DEVELOPMENT AND QUALITY EVALUATION OF FRUIT SPREADS FROM AVOCADO (*Persea americana* Mill.)

by

MEERA M V

(2017-16-004)

THESIS

Submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE IN COMMUNITY SCIENCE

(Food Science and Nutrition)

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF COMMUNITY SCIENCE

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM- 695 522

KERALA, INDIA

2019

DECLARATION

I, hereby declare that this thesis entitled "Development and quality evaluation of fruit spreads from Avocado (*Persea americana* Mill.)" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

Place: Vellayani
Date: 09-12-2019

MEERA M V
(2017-16-004)

CERTIFICATE

Certified that this thesis entitled "DEVELOPMENT AND QUALITY EVALUATION OF FRUIT SPREADS FROM AVOCADO (*Persea americana* Mill.)" is a record of bonafide research work done independently by Ms. MEERA M V(2017-16-004) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship to her.

Place: Vellayani

Date: 09-12-2019

Dr. ANITHA CHANDRAN C
Major advisor
Assistant Professor
Department of Community Science,College of Agriculture, Vellayani

CERTIFICATE

We, the undersigned members of the advisory committee of Ms. Meera M V (2017-16-004), a candidate for the degree of **Master of Science** in Community Science with major in Food science and Nutrition, agree that this thesis entitled **"Development and quality evaluation of fruit spreads from Avocado (*Persea americana* Mill.)"** may be submitted by Ms. Meera M V, in partial fulfilment of the requirement for the degree.

Dr. Anitha Chandran. C
(Chairperson, Advisory Committee)
Assistant Professor
Department of Community Science
College of Agriculture, Vellayani
Thiruvananthapuram- 695522

Dr. Suma Divakar
(Member, Advisory Committee)
Professor and Head
Department of Community Science
College of Agriculture, Vellayani
Thiruvananthapuram- 695522

Smt. Brigit Joseph
Associate Professor
Department of Agricultural Statistics
College of Agriculture
Vellayani

Dr. Reshma M. V
Senior Scientist
AgroProcessing&Technology Division
CSIR, NIIST, Pappanamcode
Thiruvananthapuram

ACKNOWLEDGEMENT

I thank Lord Almighty for his invisible presence with me in each and every step I take and for working His way through my parents, teachers, friends and each and every person of my life.

Let me place on record of my profound feeling of gratitude and sincere thanks to my chairperson of the advisory committee, ***Dr. Anitha Chandran. C,*** *Assistant professor for her valuable and affectionate guidance, constant encouragement and unfailing patience through out the course of this research work and in the preparation of the thesis. This work would not have been possible without her help and support.*

I extend my heartfelt thanks to ***Dr. Suma Divakar****, Professor and Head, Depatment of Community Science, for her motivation, guidance and advices during the course of study and writing the thesis. All those advices were extensively helpful, and I would like to thank you Madam, for that.*

I wish to express my sincere gratitude to ***Dr. Bela G.K****, Professor for her keen interest immense help, constructive suggestions and timely support and cooperation rendered throughout the course of this research endeavor.*

I avail this opportunity to pay sincere thanks to ***Dr. Reshma M.V****, Senior Scientist, CSIR, NIIST, Pappanamcode for her keen interest, immense help for freeze drying the avocados, constructive suggestions and timely support and co-operation rendered throughout my research work.*

I am also grateful to ***Dr. Brigit Joseph****, Associate Professor and Head, Department of Agricultural Statistics for his guidance, timely advice, stimulating suggestions and statistical interpretation of the experiment data.*

I am truly and deeply grateful to ***Dr. Krishnaja,*** *Assistant Professor, for her suggestions and support for my research work*

I wish to express my heartfelt thanks to ***Dr. Anil Kumar****, Dean, College of Agriculture, Vellayani for providing me all the necessary facilities from the university during the whole course of study.*

From the depth of my heart I thank my dearest classmate ***Archana L,*** *for her indispensable help, love, moral support and constant encouragement.*

My loving thanks to my seniors ***Subha chechi, Anila chechi, Sowmya chechi, Kavitha chechi*** *and also my juniors* ***Abhina****,* ***Himabindu*** *for their support and encouragement for my research work.*

I also thank non-teaching staffs of the department for all their love and support.

I express my thanks and wholehearted cheers to my friends ***Pooja, Tessa, Soumya, Anjana*** *for their help, love, encouragement and support which made my days more beautiful and joyful.*

Words are failed to express my love and gratitude from my deep heart to my dearest ***Achan, Amma*** *and* ***Chettan****. The love, support, patience and constant*

encouragement given by them was a real source of inspiration without which I could not complete this research endeavor.

I thank all those who extended help and support to me during the course of my work.

Meera M V

DEDICATED TO MY FAMILY

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

%	Per cent
^{0}Brix	Degree brix
^{0}C	Degree Celsius
CD	Critical difference
cfu/g	Colony forming units per gram
et al.	And other co workers
µg	Microgram
G	Gram
g/100g	Gram per 100g
Ha	Hector
Mg	Milligram
Ml	Milli Litre
viz.	Namely
p^{H}	Negative logarithm of hydrocarbon ions
Fig.	Figure

INTRODUCTION

1. INTRODUCTION

Fruit consumption has enjoyed during the past decade. Consumers are eating more fruits as they learn about the health benefits by information from current nutrition studies. Many tropical fruits that used to be considered exotic and expensive are now commomly consumed and many other processed foods.

Avocado botanically known as *Persea americana,* is an evergreen plant and can grow in diverse environmental conditions. On an average, one avocado tree produces about 120 to 150 fruits annually.

Avocado is an energetic fruit with high nutritional value and is considered a major tropical fruit, since it is rich in protein and contains fat soluble vitamins lacking in other fruits, including Vitamins A and B, and median levels of vitamins D and E. It contains different oil levels in the pulp, thus it is widely used in pharmaceutical and cosmetic industries, and for obtaining commercial oils similar to olive oil, because of their similar fatty acid composition (Bergh, 1992).

Avocado growth and development is intense, differing from other fruit species. After harvest, the fruit completes maturation, with major changes in metabolism and higher respiratory rate, and thus high production of ethylene, being highly perishable under environmental conditions leading to the production of high amounts of waste. In this sense, the avocado pulp processing can contribute to its best use, either as a food product or for oil extraction (Golukeu & Ozdemir, 2010).

According to Jacobo & Hernandez (2012), avocado is characterized by an attractive color, a distinguishing texture, and an exquisite flavor and aroma. All these sensory attributes are closely related to its eating quality, which increases as the fruit ripens, and some of them are used for consumers as a guide at purchasing time. Larmond (1999) opined that consumer acceptability is mainly correlated with pulp texture (more than flavor or oil content) and it is negatively affected by the presence of fibers and mesocarp discoloration.

The avocado has various uses as a natural cosmetic, with advantages in rapid skin penetration, and as a superior natural sunscreen. Avocado oil has several culinary and health benefits. The greater use of whole fruit has important advantages: usefulness in human weight control, high nutritional density, source of major antioxidants, stroke prevention, fruit protein source, fiber source; as baby food, and other dietary benefits. Erroneous public perceptions of avocado calorie content and of cancer influences are noted.

Increasing recognition of unhealthful consequences from additives, preservatives, processing, and artificial products generally gives the avocado a major advantage as a food and also as a cosmetic. With increasing concern for the environment, an added plus for avocado cosmetics is that they are biodegradable. Consumers are beginning to favor basic, natural ingredients.

Palou (2000) mentioned the use of the avocado as a skin moisturizer, cleansing cream, makeup base, sunscreen, lipstick, bath oil, and hair conditioner. Toxicological tests of avocado oil products have provided an official health/safety assessment.

There is a wide variety of processed foods derived from avocado, such as guacamole, frozen products, refreshing drinks and avocado paste, as well as numerous uses of it in the cosmetic, soap, and shampoo industry. Moreover, avocado oil is gaining interest in the fat and oil market, as this fruit is the only one that can rival the olive and palm fruits in oil content, and also because diverse health effects have been attributed to its consumption-although, as stated above, it is also used in cosmetics(Lopez, 1999).

Industries are taking advantage of avocado by products (seed and peel) to extract oil, as well as several interesting compounds that are present at important concentration levels and can be used as antioxidants, flavoring, colorants or

texturizer additives, making possible a better exploitation of avocado fruit (Rachimoellah *et al.*,2009).

The economic and social importance of avocado principally resides in the benefits that its cultivation gives to producers, processors, and consumers. The orchards create jobs by demanding labor for farming operations, harvest, packinghouse operations, transportation, and marketing. In addition, the development of new products would also promote the creation of processing plants, which in turn would generate new jobs, and increase the farmers' profits.

In order to increase commercialization on a larger scale and give avocado an added value, it is important to develop food products derived from this fruit with a long enough shelf-life to assure their transportation and distribution to consumers.

Hence the present study "Development and quality evaluation of fruit spreads from avocado (Persea *americana* Mill.)" was undertaken with the objective to study the effect of pre-treatments on quality parameters of avocado cultivar and to develop fruit spread and its quality evaluation.

REVIEW OF LITERATURE

3. REVIEW OF LITERATURE

The relevant literature available on the study entitled "Development and Quality evaluation of fruit spreads from avocado (*Persea americana* Mill.) have been briefly reviewed here.

2.1 Avocado as a Unique Fruit

2.2 Medicinal properties of Avocado

2.3 Avocado – Substitute for Butter

2.4 Avocado Processed products

2.5 Shelf life of Avocado products

2.6 Consumer Acceptance of Avocado

2.1 AVOCADO AS A UNIQUE FOOD

Avocados are a delicious and unique fruit that offer a range of benefits when consumed. The avocado is a unique fruit ,while most fruits primarily consist of carbohydrates, avocado is high in healthy fats. This fruit is prized for its high nutrient value and is added to various dishes due to its good flavor and rich texture. It is the main ingredient in guacamole.

Persea americana Mill, commonly known as avocado pear, is an evergreen tree belonging to the family Lauraceae. It is a tropical tree native to Mexico, Central America and South America but it is now grown worldwide (Duester, 2000).

Bergh (1992), opined that the avocado fruit has been a major food for the people of Central America for, apparently, several thousand years .The fruit is rich in unsaturated fats and vitamins and the flesh has more energy value than meat of equal weight.

The avocado is now grown throughout most of the tropics or subtropics,but appears to have originated in Central America (Bergh,1992). The commercial varieties are placed for horticultural purposes in one of three groups or races - West Indian, Guatemalan or Mexican.

They are sometimes described as tropical, subtropical and semitropical on the basis of increasing cold hardiness and general climactic adaptation (Bergh,1992).

Roger (2007) and Palou (2000) reported that avocado fruit is dispersed worldwide in tropical and subtropical regions. There are numerous varieties of avocado around the world, according to the climate in which they grow, with different shapes, flavours, textures, colours and smells. The most well-known and marketed types are the Hass and Fuerte varieties.

According to Lin and Tang (1986); Malo (1999); Mendez and Hernandez(2007), avocado is botanically classified into three groups, which have been termed the Mexican (Persea americana var.drymifolia), Guatemalan (Persea nubigena var. guatemalensis) and West Indian (Persea americana var. americana) types or races. The names are based on the respective origins and differences in growing conditions and characteristics of the fruit. Chia and Dykes (2009) reported that commercial varieties are mainly based on the Guatemalan and Guatemalan-Mexican hybrid cultivars, for example, the Hass variety is a Guatemalan-Mexican hybrid race .

Koller (1992) reported that fruit characteristics including size and skin texture vary considerably among the races. Prominent commercial varieties include Fuerte and Hass. Fuerte is a Guatemalan/Mexican hybrid and Hass originated from a Guatamalan seedling.Manal,Shehat and Sahar (2013) opined that other commercially important varieties of avocado include Lula, Booth 8,Walden, Pollock .

Recently a considerable international trade in avocado fruits has developed.Total world production of avocados in 1990 was around 1.4

millionmetric tonnes, with major producing countries including Mexico, USA,Brazil, Dominican Republic, Indonesia, Zaire, South Africa and Israel(California,Avocado Commission, 2011).

Chia and Dykes (2009), found that fruit growth in avocado follows a pattern similar to the development of that in other fruits, with rapid cell division at the early stages. However, in the avocado cell multiplication continues in the mature fruit and in general avocado fruit tend to continue growing while attached to the tree.

Chong *et al.*, (2009) reported that avocados having more than the minimum oil content may be lacking in organoleptic qualities, though raising the oil content standard might eliminate from the market avocado varieties or crops whose organoleptic qualities are adequate.A strong relationship is apparent between avocado fruit growth and maturity and between oil content and dry weight(Chia & Dykes,2011).

Bizimana *et al.*,(1993) reported that ripening of avocado fruit may occur a few days after harvest. Ripening and softening can be delayed by pre cooling immediately after harvest. Some cultivars, e.g. Booth 1, Booth 8, Taylor, which are chilling tolerant can be stored for 4 to 8 weeks at 4.4°C. Other chilling-sensitive varieties store best at 13°C for a maximum period of 2 weeks. Ripening is also delayed by holding the fruit in low O2 (2-5%) and high CO2 (3-10%) conditions .

2.2 MEDICINAL PROPERTIES OF AVOCADO

Now a days, the avocado has become an incredibly popular food among health-conscious individuals. It's often referred to as a super food, which is not surprising given its health properties .They have a creamy, rich, fatty texture and blend well with other ingredients.

The edible fleshy part of avocado is most nutritious of all salad fruits and served as a salad vegetable.Avocado can also be eaten raw or on bread and sandwich filling (Fulgoni *et al.*, 2010).

Hidalgo *et al.*, (2010) opined that the avocado is a medium energy dense (1.7 kcal/g) fruit because it contains about 80% water and dietary fiber. Unlike other fruits, avocados are low in sugar and contain 15% MUFA rich oil, which helps to increase the bioavailability of carotenoids from salads and salsa often consumed with avocados . Avocados also contain a variety of vitamins, minerals and phytochemicals such as lutein, phenolic antioxidants, and phytosterols associated with numerous potential health benefits.

Avocado is a high metabolic rate fruit, completing its ripeness within 5 to 7 days at 25 °C, after harvesting. Unlike many other fruits, avocado's ripeness does not occur on the tree, but takes place several days after harvest (Batista *et al.*,1993).

Bates (1999), reported that the post harvest ripening process is related to the amount of surrounding and endogenous ethylene, which increase the respiration rate During this process, avocado undergoes many physiological and biochemical changes, including biosynthesis and accumulation of pigments, lipids vitamins and antioxidants among others (Chia and Dykes, 2010)

Phytosterols are present in avocado whose structure is very similar to cholesterol and it inhibits intestinal cholesterol absorption and decreases hepatic cholesterol synthesis(Chia & Dykes, 2010).

White *et al.*, (2009) reported that in Brazil, the ripe fruit is consumed together with sugar, honey and liqueurs and consumption is increased by its sensory and nutritional characteristics.The fruit contain 339mg – 100g-1 of

potassium levels when compared to other fruits which protects the body from cardiovascular diseases(USDA, 2009).

Avocado consumers tend to consume more of dietary fiber, Vitamin K, potassium and magnesium in their diet than non - avocado consumers(Fulgoni *et al.*, 2011).

About 80% of the avocado edible fruit consist of water (72%) and dietary fiber(6.8%) and thereby it has an effect on weight control(USDA and HHS, 2011).

A Study conducted by Hughes *et* a*l.*, (2009) isolated 1,2,4-trihydroxyheptadec-16-ene 1,,2,4-trihydroxyheptadec-16-yne and 1,2,4-trihydroxynonadecane from the unripe fruits of *P. americana*, and found these substances to be moderately cytotoxic when evaluated against a small panel of cancer cell lines.

Hughes *et al.*,(2019) isolated 5 alkanols from avocado fruits with "liver suppressing activity" (as determined by the changes in plasma levels of alanine aminotransferase and aspartate aminotransferase), including compounds 9-11.

Jackson (2003) in his study found that two analogs, persenones A and B , along with persin , were found to inhibit superoxide ($O_2^{\cdot}$) and nitric oxide (NO) generation in cell culture, and may thus serve as cancer chemopreventive agents in inflammation-related organs.

A study conducted by Adeyemi *et al.*, (2002) reported that the aqueous leaf extract of *P. Americana* (800 mg/kg) produced a significant inhibition of the swelling caused by carrageenan at 3 h. This effect was similar to that produced by indomethacin in the same duration.

Olaeta *et al.*, (2007) reported that aqueous leaf extract of *P. americana* possesses anticonvulsant activity and the effectiveness of the plant extract in the experimental convulsion paradigm used probably suggests that the plant could be used in both *petit* and *grand mal* types of epilepsy.The methanolic leaf extract of *P. americana* and its hepatoprotective action against acute paracetamol toxicity make it a potential agent against liver diseases and other pathologies.

The antioxidant activity exhibited by the methanolic leaf extract of *P. americana* and its hepatoprotective action against acute paracetamol toxicity make it a potential agent against liver diseases and other pathologies associated with oxidative stress.associated with oxidative stress.

Anaka *et al.*, (2009) reported that aqueous leaf extract of *P. Americana* possesses hypo glycemic effects and the maximum anti diabetic activity was reached at 6 h after a single dose of the extract was administered, producing 60.02 ± 6.83% reduction in blood glucose level.

Fulgony (2010), reported that avocado contributes minerals including magnesium, potassium, iron, copper, and phosphorus,and vitamins such as vitamin C, E, and β-carotene.

Flag *et al.*, (1994)in his study found that date of harvesting is also known to affect the nutritional quality and antioxidant activity (AOC) of avocado fruits They harvested Hass avocados at seven different dates,ripened at 25 °C followed by 21 or 35 days ofcold storage. The phenolic and glutathione contents increased and ascorbic acid contentdid not show significant difference in early harvested fruits (January–March). Phenolic,glutathione, ascorbic acid, and antioxidant activity increased slightly and then decreased in late-harvested fruits (April to June). AOC in early-harvested fruitafter storage for 35 days was much higher than the late harvested fruit after storage for 21days. They recommended that avocados

can be harvested early for economic benefits, according to the markets and still maintain high nutritional quality.

,Hozaw *et al.*, (2014) suggested the consumption of carotenoids with a lipid-rich food such as avocado for maximum absorption and conversion to vitamin A.

Honarbakhsh (2015), identified two acetogenins (Persenone C and Persenone A) in avocado pulp that inhibit platelet aggregation with a potential preventive effect on thrombus formation in patient suffering from ischaemic diseases.

2.3 AVOCADO – SUBSTITUTE FOR BUTTER

Jacob and Brenes (2013), reported that the avocado is characterized by an attractive color, a distinguishing texture, and an exquisite flavor and aroma. All these sensory attributes are closely related to its eating quality, which increases as the fruit ripens, and some of them are used for consumers as a guide at purchasing time.

Larmond (1999),in his study, found that consumer acceptability is mainly correlated with pulp texture (more than flavor or oil content) and it is negatively affected by the presence of fibers and mesocarp discoloration. When an evaluation with panelists was carried out to study avocado likeability or acceptability, texture and flavor are usually the most widely evaluated attributes. The descriptors usually included in terms of texture are mushy, firm, stringy, gritty, creamy, smooth, dry, watery and oily; whereas the terms more widely used to describe the flavor are bland, grassy, woody-pine, sweet, nutty, buttery, savory, oily, rancid, canned pea, with sharp, astringent, metallic and bitter (referring to aftertaste).

Obenland *et al.*, (2014) reported that the higher fruit likeability was achieved for ripe avocados, which presented creamy, smooth and buttery texture with nuttiness and a minimum of grassy flavor.

Avocado Central (2010), also carried out a sensory evaluation, where the tasters described the texture of the preferred fruits as creamy, smooth and buttery, and the flavor as buttery and nutty. The ripening process has a substantial influence on the sensory attributes of avocados; indeed, it is over this process when one of the main alterations of this fruit happens: the softening. This textural change is the most remarkable event during ripening and it is the result of enzymatic degradation of structural and storage polysaccharides.

Avocado Central (2010), found that the final texture of avocado fruit is affected by several factors, such as turgor pressure generated within cells by osmosis, accumulation of storage polysaccharides, or structural integrity of the primary cell wall and the middle lamella, among others .

Arias *et al.,* (2012), opined that avocado flavor varies considerably during ripening too, as it is strongly influenced by fruit composition, especially in terms of sugars, acids and lipids. Over the last few years several authors have described the close connection between flavor and aroma .Aroma is due to the presence in avocado of volatile compounds, which can be alcohols, aldehydes, and esters. The most abundant are aldehydes, as they derive from lipid degradation and, as stated before, avocado is a rich lipid matrix.

Akpabio *et al.*, (2011), found that aldehydes found in avocado pulp may contribute to a fruit flavor with a grassy aroma, although there are other volatile compounds that are also involved. The concentration of these aldehydes decreases as fruit ripen at the same time as the perception of grassiness diminish. We think that taking into account the preferences of the consumers on the basis of sensory

attributes is, nowadays, essential to establish future research as well as conceive the best marketing strategies.

2.4 AVOCADO PROCESSED PRODUCTS

Avocados are grown in many countries of the world and are consumed principally as fresh fruits. Avocado require special handling because of their highly perishable nature. Therefore, the development of new avocado products and of improved methods of preservation are of interest to avocado growers . These Avocado products include the paste, puree and guacamole and among these guacamole is a fruit pulp seasoned with salt,onion,lemon,pepper , tomato and this is the most marketed product of Avocado by U S companies (Daiuto *et al.*, 2011).

The minimally processed avocado product will provide conditions that are ideal for the growth of spoilage bacteria.Since these foodproducts are ready to eat, microbial growth must be strictlycontrolled..The commonly used preservative techniques are traditional technologies like thermal treatments and chemical preservatives which reduce microbial load but can lead to the generation of bitter off-flavours (Malo, 1999).

The preservation methods used to obtain a stable avocado pulp including pasteurization, drying, oil extraction, freezing and freeze(Stephens *et al.*, 2000).The processed avocado pulp is an alternative to utilize fruits, which can be used in various value-added products. Fluid extract of the avocado leaves is widely used in pharmaceutical products, mainly due to the diuretic characteristic of the present compounds in plant leaves.

GUACAMOLE

Taah *et al.*, (2003) reported that the value added product, guacamole, is prepared from a fully ripe fruits by blending the pulp with herbs, spices, lemon juice, and salt for flavoring .

Malo *et al.*, (1999) reported that after the ripening is completed, the fruit is chilled to 5 °C. The fruit is dipped in 200 ppm hypochlorite solution to lower the microbial load on the surface. Avocado stems are removed, fruit is cut into halves, and the seed is removed. The pulp is removed from peel either by a ricing machine or manually. All the remaining spices and other ingredients (as per formulation) are added to the pulp and blended to obtain a uniform flavored guacamole. The product is filled into containers, vacuum sealed (or nitrogen-flushed), and stored frozen (−22 °C).

Guacamole will spoil within the first 5 days ,even when it is stored in 5C(41F) (Tom,1990).The main groups of microorganisms responsible for the quick spoilage of these product include Lactic acid bacteria, moulds and yeasts and it can be controlled by HPP.

