DEVELOPMENT OF PROCESS FOR PREPARATION OF TURMERIC PASTE

A Thesis submitted to
DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH
DAPOLI – 415 712.
Maharashtra State (India).

In the partial fulfillment of requirements for degree

of

MASTER OF SCIENCE
(POST HARVEST MANAGEMENT)
in

MEDICINAL, AROMATIC, PLANTATION, SPICES AND FOREST CROPS

by

Miss. Jadhav Shivali Shashikant
B.Sc. (Horti.)

DEPARTMENT OF POST HARVEST MANAGEMENT OF MEDICINAL, AROMATIC, PLANTATION, SPICES AND FOREST CROPS, KILLA-ROHA
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NOVEMBER- 2020.

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CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or any other person to any other University or Institute for a Degree or Diploma

Place: PGI-PHM, Roha

Dated: / / 2020

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This is to certify that the thesis entitled, "DEVELOPMENT OF PROCESS FOR PREPARATION OF TURMERIC PASTE" submitted to Department of Post Harvest Management of Medicinal, Aromatic, Plantation, Spices and Forest Crops, Post Graduate Institute of Post Harvest Management, Killa- Roha, Faculty of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, (Maharashtra State), in partial fulfillment of the requirement of award of degree of MASTER OF SCIENCE (POST HARVEST MANAGEMENT) in MEDICINAL, AROMATIC, PLANTATION, SPICES AND FOREST CROPS, embodied the result of piece of bona-fide research work carried out by MISS. SHIVALI SHASHIKANT JADHAV (Reg. No.– PHMRM0180161) under my guidance and supervision. The result embodied in this project report has not been submitted to any other university or institute for the award of degree or diploma. The assistance and help received during the course of this project work and sources of the literature have been duly acknowledged.

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ACKNOWLEDGEMENT

First and foremost, thanks are to **Father**, **Mother, Brother and Harshal** the most beneficent and merciful, without their aid this work couldn't be done. I especially feel immense pleasure in expressing my deepest sense of gratitude to my research guide **Dr. J. H. Kadam sir**, Associate Professor, Department of Post Harvest Management MAPSF, Post Graduate Institute of Post Harvest Management, Killa-Roha for his precious guidance, valuable suggestions, constant encouragement and help throughout the research work.

It is my proud privilege to express my sincere gratitude to **Dr. K.H. Pujari sir**, former Associate Dean, Post Graduate Institute of Post Harvest Management, Killa-Roha for his valuable suggestions from very inception and constant interest in this research work and for giving me an opportunity for undergoing this research work and providing me necessary facilities whenever needed for the same.

I mention my sincere gratitude to **Dr. S. B. Patange sir** Associate Dean, Post Graduate Institute of Post Harvest Management, Killa-Roha **Dr. (Mrs) G. D. Shirke madam,** Professor and Head Department of MAPSF, Post Graduate Institute of Post-Harvest Management, Killa, Roha, **Dr. R.C. Ranveer sir**, Associate Professor, Department of Post-Harvest Management MPF and **Dr. Relekar sir** Professor and Head Department of Post-Harvest Management FVF Post Graduate Institute of Post Harvest Management, Killa-Roha for their valuable suggestions from very inception and constant interest in this research work.

I would like to thank to **Dr. M. S. Talathi.** Program coordinator, KVK Killa-Roha, for his valuable advice, guidance and cooperation throughout the research work. I am thankful to **Mr. L.S. Khapre sir and Miss. R. M. Jadhav madam**, Assistant professor, Post Graduate Institute of Post Harvest Management MAPSF, Killa-Roha, for their valuable suggestions from very inception and constant interest in this research

I am thankful to **Dr. S. B. Swami sir** and **Miss. G. Waikar madam** (Hostel monitor) and library incharge **Mr. Mukhedkar sir** librarian of Post Graduate Institute of Post Harvest Management, Killa, Roha, **Mr. Dalwatkar and Mr. Mohite sir** laboratory incharge for their valuable advice, guidance and cooperation throughout the research work and whole journey at PHM. I place on record my deep sense of gratitude to all my course teachers and scientists and all staff members of Post Graduate Institute of Post Harvest Management, Killa-Roha for their help and involvement during the course of study.

