion among total sugar of mangoes was mostly sucrose and the rapid increase in total sugar was observed with increase in ripening period (Kittur et al., 2001).

The increase in total sugar may be due to the high acidity of glucogenic enzyme fructose 1, 6-diphosphate in ripe fruit of mango. Similar trends were reported by Gowda and Huddar (2001).

Byni (1997) studied the chemical composition of 20 mango varieties and reported that the reducing sugar content ranged between 2.06 to 6.44 per cent. In the present study the reducing sugar of Neelum was found to be 6.26 per cent as against 6.43 per cent in Kottukonam.

The reducing sugar content increased during ripening process. This may be due to conversion of starch into reducing sugar and loss of starch during ripening process (Khurdiya. 1996).

Total phenol content of Neelum and Kottukonam mango varieties was 17.5 and 14.65 µg/ 100 g respectively.

5.3 Chemical constituents of stored Neelum and Kottukonam mango chunks

5.3.1 Moisture

Moisture content influences the keeping quality of the chunks.

Significant difference was observed in the moisture content of the chunks formulated from the two varieties of mango Neelum and Kottukonam through out the storage period. Moisture content of mango ranged from 29.50 to 68.45 per cent. Lakshminarayanan (1980) analyzed the moisture content of different cultivars of mango which ranged between 70.00 to 84.20 per cent. Mango bar developed by Jyothi (1997) was found to have a moisture content of 8.8 per cent.

During the earlier period of storage, the moisture level in the chunks had very little change. However after a period of 30 days the moisture content of all the chunks were found to be decreased. According to Rathore et al. (2007) lower moisture content will give longer shelf stability.

In contrast, Mir and Nath (1993) found that moisture content of the fortified mango chunks increased with storage of 90 days.

Significant difference with respect to moisture was observed between the mango chunks formulated. The moisture content of Kottukonam mango chunks (64.05) was comparatively higher as compared to Neelum mango chunks (61.50).The lowest moisture content was recorded for Neelum T_4 UB (29.50).

The chunks formulated by applying various treatments were found to vary .The highest moisture content was observed in T_4 UB (64. 05) Kottukonam chunks when stored at ambient condition and lowest in Neelum chunks (68.45) when stored at refrigerated condition. Mango itself is quite watery and contributes to high moisture level.

Significant difference was observed in the moisture content of blanched mango chunks. The mean values of blanched chunks noticed were 54.49 per cent in Neelum and 53.01 per cent in Kottukonam.

Significant interaction was observed with respect to moisture content between variety and storage period ($F_{2, 96} = 3.57$), variety and treatment ($F_{3, 96} = 6.91^{**}$), treatment and condition ($F_{3, 96} = 26.35^{**}$).

5.3.3 pH

pH is an indirect measure of sweetness or sourness in the product. It is of important as a measure of the acidity, which not only influences the flavour or palatability of a product but also affect the keeping quality and the processing requirement of a product (Mehta et al., 2002).

The pH of mango chunks increased after the treatments as compared to the pH of fresh mango chunks. Comparison of treatment means showed an increasing trend of pH in all treatments during storage .Maximum pH value was noticed in T_3 (4.46) followed by T_4 (4.37).

As shown in table 4(a) and 4(b) there was a significant difference in pH of mango chunks in all the treatments during storage. On comparing the CD values, it was observed that a significant difference was observed between 0, 15, and 30 days of storage in all treatments. The increase in pH was attributed to increase in acidity.

Data regarding storage intervals depicted a gradual increase in pH during storage. The pH value noted on 0 days of storage was 4.22 whereas after 30 days, pH value was increased to 4.65. This might be due to decrease in acidity through the biochemical changes with in the fruits during storage .The acidity and pH had direct effect on each other. The observations are in accordance with findings of Islam (1986) who found that pH value of mango / mango juice increased during storage intervals.

Byni (1998) studied the pH content of 20 varieties of mango and found to range between 3.8 to 5.8. Irene (1997) reported a pH content of 3.31 to 4.14 in mango

squash and pH content of 4.11 to 5.43 in jam prepared using different cultivars of mango.

Beena (1998) reported a significant difference in the fruit leather prepared from mango pulp. Similar results were also reported by Jyothi (1997) in mango bars during storage of six months.

Irene (1997) had reported a decrease in pH of jam and squash prepared from different cultivars of mango stored for eight weeks under ambient condition.

Kumar and Manimeghalai (2003) noticed a decrease in pH in the pineapple RTS beverage.

5.3.4 Acidity

Acidity indicates flavour as well as wholesomeness of the products (Mehta et al., 2002). Ashurst (1986) reported that acidity gives flavour and offer antimicrobial protection to the beverages.

The results in table 5(a) and 5(b) revealed that titrable acidity of mango chunks ranged from 0.84-1.08 per cent and 0.85-1.06 per cent in Neelum and Kottukonam chunks respectively when stored at ambient condition. It was observed that acidity had increased when stored under two conditions of storage and shown in figure 4. Acidity of mango chunks stored at ambient and refrigerated conditions revealed that only negligible difference was observed in mango chunks. The increase in acidity might be due to the formation of organic acids. The results are in line with the findings of Prasad and Mali (2000). Increase in acidity was reported in whey based mango RTS by Kumar and Manimeghalai (2001). Study conducted by Tripathi

et al. (1988) also reported an increase in acidity in amla juice during storage. Similar increase in acidity was reported by Hema (1997); Joshua (1997); Soji and Singh (2001) and Kumar and Manimeghalai (2003).

On the other hand, no change in acidity of mango RTS was observed by Byni (1997) for a period of 2 weeks but there after it increased.

In contrast, Rathore et al. (2007) reported that titrable acidity of Deshehari mango ranged from 0.5 to 0.94 per cent with an average mean of 0.28 per cent during storage. The authors also reported that titrable acidity had decreased during 15 days of storage and might be due to their conversion into sugars and their further utilization in metabolic process in the fruit.

Gowda and Huddar (2001) had also reported similar findings in different varieties of mango fruit stored at 18-34 ^{0}C. These results further correspond with Srinivasa et al. (2002) who found that titrable acidity values of Alphonso mango either packed in carton or control sample also showed a decreasing trend from 2.17 per cent to 0.08 percent on 12th day when stored at ambient temperature and 65 per cent RH. Similar changes were noted by Kudachikar et al. (2001) in Neelum mango which had optimum stage of maturity of 110 days after the fruit set and found that pH value was decreased (3.0) and acidity was increased (1.9%) up to 90 days after the fruit set.

A decreasing acidity during storage was reported by Rathore et al. (2007).

The acidity was found to be higher for Neelum chunks (1.28 per cent) as compared to Kottukonam Chunks (1.09 per cent) during storage.

Different treatment levels of mango chunks exhibited different levels of acidity. The highest acidity was found in NeelumT_2 chunks (1.28%).while Neelum T_2 chunks showed the lowest acidity (0.78%) during storage. As pointed out by Kalra et al. (1991) higher acidity of mango pulp (0.20-0.30%) contributed higher acidity in the product. Acidity of mango chunks under study increased with storage and was found to be significant after 30 days of storage.

Gowda and Ramanjaneya (1995) observed an increase in acidity in mango bars after 6 months of storage. Mir and Nath (1993) also noted a significant increase in acidity in 3 types of mango bars when stored for 90 days. Beena (1993); Jyothi (1997) and Vennila (2004) also reported an increase in acidity in papaya mango fruit leather and mango bars respectively with storage.

5.3.5 Total sugar

Results of table 6(a) and 6(b) showed an increasing trend of total sugars in all treatments. The maximum sugar percentage (17.29) was noticed in Neelum and minimum (12.30) percentage was noted in Kottukonum. The increase in total sugar might be due to the alteration in cell wall structure and breakdown of complex carbohydrates into simple sugars during storage. The results are in accordance with the findings of Kays (1991) and Kittur et al. (2001).

The rapid increase in total sugar was observed with the increase in ripening period of mango fruit and mostly sucrose (12%) formed the major portion (Singh et al., 1981).

Data regarding storage interval means revealed that there was continuous increase in total sugar up to 30 days of storage. On 1st day of storage the total sugar content was 13.70 per cent and after 30 days the value was 14.78 per cent .The results are supported by Badshah et al .(1994).

content was 13.70 per cent and after 30 days the value was 14.78 per cent .The results are supported by Badshah et al .(1994).

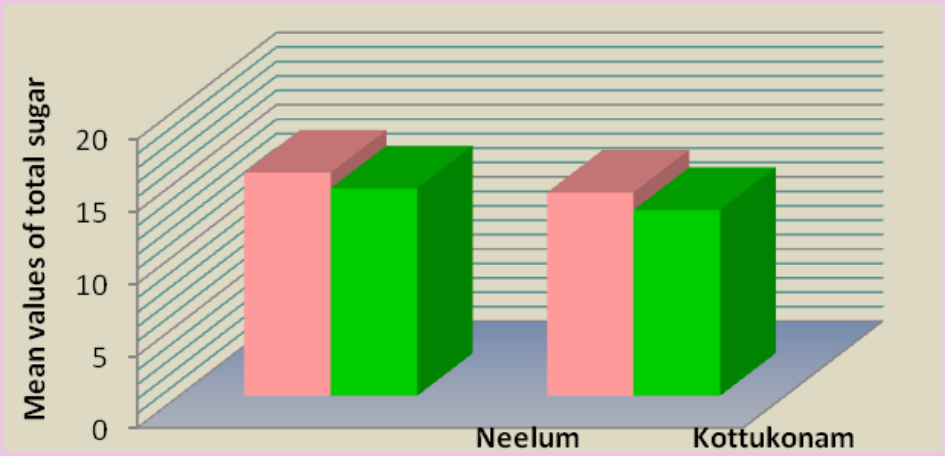
Mehta and Bajaj (1993) observed an increase in total sugar in citrus juices when stored for eight months. Beena (1998); Jyothi (1997) and Irene (1997) also reported an increase in total sugar content in mango pulp during 6 to 8 months of storage.