AVOCADO OIL

Ukwe (2005), in his study found that although several methods for the recovery of avocado oil from the pulp have been practised, the preferred method for obtaining natural oil without solvent impurities is by centrifugation..The crude oil obtained by this method is dark green and has a chlorophyll content of 40 parts per million (ppm) or more.

Tripathi and Karunakaran (2013), reported that steps involved in total processing of crude avocado oil to the more highly refined oil include alkali refining, bleaching, deodorization and winterization before drumming.

Avocado oil is known to be rich in many bioactive substances that can prevent and control hyperlipidemia (Tango *et al.*, 2004)

Whiley (2000) reported that because of its unique nutritional quality, avocado oil has been named as the new wonder oil developed a rapid method for the sequential extraction and subsequent estimation of fatty acids and sugars from avocado mesocarp tissues. The fatty acid composition and phytosterols present in avocado oil are similar to olive oil (Yasir and Kharya, 2010).

Depending on the season and location of orchard, the oil content in Hass variety of avocado can vary from 16% to 30%. Not only do the late-season fruits

have more oil, but also it is easier to extract oil from the idioblast cells that contain fat.

Avocados oil can be extracted by one of the three methods: (1) solvent extraction from dehydrated avocado pulp (gives nearly complete recovery of oil); (2) hydraulically from dried avocado flakes (yields are very low); and (3) centrifugation from soft fruit (recovery only 50% of the oil present). The crude oil, thus, extracted from the avocado is further refined. Refining process removes the off-flavors, free fatty acids, most of the chlorophyll, phosphatides, and waxes. The refining process consists of alkali treatment, bleaching, deodorization, and winterization (Man, 2002).

Garcia *et al.,* (1996) reported that the modern "cold-press" method involves maceration of fruit flesh by a high-speed grinder. Then, oil, water, and pulp solids are separated by decanting. The oil fraction goes through Alfa Laval olive oil processing equipment. Depending on the season, the typical oil yield comes between 10% and 18% of the whole fruit

NATURAL COLOURANT

Pino *et al.,* (2004) in his study examined a colored extract produced enzymatically in avocado seed. Avocado seeds are not currently commercially useful and represent a large waste stream. Their application as a source of natural colorants could be of significant commercial value. Because of its high phenolic content; the colored extract may have additional functional attributes which should be explored.

AVOCADO PUREE/SAUCE

Arias(2014)opined that the process for avocado puree or sauce is similar to guacamole up to pulp extraction step. The next step consists of high shear blending of pulp with water, gums, thickeners, and spices. A thick sauce should have an apparent viscosity of 8,000–12,000 centipoises as measured by a

Brookefield viscometer using spindle number 4.The sauce is then filled into polyethylene jars and frozen stored at −18 °C.

The use of traditional heating of avocado puree produces off flavors and, therefore, use of an alternative process of high temperature short time (HTST) heating using microwave energy has been investigated by California Avocado Commission, (2012).

According to Dinubile (2010) found that use of 120 ppm of zinc chloride and 12 ppm of copper chloride during microwave heating of avocado puree resulted in preservation of color for 7 days at refrigerated storage. In another study, use of microwave heating of avocado puree at high energy for 180 seconds brought only 60% reduction in PPO activity (Jimenez *et al.*, 2001).

Fernandes *et al.*, (2010) reported that the kinetics of PPO activity and browning of avocado puree preserved by antibrowning agents (ascorbic acid, or EDTA) and antimicrobial agents (sorbic acid). They proposed a fractional conversion model to predict the shelf-life of minimally processed avocado puree in terms of visual appearance. Morris *et al.*, (2014) found that the avocado puree when added to the sausage formulation had no adverse effect on the acceptability of this meat product .

DEHYDRATED AVOCADO

Olaeta *et al.*, (2007) reported that during dehydration, many quality characteristics such as color, texture, flavor, porosity, and the rehydration ratio, are affected.

Santana *et al.*, (2015) in his study found that drying of avocado has a few special problems. Avocados are dried either by the spray drying orby the drum drying process. These drying techniques produce a product that has only pale green color and has a chalky off-flavor, which does not have a big market. By adding a few spices, the off-flavor can be masked and a ready mix of guacamole is produced. The dehydrated avocado may find use in pet food manufacturing as an ingredient rich in oil .

A number of patents have been issued for dehydrated avocado pieces (Sanjust, 2008), powdered compositions,avocado concentrate and osmotic drying (Sackett *et al.*, 2010).

Saxena (2003) investigated that the effect of synthetic and natural antioxidants on the oxidative stability and palatability of stored avocado powders at temperatures ranging from 6 to 40 °C. During storage, peroxide value was measured and the development of rancidity was determined by sensory evaluation. Tertiary butylated hydroxyquinone (0.05%) + citric acid (0.1%) mixture coupled with nitrogen packaging were found to be the most effective in extending the shelf-life of spray-dried avocado powder during ambient storage. Taah *et al.*, (2003) developed a mathematical model based on one dimensional, steady state to suitably describe the rehydration behavior.

Tripathi & Karunakaran , (2014) reported that manufacture of high quality freeze dried guacamole and Unlu *et al.*, 2005 investigated the hygroscopic properties of freeze dried guacamole during storage.

FROZEN AVOCADO

Saxena (2003) reported that commercial processing of avocados started in the United States in 1964 at the Frigid Foods, Inc.,Escondido, California, by Calavo Growers. The company developed frozen avocado halves andslices by immersing in liquid nitrogen (−196 °C).

Sackett *et al.*, (2010) investigated that the processing potential of avocado cultivars at different stages of fruit maturity and the composition of edible parts of avocado fruit (mesocarp) varied,depending on the cultivar and harvest season.They reported various constituents such as drymatter (19.18–30.29%), fat (8.3–16.75%), protein(2.1–2.3%), carbohydrates (6.8–8.1%), and mineral ash (0.7–1.2%). Fruits harvested near to theend of harvesting season gave the highest values for these constituents.

Xu *et al.*, (1995), reported that the effect of cultivar and maturity on the quality of frozen (−40 °C) avocado pulp stored at −18 °C. Of the five cultivars

tested, Edranol gave the best quality frozen product. A minimum of 15% oil content was required in these cultivars at their maturity level to obtain an acceptable quality frozen avocado pulp product.

2.5 SHELFLIFE OF AVOCADO AND ITS PRODUCTS

Wu *et al.*, (2004) highlighted that avocados are classified into climacteric fruits and these type of fruits undergoes a sudden period unique to certain fruits, and during the process occurs a series of biological changes that begin with ethylene making process.

Prieto *et al.*, (2007) reported that climacteric fruits, after harvesting, will experience changes in the rate of respiration increased so that maturation process will be faster. Therefore, avocado has a fairly short shelf life after harvesting, about 7 days (since picking to ready to be consumed), based on research from Deputy Minister of Research and Technology for Science and Technology Utilization and Socialization. The shelf life of avocado is also influenced by external factors such as microorganisms. High levels of avocado water make avocados susceptible to microorganisms.

Rainey (1994), in his study found that avocados are picked by hand using special clipper sand ladders. Once picked, they are pre cooled overnight to remove field heat in the packinghouse to ensure the quality. Before packaging, avocados are washed, lightly cleansed, sized, and graded for quality. The highest grade is separated for supply to supermarket for raw consumption; others are used for processing. The packed avocados are maintained at optimum cool temperature to ensure ripeness and quality while awaiting shipment. Once picked, avocado ripens quickly at room temperature because of the production of ethylene gas during storage. All these steps from picking to grading take 5–9 days.

Rombauer (1997), remarked that skin of avocado changes color upon ripening; for example, Hass avocados change color from green to purple to black. To enhance shelf life, most producers size avocados by weight or separate by firmness. Heterogeneity in firmness can cause variability in ripening and, thus,

setting up of the climacteric process. It is important to sort avocados in lots of different ripening stages and employ post harvest measures to extend shelf-life and quality, as ethylene production from some avocados in a lot can trigger ripening that, once initiated, is hard to stop.

Avocado based industrial products are susceptible to browing reactions and deterioration and technologies like vaccum-expansion is used to reduce browning. Vaccum expansion is a process in which plant material is heated by steam and then introduced in t o a vaccum chamber where disintegration occurs due to their instantaneous vaporization of part of the water constituent (Azanha & Faria, 2005).

According to Arts and Hollman, (2004), HPP has a minimal effect on low molecular weight compounds after pressurization and thereby contributing the conservation of sensitive molecules such as vitamins, pigments, antioxidants and other substances with relavant biological activity, sensitive to thermal treatments.

FAO (2013) found that conservation of colour is considered as an indication of quality in dried fruits given that non-enzymatic browning processes develop during the drying process.Freeze dried fruits maintain better colour than fruits dried using traditional methods. A study conducted by Arts & Hollman,(2004) reported that food packaging research has focused more on biodegradable films, including films made from plant sources. Because consumers demand less use of chemicals on minimally processed fruits and vegetables, more attention has been paid to search for naturally occurring substances able to act as alternative antimicrobials and antioxidants.

Gabay *et al.,* (2008) reported that the ability of edible films to retard moisture, oxygen, aromas and solute transport may be improved by including additives such as antioxidants, antimicrobials, colorants, flavors, fortifying nutrients and spices in film formulation.

According to Goluku and Ozdemir (2010), Mexico is the largest producer of avocados in the world however this country faces several requests for approving the exportation of the avocados to the United States and Europe. Roberts and Orden, (1996) reported that the shelf life of these fruits is very short

and their quality is seriously affected by the attack of phyto pathogenic fungi,mainly Colletotrichum gloesporioides. For this reason in the last 14years, growers and packers are developing grove management techniques, packing practices and shipping practices in order to export their avocados with attractive results. The short shelf life of Mexican avocados is the biggest problem to solve.

Gregory and Onwuka (2005), opined that edible film based on candelilla wax with a potent antioxidant ellagic acid on whole fruits is a good alternative to conserve fresh avocados.

Gyesley (2003), opined that avocado applied edible coating and stored at room temperatures had lower weight loss than avocado without edible coating, lower acid number, tend to be more able to maintain color rather than avocado without edible coating.

Gregory and Onwuka (2006), reported that edible components used as packing materials consist of polysaccharides, lipids, and proteins. The commonly used polysaccharides are cellulose derivatives, chitosan, starch, alginate, kagarenan and pectin. The edible coating is generally made from starch. The advantage of using starch is a presence of abundant starch in nature, available in commercial form, inexpensive and readily biodegradable.

A study conducted by Guine and Barroca (2012) concluded that enhancement of avocado shelf life can be done by applying edible film and edible coating. The edible coating is a primary packaging material made of edible components

Avocado is a typical climacteric fruit with a relatively short storage life owing to rapid flesh softening and decay(Jules,2008 ; Hammami and Rene 1997) opined that applying 1-methylcyclopropene seems to be promising for de laying avocado fruit ripening, but increases the risk of decay . Kim and Janick (2000) reported that cold storage is effective for chilling injury, which manifests as black skin and pits.

Khazan (2015), reported that in the major avocado production countries, such as Indonesia, Kenya, China, Rwanda, and Brazil, avocados are mainly sent to local markets where more than 30% of the fruits are lost after harvest owing to

poor cold storage facilities and postharvest handling systems . Therefore, it is necessary to develop alternative, less sophisticated, low-cost technologies that do not require refrigeration to extend the postharvest life of avocado fruits.

Marques *et al.*, (2009) pointed out that pre-cooling is the first most important handling process in the entire cold supply chain management of fruits. Martin *et al.*, (2014) in his study found that it is usually recommended that avocado fruits should reach the pack house within two hours after harvest. On arrival, the fruits should be pre-cooled to16ÊC or colder. Commercially, hydro-cooling is the most common method used at the pack house. Recently, cold shock treatment (CST) has attracted extensive attention as a modified pre-cooling approach. CST rapidly lowers the internal temperature of agricultural products by cold air or ice water, which can extend shelf-life and improve the quality of some fruits and vegetables. The beneficial effect of rapid cooling with low-temperature air or water for inhibiting chilling injury development in West Indian avocados was also reported (Pisani, 2014).

2.6 CONSUMER ACCEPTANCE OF AVOCADO

Sulaiman *et al.*, (2011) reported that consumer acceptance is high for the product stored in container with gas barrier when comapared to that stored in polyethylene package.

Scora *et al.*, 2004) in their study found that avocado pulp can be dehydrated and defatted by cold pressing and avocado oil to partially replace wheat flour and butter. The flour from avocado pulp showed characteristics similar to those of conventional flour and whole wheat flour. In avocado pulp, meat derivatives can also be supplemented and most of these processed foods contains relatively high levels of saturated fats and thereby consumption is restricted because of health issues.

Stachys (2001) reported that avocados are highly perishable compared to other fruits produced. While fruit are often stored for 4 weeks, it is a challenge to commercially store fruit for 6 weeks the fruit is ethylene sensitive and has a short shelflife once ripening has been initiated (Sauccdo *et al.*, 2014).

The fruit are highly susceptible to latent infections that are expressed during ripening as well as to physiological disorders associated with chilling injury (Sivasankar, 2013).

Arias *et al.*, (2013) opined that given the physiological behaviour of the fruit and its susceptibility to rots, it is not surprising that this fruit provides some distinct challenges for both marketers and consumers. For the 'Hass' cultivar, the major flesh defects in fruit from the retail shelf are rots and bruising . These are not obvious on the outside of the ripe fruit, so consumers can be disappointed when, upon cutting and preparing fruit for consumption, they discover that the flesh is damaged or rotten.

Eyres *et al.*, (2001) reported that bruising can occur as avocados move through the supply chain as well as during the squeezing of individual fruit during selection by consumers .

Industry-funded surveys of avocado fruit quality in retail stores and associated consumer perceptions have highlighted to the avocado industry that management of the processes during production and postharvest is critical to achieving on-going consumer acceptance for their produce.

Duester (2000) opined that the three main factors likely to affect consumer behaviour are maturity (through dry matter), the stage of ripeness (based on fruit firmness) and flesh damage. With flesh damage, it was surmised that consumers would be more concerned about the percentage of unusable flesh rather than the type of damage. Bruising is a common defect in store-bought fruit, so this form of damage was used.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The study entitled "Development and quality evaluation of fruit spreads from avocado (*Persea americana* Mill.)" is a comprehensive study carried out with an objective to study the effect of pre-treatments on quality parameters of avocado fruit and to develop fruit spreads and its quality evaluation.

The methodology followed in the present study is explained under the following headings.

3.1Selection of avocado fruits

3.2Effect of different pre treatments on the quality of avocado fruits

3.3Development of fruit spreads

3.4Statistical Analysis

3.1 SELECTION OF AVOCADO FRUITS

Avocado cultivar commonly found in the households of Wayanad named Purple Hybrid was selected for the study. Mature fruits were collected from Regional Agricultural Station, Ambalavayal, Wayanad District for the present investigation.

3.2 EFFECT OF DIFFERENT PRETREATMENTS ON THE QUALITY OF AVOCADO FRUITS

The avocado fruits when ripe have short life span and would discolour and rot whether refrigerated or not, and lose its flavour (Bates, 1999).

Hence different pre-treatments were applied to the fruits to deactivate the action of enzymes present in fruit.

3.2.1 Pre-treatments in avocado fruits

Blanching is an important intermediate thermal processing step to enhance preservation and quality of foods by inactivating enzymes that can cause loss of

flavour and colour. (Andrews, 1992). Commercially prepared mixes of ascorbic acid and citric acid and sugar are used to prevent darkening of fruit. (Bates, 1999). Sulfur and sulfite compounds have been used for centuries as pre treatments to prevent darkening of preserved fruits. They also prevent microbial growth and reduce spoilage (Hernandez *et al.*, 2006).

Pre-treatments processing methods such as blanching, immersing in of sugar syrup, honey, brine solution, citric acid, KMS were tried out separately to select two best pre-treatments methods for the development of two fruit spreads.

The various treatments applied on avocado fruit are given in table 1.

Table 1: Pre treatments in avocado fruit

Sl No	Pre-treatments	Particulars
1	(T1)Blanching	3 mins at 100^0 C
2	(T2)Sugar	60g
3	(T3)Salt	2g
4	(T4)Honey	60g
5	(T5)KMS : Citric acid : Sugar	0.25 : 0.1 : 60
6	(T6)KMS : Citric acid : Salt	0.25 : 0.1 : 2
7	(T7)Citric acid	0.1
8	(T8)KMS	0.25
9	(T9)Control	-

Hundred gram pulp of Purple hybrid with respective additives were immersed for one week except blanching.

3.2.2 Organoleptic evaluation of different pre-treatments

All the pre treatments were evaluated for sensory characteristics and overall acceptability by a panel of 10 judges using 9 point hedonic rating scale (Appendix-1). The major quality attributes included for scoring were appearance,

colour, flavour, taste and texture. Based on the organoleptic evaluation two best pre treatments selected by the judges were subjected for the development of two fruit spreads.

3.3 Development of fruit spreads

Two fruit spreads namely sweet avocado spread and spicy avocado spread was standardized and developed independently utilizing the selected best two pre-treatment methods. Fruit spreads were standardized using selected pre-treated avocado pulp as constant (100 per cent) along with added adjuncts. Appropriate adjuncts in various combinations were added to develop the products.

3.3.1 Development of Sweet Avocado Spread.

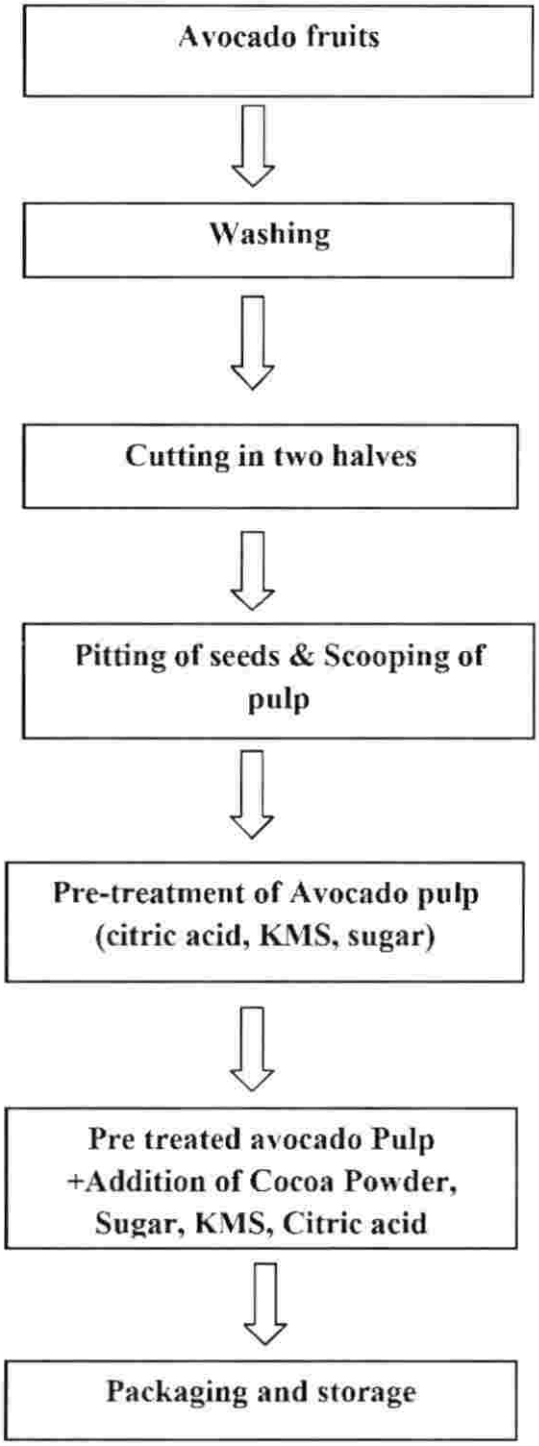
Sweet fruit spread developed included a mixture of pre treated avocado pulp, sugar, cocoa powder, Citric acid and KMS in different proportions as given in Table 2.

The best one treatment was organoleptically identified by a panel of judges using 9 point hedonic rating scale for further qualitative studies

Table 2: Composition of Ingredients for the standardization of Sweet Avocado Fruit Spread

Sl No	Treatments	Ingredients	Proportion of Ingredients (g)
1	T_1	Avocado pulp : Cocoa Powder : Sugar : Citric acid : KMS	100 : 10 : 100 :0.1 : 0.25
2	T_2	Avocado pulp : Cocoa Powder : Sugar : Citric acid : KMS	100 : 20 : 100 : 0.1: 0.25
3	T_3	Avocado pulp : Cocoa Powder : Sugar : Citric acid : KMS	100 : 30 : 100 : 0.1 : 0.25
4	T_4	Avocado pulp : Cocoa Powder : Sugar : Citric acid : KMS	100 : 40 : 100 : 0.1: 0.25
5	T_5	Avocado pulp : Cocoa Powder : Sugar : Citric acid : KMS	100 : 50 : 100 : 0.1: 0.25

Fig 1.The flow chart for the development of Sweet Avocado Fruit Spread



3.3.2 Development of Spicy Avocado Spread

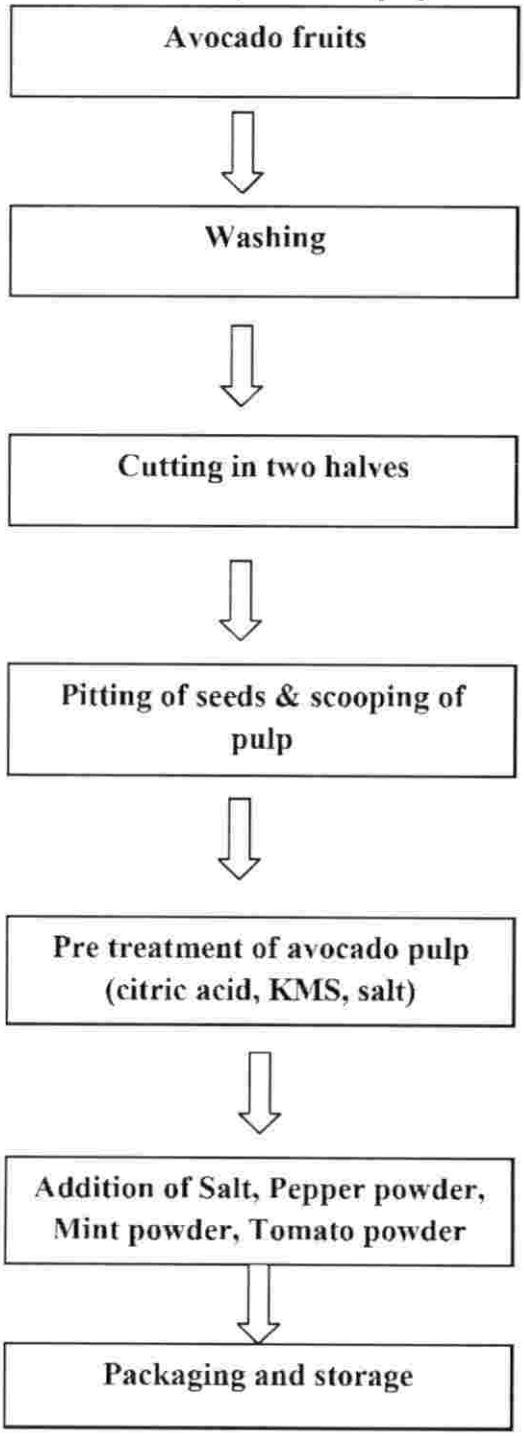
Spicy fruit spread developed included a mixture of pre treated avocado pulp, salt, pepper powder, Tomato powder, Mint powder, Citric acid, KMS in different proportions as given in Table 3.