I am especially thankful to my friends **Shivani, Ashwini, Priyanka, Nikhil, Chinmay** my seniors **Pooja tai, Kajal tai, Sandhya tai, Sonali tai, Ranu tai, Komal tai, Akash sir and Kishor sir** for the constant encouragement and timely help during this research work. I am also thankful to the field workers **Rupesh dada, Chandorkar dada, Rahul dada, Khaire kaku, Kadam kaku, Harshali kaku, Chougule sir** for their consistent help during my work

My vocabulary fails to get words to express deep sense of gratitude and indebtedness to my parents **Mr. Shashikant P. Jadhav** and **Mrs. Jayashree Shashikant Jadhav,** my Brother **Mr. Shivraj Shashikant Jadhav,** my friends **Chandtara, Priyaka, Suyog** and all my friends and my family members who always wanted my success and inspired me with their love affection, blessings and for all that they have done.

At the end I wish to thank all those who directly or indirectly played a pivotal role in successful completion of my post-graduation and this manuscript.

Place: PGI-PHM, Roha.

Date: / / 2020 **(S. S. Jadhav.)**

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LIST OF SYMBOLS

Symbols	Description
°C	Degree Celsius
%	Percent
±	Plus minus
°B	Degree Brix
<	Less than
≤	Less than or equal to
/	Per
µ	Micron
r^2	Regression coefficients

LIST OF ABBREVIATIONS

Abbreviations	Meanings
A	Redness and greenness
ANOVA	Analysis of Variance.
AOAC	Association of Official Analytical Chemists
B	Yellowness and blueness
B_3	Niacin
CD	Coefficient of determination
CD	Critical Difference
CFU	Colony Forming Unit
Cm	Centimetre
CRD	Completely Randomized Design

Abbreviations	**Meanings**
$CuSO_4$	Copper sulfate
Cv.	Cultivar
et al.,	and others
etc.	et cetera
FCRD	Factorial Completely Randomized Design
Fig.	Figure
G	Gram
GMP	Disodium guanylate
H_2SO_4	Sulphuric acid
HCl	Hydrochloric acid
HDPE	High Density Polyethylene
Hr	Hour
i.e.	that is
IMP	Disodium inosinate
K	Consistency index
K_2SO_4	Potassium sulfate
Kg	Kilogram
L	Lightness
L	Liter
M	Meter
Mg	Milligram
Min	Minute
Mm	Millimetre
MPa	Megapascal
MPP	Metallized Polypropylene
MSG	Monosodium glutamate
N	Normality
N	Flow behaviour index

Abbreviations	**Meanings**
Na_2CO_3	Sodium Carbonate
NaOH	Sodium hydroxide
Nm	Nanometre
Non sign.	Non-significant
PET	Polyethene terephthalate
R	Replication
RH	Relative humidity
Rpm	Revolution per minute
S	Storage
SD	Standard Deviation
SE_m	Standard Error
SIG	Significant
T	Treatment
TPC	Total Plate Count
TS	Total solids
TSS	Total Soluble Solids
UV	Ultraviolet
w/v	Weight per volume
w/w	Weight per weight
YMC	Yeast and Mould Count

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Year of submission:	2020

ABSTRACT

The present research was carried out to develop a process for preparation of turmeric paste and to study the optimization of blanching period for production of turmeric paste to evaluate physico-chemical characters of turmeric paste as well as to evaluate storage stability of turmeric paste. The quality paste with good shelf life was prepared from 50.5 per cent raw turmeric, 25 per cent water, 24 per cent vinegar, 0.5 per cent starch and 250 ppm sodium benzoate. Colour deterioration was observed with increase in blanching period. Flow behaviour index, moisture, TSS, curcumin, acidity, starch, sugars, fiber, fat, protein and ash content decreased and consistency index and pH increased with increase in blanching period. The paste was packed in HDPE pouches and glass bottles which were stored at refrigerated temperature (5±2°C) for 180 days to study their storage feasibility.