The mango chunks stored under ambient condition depicted higher increase in total sugar content (14.78%) when compared to chunks stored under refrigerated condition (13.63%) (Fig.2). The results are in accordance with the findings of Raj and Khurdiya (2003) who reported that fruit chunks stored under room temperature showed higher increase in total sugar content when compared to chunks stored under refrigerated condition. Kurla and Tandon (1985) reported an increase in total sugar in mango pulp stored under ambient conditions. In support of above findings, Sunderraj et al. (2003) observed that the rate of increase in total sugar was faster at room temperature than in cool chamber.

In a study, Tefera et al. (2008) reported that mangoes stored at ambient condition with high temperature and lower RH resulted in rapid deterioration in sugar content as compared to the cold storage.

However, Kumar and Manimeghalai (2001) reported a remarkable decrease in total sugar content of mango pulp. Sagar (2003) reported a decrease in total sugar content in plum leather over a period of 130 days. Vennila (2004) also reported a decrease in total sugar content in guava – papaya fruit bar during storage.

Fig 2: Effect of storage condition on total sugar content of mango chunks



Ac- Ambient condition

Rc- Refrigerated condition...

Significant interaction was observed with respect to total sugar between treatment and variety ($F_{3, 96}$= 90.16**), storage period and variety ($F_{2,96}$ = 4.65*) and variety and storage condition ($F_{1, 96}$ = 7.19**).

5.3.6 Reducing Sugar

Figure 4shows the changes in reducing sugar content of the stored mango chunks. On assessing the changes in the reducing sugar content of the mango chunks, there was an increase with storage. The mean reducing sugar of all chunks increased from 6.04 to 6.97 per cent. The highest mean value (7.11) was noticed in Neelum, and the lowest (5.30) in Kottukonum. The study revealed that reducing sugar content was getting increased as the storage period prolonged. Increase in reducing sugar during storage might be due to the acid hydrolysis of sucrose. Jain et al. (1996) and Byni (1997) also reported an increase in reducing sugar content of mango RTS with the increase in storage period.

Reducing sugar content was found to be higher in Neelum chunks (6.08 per cent) as compared to Kottukonam chunks (5.78 per cent).

Reducing sugar was found to be more in mango chunks stored at ambient condition (6.04 per cent)compared to chunks stored in refrigerated condition (5.82) (Fig.3)

.

Reducing sugar of the mango chunks was also influenced by treatments applied.T_3UB Neelum (7.11) recorded highest reducing sugar content while lowest was observed in T_1B Kottukonum (5.30) . Reducing sugar content in mango chunks increased during storage with respect to various treatments and the increase was found to be significant.

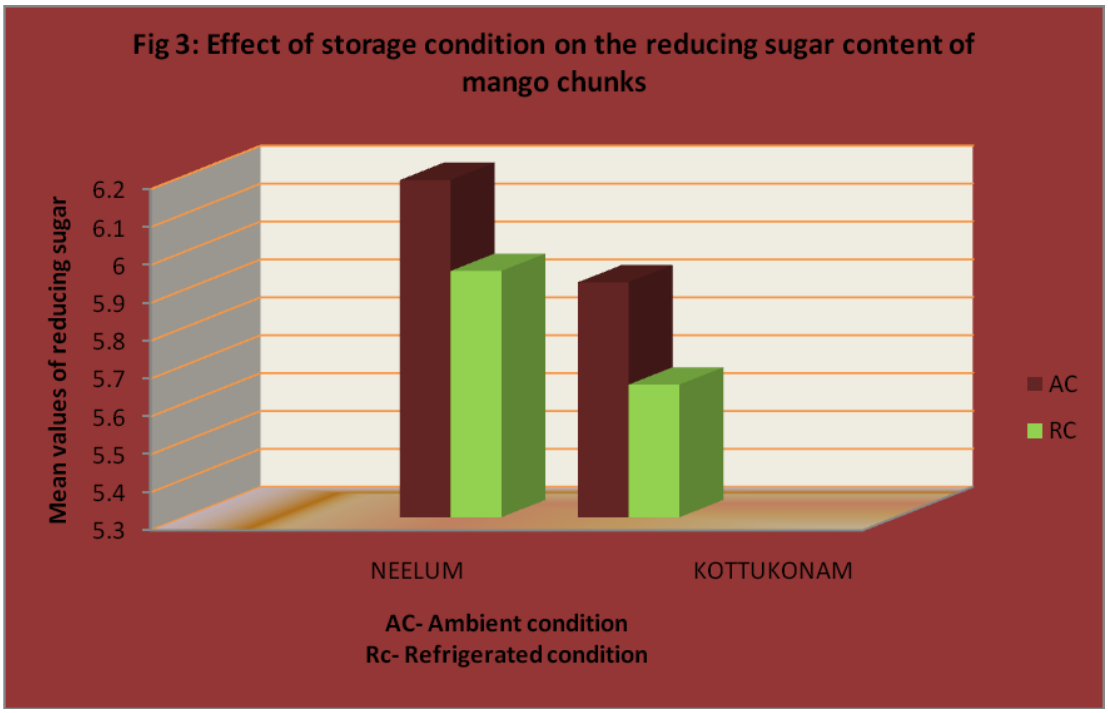


Fig 3: Effect of storage condition on the reducing sugar content of mango chunks
Mean values of reducing sugar
6.2
6.1
6
5.9
5.8
5.7
5.6
5.5
5.4
5.3
NEELUM
KOTTUKONAM
AC
RC
AC- Ambient condition
Rc- Refrigerated condition

In support of the above findings, Chauhan et al. (1997) noticed an increase in reducing sugar content of mango bar during storage. Jyothi (1997) and Beena (1998) also reported an increase in reducing sugar in the fruit bars standardized from mango pulp and papaya mango pulp respectively when stored for a period of 6 to 8 months.

5.3.7 Total phenol

Chemical changes due to post harvest treatments could lead to the formation of various compounds, which have antioxidant or pro-oxidant properties and could exert complex effects on the antioxidant activity of phenolic compounds Lee (1992).

The antioxidant properties of phenol containing foods were different depending on the oxidative degree of phenol compounds (Nicoli et al., 2000).

As indicated in table 8(a) and 8(b) significant difference was observed in the phenol content of mango chunks of both varieties .The variety Neelum had exhibited higher phenol content (13.49) when compared to variety Kottukonam(12.11).

Significant difference in phenol content was noticed during the storage of mango chunks at ambient and refrigerated condition. The study is in tune with the findings of Vander Sluis et al. (2005) that phenolic content may either decrease or increase in fruits and vegetables depending on storage condition. Kalt et al. (1999) reported an increase in total phenolic content in raspberries during storage at 20^0 C.

A decrease in total phenol content was observed during storage of mango chunks for a period of 30 days . Mean values of phenol content was found to be 13.11 mg at 0 days of storage, which decreased to 12.89 mg at the end of 15 days of

storage and 12.41 mg at the end of 30 days of storage. Statistical analysis of the data revealed that the decrease in phenol content during storage was found to be highly significant.

A significant decrease in phenol content was also noticed with respect to various treatments. The results are in accordance with the findings of Pupponen et al. (2003) who reported that phenolic anti oxidants are degraded during processing.

5.4 Assessment of organoleptic qualities of mango chunks

Scientific methods of sensory analysis of food are becoming increasingly important in evaluating the acceptability of the food product.

Sensory evaluation of food is assigned to be of increasing significance as this provides information that may be utilized for product development .The organoleptic qualities are usually assessed by the method of sensory evaluation. According to Herington (1991) sensory evaluation technology is a method using skilled management and trained panelists to provide information on the acceptability of the product profile, consumer acceptability and consistency.

The mango chunks treated with different levels of preservatives were evaluated for appearance, colour, flavour, texture, taste and overall acceptability during storage interval of 0, 15 and 30 days.

5.4.1 Appearance

Appearance is the criterion for the desirability of any food product. The appearance of the food product is contributed by surface characteristics viz size, shape, colour, transparency, opaqueness, turbidity and dullness (Srilakshmi, 2003).

The mean score obtained for appearance of stored mango chunks was found to be 4.22 and 4.28 in Neelum and Kottukonam chunks respectively.

Statistically significant difference was observed in the quality attribute appearance during storage. Mean scores for appearance was found to be decreased during storage.

The results obtained by Jyothi (1997) also reported a decrease in scores for appearance in mango bars during storage.

Data regarding blanching of mango chunks revealed a linear decrease in appearance as a result of blanching.

The mango chunks stored at refrigerated condition showed significant superiority of scores (4.53) throughout storage period in terms of appearance.

5.4.2 Colour

It is famous that consumers eat with his eyes and the major quality characteristic that create attraction towards the fruit is its colour which is one of the quality parameters.

Colour, one of the important visual attribute has been used to judge the overall quality of food for a very long time. If the colour is unattractive, a potential consumer may not be impressed by any other attributes.