Table 3: Composition of Ingredients for standardization of Spicy Avocado Fruit Spread

Sl No	Treatments	Ingredients	Proportion of Ingredients (g)
1	T_1	Avocado pulp : Pepper Powder : salt : Tomato Powder : Mint Powder : Citric acid : KMS	100 :2 : 2 : 2 : 0.5 : 0.1 : 0.25
2	T_2	Avocado pulp : Pepper Powder : salt : Tomato Powder : Mint Powder : Citric acid : KMS	100 : 5 : 2 : 3 : 1 : 0.1 :0.25
3	T_3	Avocado pulp : Pepper Powder: salt : Tomato Powder : Mint Powder : Citric acid : KMS	100 : 4 : 2 : 3 : 2 : 0.1 : 0.25
4	T_4	Avocado pulp : Pepper Powder : salt : Tomato Powder : Mint Powder : Citric acid : KMS	100 : 3.5 : 2 : 4 : 2.5 : 0.1 : 0.25
5	T_5	Avocado pulp : Pepper Powder: salt: Tomato Powder : Mint Powder : Citric acid : KMS	100 : 3 : 2 : 5 : 1.5 :0.1 : 0.25

One treatment selected through organoleptic scoring method by a panel of 10 judges was utilized for further qualitative studies

Fig 2.The flow chart for the development of spicy avocado fruit spread



3.3.1 Quality studies in avocado spreads

Developed two fruit spreads were further evaluated for its chemical, nutritional, shelf life qualities, consumer acceptability and cost analysis using standard techniques.

3.3.1.1 Assessment of nutritional composition

Table 4: Method of analysis of nutrients and chemical composition

Carbohydrate	Sadasivam and Manickam (1992)
Protein	AOAC (1995)
Total Fat	Sadasivam and Manickam (1992)
Dietary fibre	AOAC (1995)
Moisture	Sadasivam and Manickam (1992)
Acidity	Ranganna (2001)
TSS	Sreevastava and Kumar (1994)
Total Sugars	AOAC (1995)
Reducing sugars	AOAC (1995)
Peroxide value	AOAC (1995)
Beta carotene	Sreevastava and Kumar (1994)
Vitamin C	Ranganna (2001)
Total minerals	AOAC (1995)
Calcium	AOAC (1995)
Potassium	AOAC (1995)
Sodium	AOAC (1995)
Iron	AOAC (1995)
Total Phenolic Content	Sreevastava and Kumar (1994)
Total Antioxidant Activity	Thimmiah (1999)

3.3.1.2 Sensory Evaluation studies in developed fruit spreads

Sensory evaluation of developed sweet and spicy avocado fruit spreads was carried out by a panel of 10 judges using a nine point hedonic rating scale. The major quality attributes included for scoring were appearance, colour, flavour, taste and texture.

3.3.1.3 Shelf life study

Developed fruit spreads was filled and stored in glass bottles, plastic containers and polyethylene bags to study its shelf life period both in ambient temperature and refrigerated conditions. Storage qualities in terms of acceptability score, moisture content, acidity, peroxide value and microbial growth were recorded at weekly intervals.

The stored avocado spreads was assessed for the presence of various microorganisms such as bacteria, fungi and coli form initially and at weekly intervals up to one month. This was done by serial dilution and pour plating method suggested by Sackett *et al.*, (2010).

3.3.1.4 Assessment of Consumer Acceptability

Consumer acceptance and preference of the developed products were studied among 50 adolescents applying hedonic rating scale.

3.3.1.5 Cost Analysis

Cost of production was calculated based on the input cost, which means cost of different ingredients used for the preparation of avocado spreads, cost of packaging materials and overhead charges (20) percent of the cost of raw materials which includes fuel and labour charges.

3.4 Statistical Analysis

In order to obtain suitable interpretation, the generated data was subjected to statistical analysis such as ANOVA and Non-parametric methods.

RESULTS

4. RESULT

The results of the present investigation entitled "Development and quality evaluation of fruit spreads from avocado (Persea *americana Mill)"* are detailed under the following headings

4.1 Selection of avocado fruits

4.2 Effect of different pre treatments on the quality of avocado fruits

4.3 Development of Sweet Avocado fruit Spread

4.3.1 Standardization of Sweet Avocado fruit Spread

4.3.2 Quality studies in Sweet Avocado Fruit Spread

4.3.3 Consumer Acceptability of Sweet Avocado Fruit Spread

4.3.4 Cost Analysis

4.4 Development of Spicy Avocado Fruit Spread

4.4.1 Standardization of Sweet Avocado fruit Spread

4.4.2 Quality studies in Sweet Avocado Fruit Spread

4.4.3 Consumer Acceptability of Sweet Avocado Fruit Spread

4.4.4 Cost Analysis

4.1 Selection of avocado fruits

Purple hybrid, common cultivar found in the households of Wayanad District was selected for the study.

Plate 1:Purple Hybrid

4.2 Effect of different pretreatments on the quality of avocado fruits

Pre-treatment processing methods such as Blanching, Immersion in of Sugar syrup, Brine solution, Citric acid, KMS and control (table 1) was tried out to select two best pre-treatment methods for the development of two fruit spreads.

In order to select the best two pre-treatment for the development of avocado fruit spreads, organoleptic evaluation was conducted by a selected panel of judges using a five point score card.

Table 5: Sensory scores of pre treated avocado

Treatments	Mean rank values					
	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
(T_1)Blanching	47.75	54.90	38.05	34.45	31.00	38.45
(T_2)Sugar	47.75	53.20	29.05	32.50	33.15	35.65
(T_3)Salt	34.30	24.80	43.85	61.90	74.30	46.86
(T_4)Honey	32.25	25.95	44.00	55.90	56.70	39.25
(T_5)KMS:citric acid:Sugar	74.90	71.50	79.00	78.90	76.80	85.00
(T_6)KMS:citric acid:Salt	69.40	58.10	71.15	74.35	68.95	75.75
(T_7)Citric acid	44.55	58.10	40.65	32.50	33.40	45.35
(T_8)KMS	47.50	51.40	37.75	25.50	24.05	36.20
(T_9)Control	11.10	6.55	26.00	13.50	11.15	11.40
K value	46.66	59.39	41.94	65.66	72.22	61.04
X^2(0.05)	15.51					

Appearance

T_5 comprising of KMS(0.25),Citric acid(0.1)and Sugar(60) got the maximum score of 74.90 followed by T_6(69.4), T_1(47.75), T_2(47.75), T_8(47.50), T_7(44.55), T_3(34.30), T_4(32.25).Least score was obtained for control.

Colour

Among the pre-treatments, T_5 got the highest score (71.50) followed by T_6(58.10), T_7(58.10),T_1(54.90), T_9 (24.80), T_4(25.95), T_3(24.80).Control recorded the least mean rank for this attribute.

Texture

Table (5) depicts that the mean rank values obtained for pre-treatments done in avocado fruit pulp. Statistical analysis of data showed that, there was significant difference between nine treatments including control. The average score for texture ranged from 26 to 79 with a maximum score of 78 received for T_5 . T_5 received the highest mean rank value (79) in this attributes, followed by T_6(71.15), T_4(44), T_3(43.85), T_7(40.65), T_1(38.05), T_8(37.75).Control received the least mean rank value(26).

Flavour

Flavour evaluation of samples was assessed and the mean score obtained was seen and range from 25.50-78.90.The highest mean score was recorded by T_5(78.90).The least mean score value was recorded by Control (13.50).

Taste

The obtained mean rank value for taste of pre-treated avocado pulp ranged from 24.05-76.80.T_5 gained the highest mean rank value(76.80) and T_8 got the lowest mean rank value(24.05) for this attribute.

Overall Acceptability

Table (5) reveals the overall acceptability of the different pre-treatment done in avocado fruit pulp ranged from 35.65-85.00. T_5 scored maximum mean rank value (85), followed by T_6(75.75), T_3(46.86), T_7(45.35), T_4(39.25), T_1(38.45),T_8(36.20). Based on the organoleptic evaluation two best pre treatments T_5 and T_6 was selected for the development of two fruit spreads

4.3 Development of Sweet Avocado

Based on the organoleptic evaluation of pre-treatments, T_5 was selected for the development of sweet avocado fruit spread.

The avocado fruits were collected and washed under running water and it was cut in to halves.The pulp was taken out by pitting and scooping and blending well using a blender.The Ingredients namely sugar,cocoa powder,KMS,itric acid were added and thoroughly mixed in to the puree.The spread was then poured in to glass bottles, plastic bottles and polyethylene bag at ambient temperature and refrigerated temperature.

Product development may involve making a completely new food product – new ideas followed by drawing up the product profile with respect to shape, size; modifying an existing food product making changes to an original recipe *e.g.* adding or removing an ingredient to improve flavor / changing the size or shape of a product and matching with an existing food product - copying other popular branded products of similar types. Sensory analysis testing is carried out at many stages as the product is being developed.

4.3.1 Standardization of Sweet Avocado Fruit Spread

Sensory evaluation has evolved as an independent function in the food industry, where it has been defined as a scientific discipline. As a scientific discipline it is both investigative and informative (Andrews, 2005).

For sensory evaluation, avocado fruit spreads were assessed for various parameters viz colour, texture, flavour ,odour and overall acceptability by a group of 50 adolescents on 9- point hedonic rating scale with a maximum score of 9 for "like extremely" and minimum of 1 for "dislike extremely".

The main advantages of sensory information includes development of food products in an economical way by lowering risks in decisions about product development and strategies for meeting consumer needs. Inorder to standardize the product (T_1,T_2,T_3,T_4,T_5), it was evaluated in four different ways and sensory evaluation was done. The results of the organoleptic evaluation and overall acceptability score are presented in Table 6.

Plate 2 : Treatments of Sweet Avocado Fruit Spread

Table 6: Sensory evaluation of Sweet Avocado Fruit Spread

Treatments	Appearance	Taste	Colour	Flavour	Odour	Overall Acceptability
	Mean Rank	Mean Rank	Mean Rank	Mean Rank	Mean Rank	Mean Rank
T_1	19.05	15.10	15.55	14.8	12	12.2
T_2	19.8	24.85	22.85	17.3	16.90	21.4
T_3	44.7	45.3	44.25	45.4	43.5	45.5
T_4	22.55	27.55	26.25	27.8	26.8	29.40
T_5	21.4	14.7	18.60	22.2	25.88	19
K value	22.88	30.5	25.08	29.67	30.07	33.05
$X^2(0.05)$	9.49					

Appearance

It is evident from the table 6 that score for appearance varied from minimum of 19.05 to a maximum of 44.7.The treatment T_3 obtained the highest mean rank value for appearance compared to the other treatments. The treatment T_1 obtained the lowest mean rank value (19.05).

Taste

The mean rank value ranged from 14.7-45.3.Among the five treatments,T_3 was observed to get highest mean rank value(45.3).T_4 was placed second with the mean rank value (7.55) and least mean rank value was scored by T_5 with the score (14.7).

Colour

The mean rank value of colour ranged from 15.55-44.25.Among the five treatments,T_3 obtained highest mean rank value(44.25).T_4 ranked second with the mean rank value(26.25),while T_1 scored the least mean rank value(15.55).

Flavour

As revealed in table, maximum mean rank value (45.4.) was secured by T_3, followed by T_4 (27.8) while T_1 obtained the minimum mean rank value (14.8).

Odour

The result points out that, the mean rank values for odour ranged from 12-43.5. From the table, it was found that, highest mean rank value was recorded by T_3 (43.5), T_4 ranked second with the mean value(26.8) and T_1 scored the least mean rank value(12).

Overall Acceptability

It was noted that T_3 obtained the highest mean value rank of 45.5 and T_1 obtained lowest mean rank value of 12.2.

4.3.2 Quality studies in sweet avocado fruit spread

To assess the nutrient composition of sweet avocado fruit spread, the following parameters were determined with respect to Carbohydrate, Protein, Total Fat, Minerals and Phytochemicals. To determine the shelf life parameters, the following parameters acidity, moisture, peroxide value and microbial count was evaluated. All analysis were carried out in triplicates.The chemical and nutrient composition of sweet avocado fruit spread and raw avocado fruit were compared.

4.3.2.1 Determination of proximate composition of sweet avocado fruit spread

The proximate composition analysed were carbohydrate,reducing sugars,total sugars,dietary fiber,TSS,protein and Fat.

Table7: Proximate composition of sweet avocado fruit spread

Proximates	**Sweet Avocado Fruit Spread (Values per 100g)**	**Raw Avocado Fruit (Values per 100g)**
Carbohydrate (g)	11	8.53
Reducing Sugars (g)	0.6	0.2
Total Sugars (g)	1.8	0.3
Dietary Fiber (g)	6.89	6.7
TSS (^{0}brix)	8	6
Protein (g)	3.1	2.
Fat (g)	42	19.4

Carbohydrate

Carbohydrates are the major source of energy and are used as building blocks in plant biosynthetic reactions, participating in the formation of proteins and lipids (ADA, 2009). Carbohydrates can be used as a starting material for the biological synthesis of other types of compounds in the body, such as fatty acids and certain amino acids (Hamid *et al.*, 2010).

From the table (7), it can be seen that sweet avocado fruit spread contained 11 g of carbohydrate. The Carbohydrate content of the raw avocado fruit was found to be 8.53g.

Protein

Proteins are fundamental structural and functional elements within every cell of the body and are involved in a wide range of metabolic interactions. The protein content in the sweet avocado fruit spread is3.1g and in the raw avocado fruit the protein content is 2g.

Total Fat

As a rich source of monounsaturated fatty acids, avocado is a very unusual fruit. Dietary fat is a major factor in determining the fatty acid composition of adipose tissue (Gyles *et al.,* 1960). Avocados contain 15% MUFA rich oil, which helps to increase the bioavailability of carotenoids from salads and salsa which are often consumed with avocados. As the avocado fruit ripens, the saturated fat decreases and the monounsaturated oleic acid increases (Lu et al., 2009; Slater et al., 1975; Moreno et al., 1980). The use of avocado dips and spreads as an alternative to more traditional hard, SFA rich spreads or dips can assist in lowering dietary SFA intake (Avocado Central, 2010).

The total fat content of sweet avocado fruit spread was estimated as 42g. The fat content of the raw avocado fruit was found to be 19.4g.

Dietary Fiber

Fiber shows potential benefit in obesity and diabetes and it has immense benefits in the treatment or prevention of obesity because of its ability to increase satiety and lower overall caloric ingestion. Foods high in fiber are generally less energy-dense and larger in volume. Dietary fibre rich foods take longer to eat, and their presence in the gut creates a feeling of satiety sooner. The breakdown by acid and intestinal enzymes also takes longer, resulting in lower postprandial blood glucose and insulin concentrations, in case of patients with diabetes (Fulgoni *et al.,* 2011). From the table (7), it can be seen that sweet avocado fruit spread contain 6.89 g of dietary fibre. The dietary fiber content of the raw avocado fruit was found to be 6.7g.

TSS

The TSS content of sweet avocado fruit spread was found to be 8°brix.The TSS content of raw avocado fruit was found to be 6^0brix..

Reducing Sugar

The reducing sugar content of sweet avocado fruit spread was found to be 0.6 g while raw avocado fruit contain 0.2g.

Total Sugars

The Total sugar content was estimated as 1.8 g. The TSS content of raw avocado fruit was found to be 0.30g.

4.3.2.2 Determination of Mineral composition of sweet avocado fruit spread

The minerals analysed were calcium, Iron, potassium, sodium and total minerals.

Table 8: Mineral Composition of Sweet Avocado Fruit Spread

Minerals	**Sweet Avocado Fruit Spread Values(per 100g)**	**Raw Avocado Fruit Values(per 100g)**
Calcium	9.00mg	12.00mg
Iron	0.72mg	0.55mg
Potassium	432.00mg	345.00mg
Sodium	6.30mg	5.50mg
Total Minerals	1.45g	1.22

Calcium

Calcium is very essential mineral needed for muscle contraction, oocyte activation, building of strong bones and teeth, blood clotting, nerve impulse,

transmission, regulating heart beat and fluid balance within cell. The Calcium content of sweet avocado fruit spread was estimated as 9 mg while 12 mg in the raw avocado fruit.

Iron

Iron has several vital functions in the body. It serves as a carrier of oxygen to the tissues from the lungs by haemoglobin, as a transport medium for electrons within cells, and as an integrated part of important enzyme systems in various tissues. The Iron content of sweet avocado fruit spread was found to be 0.72 mg and 0.55 mg in the raw avocado fruit.

Potassium

Potassium is an essential mineral, needed for blood pressure control and heart health. Avocados contain more potassium than bananas (Jacobsen *et al.*, 2017). Potassium helps the body to regulate fluid, send nerve signals and regulate muscle contractions. A potassium-rich diet may reduce blood pressure by helping the body remove excess sodium. Increasing potassium intake can reduce the risk of cardiovascular diseases, such as heart disease and stroke, by lowering blood pressure. The Potassium content of sweet avocado fruit spread was estimated as 432 mg while 345 mg is reported in the raw avocado fruit(Johnson *et al.*,2010)

Sodium

Sodium is an essential electrolyte that helps maintain the balance of water in and around the cells. It is needed for proper muscle and nerve function. It also helps maintain stable blood pressure levels. The sodium content in sweet avocado fruit spread was 6.3 mg while 5.5 mg was reported in the raw avocado fruit.

Total Minerals

The Total mineral content in sweet avocado fruit spread was 1.45g and that reported in raw avocado fruit is 1.22 g.

4.3.2.3 Determination of Phytochemical composition of sweet avocado fruit spread

The phyochemicals analysed were Beta carotene, Vitamin C, Total phenolic content and total antioxidant activity.

Table 9 : Phytochemical composition of Sweet Avocado Fruit Spread

Phytochemicals	**Sweet Avocado Fruit Spread Values(per 100g)**	**Raw Avocado Fruit Values(per 100g)**
Beta Carotene	140mg	417mg
Vitamin C	7.32mg	6.00mg
Total Phenolic Content	18.40mg	20.45mg
Total Antioxidant Activity	423mg	340mg

Vitamin C

Vitamin C plays an important role in a number of bodily functions including the production of collagen, L-carnitine, and some neurotransmitters. It helps metabolize proteins and its antioxidant activity may reduce the risk of some cancers. The role of vitamin C as an antioxidant also helps repair tissue and reduce damage from inflammation and oxidation. Vitamin C is water soluble, and the body does not store it. To maintain adequate levels of vitamin C, humans need a daily intake of food that contains it.Vtamin C content of sweet avocado fruit spread was estimated to 7.32 /100g while raw avocado fruit is reported to have 6mg /100g.

Beta Carotene

The consumption of avocados can be an important dietary source of xanthophyll carotenoids (Lu *et al.*, 2009). The colour of avocado flesh varies from

dark green just under the skin to pale green in the middle section of the flesh to yellow near the seed (Lu et al., 2009). The total carotenoid concentrations were found to be greatest in the dark green flesh close to peel (Lu et al., 2009).From the table (9) it was observed that about 140mg of beta carotene was present in 100 g of sweet avocado fruit spread. Avocado fruit contain 417mg/100g.

Total Phenolic Content

Fruits and vegetables receive considerable interest depending on type, number, and mode of action of the different components, so called as "phytochemicals", for their presumed role in the prevention of various chronic diseases including cancers and cardiovascular diseases. Plants are rich sources of functional dietary micronutrients, fibers and phytochemicals, such as ascorbic acid, carotenoids, and phenolic compounds, that individually, or in combination, may be beneficial for health since they demonstrate antioxidative activity in vitro (Marinova *et al.*,2005). From the table,(9) it was observed that about 18.40 mg of total phenolic content was present in 100 g of sweet avocado fruit spread and also 20.45mg was reported in 100g of raw avocado fruit.

Total Antioxidant Activity

Antioxidants are substances that can prevent or slow damage to cells caused by free radicals, unstable molecules that the body produces as a reaction to environmental and other pressures. Antioxidants can protect against the cell damage that free radicals cause, known as oxidative stress (Pandey & Rizvi, 2010). From the table,(9) it was observed that about 423mg of Total Antioxidant Activity was present in 100 g of sweet avocado fruit spread. Raw Avocado fruit, however contained 340mg/100g of total antioxidant activity.

4.3.2.4Shelf life studies of Sweet Avocado Fruit Spread

The stored avocado spreads was assessed for the presence of various microorganisms such as bacteria, fungi and coliform and initially and at one week interval up to one month. This was done by serial dilution and pour plating

method suggested by Sackett *et al.*, (2010).Storage qualities in terms of moisture content, peroxide value, acidity and microbial growth of each of the avocado spread were recorded at weekly intervals. Microbial Profile of bacteria, fungi, yeast was determined using nutrient agar, eosine methylene blue. From the microbial evaluation it was revealed that bacterial, fungal and colonies were present in the sample.

Acidity

Rufino *et al.*, (2010) reported that acidity gives flavour and offers antimicrobial activity. Acidity is one of the prime chemical constituents which indicate the deteriorative changes in the product.

Table10: Acidity content of sweet avocado fruit spread during storage (%)

Storage condition		Initial	1st week	2nd week	3rd week	4th week
Glass bottle	Ambient condition	0.002	0.010	0.011	0.012	0.013
	Refrigerated condition	0.002	0.006	0.011	0.012	0.014
Plastic bottle	Ambient condition	0.002	0.013	0.013	0.015	0.016
	Refrigerated condition	0.002	0.014	0.015	0.015	0.017
Polyethylene bag	Ambient condition	0.002	0.012	0.018	0.026	0.026
	Refrigerated condition	0.002	0.017	0.018	0.019	0.020
CD(0.05)		-	0.007	0.004	0.005	0.001

The changes in acidity content in sweet avocado fruit spread are depicted in table 10 .The acidity content was observed higher in sweet avocado fruit spread stored in polyethylene bags at ambient temperature(0.026%),the lowest content of acidity was observed in sweet avocado fruit spread stored in glass bottle at refrigerated temperature(0.013 %).

Moisture

Moisture content is one of the vital parameters which interfere with the quality of sweet avocado fruit spread during storage.

Table11: Moisture content of sweet avocado fruit spread during storage(%)

Storage condition		Initial	1st week	2nd week	3rd week	4th week
Glass bottle	Ambient condition	42.33	55.00	56.33	63.00	67.90
	Refrigerated condition	42.33	44.24	51.95	54.89	56.29
Plastic bottle	Ambient condition	42.33	72.23	74.38	75.55	78.71
	Refrigerated condition	42.33	61.31	62.32	68.94	69.31
Polyethylene bag	Ambient condition	42.33	72.54	73.31	74.25	76.51
	Refrigerated condition	42.33	71.45	72.21	72.58	73.36
CD(0.05)		-	5.83	3.44	1.37	0.28

Table 11 indicate the moisture content of sweet avocado fruit spread stored in glassbottle,plastic bottle and polyethylene bags in ambient and refrigerated

temperatures.The moisture content of the stored sweet avocado fruit spread gradually increased during storage period.