Among the different blanching treatments, blanching for 5 min gives significant results. Hence this treatment was used further for storage study of turmeric paste. The paste prepared from this treatment having moisture 86.34 per cent, TSS 6.73°B, titratable acidity 0.97 per cent, pH 4.30, total sugars 28.23 per cent, reducing sugar 7.55 per cent, starch 30.42 per cent, total ash 1.91 per cent, curcumin 5.16 per cent, fiber 0.70 per cent, flow behaviour index 0.1369, consistency index 1.2365 Pa.sn, colour value for L*, a* and b* was 77.13, 10.63 and 92.06 respectively, yellowing index 170.51 and fat 7.36 per cent. Analysis of paste was carried out at a regular interval of 60 days. As the moisture content in storage decreased curcumin content, pH, total soluble solids, reducing sugar, total sugar, protein, fiber, fat, total ash and flow behaviour index increased. Although decrease in starch content, titratable acidity, consistency index and color were observed. All the parameters were significantly influenced by packaging material and storage time. The decrease in curcumin content on dry weight basis was found to be non-significant during storage period.

The paste samples stored in HDPE pouches were found better with more retention of nutrients as compared to samples stored at in glass bottle in any aspect, however both the samples were found to be acceptable with physico-chemical changes and also microbiologically safe for human consumption for 180 days of storage at refrigerated temperature.

Keywords - Turmeric, fresh turmeric rhizome, turmeric paste, curcumin content, blanching of turmeric, storage of turmeric paste etc.

औषधी, सुगंधी, रोपण, मसाले आणि वन पिके काढणी पश्चात व्यवस्थापन विभाग

काढणी पश्चात व्यवस्थापन पदव्युत्तर संस्था, किल्ला-रोहा

डॉ. बाळासाहेब सावंत कोंकण कृषी विद्यापीठ, दापोली-४१५ ७१२ जि. रत्नागिरी,

(महाराष्ट्र)

प्रबंध शीर्षक :	हळद पेस्ट तयार करण्याच्या प्रक्रियेचा विकास करणे.
विद्यार्थ्याचे नाव :	कु. शिवाली शशिकांत जाधव.
नोंदणी क्रमांक :	पी एच एम आर एम ०१८०१६१
अधीनता वर्ष :	२०२०
अभ्यासक्रम :	एम. एस सी. (का. प. व्य.)
संशोधन मार्गदर्शकाचे नाव आणि हुद्दा :	डॉ. जे. एच. कदम. सहयोगी प्राध्यापक, काढणीपश्चात व्यवस्थापन पदव्युत्तर संस्था किल्ला-रोहा. डॉ. बाळासाहेब सावंत कोकण कृषी विद्यापीठ, दापोली

प्रबंध सारांश

उपस्थित संशोधन हे हळदीची पेस्ट तयार करण्याच्या प्रक्रियेचा विकास करणे आणि उकळत्या पाण्याच्या प्रक्रियेच्या वेळेचे ईष्टतमीकरण करून उत्पादनासाठी हळदीच्या पेस्ट चे भौतिक-रासायनिक मूल्यमापन आणि पेस्टच्या वैशिष्ट्या बरोबरच साठवण स्थायित्वचे मूल्यमापन करण्यासाठी करण्यात आले. उत्कृष्ट प्रतीची हळद पेस्ट बनवण्यासाठी ५०.५ टक्के

कच्ची हळद, २५ टक्के पाणी, २४ टक्के विनेगर, ०.५ टक्के पिष्ट आणि २५० पीपीएम सोडियम बेंन्झोएट यांचा वापर करण्यात आला होता. उकळत्या पाण्याच्या प्रक्रियेच्या वाढत्या वेळे बरोबर हळदीच्या पिवळ्या रंगाचा ऱ्हास होताना दिसून आले. उकळत्या पाण्याच्या प्रक्रियेच्या वाढत्या वेळेबरोबर प्रवाह वर्तन निर्देशांक, एकूण विद्राव्य घटक, कुरकुमीन, आम्लता, पिष्टमय पदार्थ, शर्करा, तंतू, मेद, प्रथिने आणि राख कमी झाले आणि सुरंगतता निर्देशांक आणि पीएच हे वाढताना दिसून आले. पेस्ट एच. डी. पी. ई. कोष्ठमध्ये आणि काचेच्या बरणीमध्ये प्रशीतन तापमानात (५±२°C) १८० दिवस साठवणुकीचा अभ्यास करण्यासाठी साठवण्यात आले.

