DEVELOPMENT OF FRUIT BLENDED YOGHURTS AND QUALITY EVALUATION

By

PRAVITHA P.G.

(2019-16-004)

THESIS

Submitted in partial fulfilment of the requirements of 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

2021

DECLARATION

I, hereby declare that this thesis entitled **"DEVELOPMENT OF FRUIT BLENDED YOGHURTS AND QUALITY EVALUATION"** 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, associateship, fellowship or other similar title, of any other University or society.

Vellayani
Date: 06/04/2022

PRAVITHA P.G.
(2019-16-004)

CERTIFICATE

Certified that this thesis entitled **"DEVELOPMENT OF FRUIT BLENDED YOGHURTS AND QUALITY EVALUATION"** is a bonafide record of research work done by **Ms. PRAVITHA P.G. (2019-16-004)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship, associateship to her.

Vellayani
Date: 06/04/2022

Dr. Anitha Chandran .C
Major Advisor, Professor
Department of Community Science
College of Agriculture, Vellayani,
Thiruvananthapuram- 695 522

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. PRAVITHA P.G. (2019-16-004)**, 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 OF FRUIT BLENDED YOGHURTS AND QUALITY EVALUATION"** may be submitted by Ms. PRAVITHA P.G. 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- 695 522

Dr. Suma Divakar
(Member, Advisory Committee)
Professor and Head
Department of Community Science
College of Agriculture, Vellayani
Thiruvananthapuram- 695 522

Dr. Geetha Lekshmi P R
(Member, Advisory Committee)
Assistant Professor
Department of Post-Harvest Technology
College of Agriculture, Vellayani
Thiruvananthapuram- 695 522

Dr. Chitra N
(Member, Advisory Committee)
Assistant Professor
Department of Agrl. Microbiology
College of Agriculture, Vellayani
Thiruvananthapuram- 695 522

ACKNOWLEDGEMENT

First and foremost, I bow my head before the almighty god whose grace has endowed me the strength and confidence to complete this work successfully on time.

I feel immense pleasure and a deep sense of gratitude to ***Dr. Anitha Chandran .C, Assistant Professor, Department of Community Science and the chairperson of the advisory committee*** *for her guidance suggestions ever glowing smile with patience that gave me constant encouragement, and above all, the kind of understanding throughout the course of this research work and preparation of the thesis.*

I wish to express my sincere gratitude to ***Dr. Suma Divakar, Professor and Head****, Department of community science and advisory committee for her whole hearted co-operation and help during the course of study and period of investigation.*

I express my sincere thanks to ***Dr, Krishnaja U, Dr Beela G, K*** *Teachers of the department of community science for the well wishes and support which had rendered heartedly throughout my course of study.*

I am grateful to ***Dr. Geetha Lekshmi P R Assistant Professor,*** *Department of Post-Harvest Technology and advisory committee for the help rendered for the research work, co-operation and critical evaluation of thesis.*

I extend my sincere gratitude to ***Dr. Chitra N*** *Assistant Professor and* ***Ms Bindhu****, Teaching assistant Department of Agriculture Microbiology for the help rendered for the Microbial analysis.*

My deep sense of gratitude to ***Dr. Brigit Joseph****, Associate Professor of Agricultural Statistics in the statistical analysis of my research work.*

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

Words cannot express enough the gratitude I feel for my ***dear classmate U Geethanjali,*** *for being with me from beginning to end, lending me a helping hand whenever needed the most. I am also most thankful to my friends* ***Archa P S, Anju*** *and many other friends who were supportive to me during the difficult times.*

I am grateful to my seniors ***Abhina, Hima bindu, Soumya chechi, Kavitha chechi, Tharani chechi, Gopika chechi, Priya chechi, Siji chechi, Bensi chechi, Megha chechi, Sruthy*** *my lovely juniors* ***Sreejaya, Revathi, Gayathri, Malavika*** *and*

Sanam *for their sincere encouragement, care, help, emotional support and affection during these days without which my work wouldn't have been completed.*

My Loving and wholehearted thanks to ***Sheeba Chechi****, Lab Assistant without whom this research will not be completed.*

I am thankful to nonteaching staff of Department of Community Science especially ***Manju chechi****, for the support during the course of study.*

I am most Indebted to my husband ***Sajin M Sivan*** *and my parents,* ***Gopi, Premalatha, Omana, Sadhasivan*** *and my brother* ***Prasanth*** *for their affection, moral support and blessings that have enabled me to finish the work.*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF GRAPHS

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
AOAC	Association of Official Agricultural Chemists
BP	Bifidobacteria
CD (0.05)	Critical difference at 5% level
Cfu	Colony Forming Units
CRD	Completely Randomised Design
° B	Degrees Brix
°C	Degrees Celsius
EMB	Eosin Methylene Blue
EPS	Exopolysaccharides
et al.	Co-workers/Co-authors
Eq. Wt.	Equivalent weight
Fig	Figure
FP	Fruit Pulp
g	Gram
HTM	Homogenised Toned Milk
Kg	kilogram
LAB	Lactic Acid Bacteria
LA	Lactic Acid
LB	*Lactobacillus bulgaricus*
mEq	milliequivalents
mg	Milligram
mL	Millilitre
No.	Number
PCA	Plate Count Agar
PDA	Potato Dextrose Agar
%	Per cent
ppm	parts per million
Rs.	Rupees
S	Sugar
ST	*Streptococcus thermophilus*
TSS	Total Soluble Solids
UHT	Ultra Heat Treatment
Viz.,	Namely
YEPD	Yeast Extract Peptone Dextrose

Introduction

1. INTRODUCTION

Yoghurt is obtained from milk through the fermentation process with the required amount of starter culture that contains *Streptococcus thermophilus* and *Lactobacillus delbrueckii ssp. bulgaricus*. Among all dairy fermented products, yoghurt is typical and more well-known also has more acceptability and consumer preference throughout the world (Coisson *et al*., 2005). It is considered that the term “Yoghurt” comes from a Turkish word called “Yogurmak” which means to thicken, coagulate, or curdle (Fisberg and Machado, 2015). Yoghurt is a traditional dairy product that was included in the human diet from 10000–5000 BC (Moreno *et al*., 2013).

In the past, it was very difficult to preserve milk for a long time as it was easily damaged due to lack of technology and storage facilities (McGee, 2004). In India, especially in the eastern region, yoghurt is prepared by adding sugar and a small amount of starter culture and stored for fermentation at night (Meenakshi *et al*., 2018). Lactic acid bacteria are the primary organism responsible for the fermentation of milk products. Its acidification reaction during metabolism results in certain physiochemical, sensory, and microbial changes in the milk (Casarotti *et al*., 2014). Milk products are taken as good carriers of probiotics (Lourens-Hattingh and Viljoen, 2001).

The number of vitamins and salts in yoghurt is higher than in the same amount of milk, because the dry matter content of yoghurt is higher than that of milk. The vitamins B, C, A, D and E in yoghurt and all the components and properties of milk yoghurt strengthen the stomach and help digest food and relax the nerves as it contains B vitamins (Mansour *et al*., 1994). Oberman and Libudzisz (1998) recommended that patients should consume at least 250 ml of yoghurt in their daily diet when taking antibiotics for more than two weeks. Due to its low lactose content, it is easier to digest and tastier than milk. It is valued for controlling bacterial growth, curing intestinal diseases such as constipation, diarrhoea, and vomiting, having an anti-cancer effect and lowering blood cholesterol (Islam *et al*., 2002).

As the campaign against artificial flavours in drinks and beverages increases (these are associated with various carcinogens that are believed to cause cancer), the use of natural fruit in yoghurt production needs to be explored. The addition of fruits not only acts as a flavouring agent but also contributes significantly to valuable nutrients (Otieno, 2009). The tendency to fortify natural fruits, juices, pulp, and dried fruits is on the rise these days (Gadge *et al*., 2008). Fruit yoghurts are obtained by mixing fruits, their nectar, jams, marmalades, fruit jellies, fruit syrups, and concentrated fruit drinks with yoghurt or processed pasteurized milk. In addition, it is reported that the combination of fruits effectively enhances the taste and therapeutic properties of plain yoghurt (Zainoldin and Baba, 2009). Cakmakc *et al*. (2012) found that fortifying yoghurt with various fruits enhances the flavour and improves the nutritional and sensory qualities.

Natural antioxidants, particularly those found in fruits and vegetables, have recently caught the interest of consumers and scientists alike, as epidemiological studies have found regular use of natural antioxidants to a lower risk of cardiovascular disease and cancer (Thaipong *et al*., 2006; Temple, 2000). Thus, in addition to their role as flavouring agents, supplementing yoghurt with products produced from fruit and vegetables is drawing the attention of both processors and consumers to improve yoghurt sales. Vitamins, phenolics, and carotenoids are three key classes of chemicals responsible for the protective effects of natural antioxidants in fruits and vegetables.

Mango contains different types of sugars and acids, antioxidants like ascorbic acid and polyphenols mainly carotene as vitamin A and a large number of phytochemicals in mango prevent leukemia, prostate, breast, and colon cancers (Shang *et al*., 2021; Lebaka *et al*., 2021; Zeng *et al*., 2020 and Rajendran *et al*., 2015). Moovandan is an underexploited traditional mango variety found in the central part of Kerala (Renisha, 2012) which needs to be exploited.

Kerala accounts for 50% of the total area under banana cultivation and mostly is sold locally. Banana is one of the highly nutritious fruits with an intense source of potassium and carbohydrate and is good food for all ages of people. Robusta banana contains 22.63g of carbohydrate, 1.33g protein, 0.85mg calcium per 100g (Siji, 2017). After harvest, fresh bananas have a short shelf life under tropical climates (Anon 2007; Kudachikar *et al*., 2007), so their shelf life can be extended by making value-added products.

Passion fruit is processed into fruit concentrate, juices, and other preparations due to its unique aroma, nutrition, and other important properties. It is rich in vitamin A (1300-2500 IU/ 100 g pulp), vitamin C (30–50 mg/100 g pulp), potassium, sodium, magnesium, sulfur, and chloride (Tripathi, 2018).

Avocado (*Persea americana*) is a fruit with a high nutritious profile, and its inclusion helps yoghurts maintain their healthy image. However, enzymatic browning or the development of brown colour melanoidins from the polyphenol oxidase enzyme in avocado limits its use in setting yoghurt (Kulasinghe and Abesinghe, 2015). Avocados are rich in nutrients, and they can play an important role and contribute to the modern world human diet. Avocado pulp is high in fat (30%) and protein (4%) and possesses high energy value than any fruit and is rich in vitamins and minerals.

Pineapple can be eaten fresh, canned, and in a variety of foods - as a supplement to desserts, fruit salads, jams, yoghurts, ice cream, and confectionery. Pineapple is rich in calcium, potassium, magnesium, fiber, and vitamin C. It is low in fat and cholesterol and is a good source of vitamin B1, vitamin B6, copper, and dietary Fiber (Debnath *et al*., 2012).

Soursop fruits are very perishable, one hundred grams of raw sour fruit provides 66 kcal, 18% carbohydrates, 1% protein and 24.5% unsweetened sugar. Soursop is an abundant source of vitamin C, B1 and B2, potassium, calcium, phosphorus, and chloride (Athira and Saranya, 2019).

For the past years only, plain yoghurt was available in the world market. The popularity of yoghurt has recently increased as it is fortified with sugar and fruits. Nowadays there is a good demand for fruit yoghurt, especially among kids, teenagers and the elderly who will love the sweet fruit-based yoghurt. Fruit yoghurt has a lot of potentials to popularize in India (Khedkar *et al*., 2015). Fruits like avocado, banana, mango, passion fruit, pineapple, and soursop are nutritious and suitable for making fruit blended yoghurts.

Hence in the present study, an attempt was done to develop fruit blended yoghurt from avocado, banana (Robusta), mango (Moovandan), passion fruit, pineapple, and soursop and to evaluate its quality parameters for commercialization.

Review of Literature

2. REVIEW OF LITERATURE

The literature reviewed which is pertinent to the study "Development of fruit blended yoghurts and quality evaluation" is presented under the following subheads:

2.1 Yoghurt as a functional food

Functional foods can offer health benefits beyond nutritive functions when they are consumed on a regular basis in a sufficient amount and have a positive effect on a person's health, physical performance, or state of mind (Srilakshmi, 2015). Yoghurt has been called a "functional food" because of the beneficial action of probiotic bacteria that are involved in combat with pathogens, thus improving digestion and intestinal hygiene (Samedi and Charles 2019). Yoghurt can be considered a probiotic food (Guarner *et al*., 2005).

Srilakshmi (2015) said that there are many microorganisms that possess nutraceutical properties, the microorganisms present in yoghurt includes *Lactobacillus* bacteria and *Bifidobacterium streptococcus salvarius* can give health benefits due to their action.

Foods containing probiotics, such as fermented milk, yoghurts, and cheese, are classified as functional foods, which include any fresh or processed food that is claimed to have health-promoting and/or disease-preventing properties in addition to its basic nutritional function of supplying nutrients (Van de Water and Naiyanetr, 2003).

Meira *et al*. (2012) observed that the functional properties of microorganisms in fermented product also contain antimicrobial property. *Lactococcus lactis* isolated from dahi, Indian curd, produces nisin Z that can inhibit *L. monocytogenes* and *Staphylococcus aureus* (Mitra *et al*., 2010). The yoghurt starter bacteria are capable to produce bacteriocins, an antimicrobial agent to inhibit the contaminant pathogenic bacteria. Bacteriocins are proteins or peptides (Nandkumar and Talapatra, 2014).

2.2 Nutritional importance of yoghurts

Yoghurt is a delicious cultured dairy product obtained through the fermentation of milk using a starter culture containing lactic acid producing bacteria (Munzur *et al*., 2004). Naturally, yoghurt contains a trace amount of both monosaccharides and disaccharides, but lactose is the prominent sugar among them (Tamime, 1977; Scrimshaw and Murray, 1988; Barrantes *et al*., 1994).

Yoghurt's nutritional value is attributed to its fat, sugar, and casein composition (El-Malt *et al*., 2013). Because the nutritious value of milk proteins is highly kept during the fermentation process, yoghurt and milk proteins are of good biological quality. As a result, yoghurt is advised for persons who are unwell or recovering (Ebringer *et al*., 2008). Ayar and Gurlin (2014) opined that yoghurt can be considered as a nutritionally dense food because it is rich in available protein, calcium, milk fat, potassium, magnesium, vitamin B2, B6, and B12.

Adolfsson *et al*. (2004) argued that because of the conditional predigesting of milk proteins in yoghurt, it is claimed that proteins from yoghurt are generally more digestible than proteins from milk. This argument is reinforced by the fact that yoghurt contains more free amino acids, particularly proline and glycine, than milk. Heat treatment and acid generation cause casein to coagulate during fermentation, which contributes to yoghurt's higher protein digestibility than milk. Yoghurt's whey proteins and caseins are high in important amino acids. Because the nutritious value of milk proteins is highly conserved during fermentation operations, yoghurt proteins are of outstanding biological grade as milk proteins.

Lourens-Hattingh and Viljoen (2001) stated that yoghurt contains proteins of high biological value and all the essential amino acids in the required amount. Proteins in the yoghurt contain higher amount of proline and glycine than in regular milk (Mckinley, 2005). Kim *et al*. (2017) has been suggested that protein from yoghurt is easier to digest than protein from milk, due to the possibility of bacterial predigestion of milk proteins in yoghurt.

Weerathilake *et al*. (2014) reported that availability of fat in yoghurt may vary according to the type of milk added and it can be increased or decreased by adding substitutes like skimmed milk powder, cream or butter fat and whey concentrates.

Mckinley (2005) noted that a 150g serving of whole milk plain yoghurt and low-fat plain yoghurt will provide 31% and 30% of an adult’s daily riboflavin requirement respectively whereas the same amount of serving of each type of yoghurts will provide

23% and 45% of an adult's daily thiamine requirement. Folic acid/folate content of yoghurt can be varied depending on the composition of lactic acid bacteria used as some of the LAB species such as *S. thermophilus* and *Bifidobacteria* synthesize certain vitamins including folate by their own.

Yildiz (2010) estimated that yoghurt contains 0.2 to 3.8g fat, 3 to 6.5g protein, and 122 kcal per 100g edible portion and contribute a high amount of calcium and vitamin D (Williams *et al*., 2015).

Adolfsson *et al*. (2004) and Han *et al*. (2012) viewed that yoghurt contains a naturally occurring trans fatty acid called conjugated linoleic acid derived from omega 6 essential fatty acid than the milk from which it was processed. Yoghurt is acidic in nature its acidic pH, it helps to ionize the calcium, and this facilitates intestinal calcium uptake (Adolfsson *et al*., 2004). Dairy products are the major source of bioavailable calcium (Zittermann, 2011).

Chandan and Kilara (2011) viewed that lactose is the primary carbohydrate in unsweetened yoghurt, which have the ability to enhance the absorption of calcium and magnesium. Lactose has a lower glycemic index (46) than glucose (100) and sucrose (60), which may contribute to satiety in combination with whey proteins present in the yoghurt (Dougkas *et al*., 2011). Although a number of mono and disaccharides are present in minute amounts in natural yoghurt, lactose remains the dominating sugar; even after fermentation, the product may include 4-5g lactose per 100g lactose. The reason for this residue is because processed milk is frequently supplemented to 14-16g per 100g total solids (i.e., up to roughly 8g per 100g lactose), resulting in a lactose level that is similar to that of normal milk (Tamine and Robinsion, 2000).

2.3 Health benefits of yoghurt

Nandkumar and Talapatra (2014) stated that from ancient times itself fermented dairy products were used to enhance intestinal health. They are able to improve the metabolic activity and composition of microflora and also used to alleviate diarrhoea caused by the infection of pathogenic bacteria. Milk and milk products are great carriers for probiotic bacteria. Most of them may easily use lactose as a source of energy for growth (Mckinley, 2005). As a result, milk provides a crucial necessity for intestinal tract growth. Probiotic bacteria are likewise protected by milk proteins throughout their journey through the stomach (Pereira *et al*., 2013). Yoghurt provides a good habitat for the growth of microorganisms in addition to being a nutritional diet for humans (Lourens-Hattingh and Viljoen ,2001).

Ley *et al*. (2006) reported that microbial load in the gut of obese people is quite different from that of lean people and consumption of a low-calorie diet along with fermented dairy products are associated with increased weight loss mainly from the abdomen. Yoghurt consumption has a positive effect in reducing or controlling weight and waist circumference in men and women (Kelishadi *et al*., 2014).

Nabavi *et al*. (2014) said that there is a reduction of 4.67% and 5.42% in serum levels of indicator enzymes of fatty liver alanine aminotransferase and aspartate aminotransferase, in people who consumed probiotic yoghurt containing *L. acidophilus* La5 and *B. lactis Bb12*, when compared with the control group.

The data obtained from Astrup (2014); Marette and Pickard-Deland (2014) said that consumption of yoghurt along with a well-balanced diet can have a beneficial effect in the prevention of cardiovascular diseases.

Srilakshmi (2015) revealed that the consumption of yoghurt enhances the better utilization of calcium, phosphorous, and iron, thus improves bone health and reduces the risk of fractures in future (Prentice, 2014; Morelli, 2014).

When comparing the diet quality of a yoghurt consumer to non-consumer had health benefits like improved potassium intake, reduced level of circulating triglyceride, glucose, lower systolic pressure, insulin resistance and have adequate nutrition intake (Wang *et al*., 2013). Nutrient density, probiotic bacteria count and fermented properties are the major potent benefits attributed from yoghurt (Wang *et al*., 2013; Marette and Pickard-Deland, 2014).

Brassart and Schiffrin (1997); Lee *et al*. (1996); and El-Abbadi *et al*. (2014) find out that lactobacilli in yoghurt can stimulate macrophage activity against different species of bacteria when they are administered by mouth. Lactobacilli elicit a systemic as well as a local immunological response. Yoghurt may boost the immune response by boosting the percentage of B cells and the proliferative responses of Peyer's patches in the intestine generated by phytohemagglutamine and lipopolysaccharide (Mazahreh and Ershidat ,2009).

A recent review from King *et al*. (2014) says that intake of yoghurt along with probiotics helps to decreases the duration of common cold and upper respiratory tract infections. Conjugated linolenic acid (CLA) has anti-carcinogenic, anti-adipogenic, antidiabetic, anti-atherosclerotic, and immunostimulatory characteristics, according to studies (Adolfsson *et al*., 2004; Han *et al*., 2012). Cancer is caused by a combination of hereditary and environmental factors. Some factors, such as a diet rich in cultured dairy products, have been shown to suppress the growth of several types of cancer, including breast tumours, colon cancer, and liver cancer (Rayes *et al*.,2008).

Probiotics are responsible for maintaining a food balance of host intestinal microflora and inhibition of carcinogens and can increase lactose tolerance for dairy products (Pereira and Gibson, 2002) and also protects from osteoporosis (Park, 2013).

Yoghurt is good for lactose intolerance because it aids in the removal of toxic or anti-nutritive factors (lactose and galactose) that can cause lactose malabsorption by LAB (Wouters *et al*., 2002). Lactic acid bacteria used as starter cultures for fermentation process, probiotic bacteria such as *L. acidophilus* and *B. bifidum* produce b-d-galactosidase enzyme that hydrolyses lactose, which results in increased tolerance for dairy products (Kim and Gilliland, 1983).

2.4. Bacterial culture and fermentation in yoghurt

Fisberg and Machado (2015) stated that the major form of commercial yoghurt starter is *Streptococcus thermophilus* and *Lactobacillus delbrueckii ssp. Bulgaricus*. In industrial production these species are used to ferment the milk. Hence milk products are considered as the favourable medium for probiotics (Lourens-Hattingh and Viljoen, 2001). Probiotics are “live microorganisms” which when administered into the host can have health benefit by balancing the microbial load in the gut or intestine of the host (Srilakshmi, 2015).

Casarotti *et al*. (2014) viewed that the acidification action of lactic acid bacteria results in the fermentation of milk which causes physicochemical, sensory, and microbiological changes in the milk.

Srilakshmi (2015) observed that lactic acid production along with a small amount of acetic and formic acids helps to drop in pH, which inhibits food spoilage and growth of poisonous bacteria and also kills pathogens by the degradation of a substance called mycotoxin.

According to Tamime and Robinson (1999) there is a relation between *Streptococcus thermophilus* and *Lactobacillus delbrueckii ssp. Bulgaricus* is known as protocooperation. Because they can have a mutual benefit and each of them can grow alone in dairy products. The protocooperation mechanism can improve certain yoghurt properties like texture through the production of exopolysaccharides (Bouzar *et al*., 1997).

Azcarate-Peril *et al*. (2004) revealed that *Lb. bulgaricus* has the ability to handle acidic environments than *S. thermophilus* by transferring ornithine into putrescine, which raises the intracellular pH.

Ghadge *et al*. (2008) says that for manufacturing yoghurt with desirable characteristics, about 2–4% yoghurt starter culture needed to be added for sustain its viability. Guler and Park (2011) opined the major functions of starter bacteria in yoghurt are the acidification of milk that denatures casein micelles and leads to the formation of coagulated gel structure in the yoghurt and the other one is synthesis of aromatic compounds in the product. Lactic acid bacteria are mainly responsible for the taste, colour, and texture due to the production of various compounds (Rattanachikunsopon and Phumkhachorn, 2010). The activity of microbes in starter cultures produces many of the flavour components found in yoghurt (Smit *et al*., 2005).

Steele *et al*. (2013) found that during fermentation, these bacteria in yoghurt perform three major biochemical conversions of milk components: (i) carbohydrate conversion to lactic acid or other metabolites (glycolysis), (ii) casein hydrolysis to peptides and free amino acids (proteolysis), and (iii) milk fat breakdown to free fatty acids (lipolysis). The lactic acid bacteria aids in converting lactose into lactic acid, which offers the yoghurt an acidic flavour. During the production of yoghurt about 20-40% of lactose is converted into lactic acid (Tamime and Robinson, 1999; Shiby and Mishra, 2013).

Depending on the LAB species, the substrate, and the ambient conditions, variations in the metabolic products of lactose metabolism have resulted in two primary kinds of fermentation: homofermentation and heterofermentation (Chen *et al*., 2015). Homofermentative pathways produce lactic acid as the principal end product, whereas heterofermentative metabolism produces ethanol, carbon dioxide, or acetic acid (Endo *et al*., 2014).

Recently, (Walstra *et al*., 2006; Tamime *et al*., 2007) observed that the fermentation phase is the most crucial part of the yoghurt production process. The yoghurt curd is created at this stage, and its physical qualities and peculiar flavour are developed.

Heat treatment decreases the number of pathogenic organisms in milk to levels that are safe for consumers' health. There are a variety of heat treatments that can be used, each of which is classed depending on the duration and temperature. Thermalization, low and high pasteurization, sterilization, and UHT (Ultra Heat Treatment) are the most prevalent (Lewis, 2003; Walstra *et al*., 2006; Tamime *et al*., 2007).

To be classified as "yoghurt," a fermented dairy product must include abundance of the two live bacterial strains *Streptococcus salivarius* subsp. *thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*. *Lactobacillus acidophilus*, *Lactobacillus casei*, *Lactobacillus lactis*, *Lactobacillus jugurti*, *Lactobacillus helveticus*, *Bifidobacterium longum*, *Bifidobacterium bifidus*, and *Bifidobacterium infantis* may all be found in yoghurt starter cultures. The only species of streptococcus genus that is used in dairy starter cultures is *Streptococcus thermophilus* subsp. *thermophilus* (Sfakianakis and Tzia, 2014). ST is Gram-positive and commonly considered thermophilic, because the optimum temperature for its growth is 35–53 °C, it can be called "thermotolerant." During the early stages of its life, its cells are spherical, forming chains, but as they mature, they take on a more rod-like morphology, favouring colonial expansion. *Lactobacillus delbrueckii* subsp. *bulgaricus* (LB) is a rod-shaped Gram-positive anaerobic bacterium that grows best around 40–44°C. By metabolizing lactose, LB can generate a large amount of lactic acid (Vedamuthu, 2006; Walstra *et al*., 2006).

Sfakianakis and Tzia (2014) *Streptococcus thermophilus* subsp. *bulgaricus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* work together in the milk environment, metabolizing lactose into lactic acid and lowering milk pH. The synergism between ST and LB is based on their distinct properties, and as a result, more lactose metabolism and lactic acid generation are achieved than if they each worked alone. ST is more "aerotolerant" than LB, but it lacks good proteolytic capabilities. However, it has better peptidase activity. When grown in milk together, ST develops quickly at first, while LB grows slowly. ST produces a lot of peptides to drive the growth of LB because of its high proteolytic activity.

Vedamuthu (2006) studied that the symbiotic culture's growth causes changes in the original components of the milk, which are responsible for yoghurt's physicochemical and sensory properties. Lactose, milk proteins, and microbial content, as well as numerous carbon compounds, undergo large modifications during fermentation, whereas vitamins and minerals undergo minimal alterations. Lactose is decreased by 30% and lactic acid is produced in double the molar amount. Proteins (caseins and whey) clump together, giving yoghurt a thicker consistency. Even when stored at 4 °C, amino acids (mostly proline and glycine) are released into the yoghurt due to proteolysis generated by the starter culture.

Boelrijk *et al*. (2003) reported that during incubation, the starting culture grows, increasing the microbial load of the system from 10^8 to 10^{10} CFU g^{-1}. Lactic acid, acetaldehyde, dimethyl sulfide, 2,3-butanedione, 2,3-pentanedione, 2-methylthiophene, 3-methyl-2-butenal, 1-octen-3-one, dimethyl trisulfide, 1-nonen-3-one, acetic acid, methional, (*cis*,*cis*)-nonenal, 2-methyl tetrahydrothiophen-3-one, 2-phenyacetaldehyde, 3-methylbutyric acid, caproic acid, guaiacol and benzothiazole are the chemicals contribute to yoghurt's characteristic flavour. Several free fatty acid molecules, notably stearic and oleic acid, are liberated by lipase activity when it comes to lipids. Throughout the fermentation and storage processes, the only change in vitamin content is an increase in Vitamin B. Finally, the amount of minerals in yoghurt is the same as in milk; the only difference is that these minerals are in ionic rather than colloidal form due to the lower pH.

When the pH of the yoghurt approaches 5.0, ST activity decreases, and LB gradually takes over the entire fermentation process until the pH target is attained, at which point the fermentation process ends. The fermentation process is usually ended by reducing the temperature to 4 degrees Celsius. The culture is still alive at this temperature, but its activity is substantially reduced to allow for regulated flavour throughout storage and distribution (Vedamuthu, 2006; Walstra *et al*., 2006).

Recently Surajit (2019) stated that due to the rapid consumption of phenolic compounds and organic acids such as citric acid by probiotic cultures, fruit supplemented yoghurt had higher probiotic viability than plain yoghurt. Traditional or home-made yoghurt should be supplemented with probiotic cultures and fruits to improve their useful characteristics.

2.5 Shelf life and spoilage of yoghurt

The shelf life of dairy goods, which are highly perishable by nature, is the determining element in their distribution. The total amount of time between manufacturing and consumption is defined by shelf life. Non-sterile dairy products like yoghurt and fermented milk products have a shelf life of one to three weeks (Salvador and Fiszman, 2004).

The main sources of contamination are fruits and nuts added to yoghurt for flavour enhancement. The main pollutants in yoghurt are moulds and yeasts. *Aspergillus*, *Penicillium*, *Rhizopus*, *Fusarium*, and *Trichoderma* are the most frequent moulds that cause yoghurt spoiling. *Candida spp*., *Debaryomyces*, *Kluyveromyces*, *Torulopsis*, and *Saccharomyces spp*. are the most prevalent yeasts that ruin yoghurt. Off-flavor, gas generation, discolouration, and other issues are caused by them. Molds and yeasts that induce yoghurt spoiling create a drop in acidity, which leads to proteolysis and bacteria putrefaction (Magar, 2021).

Vargavisi and Papai (2015) observed that yoghurt is very sensitive to temperature variation due to the metabolism of active probiotics that contains it, and it needs to be stored in refrigerated condition to maintain its quality.

Reddy *et al*. (1976) found that there is a reduction in the folic acid and vitamin B12 content of yoghurt during storage at 5˚C. The vitamin level of yoghurt is largely depending on the age of the yoghurt.

Minervini *et al*. (2001); Viljoen. (2001) and Mayoral *et al*. (2005) studied that the major contributors in the spoilage of yoghurts are *Debaryomyces hansenii, Kluyveromyces marxianus, Yarrowia lipolytica, Rhodotorula mucilaginosa, Rhodotorula rubra, Rhodotorula glutinis,* and *Saccharomyces cerevisiae.*

MacBean (2009) said that Fruits are a potential source of yeast and mould thus the addition of fruit preparation can cause contamination. Heat-treated fruit preparations can prevent post-processing contamination and can extend the shelf life of fruit-flavoured yoghurt to 8 weeks.

Fleet (1990), (1992); Mataragas *et al*. (2011) and Gougouli *et al*. (2011) suggested that poor selection of raw materials improper production practices and unfavourable storage conditions can spoil the yoghurt in a short time with yeasty, fermented odour and flavour, and a visible swelling caused by the gas produced.

According to Gomez-Alonso (2004) important quality parameters of yoghurt involve acidity, viscosity, lactic acid bacteria (LAB) count, and sensory evaluation. So, it is essential to monitor them during the storage of yoghurt because these parameters are strongly connected to temperature.

The first and most fundamental constraint of a food's shelf life in general, and yoghurt in particular, is microbial activity. The presence of live starter bacteria, yeast, and mould contaminants, as well as packaging and storage conditions, cause off-flavours and other undesired physicochemical changes, which finally lead to product failure (Salji *et al*., 1987; Muir and Banks, 2000). When production parameters, handling, and cooling are not controlled, yoghurt is renowned for spoiling, especially in the development of harsh-acidic flavour and thinning (low viscosity) (Bille and Keya, 2002).

2.6. Types of yoghurts

To fulfil nutritional needs, a variety of yoghurt kinds are currently available on the market. Yoghurt comes in a variety of textures (liquid, set and stirred), fat content (high fat, moderate fat, low fat), and flavours (natural, fruit, cereal, chocolate) (Mckinley, 2005). Yoghurt can be classified based on its physical and chemical properties, as well as added tastes and post-incubation treatments.

Weerathilake *et al*. (2014) said that regular, low fat, and non-fat yoghurt are the three main variants of yoghurt based on fat content. Low-fat yoghurt is made from low fat or partially skim milk, whereas regular yoghurt is made from full fat milk. Skim milk is used to make non-fat yoghurt. According to Kaur *et al*. (2013) yoghurt can be classified into three groups based on its physical properties: solid, semi-solid, and fluid. Set type yoghurts are solid in nature (jellylike texture), and they are incubated and cooled down in the final packaging.

Stirred Yoghurts are yoghurt that has been stirred into a semi-solid form. Stirred yoghurts are made by incubating the mixture and then stirring it to break it up before chilling and packaging. Stirred yoghurt has a less hard texture than set yoghurt; it seems to be very thick cream, and it reforms slightly after packaging (Aswal *et al*., 2012). Weerathilake *et al*. (2014) estimated that yoghurt in a liquid condition is referred to as "drinking yoghurt." Drinking yoghurt normally goes through a homogenization procedure to minimise particle size, ensuring hydro colloidal distribution and protein suspension stabilisation.

Dowden (2013) opined that yoghurt is divided into two varieties based on flavour: plain/natural and flavoured yoghurt. Plain/Natural type of yoghurt is the simplest and least adulterated, as it is made from pasteurised milk fermented with lactic acid bacteria to give it its texture and flavour. It's a basic and unsweetened fermented milk product with no extra colours or additives. It has a pure yoghurt flavour and a high calcium content, among others.

Aswal *et al*. (2012) reviewed that fruit (apple, blue berry, apricot, lemon, black cherry, black currant, peach, strawberry), vegetables, cereal, chocolate, caramel, vanilla, and other flavours are available in flavoured yoghurt. These additives comprise

50% sugar, whereas people prefer goods that are minimal in fat and sugar. Saccharin and aspartame are often used to sweeten low- or no-sugar yoghurt. Flavour is added before or just before filling the cups. Frozen yoghurt and concentrated yoghurt are two other forms of yoghurt. Frozen yoghurt is made in a similar way to stirred yoghurt at first. In the same way that stirred yoghurt is inoculated and incubated, this method is used. It's made by freezing a pasteurised mixture while stirring it. Cooling is accomplished in the same way as the ice cream is. Yoghurt that has been inoculated and fermented in the same way as stirred yoghurt is known as concentrated yoghurt. After that, the coagulum is broken, and the yoghurt is concentrated by boiling off some water under vacuum to lower the temperature required. Heating low pH yoghurt causes protein denaturation, resulting in rough and gritty textures.

The report by Weerathilake *et al*. (2014) says that pasteurized yoghurts are yoghurts that have undergone heat treatment with various time-temperature combinations after fermentation. These products are created to extend the shelf life of yoghurt or to reduce the natural tartness of yoghurt. Pasteurized yoghurt, on the other hand, has the disadvantage of destroying live and active cultures during heat treatment.

Meyer (2012) opined that traditional Yoghurt has a creamy texture and a tangy flavour, and it comes in a variety of flavours and textures. Whole-milk, low-fat, and fat-free variants are also available. Greek yoghurt is made by straining regular yoghurt many times to remove some of the liquid. As a result, the product is concentrated, thick, and sour, with more protein per serving than traditional yoghurt but with less calcium. Because some lactose is eliminated with the liquid, it has less lactose. The Greek yoghurt has less lactose and certain types are lactose-free, it may be better for persons with lactose sensitivity.

Organic milk is used to make organic yoghurt. Only if an item fits certain criteria, such as the use of few or no pesticides, hormones, chemical fertilisers, or antibiotics at any stage of production, can it be declared organic. Ingredients used in animal feed, for example, must have been farmed with a limited amount of permitted pesticides and chemical fertilisers, if any, and milk-producing animals must not have been given hormones or antibiotics. Organic products are more expensive, but they are gaining favour among some consumers due to supposed health and environmental benefits. Non-dairy yoghurts are a good alternative for people who have milk allergies or who have gastrointestinal difficulties after eating dairy-based yoghurt. They're also a good choice for folks who don't eat dairy products for religious or personal reasons (Meyer, 2012).

If fortified with minerals like calcium and vitamin D, these yoghurts have nutritional profiles that are similar to yoghurt manufactured from milk.

2.7. Organoleptic properties of yoghurts

Soukoulls *et al*. (2007) noted that the flavour and texture are the most important factors that influence yoghurt quality and acceptance, and they are influenced by a variety of factors including incubation temperature, starter culture, processing conditions (heat treatment and homogenization), and the compositional properties of the milk base. Chemical parameters such as pH and organoleptic characteristics, as well as physical characteristics such as viscosity, smoothness, and hardness, should be at standard levels, i.e., ideal levels for consumer choice.

The ingredient combination of yoghurt can vary widely, determining consumer acceptance is critical for commercial success. As a result, the flavour and texture of yoghurt products are given a lot of attention. Acidity (sourness), sweetness, aroma perceptions, and the product's textural qualities all influence consumer acceptance of yoghurt (Beal *et al*., 1999). The aroma of yoghurt is often attributed to acetaldehyde, which is produced by *L. bulgaricus* and *S. thermophilus* from threonine (Marschall and Cole, 1983). The ideal range for acetaldehyde in yoghurt, according to Vedamuthu (1991), is 10-15 ppm.