The statistical data showed that the moisture content of developed sweet avocado fruit spread varied from 44.2 to 72.5 percent during the first week period. The highest moisture content was recored for sweet avocado fruit spread stored in plastic bottle (78.7) at ambient temperature. The lowest was observed for sweet avocado fruit spread stored in glass bottles at refrigerated condition (56.29).

Peroxide Value

Table12: Changes in Peroxide content of sweet avocado fruit spread during storage

Storage condition		Initial	1st week	2nd week	3rd week	4th week
Glass bottle	Ambient condition	1.96	3.40	8.46	12.36	16.40
	Refrigerated condition	1.96	2.90	5.20	8.20	10.13
Plastic bottle	Ambient condition	1.96	4.23	10.33	14.13	16.20
	Refrigerated condition	1.96	2.26	5.33	8.53	12.20
Polyethylene bag	Ambient condition	1.96	4.33	9.40	17.60	19.26
	Refrigerated condition	1.96	3.23	9.03	17.60	19.26
CD(0.05)		-	0.35	0.60	0.43	0.37

The statistical data showed that the peroxide content of developed sweet avocado fruit spread varied from 2.2 to 4.3 percent during the first week period.

The highest peroxide content was recorded for sweet avocado fruit spread stored in Polyethylenge bags at ambient (19.26) and refrigerated temperature(19.26).The lowest was observed for sweet avocado fruit spread stored in glass bottles at refrigerated condition(10.13).

Microbial Count

Table 13: Microbial Count of Sweet Avocado Fruit Spread stored at Ambient Condition

Glass Bottle	Ambient condition			
	Storage period (week)	Bacteria (cfu/g)	Yeast (cfu/g)	Fungi (cfu/g)
		10^{-3}	10^{-3}	10^{-4}
	Initial	1.8×10^{-2}	-	-
	1st week	2.2×10^{-3}	-	-
	2nd week	2.7×10^{-3}	-	-
	3rd week	3.5×10^{-3}	-	-
	4th week	6.7×10^{-3}	-	2.6×10^{-3}
Plastic bottle	Initial	1.8×10^{-2}	-	-
	1st week	2.8×10^{-3}	-	-
	2nd week	3.8×10^{-3}	-	-
	3rd week	4.5×10^{-3}	2.4×10^{-3}	3.3×10^{-2}
	4th week	7.2×10^{-3}	3.6×10^{-3}	3.9×10^{-3}
Poly ethylene bag	Initial	1.8×10^{-3}	-	-
	1st week	3.8×10^{-3}	-	2.2×10^{-3}
	2nd week	5.5×10^{-3}	3.4×10^{-3}	3.2×10^{-3}
	3rd week	7.6×10^{-3}	4.3×10^{-3}	4.4×10^{-3}
	4th week	12×10^{-3}	5.4×10^{-3}	5.2×10^{-3}

Keeping quality of a product very much depends up on the microbial contamination. The microbial growth is seen within the permissible limit. The bacterial population was found in all containers kept under ambient condition. Fungal colonies was found in the fruit spread kept in glass bottle during 4^{th} week. Yeast growth was recorded nil in fruit spread stored in glass bottle. Yeast and fungal colonies was found higher in fruit spreads kept in polyethylene bags compared to glass and plastic bottle.

Plate 3: Sweet Avocado Fruit Spread Stored at Ambient Temperature

Table 14 : Microbial Count of Sweet Avocado Fruit Spread at Refrigerated Condition

		Refrigerated condition		
Glass Bottle		Bacteria (cfu/g)	Yeast (cfu/g)	Fungi (cfu/g)
		10^{-3}	10^{-3}	10^{-4}
	Initial	1.8×10^{-2}	-	-
	1st week	1.6×10^{-3}	-	-
	2nd week	2.2×10^{-3}	-	-
	3rd week	3.2×10^{-3}	-	-
	4th week	6.3×10^{-3}	-	2×10^{-3}
Plastic Bottle	Initial	1.8×10^{-2}	-	-
	1st week	2.2×10^{-3}	-	-
	2nd week	4.8×10^{-3}	-	1.6×10^{-3}
	3rd week	3.6×10^{-3}	1.4×10^{-3}	1.8×10^{-3}
	4th week	6.6×10^{-3}	2.8×10^{-3}	3.2×10^{-3}
Polyethylene Bag	Initial	1.8×10^{-3}	-	-
	1st week	4.2×10^{-3}	-	1.6×10^{-3}
	2nd week	5.8×10-$^{-3}$	2.1×10^{-3}	2.8×10^{-3}
	3rd week	6.2×10^{-3}	2.6×10^{-3}	4.7×10^{-3}
	4th week	7.5×10^{-3}	3.8×10^{-3}	5.8×10^{-3}

During the storage period, in this study bacterial colonies were found to appear in developed sweet avocado fruit spread. Fungal colonies were found to be higher in fruit spread kept in polyethylene bag. Yeast growth was recorded nil in fruit spread stored in glass bottle.

Plate4:Sweet Avocado Fruit Spreads stored at Refrigerated Temperature

4.3.3Consumer Acceptability of Sweet Avocado Fruit Spread

Sensory evaluation is used to estimate shelf life of the food products as sensory characteristics of the product depreciate ahead of microbial quality. Customer evaluation is extensively employed in the investigation arena. It explores new technologies for product development and understanding the consumer behaviour.

Hedonic assessment is the economical and ideal method to find out the influence of variations in ingredients, manufacturing, wrapping, or shelf life.

The successful sensory evaluation in food industries is achieved by linking sensory properties to physical, chemical, formulation and process variables which enables manufacturing food products with maximum consumer acceptance.

According toMan (2002), sensory evaluation is a scientific method used to evoke measure, analyse and interpret those responses to products as perceived through the senses of sight, hearing, touch, smell and taste.The results of the consumer acceptance studied among 50 adolescents applying hedonic rating scale is presented in table 15.

Table15: Consumer Acceptance Scores of Sweet Avocado Fruit Spread

Treatment	Mean Scores					
	Appearance	Taste	Colour	Flavour	Odour	Overall Acceptability
T_3	7.60	8.38	7.68	7.82	7.20	8.5 0

Appearance

Appearance is the first characteristic perceived by the human senses and play an important role in the identification and final selection of food.It was observed that Sweet Avocado fruit Spread got 7.6 for appearence in consumer acceptance.

Taste

Taste involves the perception of constituents after being dissolved in saliva, oil or water by taste receptors in the taste buds found superficially on the

tongue and other parts of the mouth. It was recorded that Sweet Avocado fruit Spread got 8.38 for taste in consumer acceptance

Colour

The colour of a meal has shown impact on apetite stimulation. It was recorded that Sweet Avocado fruit Spread got 7.68 for colour in consumer acceptance

Flavour

Flavour is a sensory phenomenon which is used to denote the sensations of odour, taste and mouth feel. It was analysed that Sweet Avocado fruit Spread got 7.82 for flavour in consumer acceptance.

Odour

The odour associated with food products is sensed by olfactory receptors present in the nasal epithelium. It was analysed that Sweet Avocado fruit Spread got 7.20 for odour in consumer acceptance.

Overall Acceptability

It was reported that Sweet Avocado fruit Spread got 8.5 for overall acceptability in consumer acceptance.

4.3.4Cost Analysis

In order to realize the economic feasibility of the developed sweet avocado fruit spread, its cost was calculated by taking individual cost of the ingredients used with 20 percent over head charges. The cost of 100 g sweet avocado fruit spread was thus calculated on the basis of the market value of ingredients used for the formulation of spread. It was found that 1kg of sweet avocado fruit spread costs Rs. 550/-.

It was found that the cost of the developed sweet avocado fruit spread was less when compared to the sweet choco spreads available in the market.

4.4 Development of Spicy Avocado Fruit

Based on the organoleptic evaluation, T_6 was selected as the best pre treatment method for the development of spicy avocado fruit spread. The avocado fruit were collected and washed under running water and it was cut in two halves. The pulp was taken out by pitting and scooping and blended well using a blender. The Ingredients namely Salt, Pepper powder, Tomato powder, Mint powder, KMS, Citric acid were added and thoroughly mixed in to the puree. Tomato and Mint powder were powdered after drying in oven for 7-8 hours at 65^0C.The spread were then filled in glass bottles, plastic bottles and polyethylene bag and stored at ambient and refrigerated temperature.

4.4.1Standardization of Spicy Avocado Fruit Spread

Standardization of spicy avocado fruit spread was done adding different proportions of salt, pepper powder ,tomato powder, mint powder ,KMS,citric acid as treatments with uniform quantity of avocado pulp(100g).Spicy avocado fruit spread with best proportion was selected for further standardization studies. The composition of the different ingredients for spicy avocado fruit spread was given in table 1.

The scores assigned by the sensory panel members were analysed using Kruskal wallis test is described in table 16.

Plate 5 : Treatments of Spicy Avocado Fruit Spread

Table 16:Sensory Scores of Spicy Avocado Fruit Spread

Treatments	Appearance	Taste	Colour	Flavour	Odour	Overall Acceptability
	Mean Rank	Mean Rank	Mean Rank	Mean Rank	Mean Rank	Mean Rank
T_1	17.70	15.80	20.05	18.50	19.00	15.50
T_2	15.20	18.80	16.50	16.45	12.60	14.00
T_3	21.60	17.30	22.15	19.65	24.50	23.20
T_4	28.80	32.70	25.30	27.90	26.95	29.30
T_5	44.20	42.90	43.50	45.00	44.45	45.50
K value	27.23	28.71	23.29	27.74	29.85	33.77
$X^2(0.05)$	9.49					

Appearance

The mean rank values for appearance of the five treatments of spicy avocado fruit spread ranged from 15.20-44.20.The highest mean rank(44.20) for appearance was obtained for the treatment T_5 which was the combination of Pulp(100g):Pepper powder (3g): Salt(2g): Tomato powder(5g): Mint powder (1.5g): Citric acid(0.1g):KMS(0.25g)

Taste

The sensory evaluation revealed that the mean rank value for taste of spicy avocado fruit spread ranged between15.80-42.90.From Kruskall-wallis test it was analyzed that T_5 obtained the highest mean rank value of 44.90 and T_1 obtained the lowest mean rank value of 15.80.

Colour

The sensory evaluation revealed that the mean rank value for colour of spicy avocado fruit spread ranged between 16.50-43.50.From Kruskal Wallis test it was analyzed that T5 obtained highest mean rank value of 43.50 and T2 obtained least mean rank value of 16.50.

Flavour

The flavour of different treatments of spicy avocado fruit spread were evaluated and the mean rank value ranged from 16.45-45.The highest mean rank value was recorded by T_5 and the least mean score by T_2.The combination of pulp(100g): pepper powder(5g): salt(2g): Tomato powder(3g): Mint powder(1g): Citric acid(0.1g): KMS(0.25g) was responsible for the poor flavour of T_2.

Odour

From the evaluation of odour of spicy avocado fruit spread, it was found thatT_5 got the highest mean rank value of 44.45 and T_2 got lowest mean rank value of 19.00.

Overall Acceptability

Overall acceptability of food products can be judged through their appearance, taste, colour, flavour, odour of the product. It was noted that T_5 obtained the highest mean rank value of 45.50 and T_2 obtained lowest mean rank value of 14.

Among the five treatments of spicy avocado fruit spread, T_5 with pulp(100g):Salt(2g):Pepperpowder(5g)Mintpowder(1.5g):Citricacid(0.1g):KMS(0.25g) selected as the best combination.

4.4.2Quality Studies in Spicy Avocado Fruit Spread

To assess the nutrient composition of spicy avocado fruit spread, the following parameters were determined with respect to Carbohydrate, Protein, Total Fat, Minerals and Phytochemicals. To determine the shelf life parameters, acidity, moisture, peroxide value and microbial count was evaluated. All analyses was carried out in triplicates. The chemical and nutrient composition of spicy avocado fruit spread and raw avocado fruit were compared.

4.4.2.1 Determination of proximate composition of spicy avocado fruit spread

The proximate composition analysed were carbohydrate, reducing sugars,total sugars,dietary fiber,TSS,protein and Fat.

Table17: Proximate composition of spicy avocado fruit spread

Proximates	**Spicy Avocado Fruit Spread (Values per 100g)**	**Raw Avocado Fruit Values(per 100g)**
Carbohydrate (g)	8.18	8.53
Reducing Sugars(g)	0.78	0.2
Total Sugars(g)	0.98	0.3
Dietary Fiber(g)	6.12	6.7
TSS(^{0}brix)	5	8
Protein(g)	3.9	2
Fat(g)	57.00	19.40

Carbohydrate

Carbohydrates are the main fibre in the diet which provides bulkiness for better digestion. Carbohydrates help clear gut and prevent constipation. From the table (17), it can be seen that spicy avocado fruit spread contained 8.18g of

carbohydrate. The carbohydrate content of raw avocado fruit has been reported to be 8.53g.

Reducing Sugars

A reducing sugar is any sugar that is capable of acting as a reducing agent because it has a free aldehyde group or a free ketone group. The reducing sugar content was estimated as 0.78g while reducing sugar content of raw avocado fruit was found to be 0.20g

Total Sugars

The Total Sugar content in Spicy avocado fruit spread was estimated as 0.98g. The total sugar content of raw avocado fruit is reported as 0.3g.

Dietary Fiber

The Dietary fiber content in Spicy avocado fruit spread was estimated as 6.12g. This is almost equivalent to the dietary fiber content of the raw avocado (6.7g).

TSS

The TSS content in Spicy avocado fruit spread was estimated as 5^0brix. The TSS content of raw avocado fruit was found to be 8^0brix.

Protein

Protein is essential to the formation of red blood cells, for the proper functioning of antibodies resisting infection, for the regulation of enzymes and hormones, for growth, and for the repair of body tissue. The protein content in Spicy Avocado Fruit Spread was estimated as 3.9g. The protein content of raw avocado fruit has been reported as 2g.

Fat

The body uses fat as a fuel source, and fat is the major storage form of energy in the body. Fat also has many other important functions in the body, and a

moderate amount is needed in the diet for good health. Fats in food come in several forms, including saturated, monounsaturated, and polyunsaturated.

The fat content in spicy avocado fruit spread was estimated as 57g. The fat content of raw avocado fruit was found to be 19g.

4.4.2.2 Determination of mineral composition of spicy avocado fruit spread

The minerals analysed were calcium, iron, potassium, sodium and total minerals.

Table 18: Mineral Composition of Spicy Avocado Fruit Spread

Minerals	**Spicy Avocado Fruit Spread (Values per 100g)**	**Raw Avocado Fruit Values(per 100g)**
Calcium	8.2mg	12mg
Iron	0.97mg	0.55mg
Potassium	482mg	345mg
Sodium	7.3mg	5.5mg
Total Minerals	2.06g	1.22g

Calcium

Calcium is a mineral found in many foods. The body needs calcium to maintain strong bones and to carry out many important functions. Based on analysis of Spicy avocado fruit spread 8.2 mg calcium was present in 100g of sample. The Calcium content of raw avocado fruit was found to be 12 mg.

Iron

Iron is one of the important elements necessary for the metabolism of the human body.

The Iron content content in Spicy avocado fruit spread was estimated as 0.97. The Iron content of raw avocado fruit was found to be 0.55mg.

Potassium

Potassium is one of the most important electrolytes in the human body, and this helps to maintain a healthy balance of fluids in the body. The Potassium content content in Spicy avocado fruit spread was estimated to be 482 mg. The Potassium content of raw avocado fruit was reported to be 345 mg.

Sodium

Sodium occurs naturally in many foods. The body uses sodium to control blood pressure and blood volume. The Sodium content in Spicy avocado fruit spread was recorded as 7.3 mg. The Sodium content of raw avocado fruit was found to be 5.5 mg.

Total Minerals

Ash content represents the total minerals content in food. The Total mineral content content in Spicy avocado fruit spread was estimated as 2.06 g. The Total mineral content of raw avocado fruit was found to be 1.22 g.

4.4.2.3 Determination of phytochemical composition of spicy avocado fruit spread

The main phytochemicals analysed were Beta carotene,Vitamin C, Total Phenolic content,Total antioxidant activity.

Table 19 : Phytochemical composition of Spicy Avocado Fruit Spread

The phytochemicals analysed were Beta carotene,Vitamin C, Total phenolic content and total antioxidant activity.

Phytochemicals	**Spicy Avocado Fruit Spread (Values per 100g)**	**Raw Avocado Fruit Values(per 100g)**
Beta Carotene	265mg	417mg
Vitamin C	19.1mg	6mg
Total Phenolic Content	78mg	20.45mg
Total Antioxidant Activity	520mg	340mg

Vitamin C

Vitamin C content of spicy avocado fruit spread was estimated to 19.1mg.The Vitamin C content of raw avocado fruit was reported as 6mg/100g.

Beta-Carotene

From the table, (17), it was observed that about of 265mg beta carotene was present in 100g of spicy avocado fruit spread. The beta carotene content of raw avocado fruit was found to be 417mg/100g.

Total Phenolic Content

From the table (17),it was observed that Total Phenolic content was 78mg present in 100g of spicy avocado fruit spread and raw avocado fruit contain 20.45mg/100g of Total Phenolic Content.

Total Antioxidant Activity

Total Antioxidant Activity of spicy avocado fruit spread was estimated to 520mg/100g.Total Antioxidant Activity of raw avocado fruit was found to be 340mg/100g.

4.4.2.4 Shelf life studies in Spicy Avocado Fruit Spread

The spread was filled and stored in different packaging materials at ambient and refrigerated temperature for a period of 4 weeks and examined its shelf stability at weekly intervals.

Acidity

Acidity indicates flavour as well as wholesomeness of the product. The acidity content of the spicy avocado fruit spread was depicted on Table 20.

Table20:Acidity Content of Spicy Avocado Fruit Spread during storage(%)

Storage condition		Initial	Ist week	2nd week	3rd week	4th week
Glass bottle	Ambient condition	0.006	0.012	0.023	0.036	0.046
	Refrigerated condition	0.006	0.011	0.026	0.028	0.033
Plastic bottle	Ambient condition	0.006	0.010	0.033	0.042	0.063
	Refrigerated condition	0.006	0.007	0.026	0.026	0.032
Polyethylene bag	Ambient condition	0.006	0.013	0.029	0.046	0.064
	Refrigerated condition	0.006	0.016	0.019	0.023	0.038
CD(0.05)		-	0.003	0.004	0.005	0.006

The changes in acidity content in spicy avocado fruit spread are depicted in table 20 .The acidity content was observed higher in spicy avocado fruit spread stored in polyethylene bags at ambient temperature(0.064),the lowest content of acidity was observed in spicy avocado fruit spread stored in plastic bottle at refrigerated temperature(0.032).

The statistical data showed that the acidity content of spicy avocado fruit spread varied from 0.012 to 0.016 per cent

Moisture

Moisture can cause adverse effects in the keeping quality of foods. Low moisture is highly important for longer storage period. The moisture content of the spicy avocado fruit spread was depicted on Table 21.

Table21:Moisture Content of Spicy Avocado Fruit Spread during storage(%)

Storage condition		Initial	1st week	2nd week	3rd week	4th week
Glass bottle	Ambient condition	55.33	63.0	64.30	71.13	73.16
	Refrigerated condition	55.33	58.52	61.93	63.2	64.13
Plastic bottle	Ambient condition	55.33	62.63	64.21	69.92	73.28
	Refrigerated condition	55.33	60.1	60.57	64.83	65.48
Polyethylene bag	Ambient condition	55.33	60.1	65.14	69.07	73.71
	Refrigerated condition	55.33	61.3	62.17	64.47	66.59
CD(0.05)		-	0.95	0.5	1.46	0.63

Table 21 indicates the moisture content of spicy avocado fruit spread stored in glassbottle, plastic bottle and polyethylene bags in ambient and refrigerated temperatures. The moisture content of the stored spicy avocado fruit spread gradually increased during storage period.

The statistical data showed that the moisture content of developed spicy avocado fruit spread varied from 58.20 to 63 percent during the first week period. The highest moisture content was recorded for spicy avocado fruit spread stored in Polyethylenge bags (73.71), plastic bottles (73.28) and glass bottles (73.16) at ambient temperature. The lowest was observed for spicy avocado fruit spread stored in glass bottles at refrigerated condition (64.13).

Peroxide Value

The changes in peroxide value of Spicy avocado fruit spread are depicted in Table 22.

Table22:Changes in Peroxide Content of Spicy Avocado Fruit Spread during storage

Storage condition		Initial	1st week	2nd week	3rd week	4th week
Glass bottle	Ambient condition	0.88	1.8	3.2	5.6	7.23
	Refrigerated condition	0.88	1.76	2.04	3.7	5.43
Plastic bottle	Ambient condition	0.88	2.3	4.60	6.73	9.33
	Refrigerated condition	0.88	2.46	3.33	5.5	7.66
Polyethylene bag	Ambient condition	0.88	3.63	6.5	8.66	11.63
	Refrigerated condition	0.88	3.03	4.43	6.40	9.56
CD(0.05)		-	-	0.25	0.31	0.36

The peroxide value was observed up to a period of 4 weeks of storage.

The statistical data showed that the peroxide content of developed spicy avocado fruit spread varied from 1.76 to 3.63 percent during the first week period. The highest peroxide content was recorded for spicy avocado fruit spread stored in Polyethylenge bags at ambient temperature(11.63).The lowest was observed for spicy avocado fruit spread stored in glass bottles at refrigerated condition(5.43).

Microbial Count

Table 23: Microbial Count of Spicy Avocado Fruit Spread at Ambient Temperature

Glass bottle	Ambient condition			
	Storage period (week)	Bacteria (cfu/g)	Yeast (cfu/g)	Fungi (cfu/g)
		10^{-3}	10^{-3}	10^{-4}
	Initial	2.2×10^{-2}	-	-
	1st week	2.8×10^{-3}	-	-
	2nd week	3.8×10^{-3}	-	-
	3rd week	4.4×10^{-3}	-	2.8×10^{-2}
	4th week	7.5×10^{-3}	-	4.3×10^{-3}
Plastic bottle	Initial	2.2×10^{-2}	-	
	1st week	3.3×10^{-3}	-	
	2nd week	5.2×10^{-3}	3.2×10^{-3}	2.2×10^{-3}
	3rd week	7.5×10^{-3}	3.8×10^{-3}	3.2×10^{-3}
	4th week	7.2×10^{-3}	4.6×10^{-3}	4.6×10^{-3}
Poly ethylene bag	Initial	2.2×10^{-3}	-	
	1siweek	4.2×10^{-3}	3.8×10^{-2}	2.3×10^{-3}
	2nd week	6.5×10^{-3}	4.2×10^{-3}	4.6×10^{-3}
	3rd week	8.8×10^{-3}	5.2×10^{-3}	5.8×10^{-3}
	4th week	15×10^{-3}	6.6×10^{-3}	6.7×10^{-3}

No bacterial, fungal and yeast colonies were seen in 10^{-4} dilution during one month of storage. Bacterial colonies were present in 3 storage conditions. Yeast and fungal colonies was found higher in fruit spreads kept in polyethylene

bags. During the storage period, the spicy avocado fruit spread experienced complete spoilage on 4th week and the microbial count was Bacteria($15x10^{-3}$), Yeast($6.7x10^{-3}$),Fungi($6.7x10^{-3}$).