The mean scores of judges for colour were significantly increased during storage (4.07 to 4.11). The results are in accordance with the findings of Rathore et al. (2007) who found that colour score was increased during 15 days of storage at ambient temperature. The increase in colour score during storage might be due to series of physico-chemical changes like the breakdown of chlorophyll and increase in carotenoid pigments of the pulp caused by enzymatic oxidation and photo degradation. For treatments, maximum mean score was observed in Neelum sample T_3 (4.54) while minimum mean score was recorded in Kottukonam samples T_2 and T_4 (4.01).

In another study Gowda and Huddar (2001) stated that due to a series of physico-chemical changes that occurring during ripening leads to disappearance of green colour in mango and development of carotenoids. The author also reported that in fruits stored at 18-34 ^{0}C undergone a series of changes and one of the major changes were increase in carotenoids from 498 to 807 µg/100g.

But according to Saini and Grewal (2000) the mean scores of judges for colour decreased significantly (9 to 4.04) during storage of mango pulp.

The findings are further supported by Yahia and Hernandez (1993) who observed that fruits stored in open atmosphere lost their green colour and those stored in controlled atmosphere remained green.

5.4.3 Flavour

Flavour is the blend of taste and smell perceptions noted when the food is in the mouth .The overall flavour impression is the result of the tastes perceived by the

taste buds in the mouth and the aromatic compounds detected by the epithelium in the olfactory organ in the nose (Hayat et al ., 2005).

Flavour is an important factor which enriches the consumer's preference to particular product. Stillman (1993) had stated that flavour is seen in general sensation originating from the elements of the taste receptors, olfactory receptors and nerve fibers, touch and chemical feelings.

Table 11(a) and 11(b) indicated highly significant result with respect to condition, treatments and storage. The mean score of judges for flavour were significantly decreased from 3.99 to 3.94 during storage. For treatments, maximum mean score was observed in T_4 (4.08), while minimum mean score was recorded for sample T_1 (3.88).

Flavour of unblanched chunks was more acceptable than the flavour of blanched chunks. Similarly chunks stored at refrigerated condition retained more flavour (4.03) than the chunks stored at ambient condition (3.88).

The results are in accordance with the studies carried out by Hashmi et al. (2007) who found that the flavour of mango pulp were decreased from 8.76 to 3.74 during storage. Hussain et al (2003) observed similar results in mango pulp.

A study conducted by Rathore et al. (2007) on storage of mango reported that flavour score had decreased up to 5.66 at 3 rd day of storage and then decreased to 1.57 at 15 th day of storage, showing an increasing trend first and then significant decrease of flavour score during storage.

The decrease in flavour score might be due to the changes in volatile compounds present in mango. The results are corresponding with Hayat et al. (2005) and Raje et al. (1997) who reported that organoleptic evaluation such as flavor / taste of Alphonso mangoes showed significantly decreasing trend with the passage of storage period when stored at 32-36 ^{0}C and RH of 70-75 per cent.

5.4.4 Texture

Texture is one of the important quality parameter in sensory evaluation which plays an important role at the time of selection of fruit by consumer (Kudachikar et al., 2001).

Texture of Kottukonam chunks was found to be good as compared to Neelum chunks.

.

Significant difference was not observed in textural qualities during storage of mango chunks. Jyothi (1997) reported a decrease in texture score during storage of mango pulp.

Significant varietal difference was observed in the present study ($F_{1,384}$=8.66**). Storage condition influenced the texture of the chunks. The texture of the mango chunks stored under ambient condition declined at a higher pace as compared to refrigerated condition. Raj and Khurdiya (2003) reported a faster decrease in texture score of RTS beverage from apple pomace stored at ambient condition compared to sample stored under refrigerated condition.

Jyothi (1997) reported a decrease in texture score during storage of mango pulp. Beena(1998), Diju (1995) , Irene (1997), and Hema (1997) were also reported a

similar decrease in texture scores in the RTS beverages formulated from different fruits.

5.4.5 Taste

Taste is mainly due to sugar acid ratio. It is perceived by specialized taste buds on the tongue. Although there are many different tastes, most appear to primarily represent combinations of four dominant chemical sensations in some fruit. Thus, sweetness due to sugar and sourness from org**a**nic acids are dominant components in the taste of many fruits (Kays, 1991).

Analyzing the effect of storage period on the taste attribute revealed a decreasing trend from 4.13 to 4.07 at the end of 30 days of storage, showing a decreasing trend of the taste score during storage and this, might be due to the fluctuations in acids , pH and sugar/ acid ratio (Malundo et al., 2001) .

The taste of the chunks stored at refrigerated condition (4.76) was found to be more acceptable as compared to mango chunks stored under ambient condition (4.14).

5.4.6 Overall acceptability

According to Savithri et al. (1990) the overall acceptability depends on the concentration of amount of particular components, the nutritional and other hidden attributes of the food and its palatability or sensory quality.

Significant varietal difference was noticed in the overall acceptability of mango chunks (Fig.4).

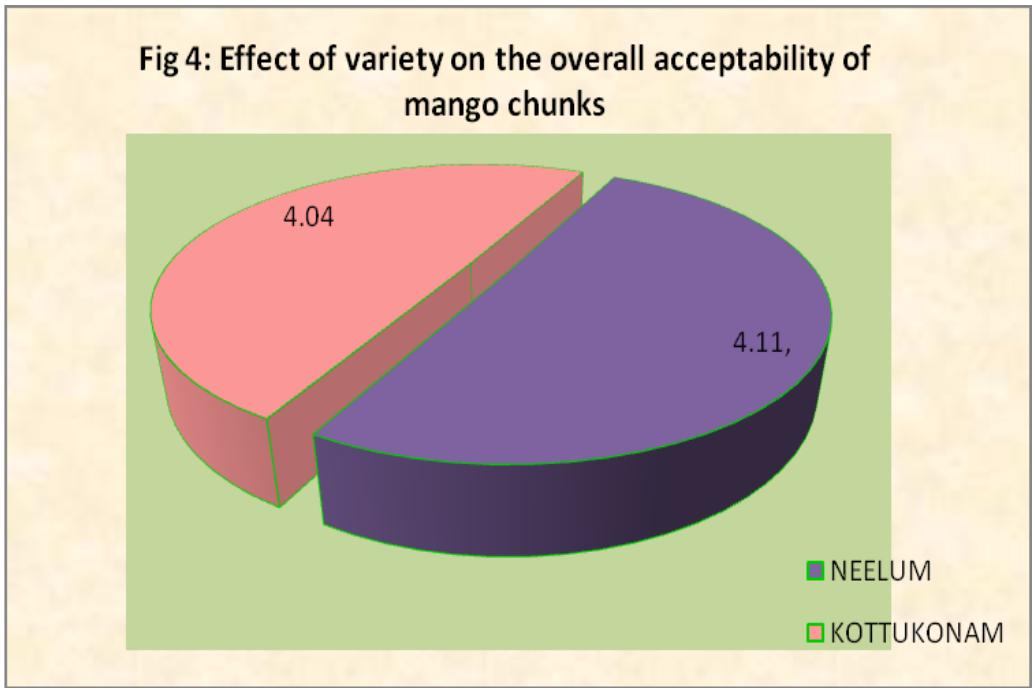


Fig 4: Effect of variety on the overall acceptability of mango chunks
4.04
4.11,
NEELUM
KOTTUKONAM

Storage condition had a significant influence on the overall acceptability of the chunks. (Fig.5). Maximum score for overall acceptability was noticed in Neelum chunks stored at ambient condition (4.01) while it was 4.12 when stored at refrigerated condition (Maximum scores of overall acceptability in Kottukonam chunks recorded were 3.99 and 4.09 when stored at ambient and refrigerated conditions respectively.

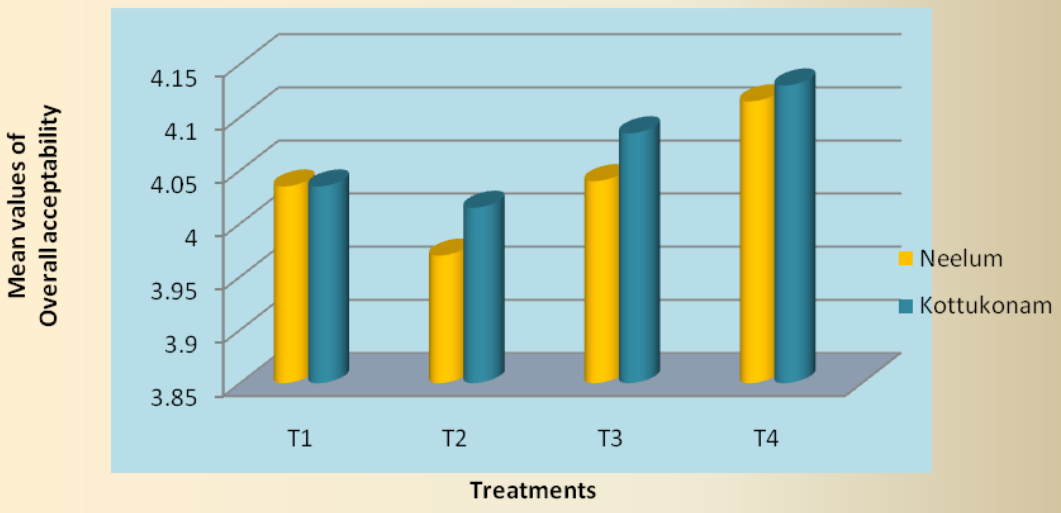
The overall acceptability of mango chunks decreased when the storage period increased. Beena (1998) and Jyothi (1997) reported a decrease in the overall acceptability scores of the fruit bars formulated from papaya and mango during storage.

