Standardization of pulp extraction and recipe for the preparation of Ready-to-Serve beverage from tamarind (*Tamarindus indica* L.)

A
Thesis submitted to the
Odisha University of Agriculture and Technology
in partial fulfillment of requirements for the degree of
Master of Science in Agriculture
(Fruit Science and Horticulture Technology)

By
SUMITRA HANSDAH
Adm.no-201221907

DEPARTMENT OF FRUIT SCIENCE AND
HORTICULTURE TECHNOLOGY
COLLEGE OF AGRICULTURE
ODISHA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
BHUBANESWAR- 751003, ODISHA

2022

ODISHA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
DEPARTMENT OF FRUIT SCIENCE AND HORTICULTURE TECHNOLOGY
COLLEGEOFAGRICULTURE
BHUBANESWAR- 751003,ODISHA

Dr. Ajit Kumar Sahoo
Assistant professor (Horticulture),
AICRP on Palms,
OUAT, Bhubaneswar

Bhubaneswar
Date: 14-11-2022

CERTIFICATE-I

This is to certify that the thesis entitled **"Standardization of pulp extraction and recipe for the preparation of Ready-to-Serve beverage from tamarind (*Tamarindus indica* L.) "** submitted in partial fulfillment of the requirements for the award of the Degree of **MASTER OF SCIENCE IN AGRICULTURE (FRUIT SCIENCE AND HORTICULTURE TECHNOLOGY)** of the Odisha University of Agriculture and Technology, Bhubaneswar is an authentic record of bona fide research work carried out by **SUMITRA HANSDAH**, Adm. No- **201221907** under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma or published in any other form.

It is further certified that the help and assistance as well as sources of information availedduring the course of this investigation have been duly acknowledged by him.

AKSahoo 14.11.22

Dr. Ajit Kumar Sahoo
CHAIRMAN
ADVISORY COMMITTEE

ODISHA UNIVERSITYOFAGRICULTUREAND TECHNOLOGY
DEPARTMENT OF FRUIT SCIENCE AND HORTICULTURE TECHNOLOGY
COLLEGEOFAGRICULTURE
BHUBANESWAR- 751003, ODISHA

CERTIFICATE-II

This is to certify that the thesis entitled **"Standardization of pulp extraction and recipe for the preparation of Ready-to-Serve beverage from tamarind (*Tamarindus indica* L.)''** submitted by **SUMITRA HANSDAH**, **Adm. No-201221907** to the Odisha University of Agriculture and Technology, Bhubaneswar in partial fulfillments of the requirements for the Degree of **MASTER OF SCIENCE IN AGRICULTURE** in the discipline of **FRUIT SCIENCE AND HORTICULTURE TECHNOLOGY** has been approved by the Student's Advisory Committee after an oral examination on the same in collaboration with the External examiner.

Advisory Committee's

Chairman: **Dr. Ajit Kumar Sahoo**
Assistant Professor(Horticulture),
AICRP on Palms,
OUAT, Bhubaneswar
AKSahoo 15.11.22
____

Members 1. **Dr. Sashikala Beura**
Professor and Head, Department of
Fruit Science and Horticulture
Technology, C.A., OUAT,
Bhubaneswar.
15/11/2022
____

2. **Dr. Kundan Kishore**
Principal Scientist,
Horticulture-Fruit Science,
CHES(ICAR-IIHR)
Bhubaneswar,Odisha-751019
15/11/22
____

3. **Dr. Nihar Ranjan Sahoo**
Professor,
Department of Agricultural Processing
& Food Engineering,
College Agricultural Engineering & Technology,
OUAT, Bhubaneswar
15/11/22
____

EXTERNAL EXAMINER:
____
Name and Designation
Bikash Das
Principal Scientist
ICAR RCER FSRCHPR,
Ranchi

ODISHA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
DEPARTMENT OF FRUIT SCIENCE AND HORTICULTURE TECHNOLOGY
COLLEGEOFAGRICULTURE
BHUBANESWAR- 751003,ODISHA

CERTIFICATE OF ANTI-PLAGIARISM

This is to certify that the M.Sc. (Ag.) thesis of **Sumitra Hansdah, Adm. No. 201221907**, Department of Fruit Science and Horticulture Technology, College of Agriculture, OUAT,Bhubaneswar has been checked for anti-plagiarism by using Turnitin web portal and similarityindex was found within 15% level (From Abstract to Summary and Conclusion) as prescribed byOUAT.

Sumitra Hansdah
Student

14.11.22
Chairman

14/11/2022
Head of Department

ACKNOWLEDGEMENT

Time marches on, the seasons change and it is time to relish what has been accomplished. This work has behind it the encouragement, sustained interest and help of many. It is by the race and abundant blessings of Almighty that I have been able to bring to life this humble piece of work to which I am eternally indebted.

I am extremely delighted and feel blessed to have worked under the guidance of excellent pursuing and ever helpful personality, Honorable chairman of my Advisory committee, **Dr. Ajit Kumar Sahoo**, Assistant Professor (Horticulture),AICRP on Palms, OUAT, Bhubaneswar. His invaluable and timeless suggestion, constant inspiration, affectionate dealings, constructive criticism and advice helped me at every stage. His innovative ideas, meticulous nature and close monitoring of the research work moulded the manuscript with perfection. My sense of obligation is negligible and unquantifiable in respect of his energy and time spent on this endeavour. His benevolent personality made a great impression on me and I wish to inculcate his positive energy. It was a life time opportunity to work with him, to know about an experimental man in work and to gather valuable knowledge and experience, suggestions during the course of my investigation.

It is my pleasure to express my deepest sense of regards to **Dr. Sashikala Beura**, Professor and Head, Department of Fruit Science and Horticulture Technology , College of Agriculture ,OUAT, Bhubaneswar for her kind words, immense patronage and encouragement in the study period.

I take privilege of expressing gratitude and gratefulness to **Dr. Nihar Ranjan Sahoo**, Professor ,Department of Agricultural Processing & Food Engineering, College of Agricultural Engineering & Technology, OUAT, Bhubaneswar for his concern, magnanimity, guidance, criticism, incredible patience and freedom of work he provided all throughout my project work. His help and advice is always invaluable and it is my golden opportunity to have him as the member of my Advisory committee.

I record my thanks to **Dr. Kundan Kishore**, Principal Scientist, Horticulture-Fruit Science ,CHES(ICAR-IIHR), Bhubaneswar, Odisha-751019,for his cooperation to make this effort successful.

I feel greatly indebted and convey my profound sense of gratitude to my esteemed professors, **Dr. P.K. Panda**, **Dr. Kabita Sethi** (Department of FruitScience and Horticulture Technology), **Dr. G.S. Sahu** (Head, Dept. of Vegetable Science), and **Dr. Pradyumna Tripathy** (Dept. of Vegetable Science) during the entire course of my study.

I express my deepest gratitude for the unhesitant assistant and support from Bububhai, Rama bhai, Bidyadharbhai, Prabhati ma'am and nonteaching staffs of Department of Fruit Science and Horticulture Technology ,OUAT,Bhubaneswar throughout my research study.

I wish to place on recorded my sincere thanks to senior Lisa Lismayeedidi,Dipika, Deepti, Sangeeta, Suprija, Namrata, Rashmifor their constant support and sound suggestions throughout my M.Sc. I take this opportunity to express my heartfelt indebtedness and deepest sense of gratitude to my PG friends Tapas, Sagarika,Sonali,Prasanta, Sasmita, Sunil, Adyashakti, Sravani, Rakhi ,Dolly, Soumen for helping me in each and every stage and for being such a great support.

I seek the utterance of a blessing of my Parents for my progress and prosperity. I am very much thankful to my father, Mr. Piru Hansdah and mother, Mrs. Jasmimoni Hansdah for their blessings that made me to reach this extent. Thank you so much my loving parents for your blissful blessings, selfless sacrifice and eternal benediction which has instrumental in every step in my career. I still pray for your blessings to be bestowed upon me like this only always in my life. I would like to confess my deep sense of regard to my sister and brother, whose love, support and care endlessly helped me to do this research work sincerely.

My special thanks to Ranjit bhai for neat alignment and binding of the manuscript in the prescribed format within a very short time.

Finally, I thank the unknown and known persons whose names are not mentioned here, but who made their contribution in this thesis directly or indirectly. My apologies to those that I have inadvertently overlooked or forgot to mention in my acknowledgements but who equally deserve.

Sumitra Hansdah

SumitraHansdah

Adm No.: 201221907

Place : Bhubaneswar

Date : 1411-2022

CONTENTS

LISTOF TABLES

LIST OF FIGURES

LIST OF PLATES

ABBREVIATIONS USED

%	:	Percent
/	:	Per
gm	:	Gram
Ml	:	Millilitre
Hr	:	Hour
ANOVA	:	Analysisofvariance
SEm(±)	:	Standarderrormean
CD at 5%	:	Criticaldifferencewithsignificancelevel at 5%
Fig.	:	Figure
No.	:	Number
i.e.	:	Thatis
^{0}C	:	DegreeCelsius
^{0}Brix	:	Degreebrix
^{0}	:	Degree
TSS	:	Totalsoluble solids
pH	:	Potentialof Hydrogen
viz.	:	Videlicet(namely)
etal	:	etalia(Co-workers)
F.P.O	:	Food Product Order
CFU	:	Colony Forming Unit
ppm	:	Parts per million
₹	:	Rupees
RTS	:	Ready-to-Serve

ABSTRACT

The present investigation "Standardization of pulp extraction and recipe for the preparation of Ready-to-Serve beverage from tamarind (*Tamarindus indica* L.)" was conducted in the Laboratory of the Department of Fruit Science and Horticulture Technology, College of Agriculture, OUAT, Bhubaneswar during the year 2021-2022. This experiment was carried out with twelve recipe treatments, which had a Completely Randomized Design and three replications.

A local variety of good-quality, ripened and dried tamarind fruit was used to prepare the RTS beverage and for flavouring chilli juice, cumin juice and sugar were added and class-II preservatives like sodium benzoate, potassium sorbate and potassium metabisulphite and stabilizers (pectin) were used as part of the experiment. For further study, the prepared product was put in cap bottles with capacities of 200 ml unit size and kept at ambient condition and refrigerated condition. The chemical observation as well as sensory evaluation and microbiological contamination study was done for both ambient conditions and refrigerated storage RTS.

The RTS beverage prepared out of 100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr +sodium benzoate (SB) 70ppm and potassium sorbate (PS)150ppm (T_4) significantly maintained the general acceptance up to 30 days of storage among the various recipe treatments developed in this experiment. Regarding the product's chemical characteristics during storage of RTS, the acidity, tartaric acid, TSS, total sugar, reducing sugar and non-reducing sugar content all showed an increasing trend with increasing storage time, whereas the ascorbic acid content showed a decreasing trend under ambient conditions. Additionally, it was found that during the 30 days of refrigerated storage, bacterial and fungal growth was very low. In terms of the economics, the treatment T_4 (100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr +sodium benzoate (SB) 70ppm and potassium sorbate (PS)150ppm) had the highest benefit-to-cost ratio (2.28).

INTRODUCTION

The plant *Tamarindus indica (T. indica),* more commonly known as tamarind, is a member of the dicotyledonous "Leguminosae" Family (Lewis *et al.,*2005) and its cultivation is primarily done for the pulp from its fruit, which is used to make a beverage and flavour curries, sauces, and confections. The word "tamarind" was derived from the Arabic "Tamar-u'l-Hind" which means "date of India" .So "Indian Date" is another name for it because the dried pulp has a date-like appearance. Nearly every region of the world that mankind is aware of uses *T. indica* as a common herbal remedy (Siddhuraju, 2007). The fruit has a good amount of calcium, phosphorus, iron, and vitamins and it also has trace amounts of vitamins A and C (Manjula *et al.*,2017). Tamarind's most notable quality is its extreme acidity, with a total acidity range ranging from 12.2 to 23.8% as tartaric acid. The tamarind fruit pulp is soft and thick, brown or reddish brown in colour and makes up 55 % of the fruit; the remaining 34% and 11% are made up of seeds and shells respectively (Yahia *et al.,* 2011).The primary acidulant present in fruit pulp is used in food preparation in India and other Asian nations, and is the richest natural source of tartaric acid (Singh *et al.,* 2007).

The plant is grown all over the world and is widely distributed in the subtropics and semiarid tropics and is grown as an evergreen crop. The tree is native to India and may be in Tropical America. In India, tamarind is grown in 47('000Ha) hectares area with a production of 189 (000MT) (Horticulture Statistics Division, DAC&FW) . India produces and exports the most tamarind pulp about 300,000 tonnes, followed by Thailand (140,000 tonnes) and only 45% of tamarind trees are planted for the fruit pulp, which has both food and medicinal uses (Narina *et al.*, 2018). Although it has been somewhat domesticated, the tree grows wild. The tree is particularly common in Madhya Pradesh, Bihar, Andhra Pradesh, Tamil Nadu, Karnataka and Odisha in India.

Tamarind pulp is an excellent source of antioxidants, especially vitamin C, flavonoids, carotenoids, and vitamin B complex, as well as one that strengthens and supports the immune system. Tamarind pulp is also a great source of potassium, which is used to regulate blood pressure and heart rate, and lowers levels of bad cholesterol because it is high in carotene. Tamarind juice functions as a tonic, carminative, antiseptic, cleaning agent, and febrifuge, and controls the malfunction of the intestines and other digestive organs. Bronchitis and sore throats are treated with tamarind juice extract. Conjunctivitis can also be treated successfully with heated tamarind juice. Biliousness and other bile conditions can be effectively treated by diluting tamarind juice with lemon, milk, honey, and dates. When given to kids, a mild decoction of the pulp aids in the removal of worms and other intestinal parasites.

Tartaric acid, reducing sugar, pectin, tannin, fibre, and cellulosic material are the primary components of tamarind fruit pulp. The ripe pod's edible component has a pH of 3.15 and is composed of sugars (23-30%), proteins (1.4-3.30%), fat (0.27-0.81%), sucrose (0.10-0.80%), cellulose (1.80-3.20%), ascorbic acid (3.0-3.9mg/100g), tartaric acid (8.4-12.4%), sugars (23-30%), and ascorbic acid (3.0-3.9mg/100g) (Shankaracharya,1998).The fruit includes a little quantity of vitamins A and C but is a high source of calcium, phosphorus, and iron as well as a great source of riboflavin, thiamin, and niacin(Siddig *et al*.,2006).

Tamarind trees can withstand strong winds and have strong, flexible branches that gracefully droop at the ends and has dark gray, rough , fissured bark and are also found growing in backyards, along roadsides, or in wastelands (Gunasena *et al*.,2000).

The pulp made from the tamarind fruit is typically consumed raw, though it can also be processed and turned into juice, brine, or infusion and also used to make jams, sweets, RTS etc. The most significant and practical sizing material, tamarind kernel powder (TKP), is therefore regarded as the main tamarind seed product with industrial significance. It is used in some of the most well-known industries, including the papermaking industry, textile industry, and jute industry (Kumar and Bhattacharya,2008). Because of its jelly-forming properties and carbohydrate nature, this polysaccharide (pectin) is now used as a stabiliser in the commercial production of cheese, ice cream, and mayonnaise (Siddig *et al.*,2006).

Additionally, scientists have suggested using it as an agent or as a potential ingredient in the manufacture of various pharmaceutical products. The leaves and flowers of tamarind are being consumed as fresh, raw vegetables by people in many regions and can also be made into a variety of restaurant quality dishes (ICRAF,2007). Its timber is used to make fuel wood, charcoal, rice pounders, tool handles, and furniture. Almost all of the tree's parts are utilised.

The most urgent issue facing the nation's processing industries is the post-harvest loss of fresh tamarind. Therefore, the key components for resolving these issues are value addition and product diversification. Fruits must be processed right away because they are perishable, to prevent post-harvest losses. Approximately 90% of tamarind fruits are consumed fresh, with very little of them being processed (Archana *et al.*, 2015). Tamarind fruits can be processed into a variety of value-added products to create a convenient product with the benefit of ease of handling, transportation, storage, and use. The beverage is not very popular because it leaves a long-lasting tart taste on the tongue. One of the reasons tamarind beverages are not well-liked in the Indian market is the lack of appropriate technology or standard formulations. Currently, efforts are being made to create healthy drinks or beverages from fruits like tamarind, which has several therapeutic properties.