Table 24 : Microbial Count of Spicy Avocado Fruit Spread at Refrigerated Temperature

Glass Bottle		Refrigerated condition		
	Storage period (week)	Bacteria (cfu/g)	Yeast (cfu/g)	Fungi (cfu/g)
		10^{-3}	10^{-4}	10^{-4}
	Initial	2.2×10^{-2}	-	-
	1st week	2.6×10^{-3}	-	-
	2nd week	3×10^{-3}	-	-
	3rd week	3.2×10^{-3}	-	2.5×10^{-2}
	4th week	6.9×10^{-3}	-	3.5×10^{-3}
Plastic bottle	Initial	2.2×10^{-2}	-	-
	1st week	2.9×10^{-3}	-	-
	2nd week	3.7×10^{-3}	1.8×10^{-3}	3.2×10^{-3}
	3rd week	6.6×10^{-3}	1.4×10^{-3}	4.4×10^{-3}
	4th week	6.6×10^{-3}	2.8×10^{-3}	5.6×10^{-3}
Polyethylene bag	Initial	2.2×10^{-3}	-	-
	1st week	5.2×10^{-3}	1.7×10^{-3}	3.4×10^{-3}
	2nd week	5.8×10^{-3}	3.3×10^{-3}	5.5×10^{-3}
	3rd week	6.2×10^{-3}	5.2×10^{-3}	6.4×10^{-3}
	4th week	8.6×10^{-3}	6.6×10^{-3}	7.8×10^{-3}

Yeast and fungal colonies was found higher in Spicy fruit spreads kept in polyethylene bags when compared to glass bottle and plastic bottle. On refrigerated storage, spicy avocado fruit spread experienced complete spoilage on

4th week and the bacterial count of 8.6 x 10^{-3} , fungal count of 6.6 x 10^{-3} and the fungal count was 7.8 x 10^{-3}.

Plate 6:Spicy Avocado Fruit Spread stored at Ambient Temperature

Plate 7: Spicy Avocado Fruit Spread stored at Ambient Temperature

4.4.3 Consumer Acceptability of Spicy Avocado Fruit Spread

Table:25 Consumer Acceptance Scores of Spicy Avocado Fruit Spread

Treatment	Mean Score					
	Appearance	Taste	Colour	Flavour	Odour	Overall Acceptability
T5	7.46	7.4	7.04	7.24	7.1	7.56

Sensory evaluation plays significant role in quality control and marketing of the products. It is frequently used in food industries for new product development and recipe modification of the products. It is carried out to find out differences among the products, nature of difference and possible acceptance or rejection of products on the basis of differences. Sensory characteristics of food products can be assessed by using discriminatory, difference, descriptive and affective methods (Fulgoni *et al.*, 2010))

Appearance

Appearance is the first characteristics perceived by the human senses and play an important role in the identification and final selection of food. This is the visual perception of food comprised of color, shape, size, gloss, dullness and transparency. It was recorded that spicy avocado fruit Spread got 7.46 for consumer acceptance.

Flavour

It is sensory phenomenon which is used to denote the sensations of odor, taste and mouth feel. Flavoring substances are aromatic compounds which are conceived by the combination of taste and odor and perceived by the mouth and nose. It was recorded that spicy avocado fruit spread got 7.24 for consumer acceptance.

Taste

Taste helps in identification, acceptance and appreciation of food. It is perceived by the taste buds on the tongue. It was recorded that spicy avocado fruit spread got 7.4 for taste in consumer acceptance

Odour

Odour of the product usually determines whether a product is accepted or rejected; therefore this one of the most critical quality attributes. It was recorded that Spicy Avocado fruit Spread got 7.1 for odour in consumer acceptance.

Overall Acceptability

Overall acceptability of a food product can be judged through its appearance, colour, flavour, taste and odour of the product. It was recorded that Spicy Avocado fruit Spread got 7.56 for overall acceptability in consumer acceptance.

4.4.4 Cost Analysis

The cost of 1 kg spicy avocado fruit spread was thus calculated on the basis of the market value of ingredients used for the formulation of spread. It was found that 1 kg of spicy avocado fruit spread costs Rs 600. /-.

It was found that the cost of the developed spicy avocado fruit spread was less when compared to the fat spreads available in the market.

DISCUSSION

5. DISCUSSION

The results of present investigation entitled "Development and quality evaluation of fruit spreads from avocado (*Persea americana* Mill.)" are discussed below:

5.1 Selection of avocado fruits

5.2 Effect of different pre treatments on the quality of avocado fruits

5.2.1 Selection of Pre-treatments

5.3 Development of Sweet Avocado fruit Spread

5.3.1 Standardization of Sweet Avocado fruit Spread

5.3.2 Quality studies in Sweet Avocado Fruit Spread

5.3.3 Consumer Acceptability of Sweet Avocado Fruit Spread

5.3.4 Cost Analysis

5.4 Development of Spicy Avocado Fruit Spread

5.4.1 Standardization of Sweet Avocado fruit Spread

5.4.2 Quality studies in Sweet Avocado Fruit Spread

5.4.3 Consumer Acceptability of Sweet Avocado Fruit Spread

5.4.4 Cost Analysis

5.1 Selection of avocado fruits

The cultivar which was popular in the Wayanad district of Kerala was selected for Avocado fruit spread development. In order to exploit the cultivar for product development and transfer of technology, the cultivar purple hybrid, which is cultivating in majority of households in Wayanad district was selected for fruit spread development.

Avocado is mainly used fresh, in sandwich filling or in salads. It can also be used in ice creams and milk shakes and the pulp may be preserved by freezing.

USDA & HHS, (2011) reported that The Purple and Green varieties were introduced into India from Ceylon in 1941.

5.2Effect of different pre treatments on the quality of avocado fruits

Gorny *et al.,* (2002) reported that cut-surface browning of fresh-cut fruits and vegetables is one of the most fundamental factors affecting acceptability of the products by consumers. Most of them are caused by the action of polyphenol oxidase (PPO) on phenolic compounds released during the process of cutting called enzymatic browning.

Surface treatments by dipping fresh-cut products in the appropriate anti browning agents can effectively help to delay discoloration.

Son *et al.*,(2001) reported that several nature identical anti browning agents extensively used to control excessive browning include ascorbic acid (AA), citric acid (CA) and oxalic acid (OA) that are weak organic acids found in fresh fruits and vegetables

5.2.2 Standardization of pre-treatments

Standardisation plays a key role in product formulation which facilitates the growth of food industry as it is a pre requisite of any food based industry.

In this study, the best pre-treatment methods identified for the development of sweet avocado fruit spread was, citric acid + KMS + sugar (T5) blend in the ratio of 0.25:0.1:100. The citric acid + KMS + salt (T6) in the combination of 0.25:0.1:10 was selected organoleptically for the development of spicy avocado fruit spread.

Gorny *et al.*, (2002) reported that the immersion increases the strength of the product.

5.3 Development of Sweet Avocado Fruit Spread

Fruits spreads are made by processing fruit juice, concentrated form of fruit juice or whole fruit along with sugar and pectin. The fruit concentration in these spreads can vary from 30% to 60%. They are used in salad dressings, baked products, snacks, breakfast syrups, dessert glaze, cake icing, smoothies etc. The fruit spreads are available in different flavours and textures.

Butter is a type of fruit spread which is thick and made from sugar cooked fruit puree. Conserves are the fruit spreads consisting of a mixture of fruits along with nuts and sugar. Jams are made from chopped or crushed fruits along with sugar and pectin to soften the fruit. Jams account for major share in the global fruit spreads market in terms of consumption. The other types of fruit spread include marmalades, jellies, and preserve, which differ in consistency. Fruit spreads are also available in organic flavour which consists of a mixture of fruit, vegetable or flower (Gorny *et al.*, 2002).

In this study, T_5 was selected for the development of sweet avocado fruit spread based on the organoleptic evaluation of pre-treatments.

5.3.1 Standardization of Sweet Avocado Fruit Spread

Sugar is important in determining the shelf life of fruit spreads. Low sugar fruit spreads will mold more easily than the standard kind. Honey, corn syrup, low-calorie sweeteners may not be substituted one for one for sugar in fruit spreads (Sarah & Francis; 2011).

Disha *et al.,*(2017) reported that the quality of jam is determined by the proportions of sugar and pectin added to the fruit pulp. To optimize the sugar and pectin content in the final product, trial jams were developed using different variations.

In this study, sweet avocado fruit spread were developed using cocoa powder, sugar, KMS, citric acid. Cocoa powder has highest water absorption capacity and thereby reduces the moisture content and improve shelf life.Among the five treatments, T_3 was selected as the best with ingredients of proportion of pulp(100g):cocoa powder(30g):sugar(100g):KMS(0.25):Citric acid(0.1).

5.3.2 Quality studies in Sweet Avocado Fruit Spread

The quality of fresh-cut fruits and vegetables determines the value to the consumer and is a combination of parameters including appearance (size, shape, color, gloss and defects), texture (firmness, crispness and juiciness), flavor (sweetness, sourness, astringency and bitterness) and nutritional value (vitamins, minerals and dietary fiber). The relative importance of each quality depends on the product. Colour is one of the most important attributes affecting the consumer's decision to purchase. However, subsequent purchases depend on the consumer's gratification in terms of texture, flavour and nutritional value of the products (Kader, 2002).

There is a considerable demand for fresh fruits as well as their products. Since many types of fruit are seasonal and their shelf life is limited, they must be processed to keep the quality. The fruits contain good amount of antioxidants and flavonoids which plays a very important role in preventing oxidative stress.

Hence nutritional quality of sweet avocado fruit spread was carried out with respect to nutrients viz. Carbohydrate , Protein ,Total Fat, Dietary Fiber, Reducing Sugar, Total sugars, TSS, Calcium, Iron, Sodium, Potassium, Total Minerals , Total Phenolic content, Total Antioxidant Activity Vitamin C ,Beta carotene and shelf life parameters including Acidity, Moisture, Peroxide Value.

Carbohydrate

In this study,11g of carbohydrate was present in 100g of sweet avocado fruit spread. The Carbohydrate content of the raw avocado fruit was found to be 8.53g. Ifesan, (2015)reported that strawberry jam provide the highest carbohydrate content while grape jam gave the lowest.

Protein

The present study revealed that protein content of sweet avocado fruit was 3.1g .This value was higher than the value of protein content present in the raw avocado fruit ie,2g.

FA0, (2011) reported that grape jam have the lowest content of protein while apricot have the highest which is comparable to the protein content of jackfruit jam(0.19g/100g) and pineapple jam(0.46g/100g).

Fat

In this investigation, Fat content of sweet avocado fruit spread was 42g.This value was higher than the value of fat content present in the raw avocado fruit ie,19.4. While most fruit consists primarily of carbohydrate, avocado is high in healthy fats.

The lipid content of other crops as reported by USDA (2009) are: 0.1g (Apple), 0.3g (Banana), 0.1g (Grape), 0.1g (Melon) and 0.1g (orange).FAO,(2011) reported that apricot jam contain no fat.

Dietary Fiber

The findings of present study revealed that Dietary fiber content of sweet avocado fruit spread was 6.89 g. The dietary fiber content of the raw avocado fruit was found to be 6.7g.

FAO (2011) reported that grape, strawberry and blueberry jam having the lowest dietary fiber content.

In this study, it is found that sweet avocado fruit spread contain high dietary fiber which is good for health.

Reducing Sugar

Sugars with reducing property are called reducing sugars. Estimation of reducing sugar is done to find out the starch material content.

Changes in the values of reducing sugars were more due to the ambient temperature. This was mainly due to the hydrolysis of non-reducing sugars, resulting into their increase (Sudheer & Dash, 1999).

FAO (2011) reported that the grape jam have the lowest reducing sugar content of 1.02g/100g and this was followed by blueberry and apricot jams at 5.08g/100g and 8.47g/100g respectively.

The present study revealed that Reducing Sugar content of sweet avocado fruit spread was 0.6g while raw avocado fruit contain 0.2g.The reason for increasing the reducing sugar in spread might be due to presence of invertase enzymes.

Total Sugars

In this present investigation, Total Sugar content of sweet avocado fruit spread was found to be 1.8g.One-half an avocado contains about 0.2g sugar(eg: sucrose, glucose and fructose).Compared to other fruits, avocados contain little

sugar. The noticeable differences could be caused by the addition of sugar during jam-making process.

FAO (2011) reported that grape jam had the lowest total sugar contents ranging from 52.43g/100g to 54.78g/100g.

TSS

The present study revealed that TSS content of sweet avocado fruit spread was 8^0brix. The TSS content of raw avocado fruit was found to be 6^0brix.

Rao *et al.*, reported that total soluble solid of apple olive blended jam samples was 70^0brix.This value is higher than tha value of sweet avocado fruit spread.

Calcium

FAO (2011) reported that apricot and blueberry jams tend to have lower calcium levels when compared to grape and strawberry jams.

In this present investigation, the calcium content was found to be 9mg/100g while 12 mg in the raw avocado fruit.

Iron

The iron content of sweet avocado fruit spread was found to be 0.72mg/100g and 0.55 mg in the raw avocado fruit.

FAO (2011) reported that blueberry and strawberry jams tend to contain higher iron levels. the Iron content of strawberry jam(0.72mg/100g) to be similar as reported in this study.

Potassium

The findings of present study revealed that potassium content of sweet avocado fruit spread was found to be 432mg/100g. Avocados contain about

152mg and 345 mg of potassium per 30g and one-half fruit (USDA & HHS, 2011).

Potassium is a nutrient most people don't get enough from their diet. Consumption of Sweet avocado fruit spread can provide enough potassium in the body. High potassium can reduce blood pressure which is a major risk factor for heart attacks and strokes.

Sodium

The sodium content of sweet avocado fruit spread was found to be 6.3mg/100g.Avocados are naturally low in sodium with 2 mg and 5.5 mg (USDA & HHS, 2011).

FAO (2011) reported that strawberry jam had the lowest sodium content followed by grapejam(4.07mg/100g).

Total Minerals

Ash content of a foodstuff represents inorganic residue remaining after destruction of organic matter (Rao *et al.*, 2003)

Siddapa, (1987) reported that there was no remarkable change in ash content of jam during storage where as the mineral compounds decreased during storage.

In this present investigation, the total mineral content of sweet avocado fruit spread was found to be 1.45g.

Beta carotene

The Beta carotene content of sweet avocado fruit spread was found to be 140mg/100g . Raw avocado fruit contain 417mg/100g.

Vitamin C

The Vitamin C loss was to the extent of 11.1%, 22.2% and 50% after 30 day 60 day and 90 day respectively for Jam (Fennema,1977).

Gupta, (2000) reported that the vitamin C content decreased during storage. This may be due to oxidation of ascorbic acid to dehydro ascorbic acid

The findings of present study revealed that Vitamin C content of sweet avocado fruit spread was found to be 7.32mg/100g while raw avocado fruit is reported to have 6mg /100g.

Total Phenolic Content

In this present investigation, the total phenolic content of sweet avocado fruit spread was found to be 18.4mg/100g while 20.45mg is reported in 100g of raw avocado fruit.

Ifesan, (2015) reported that banana jam contain 53 mg of total phenolic content.

Total Antioxidant Activity

The total antioxidant activity of spicy avocado fruit spread was found to be 423mg/100g while Raw Avocado fruit, however contained 340mg/100g of total antioxidant activity.

In this study, total antioxidant activity shows that it was higher in sweet avocado fruit spread than raw avocado fruit. This may be due to the antioxidant activity of cocoa powder added.

Shelf life Studies

Shelf life study was carried out to check the keeping quality of sweet avocado fruit spread.

Kalra & Tandon(1985), reported that formulated peanut soy spread was filled into plastic jars and stored at -12C until evaluation by sensory analysis (within seven days).

Acidity

Acidity is the measure of shelf-life of the product. Titrable acidity studied to ensure physico-chemical changes during preparation and during storage (Kalra & Tandon, 1985).

Sandhu *et al.*, (1998) reported that in jam, acid content was 0.51% at 30days and 1.55% and 2.5% at 60 and 90 days of storage respectively.

Disha *et al.*, (2017),reported that acidity of apple olive blended jam was greater than that observed before storage. Decreasing trend in pH might be due to the hydrolysis of pectic bodies and formation of acidic compound during degradation of sugar contents.

Gorny *et al.*, (2002) reported that the increase in acidity of the apple olive blended jam might be due to the breakdown of pectic bodies to pectenic acid. The reason for increasing trend of acidity was due to the formation of different organic acids during carbohydrate degradation and hydrolysis at storage.

During storage, increase in acidity was noted in sweet avocado fruit spread stored at all containers. On the 1st week of storage, the maximum acidity was reported in sweet avocado fruit spread stored in polyethylene bag at refrigerated temperature (0.017) and minimum in sweet avocado fruit spread stored in glass bottle at refrigerated temperature(0.006).

On the 2nd week, the acidity content of spicy avocado fruit spread ranged from 0.011 to 0.018.

On the 3rd week, the higher acidity was recorded for the sweet avocado fruit spread stored in polyethylene bag at ambient temperature(0.026) and the minimum acidity was noted in glass bottle at refrigerated and ambient temperature (0.012).

On the 4th week, the value of acidity increases on the sweet avocado fruit spread stored in all containers and the highest was recorded in the sweet avocado fruit spread stored in polyethylene bag at ambient temperature (0.026).

In this study, the acidity content was observed higher in sweet avocado fruit spread stored in polyethylene bags at ambient temperature (0.026), the lowest content of acidity was observed in sweet avocado fruit spread stored in glass bottle at refrigerated temperature (0.013).

Moisture

In this study, it was found that the moisture content of the stored sweet avocado fruit spread gradually increased during storage period. The highest moisture content was recorded for sweet avocado fruit spread stored in plastic bottle (78.7) at ambient temperature. The lowest was observed for sweet avocado fruit spread stored in glass bottles at refrigerated condition(56.29).

On the 1st week of storage, the moisture content of sweet avocado fruit spread ranged from 44.24 to72.54.

On the 2nd week, the moisture content of sweet avocado fruit spread stored in all containers were increased and the least content was recorded in the sweet avocado fruit spread stored in glass bottle at refrigerated temperature(51.95).

On the 3rd week of storage, the moisture content of spicy avocado fruit spread stored in all containers was found increased.

The spicy avocado fruit spread stored in glass bottle at refrigerated temperature reported the lowest moisture(67.90) in 4th week.

Gothwar *et al.* (1998), reported that the replacement of sugar free jellies with blueberry pulp treated with 18% of Fructoligo saccharide had slightly lower moisture content than the other concentrations which might be partly attributed to the change form crystalline to the amorphous form of substances which permits the binding of water.

Peroxide Value

In this study,the highest peroxide content was recorded for sweet avocado fruit spread stored in Polyethylene bags at ambient (19.26) and refrigerated temperature(19.26).The lowest was observed for sweet avocado fruit spread stored in glass bottles at refrigerated condition(10.13).

Kirk & Sawyer (1991) reported that a rancid taste was noticeable when the peroxide value was between 20 and 40 mEq kg^{-1} in oily products.

On the 1st week,highest peroxide value was noted in sweet avocado fruit spread stored in polyethylene bag at ambient temperature(4.33) and least in spicy avocado fruit spread stored in glass bottle at refrigerated temperature(2.90).

On the 2nd week , the peroxide value of sweet avocado fruit spreads stored at all containers increased and the sweet avocado fruit spread stored in plastic bottle at ambient temperature recorded the highest value(10.33)).Least was recorded in the sweet avocado fruit spread stored in glass bottle at refrigerated temperature(2.90).

On the 3rd week, the maximum peroxide value was obtained in the sweet avocado fruit spread stored in polyethylene bag at ambient and refrigerated temperature(17.60) followed by plastic bottle at ambient temperature(14.13),glass bottle at ambient temperature(12.36),plastic bottle at refrigerated temperature(8.53), glass bottle at refrigerated temperature(8.20) .

On the 4th week, the peroxide content of sweet avocado fruit spread increases.

In this present investigation it was observed that sweet avocado fruit spread stored in glass bottle at refrigerated temperature had lower peroxide value (10.13)proving its higher shelf life.

Microbial Count

Kader (2002) reported that the bacterial population of banana powder packed in polyethylene pouches ranged from 5.68-5.88 x 10^3 cfu/g. In this present investigation, microbial load was high in fruit spreads stored in polyethylene bags compared to glass bottle and plastic bottle.

Sarah & Francis (2011) reported that blackcurrant jam prepared without chemical additives had shown that the jam can remain stable for a period of 13 months at low temperature. Microbial analyses carried out at regular should no growth of bacteria,yeasts,molds, spore formers and pathogens.

5.3.3 Consumer Acceptability of Sweet Avocado Fruit Spread

Sudheer & Dash (1999) reported that the Hedonic scale has been accepted by sensory professionals to infer consumer acceptance from "liking", despite its flaws, because it provides internal validity (accurate and precise results of consumer liking) at the expense of external validity (relevance to the marketplace). It was reported that Sweet Avocado fruit Spread got 8.5 for overall acceptability in consumer acceptance.

Chocolate products are desired and eaten,due to their attractive flavours and appearance.Now a days,consumers are more concerned with the nutritional status of food stuffs and considering that cocoa powder and cocoa rich products are extremely rich sources of many essential nutrients and phytochemicals that can contribute to a healthy diet highlight renewed interest in such products.

Fennema (1977) reported that based on consumer acceptability testing(three-point scale), the commercial peanut butter and peanut soy spreads were acceptable products while the commercial soy not butter was not acceptable.

5.3.4 Cost Analysis

The cost of 1 kg Sweet avocado fruit spread calculated was Rs.550.This cost is low when compared to the fruit spreads available in the market.

In guava-mango jam, cost of production was recorded maximum (Rs. 83.59/kg) in treatment (0 guava:100 mango) and minimum (Rs. 74.11/kg) in treatment (100 guava:0 mango). In guava-mango chutney, cost of production was recorded maximum (Rs. 80.79/kg) in treatment (0 guava:100 mango) and minimum (Rs. 66.17/kg) in treatment (100 guava:0 mango) (Aruna *et al.*,1998).

5.4 Development of Spicy Avocado Fruit Spread

Preparation of fruit spread is one way of utilization of fruits.Processing of fruits not only serves as a purpose of its preservation but also several other purposes such as diversification of the economy, reduction of imports and meeting export demands, stimulate agricultural production by obtaining marketable products, generate employment, reduce fruit & vegetable losses, develop new value added products which are also available during off-seasons (Siddapa,1987).

Son *et al.*, (2001)reported that Spreadability is achieved through the right combination of fruit, pectin, acid and sugar. Banana base has been used widely to provide the desirable consistency in fruit spreads.

In this study, T6 was selected as the best pre treatment method for the development of spicy avocado fruit spread.