A study conducted by Sudhakar Rao and Gopalakrishna Rao (2009) on two varieties of mango stored at 8^0C under controlled atmosphere revealed that the varieties were quite acceptable based on the appearance , texture, colour, flavour and taste.

Considering the treatments, T_2 and T_4 showed higher changes when compared to T_1 and T_3 Our results proved that treatment T_4 was found to be the best among the four treatments selected (Fig.6). Study by Saini and Grewal (2000) observed that pulp preserved with potassium metabisulphite either individually or combination with other preservatives retain maximum overall acceptability.

The present study revealed that unblanched Kottukonam mango chunks preserved in 50^0 Brix sugar syrup with potassium metabisulphite in combination with sodium benzoate retains maximum overall acceptability if stored at refrigerated condition. The reason might be due to pectic substances present in variety

Fig 5: Effect of treatments on the overall acceptability of mango chunks during storage



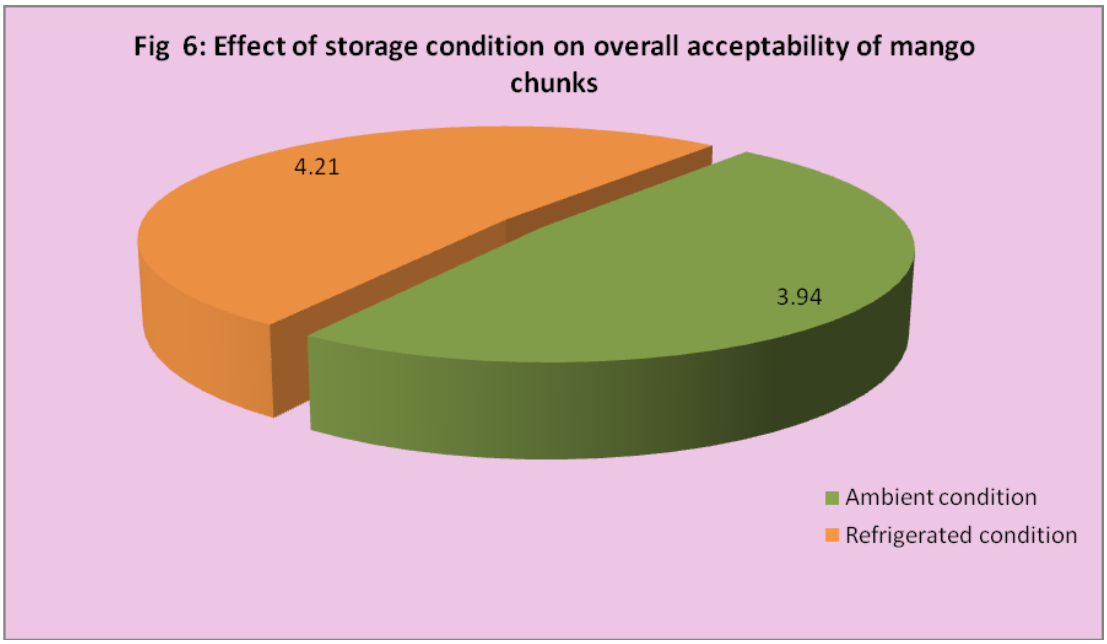


Fig 6: Effect of storage condition on overall acceptability of mango chunks
4.21
3.94
Ambient condition
Refrigerated condition

kottukonam which play an important role in sensory evaluation and is responsible for the firmness.

5.5 Microbial assessment of mango chunks

The development and type of spoilage of food products depends on several factors such as physical state of the food, its colloidal nature, type of preparation, treatments, chemical composition and nature of containers and such other factors. Khan et al. (2002) stressed the need for microbiological safety of foods. Spoilage causing microorganisms are responsible for the development of an off flavour and off taste that leads to economic loss (Rao, 1998). The concepts of spoilage by microorganism are the primary cause curtailing the shelf life and hence reducing initial microbial population is a strategy to extend shelf life (Zargory, 1999).

The keeping quality of the products very much depends up on the microbial contamination. Initially the microbial count was recorded nil to very low in some treatments. However during final stage of storage, the bacterial count was not detected, but yeast and moulds were detected in Neelum chunks in the range of 02-05x10^{-2} cfu/ml. While in Kottukonam chunks it was found to be in the range of 04-10x10^{-2} cfu/ml.

Vijayanand et al. (2001) reported that mango chunks treated with 20^0 brix and 40^0 brix sugar syrup and stored for 30 days at 27^0 C had aerobic counts of 80 and 60 respectively and increased to 800 in both the treatments after 60 days of storage. The authors also opined that yeast and mould count was 40 at 30 days of storage and it increased significantly after 60 days of storage. Coliform count was negative in all the treatments.

A study on effect of chemical preservatives such as sodium benzoate, potassium metabisulphite and potassium sorbate used individually and in combination on the microbial and sensory quality of the mango pulp packed in plastic/ glass containers and stored at ambient temperature for 90 days was carried out by Hashmi et al.(2007). The results revealed that mango pulp with 0.2 % potassium metabisulphite packed in plastic containers had negligible microbial growth, maintained maximum nutrients stability and had best quality characteristics during storage.

Irene (1997) detected colonies of pencillium in the RTS beverage prepared from Neelum mangoes after one month of storage. There was no microbial contamination up to 10 months in differently treated mango bars during the storage period of 6 months (Jyothi, 1997).

Understanding the type and the nature of microbiological contamination in the products will indicate how long it will stay without spoilage and help to improve the quality measures to be taken to stretch the keeping quality of the products.

5.6 Cost benefit analysis of mango chunks

Costing can be defined as the process of determining how much it costs to produce and sell a product. Costing is very important as the cost of a product can decide its profit or loss.

The cost of processed product depends on the purchase of the raw material, cost involved in processing, packaging and marketing and profit margin set by the industry (Kumbhar and Singh, 1991).

Amla (1993) reported that while developing new products, the cost is to be kept at minimum. Nagarajan (1993) opined that the strategy for the development of the food products is to be based on affordable price and cost effectiveness.

Cost benefit analysis was carried out to assess the expenses incurred for obtaining different finished products from mango.

The cost of production of 1kg of chunks developed was found to be ranged between Rs.61.00 to 62.00 for Neelum variety and Rs.71.00 to 72.00 for Kottukonam variety. According to Jyothi (1997) the cost of developed mango bar was found to be Rs.68 per kilogram while it ranged from Rs.58 to Rs.66 per kg for mango bar blended with papaya.

Irene (1997) opined that the cost of RTS beverages developed from mango ranged from Rs.12.00 to 14.00 per litre while the cost of squashes prepared from different cultivars of mango were found to range between Rs.22.00 to Rs.24.00 .The author also reported that the cost of production of jams was found to range between Rs.24.00 to 26.00.

According to Jyothi (1997) cost of developed mango bar was found to be Rs.68 while mango bar blended with papaya was ranged from Rs.66 per Kg.

SUMMARY

6. SUMMARY

The present study entitled “Preservation of ripe mango chunks by hurdle technology” is a comprehensive study carried out with an objective to increase the shelf life of mango chunks using hurdle technology.

A detailed study on the different quality parameters of mango such as physical characteristics, chemical composition, organoleptic and shelf life qualities were assessed and the changes in above mentioned parameters were monitored during storage for a period of 30 days.

Two popular local varieties of mango viz Neelum and Kottukonam were selected for the study. The selected mangoes were washed, peeled and cut in to pieces and divided in to two portions. Half of the chunks were subjected to blanching and the remaining was kept unblanched.Both the blanched and unblanched chunks were subjected to different concentrations and combinations of treatments using sugar, citric acid, KMS and sodium benzoate. The prepared fruit chunks were stored in glass containers at ambient and refrigerated temperatures for a period up to thirty days.

The physical characteristics of the selected mango varieties were assessed. The major physical characteristics assessed were fruit length, fruit weight, peel weight, stone weight and flesh weight. Among these, maximum fruit length, fruit weight, peel weight, stone weight and flesh weight were found in favour of Neelum variety.

Chemical composition of the stored mango chunks in two storage conditions were assessed with regard to moisture, pH, acidity, total sugar, reducing sugar and

total phenol contents. The above indicators were assessed using the standard laboratory procedures at an interval of 0, 15 and 30 days of storage.

The variety Kottukonam chunks had higher moisture level as compared to Neelum chunks when stored at refrigerated condition. The moisture level of mango chunks increased as a result of blanching and decreased during storage period.

pH of mango chunks revealed that variety Kottukonam had higher pH and the value was decreased as a result of blanching. The mango chunks stored at refrigerated condition were having higher value of pH. The pH of chunks showed linear increase during storage period.

Acidity of the mango chunks was found to be enhanced with storage. The variety kottukonam was found to be slightly acidic when compared with variety Neelum and the difference was not comparable. With regard to treatments given, treatment T_4 was found to be less acidic (0.87).

Total sugar was observed to be more in Neelum variety. Storage condition influenced the total sugar content of the mango chunks. Chunks stored under ambient condition depicted higher value when compared with chunks stored under refrigerated condition. The total sugar content increased significantly as the storage period increased and was found to be more in unblanched mango chunks. Significant difference in total sugar content was observed with respect to various treatments given. Treatment T_4 had observed higher total sugar content.

The reducing sugar content was more in variety Neelum and was decreased as a result of storage and blanching. There was a significant increase in reducing sugar content during storage period. The mango chunks stored at ambient condition had

higher reducing sugar when compared to chunks stored at refrigerated condition. Significant difference was observed in reducing sugar with respect to various treatments given. The study revealed that treatment T_4 had recorded higher reducing sugar.