Ready-to-Serve (RTS) is a type of fruit beverage that contains at least 10% fruit juice,10% TSS (total soluble solids) & 0.3% acidity (F.P.O.,1995) and could be prepared from the processed juice of tamarind.

In various parts of the world, tamarind pulp is used to make beverages. A high-quality ready-to-serve beverage, syrup & concentrate can be prepared with a shelf life of six months when stored at room temperature.

For improving the flavour, palatability & nutritive value of tamarind products;chilli& cumin may be used as blends as these fruits are valued very much for their refreshing juice with nutritional & medicinal properties. However, as per the literature little work has been done on value added product of tamarind. Keeping this in view, the present investigation “Standardization of pulp extraction and recipe for the preparation of Ready-to-Serve beverage from tamarind (*Tamarindus indica* L.)” was carried out with the following objectives.

a) Standardization of methods for extraction of tamarind pulp
b) Standardization of recipe for the preparation of Ready-to-Serve beverage from tamarind pulp
c) Storage stability of tamarind RTS beverages

REVIEW OF LITERATURE

India is the second-largest fruit producer in the world, but less than 2% of the fresh produce is processed, and there is an estimated 25–30% wastage due to poor marketing, transportation, and processing facilities. The Indian government has given the food processing sector as high priority recently, and infrastructure facilities have recently undergone significant improvement. India is the chief producer and consumer of tamarind products. Tamarind pulp is used to make a variety of traditional refreshing and extremely energising drinks because the fruit's high acidity blends well with sugar and other flavours.

Ready-to-Serve beverages are made out of juice, sugar, and water and consumed as such. These contain the goodness of fresh fruit, delicious and nutritious. Because of their taste, flavour, and nutritional value, RTS is becoming more and more popular in comparison to artificial drinks. It is superior to almost all types of aerated drinks, which have essentially no nutritional value, and is highly digestible, energising, refreshing, and thirst-quenching.

Since very little research on tamarind processing has been reported, the literature in this area on other significant fruit crops is also reviewed under the following sub headings.

- **Extraction of tamarind pulp**
- **Preparation of Ready-to-Serve beverages**
- **Changes in physico-chemical composition of tamarind Ready-to-Serve beverages during storage**
- **Effect of microorganism on RTS beverage of tamarind**

2.1 Extraction of tamarind pulp

Srivastava and Sanjeevkumar (1998) studied fruit structure and composition influence how fruit juice is extracted in different ways. Fruit juice is typically extracted from fresh fruits by crushing and pressing. The easy release of juice from some fruits necessitates heat treatment.

Kotecha and Kadam (2002) studied that the tamarind fruit's pulp and juice were extracted using four different techniques: cold extraction, hot extraction, cold enzymatic extraction, and hot enzymatic extraction. The maximum pulp recovery was achieved by hot enzymatic extraction (86.10%) among the different extraction techniques. The moisture content ranged from 59.87 to 61.20% in pulp obtained using various extraction techniques, and it was lowest (59.87%) in pulp obtained using the hot extraction technique. The pulp extracted using the hot-enzymatic method had a high concentration of sugar and a low concentration of ascorbic acid, whereas the pulp extracted using the cold extraction method had a higher concentration of minerals (Ca, P and Fe). The maximum juice was recovered when pulp was treated for 6 hours with 0.5% Biotropicase L, a pectolytic enzyme.

Siddig *et al.*(2006) reported that because of the pulp's stickiness and low water content, the extraction of tamarind pulp is a challenging process. The shell is manually removed during the pulping process, and then the seeds are agitated in water to spread the pulp and separate it from the seeds. The pulp and seeds can also be separated by putting the pulp in a steam bath with water for several hours, letting it stand overnight, filtering it through muslin cloth, and then washing it in hot water. They also included a pre-fermentation of pulp (fruit:water @ 1:2) dilution before pulping and heat treatment. For easier extraction, the fruit pulp was soaked for 24, 48, and 72 hours.

Joshi *et al.*(2012) developed a more efficient extraction method for tamarind pulp. Among the dilution ratios (1:1, 1:1.5, and 1:2), the 1:2 dilution produced the highest yields of soluble and total solids with superior fruit flavour. The tamarind extracts were made by blending the pulp with either cold or hot water and then pressing it through cloth to extract the juice. The extraction was found to be better and the enzyme activity to be completed in less than six hours when the pulp was mixed with hot water to a temperature of 40° C. The extract was filtered and used to make juice concentrate.

2.2 Preparation of Ready-to-Serve beverages

Chavan (1997) prepared with a recipe of 20% fruit juice, 20° Brix TSS, and 0.3% acidity, RTS beverages are made from cashewapple, raw and ripe karonda, kokum, and lime fruit.

Pandey and Singh (1999) studied the various recipes for preparation of guava ready-to-serve beverage. It is studied that the recipe with 10% pulp, 11% TSS, and 0.25% acidity had the highest rating and was deemed the best for guava ready-to-serve beverages.

Kotecha and Kadam (2003) reported the tamarind juice-based RTS beverage had a 10% juice content, 15 ˚Brix TSS, and 0.50% acidity.

Singh *et al.*(2005)(a) evaluated various recipes for preparation of RTS from pomegranate fruit. The analysis of the results showed that the composition of 13% juice, 11% total soluble solids, and 0.30% acidity was ideal for the preparation of pomegranate RTS.

Shanbhag (2005) prepared with a recipe of 20% fruit juice, 20° Brix TSS, and 0.3% acidity, RTS beverage made from cashewapple, kokum, pineapple, karonda, jamun, and mango was successfully stored for six months.

Verma and Gehlot (2007) observed among all the treatments, bael nectar with 20% bael pulp, 150 B total soluble solids, and 0.25 % acidity was deemed to be the most palatable.

Tandon *et al*. (2007) studied ready-to-serve (RTS) drinks made from a blend of bael and papaya pulp in the following ratios: 1:0, 4:1, 3:2, 2:3, 1:4, and 0:1. These drinks contain 10% pulp, 15˚B TSS, and 0.26% acidity. They also noted that the ideal ratio for the bael:papaya pulp mixture was 2:3.

Amaravathi *et al.* (2014) prepared a spiced RTS beverages with mango 85 % and pineapple 15 % juices are combined with aqueous spice extracts. The aqueous spice extracts contained 0.5 percent curry leaf, 0.25% cumin, 0.25% cardamom, 0.15% black pepper, 0.5–2.0 percent ginger juice, and 0.4 percent mint juice, along with 1-2 percent salt (common and black salt).

2.3 Changes in physico-chemical composition of tamarind Ready-to-Serve beverages during storage

2.3.1 Total soluble solids (T.S.S)

Sattar *et al.*(1988) found that the production of water soluble pectin fractions caused an increase in total soluble solids during the 32-day storage period of pasteurised orange drink.

Chavan (1997) reported that after 8 months of storage, the blended and carbonated cashew, karonda, and lime nectar (RTS) beverage showed an increase in the T.S.S. in all treatments.

Kotecha and Kadam (2002) examined the physico-chemical properties of the flesh and fruit of the tamarind. They found that the pulp of the tamarind fruit contained 32.20˚B total soluble solids.

Rajput and Haribabu (2002) reported that the T.S.S. of acid lime fruit was between 8.1 and 10.4 ˚B, as well as 9 ˚ B T.S.S. for naval orange.

Bhatnagar and Chandra (2002) studied the nine fruit growers' orchards in Rajasthan state that use the acid lime CV. Kagzi lime. They observed that during the rainy season, the T.S.S. content in kagzi lime varied from 8.62 to 9.87 ˚B and averaged 8.76 ˚Brix.

Kannan and Banumathi (2005) reported the spiced RTS made from tamarind fruit and found that during storage, the TSS content of the spiced RTS increased.

Singh *et al.* (2005) (b) recorded a rise in the T.S.S value of pomegranate nectar over the course of six months of storage.

Masalkar (2005) reported the T.S.S. of the blended pomegranate and ginger juice carbonated RTS during storage increased marginally in all treatments.

Jain *et al*. (2007) observed a steady rise in the TSS value of the aonla nectar over the course of the 4 months of storage.

Shere *et al*. (2008) worked on the preparation, storage, and analysis of the amla RTS beverage revealed a slight increase in the total soluble solids. Initially, the TSS remained unchanged for 45 days. However, the TSS slightly increased after 60 days of storage.

Khan *et al.* (2010) reported the three species (35 var.) of citrus fruit. In Citrus sinensis, the Salustiana fruit had the highest average T.S.S. content (9.82˚B) and the Valencia late fruit had the lowest (2.89˚B), whereas in Citrus reticulate, the Tangerine fair child and Mandarin wilking had 8.96 and 3.79˚B T.S.S., respectively.

Rasala *et al.* (2011) observed the total soluble solids in fresh tamarind range from 18 to 48˚Brix.

Joshi *et al.* (2012) found the TSS of tamarind pulp used to make commercial value-added products was found to be 31˚Brix in local tamarind, followed by 27˚Brix and 26˚Brix in Ajanta and Thailand varieties respectively.

Kshirsagar (2012) reported fresh kokum rind juice has a T.S.S. of 7.20˚Brix.

Ravindra *et al*. (2012) recorded shatavari, aloe, and mango ginger blended nectar was stored for three months and showed an increasing trend in T.S.S.

Lad *et al.* (2013) recorded regardless of storage time, the T.S.S. of SaiSarbati lime squash increased during storage.

2.3.2 Titratable acidity

Shankaracharya (1998) reported that tartaric acid, which is the main acidulant used in food preparation in India, was found in highest concentrations in fruit pulp (8–18%).

Kotecha and Kadam (2002) reported that tamarind fruit pulp had a titratable acidity
of 4.06 %.

Dwivedi and Pathak (2009) reported the processing and preservation of RTS and nectar from mulberry fruits and found that the acidity of both products remained stable for the first two months of storage before slightly increasing over the remaining six months from 0.30 to 0.37 percent.

Masalkar *et al.* (2009) reported that the titratable acidity of the kagzi lime CV. SaiSarbati fruit was 6.20%.

Lande *et al.* (2010) studied the process for making ready-to-serve beverage from wood apple pulp and found that during storage, RTS beverage's titratable acidity increased from 0.30 to 0.32 percent.

Yadav *et al.* (2010) developed whey-based banana RTS and revealed that, after 20 days of storage, the acidity of the beverage rose from 0.38 to 0.49 percent.

Khan *et al*. (2010) studied the 35 varieties of citrus fruit from three species. While *Citrus reticulate* had an average acidity of 1.1% (*Tangerine dancy*) and 0.86% (*Mandarine wilking*), *Citrus sinensis* had an average acidity that was highest in Shamouti (1.57%) and lowest in *Cassa geande* (0.49 g/100 ml). They added that in *Citrus Paradise*, the acidity was 2.17% (Ruby Red) and 0.97 % (Ruby Blood).

Joshi *et al*.(2012) reported that as tartaric acid, an uncommon acid plant tissue, the total acidity ranged from 12.2 to 23.8%.

Kumar *et al*.(2013) extracted the pulp from ripe bananas and banana RTS reported that after 90 days of storage, the beverage's acidity slightly increased.

Kshirsagar (2012) observed 2.3% acidity in the juice of fresh kokum rinds.

2.3.3 Reducing sugar

Morton (1958) reported reducing sugar of tamarind pulp was 30 to 41% .

Ahmad *et al*.(1986) noted an increase in reducing sugars, which may be the result of non-reducing carbohydrates converting to reducing sugars due to longer storage times in citrus and mango squashes.

Gunasena *et al.* (2000) observed the chemical make-up of tamarind pulp after drying revealed 25 to 45 % reducing sugars.

Kotecha and Kadam (2002) studied reducing sugar content in tamarind fruit was 16.20 %.

Kannan and Banumathi (2005) observed that the reducing sugars in the various spiced RTS treatments made from tamarind fruit showed an increasing trend during storage.

Barwal *et al.* (2006) evaluated that the ready-to-serve bittergourd beverage displayed an increase in reducing sugars over the course of the 180-day storage period, which may have resulted from hydrolysis or the inversion of non-reducing sugars to reducing sugars.

Jain *et al.* (2007) monitored the cultivars of aonla for nectar production. They made nectar from the eight aonla cultivars using various recipes, which was then examined after five months of storage. They noticed that the reducing sugars in the nectar steadily increased during storage.

Lande *et al.* (2010) discovered that the reducing sugars in RTS beverages made from wood apple pulp increased during storage, rising from 0.40 to 0.53 percent.

Lad *et al.* (2013) observed that during the 90 days of storage, the reducing sugars in lime squash CV. SaiSarbati showed an increasing trend.

2.3.4 Total sugars

Kannan and Thirumaran (2002) studied that during storage, different jamun products' reducing sugar content rises.

Gunasena *et al.* (2000) recorded total sugar content ranges from 41.2 to 58.7% in dried tamarind pulp.

Kotecha and Kadam (2002) observed that the fresh tamarind fruit had a 20.40% total sugar content.

Sidding *et al.* (2006) recorded the total sugar content of tamarind is 21.40 – 30.85%.

Jain *et al.* (2007)reported that the nectar's total sugar content steadily increased during storage, which may have been caused by complex carbohydrates partially being hydrolyzed.

Tandon *et al.* (2007) examined a storage study on a bael-papaya blended RTS beverage and found that the beverage's total sugar content changed very little over the course of a six-month storage period.

Kumar *et al.* (2009) conducted the impact of various pulp concentrations and their treatments on nectar storage. They discovered that storage had little impact on nectar's overall sugar content.

Lande *et al.* (2010) reported the storage of RTS beverage made from wood apple pulp resulted in an increase in total sugars from 13.83 to 14.75 percent.

Kalunkhe *et al.* (2012) observed that during storage, the Konkan seedless lemon squash's total sugar content significantly increased.

Ravindra *et al.* (2012) reported the rise in total sugar content over a three-month period of shatavari, aloe, and mango ginger nectar beverage storage.

Hiremath and Rokhade (2012) recorded 13.54% total sugar content in sapota fruit was found in an experiment on the preparation and preservation of sapota juice.

2.3.5 Ascorbic acid

Shanbhag (2005) reported that during the six months that blended carbonated cashew apple, jamun, and karonda nectar was stored, ascorbic acid levels decreased.

Singh *et al.* (2005)(b) reported he pomegranate nectar's ascorbic acid content is steadily declining.

Barwal *et al*. (2006) observed during 180 days of storage, the ascorbic acid content of bittergourd RTS drink decreased from 8.84 mg/100g to 7.67 mg/100g. This decrease was attributed to ascorbic acid's conversion to dehydro-ascorbic acid, furfural, or hydroxy methyl furfural.

Siddig *et al.* (2006) found that the amount of ascorbic acid in tamarind pulp varies from 2 to 20 mg/100g.

Jain *et al.* (2007) reported throughout the storage period, the ascorbic acid content of aonla nectar decreased steadily, with the exception of the third and fourth storage months, where changes were found to be significant.

Kumar *et al.* (2009) conducted the impact of various ber fruit pulp concentrations and their treatments on nectar storage. The pulp of the cv. Kaithali was used to make the nectar, which contained 20 and 25 percent pulp, 0.3% acidity, and 15 ˚B TSS. They noticed that, irrespective of storage period, nectar prepared with 25% pulp and treated with KMS recorded significantly higher ascorbic acid levels (14.81 mg/100ml) and lower ascorbic acid levels (3.18 mg/100ml) than nectar with 20% pulp sugar treatment. Irrespective of pulp concentrations and treatments, the ascorbic acid content of nectar decreased from 10.80 mg/100 ml to 8.19 mg/100 ml between the start of storage and 90 days later.

Lande *et al*. (2010) observed the ascorbic acid content of the ready-to-serve beverage made from wood apple pulp was found to have decreased from 0.20 to 0.10 mg/100 ml during storage.

Joshi *et al.* (2012) reported ascorbic acid was present in the highest concentration i.e, 5.4%, in the native tamarind, followed by 3.9% in the Ajanta variety and 3.0% in the Thailand type.