5.4.1 Standardization of Spicy Avocado fruit Spread

Sucharitha *et al.*, 2012 reported that three different samples were worked out to develop Ber-pineapple jam in laboratory. In the first sample-I the Ber pulp and pineapple pulp were taken in the ratio of 80:20. The other basic ingredients taken were sugar and commercial pectin. Sugar to the blended pulp was taken in the ratio of 1:1. Pectin was taken at the rate of 0.1%. In sample-II the Ber pulp and pineapple pulp were taken in the ratio of 70:30. The other ingredients were same as in the first sample-I. The ratio of Ber pulp to the pineapple pulp in sample-III

was taken in a ratio 60:40. The other ingredients were kept same for this sample as well.

Based on the organoleptic evaluation the treatment T5 with Pulp (100g):PepperPowder(3g):Salt(2g):TomatoPowder(5g):MintPowder(1.5g):Citrica cid(0.1g):KMS(0.25g) was selected as the superior blend for the development of spicy avocado spread.

5.4.2 Quality studies in Spicy Avocado Fruit Spread

There is a considerable demand for fresh fruits as well as their products. Since many types of fruit are seasonal and their shelf life is limited, they must be processed to keep the quality. The fruits contain good amount of antioxidants and flavonoids which plays a very important role in preventing oxidative stress.

Hence nutritional quality of spicy avocado fruit spread was carried out with respect to nutrients viz. Carbohydrate, Protein, Total Fat, Dietary Fiber, ReducingSugar,Totalsugars,TSS,Calcium,Iron,Sodium,Potassium,TotalMinerals, Total Phenolic content, Total Antioxidant Activity Vitamin C, Beta carotene and shelf life parameters including Acidity, Moisture, Peroxide Value.

Carbohydrate

In this study, 8.18g of carbohydrate was present in 100g of spicy avocado fruit spread. The carbohydrate content of raw avocado fruit has been reported to be 8.53g.

Carbohydrate content of avocado pear was determined to be 7.4g per 100g, this is more than the value of 1.9g obtained by Wood (2000), on comparing this value with other fruits such as lemon 9.32g, Apple 11.8g, Banana 23.2g, melon 5.5g, orange 8.5g, strawberries 5.7g, (USDA, 2009); It shows that the value of carbohydrate in avocado pear compares favourably with them. Carbohydrate is a major food substance for animal and human being needed for growth and strong health.

Protein

The present study revealed that protein content of spicy avocado fruit was 3.9g . The protein content of raw avocado fruit has been reported as 2g.

Anju *et al.*, 2004 reported that the highest protein content of 3.40 per cent was obtained in peach-soy leather of 70:30 ratios(B7) and the lowest of 1.28 per cent in control(B1).

Fat

In this investigation, Fat content of spicy avocado fruit spread was 57g.This value was higher than the value of fat content present in the raw avocado fruit. The protein content of raw avocado fruit has been reported as 2g.

Chauhan *et al.*, (2012) reported that the initial fat content of tender coconut blended spread varied from 1.49 to 1.64 g/100g. The highest fat content was recorded in the spread prepared using 50%TCP+50%PE. The 100% TCP formulation recorded the highest percentage of fat (6.80 %) as against the 100% pineapple jam.

Dietary Fiber

The findings of present study revealed that dietary fiber content of spicy avocado fruit spread was 6.12 g. This is almost equivalent to the dietary fiber content of the raw avocado (6.7g).

Avocados tend to be rich in dietary fiber is very high compared to other foods.Dietary fiber play an important role in weight loss and metabolic health.

Reducing Sugar

The present study revealed that reducing sugar content of spicy avocado fruit spread was 0.78g while reducing sugar content of raw avocado fruit was found to be 0.20g.

Muralikrishna *et al.*, (1969) reported that the jamun jam had 8.22g/100g of reducing sugar.

Total Sugars

In this present investigation, Total Sugar content of spicy avocado fruit spread was found to be 0.98g. The total sugar content of raw avocado fruit is reported as 0.3g.

Thakur *et al.*, (2000) reported that the jackfruit jam contain 38g/100g of total sugars.

TSS

The present study revealed that TSS content of spicy avocado fruit spread was 5^0brix while TSS content of raw avocado fruit was found to be 8^0brix.

Kundu et al.,2017 reported that the TSS of plum jam was 68^0brix.This value is higher than the spicy avocado fruit spread.

Calcium

In this present investigation, the calcium content was found to be 8.2mg/100g. The calcium content of raw avocado fruit was found to be 12 mg.

Ifesan, (2015) reported that jackfruit jam contain 8.2 mg of calcium.

FAO (2011) reported that higher calcium content(27.26-55.44mg/100g) was observed in strawberry jams when compared to apricot and blueberry jams.

Iron

The iron content of spicy avocado fruit spread was found to be 0.97mg/100g. The Iron content of raw avocado fruit was found to be 0.55mg/100g.

The iron content is less in avocado compared to other fruits.

Potassium

The findings of present study revealed that potassium content of spicy avocado fruit spread was found to be 482mg/100g. The potassium content of raw avocado fruit was reported to be 345 mg.

Ifesan, (2015) reported that banana jam contain 320mg/100g of potassium.

The avocado contain more potassium than banana.So consumption of this fruit spread is health beneficial.

Sodium

The sodium content of spicy avocado fruit spread was found to be 7.3mg/100g. The Sodium content of raw avocado fruit was found to be 5.50 mg.

Ifesan, (2015) reported that strawberry jam contain 1.41mg of sodium. The sodium content is high in spicy avocado fruit spread compared to raw avocado fruit. This might be due to the addition of salt during processing of spicy avocado fruit spread.

Total Minerals

Ash content between treated and untreated strawberry jelly samples did not differ significantly during the storage period it was around the range of 0.42-0.49(Sandhu *et al.*, 2015)

In this present investigation, the Total Mineral Content of spicy avocado fruit spread was found to be2.06g. The Total mineral content of raw avocado fruit was found to be 1.22 g.

Beta carotene

The Beta carotene content of spicy avocado fruit spread was found to be 265mg/100g. .The Beta carotene content of raw avocado fruit was found to be 417mg/100g.

Beta carotene is an antioxidant that inhibits the oxidation of other molecules; it protects the body from free radicals. Consumption of beta carotene rich foods like spicy avocado fruit spread is good for health.

Vitamin C

The findings of present study revealed that Vitamin C content of spicy avocado fruit spread was found to be 19.10mg/100g. The Vitamin C content of

raw avocado fruit was reported as 6.0mg/100g.The high vitamin C content of spicy avocado fruit spread may be due to the addition of pepper powder and tomato powder.

Morton, (1987) reported that vitamin C content value obtained for jackfruit jam was 14.63mg/100g.

Total Phenolic Content

In this present investigation, the total phenolic content was found to be 78 mg/100g while raw avocado fruit contain 20.45mg/100g of Total Phenolic Content.

Salgado *et al.*, 2008 reported that phenolic level in jackfruit jam vary from 2.3 to 5.7%.

In this study, it was observed that total phenolic content was higher when compared to the raw avocado fruit. This might be due to the addition of mint powder, pepper powder and tomato powder which is a rich source of phenolic content.

Total Antioxidant Activity

The total antioxidant activity of spicy avocado fruit spread was found to be 520mg/100g. Total Antioxidant Activity of raw avocado fruit was found to be 340mg/100g.

In this study, it is found that that the antioxidant activity is higher in spicy avocado fruit spread than raw avocado fruit. This might be due to the addition of tomato powder which is rich in antioxidants. Also it may be due to capacity of avocado to increase antioxidant absorption from other foods.

Shelf life studies

Shelf life study was carried out to check the keeping quality of spicy avocado fruit spread.

Acidity

Increase in acidity was due to the formation of acids by degradation of polysaccharides and oxidation of reducing sugar or by breakdown pectic substance and uronic acid(Salgado *et al.*, 2008). In this study, it was found that the acidity content was observed higher in spicy avocado fruit spread stored in polyethylene bags at ambient temperature (0.064), the lowest content of acidity was observed in spicy avocado fruit spread stored in plastic bottle at refrigerated temperature (0.032).

During storage, increase in acidity was noted in spicy avocado fruit spread stored at all containers. On the 1st week of storage, the maximum acidity was reported in spicy avocado fruit spread stored at refrigerated temperature(0.016) and minimum in spicy avocado fruit spread stored in plastic bottle at refrigerated temperature(0.007).

On the 2nd week, the acidity content of spicy avocado fruit spread ranged from 0.019 to 0.029.

On the 3rd week, the higher acidity was recorded for the spicy avocado fruit spread stored in polyethylene bag at ambient temperature(0.046) and the minimum acidity was noted in polyethylene bag at refrigerated temperature (0.023).

On the 4th week, the value of acidity increases on the spicy avocado fruit spread stored in all containers and the highest was recorded in the spicy avocado fruit spread stored in polyethylene bag at ambient temperature.

Moisture

In this study, it was found that the moisture content of the stored spicy avocado fruit spread gradually increased during storage period. The highest moisture content was recorded for spicy avocado fruit spread stored in Polyethylene bags (73.71), plastic bottles (73.28) and glass bottles(73.16) at

ambient temperature. The lowest was observed for spicy avocado fruit spread stored in glass bottles at refrigerated condition (64.13).

On the 1st week of storage, the moisture content of spicy avocado fruit spread ranged from 58.52 to 63.

On the 2nd week, the moisture content of spicy avocado fruit spread stored in all containers were increased and spicy avocado fruit spread stored in glass bottle(64.30) and plastic bottle(64.21)at ambient condition were on par and the least content was recorded in the spicy avocado fruit spread stored in glass bottle at refrigerated temperature(61.93).

On the 3rd week of storage, the moisture content of spicy avocado fruit spread stored in all containers was found increased.

The spicy avocado fruit spread stored in glass bottle at refrigerated temperature reported the lowest moisture(64.13) in 4th week.

Endres, (2001) reported that the highest moisture content of 21.99 per cent was recorded in control(B1) while the lowest of 17.50 per cent was recorded in peach-soy jam of 70:30 ratios(B7).

Peroxide Value

The highest peroxide content was recorded for spicy avocado fruit spread stored in Polyethylene bags at ambient temperature(11.63).The lowest was observed for spicy avocado fruit spread stored in glass bottles at refrigerated condition(5.43).

Krik & Sawyer (1991) reported that fresh oils have values less than 10mEq kg^{-1} and values below 10 characterize the majority of conventional oils.

In this study, it was observed that spicy avocado fruit spread stored in glass bottle at refrigerated temperature had lower peroxide value (5.43)proving its higher shelf life.

On the 1st week, highest peroxide value was noted in spicy avocado fruit spread stored in polyethylene bag at ambient temperature and least in spicy avocado fruit spread stored in glass bottle at refrigerated temperature.

On the 2nd week , the peroxide value of spicy avocado fruit spreads stored at all containers increased and the spicy avocado fruit spread stored in polyethylene bag at ambient condition recorded the highest value(6.50).Least was recorded in the spicy avocado fruit spread stored in glass bottle at refrigerated temperature.

On the 3rd week, the maximum peroxide value was obtained in the spicy avocado fruit spread stored in polyethylene bag at ambient temperature(8.66) followed by plastic bottle at ambient temperature(6.73),polyethylene bag at refrigerated temperature(6.40),glass bottle at ambient temperature(5.60), plastic bottle at refrigerated temperature(5.50) .

On the 4th week, the peroxide content of spicy avocado fruit spread increases.

Microbial Count

During the storage period, the spicy avocado fruit spread experienced complete spoilage on 4th week and the microbial count was Bacteria($15x10^{-3}$), Yeast($6.7x10^{-3}$),Fungi($6.7x10^{-3}$).

There was acceptable amount of microbes has observed at the end of the storage period showed that after one month storage no microbial growth was observed in properly sealed jars (Gargi *et al.*, 1995).

Pilgrim *et al.*,(1991) reported that the replacement of reduced sugar jelly treatments exhibited no detectable yeast and mould during 30 days of refrigerated or accelerated shelf life storage. Jellies depend on their high sugar concentration for microbiological stability but in humid weather conditions may promote the growth of mould on the surface of the container.

5.4.3 Consumer Acceptability of Spicy Avocado Fruit Spread

Endres *et al.,* (2001) reported that Consumer acceptability is based on the percentage distribution that rated that product as tastes great or acceptable.

An examination of consumers' favourite fruit snacks indicate that some nutritionally rich fruits have dropped in consumer preference (Pilgrim *et al.,* 1991)).Consumer acceptability of developed spicy avocado fruit spread were observed as good. This product has a mild taste of spice liked by children and it is highly nutritious.

5.4.4 Cost Analysis

Costing can be defined as the process of determining how much a product costs to prepare and sell a product. Costing is very important as the cost of the product can decide its profit or loss. The cost of processed products depends on the purchase of the raw material, cost involved in processing, packaging and marketing and the profit margin set by the industry (Gargi *et al.,* 1995)).

Thakur *et al.,* (2000) reported that while developing new products, the cost is to be kept to the minimum and the strategy for the development of the food product is to be based on affordable prices and cost effectiveness. In order to realize the economic feasibility of the developed products, cost per kg was computed separately. The cost of 1 kg Spicy avocado fruit spread calculated was Rs.600.This amount is low when compared to the commercial spread available in the market.

Heat processing of avocado fruit will develop off flavour and bitter taste in value added products against the nutty flavour of fresh fruits. Being a super fruit with poor shelf life qualities, the developed sweet and spicy avocado fruit spread, which secured high consumer acceptance can be branded and marketed successfully for reducing wastage and economic prosperity.