Phenol content was found to be more in the variety Neelum. Blanching of mango chunks decreased the phenol content significantly. The phenol content of mango chunks was found to be decreased with increase in storage period and storage in refrigerated condition.

The organoleptic qualities of the mango chunks such as appearance, colour, flavour, texture, taste and overall acceptability were assessed by a panel of selected Judges using a score card. The quality attributes such as appearance, flavour and texture was found to be in favour of Kottukonam mango chunks while the colour and taste was more in Neelum variety. Significant difference was observed in Neelum and kottukonam mango chunks with respect to appearance, colour, flavour and texture. Varietal difference and storage condition reflected in the quality attributes with respect to appearance, colour, flavour, texture and taste. Treatments and blanching significantly influenced the quality attributes of mango chunks such as appearance and flavour. Blanching of mango chunks decreased the quality attributes such as appearance, colour, flavour, texture and taste. Treatment T_4 had retained maximum scores for appearance, flavour, texture and taste during storage.

Overall acceptability of the mango chunks was influenced by the storage condition and the overall acceptability was decreased as the storage period increased. The results revealed that unblanched Kottukonam mango chunks (T_4) stored in glass bottles at refrigerated condition were more found to be highly acceptable for the judges till a period of 15 days.

Mango chunks were assessed for microbial contamination soon after it was prepared and at an interval of 15 and 30 days of storage at ambient and refrigerated condition. The results revealed that bacterial contamination was not detected in any of the samples stored at ambient and refrigerated condition up to a period of 30 days. However negligible contamination was observed at the end of 15^{th} and 30^{th} days with yeast and mould in Neelum and Kottukonam mango varieties when stored at ambient condition. Yeast and mould contamination was not detected in any of the samples up to a period of 15 days of storage at refrigerated condition in order to ensure shelf stability of the products. Microbial contamination was found to be less in blanched mango chunks.

Cost of the mango chunks worked out for all the treatments indicated that Kottukonam chunks were found to be slightly expensive (Rs.72) as compared with Neelum (Rs.62) and were found to be reasonable.

Based on the research findings, following conclusions could be drawn.

Preservation of ripe mango chunks by Hurdle technology should be popularized and taken up at commercial level in order to avoid wastage of mango fruits during the glut season.

Minimal processing and preservation by Hurdle technology is an emerging area for the preservation of fruits and vegetables. A combination of hurdles can effectively check deterioration of the preserved foods, while individually each hurdle is in effective in protecting food from deterioration.

REFERENCES

REFERENCES

Aguilar, G.G.A., Fortiz, J., Cruz, R., Baez, R., Wang, C.Y. 2000. Methyl jasmonate reduces chilling injury and maintains post harvest quality of mango fruit. J.Sci Food Agric 48: 515-519

Aguilar, G.G.A., Wang, C.Y., Buta, J.G., Krizek, D.T. 2001. Use of U-V-C irradiation to prevent decay and maintain post-harvest quality of ripe 'Tommy Atkins' mangoes . Ind J Food Sci Technol 36: 767-773

Aguilera, J.M. and Chirife, J. 1994. Combined methods for the preservation of foods in Latin America and cited- D project. J. Food Engineering, London, 22 (1-4): 433 – 444

Alzamora, S. M., Gerschenson, L. N., Cerrutti, P. and Rojas, A.M. 1989. "Shelf stable pineapple for long-term non refrigerated storage". Lebensmittel Wissenschaftund Technologie 22: 233-236

Alzamora, S.M., Tapia, M.S., Argaiz and Welli, A. A.J. 1993. . "Application of combi-ned methods technology in minimally processed fruits". Food Research International 2: 125 – 130

Alzamora, S.M, Cerrutti, S. Guerrero López-Malo, A. 1995."Minimally processed fruits by combined methods". In Food Preservation by Moisture Control - Fundamentals and

Lancaster, USA. pp. 463-492

Alzamora, S. M., Tapia, M. S. and Welti-Chanes, J. 1998. "New strategies for minimal processing of foods: the role of multi target preservation". Fd Sci Technol Int 4: 353-361

Amanatidou, A., Simid, F.I. and Gorris, L.G.M. 1999. Effect of elevated oxygen and carbondioxide on the surface growth of vegetable associated microorganism. J. Appl Microbiol 86:429-438

Amla, B.L. 1993. Food processing. Oxford publishing Co., New Delhi, p 333

AOAC. 1990. Official and tentative methods for analysis. 13th ed. Association of Official Analytical Chemists, Washington D.C., USA, pp. 10-18

Azhurst, V.L. 1986. Food flavourings. The AVI Publishing Company, Connecticut, p 150

Athpol, N., Nirat, T. 2007. Controlled atmosphere storage of mango fruit, Mangifera indica . C.V. RAD. J. Fd. Processing and Preservation. 19: 271- 281

Badshah, N., Haroon, U.R. and Safi, S. 1994. Role of calcium in prolonging the shelf life of apple. Sarhad. J. Agri. 10(6): 639-645

Baldwin, E.A., Burns, J.K., Kazokas, W. Brecht, J.K., Hagenmaier, R.D., Pesis, E. 1999. Effect of two edible coatings with different permeability characteristics on mango (Mangifera indica L.) ripening during storage. Postharvest Biol Technol 17 : 215 – 226

Beena, C.1998. Development of Papaya based blended products . M.Sc. (H.Sc) thesis, Kerala Agricultural University, Thrissur. P.130

Beverage and Food World. 1994. “Mango”. 21(1): 24- 27

Boss, T .K. and Mitra .1990. Fruits tropical and subtropical. published by Naya prakash, Culcutta. pp. 1- 8

Bourne, M.C. 1986. Proper case of foods needed after harvest. Agricultural Information Development Bulletin. 10(1): 11-14

Bower, J.P., Dennison, M.T., Fowler, K . 2003. Avocado and mango - cold storage damage as related to water loss control. Acta Hort 628 : 401 – 406

Bright, J., Alister, M.C.S. and Renfree, R. 2001. Foliar nitrogen. Nutrition Trials in mango. Hort Technol. Annual report

Bringas, T.E., Mercado – Ruiz, J., Garcia – Robles , J., Gonzalez- Aguilr, G., Troncoso, R. 2005. Effect of calcium and edible wax treatments on overall quality of 'Kent mangoes' during cold storage . Acta Hort 682 : 1281 – 1286

Bron, I.U., Riberio,R.V.,Cavalini,F.C., Jocomonio, A.P., Tervison, M.J. 2005. Temperature related changes in respiration and Q10 coefficient of guava. Sci Aric 62:154-170

Byni, E.O.1997. Quality Analysis and product development of selected mango cultivars M Sc, thesis, Kerala Agricultural University, Thrissur. 56-89

Castro, J. V., Pfaffenbach, L. B., Carvalho , C.R. L., Rosetto, C.J. 2005. Effects of film packaging and cold storage on post harvest quality of ' Tommmy Atkins ' mangoes Acta Hort 682 : 1683 – 1688

CFTRI. 2002. Home scale Processing and Preservation of Fruits and Vegetables – A compi-lation method for preservation of fruits and vegetables. Central Food Technological Research Institute, Mysore, p. 288

Chadha, K.L. 1995. Status of Post harvest technology of fruits. Paper presented at the National seminar on Post harvest technology of fruits Aug 7, UAS, Bangalore

Chadha, K.L. 2005. Hand book of Horticulture . Directorate of Information and publications of Agriculture. ICAR. New Delhi, p 344-346

Chakrabarthi, S., Agarwal, M.S. and Shukhla, T.C. 2008. Studies on preservation of ready to serve beverages from watermelon(Citrullus valgaris) juice. Bev.Fd.Wld. 20:30-32

Chaplin, G.R., Cole, S.P., Landrigan, M., Nuevo,P.A., Lam, P.F., Graham, D. 1991. Chilling injury and storage of mango (Mangifera indica L.) fruit held under low temperature. Acta Hort 291:461-471

Chauhan, S.K., Lal, B.B. and Joshi, V.K. 1997. Preparation and evaluation of protein enriched mango fruit bar. Indian Food Packer. 51(5): 5-9

Conner, G. M. 1993. Microbiology of fresh cut produce. In: Fresh cut fruits and vegetables. Science Technology and Market. CRC Press

Corry, J.E.L. 1978. Relationship of water activity formed in disrupted tissues of different cabbage cultivars. J. Fd Sci 58 : 835- 839

Cottet, V., Navez, B., Villeneuve, F., Jost, M. 2007. "The organoleptic evaluation of carrots" Nutrition Abstracts and Reviews. 78 (232) pp.20 – 24

Davenport, T.L., Berg, S.P. and White, T.C. 2006. Optional low pressure conditions for long term storage for fresh commodities kill Caribbean fruit fly eggs and larvae. Hort. Technol. 16: 98- 104

Dhankar, B.S. 2001. Environment benign nutritional security from Vegetables, roots and tubers. Indian Hort. 28:14-17

Diaz-Sobac, R., Perez-Florus, L.,Vernon-Carter, E.J. 2000. Emulsion coatings to control fruit fly and anthracnose in mango (Mangifera indica cv Manila). J Hort Sci Biotechnol 75:126-128

Diju, D. P. 1995. Development, diversification and shelf life studies of passion fruit products. M.Sc.thesis , Kerala Agricultural University, Thrissur, p 140

Dilliello,R.L.1982. Standard Plate Count Method. Methods in Food and Dairy Microbio-logy.20-29

Dilley, D.R. 1982. Principles and effects of hypobaric storage of fruits and vegetables. Am Soc Heat Refrig Air Cond 88: 1461-1478

Durigan, J. F., Teixeira, G.H.A., Castanharo, N.M., Domarco, R. E. 2004. Post-harvest conservation of 'Tommy Atkins' mango fruit influenced by gamma-radiation, wax, hot water and refrigeration. Acta Hort. 645:601-604

Eckert, J.W., Ogawa, T.M. 1985.The Chemical control of post harvest diseases. Tropical and Subtropical fruits. Ann. Rev. Phyto. Pathol. 23: 421-454

El-Samahy, S.K., Youssef, B.M., Askar, A.A., Swailam,H.M.M. 2000. Microbiological and chemical properties of irradiated mango .J Food Safety 20: 139-156

*FAO, 2003. Compendium on post-harvest operations. Chapter XX mango: post-harvest operations. Food and Agricultural Organizations

FAO, 2005. Current situation and medium term outlook for tropical fruits. Food and Agricul-tural Organization, http://www. fao.org

FAO, 2007. FAO statistical data-base. Rome: FAO/ United Nations. Avilable from http:// faostat. Fao.org.