2.4 Effect of microorganism on RTS beverage of tamarind

Li *et al.* (1989) observed the impact of acidity, low temperature, and sorbates on orange juice storage.Both at 5˚C and at 25˚C, there was a rise in bacterial population during the first two weeks of storage; however, the bacterial population in the juice stored at 5˚C was lower than that at 25˚C. It was discovered that an acidification below pH 2.5 + 0.03 percent sorbic acid significantly reduced the bacterial population.

Osundahunsi (2003) reported an initial microbial load of $0.2X10^1$ CFU/mL for commercial samples of soborodo. This discrepancy may be due to differences in the initial microbial load and source of raw materials, processing methods, and levels of hygiene observed during production.

Manjula *et al.* (2003) reported after a six-month period of storage, the spiced tamarind RTS had a lower microbiological count than the samples in the control group, or those without spice.

Chandan (2004) reported a rise in aonla RTS's microbial load while storage at ambient temperatures.

Upale (2005) stated that the standard plate count (SPC) of jamun RTS samples for bacteria ranged from $2.5X10^5$ CFU per ml to $2.74X\ 10^5$ CFU per ml during the study on the microbiological load of jamun RTS.

Hiremath (2006) observed Sapota juice preserved using pasteurisation, chemical preservatives, and a combination of both revealed a lower microbial burden than fresh juice (untreated control). But because the juice had already been fermented for more than 15 days, none of these procedures could help to increase the storage life.

Sameer (2006) observed regarding all chemical parameters and microbiological load, jamun beverages held in different storage techniques showed relatively less variation under refrigerated storage than under ambient storage.

Reddy and Chikkasubhana (2008) observed that during its 90-day storage period, lime-blended amla squash remained microbially unspoiled. The panel of experts in organoleptic evaluation made no incorrect comments about the fermentation of squash.

Tanushree *et al.* (2009) reported after 90 and 105 days of storage at 25°C, the typical plate count in Malta orange squash was found to be quite safe.

Akhtar *et al.* (2010) found that the microbial growth on chemically preserved mango pulp, storage time significantly ($p < 0.05$) increased the CFU/g of the pulp samples, with the maximum growth being seen after 90 days of storage.

Chauhan *et al.* (2012) observed with an extended storage period for the functional herbal RTS beverage, the overall colony count slightly increased. The beverage's initial microbial load was discovered to be 2.53 cfu/g, and after two months of storage, that load did not significantly increase. Additionally, the microbial load was incredibly low and well below the safe.

MATERIALS AND METHODS

The present investigation "Standardization of pulp extraction and recipe for the preparation of Ready-to-Serve beverage from tamarind (*Tamarindus indica* L.)" was conducted in the Laboratory of the Department of Fruit Science and Horticulture Technology, College of Agriculture, OUAT, Bhubaneswar in 2021-2022. The various materials used and the methods followed during the course of the investigation are briefly described below:

1.1 MATERIALS

3.1.1 Tamarind pulp

Good quality dried tamarind fruit pulp with reddish brown colour was purchased from a local market and brought to the laboratory. Then sorted properly and used for the experiment. All of the seeds, impurities, seed coat fragments and fibres have been eliminated in hygienic conditions.

One preliminary investigation was done to find out a suitable ingredient to be mixed for enhancing the flavour of tamarind RTS. In the first sample, mango ginger was added to the tamarind juice; in the second sample, ginger juice was mixed and in the third sample, cumin & chilli mixed juice extract was added; whereas in the fourth sample no flavouring substances were added. These samples were tasted by 10 numbers of experts and based on their given score, chilli & cumin extracted juice was finalised for flavouring the tamarind RTS.

3.1.2 Chilli and Cumin

Similarly, chilli (*Capsicum frutescens*) and Cumin (*Cuminum cyminum*) needed for the research experiment were purchased from a local market and blended in the RTS as per standard. From chilli impurities were removed and crushed with the help of an electric mixer grinder and juice was extracted. The same way cumin juice was extracted. After extraction of chilli and cumin juice , each 10ml was taken and added to the RTS of tamarind.

3.1.3 Sugar and chemicals

Sugar was bought from a nearby market and A.R.(analytical reagents) grade chemicals needed for the analytical work were collected from the Department of Fruit Science and Horticulture Technology, College of Agriculture, OUAT, Bhubaneswar.

3.2 EXPERIMENTAL DETAILS

1) Crop : Tamarind (local variety)

2) Design : C.R.D (Completely Randomized Design)

3) Number of Treatments : 12

4) Number of Replications : 3

5) Number of bottles/treatment : 5

6) Number of bottles/treatment/replication : 15

7) Total number of bottles : 180

8) Storage condition of RTS : Ambient condition and Refrigerated

3.2.1 Treatments details

The experiment includes 12 treatments with various recipe combinations. Treatments details are presented in Table 3.1.

Table 3.1 Treatment details

Treatment No.	Treatments
T_1	100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + sodium benzoate(SB) 120ppm
T_2	100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + potassium sorbate (PS) 300ppm
T_3	100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + potassium meta bisulphite (KMS) 70ppm
T_4	100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr +sodium benzoate (SB) 70ppm and potassium sorbate (PS)150ppm
T_5	100grams pulp +150grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + sodium benzoate(SB) 120ppm
T_6	100grams pulp +150grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + potassium sorbate(PS) 300ppm
T_7	100grams pulp +150grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + potassium meta bisulphite(KMS) 70ppm
T_8	100grams pulp +150grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + sodium benzoate (SB)70ppm and potassium sorbate (PS) 150ppm
T_9	100grams pulp +200grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr +sodium benzoate(SB) 120ppm
T_{10}	100grams pulp +200grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + potassium sorbate(PS) 300ppm
T_{11}	100grams pulp +200grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + potassium meta bisulphite(KMS) 70ppm
T_{12}	100grams pulp +200grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + sodium benzoate(SB) 70ppm and potassium sorbate(PS) 150ppm

3.3 METHODS OF PRODUCT PROCESSING

3.3.1 Extraction of tamarind pulp

A clean, ripe and deseeded tamarind was used. Tamarind pulp was soaked in water in a ratio of 1:2 (flesh : water). Tamarind pulp was soaked following a predetermined time i.e, 3 hours, 4 hours and 5 hours. The homogenization was achieved by hand crushing, followed by filtering. In hot water extraction, tamarind flesh was taken and soaked in water. The flesh was soaked for 3 hours, 4 hours and 5 hours followed by heating at 50˚C for 10 minutes and allowed to cool at room temperature and homogenized by hand crushing, then the pulp is extracted and filtered through a fine strainer.

Table 3.2 Soaking time and media used for pulp recovery

Soaking media	Soaking period
Hot water	3hours
	4hours
	5hours
Normal water	3hours
	4hours
	5hours

3.3.2 Preparation of Ready-to-Serve (RTS) beverage

After tamarind pulp extraction, the standardized quantity of pulp, sugar and water was added according to different recipe treatments. Then required quantity of chilli and cumin juice (1:1), stabilizer and class II preservatives were added. The quantity of juice needed by the FPO specification was calculated for the preparation of various recipes of RTS beverages.

3.3.3 Bottling

The product was then immediately filled in pre-sterilized bottles of 200 ml capacity each. Following filling, the bottles were sealed and once more pasteurised in boiling water for 30 minutes was done. The product was then cooled, labelled, and kept at room temperature in a cool, dry place.

3.3.4 Storage

Prepared RTS bottles were kept in a dry place or ambient condition i.e, at room temperature (26 to 31˚C) and relative humidity (70.4% to 97.3%) and refrigerated condition (6˚C) for storage behaviour studies and chemical analysis.

Flow chart –I

PREPARATION OF TAMARIND RTS BEVERAGES

Selection of ripe, deseeded tamarind fruit and cleaning

Soaked the pulp in hot water (1:2) for 5 hours

Hand crushing and extraction of pulp

Sieving through muslin cloth and filter

Addition of sugar and water as per recipe

Adding spices chilli and cumin (1:1) as per recipe

Adding stabilizer and class II preservatives as per treatments

Filling in sterilized bottles and sealed

Pasteurisation

Cooling

Storage

3.4 CHEMICAL CHARACTERISTICS OF TAMARIND RTS BEVERAGES

3.4.1 pH of tamarind RTS

The pH of the tamarind Ready-to-Serve beverage of all treatments was recorded by the pH meter.

3.4.2 TSS (Total soluble solids) of tamarind RTS

TSS is determined primarily by using a hand refractometer and is expressed as a percentage or Brix (0- 32 ^{o}B). The TSS content percentage is typically influenced by the acids, sugars, vitamins, amino acids, and other soluble solids present in the juice. Two to three drops of juice were kept on the refractometer's prism to measure the TSS of tamarind RTS and each replication's observation was recorded separately. Before each observation was recorded, the refractometer's prism was properly cleaned and dried.

3.4.3 Determination of Titratable acidity(%) content in tamarind RTS

The method described by Ranganna (1979) was adopted for the determination of the acidity of tamarind RTS.

Procedure:

Ten millilitres of the sample were taken in a conical flask and diluted with 90 ml of distilled water. From that, a 10 ml sample was taken and 1 or 2 drops of phenolphthalein indicator was added to titrate the sample against 0.1 N NaOH solution. The filtration process ended when the pink colour formation was observed.

Calculation:

$$\text{Titratable acidity (\%)} = \frac{\text{Titrate value} \times \text{N of NaOH} \times \text{volume made up} \times \text{Equivalent weight of acid}}{\text{aliquot taken for titration} \times \text{sample weight X100}} \text{ X 100}$$

3.4.4 Determination of tartaric acid (%) content in Tamarind RTS.

Ten millilitres of the sample were taken in a conical flask and diluted with 90 ml of distilled water. From that, a 10 ml sample was taken and 1 or 2 drops of phenolphthalein indicator was added to titrate the sample against 0.1 N NaOH solution. The filtration process ended when the pink colour formation was observed.

Calculation:

$$\text{Tartaric acidity (\%)} = \frac{\text{Titrate value} \times \text{N of NaOH} \times \text{volume made up} \times \text{Equivalent weight of acid}}{\text{aliquot taken for titration} \times \text{sample weight X100}} \text{ X 100}$$

The equivalent weight of tartaric acid is 75.

3.4.5 Determination of Ascorbic acid (%) content in Tamarind RTS

The method described by Ranganna (1979) was used to estimate the ascorbic acid content in tamarind RTS.A known volume of sample was taken in a 100 ml volumetric flask, and then with 3% meta-phosphoric acid, the volume was made up. Then, a 10 ml aliquot from this was added to a 100 ml beaker and titrated against a 2, 6-dichlorophenol indophenol dye solution until a stable faint pink colour appeared, which can last 10 seconds. The outcome was given as mg of ascorbic acid per 100 g of edible portion.

Standardization:

By titrating it against a standard ascorbic acid solution, the 2, 6-dichorophenol indophenol dye was standardised. To produce the standard, 100 mg of pure L-ascorbic acid was dissolved in 100 ml of 3% meta-phosphoric acid. After that, a 1 ml aliquot of the ascorbic acid solution was used for titration.

Calculation:

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titrate value} \times \text{Dye equivalent} \times \text{volume made up}}{\text{Aliquot taken for estimation} \times \text{sample weight}} \text{X } 100$$

3.4.6 Determination of Total sugar (%) content in tamarind RTS

Procedure:

In a 250 ml volumetric flask, 10 ml of RTS was taken. Following the addition of 5 ml of 1N HCl, 30 ml of distilled water was added to it. After being heated for three to five minutes, it was cooled (for inversion) in a water bath. The substance was transferred to a conical flask and two drops of the phenolphthalein indicator were added to it. After that,1NNaOH taken in a burette was used to titrate it. The end result was indicated by the appearance of the pink colour. In the RTS, the non-reducing sugar was now changed to a reducing form. Once the volume was up to 100ml, the content was then poured into a burette. A 250 ml conical flask was filled with 5 ml of Fehling's A and 5 ml of Fehling's B solution followed by 40 ml of distilled water was added, and then it was heated. Two drops of Methylene blue indicator were added when the first bubble appeared, and it was then titrated against the sample (inverted sample) content of the burette. The brick red colour made the endpoint noticeable (Ranganna, 1979).

Calculation:

Total sugar (%) = $\frac{\text{Factor}\times\text{Dilution}\times 100}{\text{Titratevalue}\times\text{Volumeofsampletaken}}$

(Factor value=0.05)

3.4.7 Determination of Reducing Sugar (%) content in tamarind RTS

Procedure:

A 100 ml volumetric flask was used in which 10 ml of RTS was taken and distilled water was added to bring the volume up to 100 ml. It was then transferred to a 100 mlburette.A250 ml conical flask was filled with 5 ml of Fehling's solution A and 5 ml of Fehling's B solution, and then 40 ml of distilled water was added and mixed properly. The conical flask was heated by being placed over a gas furnace. When the first bubble appears, add 2–3 drops of methylene blue indicator. It was finally titrated against the content in a burette until the endpoint reached a brick-red colour (Ranganna, 1979).

Calculation:

Reducing Sugar (%) = $\frac{\text{Factor }\times\text{Dilution}\times 100}{\text{Titrate value}\times\text{sample taken}}$

(Factor value =0.05)

3.4.8 Determination of Non-reducing Sugar (%) content in tamarind RTS

By using the method of difference, the non-reducing sugar contents of the tamarind RTS samples were as follows:

Non-reducing sugars (%) =Total Sugars (%) – Reducing Sugars (%)

3.4.9 Microbial examination

By using the serial dilution method, bacteria and fungi can be isolated from tamarind RTS juice samples. One millilitre of juice was taken and combined with nine millilitres of sterile water for serial dilution. Similarly, one millilitre of the solution from the first test tube was dispensed into or added to a tube containing nine millilitres of sterile distilled water. As a result, the tube will have a total volume of 10 ml and the solution will be 1:100, or 10^{-2}.Similarly to this, the sample was 10^{-5} times diluted by diluting the solution four times. Onemillilitre of the solution was taken and spread on the Petri plate containing the desired media (NA media for bacteria and PDA media for fungi). This is called Spread Plate Method. Plates were incubated in an inverted position at 20 to 25°C in the incubator. Bacterial colony count was taken 72 hours after inoculation and the fungal count was taken 5 to 6 days after inoculation (Aneja, 2003).

3.4.10Organoleptic evaluation of tamarind RTS

Organoleptic evaluation of the prepared samples were evaluated by the panel of judges to evaluate the best RTS treatments with organoleptic acceptance.

Determination of sensory quality on 9 points hedonic scale

Procedure:

1. Given the sample codes, such as a, b, c etc. randomly.
2. For evaluation, keep the coded samples in a row at random (for example, c,d,c,a,b evaluation).
3. Start assessing samples for each sensory quality one at a time.
4. After evaluating each sample, the evaluator should rinse their mouth out to prevent flavour, taste, and other aspects from overlapping.
5. Give grades ranging from 1 to 9 based on pleasant and unpleasant experiences.
6. Calculate the means for a specific attribute using various evaluators (replications).
7. Identify the best sample based on the highest average score attained.

Description of 9-Points in Hedonic Scale:

- 9 – Like extremely
- 8- Like very much
- 7- Like moderately
- 6- Like slightly
- 5- Neither like nor dislike
- 4- Dislike slightly
- 3- Dislike moderately
- 2- Dislike very much
- 1- Dislike extremely

3.5 STATISTICAL ANALYSIS

The experiment was laid out in a completely randomized design (CRD) with three replications. A proper statistical analysis was performed on the mean data of all the observations. The significance of the results was evaluated using the "F" test.

The appropriate standard error for each factor was worked out to compare the two means and the critical difference (CD) was calculated at a 5% level of significance using the following formula developed by Gomez and Gomez (1984).

Estimated SE of i_{th} treatment mean, $SE_m = \sqrt{EMS/r}_i$

Where,

EMS = Error mean sum of squares,

r = number of replications

CD at 5% for treatment means $= \sqrt{2\ X\ se(m)Xt(5\%)level\ at\ error\ d.f.}$

The standard error of means (SEm), standard error of the difference in mean (SEd), and critical difference (CD) between the treatments at the 5% level of significance were calculated and analysed by following Gomez and Gomez (1984).The following procedure was used to create an analysis of variances (ANOVA) table for each character.