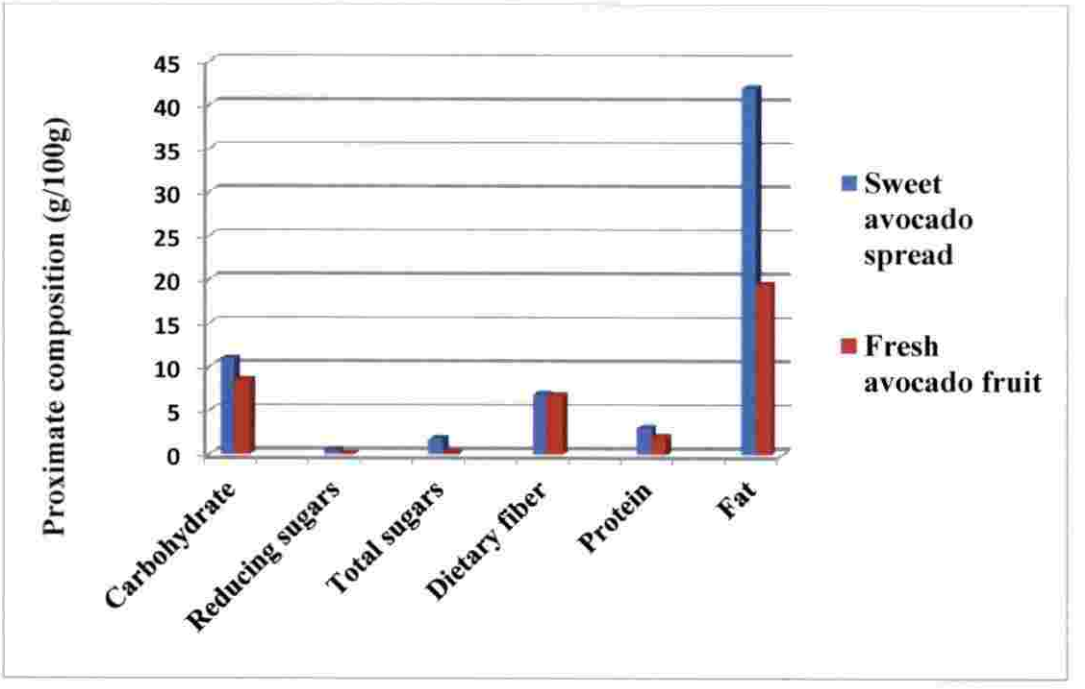


Fig. 3 Proximate composition of sweet avocado fruit spread

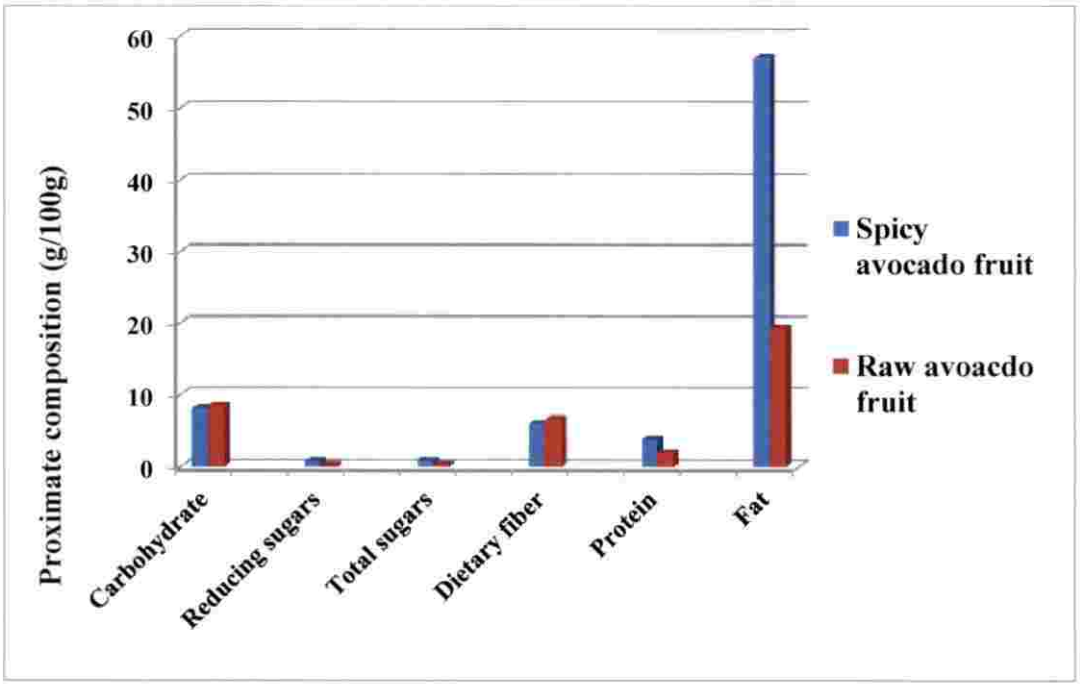


Fig. 4 Proximate composition of spicy avocado fruit spread

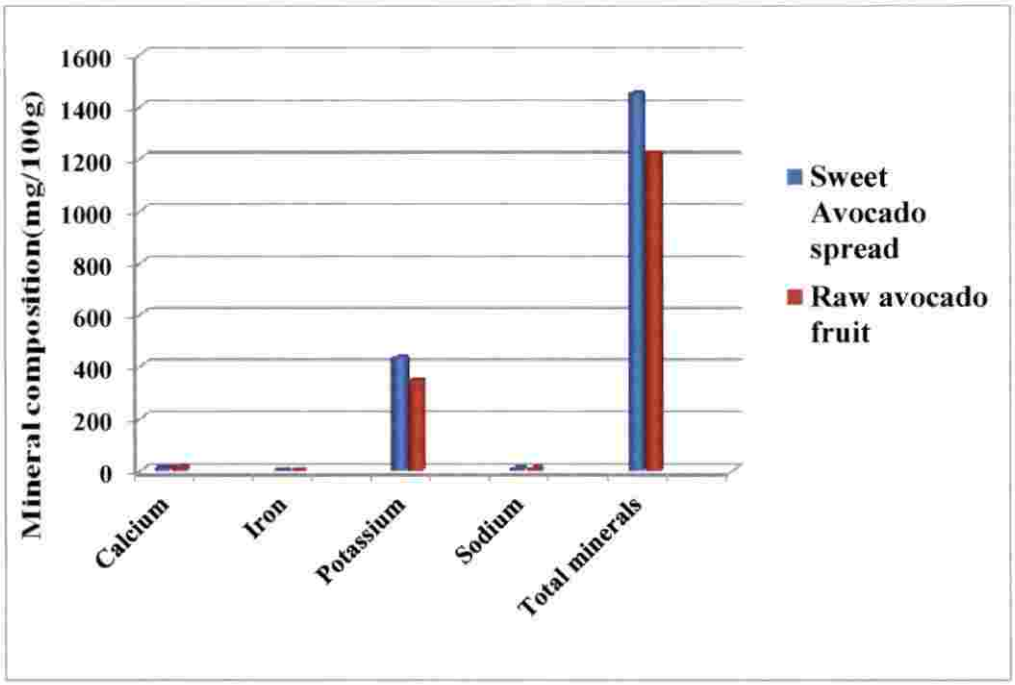


Fig. 5 Mineral composition of sweet avocado fruit spread

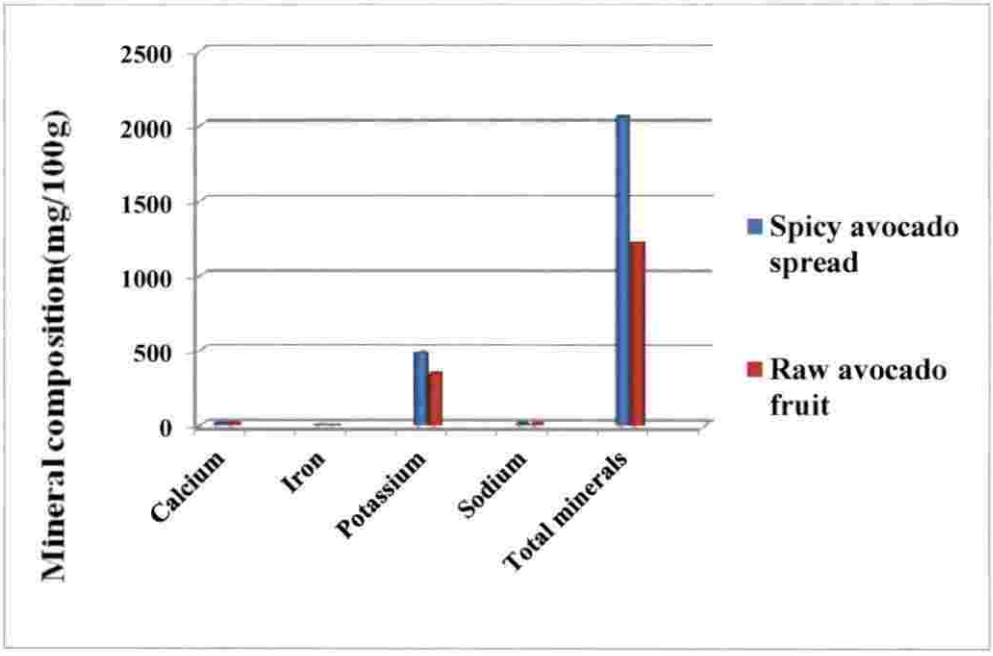


Fig. 6 Mineral composition of spicy avocado fruit spread

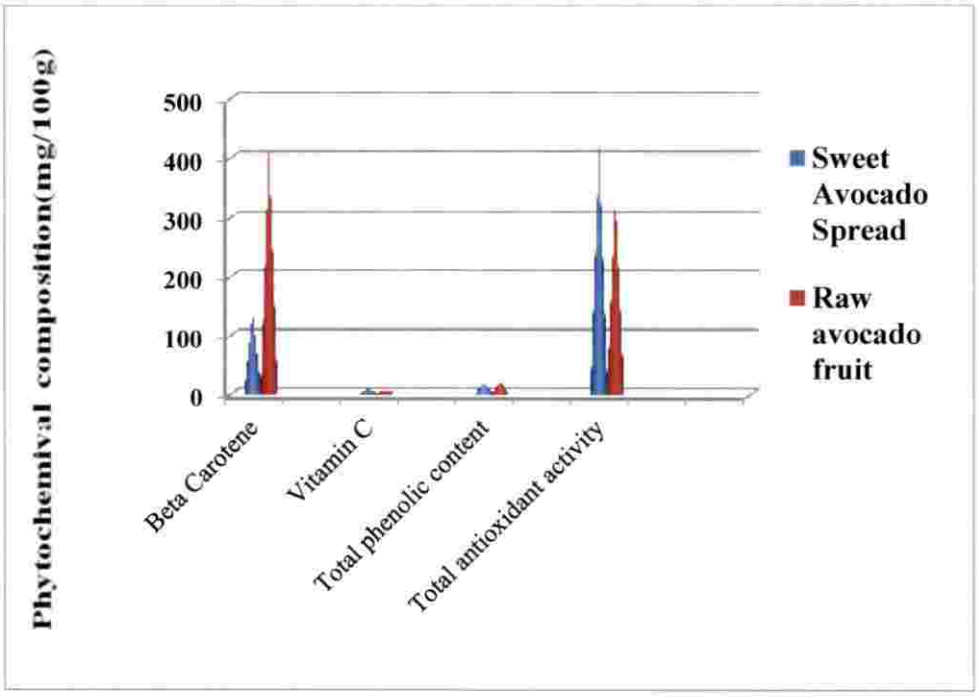


Fig. 7 Phytochemical composition of sweet avocado fruit spread

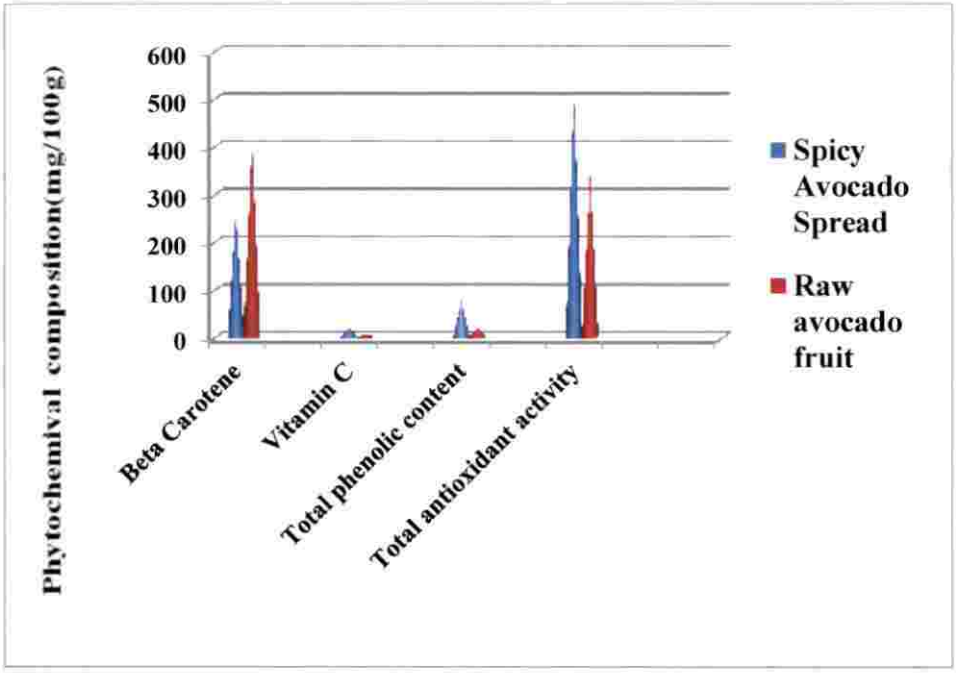


Fig. 8 Phytochemical composition of spicy avocado fruit spread

SUMMARY

6. SUMMARY

The present study entitled "Development and quality evaluation of fruit spreads from avocado (*Persea americana* Mill.)" was conducted at the Department of Community Science, College of Agriculture, Vellayani during 2017-2019. The objective of the study was to study the effect of pre-treatments on quality parameters of avocado cultivars and to develop fruit spreads from avocado and their quality evaluation.

Avocado cultivar commonly found in the households of Wayanad namely Purple Hybrid was utilized for the study. Matured fruits were collected from Regional Agricultural Research Station, Wayanad. The avocado pulp was pre-treated independently and in combination with different pre-treatment methods viz., blanching, sugar syruping, honey, brine solution, citric acid and KMS to select the best pre-treatment method organoleptically for the development of sweet and spicy spreads.

The best pre-treatment methods identified for the development of sweet spread was, citric acid + KMS + sugar (T5) blend in the ratio of 0.25:0.1:100. The citric acid + KMS + salt (T6) in the combination of 0.25:0.1:10 was selected organoleptically for the development of spicy spread.

For the development of sweet avocado spread, variation in addition of cocoa powder (adjunct) was done keeping the avocado pulp as constant. The best combination among the 5 treatments in both sweet and spicy spread was selected based on sensory evaluation using nine point rating scale. Sweet avocado fruit spread T3 with Pulp(100g):Cocoa powder(30g):Sugar(100g):Citric acid(0.1g) and KMS(0.25g) was selected organoleptically as the best spread among the five treatments.

Based on the organoleptic evaluation the treatment T5 with Pulp (100g): PepperPowder(3g):Salt(2g):TomatoPowder(5g):MintPowder(1.5g):Citricacid(0.1 g):KMS(0.25g) was selected as the superior blend for the development of spicy avocado spread.

The result of chemical and nutrient analysis of sweet avocado fruit spread revealedthat it contained Carbohydrate(11g/100g), TotalSugars(1.8g/100g), ReducingSugars(0.6g/100g), DietaryFiber(6.89g/100g), Protein(3.1g/100g), TotalFat(42g/100g),Calcium(0.238mg/100g),Iron(0.72mg/100g),Potassium(432mg/100g),Sodium(6.3mg/100g),Totalminerals(1.45g/100g),Betacarotene (140mg/100g), VitaminC(7.32mg/100g),Total Phenolic Content(81.4mg/100g), Total Antioxidant Activity(423mg/100g).

Chemical and nutrient analysis of spicy avocado fruit spread showed that it contained Carbohydrate(8.18g/100g), Total Sugars(0.98g/100g), Reducing sugars (0.78g/100g), Dietary fiber(6.12g/100g), Protein(3.9g/100g), Total fat(57g/100g), Calcium(0.267mg/100g), Iron(0.97mg/100g), Potassium(482mg/100g), Sodium (7.3mg/100g),Total minerals(2.06g/100g), Betacarotene(265mg/100g),VitaminC (19.1mg/100g), Total Phenolic Content(78mg/100g) with an Antioxidant Activity(520mg/100g).

The nutrient constituents of sweet and spicy avocado fruit spreads were compared with respect to the nutrient constituents of raw avocado fruit. Chemical composition of raw avocado fruit contained Carbohydrate(8.53g/100g), Total sugars(0.3g/100g), Reducing sugars(0.2g/100g), Dietary fiber(6.7g/100g), Protein(2g/100g), Total fat(19.4g/100g), TSS(6^0brix), Calcium(12mg/100g), Iron(0.55mg/100g), Potassium(345mg/100g), Sodium(5.5mg/100g), Total minerals(1.22g/100g), Beta carotene(417mg/100g), Vitamin C(6mg/100g), Total phenolic content(20.45mg/100g), Total Antioxidant Activity(340mg/100g.

The shelf stability of the developed avocado fruit spreads were assessed by storing the fruit spreads in glass bottle, plastic bottle and polyethylene bags at ambient and refrigerated condition. The acidity, moisture, peroxide value and microbial count were determined initially and at weekly intervals.

During the shelf life studies, it was observed that acidity, moisture, peroxide value and microbial count show significant changes with respective to packaging material and temperature. The acidity, moisture, peroxide content was

observed higher in sweet and spicy avocado fruit spread stored in polyethylene bags at ambient temperature and the lowest content of was observed in sweet and spicy avocado fruit spread stored in glass bottle at refrigerated temperature.

The acidity content was observed higher in sweet avocado fruit spread stored in polyethylene bags at ambient temperature (0.026),the lowest content of acidity was observed in sweet avocado fruit spread stored in glass bottle at refrigerated temperature(0.013).The moisture content of the stored sweet avocado fruit spread gradually increased during storage period. The highest moisture content was recorded for sweet avocado fruit spread stored in plastic bottle(78.7) at ambient temperature. The lowest was observed for sweet avocado fruit spread stored in glass bottles at refrigerated condition(56.29). The highest peroxide content was recorded for sweet avocado fruit spread stored in Polyethylene bags at ambient(19.26) and refrigerated temperature(19.26).The lowest was observed for sweet avocado fruit spread stored in glass bottles at refrigerated condition(10.13). In case of sweet avocado fruit spread kept in refrigerated temperature, the bacterial colonies was found in all storage containers. Fungal colonieswas found to be higher in fruit spread kept in polyethylene bag. Yeast growth was recorded nil in fruit spread stored in glass bottle.

The acidity content was observed higher in spicy avocado fruit spread stored in polyethylene bags at ambient temperature(0.064),the lowest content of acidity was observed in spicy avocado fruit spread stored in plastic bottle at refrigerated temperature(0.032). The highest moisture content was recored for spicy avocado fruit spread stored in Polyethylenge bags(73.71),plastic bottles(73.28) and glassbottles(73.16) at ambient temperature.The lowest was observed for spicy avocado fruit spread stored in glass bottles at refrigerated condition(64.13). The highest peroxide content was recored for spicy avocado fruit spread stored in Polyethylenge bags at ambient temperature(11.63).The lowest was observed for spicy avocado fruit spread stored in glass bottles at refrigerated condition(5.43).

Consumer acceptance study revealed that sweet spread (T3) had a score of 8.5 and spicy spread (T5) had a score of 7.56 .The cost of products were Rs.550/Kg and Rs.600/Kg for sweet and spicy fruit spreads respectively.

Heat processing of avocado fruit will develop off flavour and bitter taste in value added products against the nutty flavour of fresh fruits. Being a super fruit with poor shelf life qualities, the developed sweet and spicy avocado fruit spread, which secured high consumer acceptance can be branded and marketed successfully for reducing wastage and economic prosperity.

REFERENCES

7. REFERENCES

ADA (American Dietetic Association). 2009. Position of the American Dietetic Association: Functional foods. *J. Am. Diet. Assoc.* 109:735–746.

Adeyemi, O. O., Okpo, S. O., Ogunti, and Osencer. 2002. Analgesic and anti-inflammatory effects of the aqueous extract of leaves of *Persea Americana* Mill (Lauraceae), *Fitoterapia,* 73(3): 375-380

Akpabio, U. D., Akpakpan, A. E., Matthew, I. E and Akpan, A. U. 2011. *World. J. Applied. Sci. Technol,* 3(2): 27-34.

Anaka, O. N., Ozolua, R. I., and Okpo, S. O. 2009. Effect of the aqueous seed extract of *Persea americana* Mill (Lauracceae) on blood pressure, *Afr. J. Pharmacol.* 3(10): 485-490.

Andrews, W. 1992. Manual of food quality control 4. Rev.1. microbiological analysis, Food and Agriculture Organization of United Nations, Rome, pp.9-17.

Anju, B., Kumari, K. R., Anand, V., and Anjum, M.A. 2004. Preparation,Quality Evaluation and storage stability of Peach-Soy fruit leather, SA ARC. *J. Agri.* 12(1): 73-88.

AOAC. 1995. *Official Method of Analysis.* Association of Official Analytical Chemists, ArlintonVA. 16(4): 1-45.

Arias, L. E. H., Gómez, J. H. P. and Salazar, J. A. 2012. Application of the matrixes engineering on the development of minimally processed Hass avocado (*Persea americana* Mill) with additions of vitamin C and calcium. *Revista Lasallista Investigación,* *9*(2), 44–54. Retrived fromhttp://www.redalyc.org/articulo.oa?id=69525875016

Arias, L. E. H., Gómez, J. H. P. and Salazar, J. A. 2014. Application of the matrixes engineering on the development of minimally processed Hass avocado (*Persea americana* Mill) with additions of vitamin C and calcium. *Revista Lasallista Investigación,* *9*(2), 44–54. Retrived from http://www.redalyc.org/articulo.oa?id=69525875016.

Arias, L.E. H., Gómez, J. H. P. and Salazar, J. A. 2013. Application of the matrixes engineering on thedevelopment of minimally processed Hass avocado (*Persea americana* Mill) with additions of vitamin C and calcium. *Revista Lasallista Investigación,9*(2),44-54.Retrivedfromhttp://www.redalyc.org/articulo.oa?id=69525875016.

Arts, I. C. W. and Hollman, P. C. H. 2004. Polyphenols and disease risk in epidemiologic disease. *Am. J. Clin. Nutr.* 8:317S–25S.

Aruna, K. R., Dhanalakshmi, and Vimala, V.1998. Development and storage stability of Cereal-based papaya powder. *J. Food Sci. Technol.* 35(3): 250-254.

Avocado Central. 2010. Hass Avocado Spread Comparison: Spread on Nutrition with HassAvocados.Availablefromhttp://www.avocadocentral.com/nutrition/avocado-spread-comparison. Accessed November 29, 2012.

Azanha, A. B. and Faria, M. 2005. Use of mathematical models for estimating the shelf life of corn flakes in flexible packaging. Packaging Technology and Science 18 (4): 161-222

B.N. Wolstenholme, and A.W. Whiley (eds.). The avocado: Botany, production and uses. 1st ed. CABI, Boston, MA. Pp. 15–37.

Bates, R. P. 1999. The Retardation of Enzymatic Browning in Avocado, Proc. Fla. State Hort. Soc. 81, pp. 230-235.

Batista, C. A., Cerezal, M, P., and Funglay, V. 1993. E.I. Aguacate (*persea Americana) Nutritional Composition of Avocado Pear*. Pp: 63-69

Bergh, B. 1992. The Avocado and Human Nutrition. .Some Human Health Aspects of The Avocado. Proceedings of Second World Avocado Congress September 28-October 1 Gold Coast, Australia, pp 25-35.

Bizimana, V., Breene, W.M., and Csallany, A.S, 1993. Avocado oil extraction with appropriate technology for developing countries. *J. Am. oil che. soc,* (70):821-

822

California Avocado Commission. 2011. California Avocado history. Available fromhttp://www.avocado.org/california-avocado-history/ Accessed November 29, 2012.

California Avocado Commission. 2012. California Avocado history. Available fromhttp://www.avocado.org/california-avocado-history/ Accessed November 29, 2012.

Chauhan, O.P., Archana, B.S., Asha, P.S., Singh, and Bawa, A.S. 2012. Utilization of tender coconut pulp for Jam making and its quality evaluation during storage. *Food. Bio. Technol. 20 (11)*: 32-35. *Chem*, 4(8): 142-151.

Chia, T. W. R. and Dykes, G. A. 2009. Antimicrobial activity of crude epicarp and seed extracts from matureavocado fruit (*Persea americana*) of three cultivars. *Pharma. Biol. 48*(7), 753-756.

Chia, T. W. R. and Dykes, G. A. 2010. Antimicrobial activity of crude epicarp and seed extracts from mature avocado fruit (*Persea americana*) of three cultivars. *Pharma. Biol. 49*(9), 723-727.

Chia, T. W. R. and Dykes, G. A. 2011. Antimicrobial activity of crude epicarp and seed extracts from mature avocado fruit (*Persea americana*) of three cultivars. *Pharma. Biol. 52*(7), 812-816.

Chong, E. W. T., Robman, L. D., Simpson, J. A., Hodge, A. M., Aung, K. Z., Dolphin, T. K., English, D. R., Giles, G. G., and Guymer, R. H. 2009. Fat consumption and its association with age-related macular degeneration. *Arch. Ophthalmol.* 127(5): 674–680

Daiuto, E.R. 2011. Sensory analysis of cold-stored guacamole added with α-tocopherol and ascorbic acid. RevistaCeres. Accessed: [22 Dec. 2015]. doi: 10.1590/S0034-737X2011000200002., 58(2): 140-148

Dinubile, N. A. 2010. A potential role for avocado-and soybean-based nutritional supplementation in the management of osteoarthritis: *A review. Phys. Sportsmen.*

38(2): 71–81.

Disha, N., Ofosu, I.W., and Owusu, A.A. 2017. Modeling the formulation and shelf life of Avocado (Persea americana) Fruit Spread. *Am. J. food technol.* 6(8): 661-673.

Duester, K.C. 2000. Avocados a look beyond basic nutrition foroneofnature's whole

Endres, J.G. 2001. Soy protein products;Characteristics,nutritional aspects, and utilization. *J. Nutr.* 25(5): 18-34

Eyres, L. G., Henricks., and Sherpa, G. 2001. Avocado oil a new edible oil from FAO (FoodandAgriculturalOrganization).2011.Fao.Available<*http//www.fao.org*>Accessed [16 Aug 2012].

Fennema, 1977. Loss of Vitamins in fresh and frozen. food. *J. Food Sci. Technol.* 31(12): 32.

Fernandes, F. A. N., Rodrigues, S., Law, C. L., and Mujumdar, A. S. 2010. Drying of Exotic Tropical Fruits: A Comprehensive Review. *Food Bioprocess Technol.* DOI 10.1007/s11947-010-0323-7, published online, 24 February.

Flagg, E. W., Coates, R. J., Jones, D. P., Byers, T. E, Greenberg, R. S., Gridley, G., McLaughlin, J. K., Blot, W. J., Haber, M., and Preston, S. 1994. Dietary glutathione intake and risk of oral and pharyngeal cancer. *Am. J. Epidemiol.* 139(5):453–465

Fulgoni, V. L., Dreher, M. L. and Davenport, A. J. 2011. Avocado consumption associated with better nutrient intake and better health indices in US adults: NHANES 2011–2006. Experimental Biology. Abstract #8514. Anaheim, CA.

Fulgoni, V. L., Dreher, M. L., and Davenport, A. J. 2010. Consumption of avocados in diets of US adults: NHANES 2011–2006. American Dietetic Association. Abstract #54. Boston, MA.

Gabay, O., Gosset, M. and Levy, A. 2008. Stress-induced signaling path ways in hyalin chondrocytes: Inhibition by avocado-soybean unsaponifiables (ASU). *Osteoarthr. Cartilage.* 16(3): 373–384

Garcia, R., Andrade, J. and Rolz, C. 1996. Effect of temperature and heating time on the detection of off-flavor in avocado paste. *J. Food Sci.* 40: 200.

Gargi, N., Tandon, D.K., and Kalara, S. 1995. Determaintion of microbial load during various stepsof mango processing for pulp". *J. Food Sci. Technol.* 40(6): 576-581.

Gehlot, Rakesh. 2015. Development and evaluation of jam and chutney from guava-mango blends. *J. Nutr.* Pp: 23-29

Golukcu, M. and Ozdemir, F. 2010. Changes in phenolic composition of avocado cultivars during harvesting time. *Chem. Nat. Compounds. 46*(1): 112-115. http://dx.doi.org/10.1007/s10600-010-9541-5.

Gorny, J. R., Hess-Pierce, B., Cifuentes, R. A., and Kader, A. A. 2002. Quality changes in fresh-cut pear slices as affected by controlled atmospheres and chemical preservatives. *Postharvest Biol. Technol.* **24**: 271-8.

Gothwar, P.P., Setty , G.R., and Mookerji, K.R. 1998. Effect of processing steps for canning of guava, pineapple, carrot and drumstick on the retention of nutrients, Beverage and Food World. 25(3): 13-17.

Gregory, .I. Onwuka. 2005. *Food analysis and instrumentation, theory and practice.* Pp.63- 120.

Guine, R. and Barroca, M. 2012. Effect of drying treatments on texture and colour of vegetables (Pumkin and Green Pepper). *Food Bioproduct process.* 90 (1): 58-63.

Gupta, G.K. 2000. Standardisation of recipie forpreparation of Sweet papaya chutney. Indian Food Packer. 32(11): 80-81

Gyesley, S. W. 2003. Total Systems approach to predict shelf life of Packaged Foods. 13 p.

Gyles, C. L., Carlberg, J. G., Gustafson, J., Davlut, D. A. and Jones, P. J. H. 2010. Economic valuation of the potential health benefits from foods enriched with plant sterols in Canada. *Food & Nutr.* 54:1–6.

Haegele, A. D., Gillette, C., O'Neill, C.,Wolfe, P., Heimendinger, J., Sedlacek,S. and Thompson, H. J. 2000. Plasma xanthophyll carotenoids correlateinversely with indices of oxidative DNA damage and lipid peroxidation. *Cancer Epid. Biomarkers & Prev.* 9:421–425

Hamid, A. A., Aiyelaagbe, O. O., Usman, L. A., Ameen, O. M., and Lawal, A. 2010 . Antioxidants: Its medicinal and pharmacological applications. *Afri. J. Pure. Sci.*

2(23):23-32.

Hammami, C. and Rene, F. 1997. Determination of freeze-drying process for strawberries. *J.Food Engineering*, 32 (2): 298 – 304.

Hérnandez, M. P., Almenar, E., Ocio, M. J., and Gavara, R. 2006. Effect of calcium dips and chitosan coating on postharvest life of strawberries (Fragaria x ananassa). Postharvest Biology Technology,39(3), 247-253.

Hidalgo, M., Sánchez-Moreno, C. and Pascual-Teresa, S. 2010. Flavonoid-flavonoid interaction and its effect on their antioxidant activity. *Food Chem. 121*(3): 691−696. http://dx.doi.org/10.1016/j.foodchem.

Honarbakhsh, S. and Schachter, M. 2009.Vitamins and cardiovascular disease. *Br. J. Nutr.*101:1113–1131

Hozawa, A., Jacobs, D. R., Steffes, M. W., Gross, M. D., Steffen, L. M. and Lee, L.-H. 2007. Relationships of circulating carotenoid concentrations with several markers of inflammation, oxidative stress, and endothelial dysfunction: The coronary artery risk development in young adults (CARDIA)/young adult longitudinal trends in antioxidants (YALTA) study. *Clin. Chem.* 53(3): 447–455.

Hughes, K. J., Mayne, S. T., Blumberg, J. B., Ribaya-Mercardo, J. D., Johnson, E. J., and Cartmel, B. 2009. Plasma carotenoids and biomarkers of oxidative stress in patients with prior head and neck cancer. B*iomarker Insights*. 4:17–26.

Ifesan, B.O.T., Olorunsola, B.O., and Ifesan, B.T. 2015. Nutritional Composition and Acceptability of Candyfrom Avocado Seed (*Persea americana) Inter. J. Agri.* 3(6): 1473-2319.

International book distributing company, India, 114p

Jackson, E. A. 2003. Resources for information on herbal medicines and dietary supplements. *J. Herbal Pharmacol*, 3 57-64.

Jacobo, D. A. and Hernández-Brenes, C. 2012 Stability of avocado paste carotenoids as affected by high hydrostatic pressure processing and storage. *Innovative Food Sci. Emerging Technol.* 121p.