According to Ott *et al*. (2000) the acidity of yoghurt is more essential than the concentrations of acetaldehyde, diacetyl, or 2,3-pentanedione in determining yoghurt flavour because the perception of acidity influences the perception of the other qualities. Astringency, acetaldehyde, and sourness, which are associated with plain yoghurt, were neutralised by the sugar and fruit flavourings. As a result, a balance of sweetness and sourness is required to manufacture yoghurts with the highest overall acceptability. The texture is one of the most important factors that influence the appearance, mouthfeel, and general acceptability of yoghurt (Yoon and McCarthy, 2002).

Cayot *et al*. (2008) noted that the consistency can be experienced visually or orally in the sensory evaluation of yoghurt, with oral consistency defined as the product's viscosity on the tongue. If the yoghurt sample slides easily over the tongue, it is said to be 'fluid' (non-viscous). The yoghurt sample is "thick" if it sticks on the tongue or flows slowly and is swallowed with difficulty (viscous), whereas visual consistency is defined as the product's viscosity when the spoon is gently tilted up to 90 degrees. If the yoghurt sample flows easily, quickly, and continuously from the spoon, it is said to be 'fluid' (non-viscous).

2.8. Syneresis in yoghurt

Syneresis is a yoghurt texture defect. Syneresis is caused by a rearrangement of the network of casein micelles. Water will evacuate from the network as the gel shrinks, resulting in syneresis. The texture and wheying-off of yoghurt are influenced by the content of the base milk, the fermentation process, and the post-fermentation treatment. For high-quality yoghurt, adequate firmness without syneresis is required (Rani *et al*., 2012). Extremely high incubation temperatures, extensive treatment of the mix, low total solids content (protein and/or fat) in the mix, movement or agitation during or soon after gel formation, and very low acid production ($pH > 4.8$) are all probable reasons of wheying-off in acid gels (Magenis *et al*. 2006; Donato and Guyomarc'h, 2009).

Under aerobic conditions, polysaccharide synthesis is generally at its peak. Skriver *et al*. (2002) found that EPS produced by yoghurt bacteria gives a thicker texture and higher viscosity, improves smoothness, imparts desired body and texture qualities, and prevents gel fracture and wheying-off. Syneresis is a major apparent problem in commercial yoghurt production that causes whey to accumulate on the surface of the gel, resulting in poor consumer acceptability of the product (Ghasempour *et al*., 2012).

Body and texture problems such as gel shrinkage and syneresis may result from increased acidification to pH values below 4.0 (Jaros and Rohm, 2003).

According to Magenis *et al*. (2006) total solids content, milk composition (proteins, salts), homogenisation, type of culture, acidity arising from the growth of bacterial cultures, and heat pre-treatment of milk are all elements that influence yoghurt texture and syneresis.

Bhattarai *et al.* (2015) said that stabilizer not only aid to avoid syneresis, but also help to improve the body and texture of yoghurt by enhancing firmness. Due to its capacity to diminish syneresis, increase texture, viscosity, gel strength, and lubricating qualities in skim yoghurt, gelatin appeared to be the best hydrocolloid (among xanthan gum, carrageenan, and modified starch) (Nguyen *et al*., 2017).

According to the study conducted by Sebayang *et al*. (2019) stated that the lowest syneresis was achieved with the addition of carboxymethyl cellulose (CMC) at 0.5 per cent, with 90.66 per cent stabilization and storage life of 22 days. When compared to the control group, yoghurt prepared with pectin and whey protein concentrate had a significantly better water holding capacity (56%) and was 15 per cent less susceptible to syneresis. Furthermore, regardless of the starch type, starch is preferred in the yoghurt business due to its good thickening effect and ability to considerably reduce wheying-off in yoghurt (Temesgen, and Yetneberk, 2015; Sameen *et al*., 2016; Saleh *et al*., 2020).

According to Salvador and Fiszman (2004) the type and concentration of additional flavouring substances, as well as the storage time, have an impact on yoghurt syneresis. Measured syneresis increased with storage duration. During the preservation of fruit-flavoured yoghurt, syneresis was seen to rise (Kucukoner and Tarakci, 2003). Salwa *et al*. (2004) found that the tendency of the final product to syneresis increased as the concentration of carrot juice added to the yoghurt rose.

2.9. Importance of fruits in yoghurt

Flavoured and fortified yoghurts are also available for purchase and consumption. The addition of natural components or synthetic taste compounds, as well as fruit juices or fruit pulp, can be used to flavour the pigment (Vahedi *et al*., 2008). Many of the fruits are known to be high in anthocyanins, which have a variety of biological activities including antioxidant, anti-inflammatory, antibacterial, and anti-carcinogenic properties (Pereira *et al*., 2013).

Mbaeyi and Anyanwu (2010) noted that carotenoids are abundant in fruits and vegetables, but they are also essential sources of provitamin A, i.e., β and α – carotenoids, which are effective provitamin. The most common carotenoids found in fruits and vegetables are beta and α –carotenoids, which account for 90 per cent of total carotenoids. Thus, including fruits and vegetables (juice stabilizers) in yoghurt could help to avoid disorders (such as vision problems) linked to vitamin A deficiency while also boosting the yoghurt's antioxidant properties.

Farahat and El-Batawy (2013) says that to make value-added yoghurt, the FAO and WHO recommend using 5-15 per cent fruit concentration. Fruits or pulps from mango, guava, persimmon, pear, cactus, strawberry, blueberry, orange, peach, and date are widely used in yoghurt manufacture (Arslan and Ozel, 2012; Blassy and Abdeldaiem, 2019). Fruits have a significant impact on the body's free radical defense mechanism (Manisha *et al*., 2017). When total solids (pectin and sugars) from fruits are blended with yoghurt, the consistency and viscosity of the yoghurt increases, improving tongue feel (Amal *et al*., 2016).

Fruit and fruit preparations are added to yoghurt not only to boost nutritional value, but also to add phytochemicals such vitamin C, carotenoids, phenolic components, and antioxidants (Bae and Suh, 2007; Ariaii *et al*., 2011; Nazni and Komathi, 2014; Shori and Baba, 2014). Dried or partially dried fruit has lower acidity and a higher solid content than fruit juice, it can help yoghurt stay more stable (Athar *et al*., 2000; Celik and Bakirci, 2003; Sarmini *et al*., 2014; Selvamuthukumaran and Farhath, 2014).

Kulasinghe and Abesinghe (2015) revealed that avocado blended yoghurt will enhance the calorific value of the product, which could be used as supplement for treating underweight children and the elderly. Avocado incorporated set yoghurt is more nutritious compared to ordinary yoghurt as it has included more protein, minerals, and fiber. The carbohydrate from fruits provides immediate energy. Hence, supplementations of yoghurt with fruits will not only improve its acceptability (flavour) but also it will improve overall nutritional and therapeutic values.

According to Remya *et al*. (2019), yoghurt supplemented with 30% jackfruit pulp had the best sensory qualities. Another study found that adding the right amount of mango and papaya juice to yoghurt improved the sensory and physicochemical aspects of the yoghurt. When compared to plain yoghurts, 15 per cent mango flavoured yoghurt came out on top (Teshome *et al*., 2017).

Yoghurt and dairy products are free of fiber. Fruits, grains, seeds, and vegetables all contain fiber in their cell walls. Because of its water-holding capacity and potential to raise production output, minimize lipid retention, improve textural characteristics and structure, and lower caloric content by acting as a bulking agent, fiber of various sources is added to dairy products (Gassull *et al*., 1976; Larrauri,1999; Lunn and Buttriss,2007).

In recent years, phenolics have obtained a lot of attention because of their antioxidant, anti-inflammatory, anti-mutagenic, and anti-clotting properties, which have been linked to a lower risk of cardiovascular disease and cancer formation (Fresco *et al*., 2010; Loke *et al*., 2010; Ostertag *et al*., 2010). Fruit is the most common dietary source of phenolic compounds. Fruit juices, powders, and extracts have the potential to be used as functional additives in the food industry, including the dairy sector, according to some reports. As a result, plant-based additions were used to boost the phenolic content of yoghurt (O'Connell, 2001).

Khatoon (2021) reported that the supplementation of persimmon Diospyros kaki fruit leads to develop enriched yoghurt with the most desired features in comparison with yoghurt prepared without the addition of fruit. The syneresis value declined effectively and total phenolic content increased with the increasing amount of persimmon fruit along with treatments. The total solid content also increased significantly with the increased amount of persimmon fruit.

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled, **"Development of fruit blended yoghurts and quality evaluation"** was aimed at developing fruit blended yoghurts from avocado, banana (Robusta), mango (Moovandan), passion fruit, pineapple, and soursop and to determine its quality parameters. The developed fruit yoghurts were studied for their sensory and shelf-life qualities. In depth analysis of their chemical properties, and nutritional profiles were also undertaken. The methodology of the present study is presented in the following heads:

3.1. Selection and collection of raw materials

3.2. Extraction of fruit pulp

3.3. Standardization of fruit yoghurts

3.4. Selection of best proportion

3.5. Quality evaluation of the developed fruit yoghurts

3.6. Storage study of the fruit yoghurts

3.7. Cost analysis of the developed products

3.8. Statistical analysis of data

3.1. SELECTION AND COLLECTION OF RAW MATERIALS

The nutritional and health benefits of yoghurts are well known, and it has wide acceptance worldwide as one of the most popular fermented dairy products. Yoghurts and fruits contain different nutrients that can work together in a complementary or synergistic way to improve health (Liu, 2013).

3.1.1. Selection and Collection of Milk

Yoghurt is mostly made from bovine milk, although it can also be made from milk from other mammals. When compared to yoghurt made from low-fat milk, yoghurt made from high-fat milk has a creamier texture (Tamime *et al*., 2007). The milk selected for the standardization of fruit yoghurts was homogenised toned milk of Kerala Co-operative Milk Marketing Federation (milma) with a fat content of 3g/100ml. Milk was procured from local shops. The consistency and viscosity of yoghurt improve as the fat content of the milk increases (Shaker *et al*., 2000; Walstra *et al*., 2006).

3.1.2. Selection and Collection of Fruits

Optimum ripened fruits viz., avocado, banana (Robusta), mango (Moovandan), passion fruit, pineapple and soursop were selected for the development of fruit yoghurts. Except mango, all other fruits for the preparation of fruit yoghurt were purchased from the local market. Mangoes were procured from the local households in Thrissur. Moovandan is one of the traditional mango varieties found mainly in central Kerala.

3.1.3. Procurement of Yoghurt Starter Culture

The yoghurt starter culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* were procured from the College of Dairy Science and Technology, Thiruvananthapuram. Sugar was purchased from the local market.

3.2. EXTRACTION OF FRUIT PULP

Fresh and fully ripened fruits were washed properly. Peels were removed with the help of a sharp knife and seeds were removed manually. Fruit pulp was extracted by an electric blender. Fruit pulp except for avocado, mango, and soursop were filtered through a clean muslin cloth. Homogenized fruit pulps were then blanched separately except avocado.

3.2.1. Preparation of Fruit pulps

Blanching has the primary goal of inactivating enzymes that cause deterioration reactions such as off-flavours, smells, unpleasant colour and texture, and nutritional breakdown. Another goal is to destroy germs that contaminate food. As a result, during processing and storage, texture and nutritional quality could be maintained (Arroqui *et al*., 2001; Roy *et al*., 2015). Different processing methods were employed for the preparation of fruit pulp. All fruit pulps except avocado were blanched. Thermal treatment of avocado pulp can result in undesirable effects such as colour and flavour alterations, as well as vitamin loss (Soliva-Fortuny *et al*., 2002).

Avocado

Banana (Robusta)

Mango (Moovandan)

Pineapple

Passion fruit

Soursop

1. Ripened fruits

3.2.1.1. Avocado, Banana (Robusta) and Mango (Moovandan) pulp

Avocado and banana pulp were blended with half amount of recommended sugar (12g) for preventing the browning reaction in the fruit pulps. Kulasinghe and Abesinghe (2015) reported that sugar added to avocado pulp resulted in the least amount of brown colour development. The avocado pulp's water activity may have been decreased because of the added sugar. To preserve their normal conformation and offer their full functionality, enzymes require a specific amount of water in their structures. Avocado pulp was blended with the milk without blanching and the pulp was kept in an airtight container to prevent contact with atmospheric oxygen until used, whereas the banana pulp and mango pulp were blanched separately for 5 minutes at low flame and then cooled to room temperature for preparing the fruit yoghurt (Roy *et al*., 2015).

3.2.1.2. Passion fruit pulp, Pineapple pulp and Soursop pulp

After pulp extraction, the pulp was added with half amount of recommended sugar (12g) and was heated at 85°C for 20 minutes and cooled to 5°C until blending it with milk (Shabong *et al*., 2021). The extracted fruit pulp was blended with half amount of recommended sugar (12g) and pasteurised by heating at 75 – 80°C for 15 minutes, then cooled rapidly and stored in the refrigerator (4 – 6°C) until used (Amadou *et al*., 2016)**.** The extracted soursop pulp was added with half amount of recommended sugar (12g) and then heated at 75° C for 15 minutes before adding to the milk (Virgen-Cecena *et al*., 2019).

3.3. STANDARDIZATION OF FRUIT YOGHURTS

The prepared smooth fruit pulp obtained was used for the standardization procedures and development of fruit yoghurts. The steps involved in the standardization of fruit yoghurts are detailed below.

3.3.1. Pasteurization

The main aim of this pasteurization was the destruction of pathogenic microorganisms associated with milk (Kilara, 2006). The homogenised toned fresh milk was filtered to remove dirt and heated in a pre-washed pan on the heater at 90 °C for 10 minutes. Half the portion of sugar (6g) remaining after the preparation of fruit pulp was added to the milk during the pasteurization of milk. During pasteurization, milk was stirred continuously with the help of a stirrer to avoid the formation of cream layer.

3.3.2. Cooling, Inoculation, and Incubation

After pasteurization, the milk was cooled to the desired inoculation temperature of 40 – 45°C as recommended by Pak (1995). When the temperature attained 42°C, milk at a rate of 85%, 80%, 75%, 70%, and 65% was poured into separate PET cups. Previously treated fruit pulp (avocado, banana (Robusta), mango (Moovandan), passion fruit, pineapple, and soursop) was then added to each cup separately at a rate of 15%, 20%, 25%, 30% and 35% except control (100% milk). The ratio of milk and fruit pulp was same for all fruit yoghurts. Then the milk and fruit pulp in each cup were mixed gently for getting blended fruit yoghurts except in passion fruit yoghurt. Passion fruit was prepared as set type yoghurt due to the curdling of milk with passion fruit. *Streptococcus thermophilus* and *Lactobacillus bulgaricus* culture (2%) were inoculated at 42°C temperature to individual cups and then incubated at 42°C for 3-5 hours until complete coagulation. Plain yoghurt was also developed to compare with developed fruit yoghurts.

3.3.3. Packaging and Storage

Developed fruit yoghurts in PET cups were cooled and stored in refrigerated condition at 4°C for conducting further studies. Fruit yoghurts were developed according to the method standardized by Remya *et al*. (2019) after minor modifications as shown in Fig 1.

3.3.4. Proportions of Ingredients for the Development of Fruit Yoghurt

Different proportions for the standardization of fruit yoghurts in 100 mL are given in Table:1. The composition of milk was 85mL, 80mL, 75mL, 70mL, 65mL and 100mL in T_1, T_2, T_3, T_4, T_5 and control respectively. The proportion of added fruit pulps (avocado, banana (Robusta), mango (Moovandan), passion fruit, pineapple, and soursop) was 15mL, 20mL, 25mL, 30mL, 35mL and 0 in T_1, T_2, T_3, T_4, T_5 and control respectively.

Figure 1. Flow diagram for the preparation of fruit yoghurt

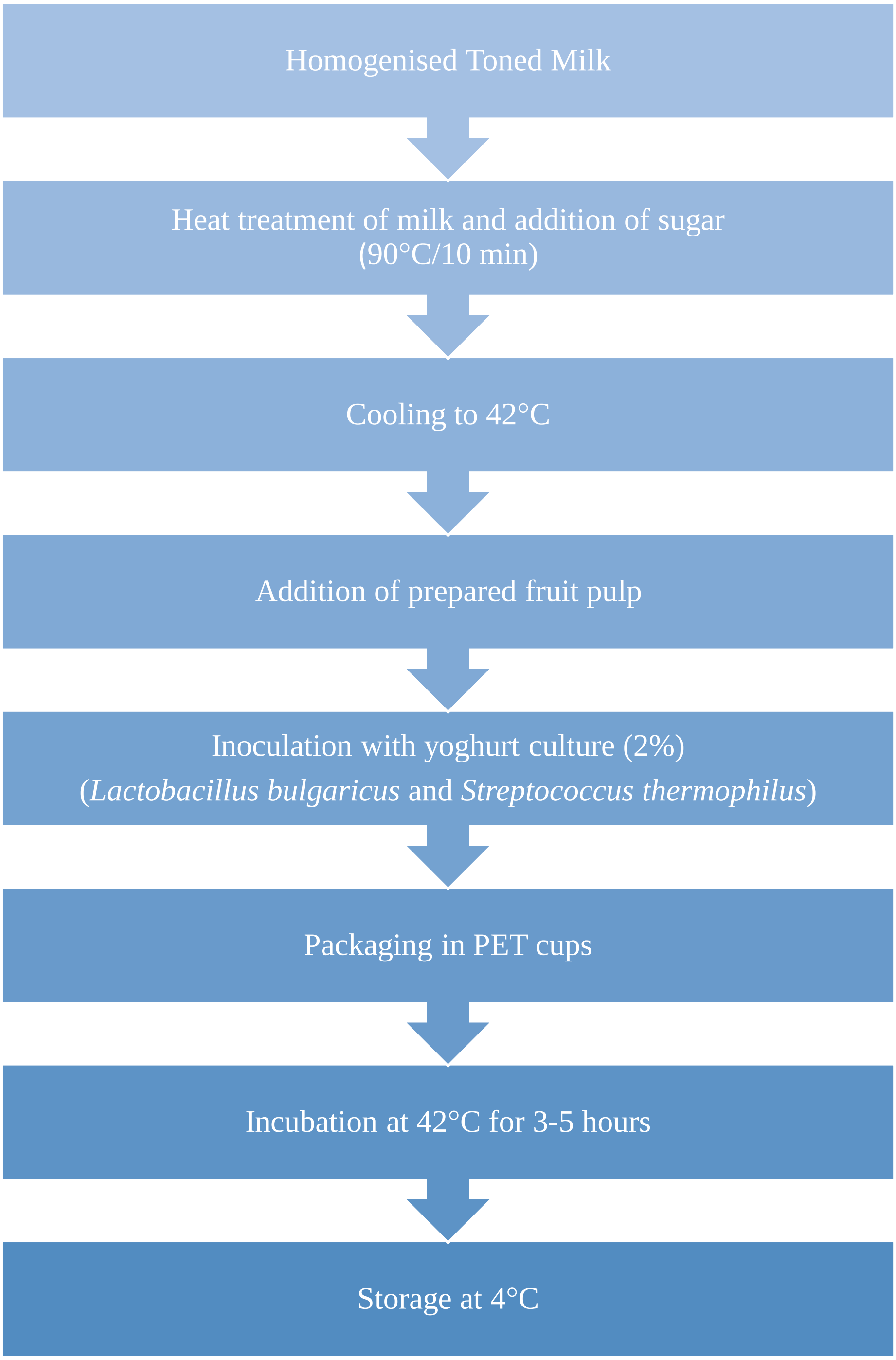


Table 1. Proportion of ingredients used for different fruit yoghurts

Sl.No	Treatments	Ingredients	
		Homogenised Toned milk (%)	**Fruit pulp (%)**
1	T_1A	85	15
2	T_2A	80	20
3	T_3A	75	25
4	T_4A	70	30
5	T_5A	65	35
6	T_1B	85	15
7	T_2B	80	20
8	T_3B	75	25
9	T_4B	70	30
12	T_5B	65	35
11	T_1M	85	15
12	T_2M	80	20
13	T_3M	75	25
14	T_4M	70	30
15	T_5M	65	35
16	T_1P	85	15
17	T_2P	80	20
18	T_3P	75	25
19	T_4P	70	30
20	T_5P	65	35
21	T_1PA	85	15
22	T_2PA	80	20
23	T_3PA	75	25
24	T_4PA	70	30
25	T_5PA	65	35
26	T_1S	85	15
27	T_2S	80	20
28	T_3S	75	25
29	T_4S	70	30
30	T_5S	65	35
31	T_6	100	0

The amount of sugar added was 12g/100mL in all the treatments. The proportion of bacterial culture (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*) used in all the treatments of fruit yoghurt was 2mL/100g.

3.4. SELECTION OF BEST PROPORTION

From the standardized five proportions of each fruit yoghurt, one best proportion was selected organoleptically by a panel of judges. Thus, six fruit yoghurt combination which found superior in sensory qualities was selected for further studies. The data pertaining to the organoleptic attributes of different treatments were subjected to the Kruskal Wallis test for the selection of the best combination. The sensory attributes tested in fruit yoghurts were appearance, colour, aroma, taste, texture, and overall acceptability. The selected best proportion from each fruit yoghurts along with control was subjected to sensorial, nutritional and shelf life studies.

3.5. QUALITY EVALUATION OF DEVELOPED FRUIT YOGHURTS

Food quality may encompass parameters such as organoleptic characteristics, physical, functional properties, and nutritional value (Fulgoni, 2009). In the present study quality parameters of developed fruit yoghurts were assessed with respect to sensory attributes, chemical constituents, nutrient composition, physical parameters, and shelf-life stability.

3.5.1 Sensory Evaluation of the Developed Products

Sensory analysis is the description and scientific measurement of the attributes of a product perceived by the senses: sight, sound, smell, taste, and touch. Sensory evaluation of the developed product was carried out by 10 semi-trained panellists aged 20-35 years on a nine-point hedonic scale.

3.5.1.1. Preparation of Score Card

Scorecards were prepared with a 9-point hedonic rating. The nine-point hedonic scale ranges from 1=Extremely unpleasant, 2=Moderately unpleasant, 3=Slightly unpleasant, 4=Unpleasant, 5=Neither like nor dislike, 6=Less liked, 7=Good, 8=Very good, and 9=Extremely good (Lawless & Heymann, 2013). Scorecard for sensory evaluation comprised of parameters - including appearance, colour, aroma, taste, texture, and overall acceptability.

3.5.2. Nutrient and Chemical Composition of Developed Fruit Yoghurts

The nutrients and other chemical composition of the developed fruit yoghurts and control were estimated as per the following standard procedures (Table:2).

Table 2. Methods of analysis of nutrient and chemical composition fruit yoghurts

Constituents	Method adopted
Energy	AOAC (1980)
Carbohydrate	Hedge and Hofreiter (1962)
Protein	Bradford (1976)
Fat	Min and Steenson (1998)
Calcium	Piper (1966)
Phosphorus	Jackson (1973)
Iron	Hseu (2004)
Sodium	AOAC (1990)
Potassium	Jackson (1973)
Magnesium	Piper (1966)
Total ash	AOAC (1994)
β-Carotene	Sadasivam and Manickam (2008)
Vitamin C	Sadasivam and Manickam (2008)
Total soluble solids	Masunder and Majumdar (2003)
Total sugar	Ranganna (1986)
Reducing sugar	Ranganna (1986)
Acidity	AOAC (2005)
Moisture	AOAC (2000)
Fibre	AOAC (2005)
Peroxide value	Cox and Pearson (1962)
Total phenol	Meda *et al*, 2005
Oxalates	Judprasong *et al.*, 2012

3.5.2.1. Total Antioxidant Activity

The total antioxidant activity of the developed six fruit yoghurts and control were determined by the phospho-molybdenum method at 695nm using a spectrophotometer, in which the antioxidant capacity is expressed as equivalent to ascorbic acid (AAE) using standard ascorbic acid (Prieto, 1999).

3.6. STORAGE STUDY OF SELECTED FRUIT YOGHURTS

Shelf life is the main indicator for safe consumption. The shelf life of food starts from the time the food is made and depends on many factors such as manufacturing process, packaging type, storage conditions and its components.

The selected fruit yoghurts were stored in the refrigerator at a temperature of 4°C to assess the storage stability. The plain yoghurt (control) and fruit yoghurts stored at refrigerated condition (4°C) were analysed on every 3 days interval for sensorial properties and acidity, moisture, peroxide value, pH, total soluble solids, syneresis, and microbial parameters like total viable count, coliform count, yeast, and mould count for two weeks.

3.6.1. Sensory Evaluation of Stored Fruit Yoghurts

On the days of assessment, yoghurts were removed from the refrigerator (4°C) 1 hour prior to the evaluation, kept at room temperature (22 ±2°C), and presented to the panellists in PET cups covered with the lid. Each assessor was provided with deionized water and also an evaluation card including the nine-point hedonic scale ranging from 1=Dislike extremely to 9=Like extremely.

3.6.2. Physicochemical Parameters of Fruit Yoghurts

Acidity, moisture, pH, peroxide value, syneresis, and total soluble solids are all significant criteria to consider while analysing during the storage of yoghurt.

3.6.2.1. Acidity

Titratable acidity in terms of % lactic acid was measured by titrating 10g of sample mixed with 10ml of boiling distilled water against 0.1 N NaOH using a 0.5% phenolphthalein indicator to an end point of faint pink colour.

$$\text{Acidity} = \frac{\text{Titre value} \times \text{Normality} \times \text{Eq. Wt.} \times V_1 \times 100}{\text{Weight} \times V_2 \times 1000}$$

V_1= Volume made up

V_2= Volume of aliquot

Equivalent weight of lactic acid= 90.08

3.6.2.2. Moisture

Moisture content was determined according to AOAC (2000). In this case, the sample materials were taken in a flat-bottom dish (pre-weighed) and stored overnight in an oven at 100 to 110°C and weighed. Weight loss is considered as a measure of moisture, which was calculated by using the following formula.

$$\text{Moisture (\%)} = \frac{\text{Weight of fresh sample} - \text{Weight of dry sample}}{\text{Weight of fresh sample}} \times 100$$

3.6.2.3. Peroxide Value

The peroxide value of the fruit yoghurts were calculated using the method given by Cox and Pearson (1962).

3.6.2.4. pH

The pH samples were measured using a digital pH meter.

3.6.2.5. Syneresis

Syneresis is a consequence of the contraction of milk protein gel, which reduces the size of casein aggregates that promote whey separation (Vital *et al*., 2015). This often happens during the refrigeration of yoghurt, which is considered a technical defect. Syneresis of prepared fruit yoghurts were estimated by the process of centrifugation as reported by Keogh and Kennedy (1998). Twenty grams of sample was taken in centrifuge tubes and the mixture was centrifuged for 10 min at 1000g.

$$\text{Syneresis (\%)} = \frac{\text{Weight of supernatant (g)}}{\text{Weight of yoghurt sample (g)}} \times 100$$

3.6.2.6. Total Soluble Solids

The total soluble solids (TSS) were determined using the method described by Masunder and Majumdar (2003) using a digital refractometer. Before use, the device was cleaned with distilled water and set to zero at 20°C. The appropriate amount of each product prepared was placed on the prism plate of the refractometer with the aid of a glass rod and the cover was returned. For each sample, the device was calibrated with distilled water.

3.6.3. Microbial Profile of Fruit Yoghurts

During storage, the food product will begin losing quality and acceptability due to oxygen, water, light, and harmful microbes and can cause the production of off-flavour, off-odour, and toxins. Changes in colour and odours are easy ways to assess the shelf-life quality of food.

3.6.3.1. Coliform count, Total viable count and Yeast and Mould content

Growth of *E-coli* was assessed by using Eosin Methylene Blue (EMB) Agar through direct dilution of samples. The number of bacterial colonies in yoghurt was assessed using Plate Count Agar (PCA). Growth of yeast and mould were assessed using Yeast Extract Peptone Dextrose (YEPD) and Potato Dextrose Agar (PDA). This was done using serial dilution of yoghurt samples. After 24 hours colonies appearing in the plates were recorded and the microbial load of the fruit yoghurts was expressed as log cfu/g of the product.

3.7 COST ANALYSIS OF THE DEVELOPED PRODUCTS

Economic analysis of the developed fruit yoghurts was assessed by taking into consideration of variable costs and fixed costs. The developed six fruit yoghurt along with plain yoghurt were subjected to cost analysis considering variable cost including the cost of raw materials, packaging, labour cost, electricity, and fuel, while fixed costs include the cost of utensils and equipment etc. The total cost of the yoghurt for market promotion was calculated by using the following equation.

TCP (Total cost of product) = FC (Fixed cost) + VC (Variable cost)

3.8. STATISTICAL ANALYSIS OF DATA

To obtain suitable interpretation, the generated data was subjected to statistical analysis like one way analysis of variance (ANOVA) and non-parametric test.

Results

4. RESULTS

The experimental data collected for the present study on "Development of fruit blended yoghurts and quality evaluation" were analyzed and the results are presented in this chapter under the following headings:

4.1. Development of fruit yoghurts

4.2. Quality evaluation of the fruit yoghurts

4.3. Storage stability of the fruit yoghurts

4.4. Cost analysis of the developed products

4.1. DEVELOPMENT OF FRUIT YOGHURTS

The addition of fruit to yoghurt enhances its flavour. This product combines the refreshing flavour of fruit with the health benefits of yoghurt. Fruit yoghurt has a more pleasant flavour (Mahmood *et al*., 2008). According to Nongonierma *et al*. (2007), fruit pectin and sugars are combined with yoghurt to increase its consistency and viscosity.

Different proportions of homogenised toned milk and fruit pulp were formulated to standardize fruit yoghurts. Six different fruit blended yoghurts using fruits like Avocado, Banana (Robusta), Mango (Moovandan), Passion fruit, Pineapple and Soursop were developed. Fruit yoghurts were formulated according to the method standardized by Remya *et al*. (2019) with certain modifications. The milk was boiled at a temperature of 90°C for 10 minutes and the inoculation was done at a temperature of 40 – 45°C. Then the processed fruit pulp was added into the milk and incubated at 42°C for 3-5 hours until complete coagulation. The finished products were stored in PET cups at 4°C for two weeks of storage study.

Plates1 to 6 present the treatments selected for the formulation of fruit yoghurts. Table-1 depicts the proportions of selected ingredients (milk, fruit pulp, sugar, and starter culture) in treatments T_1 to T_5 and control. The proportions of milk, fruit pulp, sugar and culture for different treatments were T_1 (85:12:2:15), T_2 (80:12:2:20), T_3 (75:12:2:25), T_4 (70:12:2:30), T_5 (65:12:2:35) and control (100:0:2:0). These proportions were followed for all the treatments of fruit incorporated yoghurts. The best proportion from each fruit yoghurt was identified based on sensory scores. The developed six fruit yoghurts were compared with the plain yoghurt taken as control.

4.2. QUALITY EVALUATION OF THE FRUIT YOGHURTS

The quality of a food product represents the sum of all properties and attributes of a food item that are acceptable to the customer, and it is an important factor in the success of a food product. The quality characteristics of food include external factors such as appearance (size, shape, colour, gloss, and consistency), texture, and flavour; and internal (chemical, physical, microbial). The best proportion of fruit yoghurts was selected through sensory evaluation and analyzed in order to learn the sensorial, nutritional, physicochemical and microbial attributes.

4.2.1. Sensory evaluation of the developed products

The sensory analysis brings together a variety of disciplines to better understand the sensory qualities of items and how consumers react to them.

4.2.1.1. Sensory Evaluation of Avocado Yoghurt

Sensory evaluation scores are the mean rank scores of 10 judges who were selected to evaluate the developed products. The different parameters like appearance, aroma, texture, taste, colour and overall acceptability for avocado yoghurt was scored by a panel of judges using a 9 point hedonic rating scale. The maximum score that could be attained for each attribute was 9. Sensory scores of avocado blended fruit yoghurt and control are given in Table 3.

Appearance

The appearance of any food is the most important feature, especially when it is linked to other aspects of food quality. Every raw food and manufactured product have an acceptable range of appearance that is determined by the factors associated with the consumer.

T_1A

T_2A

T_3A

T_4A

T_5A

Control

Plate 2. Avocado Yoghurts

T_1B

T_2B

T_3B

T_4B

T_5B

Control

Plate 3. Banana (Robusta) Yoghurts

T_1M

T_2M

T_3M

T_4M

T_5M

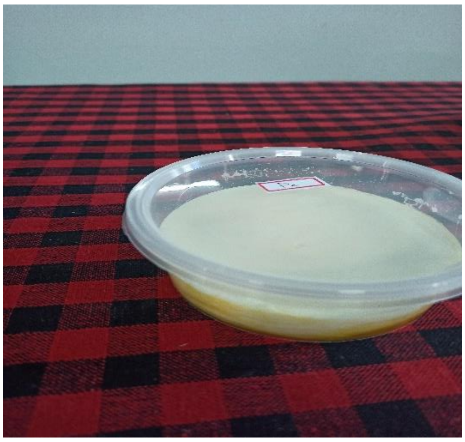
Control

Plate 4. Mango (Moovandan) Yoghurts

T_1P

T_2P

T_3P



T_4P

T_5P

Control

Plate 5. Passion fruit Yoghurts

T_1PA

T_2PA

T_3PA

T_4PA

T_5PA

Control

Plate 6. Pineapple Yoghurts

T_1S

T_2S

T_3S

T_4S

T_5S

Control

Plate 7. Soursop Yoghurts

Table 3. Sensory Evaluation Report of Avocado Yoghurt

Treatment	Appearance		Color		Aroma		Texture		Taste		Overall Acceptability	
	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS
T_1A	15.45	5.40	26.70	6.90	23.30	6.00	18.55	5.30	22.10	5.30	15.60	5.20
T_2A	36.15	6.70	23.60	6.60	30.70	6.40	22.70	5.50	25.70	5.50	22.80	5.60
T_3A	**45.65**	**7.30**	34.10	6.60	33.70	6.60	33.35	6.00	**37.90**	**6.30**	29.70	6.10
T_4A	31.05	6.40	**40.50**	**7.50**	**38.80**	**6.90**	**42.95**	**6.60**	34.30	6.00	**41.30**	**6.80**
T_5A	20.00	5.70	17.55	6.20	13.27	5.30	27.40	5.70	22.10	5.30	34.20	6.30
Control	36.15	7.00	40.40	7.10	38.55	6.80	38.05	6.20	36.70	6.20	39.30	6.60
K	22.29		17.01		17.19		16.28		12.84		17.55	
χ^2	9.48											

(MRV- Mean rank value, MS -Mean score)

Five treatments of avocado yoghurt and control were scored for selecting the best one. On analysing the data sensory evaluation revealed that the mean rank value for the appearance of avocado yoghurt ranged between 15.45-45.65. From the Kruskal-Wallis test, it was obtained that T_3A recorded the first rank with a mean rank value of 45.65, while T_1A got the last rank with a mean rank value of 15.45. The mean rank value of control was 36.15. The mean score of T_3A (7.30) was on par with T_6 (7.00) and, T_2A (6.70). All other treatments were significantly different from T_3A at 5% level.

Colour

The eyes perceive the initial quality of food and colour is one of the attributes to assess the desirability and acceptability of a food item, as well as the visual cues that can influence a person's decision. Simply changing the colour of a food can greatly improve its acceptability.

The product developed from the five different treatments along with control showed significant differences in their colour. The result highlight that the mean rank value for the colour of avocado yoghurt ranged between 17.55-40.50. Among all the treatments T_4A obtained superior rank with the mean rank value of 40.50, followed by T_6 (40.40). T_1A was on par with T_2A, T_3A and T_5A, and T_5A got the last rank with a mean rank value of 17.55.

Aroma

Humans can perceive, differentiate, and recognize odours. Stimulating odours and aromas additionally serve to quicken the appetite, even as off-aromas and odours assist purchasers to understand dangers, for example in spoiled foods. The distinct stimuli (the totality of all gustatory, olfactory, haptic, and trigeminal stimuli) perceived through the tongue and withinside the oral hollow space for the duration of ingesting account for an enormously small part of the flavour.

The mean rank value for the aroma of avocado yoghurts and control elucidates that there was no significant difference between the treatments except in T_5A. The mean rank value of T_4A was the highest (38.80). Similarly, the values of aroma were good in both T_6 and T_3A, whereas the T_5A was assessed to be having a lower mean rank value

(13.27) for aroma. The statistical data convey that T_4A was on par with T_6, T_3A and T_2A. The remaining treatment was significantly different from T_4A at 5% level.

Texture

The texture is a primary attribute in the process of sensory evaluation. Evaluation of texture is a complex, dynamic method that contains visible notion of the product surface, product conduct in reaction to preceding handling, and integration of in-mouth sensations skilled for the duration of mastication and similarly swallowing. The human mind compiles all of these, and a completely unique sensation is constructed up.

From the sensory analysis of texture, it was found that T_4A got the highest mean rank value of 42.95 for texture and it was on par with T_6 and T_3A. Among the six treatments, T_1A got the lowest mean rank value of 18.55. The mean tank value for T_2A, T_3A, and T_5A were 22.70, 33.35 and 27.40 respectively and the difference among these was found to be significant at 5% level. The control scored with a mean rank value of 38.05.

Taste

Taste is a chemical sensation that is triggered by taste stimuli hitting taste receptors on the tongue called taste buds. Humans are said to be able to discern between five or six basic taste qualities: sweet, sour, salty, bitter, umami, and fatty. Each taste has between 20 and 30 different levels of strength.

From Table 3 the most favourable taste was found in T_3A with the mean rank value of 37.90. The sensory evaluation revealed that the mean rank value for the taste of avocado yoghurt ranged between 22.10-37.90, while T_5A and T_1A got the last rank with same mean rank value of 22.10. The control showed a mean rank value of 36.70, which was the highest value after T_3A. T_4A from the data was on par with T_2A, T_1A and T_5A.