FIB, 2006. Farm guide. Government of Kerala, Kerala books and publishing society,
Kakkanad, Kochi . p 210

Fonseca, M.J.O., Salomao, L.C.C.,Cecon, P.R.,Puschmann, R. 2004. Fungicides and wax in post-harvest preservation of mango 'Haden' Acta Hort. 645: 557-563

Food Science, Food Technology and Nutrition.1993. Mangoes. Encyclopedia of Food Science Food Technology and Nutrition, Academic Press, Landon

Gandhi, G. P. 2005. Export prospects of mangoes and mango based products from India .Plant Horti Tech (5) 4 :35 – 37

Garcia, E. and Barrett,D.M., 2002. Preservation treatments for fresh cut fruits and vegetables . In. fresh cut fruits and vegetables: Science Technology and Market. Lamikanra o (ed). CRC Press. Boca Ratom.. pp 276-303

Giridhari Lal, G.S., Siddappa and Tandon, G.C. 1986. Preservation of Fruits and Vegetables, published by ICAR, New Delhi p.61

Gopalan, C., Sastri, B.V.R. and Balasubramanian, S.C.1977. Nutritive value of Indian foods. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India

Gould G.W. 1995. "Homeostatic mechanisms during food preservation by combined methods". In Food Preservation by Moisture Control - Fundamentals and Applicat-ions (pp. 397-410). Eds. J. Welti-Chanes and G. Barbosa-Cánovas. Technomic Pub. Co., Lancaster, USA

Gould and Grahame. W. 2000. New Methods of Preservation . Aspen publishers. USA. P.356

Gowda, D. and Huddar, A.G. 2001. Studies on ripening changes in mango fruits. J. Food Sci. Technol. 38: 135-137

Gowda, T.N.D . and Ramanjaneya, K.H. 1995. Studies on physico- chemical charecteristics of some commercial cultivars of mango . Indian Food Packer. XLVll(2):45

Hagenmaier, R.D. and Baker, R.A. 1998. Microbial population of shredded carrots in modified atmosphere packaging as related to irradiation treatment J Fd Sci 63:162-16

Haq, A . 2002 . Package for mango production - post harvest techniques and its export prospects , Mango Res . Inst . Shajabad , pp.1–15

Hashmi, M. S., Alam, S., Riaz, A. and Shah,A.S. 2007. Studies on microbial and sensory quality of mango pulp storage of chemical preservatives. Pak. J. Nutri. 6(1): 85-88

Hayat, I., Masud, T., Rathore, H.A. 2005. Effect of coating and wrapping materials on the shelf life of apple (Malus Domestica C.V.Borkh). Ind . J . Food safty, 5:24 - 34

Hema, S.R .1997. Development, diversification and shelf life of Jamun(Euginia jambolina L.) based products. M.Sc (H.Sc) thesis, Kerala Agricultural University, Thrissur. p 216

Herington, K . 1991 . Sensory evaluation or getting the taste right . Dairy Industries Inter-national 56 (3) : 31 – 32

Hicks, D. 1990. Production and package of non-carbonated juices and fruit beverages. Van Nonstrand Reinhold New York. Tropical fruit juice ed. Hopper. J. pp 118-122

Hoover, D.G. 2000. Microorganism and their products in the preservation of foods. Aspen Gaitenburg , M D. pp. 251-276

How, B.R. 1990. Marketing Fresh Fruits and Vegetables. Van Nonstrandard Reinhold, New york.. p 200

Hussain, I., Sabeen , N.G., Muhamad,R.K., Tariq Khan.and Iftikhar, S. 2005 . Short commu-nication varietal stability and storage stability of mango squash. Int. J. Agri. Biol., 7(6): 1038 – 1039

*Hussain, S.S., Rahman, M.A., Randhawa and Iqbal, M. 2003. Studies in physico-chemical, microbiological and sensory evaluation of mango pulp storage with chemical pre-servation .J.Res. Sci, Bahauddin zakariya Uni., Multan, Pak.14:1-9

Indian Food Packer . 1995. Mangoes from exotic to main stream . Indian Food Packer. 49(4): 59

Irene, U. 1997. Suitability of local mango cultivars for pulp based products . M.Sc. thesis, Kerala Agricultural University, Thrissur, p 52

Islam, N.V. 1986. Some physico-chemical studies on the mango pulp stored in a glass bottle,

M.Sc. Thesis, Dept. of Food Techn ., Uni.of Agri-Faisalabad, p 49

Jackson, M. L. 1973. Soil Chemical Analysis: Prentice Hall of India Pvt Ltd,

New York, pp. 2-65

Jain, N.L., Lab, G., Bemillar, J.N. 1996. Fruit processing. Bull. CFTRI 4 (55): 287-288

Jayaraman, K.S.1995. "Critical review on intermediate moisture fruits and vegetables". In

Food preservation by moisture control - fundamentals and applications Eds.J.Welti Chanes and G. Barbosa-canovas. Technomic Pub.Co.,Lancaster, USA, pp.411-422

Jiang, Y., Joyce, D.C. 2000. Effects of 1- methylcyclopropene alone and in combination with polyethylene bags on the post-harvest life of mango fruit . Ann Appl Biol 137: 321-324

Joshua, P. 1997. Studies on processed products in relation to different varieties of papaya (Carica papaya L.) PhD thesis, Tamil Nadu Agricultural University, Coimbatore. p 209

Jyothi , H . 1997. Developing blended fruit product utilizing stored mango pulp. M.Sc.thesis , Kerala Agricultural University, Thrissur. p 80

Kalra, S. K., Tandon , D.K . and Singh , B.P . 1991 . Evaluation of mango and papaya blended beverage. Indian Food Packer. 45 (1): 33 – 36

Kalra, S.K., Garg, N. and Tandon, D.K. 1993. Quality evaluation of market raw mango powder and raw mango leather. Bev. Fd Wld. 20(2):13-14

Kalt, W., Forney, C.F., Martin, A., Pair, R.L. 1999. Antioxidant capacity, Vitamin C, Phenolics and Anthocyanins after fresh storage of smell fruits. J Agri Fd Chem 47: 4638-4644

Kapoor, H.C. and Kaur, C . 2004. Production of fruits in India . Indian Hort. 48(4):48-52

Kaur, C. and Khurdiya, D.S. 1993. Improvement in the quality of fruit sector. Bev. Fd Wld. 20(1): 15-16

Kays, S.J. 1991. Post harvest Physiology of perishable plant products . Vas Nonstrand Rein Hold Book, AVI publishing Co, pp: 149-316

Ketsa, S., Prabhasavat, T. 1992. Effect of skin coating on shelf-life and quality of Nang Klangwan' mangoes . Acta Hort 321: 764-770

Ketsa, S.,Raksritong, T. 1992. Effect of PVC film wrapping and temperature on storage life and quality of 'Nam Dok Mai' mango fruits on ripening. Acta Hort 321: 756-763

Khan, P., Abidi, S. and Garakhnath, K. 2002. Food Microbiology- A Research Note. Nature Sci. Reptr. 38:43-45

Khurdiya, D.S. 1996. Beverage and its products. Indian Hort 20(5): 25

Khurdiya. 1995. Non-thermal methods for preservation of fruits and vegetables: A Critical appraisal. J. Food Sci Technol 32:441-452

Kittur, F.S., Saroja, N., Habibunnisa and Tharanathan, R.N. 2001. Polysaccharide based composite coating formulations for shelf-life extension of fresh banana and mango Eur. Fd Res. Technol. 213:306-311

Kudachikar, V.B., Kulkari,S.G., Prakash, M.S., Ramanna, K.V.R.,Prasad, B.A., and Vasantha . 2001. M.S. of mango (Magnifera Indica L.) variety "Neelam"- J.Food Sci.Technol Mysore 138: 540-542

Kumar , S . R . and Manimeghalai , G . 2003 . A study on storage behaviour of whey based pineapple juice and RTS beverage. Indian Food Packer. 57(5): 51-55

Kumar, N., Manimeghalai, G. 2001. A note on pulp characteristics of some mango varieties Orissa. J. Hort., 36:99-102

Kumbhar, B.K. and Singh, B .P. N. 1991. Ways to increase profit margin or reduce product cost in food industry . Indian Food Packer 45: 19 – 27