Jakobsen, M. U., O'Reilly, S., Heitmann, B. L., Pereira, M. A., Balter, K.,Fraser, G. E., Goldbourt, U., Hallmans, G., Knekt, P., Liu, S., Pietinen, P.,Spiegelman, D., Stevens, J., Virtamo, J., and Willett, W. C. 2009. Majortypes of dietary fat and risk of coronary heart disease: A pooled analysis of11 cohort studies. *Am. J. Clin. Nutr.* 89:1425–1432.

Johnson, E., Maras, J. E., Rasmussen, H. M., and Tucker, K. L. 2010. Intake of lutein and zeaxanthin differ with age, sex and ethnicity. *J. Am. Diet. Assoc.* 110:1357–1362

Jules, J. 2008. The Encyclopedia of Fruit & Nuts. Oxforshire, England: CABI. p. 440. ISBN 9780851996387.

Kader, A. A. 2002. Quality Parameters of Fresh-cut Fruit and Vegetable Products. In: Lamikanra O (ed.). Fresh-cut Fruits and Vegetables: Science, Technology, and Market. CRC Press, Boca Raton. Pp: 11-20

Kalra, S.K.,and Tandon, D.K. 1985. Physico-chemical changes in mango pulp during ambient storage glass containers. *J. Food Sci.and Technol.* 22: 343-345.

Khazan, O. 2015. The selling of the avocado. The Atlantic, January 31st, 2015. Availableonlineat:http://www.theatlantic.com/health/archive/2015/01/theselling-of-the- avocado/385047/ (Accessed September, 2015)

Kim, C., Janick, R. 2000. Advances in Novel nitric oxide and superoxide generation inhibitors, persenone A and B, from avocado fruit. *J. Agric. Food Chem.* 48: 1557 – 1563.

Kirk, R.S., and Sawyer, 1991. Pearson's Composition and Analysis of foods.9th edition., Longman Singapore publishers (pte) Ltd.,Singapore. Pp: 430-450

Koller. 1992. Advances in fruit breeding. Purdue University Press, Lafayette: pp. 541-

Kundu, S.S., Purple, S., Sharma, R.K., Goyal, R.K., and Sharma, V.K. 2017. Quality status of jam prepared from plum. *Pharma. Inno. J.* 6(10): 351-355.

Larmond, E. 1999. Method for sensory evaluation of food. Research Branch Canada Department of Agriculture Pub. 1286: 36-37

Lin, J. Y. and Tang, C. Y. 2007. Determination of total phenolic and flavonoid contents in selected fruits and vegetables, as well as their stimulatory effects on mouse splenocyte proliferation. *Food Chemistry*, 101, 140–147. http://dx.doi.org/10.1016/j.foodchem.

Lopez-Malo. 1999. Polyphenol oxidase activity and colour changes during storage of high hydrostatic pressure treated avocado puree. *Food. Res. Intl.* 31 (8): 549 – 556.

Lu, Q., Zhang, Y., Wang, Y., Lee, R. P., Gao, K., Byrns, R., and Heber, D. 2009. California Hass avocado: profiling of carotenoids, tocopherol, fatty acid, and fat content during maturation and from different growing areas. *J. Agri. Food. Chem, 57*(21). 1040810413. http://dx.doi.org/10.1021/jf901839h

Man, D. 2002. Shelf Life. Food Industry Briefing Series. Blackwell Science. Oxford.

Manal, M. S. M., Shehat, and Sahar, S. A. 2013. Effect of Bioactive Components of Kiwifruit and Avacado (Fruit and Seed) on Hypercholesterolenic Rats. *World J. Dairy and Food Scie* 8(1): 82-93.

Marinova, D., Ribarova, F., and Atanassova, M. 2005. Total phenolics and total flavonoids in Bulgarian fruits and vegetables. *J. Chem. Technol. Metallurgy*, 40(3), 255-260. Retrived from http://www.uctm.edu/journal/j2005-3/Marinova.pdf.

Marques, L. G.; Prado, M. M. & Freire, J. T. 2009. Rehydration characteristics of freeze-dried tropical fruits. L W T *Food Sci. Technol.* 42: 1232-1237.

Martin, F.W., Campbell, C.W. and Ruberte, R. M., 1999. Perennial Edible Fruits of the Tropics: An Inventory. Agriculture Handbook No. 642, United States Department of Agriculture. Washington, DC, USA. Pp. 252-255

Mendez, P. O. and Hernandez, G. L. 2007. HDL-C size and composition are modified in the rat by a diet supplementation with "Hass" avocado. *Arch. Cardiol. Mex*, 77(1):17–24.

Morris, A., Barnett, A., and Burrows, O. 2004. Food preservation. Food and Nutrition

Resource Manual for the Small-scale Food Processor in the Caribbean 37(3): 7-9

Morton, J.F. 1987. Economic Botany. 4: 91-102.

Muralikrishna, M., Nanjundaswamy, A.M., and Siddappa, G.S. 1969. Guava powder preparation, packaging and storage studies. *J. Food Sci. Technol.* 6: 93-98.

Obenland, D., S. Collin, J. Sievert, F. Negm, and Arpaia. 2012. Influence of maturity and ripening on aroma volatiles and flavor in 'Hass'avocado. *Postharvest Biol. Technol.* 71: 41–50.

Olaeta, J. A., Undurraga, P., and Espinosa, G. 2007. Evolución del contenido de aceite y compuestos no saponificables en paltas (*Persea americana* Mill.) CVS. Hass, Fuerte e Isabel. Actas VI Congreso Mundial del Aguacate; 12-16. Retrived from http:// www.avocadosource.com/WAC6/es/.../4b-183.pdf

Palou. 2000. High pressure-processed guacamole. Innovative Food Science and Emerging Technologies, 1: 69 – 75.

Pamplona-Roger, G. D. 2007. Encyclopedia of Foods and Their Healing Power Volume

Pandey, K. B. and Rizvi, S. I. 2010. Current understanding of dietary polyphenols and their role in health and disease. *Current Nutr. Food Sci.* 5: 249-263. Retrived from http://www.benthamscience.com/cnf/...4/D0004NF.pdf *Persea Americana* Mill., *Pharmacogn Rev.* 4: 77.

Pilgrim, G.W.,Walter, R.H. And Oakenful, D.G. 1991. Jams, Jellies, and Preserves. In The Chemistry and Technology of Pectin (R.H. Walter, Ed.) Academic Press, Inc., San Diego, Ca. Pp: 23-55

Pino, J. A., Marbot, R., Rosado, A., and Fuentes, V. 2004. Volatile components of avocado (*Persea americana* Mill.) grown in Cuba. *J.Essential Oil Res. 16*(2): 139-140.

Pisani, C., Ritenour, M. A., Stover, E., Plotto, A., Gutierrez, O.A. and Kuhn, D. 2014. California avocados in Florida? Finding the perfect avocado for production in east- central Florida. *Proc. Fla. State Hort. Soc.* 127:131–134.

Prieto, M. Cecchini., and Kuziw. 2007. Proceedings VI World Avocado Congress

(Actas VI Congreso Mundial del Aguacate) Viña Del Mar, *Chile*. Pp. 12 – 16. ISBN No 978-956- 17-0413-8.process on chemical composition and fatty acids profile of avocado pulp. *Rev Chil Nutr.*

Rachimoellah, H. M., Resti, D. A., Zibbeni, A., Susila, I. W. 2009. Production of biodiesel through trans-esterification of avocado (*Persea gratissima*) seed oil using base catalyst. *J. Tecknik Mesin*. 11 (2): 85 – 90.

Rainey, C., Affleck, M., Bretschger, K., and Roslyn, A.S. 1994. The California avocado: A new look. *Nutr. Today*. 29:23–27.

Ranganna, S. 2001. Hand book of Analysis and Quality for Fruits and Vegetable Products. (IInd ed). Tata Mc Graw Hill, Publishing company Ltd, India. 112p.

Rao, Ray, Rao, P.K., and Das, H. 2003. Fuzzy logic based optimization of Ingredients for production of Mango Bar and its properties. *J. Food Sci. and Technol.* 40(6): 576-581.

Rombauer, I. S., Becker, M. R., Becker, E., and Guarnaschelli, M. 1997. JOC All *New Rev.*Scribner. p. 95. ISBN 978-0-684-81870-2.

Rufino, M. S. M., Alves, R. E., Brito, E. S., Morais, S. M. Sampaio, C. G., Pérez-Jiménez, J., Saura-Calixto, F. D., and Mancini-Filho, J. 2010. Bioactive compounds and antioxidant capacities of 18 non-traditional tropical fruits from Brazil. *Food Chem.* 121 (4): 996 – 1002.

Sackett, L., Pestka, J., and Gisslen, W. 2010. Professional Garde Manger: *A Comprehensive Guide to Cold Food Preparation.* John Wiley & Sons. p. 298. ISBN 978-0-470-17996- 3.

Sadasivam, S. and Manickam, A. 1992. Biochemical Methods for Agricultural Sciences. New Age International Pub. (P) Limited. Pp 20-27.

Salgado.J.M., Rural, C.,and Maria,S. 2008. Effect of the has avocado(Persea Americana Mill) on hipercolesterolemic rats.Alimentos. Pp.20-26.

Sandhu, K.S., Bhatia, K.S., and Shukla, F.G. 1998. Physico chemical changes during storage of kinnow Parshant mandarian, orange and pineapple juice concentrates. *J. Food Sci.Technol.* 22: 343-345.

Sanjust, E., Mocci, G., Zucca, P. and Rescigno, A. 2008. Mediterranean shrubs as potential antioxidant sources. Natural Products Research, 22(8), 689-708. http://dx.doi.org/10.1080/14786410801997125.

Santana, I., dosReis, L. M., Torres, A. G., Cabral, L and Freitas, S. P. 2015. Avocado (Perseaamericana Mill.) oil produced by microwave drying and expeller pressing exhibits low acidity and high oxidative stability. *Eur. J. Lipid Sci. Technol.* 117: 999- 1007.

Sarah, L. Francis. 2011. Physicochemical and Sensory Evaluation of Pomegranate Spread, *Inter. J. Inno. Engi. Technol.* 24(13): 16-35.

Saucedo, C. C., Miramontes, E. H. V., Campos, E. T., Alvarado, A. D., Garcia, A. C. B., Ramirez, M, R. R., and Anaga, J. P. R. 2014. Effect of freeze drying and production.*J. Nutr.*23(3):23.

Saxena, R. 2003. *Effect of processing in phenolic content and antioxidant activity of commonly consumed foods.* Proc. 9th Asian Congress of Nutrition, February 23-27. (ed. Gopalan, C), New Delhi, Pp 160-162.

Siddappa, G.S., 1987. Processing, Preservation and Effect of storage on transport of fruits and vegetables. *J. Food Sci. Technol.* 17(1&2): 33-37.

Sivasankar, B. 2013. Food quality, Food Procesing and Preservation. 3rd edn. Pp 345-Son, S. M., Moon, K. D., and Lee, C. Y. 2001. Inhibitory effects of various antibrowning agents on apple slices. *Food Chem.* **73**: 23-30.

Sreevasthava, P. S. and Kumar, S. 1994. *Fruit and Vegetable preservation.* (3rd ed).

Stachys, N. M. 2001. Marketing of Smallholder Produce: A Synthesis of Case Studies in the Highlands of Central Kenya, Regional Land Management Unit: Nairobi.

Stephens, T. S., Lime, B. J. and Griffiths, F. P. 2000. Preparation of a frozen avocado mixture for guacamole. Rio Grande Valley Horticultural Society 11: 82-89.

Sucharitha, K. V., Beulah, A. M., and Sahitya, C. 2012. DEVELOPMENT AND STANDARDIZATION OF BER-PINEAPPLE JAM, Department of Home Science, Sri Venkateswara University Tirupati-517502. Inter. *J. Food. Agri. Vet.*

Sci. 2(3): 126-130

Sudheer, K. P. and Dash, S.K. 1999. Osmo-solar dehydration of Fruits and Vegetables-An Overview,Studies on Physico- Indian Food Packers. 53(3): 28-35

Sulaiman, S. F., Sajak, A. A. B., Supriatno, K. L. O., and Seow, E. M. 2011. Effect of solvents in extracting polyphenols and antioxidants of selected raw vegetables. *J. FoodCompositionAnalysis*24:506.515.http://dx.doi.org/10.1016/j.jfca.2011.01.020.

Taah, K. J., Alderson, P. G. and Power, J. B. 2003. Molecular approaches for the characterisation of Ghanaian avocado pear (*Persea americana Mill.*) germplasm. Proceedings V World Avocado Congress (Actas V Congreso Mundial del Aguacate) Malaga, Spain. pp 69-72.

Tango, S. T., carvalho, C. R. L., and Soares, N. B. 2004. Physical and chemical characterization of avocado fruits aiming its potential for oil extraction. Revista Brasileira de Fruticultura. Pp. 26.

Thakur, N.K., Kaushal Lal, B.B., and Joshi, V.K. 2000. Effect of different conditions of storage on physicochemical and microbiological qualities of debittered kinnow juice concentrate. *J. Food Sci. Technol.* 37(4): 415-418.

Tom, W. E. 1990. Kenyan Avocado Industry in the California Avocado Society 1990 Yearbook, 74: 187-189.

Tripathi, P. C. and Karunakaran, G. 2013. Bharat Mai Navaneet Phal (Avocado) Ki Kheti: Varthaman sthithi evam Sambhavanaye (InHindi) (Avocado cultivation in India: Present status and possibilities) Bhumi Nirman (Bhopal) 16th Jan -15th Feb: 11

Tripathi, P. C. and Karunakaran, G. 2014. Bharat Mai Navaneet Phal (Avocado) Ki Kheti:Varthaman sthithi evam Sambhavanaye (InHindi) (Avocado cultivation in India: Present status and possibilities) Bhumi Nirman (Bhopal) UK, pp. 67-72

Ukwe, C.V., Nwafor, S.V. 2005.Anti-ulcer activity of aqueous leaf extract of *Persea Americana* (family-Lauraceae). *Nig. J. Pharm. Res.*3: 91-95.

Unlu, N., Bohn, T., Clinton, S. K., and Schwartz, S. J. 2005. Carotenoid absorption from salad and salsa by humans is enhanced by the addition of avocado or avocado oil. *J. Nutr.* 135: 431–436.

USDA (U.S. Department of Agriculture). 2009. Avocado, almond, pistachio and walnut Composition. Nutrient Data Laboratory. USDA National Nutrient Database for Standard Reference, Release 24. U.S. Department of Agriculture. Washington, DC.

USDA and HHS. 2011. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans (Part B. Section 2: The Total Diet. B2:11). U.S. Department of Agriculture and U.S. Department of Health and Human Services. Washington, DC

Whiley, A. 2000, "Avocado Production in Australia" Food and Agriculture Organization of the United Nations. http://www.fao.org

White, A. A. Woolf, P. Hofman, and Arpaia. 2009. The international avocado quality manual. 1st ed. Plant and Food Research, New Zealand

Wu, X., Beecher, G. R., Holden, J. M., Haytowitz, D. B., and Prior, R. L. 2004. Lipophilic and hydrophilic antioxidant capacity of common foods in the U.S. *J. Agric. Food Chem.* 52:4026–4037.

Xu, L. Z., Weber, I. T., Harrison, R. W., Gidh-Jain, M., and Pilkis, S. 1995. *J. Biochem.* 34: 6083-6092

Yasir, M., Das, S., Kharya, M.D. 2010. The phytochemical and pharmacological profile of avocado *J. Food Sci. Technol.* 23(12) 124-132.

Yousif, A.K., and Alghamdi, A.S. 1999. Suitability of some date cultivars for jelly making. *J. Food Sci. Technol.* 13: 153-168.

ABSTRACT

DEVELOPMENT AND QUALITY EVALUATION OF FRUIT SPREADS FROM AVOCADO (*Persea americana* Mill.)

by

Meera M V

(2017-16-004)

Abstract of the Thesis

Submitted in partial fulfilment of the

requirements for the degree of

MASTER OF SCIENCE IN COMMUNITY SCIENCE

(Food Science and Nutrition)

Faculty of Agriculture

KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF COMMUNITY SCIENCE

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM-695 522

KERALA, INDIA

2019

ABSTRACT

The present investigation titled "Development and quality evaluation of fruit spreads from avocado (*Persea americana* Mill.)" was conducted at the Department of Community Science, College of Agriculture, Vellayani during 2017-2019. The objective of the study was to study the effect of pre-treatments on quality parameters of avocado cultivars and to develop fruit spreads from avocado and their quality evaluation.

Avocado cultivar commonly found in the households of Wayanad namely Purple Hybrid was utilized for the study. Matured fruits were collected from Regional Agricultural Research Station, Wayanad. The avocado pulp was pre-treated independently and in combination with different pre-treatment methods viz., blanching, sugar syruping, honey, brine solution, citric acid and KMS to select the best pre-treatment method organoleptically for the development of sweet and spicy spreads.

The best pre-treatment methods identified for the development of sweet spread was, citric acid + KMS + sugar (T5) blend in the ratio of 0.25:0.1:100. The citric acid + KMS + salt (T6) in the combination of 0.25:0.1:10 was selected organoleptically for the development of spicy spread.

For the development of sweet avocado spread, variation in addition of cocoa powder (adjunct) was done keeping the avocado pulp as constant. The best combination among the 5 treatments in both sweet and spicy spread was selected based on sensory evaluation using nine point rating scale. Sweet avocado fruit spread T3 with Pulp(100g):Cocoa powder(30g):Sugar(100g):Citric acid(0.1g) and KMS(0.25g) was selected organoleptically as the best spread among the five treatments.

Based on the organoleptic evaluation the treatment T5 with Pulp (100g): PepperPowder(3g):Salt(2g):TomatoPowder(5g):MintPowder(1.5g):Citricacid(0.1 g):KMS(0.25g) was selected as the superior blend for the development of spicy avocado spread.

The result of chemical and nutrient analysis of sweet avocado fruit spread revealed that it contain Carbohydrate(11g/100g), Total sugars(1.8g/100g), Reducing sugars(0.6g/100g), Dietary fiber(6.89/100g), Protein(3.1g/100g), Total fat(42g/100g), Calcium(0.238mg/100g), Iron(0.72mg/100g), Potassium(432mg/100g), Sodium(6.3mg/100g),Total minerals(1.45g/100g), Beta carotene(140mg/100g), Vitamin C(7.32mg/100g), Total phenolic content(81.4mg/100g),Total antioxidant activity(423mg/100g.

Chemical and nutrient analysis of spicy avocado fruit spread showed that it contained Carbohydrate(8.18g/100g), Total Sugars(0.98g/100g), Reducing sugars (0.78g/100g), Dietary fiber(6.12g/100g), Protein(3.9g/100g), Total fat(57g/100g), Calcium(0.267mg/100g), Iron(0.97mg/100g), Potassium(482mg/100g), Sodium (7.3mg/100g), Total minerals(2.06g/100g), Beta carotene(265mg/100g),Vitamin C (19.1mg/100g), Total Phenolic Content(78mg/100g) with an Antioxidant Activity(520mg/100g).

The nutrient constituents of sweet and spicy avocado fruit spreads were compared with respect to the nutrient constituents of raw avocado fruit. Chemical composition of raw avocado fruit contained Carbohydrate(8.53g/100g), Total sugars(0.3g/100g), Reducing sugars(0.2g/100g), Dietary fiber(6.7g/100g), Protein(2g/100g), Total fat(19.4g/100g), TSS(6^0brix), Calcium(12mg/100g), Iron(0.55mg/100g), Potassium(345mg/100g), Sodium(5.5mg/100g), Total minerals(1.22g/100g), Beta carotene(417mg/100g), Vitamin C(6mg/100g), Total phenolic content(20.45mg/100g), Total Antioxidant Activity(340mg/100g.

The shelf stability of the developed avocado fruit spreads were assessed by storing the fruit spreads in glass bottle, plastic bottle and polyethylene bags at ambient and refrigerated condition. The acidity, moisture, peroxide value and microbial count were determined initially and at weekly intervals.

During the shelf life studies, it was observed that acidity, moisture, peroxide value and microbial count show significant changes with respective to packaging material and temperature. The acidity, moisture, peroxide content was

observed higher in sweet and spicy avocado fruit spread stored in polyethylene bags at ambient temperature and the lowest content of was observed in sweet and spicy avocado fruit spread stored in glass bottle at refrigerated temperature.

Consumer acceptance study revealed that sweet spread (T3) had a score of 8.5 and spicy spread (T5) had a score of 7.56 .The cost of products were Rs.550/Kg and Rs.600/Kg for sweet and spicy fruit spreads respectively. Avocado being a perishable fruit with poor shelf life qualities, cannot be utilized for the development of shelf stable products. The present study highlighted that sweet and spicy avocado fruit spread with high consumer acceptability can be developed, branded and marketed successfully.

APPENDICES

APPENDIX-I

SCORE CARD FOR SENSORY QUALITIES OF THE PRE-TREATED AVOCADO

Product: Pre-treated Avocado

Tested by:

Particulars	Criteria	Scores	T1	T2	T3	T4	T5	T6	T7	T8	Control
Appearance	Excellent	5									
	Good	4									
	Satisfactory	3									
	Mediocre	2									
	Poor	1									
Texture	Excellent	5									
	Good	4									
	Satisfactory	3									
	Mediocre	2									
	Poor	1									
Taste	Excellent	5									
	Good	4									
	Satisfactory	3									
	Mediocre	2									
	Poor	1									
Colour	Excellent	5									
	Good	4									
	Satisfactory	3									
	Mediocre	2									
	Poor	1									
Flavour	Excellent	5									
	Good	4									
	Satisfactory	3									
	Mediocre	2									
	Poor	1									
Overall Acceptability	Excellent	5									
	Good	4									
	Satisfactory	3									
	Mediocre	2									
	Poor	1									

APPENDIX-II

SCORE CARD FOR ASSESSING THE ORGANOLEPTIC QUALITIES OF SWEET AVOCADO FRUIT SPREAD

Sample: Sweet Avocado Fruit Spread

Instructions: You are given 5 sweet avocado spread samples. Evaluate them and give scores for each criteria

Criteria	Scores				
	1	2	3	4	5
Appearance					
Taste					
Colour					
Flavour					
Odour					
Overall Acceptability					

Score

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

APPENDIX-III

SCORE CARD FOR ASSESSING THE ORGANOLEPTIC QUALITIES OF SWEET AVOCADO SPREAD

Sample: Sweet Avocado Fruit Spread

Criteria	Scores
Appearance	
Taste	
Colour	
Flavour	
Odour	
Overall Acceptability	

Score

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

APPENDIX-IV

Score card for assessing the organoleptic qualities of spicy avocado fruit spread

Sample: Spicy Avocado Fruit Spread

Instructions: You are given 5 spicy avocado spread samples. Evaluate them and give scores for each criteria

Criteria	Scores				
	1	2	3	4	5
Appearance					
Taste					
Colour					
Flavour					
Odour					
Overall Acceptability					

Score

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

APPENDIX-V

SCORE CARD FOR ASSESSING THE ORGANOLEPTIC QUALITIES OF SPICY AVOCADO FRUIT SPREAD

Sample: Spicy Avocado Fruit Spread

Criteria	Scores
Appearance	
Taste	
Colour	
Flavour	
Odour	
Overall Acceptability	

Score

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1