वेगवेगळ्या मिनिटांसाठी उकळत्या पाण्याच्या प्रक्रिया संस्कार केल्यापैकी पाच मिनिटांसाठी केलेल्या संस्काराचे साभिप्राय परिणाम मिळाले, म्हणून हा संस्कार पुढे हळद पेस्ट साठवणुकीचा अभ्यासासाठी वापरण्यात आला. या विवरण पद्धतीने बनवण्यात आलेल्या पेस्टमध्ये आर्द्रता ८६.३४ टक्के, एकूण विद्राव्य घटक ६.७३° ब्रिक्स, आम्लता ०.९९ टक्के, पीएच ४.३०, एकूण शर्करा २८.२२ टक्के, क्षपणकारी शर्करा ७.५५ टक्के, पिष्टमय पदार्थ ३०.४२ टक्के, एकूण राख १.९१ टक्के, कुरकुमीन ५.१६ टक्के, तंतू ०.७० टक्के, प्रवाह वर्तन निर्देशांक ०.१३६९, सुसंगतता निर्देशांक १.२३६५ Pa.sn, एल *, ए * आणि बी * चे रंग मूल्य अनुक्रमे ७७.१३, १०.६३ आणि ९२.०६, पिवळा निर्देशांक १७०.५१ आणि मेद ७.३६ टक्के होते. ६० दिवसांच्या अंतराने साठविलेले पेस्टचे पृथक्करण केले गेले. साठवणुकीतील ओलावा कमी झाल्यामुळे कुरकुमीन, पीएच, एकूण विद्राव्य घटक, क्षपणकारी शर्करा, एकूण शर्करा, प्रथिने, तंतू, मेद, एकूण राख आणि प्रवाह वर्तन निर्देशांक वाढले. तरी पिष्टमय पदार्थ, आम्लता, सुसंगतता निर्देशांक आणि रंग कमी होत गेले. सर्व आवेष्टन सामग्री आणि साठवण वेळेवर

लक्षणीय परिणाम करतात. साठवणुकीच्या कालावधीत शुष्क पद्धतीत कुरकुमीनच्या वजनात लक्षणीय घट नसल्याचे आढळले.

एचडीपीई कोष्ठमध्ये साठवलेल्या पेस्टचे नमुने कोणत्याही घटकाचा बाबतीत काचेच्या बरणीत साठवलेल्या नमुन्यांच्या तुलनेत पोषक द्रव्यांचा अधिक प्रमाणात टिकवून ठेवण्या करिता चांगले असल्याचे आढळले, तथापि हे दोन्ही नमुने भौतिक व रासायनिक बदलांसह स्वीकार्य असल्याचे दिसून आले आणि सूक्ष्मजीवशास्त्राच्या अभ्यासा नुसार १८० दिवसांपर्यंत प्रशीतन तापमानात मानवाच्या सेवनास सुरक्षित असल्याचे आढळून आले.

महत्वाचे शब्द - हळद, ताज्या हळदीचे कंद, हळद पेस्ट, कुरकुमीन, उकळत्या पाण्यात हळदीची प्रक्रिया, हळदच्या पेस्टची साठवण इ.

औषधी, सुगंधी, रोपण, मसाले और बंद अन फसल कटाई पश्चात व्यवस्थापन विभाग

कटाई पश्चात व्यवस्थापन पदव्युत्तर संस्था, किल्ला-रोहा

डॉ. बालासाहेब सावंत कोंकण कृषी विद्यापीठ, दापोली-४१५ ७१२ जि. रत्नागिरी,

(महाराष्ट्र)

प्रबंध का नाम :	हल्दी पेस्ट की बनाने की प्रक्रिया का विकसीत करना।
छात्र का नाम :	कु. शिवाली शशिकांत जाधव.
पंजीकरण क्रमांक :	पी एच एम आर एम ०१८०१६१
दाखल किया गया साल :	२०२०
विद्योपाधी :	एम. एस सी. (का. प. व्य.)
प्रबंधक मार्गदर्शक का नाम और	डॉ. जे. एच. कदम.
पदनाम :	सहयोगी प्राध्यापक, कटाई पश्चात व्यवस्थापन पदव्युत्तर संस्था किल्ला-रोहा. डॉ. बाळासाहेब सावंत कोकण कृषी विद्यापीठ, दापोली

प्रबंध सार

वर्तमान शोध हल्दी पेस्ट को बनाने की प्रक्रिया का विकसन करना और विवर्ण समय का अनुकूलन करके उत्पादन के लिये हल्दी पेस्ट का भौतिक-रासायनिक मूल्यांकन और पेस्ट की विशेषताओं के साथ-साथ भंडारण स्थिरता के अनुकूलन के लिए हल्दी पेस्ट का मूल्यांकन करना था। सबसे अच्छी गुणवत्ता वाली हल्दी पेस्ट को बानाने के लिये ५०.५ प्रतिशत कच्ची