Kurla,S.K., Tandon, D.K. 1985. Studies on developing mango fruits to access maturity.
Indian. J. Hort. 43: 51-58

Lagtiani, J., Chan, H.T. and William, S.S. 1998. Tropical fruit processing . Academic press INC. Harcourt Brace Jovanovich, publishers San Diego New York. Berkly Boston London Sydney Tokyo Toranto, pp. 52-73

Lakshminarayanan, S. 1980. Mango. Tropical and Subtropical Fruits. Composition, Properties and Uses. (eds. Nagy, S. and Shaw, P.E.). AVI Publishing Co., Westport, Connecticut, pp. 184-257

Lee, H.S. 1992. Antioxidative activity of browning reaction products isolated from storage- aged orange juice. J Agric Fd Chem., 46:550-552

*Leistner, L. 1994. Food design by hurdle technology and HACCP. Adalbert Raps Founda-tion, Kulmbach, Germany Leistner, L. 1999. Food preservation by combined methods. Food. Res. Int. 25:51-158

Leistner L. 2000. "Hurdle technology in the design of minimally processed foods". In Minimally Processed Fruits and Vegetables. Fundamental Aspects and Applications (pp. 13-27). Eds. S.M. Alzamora, M.S. Tapia and A. López Malo. Aspen Publishers, Inc., Gaithersburg, MD, USA

Leistner, L.G.M. Gorris 1995. Food preservation by hurdle technology. Trends in Food Science & Technology. February, 6:

Leistner L. and G.W. Gould. 2002. Hurdle Technologies. Combination Treatments for Food Stability, Safety and Quality. Kluwer Academic/ Plenum Publishers, New York, USA

Mahony, M. 1985. A text book on sensory evaluation of food. Marcel Dekker inc., New York. Pp.3-39

Malik, A.U., Sing, Z., Dhaliwal, S.S. 2003. Exogenous application of putrescine affects mango fruit quality and shelf-life. Acta Hort. 628: 121-127

Malundo, T. M. M., Shewfelt, R. L., Ware, G. O., and Baldwin, E. A . 2001. Sugars and acids influence flavour properties of mango (Mangifera indica L.) . J. Am. Soc. Hort. Sci., 126: 115-121

Manay, N.S., Swamy, S . 2002 . " Food facts and principles" . New age International Pvt Ltd , p . 51

Martha, B. 2008. Food processing and preservation online Encyclopedia 2008. http:// Encarta. msn.com

Mehtha, V. and Bajaj, S. 1993. Effects of storage and methods of preservation on the physico- chemical characteristics of citrus juices. Indian Food Packer 37: 42-51

Mehta, A., Ranote, P.S. and Bawa,A.S.2002. Indian aspects. Indian Food Industry 21 (1): 37-40

Minhas, P.P.S., Dhaliwal, G.S., Grewal, G.P.S and Singh, M.P. 1991. Physico-chemical constituents in different cultivars of mango under Ludhiana condition. Prog. Hort. 23(14): 15-17

Mir, M.A. and Nath, N.1993. Storage changes in fortified mango bars. J Fd Sci. Technol. 30(4):279-282

Mukherjee, S.K. 1997. The varieties of mango (Mangifera indica L.) and their classi-fication. Bull. Bot. Soc. Beng. 2: 101-133

Nagarajan, P. 1993. Functional food market in India. Food Digest 13:52-54

Nair, U. 2003. Jack of all Fruits . New Indian Express, March 18, p.93

Nanjundaswamy, A.M. and Mahadeviah, M. 1993. Fruit processing in advances in Horticul-ture . Fruit crops: Part 4(eds.) Chadha and Paveek, O.P., Malhotra publishing House, New Delhi, pp.1835- 1875

Neelima G..S.K., Kalra and Tandon, D.K. 1993. Quality evaluation of market raw mango powder and mango leather. Fd Wld., 20(2): 13-14

Nicoli, M.C., Calligaris, S., Manzoco, L. 2000. Effect of enzymatic and chemical oxidation on the antioxidant capacity of calichin model system and apple derivatives. J. Agric. Fd .Chem., 48: 4576- 4580

Ohlsson, T. and Bengston.2000. The hurdle concept (Chapter 7) Minimal processing tech-nologies in food industry ,CRC press LLC, Newyork.pp.175-179

Ozdemir, A.E. and Durdar, O. 2001. Effect of different post harvest applications on storage of oranges. Acta. Hort., 533(2): 561-564

Pal , R . K . 1998. Ripening and rheological properties of mango as influenced by ethereal and carbide . J . Food Sci. Technol . 35 (4) : 358 – 360

Panse , V . G and Sukhatme , P . G . 1995. Statistical methods for Agricultural workers . ICAR , New Delhi. p. 353

Parmar, P.B., Chundawat, B.S. 1989. Effect of various post-harvest treatments on the phy-siology of 'Kesar' mango. Acta Hort. 231:679-684

Pesis, E., Faure, M., Arie, R. 1997. Induction of chilling intolerance in mango by tem-perature conditioning, heat, low o2 and ethanol vapours. Acta Hort 455:629-634

Piggot , J.R. and Schaschke, C.J. 2001. Release cells , breath analysis and in mouth analysis in flavour research . Bio molecular Engineering , Glasgow, U.K, 17 : 129-136

Pirovani, M.E., Guemes, D.R., Piagnetine, A.M. 2001. Predictive models for available chlo-rine depletion and total microbial count reduction during washing of fresh cut spinach. J Fd Sci . 66: 860 864

Pott, I., Marx, M., Neidhard, S., Mulhbauer, W., Carle, R. 2003. Quantitative determination of ß – carotene stereo – isomers in fresh, dried and solar dried mangoes (Mangifera indica L.) J. Agric. Food. Chem. 51: 4527 – 4531

Prasad, M., Singh, R.P. 1996. Tailored plastics film laminates for MAP of fresh fruits. Indian Food Industry 15: 17-20

Prasad, R.N. and Mali, P.C. 2000. Changes in physico-chemical characteristics of pomegra-nate squash during storage. Indian J. Hort., 57:18-20

Pruthi, T.S. 1992. Simple innovations in mango processing technologies. Indian Food Packer.17(5):45-55

*Pupponen, P., Donner, H., Forney, C.F. 2003. Effect of production in fruit and vegetable on phenol content. J. Fd. Sci 15

*Puttaraju, T.B. and Reddy, T.V. 1997. Effect of precooling on the quality of mango . J Fd Sci and Technol 34(1)

Radha, T. and Manjula, C. 2000. Characteristics of some polyembryonic mango types grown under Kerala conditions. Acta Hort. 509: 135-142

Raj, P. and Khurdiya, D.S. 2003. Studies on preparation and storage of RTS beverage from culled apple pomace. Indian Food Packer. 57: 56-58

Raje,L.S., Sheriekar,K., Ramakrishnan, V. C., Malshe and Subbulakshmi, G. 1997. Post harvest prevention of mangoes by controlled chemical release agents and adsorbent. Acta Hort 455: 622-628

Rajkumar, P., Kailappan, R., Viswanathan, R., Parvathi, K., Raghavan, G. and Orsat, V. 2007. "Thin Layer Drying Study on Foamed Mango Pulp."Agricultural Engineering International: The CIGR Ejournal Manuscript .FP 06024 (10)

Rao, V.D. 1998. Food quality assurance: Micrological concers . Indian Fd Ind, 17: 282-283

Rathore, H.A., Tariq, M., Shehla, S. and Aijaz, H.S. 2007. Effect of storage on physico- chemical composition and sensory properties of mango (Mangifera indica L.) variety Dosehari. Pak. J. Nutrition 6(2): 143-148

Ravisankar, K.V., Anand, L. and Dinesh, M.R. 2000. Assessment of genetic related-ness among mango cultivars of India using RAPD markers. J. Hort. Sci. Biotech. 75: 198-201

Rekha, K . M ., Goswami , T . K . 2007 . Post harvest handling and storage of mangoes An – overview. J . Food Sci Technol , 44(5) , 449 – 458

Renganna, S. 2001. Hand book of Analysis and Quality Control of fruit and vegetables Products. Second edition. Tata Mc Graw Hill publishing company Ltd, New Delhi, p 112

Roy, S.K., Pal, R.K. 1991. A low- cost zero energy cool chambers for short term storage of mango. Acta Hort 291: 519-524

Sadasivam, S. and Manikkam, A. 1992. Biochemical Methods for Agricultural Sciences. Wiley Eastern Ltd., New Delhi, p 246

Sagar, V.R. 2003. Enjoy leather of Plum Santa Rose. Indian Hort. 48(3):18-19

Saini, S.P.S. and Grewal, U.S. 2000. Storage aspects of thermally processed pathranakh pear juice. Bev. Fd Wld 27:62-64

Santos, A.F., Silva, S.M., Mendonca, R.M.N., Alves, R.E. Martins, L.P. 2004. Storage of
Mango fruits cv. `Rosa' treated with calcium chloride after harvest at different maturity stage. Acta Hort. 645: 573-579

Sapers , G . M. 1993 . Browning of foods ; control by sulphites , antioxidants and other means (Scientific status summary) . Food Technol . 47: 75-83

Sathe, A.V. 1999. A first course in food analysis. New age International (P) Limited, publishers. New Delhi. p 9

Sauco, V. G . 2004 . Magazine of Chronica Horticulture . Int.Soc Hort .Sci ., 42 : 14 - 17.