Table 3.3. Analysis of Variance (ANOVA)

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F calculated
Treatments	k-1	TSS	TMSS=TSS/k-1	TMSS/EMSS
Error	K(r-1)	ESS	EMSS= ESS / k(r-1)	
Total	Kr-1	Total SS		

The significance of the treatment was assessed by comparing the estimated value of "F" with the tabular value of "T" at a 5% level of probability against the error degree of freedom.To compare the mean value of treatment, the following formulas were used to calculate standard error and critical values:

1. Standard Error of mean SE(m±) = EMS/r

2. Standard Error of difference SE(d ±) = $\sqrt{2}$ X SE (m)

3. Critical difference (CD) = SE(d) x t value at 5% error degree of freedom

PLATE 1 : TAMARIND PULP SOAKED IN NORMAL WATER AND HOT WATER

PLATE 2: EXTRACTION OF TAMARIND PULP BY DIFFERENT SOAKING METHODS

PLATE 3 : TAMARIND Ready-to-Serve BEVERAGES OF DIFFERENT TREATMENTS

PLATE 4 : CHEMICAL CHARACTERISTICS ANALYSIS OF TAMARIND RTS BEVERAGES OF DIFFERENT TREATMENTS

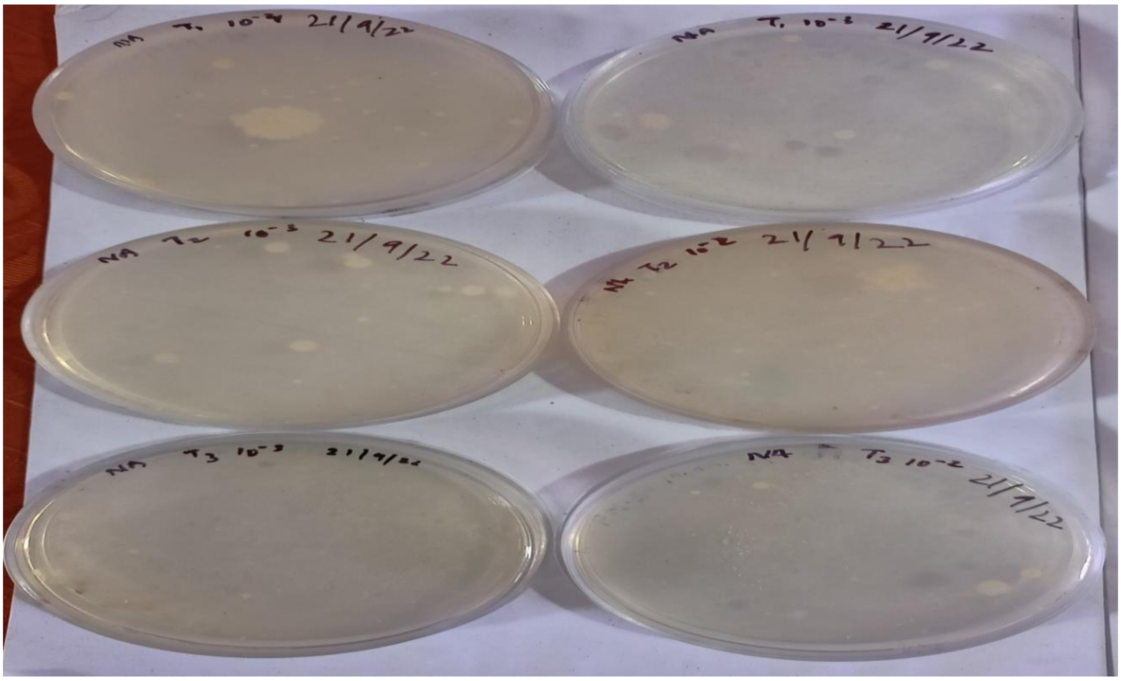

PLATE 5 : BACTERIAL GROWTH DURING 30 DAYS OF STORAGE

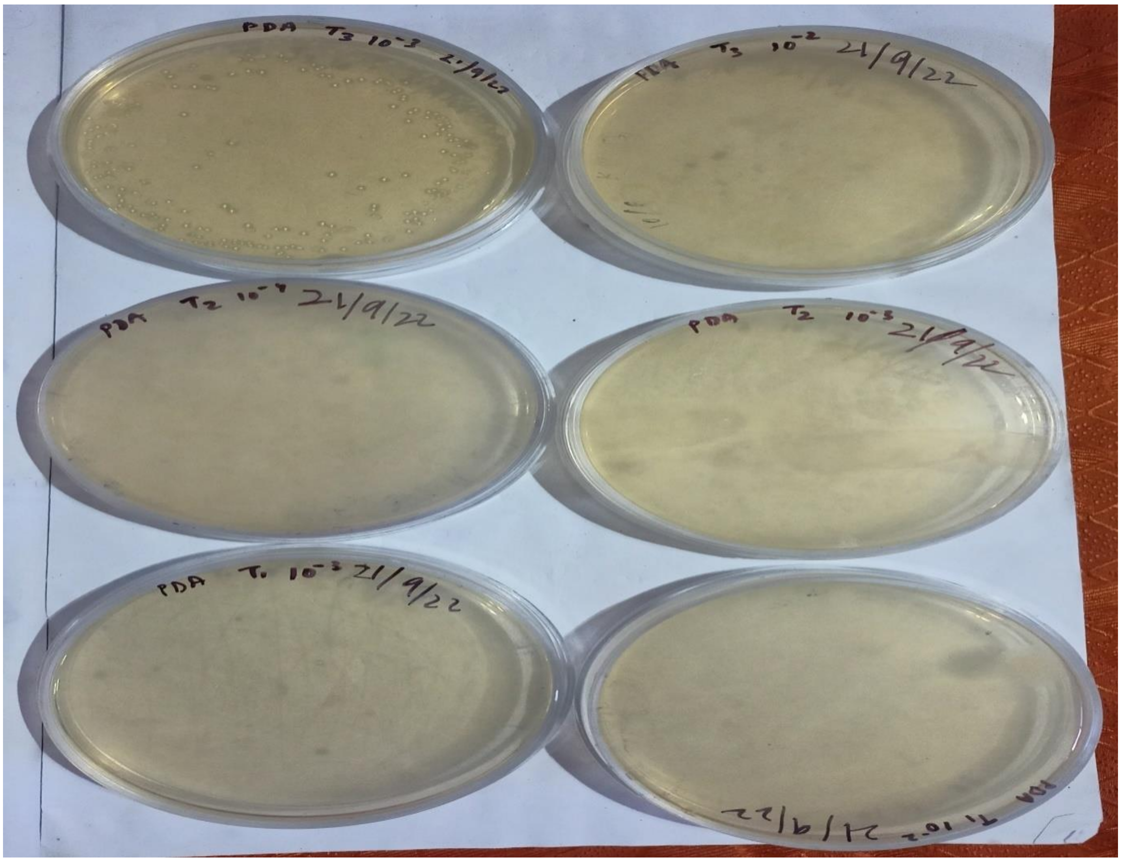

PLATE 6 : FUNGAL GROWTH DURING 30 DAYS OF STORAGE

EXPERIMENTAL RESULTS

The present investigation entitled "Standardization of pulp extraction and recipe for the preparation of Ready-to-Serve beverage from tamarind (*Tamarindus indica* L.)" conducted at the Laboratory of the Department of Fruit Science and Horticulture Technology, College of Agriculture, OUAT, Bhubaneswar in 2021-2022.

This experiment was carried out to find out the best possible way to extract the maximum quantity of pulp from the pod as well as to ascertain the best combination of different compositions for tamarind RTS. The Results from the current chapter have been briefly described on the different chemical parameters, relating to observations made on various aspects of the investigation and analyzed statistically which is represented in appropriate tables and graphs.

Table 4.1: Effect of soaking time and media on pulp recovery (%) of tamarind pulp

Soaking period	Soaking media – Pulp recovery (%)	
	Normal water	Hot water
3 hours	64.66	68.33
4 hours	66.00	70.00
5 hours	69.00	74.00
Mean	64.30	70.30
S.E(m)±	0.996	0.493
C. D at 5%	3.231	1.598

The information about tamarind pulp recovery as affected by treatments, soaking media, soaking time, and their interactions are presented in Table 4.1. It was observed that the soaking media and duration significantly affect the pulp recovery percentages as the soaking duration extended, pulp recovery gradually increased.

From table 4.1 it is observed that the pulp recovery percentage is better in hot water soaking media as compared to normal water soaking media. The pulp recovery of normal water soaking media varied between 64.66% and 69 %. Among the normal water soaking media and soaking periods (3 hours, 4 hours and 5 hours), pulp soaked for 5 hours recorded significantly highest pulp recovery (69%), whereas the lowest pulp recovery was observed in 3 hours soaking period (64.66%).

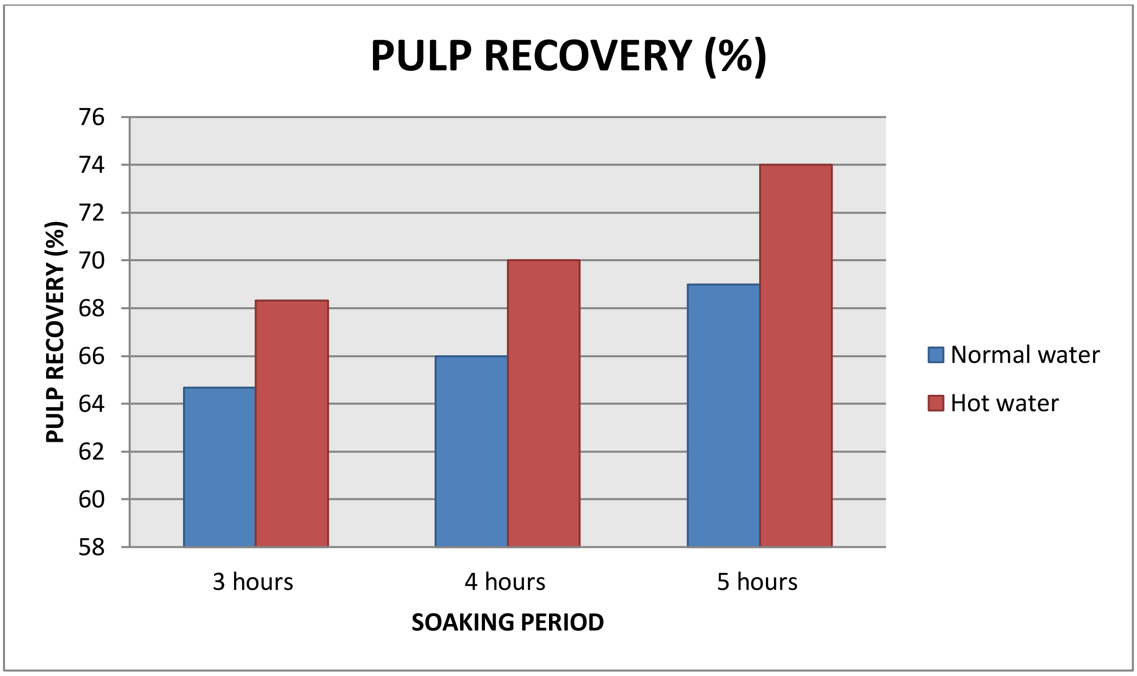

Fig.4.1: Comparison of pulp recovery (%) by different soaking media and soaking period

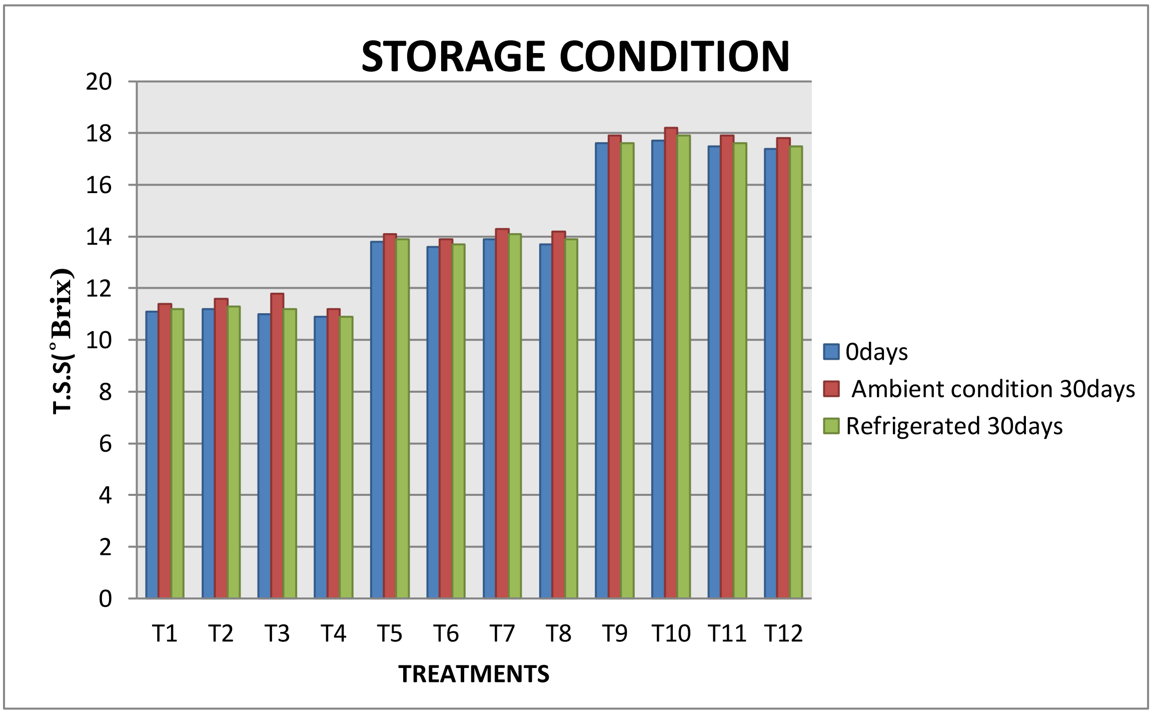

Fig.4.2: Effect of recipe treatments on TSS content (˚Brix) of tamarind RTS beverage during different storage conditions

A similar trend was also observed in hot water treatment. The pulp recovery % in hot water treatment varies between 68.33 % to 74.00 %. Among the different soaking durations (3 hours,4 hours and 5 hours), 5 hours recorded the significantly highest pulp recovery percentage (74%), whereas the significantly lowest pulp recovery was noticed in 3 hours of the soaking period (68.33%).

4.2 Effect of recipe treatments on chemical properties of tamarind RTS beverage

Table 4.2: Effect on TSS (˚Brix) content of tamarind RTS beverages during different storage conditions

Sr. No	Treatments	Storage periods (Days)		
		0 day	Ambient condition (30 days)	Refrigerated condition (30 days)
1	T_1	11.1	11.4	11.2
2	T_2	11.2	11.6	11.3
3	T_3	11.0	11.8	11.2
4	T_4	10.9	11.2	10.9
5	T_5	13.8	14.1	13.9
6	T_6	13.6	13.9	13.7
7	T_7	13.9	14.3	14.1
8	T_8	13.7	14.2	13.9
9	T_9	17.6	17.9	17.6
10	T_{10}	17.7	18.2	17.9
11	T_{11}	17.5	17.9	17.6
12	T_{12}	17.4	17.8	17.5
	Mean	13.700	14.000	13.900
	S.Em(±)	0.102	0.107	0.121
	C.D at 5%	0.328	0.334	0.376

The TSS content of tamarind RTS beverage is significantly influenced by different recipe treatments as well as storage conditions and duration are presented in Table 4.2.

It is concluded from the data that the TSS content of tamarind RTS beverage increased with the advancement of the storage period in all the treatments both in ambient storage condition as well as in refrigerated storage condition. The rate of increase in TSS content of RTS was significantly influenced by recipe treatments. On the 0days of storage, maximum TSS was recorded in the treatment T_{10} (17.7 ^{o}B) followed by T_9, T_{11} and T_{12}. Whereas, the lowest TSS content was recorded in the treatment T_4 (10.9 ^{o}B) followed by T_3, T_1 and T_2.

On the 30th day of the ambient condition of storage, the treatments T_9 and T_{11} recorded significantly the highest (17.9^{o}Brix) TSS, whereas the lowest TSS (11.2°B) was recorded in treatment T_4.But on 30 days of the refrigerated condition of storage, the treatment T_{10} recorded a maximum 17.9˚Brix and a minimum 10.9˚Brix TSS was recorded in treatment T_4.