हल्दी, २५ प्रतिशत पानी, २४ प्रतिशत सिरका, ०.५ प्रतिशत स्टार्च और ५० पीपीएम सोडियम बेंजोएट का इस्तेमाल किया गया। उबलने के बढते समय के साथ घटते पीला रंग मे मलिनिकरण देखा गया। उबलने के बढते समय के साथ प्रवाह व्यवहार सूचकांक, कुल घुलनशील पदार्थ, कुरकुमीन, स्टार्च, चीनी, फाइबर, वसा, प्रोटीन, और राख समय के साथ कम हो गए और संगती सूचकांक पीएच बढ़ गए। अध्ययन के १८० दिनों के लिए पेस्ट को एचडीपीई पाउच और कांच के बोतल में शित तापमान (५±२°C) पर संग्रहित किया गया था।

अलग-अलग विवर्ण उपचारोमेसे ५ मिनटो के लिये किया गये विवर्ण से महत्वपूर्ण परिणाम मिले, इसलिए हल्दी पेस्ट भंडारण के अध्ययन के लिए इस का इस्तेमाल किया गया। नमी ८६.३४ प्रतिशत, कुल घुलनशील पदार्थ ६.७३°ब्रिक्स, अम्लता ०.९९ प्रतिशत, पीएच ४.३०, कुल चिनी २८.२२ प्रतिशत, सापेक्ष चिनी ७.५५ प्रतिशत, ३०.४२ प्रतिशत स्टार्च, राख १.९१ प्रतिशत, कुरकुमीन, ५.१६ प्रतिशत, फाइबर ०.७० प्रतिशत, प्रवाह व्यवहार सूचकांक ०.१३६९, संगति सूचकांक १.२३६५ Pa.sn, एल *, ए * और बी * के रंग मूल्य क्रमशः ७७.१३, १०.६३ और ९२.०६ थे, पीला सूचकांक १७०.५१ था और वसा ७.३६ प्रतिशत थी। ६० दिनों के अंतराल पर पेस्ट का विश्लेषण किया गया। भंडारण में नमी में कमी से कुरकुमीन, पीएच, कुल घुलनशीलता पदार्थ, सापेक्षार चीनी, कुल चीनी, प्रोटीन, फाइबर, वसा, राख और प्रवाह व्यवहार सूचकांक में वृद्धि होती है। हालांकि, स्टार्च, अम्लता, स्थिरता सूचकांक और रंग में गिरावट दिखाई दी गई थी। सभी मापदंडों में शामिल सामग्री और भंडारण समय पर महत्वपूर्ण प्रभाव पड़ता है। भंडारण अवधि के दौरान कुरकुमीन शुष्क वजन मे कोई कमी नहीं पाई गई।

एचडीपीई पाउच में संग्रहीत पेस्ट के नमूने किसी भी घटक के संदर्भ में कांच के बोतल में संग्रहीत नमूनों की तुलना में तत्वों के अधिक बनाए रखने में बेहतर पाए गए, हालाकि दोनों नमूने भौतिक और रासायनिक परिवर्तनों के साथ स्वीकार्य पाए गए और १८० दिनों तक मानव उपभोग के लिए सुरक्षित पाए गए।

मुख्य शब्द - हल्दी, ताजी हल्दी के कंद, हल्दी पेस्ट, कुरकुमीन, हल्दी की विवर्ण प्रक्रिया, हल्दी का भांडरण आदी.

INTRODUCTION

CHAPTER I

Introduction

Turmeric (*Curcuma longa* L.) is a member of the family Zingiberaceae (Chattopadhyay *et al.,* 2004). It is used as spice in Indian food. It is also being used for medicinal value (Luthra *et al.,* 2001). It was popular even in *Vedic* times because of its unique flavor, nutritive and medicinal properties. It is also used in cosmetic, religious ceremonies and auspicious occasions (Sanchavat *et al.,* 2012). Turmeric is a spice derived from rhizomes of *Curcuma longa*, has an spicy fragrance, which on drying releases aroma due to this aroma turmeric is also called as "Indian saffron"(Aggarwal *et al.,* 2007). The bright yellow colour of turmeric comes mainly from polyphenolic pigment curcuminoids (Akram *et al.,* 2010).