Overall acceptability

Overall acceptability of a food product can be evaluated through the appearance, colour, texture and taste of the product. On considering the overall acceptability of the developed avocado yoghurts T_4A registered a highly acceptable mean rank value of 41.30. The overall acceptability rank value of control was 39.30. The mean rank value obtained for the remaining treatments were T_2A (22.80), T_3A (29.70), and T_5A (34.20) respectively. T_1A and T_2A were found to be significantly different from T_4A and the remaining treatments were on par with T_4A.

4.2.1.2. Sensory Evaluation of Banana Yoghurt

The sensory evaluation scores obtained for banana yoghurt are given in Table 4.

Appearance

The appearance is influenced by the colour quality of the illumination in terms of intensity, colour, temperature, and fidelity, as well as the nature of the product's structure. The sensory evaluation revealed that the mean rank value for appearance of banana (Robusta) yoghurt ranged between 9.00-42.00. From the Kruskal-Wallis test, it was found that T_2B obtained the first rank with the mean rank value of 42.00 which was higher than the mean rank value of control (38.35). The control obtained high mean rank value than other treatments except for T_2B, whereas T_5B got the least preference with a mean rank value of 9.00. T_2B was found on par with T_1B and T_3B and other treatments were significantly different.

Colour

For food, colour and appearance are often the first attributes to determine quality. As per sensory evaluation, it was revealed that the mean rank value for colour of banana (Robusta) yoghurt ranged between 20.50-40.20. T_2B was claimed to have the highest colour with a mean rank value of 40.20 and control also recorded a good score of (37.60). T_2B was assessed on par with T_6 and T_1B. The T_3B got the last rank with a mean rank value of 20.50. The remaining treatments were significantly different at 5% level.

Table 4. Sensory Evaluation Report of Banana (Robusta) Yoghurt

Treatment	Appearance		Color		Aroma		Texture		Taste		Overall Acceptability	
	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS
T_1B	32.80	7.00	32.00	7.20	31.40	7.00	41.45	7.90	33.35	7.50	34.50	7.60
T_2B	**42.00**	**7.50**	**40.20**	**7.70**	**43.50**	**8.70**	**47.50**	**8.40**	**47.50**	**8.40**	**45.75**	**8.30**
T_3B	29.95	6.80	20.50	6.50	22.85	6.50	26.00	7.10	25.40	6.90	28.25	7.20
T_4B	27.66	6.50	29.05	6.70	35.50	7.20	23.50	6.90	28.90	7.20	28.25	7.20
T_5B	9.00	5.50	27.65	6.90	18.00	6.20	25.55	7.00	26.00	7.00	29.80	7.30
Control	38.35	7.30	37.60	7.50	31.75	6.90	19.00	6.60	21.85	6.30	24.40	6.80
K	24.65		11.21		14.91		22.74		14.93		14.17	
χ^2	9.48											

(MRV- Mean rank value, MS -Mean score)

Aroma

Smell or aroma is recognized by breathing air that carries scent molecules. The sensory analysis of data highlights that yoghurt (T_2B) with the proportion of 85:15 (milk and fruit pulp) secured the highest percentage score and remained statistically on par with T_4B and T_1B. From the data, T_5B was noted with the last mean rank value of 18.00.

Texture

From the sensory analysis, it was revealed that the mean rank value for texture of banana (Robusta) yoghurt ranged between 23.50-47.50. As per the statistical analysis, which was revealed that T_2B obtained the superior rank with the mean rank value of 47.50 it was higher than the mean rank value of control (19.00) and remained on par with T_2B. The data showed that T_4B was assessed to be having the lowest rank. The treatments were significantly different at 5% level.

Taste

Taste is a chemical sensation caused by a taste stimulus that hits a taste receptor. Regarding the taste, it was found that the mean rank value for the taste of banana (Robusta) yoghurt ranged between 25.40-47.50 and there found a significant difference in the values of taste. T_2B claimed the first rank with the mean rank value of 47.50. The least preferred treatment among banana yoghurt was T_3B with the mean rank value of 25.40. The mean rank value for the taste of the remaining treatments were T_1B (33.35), T_4B (28.90), and T_5B (26.00).

Overall acceptability

The proportion of T_2B was superior in overall acceptability and showed maximum acceptance. From the sensory evaluation of banana (Robusta) yoghurt, it was found that T_2B scored the highest rank (45.75) than control (24.40). T_2B was selected as the best combination and was on par with T_1B. Both T_3B and T_4B got the last rank with the same mean rank value of 28.25 followed by T_1B (34.50) and T_5B (29.80). The values of all the treatments except T_1B were significantly different with T_2B at 5% level.

4.2.1.3. Sensory Evaluation of Mango Yoghurt

The sensory evaluation scores of Mango (Moovandan) yoghurt are given in Table 5.

Appearance

The sensory evaluation data of appearance elucidates that Mango (Moovandan) yoghurt with milk and fruit pulp in a ratio of 70:30 occupied the maximum mean rank value (40.65). T_3M was on par with T_1M (29.40) and T_2M (33.90). Fruit blended mango yoghurt was obtained a higher mean rank value than control (38.40), however, T_4M (22.35) and T_5M (18.30) showed significant differences with T_3M.

Colour

The mean rank value for the colour of Mango (Moovandan) yoghurt ranged between 17.10 - 43.90. The treatment (T_3M) obtained the superior rank with the mean rank value of 43.90, which was on par with T_5M (31.10) and were significantly different from other treatments at 5% level. The addition of fruit pulp improved the attractiveness of the yoghurt. T_5M was higher than the control's mean rank value (41.85), while T_2M (17.10) was the least preferred one.

Aroma

The data of sensory evaluation acquired that the mean rank value for the aroma of Mango (Moovandan) yoghurt ranged between 17.75 - 41.90. From the analysis, it was found that T_2M superior in aroma and showed good acceptance among the evaluators. The obtained value for T_2M was 41.90 which showed on par with T_4M (30.95) and T_3M (36.25). Like all other attributes aroma also scored higher than the control (29.85). A significantly low score was recorded for T_5M (17.75). The value of the other remaining treatment was T_1M (26.30) and also showed significant difference.

Texture

The mean rank value for the texture of Mango (Moovandan) yoghurt ranged between 19.20-41.45. It was analyzed that T_2M obtained the maximum value with the mean

Table 5. Sensory Evaluation Report of Mango (Moovandan)

Treatment	Appearance		Color		Aroma		Texture		Taste		Overall Acceptability	
	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS
T_1M	29.40	6.90	27.00	6.80	26.30	6.80	19.20	6.10	17.70	6.20	24.00	6.20
T_2M	33.90	7.10	17.10	6.20	**41.90**	**7.70**	**41.45**	**7.50**	28.35	6.90	37.70	6.90
T_3M	**40.65**	**7.40**	**43.90**	**7.60**	36.25	7.40	37.10	7.20	**40.65**	**7.60**	**42.30**	**7.10**
T_4M	22.35	6.50	22.05	6.50	30.95	7.10	22.60	6.30	36.66	7.30	32.30	6.60
T_5M	18.30	6.10	31.10	7.00	17.75	6.30	34.80	7.00	32.15	7.10	15.20	5.70
Control	38.40	7.30	41.85	7.50	29.85	6.90	27.80	6.60	25.15	6.30	31.50	6.50
K	15.48		21.37		12.58		13.72		12.61		17.48	
χ^2	9.48											

(MRV- Mean rank value, MS -Mean score)

rank value of 41.45 it was higher than the mean rank value of control (27.80). Statistical data elucidates that there is no significant difference between T_2M and the values of T_5M (34.80) and T_3M (37.10), while T_1M (19.20) and T_4M (22.60) were significantly different from T_2M.

Taste

The mean rank values for the taste of Mango (Moovandan) yoghurt ranged between 17.70-40.65. From the statistical test, it was noted that T_3M obtained the first rank with the mean rank value of 40.65 and it was on par with T_2M (28.35), T_4M (36.66) and T_5M (32.15). The treatment T_1M got the last rank with a mean rank value of 17.70 which showed a significant difference with T_3M.

Overall acceptability

As per the evaluation T_3M claimed to have the maximum mean rank value in overall acceptability with a value of 42.30 and recorded on par with T_2M (37.70) and T_4M (32.30). From five treatments of mango yoghurt and control it was analyzed that the value of T_3M was higher than the mean rank value of control (31.50). On considering acceptability T_5M got the last rank with a mean rank value of 15.20. The remaining treatments were T_1M (24.00) and T_2M (37.70) significantly different from T_3M.

4.2.1.4. Sensory Evaluation of Passion fruit Yoghurt

The sensory evaluation scores of Passion fruit yoghurt are given in Table 6.

Appearance

The appearance of food can be judged in terms of surface texture such as colour, surface smoothness, dry surface, glossy surface, or appearance such as lump formation, thickness or thinness, and stratification. Five treatments of passion fruit yoghurt along with control were scored for selecting the best one. From the statistical test, it was concluded that T_3P scored the maximum mean rank value of 40.35 which were on par with T_1P and T_4P.

Table 6. Sensory Evaluation Report of Passion fruit Yoghurt

Treatment	Appearance		Color		Aroma		Texture		Taste		Overall Acceptability	
	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS
T_1P	32.05	6.90	27.90	6.70	29.55	6.90	29.30	7.30	20.20	5.90	28.30	5.70
T_2P	26.45	6.50	34.10	7.00	34.95	7.30	35.80	6.90	33.75	6.90	33.90	6.40
T_3P	**40.35**	**7.30**	21.50	6.30	33.20	7.10	**43.20**	**7.50**	38.00	7.30	38.10	7.10
T_4P	26.85	6.70	**44.30**	**7.50**	**42.25**	**7.70**	19.00	5.90	**41.00**	**7.50**	**41.10**	**7.40**
T_5P	17.15	6.20	17.10	6.10	17.35	6.10	24.90	6.00	22.20	6.00	22.20	5.40
Control	40.05	7.20	38.10	7.20	25.70	6.60	30.60	6.60	27.85	6.30	27.85	6.80
K	15.45		19.88		12.87		12.58		16.30		12.31	
χ^2	9.48											

(MRV- Mean rank value, MS -Mean score)

Control obtained a value of 40.05 and it was on par with T_4P. The treatment T_5P and T_2P got the least ranks which possessed significant differences with other treatments.

Colour

The product developed from the six treatments showed difference in their colour. The analysis revealed that the mean rank value for colour of passion fruit yoghurt ranged from 17.10-44.30. The highest mean rank value (44.30) for colour was obtained by T_4P, while T_5P got the last rank with a mean rank value of 17.10. The mean rank values of T_1P, T_2P and T_3P were 27.90, 34.10 and 21.50 respectively. The mean rank value of control was 38.10.

Aroma

The mean rank value for the aroma of passion fruit yoghurt ranged between 17.35 -42.25. The highest rank value (42.25) was obtained for T_4P, the value was higher than the mean rank value of control (25.70). While T_5P got the last rank with a mean rank value of 17.35. Other treatments T_1P (29.55), T_2P (34.95) and T_3P (33.20) were significantly different.

Texture

Regarding the sensory analysis of texture, it was found that T_3P got the superior mean rank value of 43.20 it was on par with T_2P. The treatments of passion fruit yoghurt T_5P and T_1P were significantly different from the best proportion. Among the five treatments of passionfruit yoghurt, T_4P got the lowest mean rank value of 19.00

Taste

During sensory analysis, the taste of passion fruit yoghurt ranged from 20.20-41.00. T_4P was reported with a significantly high rank (41.00) which were on par with T_3P and T_2P and were significantly different from T_1P (20.20) andT_5P (22.20). It was greater than the mean rank value of control (27.85).

Overall acceptability

Overall acceptability of a food product can be evaluated through the appearance, colour, texture and taste of the product. It was found that T_4P obtained the highest mean rank value of 41.10 than control (27.85) and was on par with T_3P, while T_5P got the last rank with a mean rank value of 22.20. The recorded mean rank value for other treatments were T_1P (28.30), T_2P (33.90), and T_3P (38.10).

4.2.1.5. Sensory Evaluation of pineapple Yoghurt

The sensory evaluation scores of pineapple yoghurt are given in Table 7.

Appearance

The sensory evaluation data highlight that T_4PA (50.70) obtained a remarkable mean rank value for the appearance of pineapple yoghurt. The treatment T_2PA got significantly least rank with mean rank value of 13.15 followed by T_1PA (21.00), T_3PA (38.15), and T_5PA (30.80). On detailing the data T_4PA was on par with T_3PA and showed significant difference with other treatments.

Colour

On considering the colour of the pineapple yoghurt T_4PA was obtained appealing colour with maximum rank and remained on par with T_3PA. As per sensory evaluation, the values of colour were ranged between 10.20-37.60, while T_2PA got the lower rank with a mean rank value of 10.20. The difference in the mean rank values of T_1PA (21.75) and T_5PA (31.40) were found to be significant with T_4PA.

Aroma

From the Kruskal-Wallis test, it was analyzed that T_4PA obtained the first rank with the mean rank value of 46.85 which was on par with T_3PA, while T_2PA got the last rank with a mean rank value of 20.40. From the data analysis, it was noted that there was significant difference among the mean rank values of T_4PA, T_2PA and T_1PA treatments.

Texture

The sensorial analysis found that T_4PA with 70:30 per cent milk and fruit pulp obtained the highest rank with the mean rank value of 47.20, while the least preferred T_2PA was made in a ratio of 80:20 and it got the mean rank value of 19.55. The rank

Table 7. Sensory Evaluation Report of Pineapple Yoghurt

Treatment	Appearance		Color		Aroma		Texture		Taste		Overall Acceptability	
	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS
T_1PA	21.00	7.00	21.75	6.70	14.70	5.60	29.15	6.90	23.80	7.10	23.05	7.00
T_2PA	13.15	6.30	10.20	5.60	20.40	6.00	19.55	6.00	19.70	6.30	18.05	6.20
T_3PA	38.15	7.70	28.50	7.60	39.30	7.40	37.60	6.00	41.60	8.10	37.30	7.80
T_4PA	**50.70**	**8.40**	**37.60**	**8.00**	28.80	6.80	**47.20**	**7.40**	**49.70**	**8.60**	**49.50**	**8.50**
T_5PA	30.80	7.40	31.40	7.20	**46.85**	**7.90**	24.35	6.50	27.80	7.00	31.00	7.40
Control	29.20	7.30	37.55	7.50	32.95	6.90	25.15	6.60	20.40	6.30	24.10	6.80
K	32.81		28.50		25.29		18.29		27.16		23.47	
χ^2	9.48											

(MRV- Mean rank value, MS -Mean score)

obtained for the treatments of pineapple yoghurt especially T_2PA T_5PA and T_3PA were significantly different from T_4PA.

Taste

The sensory analysis found that the mean rank value for the taste of pineapple yoghurt ranged between 19.70-47.70. From analysis, T_4PA has obtained the first rank with the mean rank value of 49.70 which is higher than the mean rank value of control (20.40), while T_2PA got the last rank with a mean rank value of 19.70. The differences in the mean rank value were found to be different.

Overall acceptability

From the sensory evaluation of pineapple yoghurt, it was found that T_4PA obtained the highest mean rank value of 49.50 than control (24.10). T_4PA was selected as the best combination. The treatment T_2PA got the last rank with the mean rank value of 18.05. The score obtained for each treatment were significantly different.

4.2.1.6. Sensory Evaluation of Soursop Yoghurt

The sensory evaluation scores of soursop yoghurt are given in Table 8.

Appearance

The mean rank values obtained for the appearance of soursop yoghurt disclose that T_4S made using 70:30:12:2 proportions of homogenised toned milk, fruit pulp, sugar and starter culture found superior (41.70). The lowest rank (19.55) was recorded for the soursop yoghurt made with 85:15:12:2 (HT: FP:S: YC) proportions of ingredients. The obtained data revealed that T_4S was significantly different from T_2S, T_3S and T_1S, while it was on par with T_6 and T_4S.

Table 8. Sensory Evaluation Report of Soursop Yoghurt

Treatment	Appearance		Color		Aroma		Texture		Taste		Overall Acceptability	
	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS	MRV	MS
T_1S	19.55	6.30	14.40	5.80	15.60	5.60	17.75	5.50	18.30	5.20	19.15	5.90
T_2S	25.50	6.50	19.40	6.20	20.25	5.90	24.80	5.80	25.50	5.50	27.45	6.00
T_3S	23.35	6.50	23.30	6.50	29.50	6.30	29.50	6.00	35.10	5.90	33.45	6.30
T_4S	**41.70**	**7.30**	**45.00**	**7.50**	**39.95**	**6.90**	**40.20**	**6.60**	**37.90**	**6.30**	**41.10**	**6.80**
T_5S	31.65	6.80	36.50	7.00	38.45	6.70	31.85	6.10	28.70	5.70	25.30	5.60
Control	41.25	7.20	44.40	7.40	39.70	6.80	38.90	6.40	37.50	6.10	35.55	6.50
K	16.59		32.02		21.36		15.39		11.38		12.19	
χ^2	9.48											

(MRV- Mean rank value, MS -Mean

Colour

The mean rank value for the colour of soursop yoghurt comes between 14.40-45.00. The most attractive colour was found in T_4S (45.00) [HTM-70% + FP-30% + YC-2% + S-12%] followed by T_5S (36.50), while the mean rank value of control was 44.40. The treatment T_1S [HTM-85% + FP-15% + YC-2% + S-12%] got the final rank with mean rank value 14.40. T_4S was on par with T_6 and T_4S and other treatments were significantly different from T_4S.

Aroma

The data summarized in Table 8 revealed that the mean rank value for the aroma of soursop yoghurt was superior (39.95) in T_4S [HTM-70% + FP-30% + YC-2% + S-12%] and T_1S got the last rank with a mean rank value of 15.60. The mean rank value obtained for control was 39.70. The selected best combination of yoghurt was on par with T_5S and T_3S and other treatments were significantly different.

Texture

Among the treatments T_4S [HTM-70% + FP-30% + YC-2% + S-12%] acquired the superior rank (40.20) followed by T_2S (24.80) and the mean rank value for the texture of soursop yoghurt ranged between 17.75-40.20. 80:15 ratio was found to be the least scored one among other treatments T_1S (17.75) and exhibited significantly difference from T_4S. Statistically, T_4S was found to be on par with T_5S and T_3S.

Taste

The sensory analysis found that the mean rank value for the taste of soursop yoghurt ranged between 18.30-37.90. T_4S [HTM-70% + FP-30% + YC-2% + S-12%] obtained the first rank with the mean rank value of 37.90, while T_1S got significantly least rank with mean rank value of 18.30. The control obtained mean rank value of 37.50. T_4S was on par with T_2S and T_3S other treatments were significantly different from T_4S at 5% level.

Overall acceptability

From the sensory evaluation of soursop yoghurt, it was evaluated that T_4S [HTM-70% + FP-30% + YC-2% + S-12%] obtained the highest mean rank value of 41.10, while T_1S [HTM-85% + FP-15% + YC-2% + S-12%] got comparatively least rank with the mean rank value of 19.15. The value of control was 35.55. T_4S was on par with T_3S and significantly different from other treatments.

4.2.1.7. Selection of best combination

From the sensory evaluation of the fruit yoghurts (avocado, banana (Robusta), mango (Moovandan), passion fruit, pineapple, and soursop) based on parameters like appearance, colour, aroma, texture, taste, and overall acceptability, it can be concluded that the T_4A from avocado yoghurt, T_2B from banana (Robusta) yoghurt, T_3M from mango yoghurt (Moovandan), T_4P from passion fruit yoghurt, T_4PA from pineapple yoghurt and T_4S from soursop yoghurt were selected as the best combinations. These treatments got maximum mean rank values in all aspects.

A 9 point hedonic scale was used to score the developed products. Among all the six products T_4A scored a total of 40, T_2B scored 48, T_3M scored 44, T_4P scored 43, T_4PA scored 46, and T_4S scored 40. The T_2B scored highest and was the most acceptable product.

Table 9. Selected food combinations in each treatment

Treatments	Combination (%)
T_4A	HTM-70, FP-30, YC-2, S-12
T_2B	HTM-80, FP-20, YC-2, S-12
T_3M	HTM-75, FP-25, YC-2, S-12
T_4P	HTM-70, FP-30, YC-2, S-12
T_4PA	HTM-70, FP-30, YC-2, S-12
T_4S	HTM-70, FP-30, YC-2, S-12

HTM- Homogenised Toned Milk, FP- Fruit Pulp, YC- Yoghurt Culture, S- Sugar

T_4A- Avocado yoghurt, T_2B- Banana yoghurt, T_3M- Mango yoghurt, T_4P- passion fruit yoghurt, T_4PA- Pineapple yoghurt, T_4S- Soursop yoghurt

4.2.2. NUTRIENT AND CHEMICAL COMPOSITION OF FRUIT YOGHURTS

The nutrient composition of food means the amount of carbohydrates, proteins, vitamins, minerals, fats, and water present in the food. Food components are categorized as energy-giving carbohydrates and fats, as well as body-building foods. Protein-rich diets, as well as vitamins and minerals, are protective foods. In the present study nutrients like energy, carbohydrate, proteins, fat, dietary fiber, total sugar, reducing sugar and iron content of the developed products were analyzed using standard procedures as given in Table-10.

Energy

The energy released from carbs, lipids, proteins, and other organic components is referred to as food energy. The amount of energy generated by a given food is an important factor in nutrition. The developed fruit yoghurts were significantly varied in their energy content. The energy content of different fruit yoghurts in Table-10 elucidates that the T_4A recorded (Avocado yoghurt) higher energy content (144.16 kcal), while T_4S (soursop yoghurt) had the lowest energy content (99.70 kcal). The other treatments like T_2B (banana yoghurt) with 106.83 kcal and T_4PA (pineapple yoghurt) with a calorie content of 137.85 kcal were significantly different. The calorific value of passionfruit yoghurt (114.20 kcal) was on par with mango yoghurt (111.70 kcal). The plain yoghurt had 76.90 kcal which was found very low when compared with the energy content of developed fruit yoghurts.

Carbohydrates

Carbohydrates are macronutrients that are made up of simple sugars and are one of the three main sources of energy (calories) for the body. The results highlight that carbohydrate content recorded maximum in T_4PA (22.66 g/100g) followed by T_4P (18.90 g/100g), T_3M (17.76 g/100g) and these treatments significantly differed. T_2B (16.26 g/100g) was on par with T_4S (15.65 g/100g) and the least amount of carbohydrate was in T_4A (11.06 g/100g) after control (6.28 g/100g).

Proteins

Proteins can be found in both plant and animal sources. It is a crucial part of the processes that generate energy and transport oxygen throughout the body in the blood. It is made up of hundreds or thousands of smaller units called amino acids. Caseins comprise most of the proteins in yoghurt (80%). The most abundant is alpha casein. Casein aids in the absorption of minerals such as calcium and phosphorus, as well as lowering blood pressure (Ricci and Olalla, 2010; Holt *et al*., 2013). The protein content of the yoghurt was found to decrease with an increase in fruit pulp. T_2B with 20% fruit pulp reported the highest protein (4.43 g/100g) after control (5.36g/100g). T_4PA (3.93g/100g) was on par with T_4S (3.65g/100g), T_4A (3.39g/100g) and T_4P (3.06g/100g).

Fat

Fats are essential suppliers of energy that provide two times as much energy per gram as carbohydrate or protein. Fats offer insulation and cushioning for the skin, bones, and inner organs. Fat additionally includes and enables keep positive vitamins (A, D, E, and K). The seven treatments of yoghurt indicated that T_4A maintained significantly higher (9.60 g/100g) fat content followed by control (3.40g/100g). T_4PA (2.97 g/100g) was on par with T_4P (2.83 g/100g), T_2B (2.76 g/100g) and T_4S (2.68 g/100g), while T_3M (mango yoghurt) got the lowest fat content (2.60 g/100g).

Crude fiber

Crude fiber is a measure of the amount of indigestible cellulose, pentosans, and lignin. It's the plant material residue left over after solvent extraction and digesting with dilute acid and alkali. It has no nutritional value, but they offer the bulk required for appropriate peristaltic activity in the intestine. Raju and Pal (2014) stated that milk and most milk products are lacking in fiber. From the nutrient analysis of crude fiber, it was revealed that the dietary fiber content was higher in T_4PA (0.72 g/100g) which was on par with T_4S (0.58) and T_3M (0.58) and were significantly different from T_4A and T_2B.

Table 10. Nutrient composition of Fruit Yoghurts (per 100g)

SL. No	Standardized products	Energy (kcal)	Carbohydrates (g)	Proteins (g)	Fats (g)	Crude fiber (g)	Total sugar (g)	Reducing sugar(g)	Iron (mg)
1	T_4A	144.16	11.06	3.39	9.60	0.37	19.36	9.04	0.32
2	T_2B	106.83	16.26	4.43	2.76	0.22	14.18	10.96	0.37
3	T_3M	111.70	17.76	4.10	2.60	0.58	17.13	4.56	0.55
4	T_4P	114.20	18.90	3.06	2.83	0.33	16.03	9.23	0.41
5	T_4PA	137.85	22.66	3.93	2.97	0.72	32.33	4.06	0.76
6	T_4S	99.70	15.65	3.65	2.68	0.58	25.46	14.60	0.16
7	T_6	76.90	6.28	5.36	3.40	0.00	3.86	2.22	0.13
	CD (0.05)	4.31	0.71	0.41	0.35	0.30	1.99	0.32	0.06

(Results expressed are mean values of three replicates) *significant@ 5%

T_4A- Avocado yoghurt
T_2B- Banana (Robusta) yoghurt
T_3M- Mango (Moovandan) yoghurt
T_4P - Passion fruit yoghurt
T_4PA- Pineapple yoghurt
T_4S- Soursop yoghurt
T_6- Control

Total sugar

Considering the total sugar content of developed fruit yoghurts T_4PA recorded a higher total sugar content (32.33g/100g) than other treatments of fruit yoghurts. The treatments T_4S (25.46g/100g) and T_4A (19.36g/100g) were showed a significant difference in the total sugar concentration. T_3M (17.13g/100g) was on par with T_4P (16.03g/100g), T_2B (14.18g/100g) and T_6 (3.86g/100g).

Reducing sugar

Reducing sugar comes under the group of carbohydrate or natural sugar. Analysis of the reducing sugar discloses that statistically there was a variation in reducing sugar content of fruit yoghurts. The values in different treatments ranged from 4.06g -14.60g. The highest reducing sugar was recorded for the T_4S (14.60g/100g) that of control was 2.22g/100g. T_4P (9.23g/100g) was on par with T_4A (9.04g/100g) and T_3M (4.56g/100g) was on par with T_4PA (4.06g/100g).

Iron

Iron is a mineral found in each cell of the body. It is considered an essential mineral because it is essential to make haemoglobin, a part of blood cells that carries oxygen from the lungs to all parts of the body. As indicated in Table-10 the iron content was maximum in the pineapple yoghurt (0.76 mg/100g). The amount of iron was in other treatments ranged from 0.13-0.55mg/100g. The least share of iron was found in soursop yoghurt (0.16mg/100g) after control (0.13mg/100g). Statistical analysis of the data proved that T_4P (0.41mg/100g) was on par with T_2B (0.37 mg/100g) and T_4A (0.32 mg/100g) was on par with T_2B.

Ash

Ash or mineral content is the part of the food or any natural food material that stays after it's far burned at very high temperatures. Ash content represents the total mineral content that presents in foods. The data obtained reveal that the treatments of banana, pineapple, soursop, and avocado yoghurt were on similar levels with respect to ash content. It was noted that T_4P possessed the lowest (94.83%) ash content among the

Table 11. Nutrient composition of Fruit Yoghurts (per 100g)

Sl.No	Standardized products	Ash (%)	Vitamin C (mg)	β-Carotene (µg)	Total phenols (g)	Total antioxidant activity (g)
1	T_4A	98.46	3.36	13.30	0.19	31.60
2	T_2B	99.00	2.19	34.00	0.25	29.80
3	T_3M	97.06	5.73	143.60	0.18	42.98
4	T_4P	94.83	8.72	24.66	0.17	33.61
5	T_4PA	98.56	9.02	37.76	0.25	50.14
6	T_4S	98.56	9.20	19.33	0.95	33.36
7	T_6	97.36	2.26	26.66	0.24	28.14
	CD (0.05)	0.59	0.88	8.61	0.01	1.35

(Results expressed are mean values of three replicates) *significant@ 5%

T_4A- Avocado yoghurt
T_2B- Banana (Robusta) yoghurt
T_3M- Mango (Moovandan) yoghurt
T_4P - Passion fruit yoghurt
T_4PA- Pineapple yoghurt
T_4S- Soursop yoghurt
T_6- Control

seven yoghurts. T_4S (98.56%) was on par with T_4A (98.46%), while T_2B existed to be the treatment containing the highest (99.00%) ash content.

Vitamin C

Vitamin C, also referred to as L-ascorbic acid, is a water-soluble vitamin that is naturally present in some foods and helps the body to build and maintain connective tissues, heal wounds, and fight infections (Cha *et al.*, 2013). The comparative data indicated that the highest vitamin C level was found in the soursop yoghurt (9.20mg/100g) followed by pineapple yoghurt (9.02mg/100g). T_4S was on par with T_4PA and T_4P (8.72mg/100g). The vitamin C content of banana yoghurt was the lowest (2.19mg/100g) among all other treatments of fruit yoghurts and control possessed 2.26mg/100g. The statistical analysis of the data revealed that significant difference existed between the remaining treatments.

β-Carotene

Beta carotene is the yellow/orange pigment that offers vegetables and fruits their rich colours. It is a carotenoid and an antioxidant human body need vitamin A for healthy skin, mucus membranes, immunity, and for good eye health and vision. The β-carotene status of fruit yoghurts in the present study indicated that there was a significant difference among fruit yoghurts. Observation of β-carotene indicated that a significantly high level of carotene content was present in mango yoghurt (143.60 µg/100g). T_4PA (37.76 µg/100g) was on par with T_2B (34.00µg/100g). Among the fruit, yoghurts studied the comparatively lower value was found in T_4A (13.30 µg/100g). The β-carotene content in the remaining treatments ranged between 19.33 µg/100g (T_4S) - 26.66 µg/100g (T_6).

Total phenol

As mentioned in Table-11 the total phenol content was maximum in the T_4S 0.95 g/100g) and the minimum amount was observed in treatment (T_4P) of passion fruit (0.17g/100g). The values obtained for the remaining treatments ranged between 0.18-0.25g/100g. The data disclose that there is no significant difference in the total phenol content of treatments except in T_4S

Total antioxidant activity

The observation of total antioxidant activity proved that all the treatments exhibited almost good antioxidant activity. The analysis of total antioxidant activity showed that T_4PA had the highest antioxidant activity (50.14 g/100g), while T_2B shows the lowest antioxidant activity (29.80 g/100g). The values of other treatments were 42.98 g/100g (T_3M), 33.61 g/100g (T_4P), 33.36 g/100g (T_4S) and 31.60 g/100g (T_4A). The antioxidant activity of plain yoghurt was 28.14 g/100g. T_4P was on par with T_4S.

Calcium

Calcium is a micronutrient that is the most abundant mineral in the human body, and it is vital for bone health. Yoghurt is rich in calcium. The values obtained indicate that the high calcium containing treatments were higher in T_4PA (381.30 mg/100g) and T_4P (339.70 mg/100g) and the lowest calcium content was found in T_4S (132.90 mg/100g). The calcium content of control was found about 296.60 mg/100g. Composition of other treatments ranged from.159.60mg/100g (T_4A) -259.60mg/100g (T_4M). Statistical data revealed that there was significant difference between all the treatments.

Phosphorus

Phosphorus is an essential mineral that works along with calcium for healthy bones and makes new cells. The phosphorus content of the different fruit yoghurts analyzed (Table-12) and T_4PA (457.00 mg/100g) possessed a high composition of phosphorus. The analysis of data found that the values of phosphorus in all the yoghurt differ significantly. The phosphorus content of the remaining treatments was T_4P 422.50 mg/100g), T_3M (300.00 mg/100g), T_4S (230.20 mg/100g) and T_4A (194.80 mg/100g), while the lowest amount of phosphorus was present in T_2B (179.50 mg/100g). The phosphorus content of plain yoghurt was 326.60 mg/100g.

Table 12. Nutrient composition of Fruit Yoghurts (per 100g)

Sl.No	Standardized products	Calcium (mg)	Phosphorus (mg)	Sodium (mg)	Potassium (mg)	Magnesium (mg)	Oxalate (mg)
1	T_4A	159.60	194.80	186.60	277.30	454.90	2.94
2	T_2B	237.60	179.50	86.33	189.60	299.80	1.26
3	T_3M	259.60	300.00	123.60	248.60	264.00	1.46
4	T_4P	339.70	422.50	222.40	240.70	266.00	2.89
5	T_4PA	381.30	457.00	310.60	281.80	275.80	3.20
6	T_4S	132.90	230.20	113.30	158.20	282.30	2.77
7	T_6	296.60	326.60	175.30	168.00	114.60	0.96
	CD (0.05)	2.70	2.10	6.82	23.10	3.14	0.20

(Results expressed are mean values of three replicates) *significant@ 5%

T_1A- Avocado yoghurt
T_2B- Banana (Robusta) yoghurt
T_3M- Mango (Moovandan) yoghurt
T_4P - Passion fruit yoghurt
T_4PA- Pineapple yoghurt
T_4S- Soursop yoghurt
T_6- Plain yoghurt

Sodium

A small amount of sodium is needed to maintain fluid balance, but too much can lead to high blood pressure. Almost all foods naturally contain low levels of sodium. Regarding the sodium content of fruit yoghurts, the maximum value was recorded in T_4PA (310.60 mg/100g) followed by T_4P (222.40 mg/100g), T_4A (186.60 mg/100g), T_3M (123.60 mg/100g), and T_4S (113.30 mg/100g). The least amount of sodium was found in T_2B (86.33 mg/100g), while plain yoghurt contained 175.30 mg/100g. Statistically all the treatments were showed significant difference in their values.

Potassium

Regarding the potassium content of developed fruit yoghurts, the T_5PA represents the high level value (281.80 mg/100g) which were on par with T_1A (277.30 mg/100g) and closely followed by T_3M (248.60 mg/100g). The potassium content of the remaining fruit yoghurts was ranged between 240.70-158.20 mg/100g.T_2B was on par with T_4S and control.

Magnesium

Focusing on the data of magnesium it could be concluded that T_1A treatment of avocado yoghurt carried higher amount of magnesium (454.90 mg/100g). The treatments like T_2B (299.80 mg/100g), T_4S (282.30 mg/100g), and T_4P (266.00 mg/100g) were significantly differ in their values. T_4PA (275.80 mg/100g) was on par with T_4P and T_3M (264.00 mg/100g). The magnesium content of plain yoghurt was (114.60 mg/100g).

Oxalate

The analysis of oxalate indicates that higher concentration of oxalate was present in T_4PA (3.20 mg/100g). The oxalate content of yoghurt ranged from 0.96-3.20 mg/100g, while T_4A (2.94 mg/100g) was on par with T_4P (2.89 mg/100g) and T_4S (2.77 mg/100g). statistically, there is no significant difference in the oxalate content of fruit yoghurts except in T_4PA.

4.3. STORAGE STABILITY OF THE FRUIT YOGHURTS

The developed fruit yoghurts were packed in PET cups and were stored at refrigerated temperature at 4°C for two weeks. The changes in physical parameters like acidity, moisture, pH, total soluble solids and syneresis were recorded at 3 days intervals for two weeks.

4.3.1. Sensory Evaluation of Fruit Yoghurt During Storage

The main attribute that is most likely to change during storage is sensory quality. Fruit yoghurts were analyzed for various sensory parameters; appearance, colour, aroma, texture, taste and overall acceptability using 9 point hedonic scale. The sensory scores obtained for various parameters were analyzed statistically for a period of two weeks and described in Table 13-18.

Table 13. Sensory evaluation of avocado yoghurt during storage

Quality attributes	**Storage period in days**						
	0	3	6	9	12	15	CD (0.05)
Appearance	6.40	6.30	6.15	6.10	5.75	5.10	0.33
Colour	7.50	7.44	7.39	7.35	7.28	7.25	0.49
Aroma	6.90	6.83	6.75	6.70	6.68	6.65	1.23
Texture	6.60	6.50	6.48	6.45	6.41	6.30	0.92
Taste	6.00	5.78	5.60	5.30	5.15	5.00	0.48
Overall Acceptability	6.80	6.70	6.65	6.53	6.45	6.30	1.05

The data summarized in Table-13 revealed that there existed no significant difference in the sensory attributes of the avocado yoghurt. The yoghurt was stored for two weeks and sensory evaluation during storage was done on every three days intervals. The highest scores for all sensory parameters were obtained during the first day of storage. The sensory scores were ranged between 5.00-7.50 during two weeks of storage study. The sensory scores for all the attributes viz., appearance, colour, aroma, texture, taste, and overall acceptability has shown a decreasing trend in their values. The lowest value (5.00) was noted for the taste of the avocado yoghurt on the fifteenth day of storage. The values of appearance were ranged between 5.10-6.40, that of overall acceptability was ranged between 6.30-.6.80 Avocado yoghurt was obtained acceptable scores till the last day of storage.