Table 4.3: Effect on Total sugar percentage of tamarind RTS beverages during different storage conditions

Sr. No	Treatments	Storage periods (Days)		
		0 day	Ambient condition (30 days)	Refrigerated condition (30 days)
1	T_1	10.8	11.3	11.1
2	T_2	10.9	11.3	11.0
3	T_3	10.6	11.3	10.8
4	T_4	10.7	11.0	10.7
5	T_5	13.3	13.7	13.5
6	T_6	13.2	13.7	13.3
7	T_7	13.5	13.8	13.6
8	T_8	13.4	13.9	13.5
9	T_9	17.1	17.7	17.3
10	T_{10}	17.3	17.8	17.4
11	T_{11}	16.9	17.4	17.1
12	T_{12}	17.3	17.7	17.3
	Mean	13.300	13.800	13.400
	S.Em(±)	0.112	0.087	0.083
	C.D. at 5%	0.348	0.270	0.258

The details of data regarding changes in the total sugar content of tamarind RTS beverages stored at ambient condition and the refrigerated condition is presented in the Table No. 4.3. It is observed that the total sugar content increased during different storage conditions both in ambient condition and also in refrigerated condition.

The data depicted in table No. 4.3 revealed that the imposed of different treatments and storage periods in both ambient and refrigerated condition significantly affect the total sugar content in RTS. On 0days of storage, the maximum total sugar percentage (17.3%) was recorded in treatments T_{10} and T_{12}; whereas the minimum total sugar percentage (10.6%) was recorded in treatment T_3. On the 30th day of ambient storage condition, maximum total sugar content (17.8%) was recorded in treatment T_{10}, while treatment T_4 recorded minimum (11%).On the 30th day of refrigerated storage, it was recorded as maximum in treatment T_{10} (17.4%) and minimum in treatment T_4(10.7%).

Table 4.4: **Effect on reducing sugar content (%) of tamarind RTS beverages during different storage conditions**

Sr. No	Treatments	Storage periods (Days)		
		0day	Ambient condition (30days)	Refrigerated condition (30days)
1	T_1	2.24	2.46	2.34
2	T_2	2.26	2.47	2.36
3	T_3	2.23	2.45	2.33
4	T_4	2.28	2.48	2.38
5	T_5	2.25	2.45	2.35
6	T_6	2.27	2.47	2.37
7	T_7	2.23	2.43	2.33
8	T_8	2.29	2.49	2.39
9	T_9	2.26	2.44	2.34
10	T_{10}	2.24	2.46	2.36
11	T_{11}	2.23	2.43	2.33
12	T_{12}	2.27	2.47	2.37
	Mean	2.30	2.50	2.40
	S.Em(±)	0.02	0.02	0.01
	C.D. at 5%	0.06	0.05	0.02

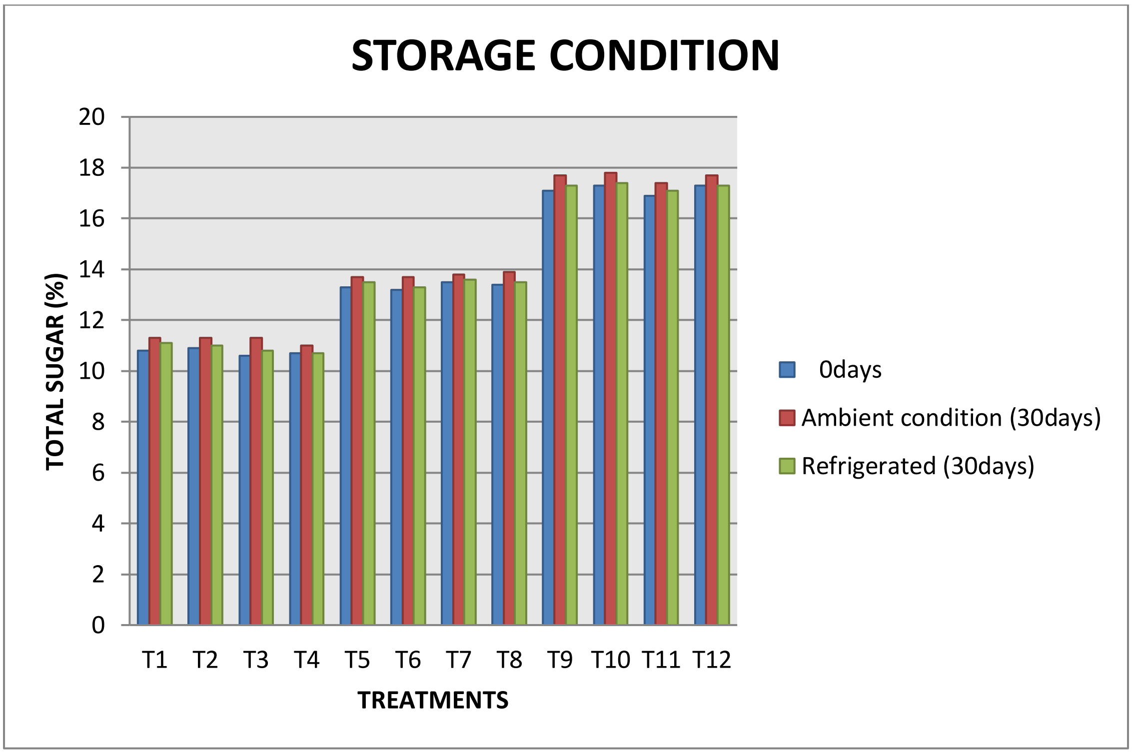

Fig.4.3: Effect of recipe treatments on Total sugar content (%) of tamarind RTS beverage during different storage conditions

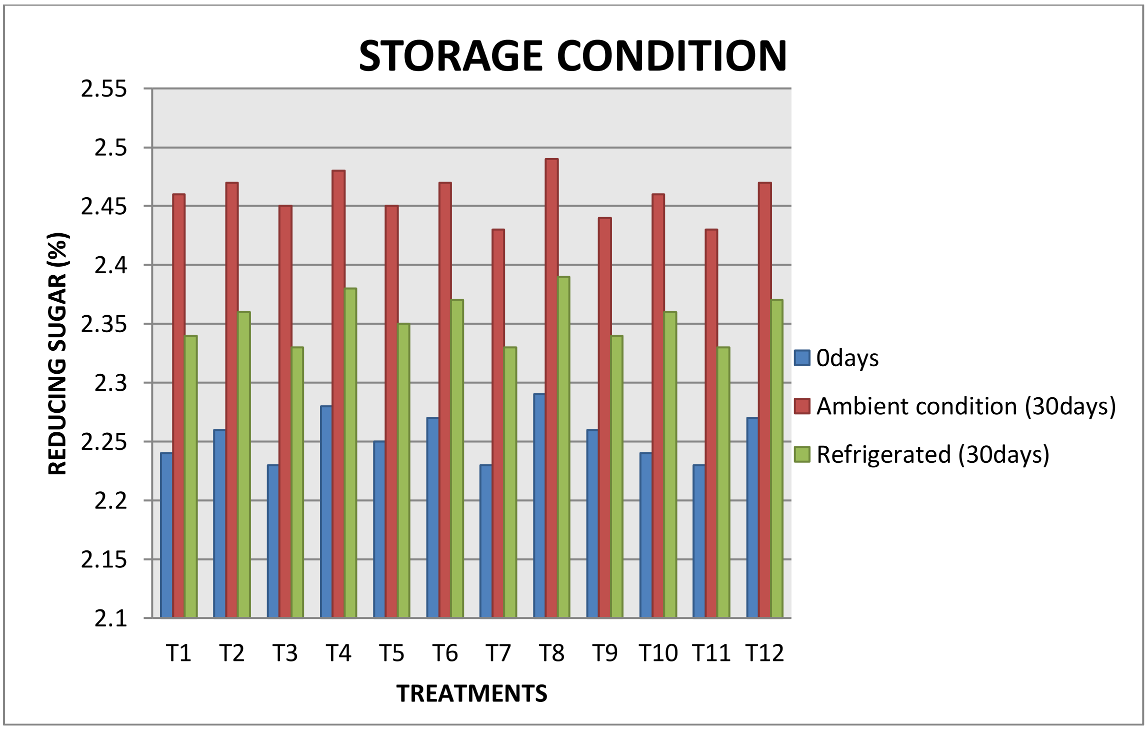

Fig.4.4: Effect of recipe treatments on Reducing sugar content (%) of tamarind RTS beverage during different storage conditions

The resulting data on changes in reducing sugar content on tamarind RTS beverages under the influence of different treatments is presented in table no. 4.4 revealed significant variations among all the treatments.

The result indicated that reducing the sugar content of tamarind RTS beverage increased with the advancement of the storage period in all the treatments. On 0 days of storage, the treatment T_9 recorded significantly the highest reducing sugar percentage (2.29%), whereas the lowest (2.23%) was recorded in treatmentsT_3, T_7 and T_{11}. On the 30^{th}day of ambient storage condition, the highest reducing sugar content (2.49%) was recorded in treatment T_8, while treatment T_7 and T_{11} recorded the lowest (2.43%) and on the 30^{th} day of refrigerated storage condition, the highest reducing sugar content recorded in the treatment T_8 (2.39%), while lowest in treatment T_3, $T_7$and T_{11} (2.33%).

Table 4.5: Effect on Non-reducing sugar percentage of tamarind RTS beverages during different storage conditions

Sr. No	Treatments	Storage periods (Days)		
		0 day	Ambient condition (30days)	Refrigerated condition (30days)
1	T_1	8.56	8.84	8.76
2	T_2	8.64	8.83	8.64
3	T_3	8.37	8.85	8.47
4	T_4	8.42	8.52	8.32
5	T_5	11.05	11.25	11.15
6	T_6	10.93	11.23	10.93
7	T_7	11.27	11.37	11.27
8	T_8	11.11	11.41	11.11
9	T_9	14.84	15.26	14.96
10	T_{10}	15.06	15.34	15.04
11	T_{11}	14.67	14.97	14.71
12	T_{12}	15.03	15.23	14.93
	Mean	10.940	11.240	10.940
	S.Em(±)	0.019	1.446	0.009
	C.D. at 5%	0.058	4.506	0.027

The observations on non-reducing sugar content in tamarind RTS are presented in table 4.5. It is noticed that there are significant variations among all the treatments. The non-reducing sugar content of tamarind RTS was significantly influenced by different recipe treatments.

The resulting data showed that the non-reducing sugar content of tamarind RTS beverages increased with the advancement of the storage period in all the treatments. On 0days of storage, a significantly maximum non-reducing sugar content (15.06%) was recorded in treatment T_{10}, whereas a minimum (8.37%) was recorded in treatment T_3. On the 30^{th}day of ambient storage condition, the highest non-reducing sugar content (15.34%) was recorded in treatment T_{10},whereas treatment T_4 recorded the lowest (8.52%) while on the 30^{th}day of refrigerated storage condition, it is recorded maximum in the treatment T_{10} (15.04%) and minimum in treatment T_4(8.32%).

Table 4.6: Effect on titratable acidity content (%) of tamarind RTS beverages during different storage conditions

Sr. No	Treatments	Storage periods (Days)		
		0 day	Ambient condition (30days)	Refrigerated condition (30days)
1	T_1	0.123	0.127	0.124
2	T_2	0.122	0.128	0.122
3	T_3	0.124	0.129	0.125
4	T_4	0.120	0.126	0.120
5	T_5	0.122	0.125	0.122
6	T_6	0.121	0.126	0.121
7	T_7	0.122	0.129	0.124
8	T_8	0.118	0.124	0.119
9	T_9	0.123	0.132	0.124
10	T_{10}	0.121	0.131	0.121
11	T_{11}	0.124	0.133	0.125
12	T_{12}	0.121	0.129	0.121
	Mean	0.122	0.127	0.122
	S.Em(±)	0.003	0.025	0.003
	C.D. at 5%	NS	0.079	NS

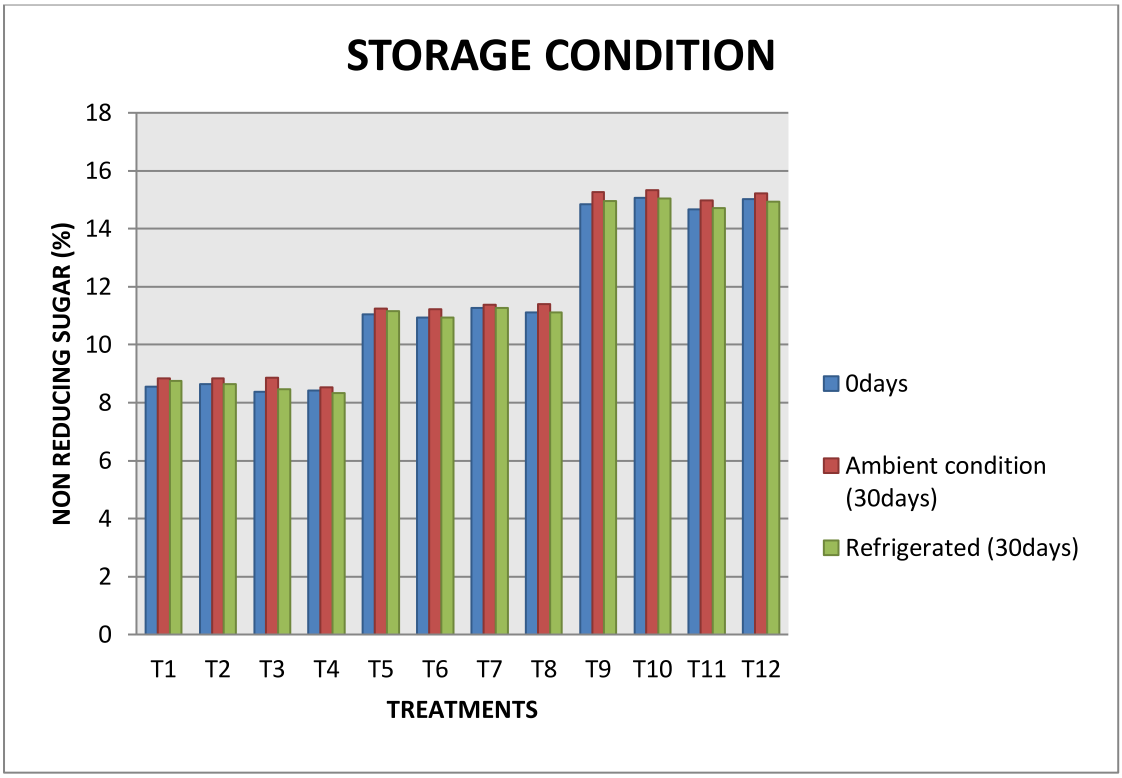

Fig.4.5: Effect of recipe treatments on Non reducing sugar content (%) of tamarind RTS beverage during different storage conditions

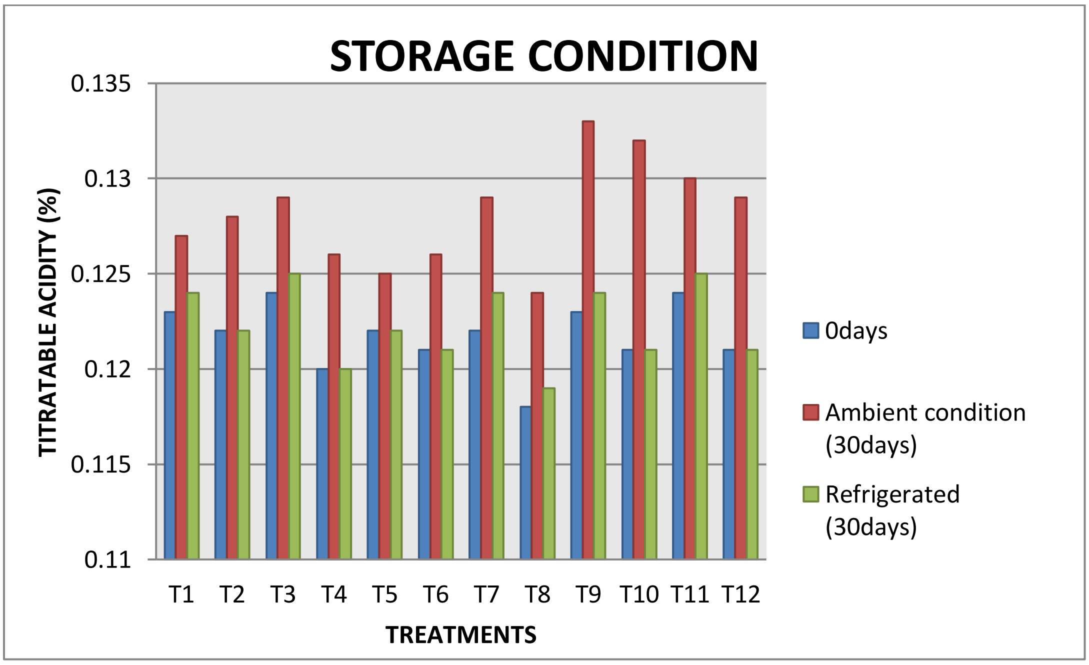

Fig.4.6: Effect of recipe treatments on Titratable Acidity content (%) of tamarind RTS beverage during storage conditions

The data on titratable acidity content in tamarind RTS is presented in table 4.6. The titratable acidity of tamarind RTS was significantly influenced by different treatments imposed as well as during different storage conditions.