India is believed to be the home of turmeric contributing the largest share in export, consumption and production in the world. It accounts for 60 % of world export and 80 % of the world production (Anonymous, 2020a). Due to high curcumin content, Indian turmeric is considered to be the best in the world market. (Murugananthi *et al.,* 2008). India is having 2,45,958 ha area under turmeric crop with production of 9,38,955 metric tons during 2019-2020 (Anonymous, 2020b). Other major producers of turmeric in the world are Sri lanka, Myanmar, Bangladesh, Nigeria, China, Pakistan, etc. (Anonymous, 2020b). The important turmeric growing states in India are Telangana, Karnataka, Tamil Nadu, Andhra Pradesh, West Bengal, Orissa, Maharashtra, Assam, Gujarat, and Haryana etc. The area under turmeric cultivation in Maharashtra is 15,342 ha with 40,140 tonnes production (Anonymous, 2020b).

Turmeric is mainly used as a[spice in Indian foods and has medicinal value well (Prasad and Aggarwal, 2011). The rhizomes are dried and ground to prepare provides a yellow and flavoured powder, used in textiles, cosmetics as well as an insect repellent (Bambirra *et al.,* 2002). Recently, turmeric is known as an ideal functional food, it has been valued worldwide due to its health promoting properties (Krishnaswamy, 1996).

Turmeric has been used as blood purifier, anti-inflammatory, digestive, for curing dermatological disorders, and anti-carcinogenic agent, for improving blood circulation, liver diseases, conjunctivitis, antioxidant, diabetic retinopathy, antimicrobial and control of cholesterol (Rathaur *et al.,* 2012). The major chronic disease including cardiovascular diseases, liver diseases, atherosclerosis, cancer, cataracts, and rheumatoid arthritis are relieved with anti-oxidants like Vitamin C, Vitamin E and turmeric (Pari *et al.,* 2008*;* Debjit Bhowmik *et al.,* 2009 and Radomska-Leśniewska *et al.,* 2019). Natural products make turmeric an ideal natural food colourant which leads to the increased market demand as food additive (Lal, 2012).

In the fresh turmeric rhizome moisture content is about 84.25 per cent, fat 1.08 per cent, carbohydrate 9.10 per cent and protein 1.20 per cent. The TSS of fresh turmeric rhizomes was noted at 7.80°B. The other parameters such as ash, acidity, pH and fibers of turmeric rhizomes were recorded like 0.66 per cent, 0.70 per cent, 5.7 and 0.72 per cent, respectively. The curcumin content of *Selam* variety rhizomes was recorded to be 5.1 per cent. (Mane *et al.,* 2018)

The post harvest process of turmeric involves many operations such as washing, cleaning, curing or blanching, drying, polishing, grinding and packaging. Harvested turmeric was washed completely to get rid of the adhering soil, scales of leaves and roots. The fingers and mother rhizomes were separated before curing. Curing is the process of boiling the raw rhizomes in water for the development of enticing colour and characteristic aroma that additionally destroys the viability of the fresh rhizomes, eliminates the raw odour and reduces the time of drying. Typically curing/boiling is carried out with alkaline water; additionally there was some recommendation as per the standard of boiling water. If the water is acidic to make it slightly alkaline 0.05 to 0.1 % sodium bicarbonate or sodium carbonate is sometimes added. Boiling in alkaline water is used to improve the colour of dried powder with bright yellow colour (Pruthi, 1992; Weiss, 2002 and Govindarajan and Stahl, 1980).

According to Pruthi (1992) and Jose and Joy (2009) traditional drying technique ends with the loss of volatile oil (up to 25 per cent) by evaporation and resulted with the desolation of some light sensitive oil constituents. The traditional drying methods are risky and result in mould growth, loss of some volatile oil has an effect on its smell through evaporation and destruction of some heat sensitive pungent properties. A fast dehydration that yields a superior quality product is often needed. Convective drying is the easiest and most economical method for dehydration of foods can be a decent resolution (Jayaraman and Das Gupta, 1992). However, there are controversies with respect to the importance of curing the rhizomes in water or alkaline solution before drying and its effect on the degree of curcuminoid pigments and on the colour of ground turmeric.