Table 14. Sensory evaluation of banana yoghurt during storage

Quality attributes	**Storage period in days**					
	0	3	6	9	12	15	CD (0.05)
Appearance	7.50	7.45	7.38	734	7.29	7.22	0.93
Colour	7.70	7.63	7.59	7.51	7.46	7.39	1.29
Aroma	8.70	8.68	8.61	8.57	8.49	8.41	0.87
Texture	8.40	8.35	8.28	8.21	8.18	8.13	0.41
Taste	8.40	8.37	8.30	8.21	8.15	8.11	0.36
Overall Acceptability	8.30	8.22	8.17	8.12	8.10	8.00	0.24

Discussing the organoleptic evaluation of banana yoghurt during storage, it was highly scored for all the parameters. During storage, changes in the values of all the parameters were observed. This yoghurt was obtained a maximum score (8.70) for the aroma and a minimum score (7.22) for appearance on the first day of storage. On the final day, the highest score (8.41) was found for aroma and the lowest score (7.22) for appearance. The values of colour, texture, taste and overall acceptability during storage were ranged between 7.39-7.70, 8.13-8.40, 8.11-8.40 and 8.00 -8.30 respectively. From the values, it was found that the scores of the yoghurt decreased gradually and there was no significant difference among the values of sensory attributes. The product was acceptable till the end of the storage period.

Table 15. Sensory evaluation of mango yoghurt during storage

Quality attributes	**Storage period in days**						
	0	3	6	9	12	15	CD (0.05)
Appearance	7.40	7.36	7.33	7.29	7.22	7.18	1.42
Colour	7.60	7.54	7.48	7.41	7.39	7.36	1.28
Aroma	7.40	7.30	7.25	7.20	7.15	7.10	0.28

Texture	7.20	7.15	7.00	6.80	6.70	6.50	1.48
Taste	7.60	7.58	7.51	7.44	7.29	7.25	0.59
Overall Acceptability	7.10	7.06	7.00	6.94	6.88	6.83	0.53

The pooled data on the sensory evaluation of mango yoghurt for two weeks proved that there were not many variations in the sensory scores. The sensory scores of mango yoghurt ranged between 6.50-7.60. This yoghurt was scored its maximum on the initial day of storage. Initially, the sensory score obtained for the appearance was 7.40 and it was 7.18 on the last day of storage. The lowest score was reported for the overall acceptability and texture of the product on the final day of storage. From the results found it can be concluded that the scores of each sensory parameter viz., appearance, colour, aroma, texture, taste, and overall acceptability were decreased during storage. However, the product was apt for consumption and statistically doesn't exhibit any significance.

Table 16. Sensory evaluation of passion fruit yoghurt during storage

Quality attributes	Storage period in days					
	0	3	6	9	12	15	CD (0.05)
Appearance	6.70	6.60	6.50	6.30	6.15	6.00	0.68
Colour	7.50	7.48	7.39	7.31	7.21	7.11	0.13
Aroma	7.70	7.61	7.55	7.48	7.32	7.20	0.21
Texture	5.90	5.70	5.60	5.50	5.10	5.00	1.42
Taste	7.50	7.43	7.32	7.25	7.20	7.14	0.38
Overall Acceptability	7.40	7.31	7.22	7.15	7.13	7.10	0.25

Table -16 elucidates that there was no significant difference in the sensory profile of the passionfruit yoghurt. The maximum score for the sensory parameters of passionfruit yoghurt was obtained when the sample was fresh and the aroma of the product scored highest (7.70) followed by remaining parameters viz., appearance (6.70), colour (7.50), texture (5.90), taste (7.50), and overall acceptability (7.40). The sensory scores on the last day of storage were 6.00 (appearance), 7.11 (colour), 7.20 (aroma), 5.00 (texture), 7.14 (taste) and 7.10 (overall acceptability). During the last day of storage appearance and texture were found with a low score this may be due to the high rate of syneresis in the passionfruit yoghurt. However, passion fruit yoghurt was acceptable for consumption despite the reduction in scores.

Table 17. Sensory evaluation of pineapple yoghurt during storage

Quality attributes	Storage period in days					
	0	3	6	9	12	15	CD (0.05)
Appearance	8.40	8.37	8.32	8.26	8.20	8.15	1.35
Colour	7.60	7.55	7.48	7.41	7.39	7.32	0.58
Aroma	6.80	6.50	6.30	6.20	6.10	6.00	1.29
Texture	6.00	5.94	5.81	5.78	5.73	5.70	0.73
Taste	8.60	8.54	8.41	8.38	8.25	8.10	0.36
Overall Acceptability	8.50	8.48	8.30	8.27	8.11	8.00	1.24

Pineapple yoghurt was one of the most acceptable yoghurts during the initial day of storage. The sensory scores of appearance, colour, aroma, texture, taste and overall acceptability during the initial day of storage were 8.40, 7.60, 6.80, 6.00, 8.60, and 8.50 respectively. The scores obtained by this yoghurt was ranged between 5.70-8.60. Till the end of two weeks, there were changes in all the parameters, but it was not statistically different. The initial sensory score of appearance was 8.40 which was reduced to 8.15 on the fifteenth day of storage. For colour initial score was 7.60 which reduced to 7.32 on the last day of storage, while the score for overall acceptability was 8.50 and it was decreased to 8.00 at the end of storage. The score for aroma was 6.80 and it gradually reduced to 6.00. All the sensory attributes of pineapple yoghurt recorded an acceptable score, and it was consumable.

Table 18. Sensory evaluation of soursop yoghurt during storage

Quality attributes	Storage period in days						
	0	3	6	9	12	15	CD (0.05)
Appearance	7.30	7.28	7.21	7.18	7.10	7.00	0.75
Colour	7.50	7.43	7.36	7.27	7.18	7.11	0.12
Aroma	6.90	6.81	6.73	6.61	6.55	6.48	0.22
Texture	6.60	6.52	6.44	6.32	6.28	6.20	0.19
Taste	6.30	6.25	6.20	6.16	6.11	6.10	1.02
Overall Acceptability	6.80	6.72	6.67	6.58	6.50	6.43	0.35

The soursop yoghurt was stored for two weeks, and the parameters analyzed during storage were appearance, colour, aroma, texture, taste and overall acceptability. The sensory scores of soursop yoghurt during the first day of storage were 7.30 (appearance), 7.50 (colour), 6.90 (aroma), 6.60 (texture), 6.30 (taste), and 6.80 (overall acceptability). On the third day of storage colour of the yoghurt scored maximum (7.43) and minimum (6.25) score was noted for taste. The fat content in the yoghurt could be the reason for lowering taste during storage. In every three day interval till the end of the fifteenth day colour of the fruit yoghurt obtained the highest score and taste was noted with the lowest score among other sensory parameters. The result of sensory evaluation of fruit yoghurt showed changes in sensory scores from the beginning to the end of storage. The scores in sensory evaluation attributes such as appearance, colour, aroma, texture, taste, and overall acceptability were gradually lowering during the storage time. However, the product was acceptable for use.

4.3.2. Physicochemical parameters of fruit yoghurts

Food materials possess physical properties. Physical properties are those properties that can be observed or measured without changing the chemical makeup of the material. Physical properties can give us clues about their chemical composition and processing characteristics.

Table 19. Acidity of stored fruit yoghurts

Acidity (%)	Days after storage					
	0	3	6	9	12	15	CD (0.05)
T_4A	4.50	4.76	5.13	6.16	7.26	7.93	0.75
T_2B	3.90	4.30	4.60	4.70	5.00	5.20	0.18
T_3M	5.13	6.10	6.17	6.70	6.90	7.70	0.22
T_4P	6.10	6.80	7.31	8.30	8.97	9.26	0.22
T_4PA	7.10	7.25	7.45	8.00	8.17	8.28	0.29
T_4S	4.17	4.45	4.50	4.90	5.80	7.30	0.41
T_6	5.60	6.30	6.30	6.50	6.90	7.00	0.21

Table 19. shows that the acidity of six fruit yoghurts ranged between 3.90%-9.26% during the two weeks of storage period. Initially, the highest acidity was recorded for T_4PA (7.10%) and the lowest was observed for T_2B (3.90%). The acidity of other treatments was T_3M (5.13%), T_4P (6.10%), T_4A (4.50%), and T_4S (4.17%), while the acidity of plain yoghurt T_6 was 6.00%.

On the third day of storage, the acidity of six treatments ranged between 4.30%-7.25% and T_4PA (7.25%) was noted for higher acidity, while T_2B shows the lowest acidity. During the sixth day of storage acidity of yoghurts ranged between 4.50%-7.45%. The highest acidity was recorded in T_4PA (7.45%), while the lowest acidity was noted for T_4S (4.50%). On the nineth day of storage, the acidity content of fruit yoghurts ranged between 4.70%- 8.30% and the highest acidity value was noted for T_4P (8.30%) and the lowest value was observed for T_2B (4.70%).

On the twelfth day of storage, the acidity ranged between 5.00%- 8.97%. The highest acidity was observed in T_4P (8.97%) and the lowest was in T_2B (5.00%). On the fifteenth day of storage, the acidity ranged between 5.20%-9.26%. The highest was in T_4P (9.26%) and the lowest was reported in T_2B banana yoghurt and T_4S with the same value (5.20%). The acidity of the other treatments was T_4PA (8.28%), T_3M (8.17%) and T_4A (7.45%).

The acidity of the products was found to be increased during the entire storage period of two weeks. There was a significant difference in the acidity content of the products during storage at 5% level.

Table 20. Moisture content of stored fruit yoghurts

Moisture (%)	Days after storage					
	0	3	6	9	12	15	CD (0.05)
T_4A	82.13	81.70	85.63	87.60	85.63	87.16	2.49
T_2B	77.66	78.70	79.13	82.26	86.56	88.53	0.31
T_3M	71.03	74.36	76.03	76.73	77.66	80.40	0.33
T_4P	67.56	68.56	69.03	70.00	75.50	65.40	0.94
T_4PA	67.53	68.20	69.30	71.73	72.63	86.66	1.24
T_4S	80.50	81.03	78.70	79.86	83.46	84.20	0.46
T_6	83.43	84.10	84.97	85.30	85.66	86.13	0.35

Table 20. shows that the moisture content of developed fruit yoghurts varied from 65.40 % - 88.53% during the two weeks of storage study. Initially, the highest moisture content was noted for T_4A (82.13%), and the lowest moisture content was observed for T_4PA (67.53%). The moisture content of the remaining treatments was T_2B (77.66%), T_3M (71.03%), T_4P (67.56%) and T_4S (80.50%), while the T_6 plain yoghurt shows a moisture content of about 83.43%.

On the third day of the shelf-life study, the moisture content ranged between 68.20% - 81.70% and the highest moisture content was found in T_4A avocado yoghurt (81.70%) and the lowest was observed in T_4PA pineapple yoghurt (68.20%). The moisture content of T_6 was 84.10 %. During the sixth day of storage, the moisture content ranged between 69.03% - 85.63% and the highest amount observed in T_4A (85.63%) and lowest was noted in T_4P (69.03%), while the moisture content of plain yoghurt was 84.97%.

During the nineth day of storage, the moisture content ranged between 70.00%-87.60% and the highest amount was in T_4A (87.60%) and the lowest amount was present in T_4P (70.00%). And in the twelfth day of storage study the highest amount was noted in T_2B (86.56) and the lowest found in T_4P (72.50%). On the last day (15th) of storage, the moisture content ranged between 65.40-88.53% and the highest amount was present in T_2B (88.53%) and the lowest was observed in T_4P (65.40%).

The moisture content of the developed fruit yoghurts was found to be increased during two weeks of shelf-life study. There was significant difference in the moisture content of the developed products during storage at 5% level.

Table 21. Peroxide value of stored fruit yoghurts

Peroxide Value (mEq/kg)	**Days after storage**						
	0	3	6	9	12	15	CD (0.05)
T_4A	7.06	7.59	8.92	9.15	10.59	11.30	0.94
T_2B	2.53	3.32	3.65	3.90	4.10	4.50	0.25
T_3M	1.90	2.07	2.27	2.63	3.20	3.23	0.31
T_4P	1.03	1.40	1.70	1.56	2.10	2.56	0.31
T_4PA	4.70	5.26	5.83	6.46	6.93	7.08	0.29
T_4S	5.90	6.13	6.50	7.01	7.37	7.64	0.21
T_6	6.80	6.82	7.48	7.70	8.03	8.40	0.49

Peroxide value is determined to identify the rancidity of the food products. The peroxide value of fruit yoghurts ranged between 1.03 - 11.30 mEq/kg. Initially, the peroxide value was higher in Avocado yoghurt (T_4A) 7.60 mEq/kg and the lowest value noted in passion fruit yoghurt (T_4P) 1.03 mEq/kg. During the third day of storage T_4A (7.59 mEq/kg) has the highest peroxide value and the lowest observed in T_4P (1.40 mEq/kg). On the sixth day T_4A showed the highest value (8.92 mEq/kg) and the lowest found in T_4P (1.70 mEq/kg). Till the 15th day the highest peroxide value was observed in T_4A (11.30 mEq/kg) and lowest in T_4P (2.56 mEq/kg).

The peroxide value of developed fruit yoghurts was found to be increased during two weeks of the storage study. There was a significant difference in the peroxide value of the developed products during storage.

Table 22. pH of stored fruit yoghurts

pH	Days after storage						
	0	3	6	9	12	15	CD (0.05)
T_4A	4.41	4.43	4.28	4.19	4.70	4.13	0.18
T_2B	5.22	5.55	5.51	5.36	5.04	4.80	0.09
T_3M	4.25	4.13	4.11	4.40	4.30	4.00	0.12
T_4P	4.41	4.37	3.98	3.76	3.59	3.40	0.34
T_4PA	4.15	4.70	4.30	4.00	3.70	3.30	0.20
T_4S	4.29	4.10	4.03	3.91	3.60	3.55	3.96
T_6	4.61	4.59	4.44	4.28	4.19	4.16	0.03

Table 22. reveals that the pH content of developed fruit yoghurts ranged between 3.30-5.55 during two weeks of shelf study. Initially, the highest pH was found in T_2B (5.22) and lowest noted in T_4PA (4.15), while the pH of the remaining treatment was T_4A and T_4P with the same pH (4.41) and T_3M and T_4S had 4.25 and 4.29.

On the third day of storage, the highest pH was observed in T_2B (5.55) and the lowest in T_4S (4.10). The pH of control was 4.59. On the sixth day, the pH ranged between 3.98-5.51 and pH of T_2B (5.51) was higher and the lowest pH was noted in T_4P (3.98). The next observation was taken on the nineth day of storage and the pH ranged between 3.76-5.36 and the highest observed in T_2B (5.36) and the lowest was noted in T_4P (3.76), while the plain yoghurt was noted with a pH of 4.28.

During the twelfth day of storage, the highest pH was noted in T_2B (5.04) and the lowest was noted in T_4P (3.59). On the last day of storage, the highest pH founded in T_4B (4.80) and the lowest was noted in T_4PA (3.30). The pH content of the developed fruit yoghurts was found to be decreased during the storage period. There was a significant difference in the pH content of the products during storage.

Table 23. Syneresis of stored fruit yoghurts

Syneresis	Days after storage					
	0	3	6	9	12	15	CD
T_4A	4.00	8.33	12.50	18.83	18.50	19.10	1.48
T_2B	3.33	7.66	9.33	11.66	12.00	15.66	1.18
T_3M	5.00	7.00	10.66	11.43	16.23	17.10	1.16
T_4P	6.27	10.00	13.32	18.10	20.76	23.23	0.40
T_4PA	5.00	6.26	9.60	12.13	16.00	18.10	0.28
T_4S	0.00	2.56	4.03	8.03	8.00	11.00	0.14
T_6	6.33	9.33	14.00	18.00	18.83	20.00	1.49

Table 23. Reveals that the percentage of syneresis in the developed fruit yoghurt ranged between 0.00-23.23% during the two weeks of storage life. Initially, the highest percentage of syneresis was reported in T_4P (6.27%) and T_4S was observed to have no syneresis. Syneresis of other treatments were T_4A (4.00%), T_2B (3.33%), T_3M and T_4PA had syneresis of 5%.

During the third day, the syneresis percentage ranged between 2.56-10.00%. The highest percentage was noted in T_4P (10%) and the lowest in T_4S (2.56%). On the sixth day of the storage study T_4P (13.32%) was shown the highest percentage of syneresis and the lowest recorded in T_4S (4.03%). On the nineth day of storage, the percentage of syneresis ranged between 8.03-18.83%. The highest percentage was noted in T_4A (18.83%) and the lowest noted in T_4S (8.03%). The percentage of syneresis in control (T_6) was 18%. On the twelfth day of storage, the percentage of syneresis ranged between 8-20.76 % and the syneresis of T_4P (20.76%) was higher and the lowest percentage observed in T_4S (8%). And the last day of the storage study the percentage of syneresis was ranged between 11-23.23%. The highest percentage was reported in T_4P (23.23%) and the lowest was in T_4S (8%). The percentage of developed fruit yoghurts were found to be increased during the storage period. There was a significant difference in the rate of syneresis of the products during storage at 5% level.

Table 24. Total Soluble Solids of fruit yoghurts

Total Soluble Solids (TSS) (°B)	Days after storage					
	0	3	6	9	12	15	CD
T_4A	15.65	14.51	14.48	13.36	13.79	12.25	1.72
T_2B	20.78	20.40	19.81	20.50	19.46	18.61	1.20
T_3M	29.26	29.30	28.01	28.25	26.78	25.53	1.10
T_4P	35.20	35.94	35.39	34.20	35.52	32.80	1.17
T_4PA	24.40	23.20	22.90	22.50	22.17	21.60	1.16
T_4S	21.16	19.86	19.26	18.00	17.93	18.23	0.91
T_6	11.47	11.25	10.36	9.93	8.64	8.13	0.70

Table 24. shows that the total soluble solids in the developed fruit yoghurt ranged between 12.25-35.94 ° B during the two weeks of storage life. Initially, the total soluble solids observed higher T_4P (35.2 ° B), and it was lower in T_4A (15.65 ° B). The total soluble solid content of plain yoghurt was 11.47° B. On the third day, the total soluble solids were reported higher in T_4P (35.94) and lowest in T_4A (14.51).

During the sixth day of storage, the total soluble solid content was found higher in T_4P (35.39° B) and lower in T_4A (14.48° B). On nineth day TSS content was higher in T_4P (34.2° B) and the lowest was noted in T_4A (13.36° B). On the twelfth of storage, TSS showed higher in T_4P (34.52° B) and the lowest in T_4A (13.79° B). On the last day (15^{th} day) of the storage study, TSS content was noted higher in T_4P (32.8° B) and the lowest content was shown in T_4A (12.25° B). While the plain yoghurt showed a TSS of 8.13° B.

The total soluble solid content of the developed fruit yoghurts was found to be decreased during the storage period. There was a significant difference in the TSS content of the products during storage at 5% level.

4.3.3. Microbial profile of fruit yoghurts

The microbial load of the developed fruit yoghurts was studied to determine the keeping quality of the products. The yoghurt was made with a starter culture that contain

Streptococcus thermophilus and *Lactobacillus bulgaricus*. The rate of bacterial colonies and contamination with yeast, mould fungus and coliforms were analyzed to ascertain the microbial profile. Microbial analysis of the products is important to determine the quality, safety and to assure the shelf life of the products. The products were stored at refrigerated temperature (4°C) for two weeks. the microbial evaluation was conducted initially in the fresh sample and at 3 days intervals up to two weeks. The microbial profile of the developed fruit yoghurts was evaluated by serial dilution of the samples. The growth of bacteria, fungi, yeast, and E-coli was determined using Plate Count Agar, Potato Dextrose Agar, Yeast Extract Peptone Dextrose and Eosin methylene Blue. From the microbial evaluation, it was revealed that bacterial, fungal and yeast colonies were present in the sample. while there is no presence of E-coli in the developed products.

Table 25. Bacterial profile of fruit yoghurts

Bacteria (log cfu/g)	**Days after storage**						
	0	3	6	9	12	15	CD
T_4A	10.36	10.41	10.45	10.31	10.26	10.06	0.05
T_2B	10.40	10.51	10.38	10.26	10.24	10.03	0.01
T_3M	10.43	10.52	10.42	10.40	10.30	10.26	0.11
T_4P	10.31	10.45	10.42	10.40	10.30	10.26	0.12
T_4PA	10.24	10.28	10.31	10.29	10.20	10.00	0.01
T_4S	10.31	10.56	10.44	10.34	10.28	10.24	0.08
T_6	10.24	10.37	10.36	10.27	10.25	10.18	0.02

Table 25 reveals that during two weeks of the storage period the bacterial colonies were detected initially itself. The bacterial colonies were higher in T_3M (10.43 log cfu/g) followed by other treatments and the lowest count observed in T_2PA (10.24 log cfu/g). Since the products were already made up of bacterial culture and observed bacterial colonies in plain yoghurt were 10.43 log cfu/g.

On the third day, the bacterial colonies were higher in T_4S (10.56 log cfu/g) and the lowest observed in T_4PA (10.28 log cfu/g). On the sixth day, the higher bacterial colonies were noted in T_4A (10.45 log cfu/g) and the lowest count present in T_4PA (10.31 log cfu/g). Also, on the nineth day, it was observed that bacterial colonies were higher in both T_3M and T_4P with the same count (10.40 log cfu/g) and the lowest count was in T_4A (10.31 log cfu/g). On the twelfth day of storage, the bacterial colonies were higher in both T_3M and T_4M with the same count of (10.30 log cfu/g) and the lowest count was present in T_4PA with a count of (10.2 log cfu/g). On the last day of storage, the highest count was in T_3M and T_4P (10.26 log cfu/g) and the lowest was in T_4PA (10 log cfu/g).

It was observed that the total viable count of bacterial colonies was decreased during the two weeks of time.

Table 26. Fungal profile of fruit yoghurts

Fungi (log cfu/g)	**Days after storage**					
	0	3	6	9	12	15	CD
T_4A	0.00	6.30	6.32	6.31	6.21	6.15	0.26
T_2B	6.25	6.37	6.36	6.29	6.19	6.08	0.05
T_3M	5.95	6.14	6.39	6.43	6.25	5.80	0.11
T_4P	0.00	6.12	6.38	6.35	6.34	6.12	0.06
T_4PA	6.02	6.36	6.42	6.40	6.31	6.16	0.09
T_4S	5.96	6.44	6.40	6.34	6.08	5.36	0.16
T_6	6.19	6.40	6.41	6.31	5.91	5.80	2.09

Table 22. Shows that the count of fungal colonies was present in the fruit yoghurts. Initially, the fungal colonies were higher in T_2B (6.25 log cfu/g) and in T_4A and T_4P there were no fungal colonies found. On the third day of storage, the fungal colonies were higher in T_4S (6.44 log cfu/g) and the lowest was present in T_4P (6.12 log cfu/g). On the sixth day the highest count was noted in T_4PA (6.42 log cfu/g) and the lowest was in T_4A (6.32 log cfu/g). Nineth day the count was higher in T_3M (6.43×10^6 cfu/g) and the lowest was in T_2M (6.29 log cfu/g). On the twelfth day the highest count was observed in T_4P (6.34 log cfu/g) and the lowest was in T_4S (6.08 log cfu/g). On the fifteenth day, the count was highest in T_4PA (6.16 log cfu/g) and the lowest was in T_3M (5.8 log cfu/g).

From the above Table 26 it can be concluded that there was the presence of fungal colonies from the initial period, and they showed gradual variations in the number of colonies, and it shows that the number of colonies was decreased during the two weeks of storage life.

Table 27. Yeast and mould profile of fruit yoghurt

Yeast and mould (log cfu/g)	**Days after storage**						
	0	3	6	9	12	15	CD
T_4A	6.30	6.49	6.55	6.51	6.42	6.32	0.04
T_2B	6.46	6.51	6.52	6.49	6.41	6.14	0.03
T_3M	0.00	6.32	6.50	6.44	6.31	5.82	0.52
T_4P	1.76	6.12	6.45	6.46	6.32	5.90	2.22
T_4PA	6.50	6.48	6.53	6.49	6.41	6.17	0.03
T_4S	0.00	6.36	6.50	6.52	6.29	6.13	0.05
T_6	0.00	6.44	6.44	6.15	6.29	6.17	0.40

Table 23. Shows that the count of yeast colonies was present in the fruit yoghurts. Initially, the yeast colonies were higher in T_4PA (6.5 log cfu/g) and in T_3M and T_4S there was no yeast colonies found. On the third day of storage, the yeast colonies were higher in T_2B (6.51 log cfu/g) and the lowest was present in T_4P (6.12 log cfu/g). On the sixth day the highest count was noted in T_4A (6.55 log cfu/g) and the lowest was in T_4P (6.45 log cfu/g). Nineth day the count was higher in T_4S (6.52 log cfu/g) and the lowest was in T_3M (6.44 log cfu/g). On the twelfth day the highest count was observed in T_4A (6.42 log cfu/g) and the lowest was in T_4S (6.29 log cfu/g). On the fifteenth day, the count was highest in T_4A (6.32 log cfu/g) and the lowest was in T_3M (5.82 log cfu/g).

From the above Table 27, it can be concluded that there was the presence of yeast colonies from the initial period, and they showed gradual variations in the number of colonies, and it shows that the number of colonies was decreased during the two weeks of storage life.

Coliform profile of fruit yoghurts

From the data, it was revealed that no coliforms had been detected in all the fruit yoghurts during two weeks of storage study.

4.4. COST ANALYSIS OF THE DEVELOPED PRODUCTS

The cost analysis of the fruit yoghurts was carried out based on the price of various commodities. This included the cost of milk, fruits, sugar, yoghurt starter culture and utensils as well as labour and fuel charges.

Table 28. Cost of the developed fruit yoghurts (per kg)

Treatments	Total Cost (Rs)
Avocado yoghurt (T_4A)	240/-
Banana yoghurt (T_2B)	150/-
Mango yoghurt (T_3M)	210/-
Passion fruit yoghurt (T_4P)	210/-
Pineapple yoghurt (T_4PA)	190/-
Soursop yoghurt (T_4S)	230/-
Plain yoghurt (T_6)	160/-

Table 28 depicts the expenses incurred for the yoghurts. The highest cost was to produce avocado yoghurt (240/-) and the cost of banana (Robusta) yoghurt was comparatively less (150/-). The lowest expense was worked out for the plain yoghurt having a cost of only Rs.160.00/kg. It is well known that the raw materials used have a direct impact on product costs. Therefore, the fruit yoghurt prepared with avocado fruit was observed to have the comparatively high cost. It could be remarked that the cost of milk and fruits are the major expenses to bear in the production of fruit yoghurts.

Discussion

5. DISCUSSION

The results of the present study entitled "Development of fruit blended yoghurts and quality evaluation" is discussed below, under the following headings:

5.1. Development of fruit yoghurts

5.2. Quality evaluation of the fruit yoghurts

5.3. Storage stability of the fruit yoghurts

5.4. Cost analysis of the developed products

5.1. DEVELOPMENT OF FRUIT YOGHURTS

Antioxidants, prebiotic fibres, and polyphenols are abundant in fruits (Fernandez and Marette, 2017). Fruits and yoghurt consumption together have the potential to deliver additional nutritional and physiological benefits, as well as a synergetic influence on health. Furthermore, the addition of fruits may have a prebiotic effect, resulting in a greater viable count of probiotics in yoghurt during storage (Senadeera *et al.*, 2018). Therefore, the present study was conducted to evaluate the addition of different fruits pulp on sensorial, nutritional, and microbiological properties of probiotic yoghurts containing *Streptococcus thermophilus* and *Lactobacillus bulgaricus* culture. Furthermore, the effects of fruit pulp on sensory properties, acidity, moisture, peroxide value, pH, syneresis and total soluble solids of fruit yoghurts during refrigerated storage (4˚C) for two weeks were also examined.

In the present study, the fruit yoghurts were developed with optimum ripened selected fruits like avocado, banana (Robusta), mango (Moovandan), passion fruit, pineapple, and soursop. Each fruit yoghurt was developed with five different combinations. The best combination from each treatment was identified using sensory scores obtained during sensory analysis and it was carried out using 10 semi-trained panellists. The 9 point hedonic scale used for sensory evaluation was comprised of sensory parameters viz., appearance, colour, aroma, texture, taste and overall acceptability.

5.2. QUALITY EVALUATION OF THE FRUIT YOGHURTS

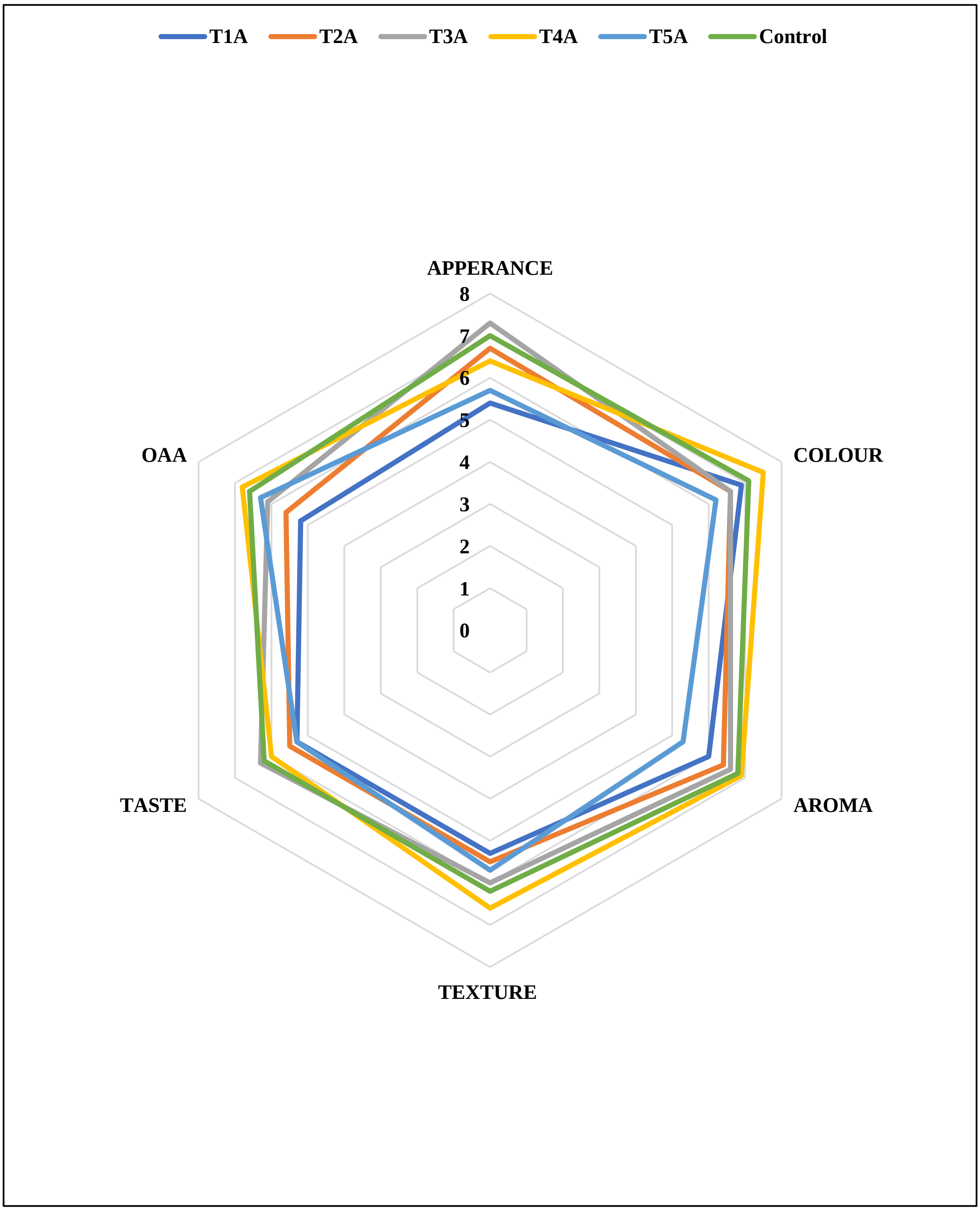
5.2.1. Sensory Qualities of the Fruit Yoghurts

The developed fruit yoghurts were analyzed for various sensory parameters of 9 point hedonic scale. The maximum score that could be attained for each attribute was 9. The result of each product is discussed here.

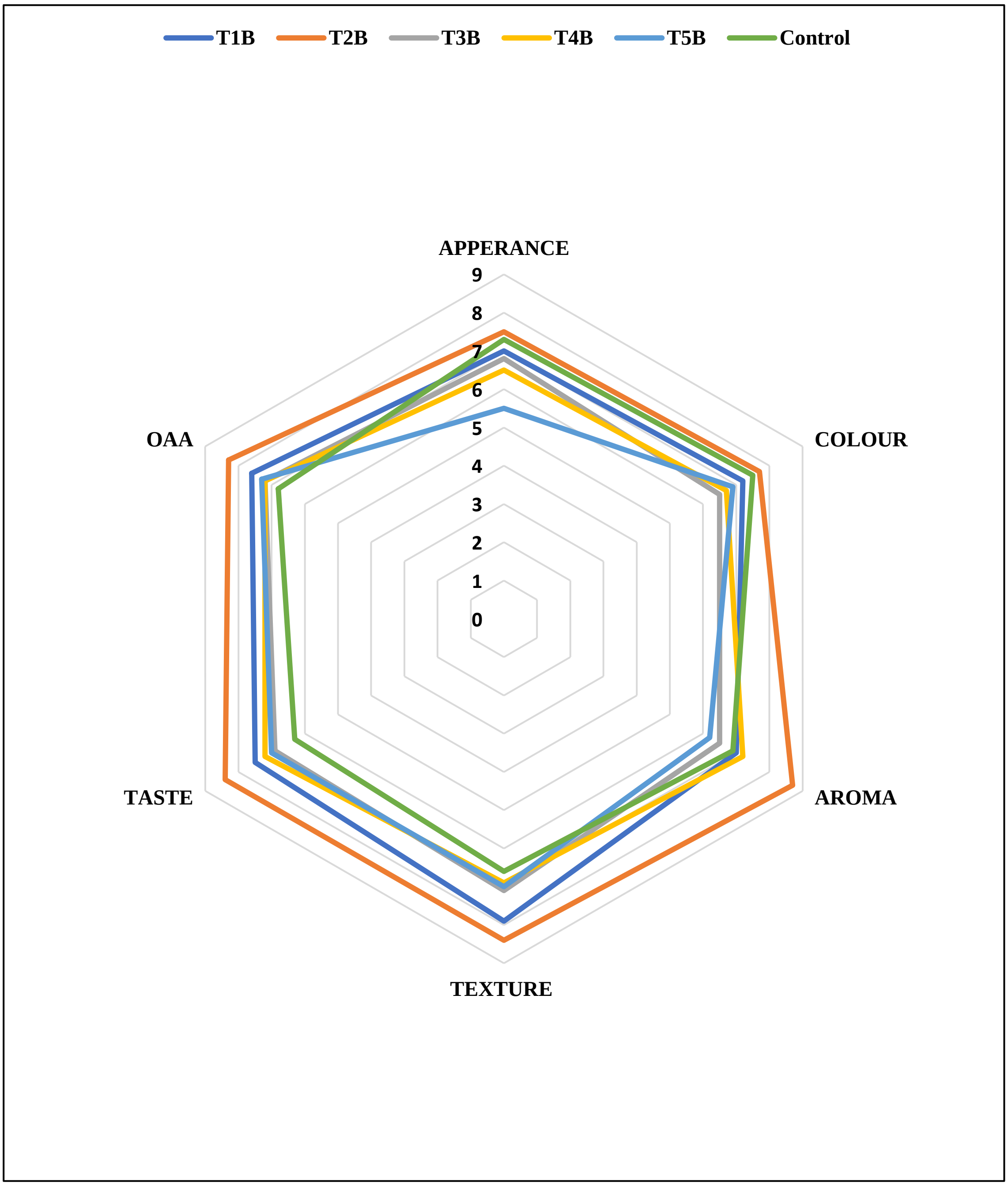
The sensory scores of fruit blended yoghurts showed significant differences in each treatment. It can be concluded from the sensory analysis of avocado yoghurt that 70% homogenised toned milk, 30% fruit pulp, 2% yoghurt starter culture, and 12% sugar got the highest score and it was the most ideal combination for the proper setting and formulation of avocado yoghurt for all sensory parameters such as appearance, colour, aroma, taste, texture, and overall acceptability when compared to the control with 100% milk and 2% yoghurt culture. This data corroborates with the findings of Remya *et al*. (2019) reported that jackfruit yoghurt prepared with 10%, 20% and 30% fruit pulp and one with 30% fruit pulp got the maximum overall acceptability. The result of the sensory analysis on avocado yoghurt proved that the treatment T_3A with 25% fruit pulp and 75% milk was contributed the best appearance and taste due to its good colour and consistency. However, the remaining treatments were exhibited low positions in sensory qualities because there was detected some colour changes in the upper portion of the yoghurt and most people do not like the taste of avocado yoghurt.

The sensory evaluation of banana yoghurt manifested that the best formulation was T_2B with 20% fruit pulp, 80% milk, 20% yoghurt culture and 12% sugar than the plain yoghurt. These proportions performed remarkably well in qualities viz., appearance, colour, aroma, texture, taste, and overall acceptability. The results are in conformity with the findings of Jeyasekaran and Deepa (2021) found that passion fruit yoghurt prepared from 10%, 15% and 20% fruit pulp with milk and the one with 20 % passion fruit pulp incorporation was found to be highly acceptable. According to Ranadheera *et al*. (2012), adding fruit-based components to fruit yoghurt could result in a higher natural sugar content, which would increase customer acceptability. These findings are supported by Sengul *et al*. (2012), found that yoghurt incorporating sour cheerful fruit pulp had the greatest overall acceptability score.