The titratable acidity of tamarind RTS beverage increased with the advancement of the storage period in all the treatments. On the 0days of storage, the titratable acidity content was found statistically non-significant among the different treatments imposed. However, the maximum quantity was noticed in treatments T_3 and T_{11} (0.124%) and minimum in the treatment T_8 (0.118%). Whereas, on the 30thday of ambient storage condition, there was a significantly variation observed in titratable acidity content among the different treatments imposed during storage condition. There was an increase in the titratable acidity content during ambient storage conditions only. The treatment T_{11} recorded a significantly maximum (0.133%) acidity whereas a minimum was observed in the treatment T_8 (0.124%). In the refrigerated storage conditions, there was non-significant variation observed among the different treatments on the 30th day of storage. It is maximum in treatment T_3 (0.125%) and minimum in treatment T_8 (0.119%).

Table 4.7: Effect on tartaric acid content (%) of tamarind RTS beverages during different storage conditions

Sr. No	Treatments	Storage periods (Days)		
		0 day	Ambient condition (30 days)	Refrigerated (30days)
1	T_1	0.15	0.17	0.16
2	T_2	0.16	0.19	0.16
3	T_3	0.17	0.19	0.18
4	T_4	0.16	0.18	0.16
5	T_5	0.16	0.20	0.17
6	T_6	0.17	0.19	0.17
7	T_7	0.15	0.17	0.16
8	T_8	0.18	0.21	0.18
9	T_9	0.17	0.20	0.19
10	T_{10}	0.15	0.17	0.15
11	T_{11}	0.14	0.16	0.15
12	T_{12}	0.16	0.18	0.16
	Mean	0.17	0.177	0.350
	S.Em(±)	0.02	0.08	0.02
	C.D. at 5%	NS	0.23	NS

The data relating to changes in tartaric acid is presented in table 4.7. The tartaric acid of tamarind RTS was significantly influenced during ambient storage conditions.

The tartaric acid of tamarind RTS beverages increased with the advancement of the storage period in all the treatments in ambient storage conditions. On the 0 days of storage, tartaric acid was maximum in treatment T_8 (0.18%) and minimum in treatment T_{11} (0.14%). On 30 days of the ambient condition of storage, the treatment T_8 recorded a significantly maximum (0.21%) tartaric acid while a minimum was recorded in the treatment T_{11} (0.16%); whereas on 30thdays of refrigerated storage, it was recorded as a maximum in treatment T_9 (0.19%) and was recorded minimum in treatments T_{10} and T_{11} (0.15%), but these variations are statistically non-significant to each other.

Table 4.8: Effect on Ascorbic acid content (mg/100ml) of tamarind RTS beverages during different storage conditions

Sr. No	Treatments	Storage periods (Days)		
		0 day	Ambient condition (30days)	Refrigerated (30days)
1	T_1	0.4	0.2	0.3
2	T_2	0.5	0.3	0.5
3	T_3	0.6	0.4	0.5
4	T_4	0.5	0.3	0.5
5	T_5	0.4	0.2	0.3
6	T_6	0.7	0.5	0.7
7	T_7	0.6	0.4	0.5
8	T_8	0.5	0.3	0.5
9	T_9	0.6	0.3	0.5
10	T_{10}	0.5	0.6	0.5
11	T_{11}	0.7	0.5	0.7
12	T_{12}	0.6	0.4	0.6
	Mean	0.595	0.458	0.558
	S.Em(±)	0.065	0.058	0.059
	C.D. at 5%	NS	0.170	NS

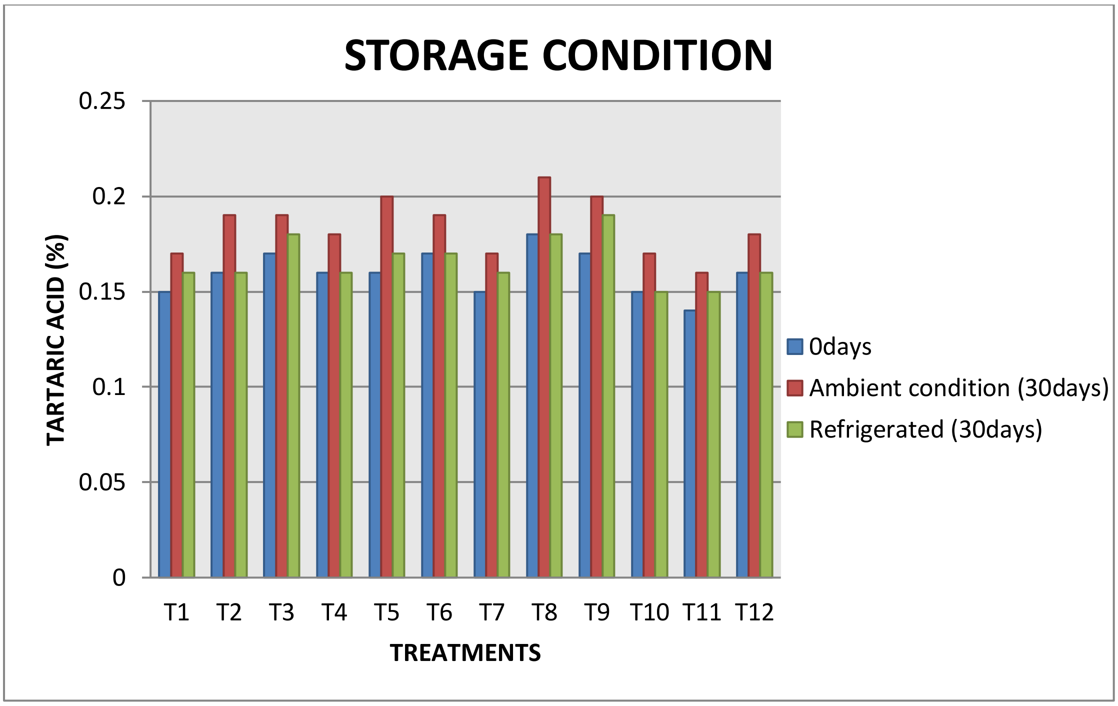

Fig.4.7: Effect of recipe treatments on Tartaric acid content (%) of tamarind RTS beverage during different storage conditions

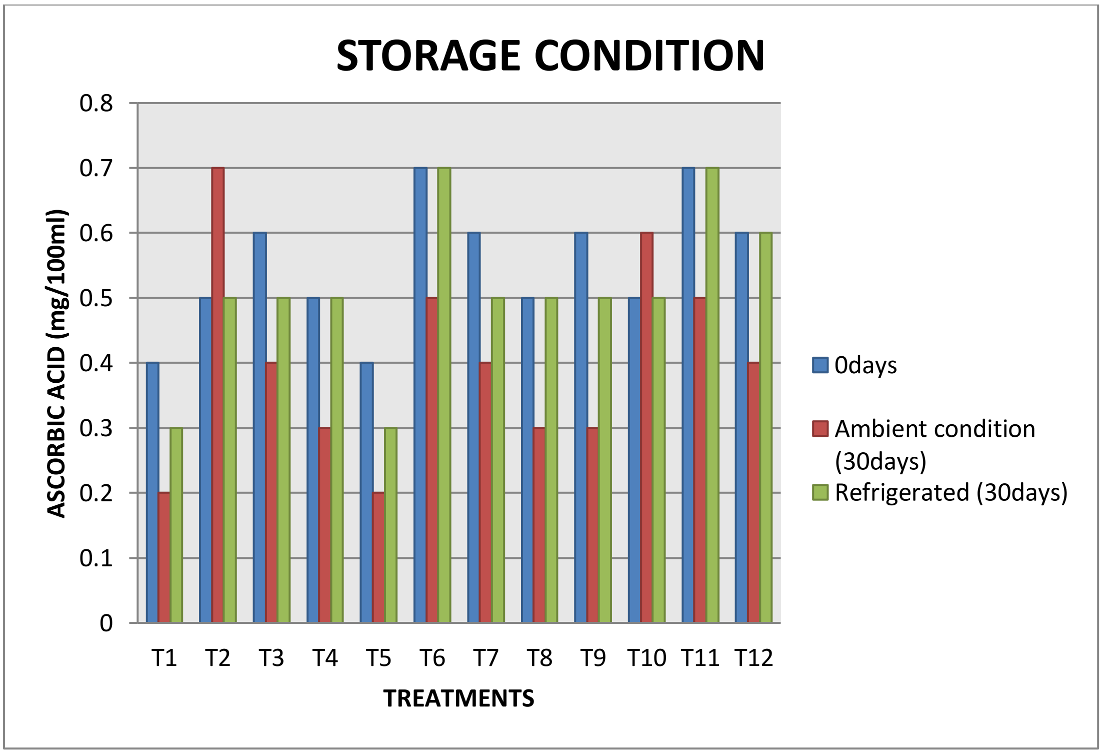

Fig.4.8: Effect of recipe treatments on Ascorbic acid content (%) of tamarind RTS beverage during different storage conditions

The changes in ascorbic acid of tamarind RTS beverage are presented in table 4.8. The ascorbic acid content decreased during the storage period. The rate of decrease in ascorbic acid content in RTS was significantly influenced by different treatments during ambient storage conditions only. On 0days of storage, the treatments T_6 and T_{11} were recorded as maximum (0.7mg/100ml) ascorbic acid, whereas minimum (0.4 mg/100 ml) was recorded in treatments T_1 and T_5. However, these variations are non-significant to each other. On the 30th day of the ambient condition of storage, the highest ascorbic acid content (0.7 mg/100 ml) was recorded significantly in treatment T_2, while treatments T_1 and T_5 recorded significantly lowest (0.2mg/100ml) and on the 30thday of refrigerated storage, there were non-significant changes occurred in the ascorbic acid content. However, the highest ascorbic acid content (0.7mg/100ml) was recorded in treatments T_6 and T_{11}, while treatments T_1 and T_5 were recorded as the lowest (0.3mg/100ml).

Table 4.9: Effect on pH of tamarind RTS beverages during different storage conditions

Sr. No	Treatments	Storage periods (Days)		
		0 day	Ambient condition (30day)	Refrigerated condition (30 days)
1	T_1	3.14	2.86	2.85
2	T_2	3.15	2.86	2.82
3	T_3	3.17	2.85	2.85
4	T_4	3.13	2.86	2.83
5	T_5	3.14	2.85	2.85
6	T_6	3.17	2.86	2.86
7	T_7	3.16	2.85	2.85
8	T_8	3.15	2.85	2.86
9	T_9	3.14	2.82	2.85
10	T_{10}	3.16	2.83	2.86
11	T_{11}	3.15	2.85	2.85
12	T_{12}	3.14	2.83	2.85
	Mean	3.20	2.90	2.90
	S.Em(±)	0.010	0.220	0.020
	C.D. at 5%	NS	NS	NS

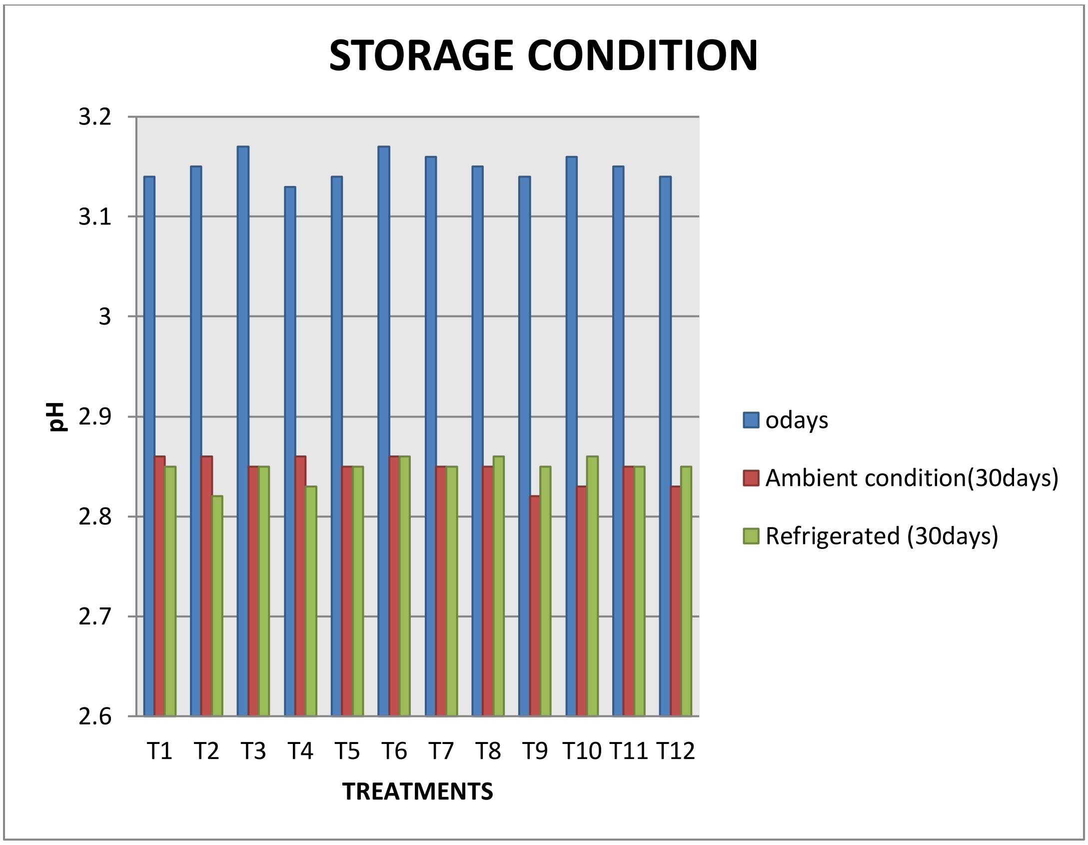

Fig.4.9: Effect of recipe treatments on pH of tamarind RTS beverage during different storage conditions

The pH data was statistically analysed and presented in table 4.9. From the above data, it is observed that there is a statistically non-significant pH value among different treatments imposed and storage conditions. However, on 0days of storage, the maximum pH value was recorded in treatments T_3 and T_6 (3.17) and the minimum pH was recorded in treatment T_4 (3.13). On 30 days of the ambient condition of storage, the maximum pH was recorded in treatments T_1, T_2, T_4 and T_6 (2.86), while treatment T_9 recorded a minimum (2.82) and on the 30th day of refrigerated storage, the maximum pH was recorded in treatments T_6, T_8 and T_{10} (2.86),while treatment T_2 was recorded minimum(2.82) pH value.

Table 4.10: Effect on microbial load in tamarind RTS beverages during different storage conditions

Sr. No	Treatments	Storage periods (Days) - microbial load (No.X10^3 CFU/ml)				
		0days	Ambient condition (30days)		Refrigerated condition (30 days)	
			Total plate counts	Total moulds and yeast counts	Total plate count	Total moulds and yeast counts
1	T_1	-	27	8	6	2
2	T_2	-	25	3	5	1
3	T_3	-	41	22	9	4
4	T_4	-	20	2	3	1
5	T_5	-	31	9	7	4
6	T_6	-	28	5	5	2
7	T_7	-	38	25	11	5
8	T_8	-	26	3	4	2
9	T_9	-	36	11	9	5
10	T_{10}	-	32	8	6	2
11	T_{11}	-	43	29	13	6
12	T_{12}	-	30	6	5	3

The findings on microbial load in tamarind RTS are depicted in table no. 4.10. It is observed that all of the recipe treatments were found to be contaminated with a wide range of bacterial and fungal species during the storage period and conditions but within the permitted limit.