Savithri, K., Ramaswamy, T. and Rajeswari, L. 1990. Acceptance of food by sensory evaluation. J Fd Sci Technol 27(3):15-18

Shaw, A., Mathur, P. and Mehratra, N.N. 1993. Food Processing: A scenario. Indian Food Packer XLVII: 5- 10

Singh, A. 1990. Fruit Physiology and Production. Third edition . Kalyani publishers, New Delhi. p. 522

Singh, R.N. and Yadav, I.S. 1992. Screening of some North Indian mango varieties for processing.Indian. J. Hort. 51: 136-140

Singh, B. P., Singh, T. P. and Narayana, C.K. 1995. Storage behaviour of Dashehari mangoes in ventilated polybags. Indian Food Packer. XLVll: 5-10

Singh, I.S., Singh, A.K. and Pathk, R.K. 2000. Jack fruit . Department of Horticulture , D. University of Agriculture and Technol., Navendra nagar(Kumargani), Faizabad, p 15

Singh, Z., Janes, J., Tan, S.C. 2001. Effects of different surfactants on calcium uptake and its effect on fruit ripening, quality and post-harvest storage of mango under modified atmosphere packaging. Acta Hort. 509: 413-418

Soji, D.S. and Singh, S. 2001. Studies on bitterness development in Kinnow juice, RTS, squash, jam and candy. J Fd Sci. Technol 38:28-30

Srilakshmi, B. 2003. . Food Science. 3d edition , New Age International Publisher Pvt. Ltd, New Delhi, p 401

Srinivasa , P., Baskaran , R., Ramesh, M., Harish, P. K., Tharanathan, R. 2002 . Storage studies of mango packed using biodegradable chitosan film. European Food Res Technol 215: 504 – 508

Stewart and Straus . 2000 . Advertising , London fruit , Inc . [http: / www . freshmangoes. com / about mangoes/ index.html]

*Stefan, J., Hau, A.M., Oppen, M. 2003. An analysis of the world market for mangoes and its importance for developing countries. Conference on International Agriculture Research for Development. Deutscher Tropentag Gottingen, Germany

Stillman, A. J. 1993. Colour influences flavour, Identification of fruit flavour in beverages. J Fd Sci. 58(4): 810

Sudhakar Rao, D. V., Gopalakrishna Rao, K.D. 2009. Effect of controlled atmosphere condition and pre-treatments on ripening behavior and quality of mangoes stored at low temperature. J Fd Sci. Technol, 46(4), 300-306

Sunderraj, S.S., Muthuswamy, S. and Sadaasivam, R. 2003. Storage of mango. Acta. Hort. (ISHS) 24: 265- 270

Tahir, F. M., Pervaz, M. A., Hameed, C. 2002. Losses of mango fruit after harvest and its control. Agri. Digest, 37:62-64

Tefera, A., Tilahun, S. and Woldetsadik, K. 2008. Effects of disinfection and evaporatively cooled storage on sugar content of mango. African J Bio Technol , Vol 7(1), pp. 65-72

Tripathi, V.K., Singh, M.B. and Singh, S. 1988. Studies on comparative composition changes in fifferent preserved products of Amla Var.Banarsi. Indian Food Packer 42:60-65

Uyttendaele, King, A. D., Higenmeier, R. D., 2001. Biochemical and microbial changes during the storage of minimally processed cantaloupe. J. Agric Food Chem. 43 : 325- 335

Vander Sluis, A.A., Dekker, M., Jagger, A., Jongen, L.M.F. 2005. Activity and concentration
of poly phenolic antioxidants in apple. Effect of cultivar. J. Agric. Fd. Chem., 49:
3606- 3613

Vasugi, E., Sekar, K., Dinesh, M.R. and Suresh, E.R. 2008. Evaluation of unique mango accessions for whole fruit pickle. J Hort Sci. 3(2): 156-160

Vennila, P. 2004. Studies on the storage behaviour of guava-papaya fruit bar Bev. Fd Wld . 31(8): 63-64

Vijayanand, P., Nair, K.K.S and Narasimhan, P. 2001. Preservation of pineapple,mango and
papaya chunks by Hurdle technology. J. Food Sci.Technol 38(1): 26-31

Vink, C.G (1994) Food preservation by hurdle technology. J. Food Technol 48(6):28-29

Wang, C.Y. 1993. Approaches to reduce chilling injury to fruits and vegetables. Hort Rev 15: 63-95

Wavhal, K.N., Athale, P.W. 1989. Studies to prolong shelf-life of mango fruits. Acta Hort .
231:771-775

Wilhelmin, K. 2005. Effects of production and processing factors on major fruit and vegetables . J. Fd. Sci. 70: 56-58

Wang, X. 1991. Storage of mango and control of flowers and harvest season.Guangxi Agric
Sci 3: 110-113

Yahia, E.M and Hernandez, M.T. 1993. Tolerance and response of harvested mango to insecticide low-oxygen atmosphere. Hort. Sci., 28:1031-1033

Zargory, D. 1999. Effect of post-harvest processing, handling and packaging on microbial population. Post harvest news and information on fresh fruit and vegetables, quality and food safety . Post-harvest Biol. Tech., 15:313

* Originals not seen

Net References

www. Wikipedia .com

www.actahort.org

www.apeda.com

www.articlebase.com

www.brighthub.com

www.fao.org

www.healthrecipies.com

www.kungfucancer.com

www.plantcultures.com

http://en.wikipedia.org

http://spore.octa.in

APPENDIX

APPENDIX I

SPECIMEN EVALUATION CARD FOR TRIANGLE TEST

Name:

Date

Product:

Time

Two of the three samples are identical
Determine the odd sample

Pair No of	Code No. of samples	Code No. of Odd sample
1		
2		
3		
4		

Signature

APPENDIX II

SCORE CARD FOR THE ASSESSMENT OF ORGANOLEPTIC QUALITIES OF MANGO CHUNKS

Name:
Product:

Date:

Criteria	Points	T1		T2		T3		T4	
		B	**UB**	**B**	**UB**	**B**	**UB**	**B**	**UB**
1. Appearance									
Excellent	5								
Very good	4								
Good	3								
Fair	2								
Poor	1								
2. Colour									
Excellent	5								
Very good	4								
Good	3								
Fair	2								
Poor	1								

. **3. Flavour** Excellent Very good Good Fair Poor	 5 4 3 2 1								
. **4. Texture** Excellent Very good Good Fair Poor	 5 4 3 2 1								
. **5. Taste** Excellent Very good Good Fair Poor	 5 4 3 2 1								

PRESENTATION OF RIPE MANGO CHUNKS BY HURDLE TECHNOLOGY

By

REKHA RAVEENDRAN.R.S

ABSTRACT OF THE THESIS
Submitted in partial fulfillment of the requirement
For the degree of
MASTER OF SCIENCE IN HOME SCIENCE
(Food Science & Nutrition)
Faculty of Agriculture
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF HOME SCIENCE
COLLEGE OF AGRICULTURE
VELLAYANI
THIRUVANANTHAPURAM

2009

ABSTRACT

Mango (*Mangifera indica* L.) is one of the most important tropical fruit crops and is often called as "King of fruits". Although India is the second largest producer of fruits, the domestic fruit industry is fraught with the massive problem of wastage caused by the woefully inadequate post harvest facilities and other supportive infrastructure including cold chain.

The present study entitled "Preservation of ripe mango chunks by hurdle technology" is a comprehensive study carried out with an objective to increase the shelf life of mango chunks by hurdle technology.

Two popular local varieties of mango viz Neelum and Kottukonam were selected for the study. The mangoes were washed, peeled and cut in to pieces and subjected to different combinations of treatments and stored in glass bottles at ambient and refrigerated conditions for a period of 30 days.

Physical characteristics such as fruit weight, fruit length, flesh weight and stone weight of the selected two mango cultivars were assessed and found to be in favour of Neelum variety.

Chemical constituents of the stored chunks such as moisture, pH, acidity, total sugar, reducing sugar and total phenol content were assessed in both the varieties of mango chunks in all the four treatments, at an interval of 0,15 and 30 days of storage at ambient and refrigerated conditions. The results revealed that moisture, pH and acidity was found to be higher in variety Kottukonam stored at refrigerated condition while total sugar, reducing sugar and total phenol contents were found to be higher in variety Neelum stored at ambient condition.

The organoleptic qualities of the mango chunks such as appearance, colour, flavour, texture, taste and overall acceptability were assessed by a panel of selected Judges using a score card. The sensory evaluation revealed that among the quality attributes, appearance, flavour, texture and overall acceptability were found to be higher in variety Kottukonam where as colour and taste attribute were found to be higher in variety Neelum. Blanching of mango chunks decreased the quality attributes significantly. Treatment T_4 had retained maximum scores for overall acceptability (4.14).

The chunks stored at refrigerated condition were found to be highly acceptable for the judges. Storage condition had influenced the overall acceptability of the chunks and found that overall acceptability of mango chunks decreased as the storage period advances.

Microbial examination of the chunks revealed that bacterial infestation was not detected in any of the samples stored up to a period of 30 days, but negligible yeast and mould growth were detected in Neelum and Kottukonam chunks stored at ambient condition. Yeast and mould growth were not detected in mango chunks stored at refrigerated condition up to a period of 15 days.

Cost of the mango chunks was worked out for all the treatments and was found to be reasonable.

It may be concluded that mango chunks remained intact with consumer appeal for a period up to 15 days if stored under refrigerated condition after treating with 50^0 Brix sugar syrup containing 0.2% citric acid with KMS (0.35%) and sodium benzoate (0.04%).