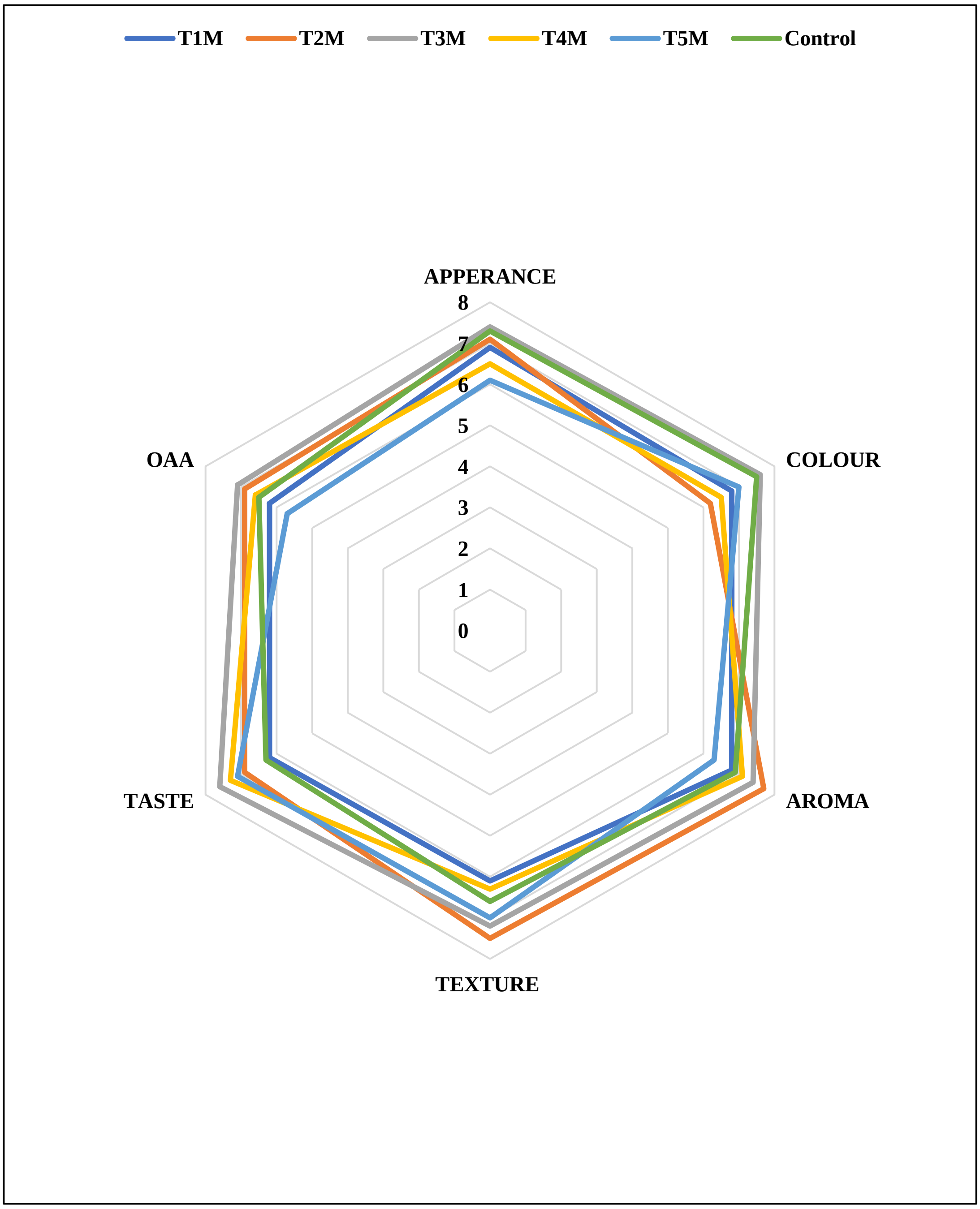
Graph:1 Sensory Evaluation of Avocado Yoghurt



Graph: 2 Sensory Evaluation of Banana (Robusta) Yoghurt



Graph:3 Sensory Evaluation of Mango (Moovandan) Yoghurt



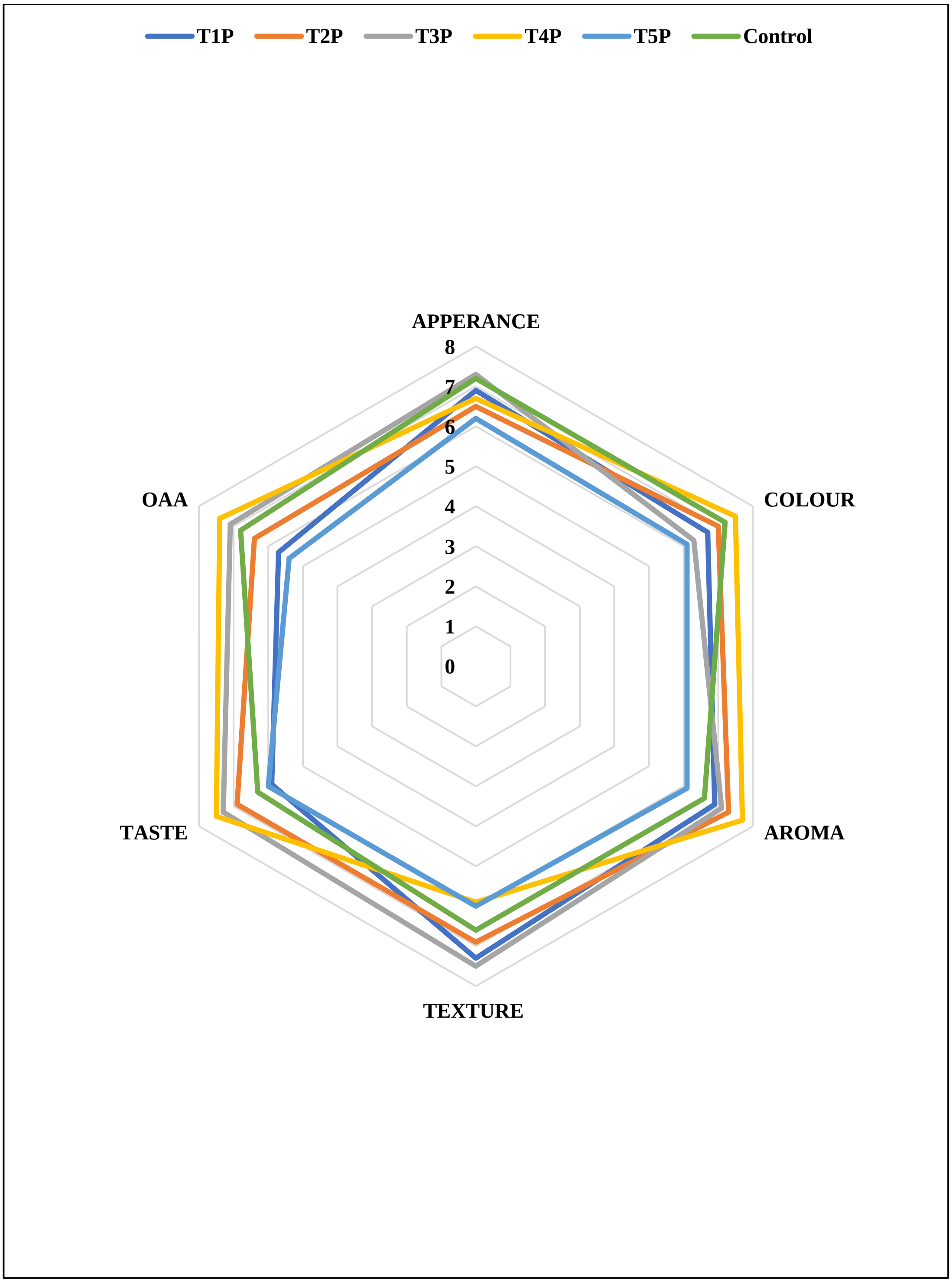
In the present study, the mango yoghurt contained 25% fruit pulp, 75% milk, 2% yoghurt culture, 12% sugar was recorded with the best scores. T_3M has scored a maximum for its appearance, colour, taste and overall acceptability. The aroma and texture were best in the treatment T_2M because the proportion of milk and fruit pulp were well balanced and contributed pleasant aroma and appealing consistency to the yoghurt. Ara *et al*., 2015 stated that the addition of fruit juice improved the colour and texture of yoghurt which supports the current findings.

Regarding the sensory data of passionfruit yoghurt, the 30% passionfruit pulp incorporated set yoghurt scored a maximum in colour and aroma, taste, and overall acceptability except for the appearance and texture. T_3P scored the best for appearance and texture because the passionfruit pulp was very acidic it was adversely impacted on its appearance and texture. When the pulp was mixed with milk for developing fruit blended yoghurt it got curdled because of its low pH. So, it was developed as a set type of yoghurt for preventing curdling and to obtain a good consistency. Syneresis was higher in passionfruit yoghurt and it was altered the texture and appearance of the product. The appearance and colour were good in T_3P when compared to T_4P. The passionfruit pulp was also mixed with half of the recommended sugar (12g) heated at 85 °C for 20 minutes and cooled to 5 °C. It has helped to reduce the acidity and enzymatic activity of the passionfruit pulp.

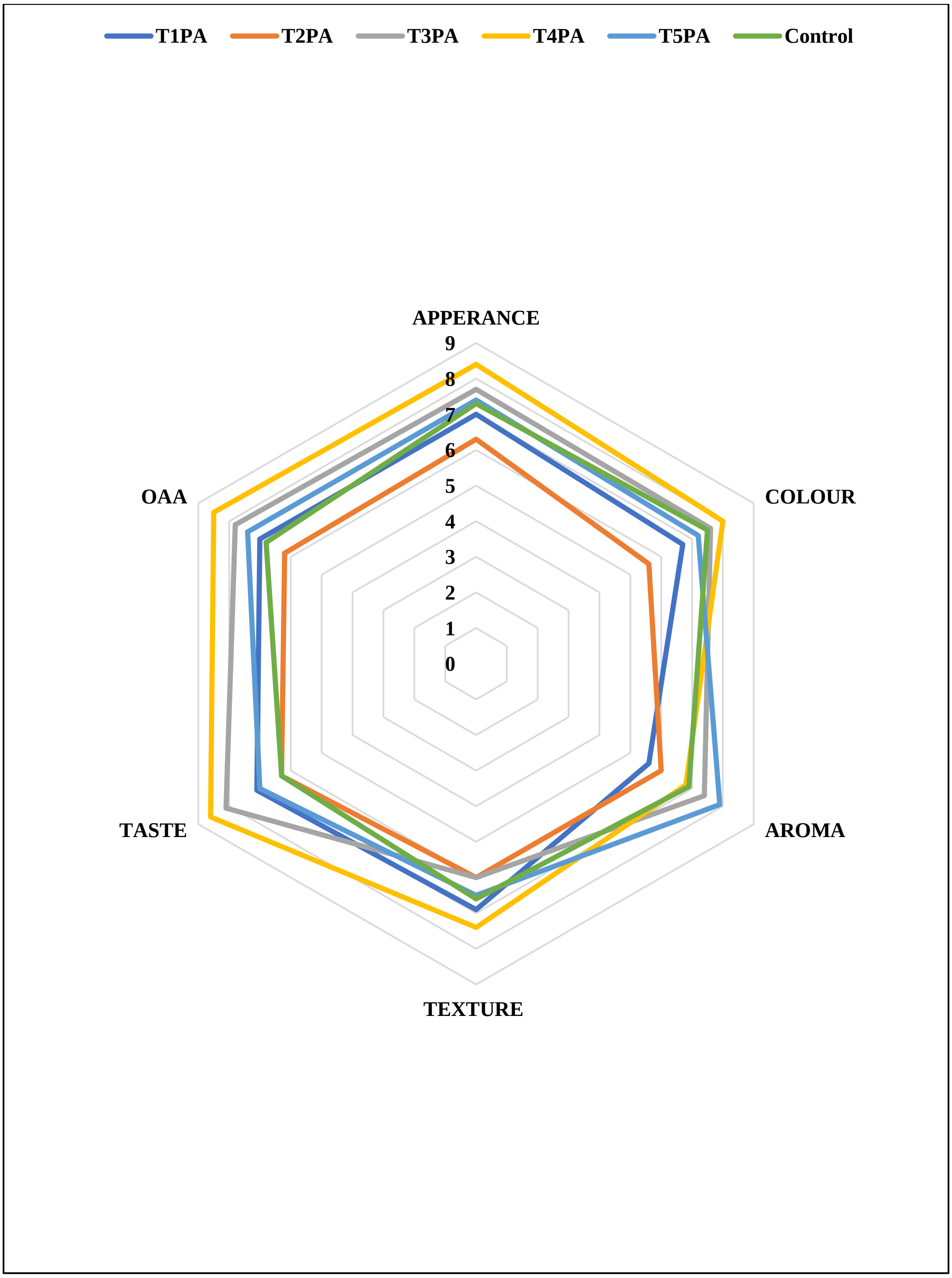
The treatment with the following proportions 70:30:12:2 of homogenised toned milk, pineapple pulp, sugar and starter culture obtained the maximum scores for most of the attributes except for aroma. The aroma was found more in T_5PA which may be due to the higher concentration of fruit pulp than in T_4PA. The acceptance of the yoghurt was increased with sufficient sweetness and acidity of fruit yoghurt. The pineapple fruit was balanced with half amount of recommended sugar (12g) and heated at 75 – 80°C for 15 minutes for inactivating the enzyme and removing the microbes from the pulp.

Soursop yoghurt prepared in the present investigation using T_4S proportion were superior in all the quality and showed maximum acceptance. The accuracy in milk, fruit pulp, sugar and starter culture blend of fruit yoghurt might also have contributed to these notably good results. The creamy colour of the fruit along with milk has given an

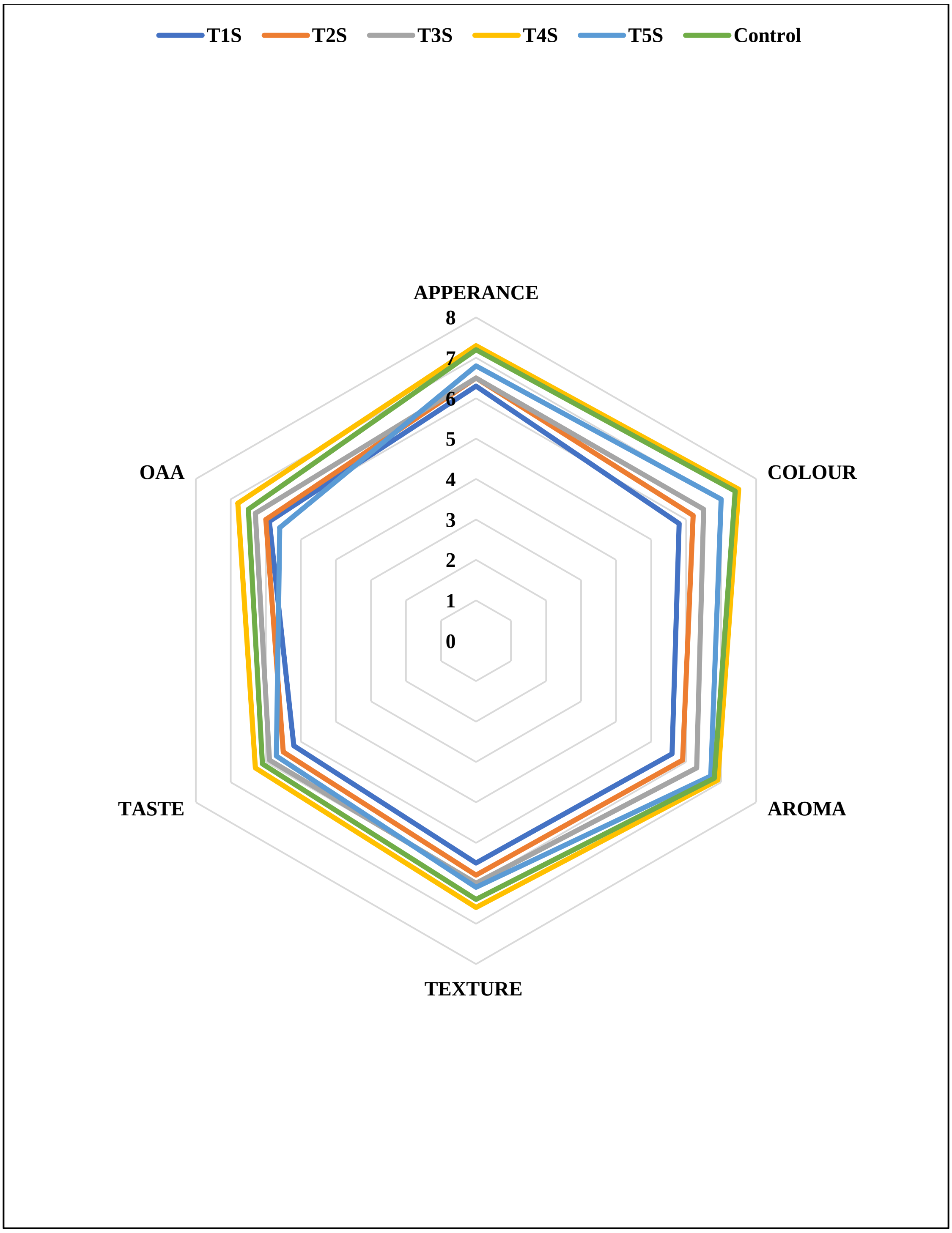
Graph:4 Sensory Evaluation of Passionfruit Yoghurt



Graph:5 Sensory Evaluation of Pineapple Yoghurt



Graph:6 Sensory Evaluation of Soursop Yoghurt



appealing colour to the final product and it was possessed good taste. Karagul-Yuceer (2006) stated that the yoghurt must have a clean acid flavour that should be free of harsh, rancid, oxidized, stale, yeasty, and dirty flavours. Flavouring ingredients must be evenly dispersed, and the flavour must be pleasant and characteristic of the flavouring used. The flavour

The data on sensorial analysis emphasized that the avocado, passionfruit, pineapple, and soursop yoghurts with 30% fruit pulp, 70% fruit pulp, 12% sugar and 2% yoghurt starter were found the most acceptable proportion. When the ratio of fruit pulp increased the taste was found good in yoghurt. All the developed fruit yoghurts were more acceptable than control in terms of appearance, colour, aroma, texture, taste, and overall acceptability. The result highlight that an increased quantity of fruit pulp benefitted the taste of fruit yoghurt.

Fruit yoghurts were favoured by the panellists than the control yoghurt. Fruit pulp was helped to keep the final products textural qualities. Improved textural characteristics in fruit yoghurts may be linked to higher solid and fibre content in fruit pulp. Farahat and El-Batawy (2013) found that stirred fruit yoghurts had improved textural quality than control yoghurts. The results of this study matched those of Kumar and Mishra (2003), who studied the preparation of mango pulp enriched yoghurt. They found that as the amount of fruit pulp in the product rises, so does its overall acceptance. Gad *et al*. (2015) made functional yoghurts using carrot and cantaloupe juice, and the fruit yoghurts were evaluated. They concluded that adding fruit juice to yoghurt increased its acceptability when compared to plain yoghurt. There was higher consumer acceptability than control yoghurt in the present study, which may be due to the natural sugars of the added fruit pulps.

5.2.2. Nutrient and Chemical Composition of Fruit Yoghurts

Nutritional parameters of the selected proportions of fruit yoghurts and control were also studied. Energy, carbohydrate, protein, fat, dietary fibre, total phenol, iron, reducing sugar, total ash, vitamin, and mineral content of the yoghurts varied with the amount of milk and fruit pulp in the fruit yoghurts.

The energy content of the developed plain yoghurt and fruit yoghurts differ significantly, and the energy content of the fruit yoghurts ranged between 99.70 kcal-144.16 kcal. Avocado yoghurt showed higher calorie content. This may be due to the higher amount of fat content present in the avocado fruit. An increase in the calorie content with the addition of fruit pulp was observed in the study. All the fruit yoghurts had enough energy range when compared to the plain yoghurt.

In the present study, the carbohydrate content of fruit yoghurts ranged between 11.06g- 22.66g. carbohydrate content was found to be increased with the increase of fruit pulp except in avocado yoghurt. This corresponds with the report by Ekere (2014) that found an increase in carbohydrate content with an increase in soursop pulp in the fruit yoghurt. The carbohydrate content in plain yoghurt was 6.28g. The highest carbohydrate was noted in pineapple yoghurt, this may be due to the higher carbohydrate content in the pineapple. This agreed with the report by Akubor (2016) he stated that pineapple juice contained a higher amount of carbohydrate content than yoghurt.

The protein level of control yoghurt was found to be higher than that of fruit yoghurts. The protein content of the control yoghurt is much higher than that of the fruit yoghurts. The findings of Roy *et al*. (2015) support this conclusion. They discovered that when the amount of fruit in fruit yoghurt increases the protein level decreases. The protein level of papaya yoghurt with 5, 10, and 15% fruit pulp is 3.76, 3.73, and 3.68 per cent, respectively. This can also be due to the use of fruit pulp in the yoghurt. Fruit pulps were found to have a significant impact on the change in protein content in yoghurt samples. Protein content in yoghurt samples decreased as pulp content increased. Raut *et al*., 2014

also stated that the decline in protein was attributable to the addition of varying proportions of mango pulp to the yoghurt drink, as well as the fact that fruit pulp has a lower protein concentration than milk. The highest (4.43g/100g) protein content was present in banana yoghurt with 20% fruit pulp and 80% milk and the lowest (3.06g/100g) protein were found in passion fruit yoghurt with 30% fruit pulp and 70% milk respectively.

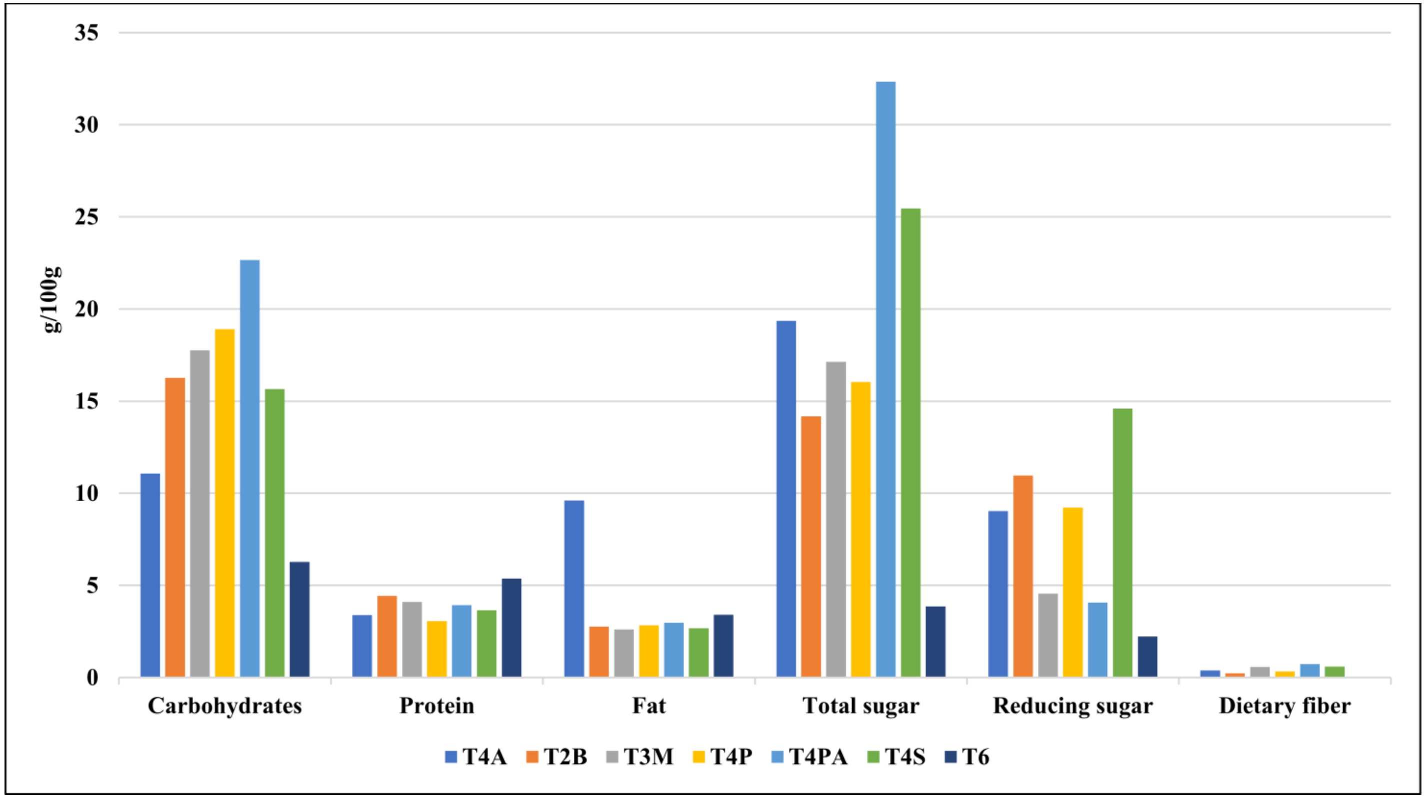
One of the most essential quality parameters in yoghurt or fruit yoghurt is fat content. It is dependent on the quality of the milk, the amount of fruit pulp used, the type of fruit used, and other treatments (Roy *et al*., 2015). It was obtained that the change in fat content in yoghurt samples was highly influenced by adding fruit juice. The fat content in yoghurt samples decreased with increasing fruit juice percentage. This could be due to fruit's lower fat content when compared to milk. This finding is consistent with Roy *et al*., (2015), who found that when the amount of banana, papaya, and watermelon pulp in yoghurt increased, the fat content of the yoghurt reduced. Hossain *et al*., (2012) discovered that when the percentage of strawberries, oranges, and grapes increased, the fat level of fruit yoghurt dropped. The result of this study indicates that the maximum and minimum fat content was found in avocado yoghurt with 30% fruit pulp. Avocado is a fat-rich fruit and adding it to yoghurt can increase the fat level of the yoghurt (Hettige *et al*., 2013).

Yoghurt is made from milk, which is its primary component. Milk is devoid of fiber by nature. As a result, any fiber in yoghurt is derived from secondary components such as almonds and fruit. Because these nutrients aren't as prevalent in yoghurt as milk, they don't contribute to the fiber content of yoghurt. The plain yoghurt had no fiber, while the fruit yoghurts contain a significant amount of fiber when compared to the control. The presence of fruits is the explanation for the enriched yoghurt's higher fiber content. Many studies have found that the rheological properties of yoghurt are influenced differently depending on the type of fiber used. Yoghurt with a higher fiber content has better rheological qualities. (Staffolo *et al*., 2004; Hashim *et al*., 2009; Luana *et al*., 2014; Raju and Pal, 2014). The addition of dietary fiber to yoghurt would enhance its beneficial properties. Hashim *et al*. (2009) found that fortifying yoghurt with 3% dates fiber produced a satisfactory product with potential health benefits.

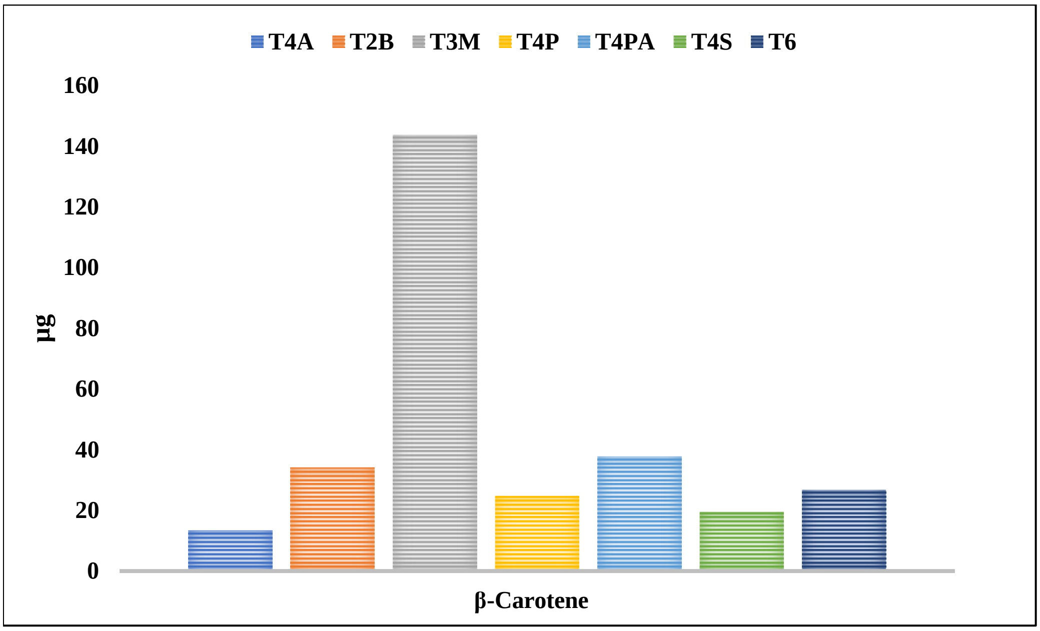
The total sugars in dairy products are generally a mix of intrinsic and added sugars (often added to increase sweetness). The term "intrinsic sugars" refers to the naturally occurring sugars found in milk and other dairy products. The only inherent sugar found in milk is lactose, a disaccharide made up of glucose and galactose units. The total and reducing sugar content of fruit yoghurt were found significantly increased than the plain yoghurt due to the addition of fruit pulp and sugar in the yoghurt.

Graph 7. Energy Content of Fruit Yoghurts

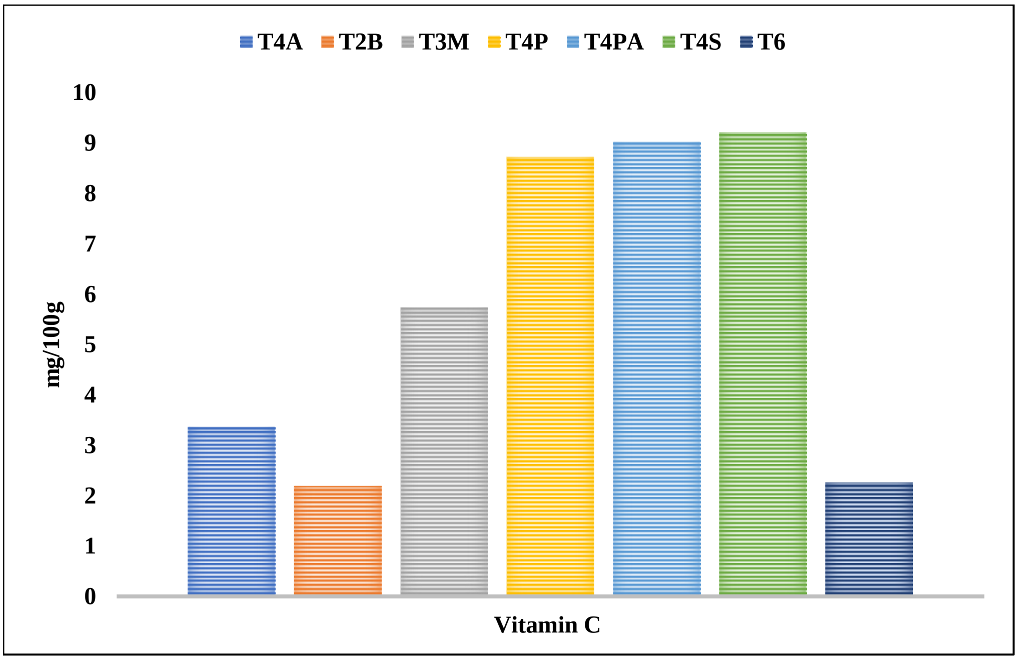
Graph 8. Nutrient Composition of Fruit Yoghurts



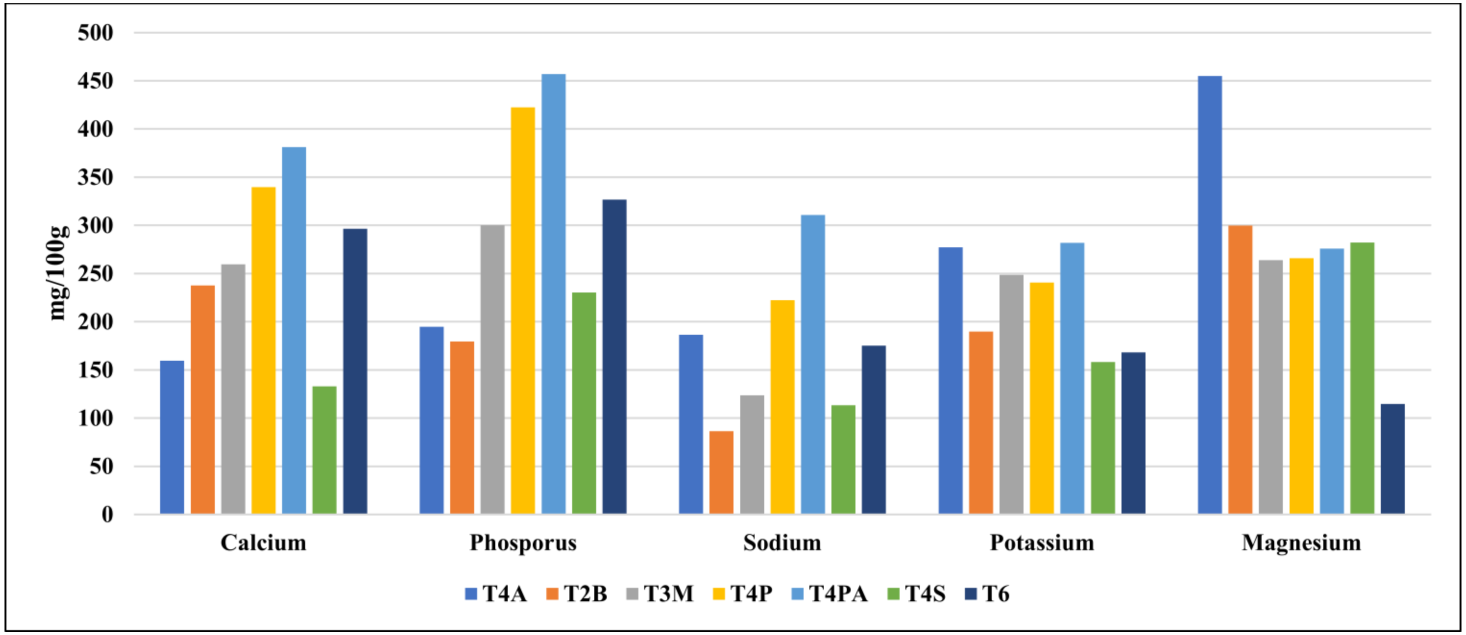
Graph 9. β Carotene Content of Fruit Yoghurts



Graph 10. Vitamin C Content of Fruit Yoghurts



Graph 11. Mineral Composition of Fruit Yoghurts



Dimitrellou *et al*. (2020) reported that the initial sugar level of milk was significantly increased when fruit juices were added. Control milk had a sugar content of 5.95 per cent w/v, whereas adding blueberry and Aronia juice boosted the sugar content to 6.45 and 6.58 per cent w/v, respectively. Pineapple fruit yoghurt had higher levels of both reducing and total sugar than other fruit yoghurts in this study. Hossain *et al*. (2015) stated that the reducing sugar was higher in pineapple pulp.

The iron concentration of pineapple yoghurt with 30% fruit pulp and 70% milk was found to be the highest. Sanchez-Segarra *et al*. (2000) discovered iron concentrations of 1.18 mg/kg for strawberry yoghurt, 3.46 mg/kg for blackberry yoghurt, 1.06 mg/kg for a yoghurt mixed with fruit, 0.45 mg/kg for normal peaches, 0.86 mg/kg for yellow peaches, 0.62 mg/kg for red peaches, and 0.78 mg/kg for pineapple yoghurt.

Ash is vital in terms of nutrients because it tells how dense the minerals are in a selected food sample. commonly, low ash content shows that the food product analyzed is not a rich source of minerals (Ndife *et al*., (2014). Ash content was lower in plain yoghurt when compared with fruit yoghurts. Phenolic content and antioxidant activity of fruit yoghurts were found to be increased than plain yoghurt. Taneva and Zlatev (2020) reported that dairy products enriched with goji berries have a higher amount of polyphenol compounds and a higher antioxidant capacity compared to the control sample. Phenolic content was higher in soursop yoghurt than the plain yoghurt and other fruit yoghurt samples.

Vitamin C content was higher in soursop enriched yoghurt. Ekere (2014) also reported that with the addition of soursop, the ascorbic acid level increased. This is due to soursop's high ascorbic acid concentration. Soursop is an antioxidant-rich fruit that contains vitamin C, which aids in the destruction of free molecular radicals. Soursop has 29.6 mg of ascorbic acid per 100 grammes. Soursop is high in vitamin C and can benefit youngsters with bladder weakness, especially if the fruit's heart is eaten (Ekere, 2014). Banana yoghurt was found with low vitamin C content among all the developed fruit yoghurt but the addition of fruit pulp into yoghurt showed a significant increase in vitamin C. Addition of mango, pineapple, passion fruit and banana respectively caused improvement in beta carotene content of yoghurts. Mango yoghurt was found with significant amount of beta carotene, and it contained 25% fruit pulp. Mango is a good source of carotenoids among fruits (Simi and Rajmohan, 2013).