It is noticed from the above table that bacterial and fungal growth was less during 30days of the refrigerated condition of storage of tamarind RTS beverage as compared to ambient conditions. On 30 days of storage, the maximum bacterial count was recorded at the ambient condition in the treatment T_{11} (33X10^3CFU/ml) and the fungal count was also in the treatment T_{11} (43 X10^3 CFU/ml), Whereas the lowest bacterial (20 X10^3 CFU/ml) and the fungal count was recorded in treatment T_4.

4.11 Organoleptic evaluation of tamarind RTS beverages

The taste of the tamarind RTS beverage was satisfied by the panel of judges during the organoleptic examination. According to a 9-point hedonic scale, the report was created.

It was found that prepared RTS from treatment T_4 scored 8 on the Hedonic scale (like very much) followed by T_2& T1 scored 7 (like moderately) on the Hedonic scale. The treatments T_9, T_{10} and T_{11} scored a minimum of 4 (dislike slightly) and the organoleptic evaluation is as follows.

4.11.1 Sensory quality evaluation on a 9-point Hedonic scale on tamarind RTS beverages

Treatments	Scale (point)	Taste (liking)
T_1	7	Like moderately
T_2	7	Like moderately
T_3	6	Like slightly
T_4	8	Like very much
T_5	6	Like slightly
T_6	6	Like slightly
T_7	6	Like slightly
T_8	7	Like moderately
T_9	4	Dislike slightly
T_{10}	4	Dislike slightly
T_{11}	4	Dislike slightly
T_{12}	5	Neither like nor dislike

4.12 Economics of the Standardized treatment

The cost of production for preparation of 10 liters of the tamarind RTS beverage from optimized standardized recipe treatment.

4.12.1 Economics of the Standardized treatment

Materials	Weight (grams)	Cost /kg	Total cost(₹)
1)Tamarind dried fruit	1351	80	110
2)Chilli	50	80	4
3)Cumin	50	100	5
4)Sugar	1000	50	50
5) Preservatives(sodium benzoate +potassium sorbate)			15
6)Stabilizer (pectin)	50	100	5
7) Bottle cost (50)	Rs. 2.5/bottle	-	125
7)Manpower(lumpsump)	-	-	100
8) Fuel cost +machinery cost	-	-	55
9)Total cost of production per 10 liter	-	-	344
10)Profit @20% of the total cost of production	-	-	69
B. Sale price per 10 liter	-	-	415
11)Sale price of the product per bottle	-	-	12
12) No. of bottles (50)	50 numbers	-	-
13)Total sale price	-	-	600
14) Total cost of product per bottle (B/12)	-	-	8.25
15)Net income per bottle (11-14)	-	-	3.75
16)Net B: C ratio(15/14)	-	-	2.28

DISCUSSION

Tamarind is a crop that is grown in arid and semi-arid areas of India and is considered to be underutilized. Though an uncommon fruit, tamarind has the highest concentration of an uncommon plant acid, i.e. (tartaric acid). Tamarind is an important spice fruit crop of dry land Horticulture. Most tamarind fruits are consumed fresh, and they are rarely processed. Therefore, there is a need to create tamarind processing technology that is both economically and commercially viable.

It became clear from reading the literature that little effort had been put into developing tamarind processing technology. A few products, such as RTS, squash, syrup, and paste, could be tested for domestic markets based on the technology currently accessible for other fruits. Additionally, efforts must be taken to standardize processing methods, assess consumer approval, and determine the products' economic sustainability. So, in the current study, an effort was made to standardize the RTS preparation processes.

Results of the experiment entitled "Standardization of pulp extraction and recipe for the preparation of Ready-to-Serve beverage from tamarind (*Tamarindus indica* L.)" presented in the preceding chapter revealed that the effect of recipe treatments significantly influenced and had a considerable impact on the chemical properties of the tamarind RTS beverage during 30 days. An effort has been made in the ensuring pages to create a cause and effect relationship amongst various parameters, which were found to be influenced significantly. To support the current results, the findings of other researchers have also been cited.

5.1 Effect of extraction methods on pulp recovery (%) of tamarind pulp

From a product cost-effectiveness perspective, pulp recovery is crucial. In the present investigation, the significantly highest recovery of the pulp was obtained by treating the pulp with hot water soaking media as compared to normal water soaking media and soaking period. Because of high temperature pulp gets easily disintegrated and melted leading to easy extraction of pulp. In normal water soaking media and soaking periods (3 hours, 4 hours, and 5 hours) the soaking period of 5 hours recorded significantly highest pulp recovery (69%), whereas the lowest pulp recovery was observed in 3 hours of the soaking period (64.66%). The pulp recovery of the hot water soaking period varied between 68.33 % and 74%. Among the soaking periods (3 hours, 4 hours, and 5 hours) 5 hours recorded significantly the highest pulp recovery (74%), whereas significantly lowest pulp recovery was noticed in 3 hours of the soaking period (68.33%). Similar observations were found by Joshi *et al*. (2012) developed a more efficient extraction method for tamarind pulp. The extraction was found to be better and the enzyme activity was to be completed in less than six hours when the pulp was mixed with hot water at a temperature of 40 °C.

5.2 Effect of recipe treatments on chemical properties of tamarind RTS beverage and during the different conditions of storage

5.2.1 Total soluble solids (T.S.S) (^{o}Brix)

The TSS increased with the gradual passage of the storage period in both ambient conditions and refrigerated storage, which might be due to the formation of water soluble fractions reported by Sattar *et al.* (1988). The maximum increase (17.9%) in TSS was recorded in treatments T_9 and T_{11} at ambient conditions and in treatment T_{10} at refrigerated storage, which was statistically superior to all the other treatments (Table 4.2). A similar result was also reported by Ravindra *et al.* (2012) recorded that Shatavari, aloe, and mango ginger blended nectar was stored for three months and showed an increasing trend in T.S.S.

5.2.2 Sugar (%)

The results revealed that the total sugar and reducing sugar content were significantly affected by all the recipe treatments (Table 4.3 and 4.4). The non-reducing sugar content, total sugar, and reducing sugar content increased significantly during the storage period in both ambient conditions and refrigerated storage, which might be due to the hydrolysis of polysaccharides into monosaccharides and oligosaccharides.

The maximum increase (17.8%) in total sugar was recorded in treatment T_{10} at ambient conditions and in treatments T_9 and T_{12} (17.3%) at refrigerated storage, which was statistically superior to all the other treatments (Table 4.3). A similar result was also reported by Lande *et al.* (2010) reported the storage of RTS beverages made from wood apple pulp resulted in an increase in total sugars from 13.83 to 14.75 percent.

The maximum increase (2.49%) in reducing sugar was recorded in treatment T_8 at ambient conditions and in treatment T_8 (2.39%) at refrigerated storage, which was statistically superior to all the other treatments (Table 4.4). It is mainly due to the conversion of non-reducing sugar to reducing sugar with the increased storage duration

(Ahmad *et al*., 1986). A similar result was also reported by Lad *et al.* (2013) observed that during the 90 days of storage, the reducing sugars in lime squash CV. Sai Sarbati showed an increasing trend.

Non-reducing sugars have increased in some fruits while decreasing in other fruits as a result of longer storage times. The maximum increase (15.34%) in non-reducing sugar was recorded in treatment T_{10} at ambient conditions and in treatment T_{10} (15.04%) at refrigerated storage, which was statistically superior to all the other treatments (Table 4.5).

5.2.3 Acidity and tartaric acid (%)

There was an increase in acidity (%) content and tartaric acid (%) content during storage (Table 4.6 and Table 4.7) which might be due to sugar being converted into acid. The result revealed that maximum acidity was recorded in treatment T_9 (0.133%) at ambient conditions and in treatments T_3 and T_{11} (0.125%) at refrigerated storage, which was superior to all the other treatments (Table 4.6). A similar result was reported in the case of tartaric acid in treatment T_8 (0.21%) at ambient conditions and in treatment T_9 (0.19%) at refrigerated storage, which was superior to all the other treatments (Table 4.7). A similar result was obtained by Kumar *et al* (2013) extracted the pulp from ripe bananas and banana RTS reported that after 90 days of storage, the beverage's acidity slightly increased.

5.2.4 Ascorbic acid (mg/100ml)

The ascorbic acid (mg/100ml) content decreased with the advancement of the storage period (Table 4.8) because it is sensitive to oxygen, light, and heat, and may have quickly oxidized in the presence of oxygen. It was indicated that beverages prepared from tamarind were very low in ascorbic acid content and the rate of decrease was also very slow in all the recipe treatments might have reduced the oxidation process. The maximum increase (0.7mg/100ml)) in ascorbic acid content was recorded in treatment T_2 at ambient conditions and in treatments T_6 and T_{11} (0.7mg/100ml) at refrigerated storage, which was superior to all the other treatments (Table 4.8). A similar result was also reported by Lande *et al*. (2010) observed the ascorbic acid content of the ready-to-serve beverage made from wood apple pulp was found to have decreased from 0.20 to 0.10 mg/100 ml during storage.

5.2.5 Microbial population

Fruit products deteriorate due to physical, chemical, and biological reasons. Most significant changes in fruit products are due to biological factors, especially microorganisms. The outcomes of the microbiological test demonstrated that microbial contamination had not adversely affected the quality of any prepared RTS beverage. According to the results of the samples' microbiological investigation, there was a slight increase in both TPC and mould growth but they were only to an acceptable limit over their 30 days storage period at both ambient and refrigerated storage.

It is noticed from Table 4.10 that bacterial and fungal growth was less during 30 days of the refrigerated condition of storage of tamarind RTS beverage as compared to ambient conditions. Some bacterial species were still observed as the acidic condition of the beverage increased during storage. On 30 days of storage the maximum bacterial growth was recorded in treatment T_{11} ($43X10^3$CFU/ml)at ambient conditions and in treatment T_{11} ($13X10^3$CFU/ml) at refrigerated storage, while on the 30 days of storage the maximum fungal growth was recorded in treatment T_{11} (29 $X10^3$CFU/ml)at ambient condition and in treatment T_{11} ($6X10^3$CFU/ml) at refrigerated storage. Similar results were also reported by Li *et al.* (1989) in orange and Manjula *et al.* (2003) in tamarind RTS.

The resulting data in table 4.10 showed that among all the recipe treatments, the minimum microbial population was recorded in treatment T_4. This might be due to the inhibitory effect of preservatives i.e, sodium benzoate and potassium sorbate have an antifungal effect. Refrigeration caused a decline in the microbial load of the beverage. The low microbial counts of the refrigerated beverage samples may be because low temperatures can control the proliferation of microbes.

5.2.6 Organoleptic evaluation of tamarind RTS beverage

Among all the various recipe treatments in the current study the highest taste value 8.00 out of 10 (like very much) on the Hedonic scale was recorded in treatment T_4 (Table 4.11.1) because of the perfect blend of sugar and flavoring agents as well as other ingredients. Preservatives added to it also influenced the taste i.e, Sodium benzoate which enhances the taste during storage, and Potassium sorbate which is tasteless and odorless. Treatments T_3 (6, like slightly), T_7 (6, like slightly), and T_{11} (4, dislike slightly)gave sulfur odour and slightly more sweet taste, so the panel judges slightly disliked these treatments due to the preservative Potassium meta bisulphite (KMS) gave sulphur odour and more sweet taste due to addition of more quantity sugar. The treatments T_9 (4-dislike slightly), T_{10} (4-dislike slightly), T_{11} (4, disliked slightly), and T_{12} (5, neither like nor dislike) were disliked very much by the panel of judges because more sweet taste compared to other treatments.

5.2.7 Economics of the Standardized treatment

The cost of production for the preparation of 10 liters of the tamarind RTS beverage from optimized standardized recipe treatment was calculated. It was found that the benefit-to-cost ratio (B: C) (2.28) and economically viable.

It is evident from the findings of the current study and the discussion that recipe treatments developed for the preparation of tamarind RTS beverages were highly successful in meeting the various objectives that were taken into consideration in this experiment. The T_4 (100grams pulp + 100grams sugar + 900ml water + 20ml of chilli and cumin juice (1:1) + pectin 5g/lt + sodium benzoate 70 ppm and potassium sorbate 150 ppm) treatment was found to be a better quality product and had the highest level of consumer acceptability. As a result, these tamarind RTS beverages can be effectively preserved for 30 days at ambient conditions and could be stored for more than 30 days in refrigerated conditions.

SUMMARY AND CONCLUSION

In India, tamarind is a well-known underutilized fruit crop that is often consumed as dried fruit or pulp and also has an export market. Because it is simple to handle, transport, store, and use, it may be processed into several value added products. Processed product has a longer shelf life and more value which encourages the producers to earn more money from them.RTS beverage preparation is one method that satisfies the need for a standard method to reduce post-harvest losses, but it requires sufficient standardisation of an appropriate recipe.

The present investigation on "Standardization of pulp extraction and recipe for the preparation of Ready-to-Serve beverage from tamarind (*Tamarindus indica* L.)" was conducted in the Laboratory of the Department of Fruit Science and Horticulture Technology, College of Agriculture, OUAT, Bhubaneswar in 2021-2022.A total of 12 recipe treatments were used in this study as given below:

Treatment No.	Treatments
T_1-	100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + sodium benzoate(SB) 120ppm
T_2-	100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + potassium sorbate (PS) 300ppm
T_3-	100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + potassium meta bisulphite (KMS) 70ppm
T_4-	100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr +sodium benzoate (SB) 70ppm and potassium sorbate (PS)150ppm
T_5-	100grams pulp +150grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + sodium benzoate(SB) 120ppm
T_6-	100grams pulp +150grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + potassium sorbate(PS) 300ppm

T_7-	100grams pulp +150grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + potassium meta bisulphite(KMS) 70ppm
T_8-	100grams pulp +150grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + sodium benzoate (SB)70ppm and potassium sorbate (PS) 150ppm
T_9-	100grams pulp +200grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr +sodium benzoate(SB) 120ppm
T_{10}-	100grams pulp +200grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + potassium sorbate(PS) 300ppm
T_{11}-	100grams pulp +200grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + potassium meta bisulphite(KMS) 70ppm
T_{12}-	100grams pulp +200grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr + sodium benzoate(SB) 70ppm and potassium sorbate(PS) 150ppm

The experiment was carried out to investigate the impact of extraction methods on tamarind pulp recovery as well as the preparation and storage of tamarind RTS beverages. The RTS prepared were stored in both ambient conditions and refrigerated conditions. During this experiment, the obtained treatment results are summarized below.

1. The pulp recovery percentage is better in hot water soaking media as compared to normal water soaking media. Pulp soaked for 5 hours recorded significantly the highest pulp recovery (69%), whereas the lowest pulp recovery was observed in 3 hours of the soaking period (64.66%). However, a similar trend was also observed in hot water treatment. Among the different soaking durations (3 hours,4 hours and 5 hours), 5 hours recorded significantly the highest pulp recovery percentage (74%), whereas significantly lowest pulp recovery was noticed in 3 hours of the soaking period (68.33%).
2. Among the recipe treatments, the recipe treatment containing T_4 (100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+ pectin 5g/ltr

+sodium benzoate 70ppm and potassium sorbate150ppm) found to be the best treatment as compared to other recipe treatment.