The mineral composition of fruit yoghurts showed a significant increase when compared with plain yoghurt. Only passion fruit yoghurt was obtained more amount calcium than plain yoghurt. This is agreeable with the study of Biswas *et al*. (2021) the passion fruit juice was found to contain an appreciable quantity of calcium. The phosphorus, sodium and potassium content were found to be higher in pineapple yoghurt. This result is similar to the findings of Ihemeje *et al*. (2015) when pepper fruit and carrot were added, calcium, phosphorus, magnesium, sodium, and potassium levels increased significantly. Ihemeje *et al*. (2013) found a comparable increase in minerals when pepper fruit was utilized in the manufacture of Zobo drinks. Magnesium content was higher in avocado yoghurt and while oxalate was found more in pineapple yoghurt.

5.3. STORAGE STABILITY OF THE FRUIT YOGHURTS

According to Kong (2011) Chemical, biological, and physical deteriorative processes can occur during food storage, resulting in changes in food colour, appearance, texture, and flavour, all of which have a substantial impact on the overall quality attributes and consumer acceptance of foods. Microbiological degradation, on the other hand, might result in food spoilage and safety concerns.

5.3.1. Sensory Evaluation of Fruit Yoghurt During Storage

During storage, the sensory quality of the products is one of the most important qualities to be observed and it can be done by assessing the changes in sensory parameters. In this study, the sensory quality of the six acceptable fruit yoghurts was observed during storage for two weeks.

In all the fruit yoghurts and control the scores for all the sensory attributes including overall acceptability decreased during the storage period of two weeks, but all the fruit yoghurts were consumable till the end of storage. The reduction in the sensory scores may be related to the decrease in pH of the yoghurts during storage. This could be due to the acidity development or the production of microbial metabolism which slightly harmed the rheological and sensory properties of the product. These results are similar to the findings of Punnagaiarasi *et al*. (2015) who reported that stirred papaya yoghurt made with 10 per cent fruit pulp also showed reduction in sensory scores during storage. Many fresh foods such as yoghurt after prolonged storage may be microbiologically safe to eat but may be rejected due to changes in its sensory properties. Sensory qualities have a clear relationship with product quality and consumer acceptance.

5.3.2. Physicochemical Parameters of Fruit Yoghurts

The changes in the physicochemical parameters like acidity, moisture, peroxide value, pH, syneresis and total soluble solids content of developed fruit yoghurts and control were studied for two weeks and the result obtained is discussed here.

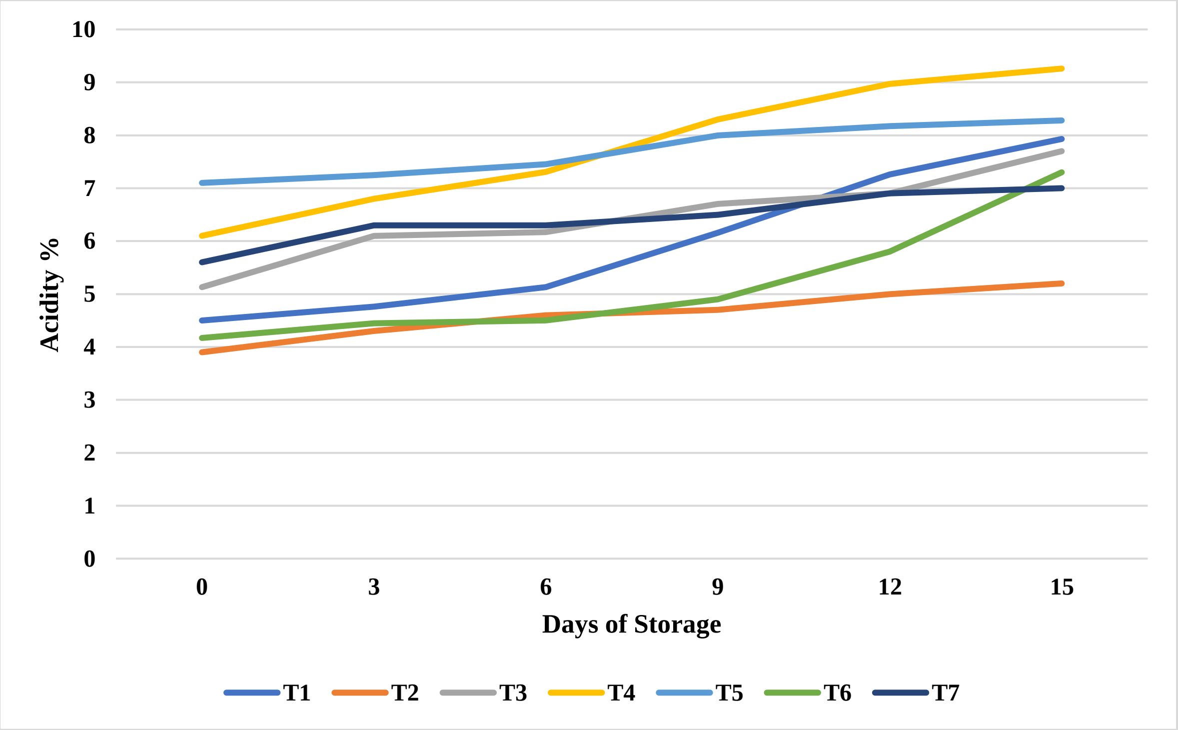
5.3.2.1. Evaluation of Acidity During Storage

The relationship between titratable acidity and pH during lactic acid fermentation were important. The total acid concentration of a food is measured by titratable acidity. Citric, malic, lactic, tartaric, and acetic acids are the most frequent organic acids found in foods. Organic acids in foods have an impact on flavour, colour, microbiological stability (pH-sensitivity characteristics of organisms), and preservation quality.

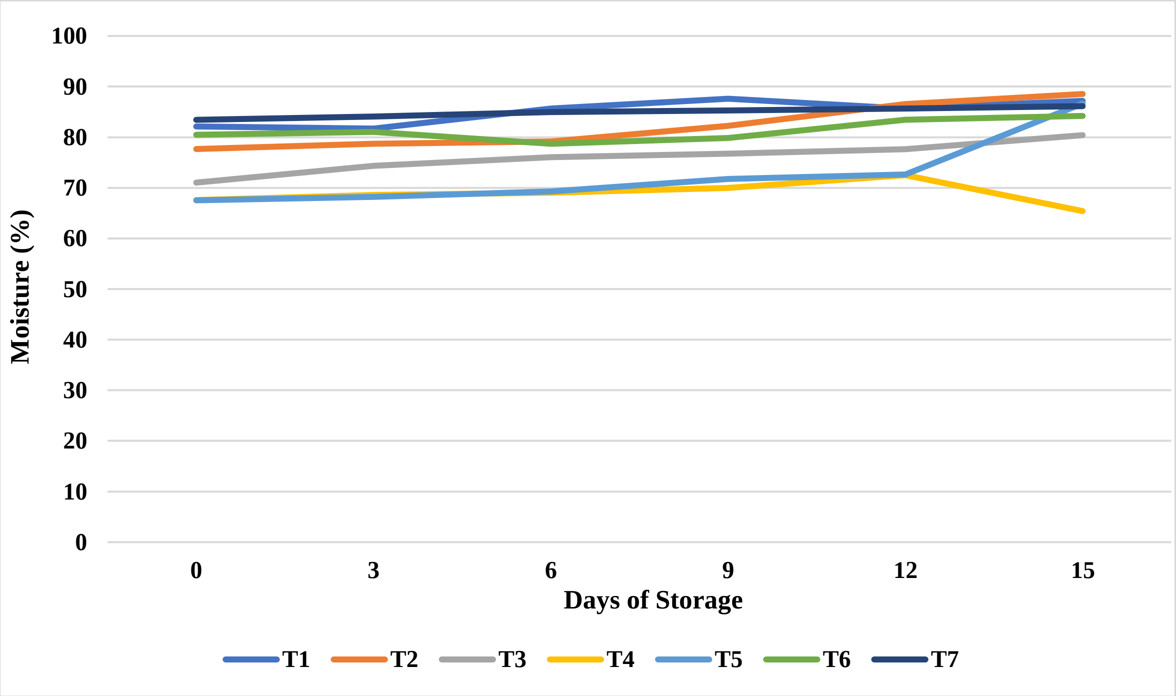
In the present study, there was a decrease in pH and an increase in titratable acidity during storage for all the treatments of fruit yoghurts and control. Increased acidity could be due to the production of lactic acid by the lactic acid bacteria. This finding was similar to the observation of Mahmood, (2008) and Tarakci, (2010) reported that the acidity of yoghurt was due to the growth of lactic acid bacteria and the lactic acid produced by that organism, which was due to a special kind of synergism between Lac. Spp. and Strep. spp.

Titratable acidity of fruit yoghurts increased with increased fruit percentage. A similar observation was reported by Debashis *et al*. (2016) who found that the acidity of fruit yoghurt was increased with increasing avocado, banana, mango, passion fruit, pineapple, and soursop pulp percentages. From the data obtained for the analysis of

Graph 12. Changes in Acidity of the fruit Yoghurts



Graph 13. Changes in Moisture Content of the fruit Yoghurts



acidity, it was found that there was a gradual increase in acidity of fruit yoghurts was with increasing percentages of fruit yoghurts. The result of this study indicates that 35% passion fruit pulp flavoured yoghurt had the highest (9.26%) titratable acidity, but it had the lowest pH of 3.3. Graph 12. shows the trend of acidity in fruit yoghurts.

5.3.2.2. Evaluation of Moisture During Storage

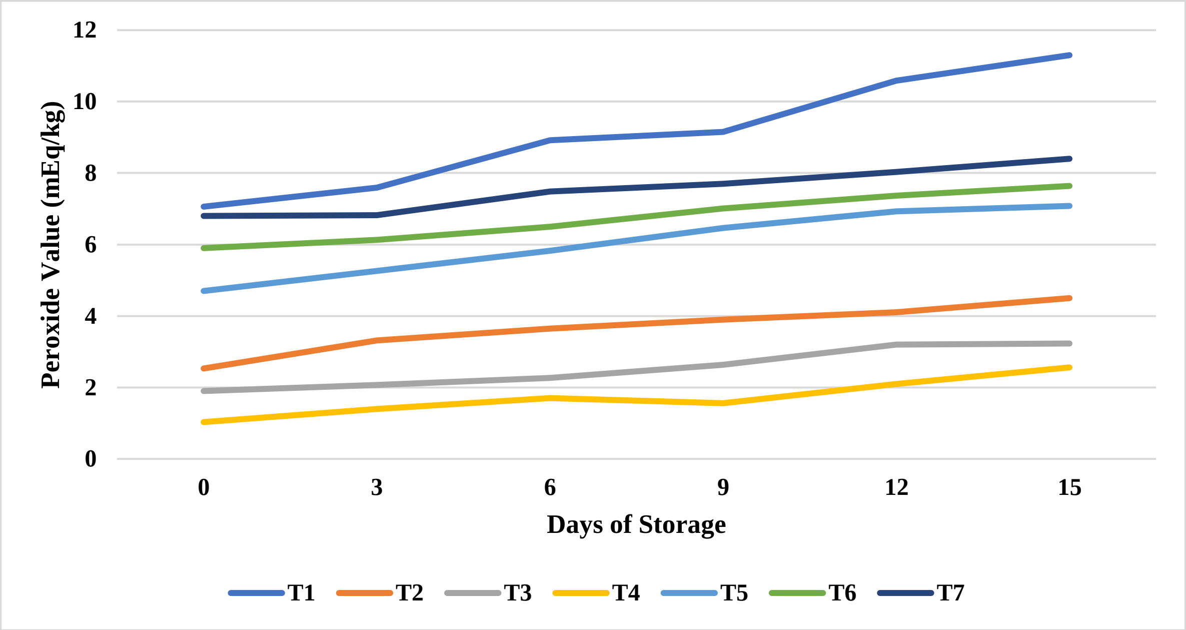
Moisture or water content is a measurement of a food product's total water content, which is normally stated as a percentage by weight on a wet basis. One of the most essential aspects of a consumer's sensory impression of food is its water content. Changes in moisture content have a significant impact on the flavour, texture, and physical and chemical qualities of foods (Mendes *et al*., 2011). The moisture change in the food will alter its texture. An increase in moisture content will increase molecular mobility in food and induce microbial growth.

There was a significant variation in the moisture content of fruit yoghurts compared to control yoghurt. Moisture content in fruit yoghurts was increased with the increase of fruit pulp except for the banana yoghurt. The highest (88.53%) and the lowest (65.4 %) moisture content were observed in T_2 and T_4 samples respectively. The moisture present in fruit pulp can influence the total moisture content of the product. This finding was consistent with the findings of Tarakci and Kucukoner's (2003) stated that the moisture level of fruit yoghurt may increase as a result of the high moisture content of fruit pulp.

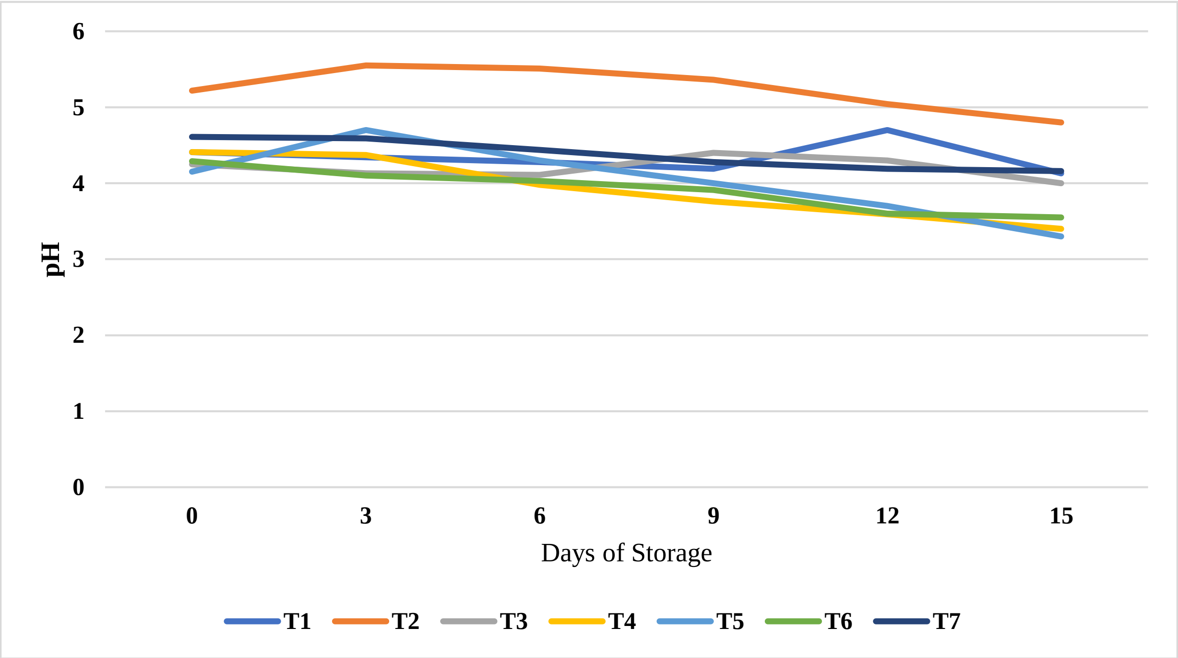
5.3.2.3. Evaluation of Peroxide Value During Storage

The milliequivalents (mEq) of peroxide per kilogram of fat is known as peroxide value. It determines how much peroxide or hydroperoxide groups are present in the oil or fat. From the analysis, it was found that the peroxide levels in all six fruit yoghurts rose with the number of days they were stored. The peroxide value of fruit yoghurts was ranged between 1.03 - 11.3. During storage, T_4A (Avocado yoghurt) reported the highest peroxide value of 11.3 mEq/kg (Table 19). Avocado fruit is a good oil source (Gunstone *et al*., 2007) that can contribute high oxidation rate in the fruit yoghurt. Zhong *et al*. (2017) reported that saturated fatty acids, which are generally stable to

Graph 14. Changes in Peroxide Value of the fruit Yoghurts



Graph 15. Changes in pH of the fruit Yoghurts



oxidation, were found in higher concentrations in yoghurt's milk fat. The changes in peroxide value during storage of fruit yoghurts was illustrated in Graph 14.

5.3.2.4. Evaluation of pH During Storage

The monitoring of pH is one of the important parts of the production of, high-quality yoghurt. Most yoghurts are inoculated with *Lactobacillus Bulgaricus* and *Streptococcus thermophilus* starter cultures. The mixture of milk and bacteria is incubated once the live culture is added, allowing lactose to be converted to lactic acid. There is a similar drop in pH as lactic acid is created. Most producers use a fixed point of pH 4.0 to 4.6. The amount of lactic acid present at this pH level is optimal for yoghurt, giving it its distinctive tartness, assisting in thickening, and acting as a preservative against bacteria strains that are harmful to humans (Masulli, 2016).

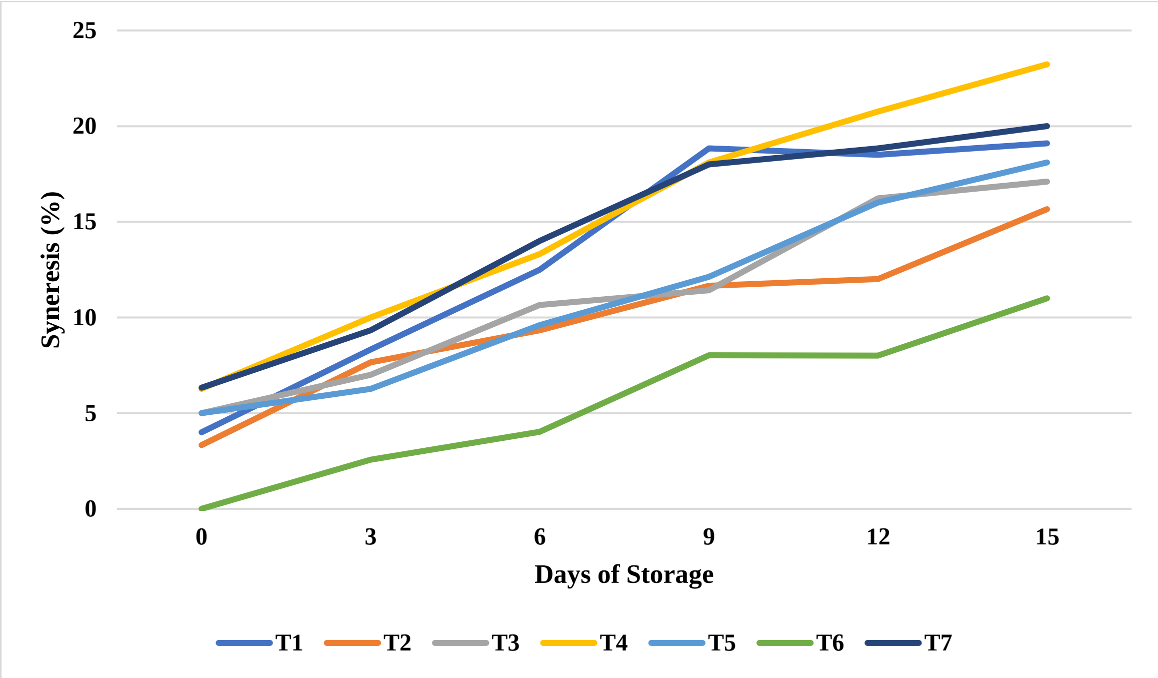
In the present study, the decreasing trend of pH was found higher in T_4 as compared to other preparations. Senadeera *et al*. (2016) reported that the lower pH was seen in the *Annona* fruit pulp containing dahi, which was attributable to the increased availability of carbohydrate supplies from fruits to the metabolic activity of yoghurt starter cultures. The change in pH of fruit yoghurt during refrigerated storage was due to the post acidification or fermentation process by the microorganisms as reported by Donkor *et al*. (2007) and Wang *et al*. (2010) also noticed the gradual reduction in pH of yoghurt.

From the evaluation of pH, it could be highlighted that there was a gradual decrease in the pH content of developed fruit yoghurts. Debashis *et al*. (2016) reported that the addition of fruit also contributes decrease in the pH of yoghurt. The highest pH was reported for T_4 (3.3) contains 35% passion fruit pulp. Changes in pH during refrigerated storages of fruit yoghurts was illustrated in Graph 16.

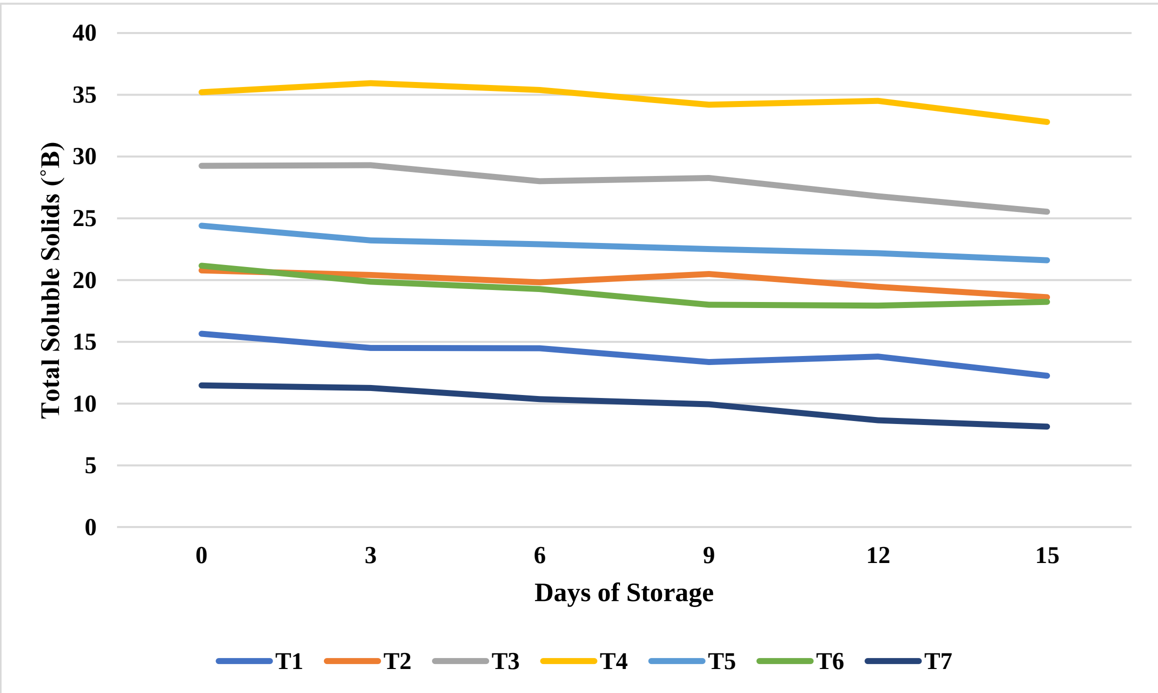
5.3.2.5. Evaluation of Syneresis During Storage

Syneresis is the process of expulsion of liquid from yoghurt, it is the opposite of the swelling process and one of the major quality parameters for assessing the quality of yoghurt. Harwalkar and Kalab, (1986) reported that a higher level of syneresis reveals that yoghurt is of low quality, and it is one of the defects frequently faced in yoghurt manufacture.

Graph 16. Changes in Syneresis of the fruit Yoghurts



Graph 17. Changes in Total Soluble Solid Content of the fruit Yoghurts



The developed fruit yoghurts and the plain yoghurt showed a high rate of syneresis during storage. Tarakci, 2003 found that both fruit concentration and storage time of fruit yoghurts can influence the percentage of syneresis. This rising tendency was in line with the findings of Lee & Lucey (2004), who found that whey separation from yoghurt increased with increased storage time due to excessive rearranging of particles that comprise the gel network in yoghurt, which influenced another rheological parameter. Olson and Aryana (2008) also reported that the extent of syneresis of yoghurt increased by decreasing the pH value. Low solid content, high incubation temperature, and poor storage conditions could all be factors in yoghurt's higher synergy value (Amaya-Liano *et al.*, 2008).

The analysis reveals that there is a gradual increase in the percentage of syneresis in all combinations of fruit yoghurts and the percentage of syneresis in the developed fruit yoghurt ranged between 0-23.23% during the two weeks of storage life. The highest percentage of syneresis was found in passion fruit yoghurt (T_4) with a pH of 3.3. The rate of syneresis during refrigerated storages of fruit yoghurts was illustrated in Graph 17.

5.3.2.6. Evaluation of Total Soluble Solids During Storage

The TSS, or sugar content, is a measurement of the fruit's carbohydrates, organic acids, proteins, lipids, and minerals. From the data evaluation, it was found that total soluble solids in the developed fruit yoghurt ranged between 35.94 – 12.25 ° B. The highest percentage of syneresis was found in passion fruit yoghurt (T_4) with a rate of 35.94 ° B that contains 35% fruit pulp. According to Salih and Abdalla (2017), the total solids content of yoghurt reduced correspondingly during storage when glucose and galactose concentrations increased, and the decrease in total solids content might possibly be related to the interaction of basic amino groups with lactose. Salwa *et al.* (2004) also discovered that adding high solids fruit preparations to fruit yoghurt increased the overall solids.

5.3.3. Microbial profile of fruit yoghurts

The yoghurt starter cultures should be either a pure culture of a certain Lactobacillus species or a 1:1 mixture of *Streptococcus thermophilus* and *Lactobacillus* *bulgaricus*. The rod, *Lactobacillus bulgaricus,* develops quicker than the coccus, *Streptococcus thermophilus,* and is principally responsible for acid generation, while the coccus gives flavour and aroma (Sansanwal *et al*., 2017). Initial bacterial counts indicated present in fruit yoghurt samples between 10.24-10.45 log cfu/g which typically meets the recommendation of at least 6 log CFU/g at time of consumption (Joint, 2011; Das *et al*., 2019). Prescott *et al.*, (2005) reported that lactic acid bacteria grow best in slightly acidic environments with pH levels between 4.5 and 6.4.

Graph 19. shows the pattern of change in total viability for fruit yoghurts held in the refrigerator (4°C). For fruit yoghurt, the bacterial count decreased 10.43 log cfu/g - 10 log cfu/g, whereas, for plain yoghurt (T_6), the bacterial count decreased from 10.24 log cfu/g to 10.18 log cfu/g. The decrease in the total viable count of bacteria for all the fruit yoghurts including control follows a similar trend. Various authors have reported a decrease in the total viable count during the storage of yoghurt (Lopez *et al*., 2014; Panesar and Shinde, 2012). Cell viability loss could be caused by a drop in pH during storage and the formation of organic acid because of growth and fermentation. (Kailasapathy *et al*., 2008).

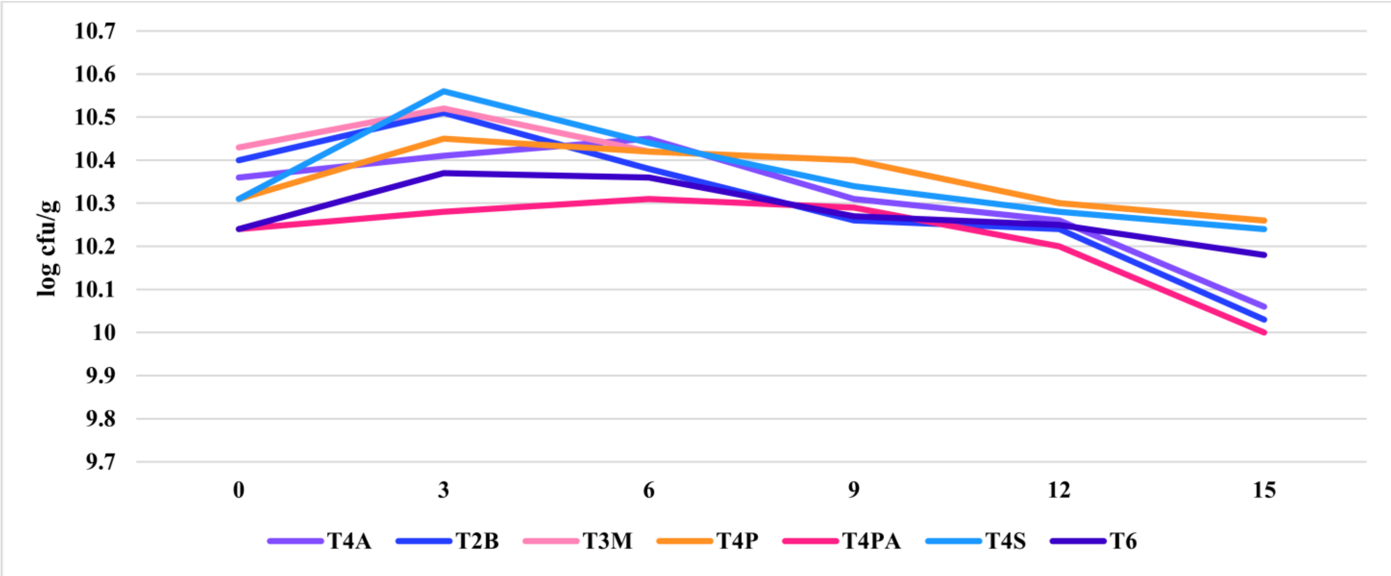
The FSSAI recommended amount bacterial count in yoghurt was 10^7 cfu/g. The developed all fruit yoghurts was met the recommended amount.

Fungal contamination of dairy products can happen at any point throughout the supply chain, from dairy farms to dairy processing plants to customers' homes. The data obtained revealed that the fungal colonies were exhibited variations in their number and showed a reduction in the number of colonies during the two weeks of storage period.

Salwa *et al*. (2004) found that the counts of yeast and mould in yoghurt made with 15% carrot juice decreased. From the study, it was found that the yeast mould rate decreased in fruit yoghurts when compared to the initial days of storage. The highest rate of decrease in yeast and mould count has occurred in mango yoghurt 5.90 log cfu/g on the last day of storage. Because of the fruit's sugar rate, the yeasts showed an increase in both incubation and storage times. (Kamber and Harmankaya, 2019).

The air and other environmental sources in processing facilities appear to be the primary causes of yeast and mould contamination of dairy products (Kure *et al*., 2001).

Graph 18. Total viable count of Bacteria



Tarakci and Kucukoner (2003) Fruit-flavored yoghurt promotes the growth of yeasts and moulds. The FSSAI recommended yeast and mould count in yoghurt was up to 50 cfu/g.

Coliforms are considered natural flora in the human and animal intestinal tracts, and their presence suggests direct faecal contamination. They have been utilized as indicators for the bacteriological quality of milk and its products. (ICMSF, 1986). After processing, the presence of coliform indicated contamination and a lack of hygiene. Because of the high temperature, short-time pasteurization, proper washing, and good hygienic processes, coliforms are not expected to be present in yoghurt (Kawo *et al*., 2006). There were no coliforms detected in all the fruit yoghurts and control during two weeks of storage study.

5.4. COST ANALYSIS OF THE DEVELOPED PRODUCTS

The cost analysis of the fruit yoghurts was done based on the cost of production. The cost of avocado yoghurt, banana yoghurt, mango yoghurt, passion fruit yoghurt, pineapple yoghurt and soursop yoghurt were Rs 240, 150, 210, 210, 190 and 230 respectively. The highest cost was to produce avocado yoghurt and the lowest cost was for banana yoghurt.

The current market price for mango and pineapple fruit yoghurts (epigamia) were Rs 270 and 380. The price for plain yoghurt was 160/kg and the cost of plain yoghurt in the market had Rs 200/- for 400g. This is a positive indication for large scale production and commercial exploitation of yoghurts from fruits (avocado, banana, mango, passionfruit, pineapple and soursop) with low production costs compared to the market price. This shows that the fruit yoghurts are economically suitable for production and promotion in the market.

Summary

6. SUMMARY

The study entitled “Development of fruit blended yoghurts and quality evaluation” was carried out at the Department of Community Science, College of Agriculture, Vellayani during the period of 2019-2021 with the objective to develop fruit blended yoghurts and to determine its quality parameters. The developed fruit yoghurts were studied for nutritional and chemical profile, organoleptic qualities, shelf life parameters and cost of production. The important findings of the study are summarized here.

Yoghurt enhanced with fruits possess high nutritional and functional value. Fruits mainly possess high fiber, potassium, antioxidants, polyphenols, and carotenoids. Furthermore, the dietary fiber in fruits can act as prebiotics for the microbes found in yoghurt. Yoghurt has wide acceptance worldwide and adding fruits to it provides additional benefits. Scientific evidence suggests that there is a lot of scope for making fruit yoghurts from wide range of fruits for market promotion.

The present study aims to utilize different underexploited fruits for the development of fruit yoghurts. Fruits selected for the study were optimum ripened avocado, banana (Robusta), mango (Moovandan), passion fruit, pineapple, and soursop. The milk selected was homogenised toned milk collected from Kerala Co-operative Milk Marketing Federation (milma) and yoghurt starter culture (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) was procured from college of Dairy Science and Technology, Thiruvananthapuram. The yoghurts were standardized using the method recommended by Remya *et al*. (2019) after some modifications. Fruit pulps were blanched at different temperature and time to reduce the enzymatic action and to remove the microorganisms present in the fruits.

The various treatments selected for the formulations of fruit yoghurts with homogenised toned milk, fruit pulp, sugar and starter culture respectively in the predetermined proportions were T_1 (85:15:12:2), T_2 (80:20:12:2), T_3 (75:25:12:2), T_4 (70:30:12:2), T_5 (65:35:12:2) and control (100:0:0:2). The treatments were similar for all the individual fruit yoghurts. The amount of sugar and starter culture were same in all combinations. The best proportions were organoleptically identified using 9 point hedonic scale.

The usage of various fruits in fruit yoghurts resulted in variations in sensory preferences. Based on the sensory evaluation of avocado yoghurt it was obtained that yoghurt with 70% homogenised toned milk, 30% fruit pulp, 12% sugar and 2% starter culture (T_4A) scored the highest value for most of the sensory parameters except appearance and taste. The other treatments of the avocado yoghurt were significantly different at 5% level. In the case of banana yoghurt 80% milk, 20% fruit pulp, 12% sugar and 2% starter culture (T_2B) was found to be the best fruit yoghurt proportion and all the five treatments of banana yoghurt were significantly different. The treatment T_3M with 75% milk, 25% fruit pulp, 12% sugar and 2% starter culture received the maximum score among all other treatments of mango yoghurt. T_4P from passion fruit yoghurt, T_4PA from pineapple yoghurt, and T_4S from soursop yoghurt with 70 per cent homogenised toned milk, 30 per cent fruit pulp, 2 per cent starter culture, and 12 per cent sugar obtained the highest score in the sensory evaluation. The selected treatments from each fruit yoghurt along with control was subjected to further organoleptic, nutrient, microbial and storage study.

The nutritional profile of the standardised fruit yoghurts differed significantly when compared with developed plain yoghurt. The energy content was found higher in avocado yoghurt (144.16 kcal) and higher concentration of calories was attributed from the fat content present in the avocado fruit. The lowest calorific value was noted in soursop yoghurt (99.70 kcal). The energy content of all fruit yoghurts was higher than the plain yoghurt (76.90 kcal). The carbohydrate content was higher in pineapple yoghurt (22.66 g/100g) while it was lower in avocado yoghurt (11.06 g/100g). The amount of protein was found higher (5.36 g/100g) in control than all fruit yoghurts because the addition of fruit pulp into the milk had greatly influenced the amount of protein content in all the developed fruit yoghurts. Among fruit yoghurts T_2B with 80% milk, 20% fruit pulp, 2 % starter culture and 12% sugar found maximum protein content because the amount of fruit pulp was lower (20%) in banana yoghurt and the major portion was occupied by the milk when compared to the remaining fruit yoghurts. A higher amount of fat was reported in the avocado yoghurt (9.60 g/100g) due to the high fat content present in avocado fruit. The plain yoghurt occupied fat content of 3.40g/100g.

The fiber content was found to be increased in fruit incorporated yoghurts., while plain yoghurt lack fiber. The highest and lowest amount of fiber content was present in pineapple yoghurt (0.72g/100g) and banana yoghurt (0.22 g/100g) respectively. The addition of fruit pulp and sugar into the yoghurt had greatly influenced the total sugar and reducing sugar content. Highest value of iron content was found in pineapple yoghurt (0.76 mg/100g).

The carotene and vitamin C contents were found to be increased in fruit yoghurts. The mango yoghurt was noted with higher (143.60 µg/100g) amount of beta carotene and lowest was in avocado yoghurt (13.30 µg/100g). Vitamin C was found more in pineapple yoghurt (9.02 mg/100g) and least in banana yoghurt (2.19 mg/100g). Calcium content in passion fruit yoghurt was higher (339.70 mg/100g) followed by other fruit yoghurts. Phosphorus (457.00 mg/100g), sodium (310.60 mg/100g), and potassium (281.80 mg/100g) content was higher in pineapple yoghurt.

The developed fruit yoghurt was stored at a refrigerated temperature of 4˚C and subjected to storage study at 3 days intervals for two weeks. During storage, the sensory scores of all parameters were found to be decreased for every fruit yoghurt.

The fruit yoghurts were analyzed for two weeks and studied for changes in physicochemical properties. The acidity of fruit yoghurts was ranged between 3.90%-9.26%. Higher acidity was found in passion fruit yoghurt because it has acidic pH. Lower pH was found in banana yoghurt. The acidity was increased due to the reduction in pH and higher concentration of lactic acid produced by the bacteria. The pH value of the developed products was ranged from 3.30 to 5.55. Maximum and minimum pH was noted in banana yoghurt and pineapple yoghurt. pH rate was found to be decreased during storage due to the fermentation process by the microorganisms and fruit pulp also aids in the pH content of yoghurts. The moisture content was increased during storage this can be due to the moisture content of fruits. Peroxide value was ranged between 1.03 - 11.30 mEq/kg. Avocado was shown high peroxide value due to the presents of high fat content. The peroxide value of all fruit yoghurt showed an increasing trend because milk contains considerable amount of saturated fatty acids. Soursop yogurt was found with no syneresis, while the passion fruit yoghurt showed high rate (23.23%) of syneresis at the end of storage period. The rate of syneresis can be influenced by concentration of fruit pulp and storage time. The total soluble solids of the fruit yoghurts were ranged between 12.25-35.94 ° B and found decreased during the entire time of storage study.