3. TSS content of tamarind RTS beverage increased with the advancement of the storage period in all the treatments both in ambient storage condition as well as in refrigerated storage condition. On the 0 days of storage, maximum TSS was recorded in the treatment T_{10} (17.7 °B). Whereas, the lowest TSS content was recorded in the treatment T_4 (10.9 °B) followed by T_3, T_1 and T_2. On the 30th day of the ambient condition of storage, the treatments T_9 and T_{11} recorded significantly the highest (17.9°Brix) TSS, whereas the lowest TSS (11.2°B) was recorded in treatment T_4.But on 30 days of the refrigerated condition of storage, the treatmentT_{10} recorded a maximum of 17.9°Brix and a minimum 10.9˚Brix TSS was recorded in treatment T_4.
4. On 0 days of storage, the maximum total sugar percentage (17.3%) was recorded in treatments T_{10} and T_{12}; whereas the minimum total sugar percentage (10.6%) was recorded in treatment T_3. On the 30th day of ambient storage condition, maximum total sugar content (17.8%) was recorded in treatment T_{10}, while treatment T_4 recorded minimum (11%) and in refrigerated storage, it was recorded maximum in treatment T_{10} (17.4%) and minimum in treatment T_4 (10.7%).
5. The reducing sugar content of tamarind RTS beverage increased with the advancement of the storage period in all the treatments. On 0 days of storage, the treatment T_9 recorded significantly the highest reducing sugar percentage (2.29%), whereas the lowest (2.23%) was recorded in treatmentsT_3, T_7 and T_{11}. On the 30th day of ambient storage condition, the highest reducing sugar content (2.49%) was recorded in treatment T_8, while treatment T_7 and T_{11} recorded the lowest (2.43%) and in refrigerated storage condition, the highest reducing sugar content was recorded in the treatment T_8 (2.39%) ,while lowest in treatment T_3, $T_7$and T_{11} (2.33%).
6. On 0 days of storage, a significant maximum non-reducing sugar content (15.06%) was recorded in treatment T_{10}, whereas a minimum (8.37%) was recorded in treatment T_3. On the 30th day of ambient storage condition, the highest non-reducing sugar content (15.34%) was recorded in treatment T_{10}, whereas treatment T_4 recorded the lowest (8.52%) while on the 30th day of refrigerated storage condition, it is recorded maximum in the treatment T_{10} (15.04%) and minimum in treatment T_4 (8.32%).
7. The titratable acidity of tamarind RTS beverage increased with the advancement of the

storage period in all the treatments in ambient storage only. On the 0 days of storage and 30 days of refrigerated storage, the titratable acidity content was found statistically non-significant among the different treatments imposed. However, on 30 days of ambient storage, treatment T_{11} recorded a significantly maximum (0.133%) acidity whereas a minimum was observed in the treatment T_8 (0.124%).

8. The tartaric acid of tamarind RTS beverages increased with the advancement of the storage period in all the treatments in ambient storage conditions only. On the 0 days of storage and 30 days of refrigerated storage, the tartaric acid content was found statistically non-significant among the different treatments imposed. On 30 days of the ambient condition of storage, the treatment T_8 recorded significantly maximum (0.21%) tartaric acid while the minimum was recorded in the treatment T_{11} (0.16%).
9. The ascorbic acid content decreased during ambient storage conditions.On the 0 days of storage and 30 days of refrigerated storage, the ascorbic acid content was found statistically non-significant among the different treatments imposed. On the 30^{th} day of refrigerated storage, the highest ascorbic acid content (0.7mg/100ml) was recorded in treatments T_6 and T_{11}, while treatments T_1 and T_5 were recorded as the lowest (0.3mg/100ml).
10. The pH of tamarind RTS was found statistically non-significant among the different treatments imposed and storage conditions.
11. On 30 days of storage, the maximum bacterial count was recorded at the ambient condition in the treatment T_{11} ($33X10^3$ CFU/ml) and the fungal count was also in the treatment T_{11} (43 $X10^3$ CFU/ml), whereas the lowest bacterial (20 $X10^3$ CFU/ml) and the fungal count was recorded in treatment T_4.
12. The RTS prepared from the treatment T_4 (100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+ pectin 5g/lt. +sodium benzoate 70ppm and potassium sorbate150ppm) liked very much by the panel of judges based on organoleptic taste and this treatment received scored 8 in Hedonic scale.
13. According to the result of the current investigation, the T4 treatment had the highest benefit-to-cost ratio (B: C) which is 2.28, the best level of acceptability.

CONCLUSION

The importance of minor fruit like tamarind could be improved by standardizing different value added products. Ready-to-serve beverage (RTS) made with 100grams pulp +100grams sugar+900ml water+ 20ml of chilli and cumin juice (1:1)+pectin 5g/ltr +sodium benzoate (SB) 70ppm and potassium sorbate (PS)150ppm(T_4) was chosen as the most desired treatment based on its chemical observations, organoleptic taste, microbiological growth and storage study. Highest B: C ratio was also obtained in the treatment $T_{4.}$ Thus, it has been decided that the recipe treatment T_4 is the most palatable and economically viable. As a result, a small business could start producing the products for sale.

These results are however based on laboratory studies, further study on this particular aspect needs to be undertaken for further confirmation.

REFERENCES

Ahmad M, Chaudhry MA and Khan I. 1986. Studies on the standardization and storage stability of citrus and mango squashes, Nucleus, **23**(1/2): 45-48.

Akthar S, Riaz M, Ahmad A and Nasir A .2010.Physico-chemical , microbiological and sensory stability of chemically preserved mango pulp, *Pakistan Journal of Botany* ,**42**(2):853-862.

Amaravathi T, Vennila P, Hemalatha G and Parimalam P. 2014. Spiced Pineapple Ready-To-Serve Beverages, *Indian Journal of Science and Technology*, **7**(11): 1827– 1831.

Aneja KR.2003.Experiment in microbiology, plant pathology and biotechnology. New Age International (P) Limited, Publishers,4:155-162.

Archana P and Laxman K .2015. Studies on preparation and storage of tamarind squash. *Journal of Spices and Aromatic Crops*.**24** (1) :37–42.

Barwal VS, Sharma R and Singh TK .2006.Utilization of Bittergourd for the development of ready to serve drink, *Beverage and Food World*, **33**(3): 47-48.

Bhatnagar P and Chandra A. 2002.Physico – chemical characteristics of Kagzi lime fruits , *Agril. Science Digest*, **22**(2):117-119.

Chandan K. 2004. Standardization of protocol for preparation of dehydrated slices and RTS beverage from anola fruits, M. Sc. (Horti.) Thesis, Uni. Agric. Sci. Dharwad (India).

Chauhan DK, Puranik V and Rai GK.2012.Development of functional RTS Beverage, *Open Access Scientific Reports*, **1**(12).

Chavan BD. 1997. Studies on blending carbonation and storage of fruit based beverages of Cashew apple (*Anacardium occidentale* L.), Karonda (*Carissa carandas* L) Kokum (*Garciniaindica Choisy*) and Lime (*Citrus aurantifolia* L.) fruits, M.Sc. (Agri.) thesis, Konkan Krishi Vidyapeeth, Dapoli, and Dist. Ratnagiri (M.S.).

Dwivedi S and Pathak S .2009.Studies on preparation and preservation of ready to serve (RTS) and nectar beverages from mulberry (Morusnigra Linn.) fruits, *Prog. Hort*., **41** (1): 63-65.

F.P.O. 1995. The Food Products Order. Central Govt. Commodities Act.115-116.

Gunasena G and Hughes A. 2000. *Tamarindus indica*, Fruits for the future, **1**:1-169.

Gunasena HPM and Hughes A. 2000. Tamarind (*Tamarindus indica* L.), International Centre for Underutilised Crops, Southampton, UK., 1-198.

Hiremath JB and Rokhade AK. 2012. Preparation and preservation of sapota juice, *Int. J. Fd. Agri. Vet. Sci*., **2**(1): 87-91.

Horticulture Statistics Division, DAC&FW, https://agricoop.nic.in/en/statistics/horticulture

ICRAF – World Agroforestry Centre .2007. ICRAF Agroforestry Tree Database: *Tamarindus indica* L. Retrieved from http://www.worldagroforestrycentre.org.

Jain V, Singh P and Singh AK .2007. Screening of aonla cultivars for nectar making,. *Ind. Fd. Packer*, **61**(6): 116- 120.

Joshi A A, Kshirsagar RB and Sawate AR.2012. Studies on standardization of enzyme concentration and process for extraction of tamarind pulp, variety Ajanta, *J. Fd. Process and Tech*., **3**(2):1-3.

Kalunkhe S. 2012. Standardization of lemon squash cv. Konkan seedless lemon. M.Sc. (PHM) thesis, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.).

Kannan S and Thirumaran AS.2002. Studies on storage life of jamun (*Syzygium cuminni* Rom) fruit products. *J. Food Sci. Technol*., **41**(2) : 186-188.

Kannan S and BanumathiP.2005. Studies on preparation and storage of spiced rts from tamarind fruit (*Tamarindus indica*), *Beverage and Food World*, **32**(6): 40-44.

Khan I, Shah A, Saeed M and Ullahshah H. 2010.Physico-chemical analysis of *Citrus sinensis, Citrus reticulate* and *Citrus paradise*, *J.Chem.Soc.Pak*., **32**(6): 774-779.

Kotecha PM and Kadam SS.2003.Preparation of ready to serve beverage, syrup and concentrate from tamarind, *J. Food Sci. Tech*., **40**(1): 76-79.

Kotecha PM and Kadam SS.2002.Studies on extraction of pulp and juice from tamarind fruits, *Indian Fd, Packer*, **56**(6):148-152.

Kshirsagar SV. 2012. Studies on standardization of kokum (*Garcinia indicaChoisy*) juice powder, M.Sc. (PHM) thesis, Konkan Krushi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra.

Kumar CS and Bhattacharya S. 2008. Tamarind seed: Properties, processing and utilization, Critical Reviews in Food Science and Nutrition, **48**:1–20.

Kumar M, Singh D and Godara RK .2009.Effect of different pulp concentrations and their treatments on storage of nectar, *Beverage and Food World*, **36** (1): 52- 56.

Kumar SC, Singh J, Yadav A and Goyal SK.2013. Studies on development and various properties of banana RTS beverage, *Annals of Horticulture*,**5** (2): 179-184.

Lad PK, Relekar PP and Pujari KH.2013. Quality evaluation and storage behaviour of lime (*Citrus aurantifolia*) squash cv. SAI SARBATI, *The Asian Journal Of Horticulture*, **8**(1): 350-353.

Lande SB, Nirmal VS and Kotecha PM.2010.Studies on preparation of ready to serve beverage from wood apple pulp, *Beverage and Food World*, **37** (2): 69-70.

Lewis G , Schrire B , Mackinder B and Lock M. 2005. Legumes of the world. Royal botanic gardens In Williams J T, Smith RW, Haq N, & Dunsiger Z. (Ed.), Tamarind, A monograph, (p1). Southampton, UK: International Centre for Under-utilised Crops, University of Southampton. [Google Scholar]

Li Z, Alli I and Kermasha S. 1989.Use of acidification, low temperature and sarbates for storage of juice, *.J. Food Sci.,* **54**(3): 674-678.

Manjula A, Kannan S and Banumathi P. 2003. Studies on preparation and storage of spiced RTS beverage from tamarind fruit.Proce. 5 th inter. Fd. Conv., 5-8 December, Mysore, p. 202.

Manjula B, Aruna R, Prasanna NS and Ramana C. 2017. Studies on physical and bio-chemical analysis of value-added products developed from tamarind pulp,*International Journal of Processing and Post-Harvest Technology*,**8**(2): 99-103.

Masalkar SD. 2005. Preparation of carbonated beverages from pomegranate fruits cv. Ganesh and Mridula.7th Agril.Sci. Cong. 16-18 Feb. 2005, Pune, India.p189-190.

Masalkar SD, Satbhai RD and Gandhi SA.2009 . Standardization of kagzi lime carbonated beverage, *Beverage and food world*,50-51.

Morton JF. 1958. The tamarind (*Tamarindus indica* L.) is food, medical and industrial uses. Florida State Horticultural Society,18.

Narina SS and Catanzaro CJ. 2018. Tamarind (*Tamarindus indica* L.), an Underutilized Fruit Crop with Potential Nutritional Value for Cultivation in the United States of America: A Review. *Asian Food Science Journal*, 1-15.

Osundahunsi OF. 2003. Microbial quality evaluation of soborodo (Hibiscus sabdariffa) drink, *Appl. Trop. Agric*. **8**:69–72.

Pandey AK and Singh IS .1999.Studies on preparation and preservation of guava ready to serve beverage ,*Indian J. Hort*., **56** (2): 130-132.

Rajput C, BS and Haribabu R.2002.Post harvest physiology of fruits , Citriculture ,Kalyani publications, New Delhi.

Ranganna S .1979. Hand Book of Analysis and Quality Control for Fruits and Vegetable Products. 2nd edn.Tata McGraw-Hill Publication Co Ltd, New Delhi, pp 1—30.

Rasala TM, Kale VV, Lohiya GK, Moharir KS, Ittadwar AM and Awari JG.2011. Chemistry and Pharmaceutical Application of Excipients Derived from tamarind, *Asian Journal of chemistry*, **23**(4):1421- 1423.

Ravindra V, Sreenivas KN and Shankarappa TH.2012. Value addition and technology development: Shatavari, Aloe and Mango Ginger blended nectar beverage, *Environment and Ecology*, **30** (3): 495-500.

Reddy AH and Chikkasubbanna V .2009.Studies on the storage behaviour of amla syrup , *The Asian Journal of Horticulture*, **3** (2) : 203-207.

Sameer AS. 2006. Processing of jamun fruits for value addition, M. Sc. (Horti.) Thesis, Uni. Agri. Sci., Dharwad, (India).

Sattar A, Durrani MJ, Khan RN and Hussain BH. 1988. Effect of packaging material and fluorescent light on HTST-pasteurized orange drink. Zeitschrift fur Lebensmitteluntersuchung und Forschung A. **188**: 430-33.

Shanbhag RJ. 2005. Studies on blending and carbonation of fruit based beverages, M.Sc. (Agri.) thesis, Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.).

Shankaracharya NB. 1998. Tamarind – Chemistry, technology and uses- A critical appraisal, *J. Food Sci. Tech.,***35**(3):193-208.

Shere PD, Rodge AB and Shere DM. 2008. Preparation and storage studies of amla rts beverag , *Beverage and Food World*, **35** (1): 63-65.

Siddhuraju P. 2007. Antioxidant activity of polyphenolic compounds extracted from defatted raw and dry heated *Tamarindus indica* seed coat. LWT - Food Science and Technology, **40**: 982– 990.

Siddig KE ,Gunasena HPM , Prasad BA, Pushpakumara DKNG ,Ramana KVR , Vijayanand P and Williams JT. 2006. Tamarind – (*Tamarindus indica* L.) Fruits for the future, (p1-198). Southampton, UK: Southampton Centre for Underutilized Crops.

Singh Dheeraj, Lobsang Wagchu and Surendra Kumar Moond.2007.Processed products of tamarind, Department of post Harvest Technology, Maharanapratap university of Agriculture and Technology Jhalawar, Rajsthan, *India.Natural product Radiance***,** **6** (4), 315-312.

Singh J, Singh AK and Singh HK. 2005(a). Evaluation of Pomegranate (*Punica granatum* L.) varieties for nectar making, *Beverage and Food World*, **32** (3): 46-47.

Singh J, Singh AK and Singh HK. 2005(b). Preparation and evaluation of Pomegranate (*Punica granatum* L.)RTS, *Beverage and Food World*, **32**(6): 46-47.

Srivastava RP and sanjeevkumar. 1998.Fruit and vegetable preservation principle and practices International book distributing Co., Luknow, pp.64-98.

Tandon DK, Kumar S, Dikshit A and Shukla DK.2007. Storage study on Bael-Papaya blended rts beverage, *Ind. Fd. Packer*, **61** (5): 91-97.

Tanushree CS , Chopra and Singh CP.2009.Studies on standardization and shelf stability of Malta (*Citrus sinensis*) orange beverages, *Indian Food Packer*, pp: 46- 53.

Upale KB.2005. Studies on processing of jamun juice and its beverages, M. Sc. (Horti.) Thesis, Uni. Agric. Sci. Dharwad. (India).

Verma S and Gehlot R.2007.Studies on utilization of bael (*Aegle marmalos Correa*.) for processing into nectar, *Crop Res. Hisar*, **34**(1/3): 277-280.

Yadav RB ,Yadav BS and Kaliya N.2010. Development and storage studies on whey based banana herbal (*Mentha arvensis*) beverages, *American Journal of food technol*., ISSN 1557-4571.

Yahia EM and Salih NK-E.2011."Chapter 22: Tamarind (*Tamarindus indica*): Post-harvest biology and technology of tropical and subtropical fruits". Wood head publishing limited: 44.