The total viable count in the fruit yoghurts including plain yoghurt found to be decreased due to the low acidity caused by the production of lactic acid by the lactic acid bacteria present in the yoghurt which in turn result in lower pH. The fruit yoghurts including control were free from coliforms, while in yeast and mould count and in fugal count a decreasing trend in the number of colonies were found during the two weeks of storage period. The microbiological analyses are thought to be possibly caused by the methods used, the types of fruit, storage durations and the starter culture used

The cost of the developed products was calculated using production costs, which comprised materials, machinery, and electric charge. The highest cost was reported for the production of avocado yoghurt with a rate of Rs 240/ kg while that of plain yoghurt was Rs. 160/kg. The production cost was profitable when compared to the market price of plain yoghurt and fruit yoghurts.

This study on the development of fruit blended yoghurts and quality evaluation summarized that the addition of fruit pulp into the yoghurt had a positive impact on the nutrient and sensory properties of the developed fruit yoghurts. The yoghurt combined with fruit pulp and homogenised toned milk at a ratio of 30:70 was the most selected proportion among the fruit yoghurt samples formulated. As per the findings of this study, fruit yoghurts of good nutritional and storage quality can be prepared without the use of any stabilizers which helps to maintain the consistency of yoghurt. The developed fruit yoghurts are rich in nutrients especially energy, vitamin C, beta carotene and fiber.

Reference

7. REFERENCES

Adolfsson, O., Meydani, S.N., and Russell, R.M. 2004. Yogurt and gut function. *Am. J. clin. Nutr.* 80: 245-256.

Akubor, P.I. 2016. Quality evaluation and storage properties of yogurt supplemented with pineapple juice. *Int. J. Sci. Knowl.* 5: 23-31.

Amadou, N.M., Yunenui, M.P., Waingeh, N.C., and Helene, I. 2016. Physicochemical, microbiological, and sensory properties of pineapple (*Ananascomosus* (L.) *Merr*.) Flavoured Yoghurt. *Int. J. Agric. Innovations Res.* 4: 1154-1158.

Amal, A., Eman, A., and Nahla, S.Z. 2016. Fruit flavored yogurt: Chemical, functional and rheological properties. *Int. J. Environ. Agric. Res.* 2: 57-66.

Amaya-Llano, S.L., Martínez-Alegría, A.L., Zazueta-Morales, J.J., and Martínez-Bustos, F. 2008. Acid thinned jicama and maize starches as fat substitute in stirred yogurt. *LWT-Food Sci. Technol.* 41: 1274-1281.

Ames, I.A., Sfakianakis, P., and Tzia, C. 2014. Conventional and innovative processing of milk for yogurt manufacture; development of texture and flavor: A review. *Foods* 3: 176-193.

Anon 2007. Scenario of banana production, utilization and trade. In: *Production and utilization of banana for economic livelihood and nutritional security*. Proceedings of a National Conference, 25–28th October 2007, New Delhi. Indian Council of Agricultural Research, India, pp. 308-311.

AOAC [Association of Official Analytical Chemists]. 2000. Official methods of analysis (17^{th} Ed.). Washington D.C. 1212p.

AOAC [Association of Official Analytical Chemists]. 2005. Official methods of analysis. PP.97-424.

AOAC [Association of Official Analytical Chemists].1980. Official methods of analysis (13^{th} Ed.). Washington D.C. 738p.

AOAC [Association of Official Analytical Chemists].1990. Official methods of analysis (12^{th} Ed.). Washington D.C. 1141p.

AOAC [Association of Official Analytical Chemists].1994. Official methods of analysis (15th Ed.), Washington D.C. 156p.

Ara, A., Uddin, J.M., Saha, S., Khan, M.H., and Baset, M.A. 2015. Intervention of fruit juice in yoghurt preparation. *J. Sci. Technol.* 11: 30-35.

Ariaii, P., Mahmoudi, M., and Amoli, R. I. 2011. The production of fruity yoghurt with banana flavor. *Food Sci. Technol.* 6: 368–370.

Arroqui, C., Rumsey, T.R., Lopez, A., and Virseda, P. 2001. Effect of different soluble solids in the water on the ascorbic acid losses during water blanching of potato tissue. *J. Food Eng.* 47: 123-126.

Arslan, S. and Ozel, S. 2012. Some properties of stirred yoghurt made with processed grape seed powder, carrot juice or a mixture of grape seed powder and carrot juice. *Milchwissenschaft* 67(3): 281-285.

Astrup, A., 2014. Yogurt and dairy product consumption to prevent cardiometabolic diseases: epidemiologic and experimental studies. *Am. J. clin. Nutr.* 99: 1235S-1242S.

Aswal, P., Shukla, A., and Priyadarshi, S., 2012. Yoghurt: Preparation, characteristics and recent advancements. *Cibtech J. Bio-Protocols* 1: 32-44.

Athar, I.H., Shah, M.A. and Khan, U.N. 2000. Effect of various stabilizers on whey separation (syneresis) and quality of yoghurt. *Pakist. J. Biol. Sci.* 3: 1336–1339.

Athira Babu, D. and Saranya, S. 2019. Standardisation and sensory quality analysis of nutritious product from an indigenous fruit (Annona muricata). *Int. J. Home Sci.* 5(1): 189-192.

Ayar, A. and Gurlin, E. 2014. Production and sensory, textural, physicochemical properties of flavored spreadable yoghurt. *Life Sci. J.* 11(4): 58–65.

Azcarate-Peril, M.A., Altermann, E., Hoover-Fitzula, R.L., Cano, R.J., and Klaenhammer, T.R. 2004. Identification and inactivation of genetic loci involved with Lactobacillus acidophilus acid tolerance. *Appl. Environ. Microbiol*. 70: 5315-5322.

Bae, S. H. and Suh, H. J. 2007. Antioxidant activities of five different mulberry cultivars in Korea. *LWT - Food Sci. Technol.* 40(6): 955–962.

Barrantes, E., Tamime, A.Y., Muir, D.D., and Sword, A.M. 1994. The effect of substitution of fat by microparticulate whey protein on the quality of set-type, natural yogurt. *Int. J. Dairy Technol.* 47: 61-68.

Beal, C., Skokanova, J., Latrille, E., Martin, N. and Corrieu, G., 1999. Combined effects of culture conditions and storage time on acidification and viscosity of stirred yogurt. *J. Dairy Sci.* 82: 673-681.

Bhattarai, N., Pradhananga, M., and Mishra, S.K. 2015. Effects of Various Stabilizers on Sensorial Quality of Yoghurt. *Sunsari Tech. Coll. J.* 2: 7-12.

Bille, P.G. and Keya, E.L. 2002. A comparison of some properties of Vat-heated and dry skim milk powder fortified set yoghurts. *J. Food Technol. Afr.* 7(1): 21-23.

Biswas, A. A. 1997. Effect of Banana (*Musa sapientum*) leaf on the keeping quality of raw milk. MSc (Ag) thesis, Bangladesh Agricultural University, Mymensingh, 24p.

Blassy, K.I. and Abdeldaiem, A.M. 2019. Effect of replacing skim milk powder by sweet lupine powder on characteristics of zebda-mango yoghurt drink. *Ismailia J. Dairy Sci. Technol.* 6(1): 9-17.

Boelrijk, A.E.M., Jong, C.D. and Smit, G., 2003. Flavour generation in dairy products. In: Smith, G. (eds), Dairy *Processing.* Woodhead Publishing LTD, Cambridge, UK, pp. 128–153.

Bouzar, F., Cerning, J., and Desmazeaud, M. 1997. Exopolysaccharide production and texture promoting abilities of mixed-strain starter cultures in yogurt production. *J. Dairy Sci.* 80: 2310–2317

Bradford, M.M. 1976. Rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding & quot. *Anal. Biochem*. 72: 248–254.

Brassart, D. and Schiffrin, E.J.,1997. The use of probiotics to reinforce mucosal defence mechanisms. *Trends Food Sci. Technol.* 8(10): 321-326.

Cakmakci, S., Cetin, B., Turgut, T., Gurses, M., and Erdogan, A. 2012. Probiotic properties, sensory qualities, and storage stability of probiotic banana yogurts. *Turkish J. Vet. Anim. Sci*. 36: 231-237.

Casarotti, S.N., Monteiro, D.A., Moretti, M.M., and Penna, A.L.B. 2014. Influence of the combination of probiotic cultures during fermentation and storage of fermented milk. *Food Res. Int*. 59: 67-75.

Cayot, P., Schenker, F., Houze, G., Sulmont-Rosse, C., and Colas, B. 2008. Creaminess in relation to consistency and particle size in stirred fat-free yogurt. *Int. Dairy J.* 18: 303-311.

Celik, S. and Bakirci, I. 2003. Some properties of yoghurt produced by adding mulberry pekmez (concentrated juice). *Int. J. Dairy Technol.* 56(1): 26–29.

Cha, J., Roomi, M.W., Ivanov, V., Kalinovsky, T., Niedzwiecki, A., and Rath, M. 2013. Ascorbate supplementation inhibits growth and metastasis of B16FO melanoma and 4T1 breast cancer cells in vitamin C-deficient mice. *Int J Oncol.* 42: 55-64.

Chandan, R.C. and Kilara, A. 2011. *Dairy Ingredients for Food Processing*. Wiley-Blackwell, Hoboken, 364p.

Chen, C., Zhao, S., Hao, G., Yu, H., Tian, H., and Zhao, G. 2017. Role of lactic acid bacteria on the yogurt flavour: A review. *Int. J. Food Properties* 20: S316-S330.

Coisson, J.D., Travaglia, F., Piana, G., Capasso, M., and Arlorio, M. 2005. Euterpe oleracea juice as a functional pigment for yogurt. *Food Res. Int.* 38: 893-897.

Cox, H.E. and Pearson, D. 1962. *The chemical analysis of foods chemical*. Publishing Campus, New York, 420p.

Das, K., Choudhary, R., and Thompson-Witrick, K.A. 2019. Effects of new technology on the current manufacturing process of yogurt-to increase the overall marketability of yogurt. *Lwt- Food Sci. Technol.* 108: 69-80.

Debnath, P., Dey, P., Chanda, A., and Bhakta, T. 2012. A Survey on Pineapple and its medicinal value. *Scholars Acad. J. Pharmacy* 1: 24-29.

Dimitrellou, D., Solomakou, N., Kokkinomagoulos, E., and Kandylis, P. 2020. Yogurts supplemented with juices from grapes and berries. *Foods* 9: 1158.

Donato, L. and Guyomarch, F. 2009. Formation and properties of the whey protein kappa $-casein complexes in heated skim milk–A review. *Dairy Sci. Technol.* 89(1): 3-29.

Donkor, O.N., Tsangalis, D., and Shah, N.P. 2007. Viability of probiotic bacteria and concentrations of organic acids in commercial yoghurts during refrigerated storage. *Food Aust.* 59: 121-126.

Dougkas, A., Reynolds, C.K., Givens, I.D., Elwood, P.C., and Minihane, A.M. 2011. Associations between dairy consumption and body weight: a review of the evidence and underlying mechanisms. *Nutr. Res. Rev.* 24: 72-95.

Dowden, A., 2013. The good yoghurt guide. Daily Mail, [online]. Available: <http://www.dailymail.co.uk/health/article-19005/The-good-yoghurt-guide.html> [4-12- 2013].

Ebringer, L., Ferencik, M., and Krajcovic, J. 2008. Beneficial health effects of milk and fermented dairy products. *Folia microbiologica* 53: 378-394.

Ekere, K.S. 2014. Production and evaluation of flavoured yoghurt from graded levels of soursop. *Innovare J. Food Sci.* 2: 14-21

El-Abbadi, N.H., Dao, M.C., and Meydani, S.N. 2014. Yogurt: role in healthy and active aging. *Am. J. Clin. Nutr*. 99: 1263S–1270S.

El-Malt, L.M., Abdel Hameed, K.G., and Mohammed, A.S. 2013. Microbiological evaluation of yoghurt products in Qena city, *Egypt Vet. World* 7: 400-404.

Endo, A. and Dicks, L.M.T. 2014. Biodiversity and Taxonomy. In: Holzapfel, W.H. and Wood, B.J.B. (eds), *Physiology of the LAB In Lactic Acid Bacteria*. Wiley-Blackwell, West Sussex, pp. 13–30

Farahat A. M. and El-Batawy O. I. 2013. Proteolytic activity and some properties of stirried fruit yoghurt made using some fruits containing proteolytic enzymes. *World J. Dairy Food Sci.* 8 (1): 38-44.

Fernandez, M.A. and Marette, A. 2017. Potential health benefits of combining yogurt and fruits based on their probiotic and prebiotic properties. *Adv. Nutr*. 8(1): 155S-164S.

Fisberg, M. and Machado, R. 2015. History of yogurt and current patterns of consumption. *Nutr. Rev.* 73(1): 4–7.

Fiszman, S.M. and Salvador, A. 1999. Effect of gelatine on the texture of yoghurt and of acid-heat-induced milk gels. *Zeitschrift fur Lebensmitteluntersuchung und-Forschung* 208(2): 100-105.

Fleet, G. 1990. Yeasts in dairy products. *A Rev. J. Appl. Bacteriol*. 4:145–155.

Florissen, P., Ekman, J.S., Blumenthal, C., McGlasson, W.B., Conroy, J., and Holford, P. 1996. The effects of short heat-treatments on the induction of chilling injury in avocado fruit (Persea americana Mill). *Postharvest Biol. Technol.* 8: 129-141.

Fresco, P., Borges, F., Marques, M.P.M., and Diniz, C. 2010. The anticancer properties of dietary polyphenols and its relation with apoptosis. *Curr. Pharma. Des.* 16:114-134.

Fulgoni, V.L., Keast, D.R., and Drewnowski, A. 2009. Development and validation of the nutrient-rich foods index: a tool to measure nutritional quality of foods. *J Nutr.*139: 1549–54.

Gad, A. S., Ghita, E. I., El-Din, H. M. F., Badran, S. M. A., and El-Messery, T. M. 2015. Evaluation yogurt fortified with vegetable and fruit juice as a natural source of antioxidant. *Int. J. Food Nutr*. Sci. 4: 21-28.

Gassull, M., Jenkins, D.A., Trowell, H., Southgate., David, A.T., Wolever, T.S., and Leeds, A.R. 1976. Dietary fibre redefined. *The Lancet* 307: 967.

Ghadge, P.N., Prasad, K., and Kadam, P.S. 2008. Effect of fortification on the physico-chemical and sensory properties of buffalo milk yoghurt. *Electr. J. Environ. Agric. food chem*. 7: 2890-2899.

Ghasempour, Z., Alizadeh, M., and Bari, M.R. 2012. Optimisation of probiotic yoghurt production containing Zedo gum. *Int. Dairy Technol.* 65: 118-125.

Gomez-Alonso, S., Mancebo-Campos, V., Ma, D.S., and Fregapane, G. 2004. Oxidation kinetics in olive oil triacylglycerols under accelerated shelf-life testing (25–75°C). *Eur. J. Lipid Sci. Technol*. 106: 369–375.

Gougouli, M., Kalantzi, K., Beletsiotis, E., and Koutsoumanis, K.P. 2011. Development and application of predictive models for fungal growth as tools to improve quality control in yogurt production. *Food Microbiol.* 28: 1453-1462.

Guarner, F., Perdigon, G., Corthier, G., Salminen, S., Koletzko, B., and Morelli, L. 2005. Should yoghurt cultures be considered probiotic. *Br. J. Nutr.* 93: 783-786.

Guler, Z. and Park, Y.W. 2011. Characteristics of physico-chemical properties, volatile compounds and free fatty acid profiles of commercial set-type Turkish yoghurts. *Open J. Anim. Sci.* 1(1): 1-9.

Gunstone, F.D., Alander, J., Erhan, S.Z., Sharma, B.K., McKeon, T.A. and Lin, J.T. 2007. Nonfood uses of oils and fats. In: Gunstone, F.D., Harwood, J.L. and Dijkstra, A.J. (eds), *The Lipid Handbook with CD-ROM*. CRC Press, Boca Raton, pp. 605-650.

Halliwell, B. 1996. Antioxidants in human health and disease. *Annu. Rev. Nutr.* 16: 33-50.

Han, X., Lee, F.L., Zhang, L., and Guo, M.R. 2012. Chemical composition of water buffalo milk and its low-fat symbiotic yogurt development. *Funct. Foods Health Dis.* 2: 86-106.

Harwalkar, V.R. and Kalab, M. 1986. Relationship between microstructure and susceptibility to syneresis in yoghurt made from reconstituted nonfat dry milk. *Food Structure* 5(2): 13-14.

Hashim, I.B., Khalil, A.H., and Afifi, H.S. 2009. Quality characteristics and consumer acceptance of yogurt fortified with date fiber. *J. Dairy Sci.* 92: 5403-5407.

Hedge, J.E. and Hofreiter, B.T. 1962. *Carbohydrate Chemistry*. Academic Press, Newyork, 17p.

Hettige, K.D.T., Ranadheera, C.S., Jayawardena, N.W.I.A. and Vidanarachchi, J.K. 2013. Quality evaluation of avocado (Persea americana) fruit yoghurt made from buffalo milk. In: *Proceedings of the International Symposium on Agriculture and Environment*, 28 November 2013, University of Ruhuna, Sri Lanka. Faculty of Agriculture, University of Ruhuna, pp. 51-54.

Holt, C., Carver, J.A., Ecroyd, H., and Thorn, D.C. 2013. Invited review: Caseins and the casein micelle: Their biological functions, structures, and behavior in foods. *J. Dairy sci.* 96: 6127-6146.

Hossain, M.F., Akhtar, S., and Anwar, M. 2015. Nutritional value and medicinal benefits of pineapple. *Int. J. Nutr. Food Sci.* 4: 84-88.

Hossain, M.N. and Islam, M.N. 2012. Quality comparison and acceptability of yoghurt with different fruit juices. *J. Food Processing Technol.* 3(8): 171-172.

Hseu, Z.Y. 2004. Evaluating heavy metal contents in nine composts using four digestion methods. *Bioresource Technol.* 5: 53–9.

Ihemeje, A., Nwachukwu, C.N., and Ekwe, C.C. 2015. Production and quality evaluation of flavoured yoghurts using carrot, pineapple, and spiced yoghurts using ginger and pepper fruit. *Afr. J. Food Sci.* 9: 163-169.

Ihemeje, A., Ojinnaka, M.C., Obi, K.C., and Ekwe, C.C. 2013. Biochemical evaluation of pepper fruit (Dennettia tripetala) and its use as substitute for ginger in zobo drink production. *Acad. Res. Int*. 4: 513-514.

International Commission on Microbiological Specification for Food [ICMSF].1986. *Sampling for Microbiological Analysis and Specific Application*. University of Toronto Press, Toronto, pp. 55 – 58.

Islam, M.N., Rahman, M.M., Parvin, S., and Rahman, M.F. 2002. Evaporation rate of moisture from dahi (yogurt) during storage at refrigerated condition. *Pak. J. Nutr*. 1: 209-211.

Jackson, M. L. 1973. *Soil Chemical Analysis* (2nd Ed.). Prentice Hall of India, New Delhi, 498p.

Jaros, D. and H. Rohm, 2003. Controlling the texture of fermented dairy products: the case of yoghurt. In:Smit, G. (ed.), *Dairy Processing*. Woodhead Publishing, Cambridge, pp. 155– 184.

Jeyasekaran, P. and Deepa, M. 2021. Formulation of stirred probiotic fruit yoghurt to boost immunity. *J. Exp. Biol. Agric. Sci.* 9(1): 169-175.

Joint, F. and World Health Organization, 2011. *Milk and milk products* (2nd Ed.). Electronic Publishing, Rome, 244 p.

Judprasong, K., Charoenkiatkul, S., Sungpuag, P., Vasanachitt, K., and Nakjamanong, Y. 2012. Total and soluble oxalate contents in Thai vegetables, cereal grains and legume seeds and their changes after cooking. *J. Food Composition and Anal.* 19: 340-347.

Kailasapathy, K., Harmstorf, I., and Phillips, M. 2008. Survival of Lactobacillus acidophilus and Bifidobacterium *animalis ssp*. lactis in stirred fruit yogurts. *LWT - Food Sci. Technol.* 41: 1317–1322.

Kamber, U. and Harmankaya, S. 2019. The effect of fruits to the characteristics of fruit yogurt. *Pakist. J. Agric. Sci.* 56(2): 495-502.

Karagul-Yuceer, Y. and Drake, M. 2006. Sensory analysis of yogurt. *Manufacturing yogurt and fermented milks*, 66(2): 265-270.

Kaur, R., Kaur, G., Mishra, S.K., Panwar, H., Mishra, K.K., and Brar, G.S. 2017. Yogurt: a nature's wonder for mankind. *Int. J. Fermented Foods* 6: 57-69.

Kawo, B.C., Srepp, T., and Bolta, J.R. 2006. Factors leading to the facture of yogurt. *J. Dairy Sci. Abstr.* 39: 149-150.

Kelishadi, R., Farajian, S., Safavi, M., Mirlohi, M., and Hashemipour, M. 2014. A randomized triple-masked controlled trial on the effect of synbiotics on inflammation markers in overweight children. *J. Pediatr*. 90: 161–168.

Keogh, M. K. and O'Kennedy, B. T. 1998. Rheology of stirred yogurt as affected by added milk fat, protein and hydrocolloids. *J. Food Sci*. 63(1): 108-112.

Khatoon, N., Ali, S., Liu, N., and Muzammil, H.S. 2021. Preparation and Quality Assessment of Fruit Yoghurt with Persimmon (*Diospyros kaki*): Quality assessment of fruit yoghurt with persimmon, *Proceedings of the Pakistan Academy of Sciences: B. Life and Environmental Sciences*, *58*(1), pp.111-128.

Khedkar, J.N., Choudhari, D.M., Pawar, B.K., and Kadam, V.S. 2015. Development of fruit based yoghurt. *Res. J. Anim. Husb. Dairy Sci.* 6: 72-75.

Kilara, A. 2006. Basic dairy processing principles. In: Chandan R.C. (ed.), *Manufacturing Yogurt and Fermented Milks.* Blackwell Publishing, USA, pp. 73–89.

Kim, H. S. and Gilliland, S. E. 1983. Lactobacillus acidophilus as a dietary adjunct for milk to aid lactose digestion in humans. *J. Dairy Sci*. 66(5): 959–966.

Kim, H.S., Kim, Y.J., Chon, J.W., Kim, D.H., Song, K.Y., Kim, H., and Seo, K.H. 2017. Organoleptic evaluation of the high-protein yoghurt containing the edible insect *Oxya chinensis sinuosa* (grasshopper): A preliminary study. *J. Dairy Sci. Biotechnol.* 35: 266-269.

King, S., Glanville, J., Sanders, M.E., Fitzgerald, A., and Varley, D. 2014. Effectiveness of probiotics on the duration of illness in healthy children and adults who develop common acute respiratory infectious conditions: a systematic review and meta-analysis. *Br. J. Nutr.* 112: 41-54.

Kong, F. and Singh, R.P. 2011. Advances in instrumental methods to determine food quality deterioration. In: Kilcast, D. and Subramaniam, P.(eds), *Food and beverage stability and shelf life*. Woodhead Publishing, Philadelphia, pp. 381-404.

Kucukoner, E. and Tarakci, Z. 2003. Influence of different fruit additives on some properties of stirred yoghurt during storage. *J. Agric. Sci.* 13(2): 97-101.

Kudachikar, V.B., Kulkarni, S.G., Vasantha, M.S., and Aravinda Prasad, B. 2007. Effect of modified atmosphere packaging on shelf-life and fruit quality of banana stored at low temperature. *J. Food Sci. Technol.* 44: 74-78.

Kulasinghe, W.M.A.A., Abesinghe, A.M.N.L., and Gunawardhane, L.K.A. 2015. Development of Avocado (*Persea americana*) Incorporated Set Yoghurt. Proceedings of the Research Symposium of Uva Wellassa University, 356p.

Kumar, P. and Mishra, H.N. 2003. Effect of mango pulp and soymilk fortification on the texture profile of set yoghurt made from buffalo milk. *J. Texture Stud.* 34(3): 249-269.

Kure, C.F., Wasteson, Y., Brendehaug, J., and Skaar, I. 2001. Mould contaminants on Jarlsberg and Norvegia cheese blocks from four factories. *Int. J. Food Microbiol.* 70: 21-27.

Larrauri, J.A. 1999. New approaches in the preparation of high dietary fibre powders from fruit by-products. *Trends Food Sci. Technol.* 10: 3-8.

Lawless, H.T. and Heymann, H. 2013. *Sensory evaluation of food: principles and practices* (2nd Ed). Springer Science & Business Media, 152p.

Lebaka, V.R., Wee, Y.J., Ye, W., and Korivi, M. 2021. Nutritional composition and bioactive compounds in three different parts of mango fruit. *Int. J. Environ. Res. Public Health* 18: 741-742.

Lee, H., Rangavajhyala, N., Grandjean, C., and Shahani, K.M. 1996. Anticarcinogenic effect of Lactobacillus acidophilus on N-nitrosobis (2-oxopropyl) amine induced colon tumor in rats. *J. Appl. Nutr.* 48: 59-66.

Lee, W. J. and Lucey, J. A. 2004. Structure and physical properties of yogurt gels: effect of inoculation rate and incubation temperature. *J. Dairy Sci.* 87(10): 3153-3164.

Lewis M.J. 2003. Improvements in the pasteurisation and sterilisation of milk. In: Smith, G. (ed.), *Dairy Processing.* Woodhead Publishing LTD, Cambridge, pp. 79–102.

Ley, R.E., Turnbaugh, P.J., Klein, S., and Gordon, J.I. 2006. Human gut microbes associated with obesity. *Nature* 444: 1022-1023.

Liu, R.H. 2013. Health-promoting components of fruits and vegetables in the diet. *Adv. Nutr.* 4: 84S–92S.

Loke, W.M., Proudfoot, J.M., Hodgson, J.M., McKinley, A.J., Hime, N., Magat, M., Stocker, R., and Croft, K.D. 2010. Specific dietary polyphenols attenuate atherosclerosis in apolipoprotein E–knockout mice by alleviating inflammation and endothelial dysfunction. *Arteriosclerosis Thrombosis Vascular Biol.* 30: 749-757.

Lourens-Hattingh, A. and Viljoen, B. C. 2001. Yoghurt as probiotic carrier in food. *Int. Dairy J.* 11(1): 1-17.

Luana, N., Rossana, C., Curiel, J.A., Kaisa, P., Marco, G., and Rizzello, C.G. 2014. Manufacture and characterization of a yogurt-like beverage made with oat flakes fermented by selected lactic acid bacteria. *Int. j. Food Microbiol*. 185: 17-26.

Lunn, J. and Buttriss, J.L. 2007. Carbohydrates and dietary fibre. *Nutr. Bull.* 32(1): 21-64.

MacBean, R.D. 2009. Packaging and the shelf life of yogurt. In: Robertson, G.L. (ed.), *Food packaging and shelf life: A practical guide*. CRC Press, Florida, pp 143–154.

Magar, S.T. 2021. Microbial Spoilage of Milk and Milk Products (Cream, Butter, Cheese, Yoghurt, Ice-cream) [Online]. Available: https://microbenotes.com/spoilage-of-milk-and-milk-products/ [24-03-2021].

Magenis, R.B., Prudencio, E.S., Amboni, R.D., Cerqueira Junior, N.G., Oliveira, R.V., Soldi, V., and Benedet, H.D. 2006. Compositional and physical properties of yogurts manufactured from milk and whey cheese concentrated by ultrafiltration. *Int. J. Food Sci. Technol.* 41: 560-568.

Mahmood, A., Abbas, N., and Gilani, A.H., 2008. Quality of stirred buffalo milk yogurt blended with apple and banana fruits. *Pakis. J. Agric. Sci.* 45: 275-279.

Mahmood, M.I. 2008. Quality of mango juice flavoured yoghurt. MSc thesis, Al-Zaiem Al-Azhari University, Khartoum North, 122p.

Mani-Lopez, E., Palou, E., and Lopez-Malo, A. 2014. Probiotic viability and storage stability of yogurts and fermented milks prepared with several mixtures of lactic acid bacteria. *J. Dairy sci.* 97: 2578-2590.

Manisha, W.H., Rajak, R., Jat, D. 2017. Oxidative stress and antioxidants: An Overview. *Int. J. Advanced Res. Rev.* 2: 110-119.

Mansour, A.A., Khalifa, M.Y., and Hanafy, N.M. 1994. Utilization of some dairy by-products in yoghurt manufacture. *Egyptian J. Food Sci*. 22: 87-97.

Marette, A. and Pickard-Deland, E. 2014. Yogurt consumption and impact on health: focus on children and cardiometabolic risk. Am. *J. Clin. Nutr.* 99(5): 1243S–1247S.

Marshall, V.M. and Cole, W.M. 1983. Threonine aldolase and alcohol dehydrogenase activities in Lactobacillus bulgaricus and Lactobacillus acidophilus and their contribution to flavour production in fermented milks. *J. Dairy Res.* 50(3): 375-379.

Masulli, D., 2016. Measuring pH of Yogurt. Food Quality & Safety.

Mataragas, M., Dimitriou, V., Skandamis, P.N., and Drosinos, E.H. 2011. Quantifying the spoilage and shelf-life of yoghurt with fruits. *Food Microbiol.* 28(3): 611-616.

Mayoral, M.B., Martin, R., Sanz, A., Hernandez, P.E., Gonzalez, I., and Garcia, T. 2005. Detection of Kluyveromyces marxianus and other spoilage yeasts in yoghurt using a PCR-culture technique. *Int. J. Food Microbiol.* 105: 27-34.

Mazahreh, A.S. and Ershidat, O.T.M. 2009. The benefits of lactic acid bacteria in yogurt on the gastrointestinal function and health. *Pakist. J. Nutr.* 8(9): 1404-1410.

Mazumdar, B.C. and Majumder, K. 2003. Methods on physico-chemical analysis of fruits. Practical Manual Book. Metropolitan New Delhi, India. neural network modeling. *J. Dairy Sci.* 90(7): 3118-3125.

Mbaeyi, I.E. and Anyanwu, L.N. 2010. Production and evaluation of yoghurt flavoured with solar-dried bush mango (*Irvingia gabonensis*) pulp. *J. Trop. Agric. Food Environ. Ext.* 9(2): 137 – 146.

McGee, H., Dorfman, P., Greene, J., and McGee, A. 2004. *Food and Cooking: The Science and Lore of the Kitchen*. New York, Scribner, 44p.

Mckinley, M. C. (2005). The nutrition and health benefits of yoghurt. *Int. J. Dairy Technol*. 58: 1-12.

Meda, A., Lamien, C.E., Romito, M., Millogo, J., and Nacoulma, O.G. 2005. Determination of the total phenolic, flavonoid and proline contents in Burkina Fasan honey, as well as their radical scavenging activity. *Food chem.* 91: 571-577.

Meenakshi, V., Suganya, A., and Umamaheswari, T. 2018. Formulation of value enriched probiotic fruit yoghurt. *Int. J. Curr. Microbiol. Appl. Sci.* 7: 1440-1450.

Meira, S. M. M., Daroit, D. J., and Helfer, V. E. 2012. Bioactive peptides in water soluble extract of ovine cheese from southern Brazil and Uruguay. *Food Res. Int.* 48: 322–329.

Meyer, S.B., Medina-Solorzano, A., and Dahl, W.J. 2012. Shopping for health: Yogurt [online]. Available: https://edis.ifas.ufl.edu › publication [17-1-2020].

Min, D.B. and Steenson, D.F. 1998. *Crude Fat Analysis In Food Analysis* (2nd Ed.). Aspens Publisher, Gaithersburg, 215p.

Minervini, F., Montagna, M.T., Spilotros, G., Monaci, L., Santacroce, M.P., and Visconti, A. 2001. Survey on mycoflora of cow and buffalo dairy products from Southern Italy. *Int. J. Food Microbiol.* 69: 141-146.

Mitra, S., Chakrabartty, P. K., and Biswas, S. R. 2010. Potential production and preservation of dahi by Lactococcus lactis W8, a nisin-producing strain. *LWT-Food Sci. Technol.* 43: 337–342.

Morelli, L. 2014. First global summit on the health benefits of yogurt: yogurt, living cultures, and gut health. *Am. J. Clin. Nutr.* 99: 1248S–1250S

Moreno, A.L.A., Cervera, R.P., and Ortega, A.R.M. 2013. Scientific Evidence about the Role of Yogurt and Other Fermented Milks in the Healthy Diet for the Spanish Population (Spanish) *Nutr. Hospitalaria* 28: 2039–2089.

Muir, D.D. and J.M. Banks, 2000. Milk and milk products. In: Kilcast, D. and Subramanian, P. (eds.). *The Stability and Shelf-Life of Food*. CRC Press, Boca Raton, pp. 197–219.

Munzur, M. M., Islam, M. N., Akhter, S., and Islam, M. R. 2004. Effect of different levels of vegetable oil for the manufacture of Dhai from skim milk. *Asian Aust. J. Anim.* Sci. 17: 1019-1025.

Nabavi, S., Rafraf, M., Somi, M.H., Homayouni-Rad., and Asgahar-Jafarabadi, M. 2014. Effects of probiotic yogurt consumption on metabolic factors in individuals with non-alcoholic fatty acid disease. *J. Dairy Sci.* 97: 7386–7393.

Nandkumar, R. and Talapatra, K. 2014. Quantitative profiling of bacteriocins present in dairy-free probiotic preparations of Lactobacillus acidophilus by nanoliquid chromatography-tandem mass spectrometry. *J. Dairy Sci*. 97(4): 1999–2008.

Nazni, P., and Komathi, K. 2014. Quality evaluation of the fruit pulp added yoghurt. *Int. J. Nutr. Agric. Res.* 1(1): 48–54.

Ndife, J., Idoko, F., and Garba, R. 2014. Production and quality assessment of functional yoghurt enriched with coconut. *Int. J. Nutr. Food Sci.* 3: 545-550.

Nguyen, P. T, M., Kravchuk, O., Bhandari, B., and Prakash, S. 2017. Effect of different hydrocolloids on texture, rheology, tribology and sensory perception of texture and mouthfeel of low-fat pot-set yoghurt. *Food Hydrocolloids* 72: 90-104.

Nongonierma, A.B., Cayot, P., Springett, M., Le Quere, J.L., Cachon, R., and Voilley, A. 2007. Transfers of small analytes in a multiphasic stirred fruit yoghurt model. *Food hydrocolloids* 21: 287-296.

O'connell, J.E. and Fox, P.F. 2001. Significance and applications of phenolic compounds in the production and quality of milk and dairy products: a review. *Int. Dairy J.* 11(3): 103-120.

Oberman, H. and Libudzisz, Z. 1998. *Physiological activity of Str. Diacetilactis and Lb. cazci strains in continuous culture system* (1st Ed.). Blackic Academic and professional, Madras, 308p.

Olson, D.W. and Aryana, K.J. 2008. An excessively high Lactobacillus acidophilus inoculation level in yogurt lowers product quality during storage. *LWT-Food Sci. Technol.* 41(5): 911-918.

Ostertag, L.M., O'Kennedy, N., Kroon, P.A., Duthie, G.G., and De Roos, B., 2010. Impact of dietary polyphenols on human platelet function–a critical review of controlled dietary intervention studies. *Mol. Nutr. Food Res.* 54: 60-81.

Otieno, W. A. 2009. Production of an acceptable cultured sour milk flavoured with a blend of passion-papaya pulps. B.Sc project, Universty of Nairobi, Kenya, 4pp.

Ott, A., Hugi, A., Baumgartner, M., and Chaintreau, A. 2000. Sensory investigation of yogurt flavor perception: mutual influence of volatiles and acidity. *J. Agric. Food Chem.* 48: 441-450.

Panesar, P. S. and Shinde, C. 2012. Effect of storage on syneresis, pH, Lactobacillus acidophilus count, Bifidobacterium bifidum count of aloe vera fortified probiotic yoghurt. *Curr. Res. Dairy Sci.* 4(1): 17–23.

Park, K.M. and Cifelli, C.J. 2013. Dairy and Blood Pressure: A Fresh Look at the Evidence. *Nutr. Rev.* 71(3): 149-157

Pereira, D.I. and Gibson, G.R. 2002. Effects of consumption of probiotics and prebiotics on serum lipid levels in humans. *Crit. Rev. Biochem. Mol. Biol*. 37(4): 259-281.

Pereira, M.C., Steffens, R.S., Jablonski, A., Hertz, P.F., Rios, A.D.O., Vizzotto, M., and Flores, S.H. 2013. Characterization, bioactive compounds and antioxidant potential of three Brazilian fruits. *J. Food Composition Anal.* 29: 19-24.

Piper, C.S. 1966. Aging of crystalline precipitates. *Analyst* 77: 1000-1011.

Prentice, A.M. 2014. First global summit on the health benefits of yogurt. Dairy products in global health. *Am. J. Clin. Nutr.* 99: 1212S–1216S

Prescott, L. M., Harley, J. P. and Klein, O. A. 2005. *Microbial nutrition, types of media, in: Microbiology* (6^{th} Ed). Mc Graw Hill Publisher, New York, 105p.

Prieto, P., Pineda, M., and Anguilar, M.1999. Spectrophotometric Quantitation of Antioxidant Capacity through the Formation of a Phosphomolybdenum Complex: Specific Application to the Determination of Vitamin E. *Anal. Biochem*. 269: 337- 341.

Punnagaiarasi, A., Elango, A., Rajarajan, G., Karthikeyan, N., and Pandiyan, C. 2015. Sensory evaluation of stirred papaya yoghurt during storage period. *History*, 22: 69-74.

Rajendran, P., Rengarajan, T., Nandakumar, N., Divya, H., and Nishigaki, I. 2015. Mangiferin in cancer chemoprevention and treatment: pharmacokinetics and molecular targets. *J. Receptors Signal Transduction* 35: 76-84.

Raju, P.N. and Pal, D. 2014. Effect of dietary fibers on physico-chemical, sensory and textural properties of Misti Dahi. *J. Food sci. Technol*. 51(11): 3124-3133.

Ranadheera, C.S., Evans, C.A., Adams, M.C., and Baines, S.K. 2012. In vitro analysis of gastrointestinal tolerance and intestinal cell adhesion of probiotics in goat's milk ice cream and yogurt. *Food Res. Int.* 49: 619-625.

Ranganna, S. 1986. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. Tata McGraw-Hill Education, 145p.

Rani, R., Dharaiya, C.N., Unnikrishnan, V., and Singh, B. 2012. Factors affecting syneresis from yoghurt for preparation of chakka. *Indian J. Dairy Sci.* 65: 135-140.

Rattanachaikunsopon, P. and Phumkhachorn, P. 2010. Lactic acid bacteria: their antimicrobial compounds and their uses in food production. *Ann. Biol. Res.* 1(4): 218-228.

Raut, V., Sawant, P., Sawant, D., and Ingole, A.S. 2015. Studies on preparation of mango yoghurt drink. *Asian J. Dairy Food Res.* 34: 13-17.

Rayes, A.A., El-Naggar, S.M., and Mehanna, N.S. 2008. The effect of natural fermented milk in the protection of liver from cancer. *Nutr. Food Sci.* 38: 578-592.

Reddy, K.P., Shahani, K.M., and Kulkarni, S.M. 1976. *B*-complex Vitamins in Cultured and Acidified Yogurt. *J. Dairy Sci.* 59: 191–195.

Remya, P.R., Sharon, C.L., Aneena, E.R., Panjikkaran, S.T., and Shahanas, E. 2019. Standardization and Quality Evaluation of Jackfruit based Low Fat Yogurt. *Asian J. Dairy Food Res*. 38: 93-97.

Renisha, M. 2012. Biodiversity analysis of traditional mango types of Kerala and studies on the reproductive biology of selected popular varieties. M.Sc (Ag) Thesis, Kerala Agricultural University, Thrissur. 89p.

Ricci, I., Artacho, R., and Olalla, M. 2010. Milk protein peptides with angiotensin I-converting enzyme inhibitory (ACEI) activity. *Crit. Rev. Food Sci. Nutr.* 50: 390-402.

Roy, D.K.D., Saha, T., Akter, M., Hosain, M., Khatun, H., and Roy, M.C. 2015. Quality evaluation of yogurt supplemented with fruit pulp (banana, papaya, and watermelon). *Int. J. Nutr. Food Sci.* 4: 695-699.

Ruan, Q.Y., Zheng, X.Q., Chen, B.L., Xiao, Y., Peng, X.X., Leung, D.W., and Liu, E.E. 2013. Determination of total oxalate contents of a great variety of foods commonly available in Southern China using an oxalate oxidase prepared from wheat bran. *J. Food Composition Anal.* 32: 6-11.

Sadasivam, S. and Manickam, A. 2008. *Biochemical Methods* (3rd Ed.), New Age International Publishers, New Delhi, India. 56p.

Saleh, A., Mohamed, A.A., Alamri, M.S., Hussain, S., Qasem, A.A., and Ibraheem, M.A. 2020. Effect of different starches on the rheological, sensory and storage attributes of non-fat set yogurt. *Foods* 9: 61.

Salih, M.A.M. and Abdalla, M.O.M. 2017. Physicochemical and sensory characteristics of stirred yoghurt flavoured with mango (*MangiferaindicaL.*) during storage period. *Pakist. J. Nutr*. 16(5): 378-383.

Salji, J.P., Saadi, S.R., and Mashhadi, A. 1987. Shelf life of plain liquid yogurt manufactured in Saudi Arabia. *J. Food prot.* 50(2): 123-126.

Salvador, A. and Fiszman, S.M. 2004. Textural and sensory characteristics of whole and skimmed flavored set-type yogurt during long storage. *J. Dairy Sci.* 87(12): 4033-4041.

Salwa, A.A., Galal, E.A., and Neimat, A.E. 2004. Carrot yoghurt: Sensory, chemical, microbiological properties and consumer acceptance. *Pakist. J. Nutr.* 3: 322-330.

Samedi, L. and Charles, A.L. 2019. Viability of 4 probiotic bacteria microencapsulated with arrowroot starch in the simulated gastrointestinal tract (GIT) and yoghurt. *Foods* 8(5): 175.

Sameen, A., Khan, M., Sattar, M., Javid, A., and Ayub, A. 2016. Quality evaluation of yoghurt stabilized with sweet potato (*Ipomoea batatas*) and taro (*Colocassia esculenta*) starch. *Int. J. Food Allied Sci*. 2: 23-29.

Sanchez-Segarra, P.J., Garcia-Martıinez, M., Gordillo-Otero, M.J., Diaz-Valverde, A., Amaro-Lopez, M.A., and Moreno-Rojas, R. 2000. Influence of the addition of fruit on the mineral content of yoghurts: nutritional assessment. *Food chem.* 71: 85-89.

Sansanwal, R., Ahlawat, U., and Dhanker, R. 2017. Yoghurt: A predigested food for lactose-intolerant people. *Int. J. Curr. Microbiol. Applied Sci*, 6: 1408-1418.

Sarmini, N., Sinniah, J., and Silva, K. F. S. T. 2014. Development of a ripened jack (*Artocarpus heterophyllus* Lain) fruit and soy (*Glycine max*) milk incorporated set yoghurt. *Int. J. Dairy Sci.* 9: 15–23.

Scrimshaw, N.S. and Murray, E.B. 1988. The acceptability of milk and milk products in populations with a high prevalence of lactose intolerance. *Am. J. Clin. Nutr.* 48(4): 1142-1159.

Sebayang, F., Bulan, R., and Wahyuni, W. 2019. The Utilization of Carboxymethyl Cellulose (CMC) from Ground (*Arachis Hypogae L*) Cellulose as Stabilizer for Cow Milk Yogurt. *J. Chem. Nat. Resour*. 1: 38-51.

Selvamuthukumaran, M. and Farhath, K. 2014. Evaluation of shelf stability of antioxidant rich sea buckthorn fruit yoghurt. *Int. Food Res. J.* 21(2): 759–765.

Senadeera, S.S., Prasanna, P.H.P., Jayawardana, N.W.I.A., Gunasekara, D.C.S., Senadeera, P., and Chandrasekara, A. 2018. Antioxidant, physicochemical, microbiological, and sensory properties of probiotic yoghurt incorporated with various Annona species pulp. *Heliyon* 4:00955.

Sengul, M., Erkaya, T., Sengul, M., and Yildiz, H. 2012.The effect of adding sour cherry pulp into yoghurt on the physicochemical properties, phenolic content and antioxidant activity during storage. *Int. J. Dairy Technol.* 65: 429–436.

Sfakianakis, P. and Tzia, C. 2014. Conventional and innovative processing of milk for yogurt manufacture; development of texture and flavor: a review. *Foods* 3(1): 176-193.

Shabong, F., Singh, A., Hossain, S.A., and Emika, E. 2021. Studies on utilization of passion fruit pulp and passion fruit peel in fruit yogurt. *The Pharma. Innovation J.* 10: 466-471.

Shaker, R.R., Jumah, R.Y., and Abu-Jdayil, B. 2000. Rheological properties of plain yogurt during coagulation process: Impact of fat content and preheat treatment of milk. *J. Food Eng.* 44: 175–180.

Shang, H.S., Chen, C.J., Shih, Y.L., Peng, S.F., Chen, Y.L., Liu, K.C., Huang, H.C., Hsueh, S.C., Chen, K.W., Lu, H.F., and Lee, M.H. 2021. Mangiferin induces immune responses and evaluates the survival rate in WEHI-3 cell generated mouse leukemia in vivo. *Environ. Toxicol.* 36: 77-85.

Shiby, V.K. and Mishra, H.N. 2013. Fermented milks and milk products as functional foods–a review. *Crit. Rev. Food Sci. Nutr*. 53: 482–496.

Shori, A. B. and Baba, A. S. 2014. Comparative antioxidant activity, proteolysis and in vitro α-amylase and α-glucosidase inhibition of *Allium sativum*-yogurts made from cow and camel milk. *J. Saudi Chem. Soc.* 18(5): 456–463.

Siji, S. 2017. Phytochemical analysis and antioxidant potential of banana (*Musa spp*). MSc (HSc) thesis, Kerala Agricultural University, Thrissur, 37p.

Simi, S. and Rajmohan, K. 2013. Evaluation of Traditional Mango (*Mangifera indica I L.*) Varieties of Southern Kerala. *J. Hortic. Sci.* 8(2): 228-233.

Skriver, A., Stenby, E., Folkenberg, D.M., Runge, M., and Jensen, N. B. 2002. Tools in the Development of Future Starter Cultures for Fermented Milk. *Bull. Int. Dairy Fed*. 0301: 55-61.

Smit, G., Smit, B.A., and Engels, W.J. 2005. Flavour Formation by Lactic Acid Bacteria and Biochemical Flavour Profiling of Cheese Products. *FEMS Microbiol. Rev*. 29: 591–610.

Soliva-Fortuny, R.C., Elez-Martínez, P., Sebastian-Caldero, M., and Martıin-Belloso, O. 2002. Kinetics of polyphenol oxidase activity inhibition and browning of avocado puree preserved by combined methods. *J. Food Eng.* 55: 131-137.

Soukoulis, C., Panagiotidis, P., Koureli, R., and Tzia, C. 2007. Industrial yogurt manufacture: Monitoring of fermentation process and improvement of final product quality. *J. Dairy Sci.* 90: 2641–2654.

Srilakshmi, B. 2015. *Food Science* (6^{th} Ed.). new Age International Limited Publishers, New Delhi.

Staffolo, M.D., Bertola, N., and Martino, M. 2004. Influence of dietary fiber addition on sensory and rheological properties of yogurt. *Int. Dairy J.* 14: 263-268.

Steele, J., Broadbent, J., and Kok, J. 2013. Perspectives on the Contribution of Lactic Acid Bacteria to Cheese Flavor Development. *Curr. Opinion Biotechnol*. 24: 135–141.

Surajit, S. 2019. Potentiality of Probiotic Fruit Yogurt as a Functional Food – A Review. *J. Nutr. Food Sci*. 49: 3-4.

Tamime A.Y. and Robisons R.K. 2007. *Tamime and Robinson's Yogurt: Science and Technology* (3rd Ed.). Woodhead Publishing LTD, Cambridge England, 772p.

Tamime, A.Y. 1977. The behaviour of different starter cultures during the manufacture of yogurt from hydrolysed milk. *Dairy Industries Int.* 42: 7.

Tamime, A.Y. and Robinson, R.K. 1999. *Yoghurt Science and technology*. Woodhead publishing, Cambridge England, 619p.

Tamime, A.Y. and Robinson, R.K. 2000. *Yoghurt Science and Technology* (2nd Ed.). CRC Press, Boca Raton, 148p.

Taneva, I. and Zlatev, Z. 2020. Total Phenolic Content and Antioxidant Activity of Yoghurt with Goji Berries (*Lycium Barbarum*). *Sci. Study Res. Chem. Chem. Eng. Biotechnol. Food Ind.* 21(1): 125-131.

Tarakci, Z. 2010. Influence of kiwi marmalade on the rheology characteristics, color values and sensorial acceptability of fruit yoghurt. *Kafkas Univ. Vet. Fakultesi Derg*isi 16: 173-178

Tarakci, Z. and Kucukoner, E. 2003. Physical, Chemical, Microbiological and Sensory Characteristics of Some Fruit- Flavored Yoghurt. *Kafkas Univ. Vet. Fakultesi Derg*isi 14 (2): 10-14.

Temesgen, M. and Yetneberk, S. 2015. Effect of application of stabilizers on gelation and synersis in yoghurt. *Food Sci. Qual. Manag*. 37: 90-102.

Temple, N.J. 2000. Antioxidants and disease: more questions than answers. *Nutr. Res.* 20: 449-459.

Teshome, G., Keba, A., Assefa, Z., Agza, B., and Kassa, F., 2017. Development of fruit flavored yoghurt with mango (*Mangifera indica L.*) and papaya (*Carica papaya L.*) fruits juices. *Food Sci. Qual. Manag.* 67: 40-45.

Tetra Pak, A.B. 1995. *Dairy Processing Handbook*. Tetra Pak, A.B. Processing Systems, Sweden, 221p.

Thaipong, K., Boonprakob, U., Crosby, K., Cisneros-Zevallos, L., and Byrne, D.H. 2006. Comparison of ABTS, DPPH, FRAP, and ORAC assays for estimating antioxidant activity from guava fruit extracts. *J. Food Composition Anal.* 19: 669-675.

Toregeani-Mendes, K.A., Arroteia, C.C., Kemmelmeier, C., Dalpasquale, V.A., Bando, E., Alves, A.F., Marques, O.J., Nishiyama, P., Mossini, S.A., and Machinski Jr, M. 2011. Application of hazard analysis critical control points system for the control of aflatoxins in the Brazilian groundnut-based food industry. *Int. J. Food Sci. Technol.* 46: 2611-2618.

Tripathi, P.C. 2018. *Passion Fruit*. Brillion Publishing, New Delhi, 245p.

Vahedi, N., Tehrani, M.M., and Shahidi, F. 2008. Optimizing of fruit yoghurt formulation and evaluating its quality during storage. *Am. Euras. J. Agric. Environ. Sci*. 3(6): 922-7.

Van de Water, J. and Naiyanetr, P. 2003. *Handbook of fermented functional foods* (2^{nd} Ed.). CRC Press, United States, 113p.

Vargavisi, E. and Papai, G. 2015. How to maintain the effective levels of probiotics throughout the shelf life in yoghurt: *A review. Acta Agraria Kaposvariensis* 19(1): 65–74.

Vedamuthu E.R. 2006. Starter cultures for yogurt and fermented milks. In: Chandan R.C. (eds.), *Manufacturing Yogurt and Fermented Milks.* Blackwell Publishing, Hoboken, pp.89-116.

Vedamuthu, E.R. 1991. The yoghurt story-past, present, and future. *Dairy Food Environ. Sanitation* 11: 202-203.

Viljoen, B. C. 2001. The interaction between yeasts and bacteria in dairy environments. *Int. J. Food Microbiol*. 69: 37–44.

Virgen-Cecena, L.J., Anaya-Esparza, L.M., Coria-Tellez, A.V., de Lourdes García-Magana, M., García-Galindo, H.S., Yahia, E., and Montalvo-González, E. 2019. Evaluation of nutritional characteristics and bioactive compounds of soursop-yoghurt and soursop-frozen dessert. *Food Sci. Biotechnol.* 28: 1337-1347.

Vital, A.C.P., Goto, P.A., Hanai, L.N., Gomes-da-Costa, S.M., de Abreu Filho, B.A., Nakamura, C.V., and Matumoto-Pintro, P.T. 2015. Microbiological, functional and rheological properties of low fat yogurt supplemented with Pleurotus ostreatus aqueous extract. *LWT-Food Sci. Technol.* 64: 1028-1035.

Walstra, P., Wouters J.T.M. and Geurts, T.J. 2006. *Dairy Science and Technology*. Taylor and Francis Group, Boca Raton, USA, 551p.

Wang, H., Livingston, K.A., Fox, C.S., Meigs, J.B., and Jacques, P.F. 2013. Yogurt consumption is associated with better diet quality and metabolic profile in American men and women. *Nutr. Res*. 33:18–26.

Wang, J., Shi, Y., Pan, Y., and Cai, Y. 2010. Perfluorinated compounds in milk, milk powder and yoghurt purchased from markets in China. *Chinese Sci. Bull.* 55: 1020-1025.

Weerathilake, W.A.D.V., Rasika, D.M.D., Ruwanmali, J.K.U., and Munasinghe, M.A.D.D. 2014. The evolution, processing, varieties and health benefits of yogurt. *Int. J. Sci. Res. Publ.* 4: 2250-3153.

Williams, E.B., Hooper, B., Spiro, A., and Stanner, S. 2015. The contribution of yogurt to nutrient intakes across the life course. *Nutr. Bull.* 40: 9-32.

Wouters, J.T., Ayad, E.H., Hugenholtz, J., and Smit, G. 2002. Microbes from raw milk for fermented dairy products. *Int. Dairy J.* 12: 91-109.

Yildiz F. 2010. *Development and manufacture of yogurt and other functional dairy products*. CRC Press, 451p.

Yoon, W.B. and Mc Carthy, K.L. 2002. Rheology of yogurt during pipe flow as characterized by magnetic resonance imaging. *J. Texture Stud.* 33(5): 431-444.

Zainoldin, K.H. and Baba, A.S. 2009. The effect of Hylocereus polyrhizus and Hylocereus undatus on physicochemical, proteolysis, and antioxidant activity in yogurt. *World Acad. Sci. Eng. Technol.* 60: 361-366.

Zeng, Z., Lin, C., Wang, S., Wang, P., Xu, W., Ma, W., Wang, J., Xiang, Q., Liu, Y., Yang, J., and Ye, F. 2020. Suppressive activities of mangiferin on human epithelial ovarian cancer. *Phytomedicine* 76: 153267.

Zhong, J., Yang, R., Cao, X., Liu, X., and Qin, X. 2018. Improved physicochemical properties of yogurt fortified with fish oil/γ-oryzanol by nanoemulsion technology. *Molecules* 23: p.56-59.

Zittermann, A. 2011. Nutrition and health-promoting properties of dairy properties: bone health. In: Fuquay, J.W., Fox, P.F. and McSweeney, P.L.H. (eds.), *Encyclopedia of Dairy Sciences*. Academic Press, New York, pp. 1009–1015.

Abstract

DEVELOPMENT OF FRUIT BLENDED YOGHURTS AND QUALITY EVALUATION

By

PRAVITHA P .G.

(2019-16-004)

ABSTRACT

of the thesis Submitted in partial fulfilment of the requirements of 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

2022

ABSTRACT

The present study entitled "Development of fruit blended yoghurts and quality evaluation" was carried out at College of Agriculture, Vellayani, Thiruvananthapuram during the period of 2019-2021. The objective of the study was to develop fruit blended yoghurts from variety of fruits and to ascertain its sensorial quality, chemical and nutritional composition, and to study the storage stability. Thus, six fruit blended yoghurts namely Avocado yoghurt, Banana (Robusta) yoghurt, Mango (Moovandan), Passionfruit yoghurt, Pineapple yoghurt and Soursop yoghurt were developed.

Homogenised toned milk with a fat content of 3g was selected for the study. Optimum ripened fruits like Avocado, Banana (Robusta), Mango (Moovandan), Passionfruit, Pineapple and soursop were selected for the development of fruit yoghurts. The yoghurt culture used was strains of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. The amount of yoghurt culture (2%) and sugar (12%) were constant in all the treatments. The fruit yoghurts were processed by the standardized procedure reported by Remya *et al*. (2019) after minor modifications. The various treatments selected for the formulation of fruit yoghurt with milk, fruit pulp, yoghurt culture and sugar respectively in the predetermined proportions were, T_1 (85:15:2:12), T_2 (80:20:2:12), T_3 (75:25:2:12), T_4 (70:30:2:12), T_5 (65:35:2:12) and control (100:0:2:0). The treatments were same for all the fruit yoghurts.

Sensory evaluation of fruit yoghurts exhibited significant difference in appearance, colour, aroma, texture, taste, and overall acceptability of the treatment combinations. From the sensory evaluation it was found that T_4A, T_2B, T_3M, T_4P, T_4PA, and T_4S were the best combinations of fruit yoghurts selected from each fruit. The selected fruit yoghurts along with control were subjected to nutritional analysis and stored at refrigerated temperature of 4°C for further study. Storage stability on sensory attributes and changes in other properties like acidity, moisture, peroxide value, pH, syneresis, total soluble solids and microbial profile were studied on every 3 days interval for two weeks.

Among six fruit yoghurt developed pineapple yoghurt revealed higher carbohydrate (22.66g/100g), dietary fiber (0.72g/100g), iron (0.76 mg/100g), vitamin

C (9.02 mg/100g), calcium(381.30mg/100g) and phosphorus (457mg/100g) content. Avocado yoghurt found was with highest energy value (114.16 kcal) and fat content (9.60 g/100g). The β-carotene content was higher in mango yoghurt (143.60 /100gμg). Pineapple yoghurt was scored maximum (50.14g) total antioxidant activity.

The sensory evaluation of all fruit blended yoghurts and plain yoghurt during storage revealed decrease in scores obtained for all the sensory parameters. However, the product was acceptable till the end of two weeks. During storage study, it was found that there was a gradual increase in acidity of fruit yoghurts with increasing percentages of fruit yoghurts. The result of this study indicates that, 30% passion fruit pulp flavored yoghurt had the highest (9.26%) titratable acidity. The moisture content and the peroxide value and syneresis were increased and pH content was dropped during shelf-life study. Banana yoghurt was noted with high rate (88.53%) of moisture content at the last day of storage. Peroxide value was higher in avocado due to the presents of fat content in the avocado fruit. Among all the fruit yoghurt passionfruit yoghurt showed high rate of syneresis. pH was dropped in all the fruit yoghurt including in control, the minimum (3.30) pH was recorded in pineapple yoghurt at the end day of storage.

In the present study T_2B was the most acceptable fruit yoghurt among other yoghurts based on sensory attributes, while the T_4PA was rich in many nutrients. The microbial profile revealed the presence of bacterial, fungal colonies and yeast mould count from the initial day itself. The coliform was absent till the end of storage period. Cost of production of one kilogram fruit yoghurts was Rs 240 (T_4A), 150 (T_2B), 210 (T_3M), 210 (T_4P), 190 (T_4PA) and 230 (T_4S) respectively

This study on development of fruit blended yoghurts and quality evaluation - concludes that the fruit yoghurts developed from various fruits were higher in nutrients and had better sensory qualities than the plain yoghurt.

സംഗ്രഹം

2019-2021കാലയളവിൽ തിരുവനന്തപുരത്തെ വെള്ളായണിയിലെ കാർഷിക കോളേജിൽ "പഴം കലർന്ന തൈരുകളുടെ വികസനവും ഗുണനിലവാര വിലയിരുത്തലും" എന്ന തലക്കെട്ടിലുള്ള ഇപ്പോഴത്തെ പഠനം നടത്തി. പലതരം പഴങ്ങളിൽ നിന്ന് പഴങ്ങൾ കലർന്ന തൈര് വികസിപ്പിക്കുകയും അതിന്റെ സെൻസറിയൽ ഗുണമേന്മ, രാസ, പോഷക ഘടന എന്നിവ കണ്ടെത്തുകയും സംഭരണ സ്ഥിരത പഠിക്കുകയും ചെയ്യുക എന്നതായിരുന്നു പഠനത്തിന്റെ ലക്ഷ്യം. അങ്ങനെ, അവോക്കാഡോ തൈര്, വാഴപ്പഴം (റോബസ്റ്റ) തൈര്, മാങ്ങ (മൂവണ്ടൻ)തൈര്, പാഷൻഫ്രൂട്ട് തൈര്, പൈനാപ്പിൾ തൈര്, മുള്ളാത്ത തൈര് എന്നിങ്ങനെ ആറ് പഴങ്ങൾ കലർന്ന തൈര് വികസിപ്പിച്ചെടുത്തു.

3 ഗ്രാം കൊഴുപ്പുള്ള ഹോമോജെനൈസ്ഡ് ടോൺഡ് പാലാണ് പഠനത്തിനായി തിരഞ്ഞെടുത്തത്. അവോക്കാഡോ, വാഴപ്പഴം (റോബസ്റ്റ),മാമ്പഴം(മൂവാണ്ടൻ), പാഷൻഫ്രൂട്ട്, പൈനാപ്പിൾ, മുള്ളാത്ത തുടങ്ങിയ ഉത്തമമായ പഴുത്ത പഴങ്ങൾ ഫ്രൂട്ട് തൈര് വികസിപ്പിക്കുന്നത്തിനായിതിരഞ്ഞെടുത്തു.സ്ട്രെപ്റ്റോകോക്ക സ്തെർമോഫിലസ്, ലാക്ടോബാസിലസ് ബൾഗാറിക്കസ് എന്നിവയുടെ സ്ട്രെയിനുകളാണ് തൈരുകളുടെ വികസനത്തിനായി ഉപയോഗിച്ചത്. എല്ലാ ട്രീറ്റ്മെന്റ്കളിലും തൈര്സ് ട്രെയിനിന്റെയും(2%), പഞ്ചസാരയുടെയും (12%) അളവ് സ്ഥിരമായിരുന്നു. രമ്യ (2019) തുടങ്ങിയവർ റിപ്പോർട്ട് ചെയ്ത സ്റ്റാൻഡേർഡ് നടപടിക്രമം അനുസരിച്ചാണ് ചെറിയ മാറ്റങ്ങൾക്ക് ശേഷം ഫ്രൂട്ട് യോഗർട്ട്സ് പ്രോസസ്സ് ചെയ്തത്. മുൻകൂട്ടി നിശ്ചയിച്ച

അനുപാതത്തിൽ യഥാക്രമം പാൽ, പഴം പൾപ്പ്, തൈര് കൾച്ചർ, പഞ്ചസാര എന്നിവ ഉപയോഗിച്ച് ഫ്രൂട്ട് തൈര് രൂപപ്പെടുത്തുന്നതിന് തിരഞ്ഞെടുത്ത വിവിധ ട്രീറ്റ്മെന്റ്കൾ, T_1 (85:15:2:12), T_2 (80:20:2:12), T_3 (75:25:2:12), T_4 (70:30:2:12), T_5 (65:35:2:12), പഴമില്ലാത്ത തൈര് (100:0:2:0).എല്ലാ പഴതൈരുകളുടെയും അനുപാതം ഒരേ രീതിയിലായിരുന്നു.

പഴതൈരുകളുടെ സെൻസറി മൂല്യനിർണ്ണയം, രൂപം, നിറം, മണം, ഘടന,രുചി, ട്രീറ്റ്മെന്റ്കോമ്പിനേഷനുകളുടെ മൊത്തത്തിലുള്ള സ്വീകാര്യത എന്നിവയിൽ കാര്യമായ വ്യത്യാസം പ്രകടമാക്കി. സെൻസറി മൂല്യനിർണ്ണയത്തിൽ നിന്ന് T4A, T2B, T3M, T4P, T4PA, T4S എന്നിവ ഓരോ പഴത്തിൽ നിന്നും തിരഞ്ഞെടുത്ത ഫ്രൂട്ട് യോഗർട്ടുകളുടെ മികച്ച കോമ്പിനേഷനുകളാണെന്ന് കണ്ടെത്തി. തിരഞ്ഞെടുത്ത പഴതൈര്, പഴമില്ലാത്ത തൈര് എന്നിവ പോഷകാഹാരപഠനം വിധേയമാക്കുകയും കൂടുതൽ പഠനത്തിനായി 4 ഡിഗ്രി സെൽഷ്യസ് ശീതീകരിച്ച താപനിലയിൽ സൂക്ഷിക്കുകയും ചെയ്തു. സെൻസറി ആട്രിബ്യൂട്ടുകളിലെ സംഭരണ സ്ഥിരത, അസിഡിറ്റി, ഈർപ്പം, പെറോക്സൈഡ് മൂല്യം, പിഎച്ച്, സിനറിസിസ്, മൊത്തം ലയിക്കുന്ന സോളിഡുകൾ, മൈക്രോബിയൽ പ്രൊഫൈൽ തുടങ്ങിയ മറ്റ് ഗുണങ്ങളിലെ മാറ്റങ്ങളും ഓരോ 3 ദിവസത്തെ ഇടവേളയിലും രണ്ടാഴ്ചത്തേക്ക് പഠിച്ചു.

ആറ് പഴത്തൈരിൽ വികസിപ്പിച്ചെടുത്ത പൈനാപ്പിൾ തൈരിൽ ഉയർന്ന കാർബോഹൈഡ്രേറ്റ് (22.66g/100g), ഡയറ്ററി ഫൈബർ (0.72g/100g), ഇരുമ്പ് (0.76 mg/100g), വിറ്റാമിൻ സി (9.02 mg/100g), കാൽസ്യം (381.30mg/100g) എന്നിവ കണ്ടെത്തി. കൂടാതെ

ഫോസ്ഫോറിസിന്റെ (457mg/100g) അളവും കൂടുതൽ ആയിരുന്നു. അവക്കാഡോ തൈര് ഏറ്റവും ഉയർന്ന ഊർജ്ജ മൂല്യവും (114.16 കിലോ കലോറി) കൊഴുപ്പും (9.60 ഗ്രാം/100 ഗ്രാം) ഉള്ളതായി കണ്ടെത്തി. മാമ്പഴ തൈരിൽ (143.60 /100gμg) β-കരോട്ടിൻ അളവും കൂടുതലാണ്. പൈനാപ്പിൾ തൈര് പരമാവധി (50.14 ഗ്രാം) മൊത്തം ആന്റിഓക്സിഡന്റ് പ്രവർത്തനം സ്കോർ ചെയ്തു.

എല്ലാ പഴതൈരിലും പഴമില്ലാത്ത തൈരിന്റെയും സംഭരണത്തിൽ സെൻസറി പാരാമീറ്ററുകൾക്കു ലഭിച്ച സ്കോറുകളിൽ കുറവ് കണ്ടെത്തി. എന്നിരുന്നാലും, രണ്ടാഴ്ചയുടെ അവസാനം വരെ ഉൽപ്പന്നം സ്വീകാര്യമായിരുന്നു. സംഭരണ പഠനത്തിനിടെ, പഴതൈരിന്റെ അസിഡിറ്റിയിൽ ക്രമാനുഗതമായ വർദ്ധനവ് ഉണ്ടെന്ന് കണ്ടെത്തി. ഈ പഠനത്തിന്റെ ഫലം സൂചിപ്പിക്കുന്നത്, 30% പാഷൻ ഫ്രൂട്ട് പൾപ്പ് ചേർത്ത തൈരിൽ ഏറ്റവും ഉയർന്ന (9.26%) ടൈട്രേറ്റബിൾ അസിഡിറ്റി ഉണ്ടെന്നാണ്. ഷെൽഫ്-ലൈഫ് പഠനത്തിനിടെ ഈർപ്പത്തിന്റെ അംശവും പെറോക്സൈഡ് മൂല്യവും സിനറിസിസും വർദ്ധിപ്പിക്കുകയും pH ന്റെ തോത് കുറയുകയും ചെയ്തു. സംഭരണത്തിന്റെ അവസാന ദിവസം ഉയർന്ന തോതിൽ (88.53%) ഈർപ്പം ഉള്ളതായി വാഴപ്പഴതൈര് ശ്രദ്ധിക്കപ്പെട്ടു. അവോക്കാഡോപഴത്തിൽ കൊഴുപ്പ് അടങ്ങിയിട്ടുള്ളതിനാൽ അവോക്കാഡോയിൽ പെറോക്സൈഡിന്റെ മൂല്യം കൂടുതലായിരുന്നു. എല്ലാ പഴത്തൈരിനും ഇടയിൽ പാഷൻഫ്രൂട്ട് തൈര് സിനറിസിസ് ഉയർന്ന നിരക്ക് കാണിക്കുന്നു. പഴമില്ലാത്ത തൈര് ഉൾപ്പെടെ എല്ലാ പഴത്തൈരിലും pH കുറഞ്ഞു, സംഭരണത്തിന്റെ അവസാന ദിവസം

പൈനാപ്പിൾ തൈരിൽ ഏറ്റവും കുറഞ്ഞ (3.3) pH രേഖപ്പെടുത്തിയിട്ടുണ്ട്.

ഇപ്പോഴത്തെ പഠനത്തിൽ, സെൻസറി ആട്രിബ്യൂട്ടുകളെ അടിസ്ഥാനമാക്കിയുള്ള മറ്റ് തൈരുകളിൽ ഏറ്റവും സ്വീകാര്യമായ വാഴപ്പഴം തൈര് T2B ആയിരുന്നു, അതേസമയം T4PA ധാരാളം പോഷകങ്ങളാൽ സമ്പന്നമായിരുന്നു. മൈക്രോബയൽ പ്രൊഫൈലിൽ ബാക്ടീരിയ, ഫംഗസ് കോളനികൾ, യീസ്റ്റ് പൂപ്പൽ എന്നിവയുടെ സാന്നിധ്യം ആദ്യ ദിവസം തന്നെ കണ്ടെത്തി. സംഭരണ കാലയളവ് അവസാനിക്കുന്നതുവരെ കോളിഫോം ഇല്ലായിരുന്നു. ഒരു കിലോഗ്രാം ഫ്രൂട്ട് യോഗർട്ടിന്റെ ഉൽപാദനച്ചെലവ് യഥാക്രമം 240 (T4A), 150 (T2B), 210 (T3M), 210 (T4P), 190 (T4PA), 230 (T4S) എന്നിങ്ങനെയാണ്.

ഫ്രൂട്ട് ബ്ലെൻഡഡ് തൈരിന്റെ വികസനത്തെയും ഗുണനിലവാര മൂല്യനിർണ്ണയത്തെയും കുറിച്ചുള്ള ഈ പഠനം - വിവിധ പഴങ്ങളിൽ നിന്ന് വികസിപ്പിച്ചെടുത്ത ഫ്രൂട്ട് തൈരിൽ പോഷകങ്ങളിൽ ഉയർന്നതാണെന്നും പഴമില്ലാത്ത തൈരിനേക്കാൾ മികച്ച സെൻസറി ഗുണങ്ങളുണ്ടെന്നും നിഗമനം ചെയ്യുന്നു.

Appendices

APPENDIX -I

Scorecard for quality of the developed products

Product:
Date:
Tested by:
Sign

Parameters	T_1A	T_2A	T_3A	T_4A	T_5A	T_6
Appearance						
Colour						
Aroma						
Texture						
Taste						
Overall acceptability						

Please rate the scores hedonically to the developed products from 1 to 9

Extremely good - 9

Very good - 8

Good - 7

Less liked - 6

Neither like nor dislike - 5

Unpleasant - 4

Slightly unpleasant - 3

Moderately unpleasant - 2

Extremely unpleasant - 1

APPENDIX -II

Scorecard for quality of the developed products

Product:
Date:
Tested by:
Sign

Parameters	T_1B	T_2B	T_3B	T_4B	T_5B	T_6
Appearance						
Colour						
Aroma						
Texture						
Taste						
Overall acceptability						

Please rate the scores hedonically to the developed products from 1 to 9

Extremely good - 9

Very good - 8

Good - 7

Less liked - 6

Neither like nor dislike - 5

Unpleasant - 4

Slightly unpleasant - 3

Moderately unpleasant - 2

Extremely unpleasant - 1

APPENDIX -III

Scorecard for quality of the developed products

Product:
Date:
Tested by:
Sign

Parameters	T_1M	T_2M	T_3M	T_4M	T_5M	T_6
Appearance						
Colour						
Aroma						
Texture						
Taste						
Overall acceptability						

Please rate the scores hedonically to the developed products from 1 to 9

Extremely good - 9

Very good - 8

Good - 7

Less liked - 6

Neither like nor dislike - 5

Unpleasant - 4

Slightly unpleasant - 3

Moderately unpleasant - 2

Extremely unpleasant - 1

APPENDIX -IV

Scorecard for quality of the developed products

Product:
Date:
Tested by:
Sign

Parameters	T_1P	T_2P	T_3P	T_4P	T_5P	T_6
Appearance						
Colour						
Aroma						
Texture						
Taste						
Overall acceptability						

Please rate the scores hedonically to the developed products from 1 to 9

Extremely good - 9

Very good - 8

Good - 7

Less liked - 6

Neither like nor dislike - 5

Unpleasant - 4

Slightly unpleasant - 3

Moderately unpleasant - 2

Extremely unpleasant - 1

APPENDIX -V

Scorecard for quality of the developed products

Product:
Date:
Tested by:
Sign

Parameters	T_1PA	T_2PA	T_3PA	T_4PA	T_5PA	T_6
Appearance						
Colour						
Aroma						
Texture						
Taste						
Overall acceptability						

Please rate the scores hedonically to the developed products from 1 to 9

Extremely good - 9

Very good - 8

Good - 7

Less liked - 6

Neither like nor dislike - 5

Unpleasant - 4

Slightly unpleasant - 3

Moderately unpleasant - 2

Extremely unpleasant - 1

APPENDIX -VI

Scorecard for quality of the developed products

Product:
Date:
Tested by:
Sign

Parameters	T_1S	T_2S	T_3S	T_4S	T_5S	T_6
Appearance						
Colour						
Aroma						
Texture						
Taste						
Overall acceptability						

Please rate the scores hedonically to the developed products from 1 to 9

Extremely good - 9

Very good - 8

Good - 7

Less liked - 6

Neither like nor dislike - 5

Unpleasant - 4

Slightly unpleasant - 3

Moderately unpleasant - 2

Extremely unpleasant - 1