Quality of a food product in terms of colour, aroma, appearance, texture, and flavour is time dependent and is an important factor to grade food quality. Some of the food and its constituents lose quality because of processing such as grinding, heating, cooking, boiling, freezing, packing and transportation etc.

(Singh and Goswami, 1999). On the other hand, storing food and its constituents over a period of time also loses quality (Liu *et al.,* 2017). Food or its materials lose its quality with the storage time and food materials get spoiled due to oxidation, because oxidation is a major cause of chemical spoilage of food. Any food material or its constituents kept over a period of time will lose its strength, quality, colour and nutritional value. Rate of losing quality varies based on the type of packaging materials, surrounding conditions and storage conditions.

There are various packaging materials generally used in households for storage of spices and they have various categories (Roy *et al.,* 2012). In the primary type of packaging materials, packing wrap is in direct contact with food material and is taken home by the consumers. Packaging materials like papers, cloths, jute bags are flexible and they have light weight and recyclability. Metallic and glass packaging materials are strong and corrosion resistant but costly. Weight and careful handling are limiting factors for using metallic and glass packaging material in their usage. Polymers are commonly used for packaging due to their transparency, softness, heat sealing capacity, low cost, good mechanical properties and they also have good barrier to heat and oxygen (Farris *et al.,* 2009). One of the limiting nature of packaging materials, which controls the shelf life of packed products, is the migration of moisture or permeability of moisture through the packaging material evaluated by the sorption isotherm. This requires understanding of the transfer mechanism of low molecular weight molecules through the packaging material that controls the exchange of the molecules such as aroma compounds, volatile compounds, water vapours etc. (Cava *et al.,* 2004).

A minute quantity of aroma compounds of packaging material when penetrates into the food material, aroma compounds of packaging material will change the organoleptic quality of the food materials. Presence of odd aroma compounds may change the product quality and lead to rejection of the food products (Sajilata *et al.,* 2007). Colour and appearance of any food product helps in judging the acceptability of the product. The sensory quality of the food or its item may affect the decision making process of purchasing food materials by the consumers (Wei *et al.,* 2012).

The processed products of turmeric involve dehydrated turmeric powder, volatile oil, oleoresin, curcumin capsule, tonics, blended juices, turmeric crackers, turmeric milk and turmeric tea. The post harvest processing of turmeric includes primary processing. Turmeric rhizomes were cleaned, graded, cured, dried, polished, coloured and sorted. During the process of turmeric curing 27-53 % loss of curcuminoids was observed with maximum loss in pressure cooking for 10 min (Suresh *et al.,* 2007). By keeping in view the wide medicinal uses, properties of turmeric, its use in food and loss of curcuminoids during processing, investigate the quality improvement of turmeric with effect of different packaging material over a period of time: The study of development the process for preparation of turmeric paste was undertaken to achieve the following specific objectives:

1. Standardization of blanching period for production of turmeric paste
2. To evaluate physico-chemical characters of turmeric paste
3. To evaluate storage stability of turmeric paste.

REVIEW OF LITERATURE

CHAPTER II

Review of literature

This chapter deals with the previously published work on paste from different crops like ginger, garlic, onion etc. and their related studies. Besides, available information related to the determination of quality parameters affected by blanching and packaging material of paste during storage as evidenced from published literature is also reviewed in the current chapter under the following headings.

2.1 Physico-chemical parameters of turmeric.

2.2 Standardization of blanching period.

2.3 Preparation of paste.

2.4 Microbial analysis

2.1 Physico-chemical parameters of turmeric

Lahari *et al.* (2020) studied the physico-chemical properties of turmeric powder and recorded curcumin content 3.12 per cent in cured turmeric powder and 2.82 per cent in non-cured turmeric powder. In further storage studies curcumin decreased from 2.816 to 0.526 over a period of time in ambient condition and refrigerated condition. Quality parameters were found listed in plastic containers.

Mane *et al.* (2018) studied evolution of physicochemical and nutritional properties of fresh turmeric rhizomes and observed moisture content 84.25 per cent, carbohydrate 9.10 per cent, protein 1.20 and fat 1.08 per cent, respectively. The TSS of fresh turmeric rhizomes was noted at 7.80˚B. The other parameters such as ash, fiber, acidity and pH of turmeric rhizome were recorded like 0.66 per cent, 0.72 per cent, 0.70 per cent and 5.7 respectively.

De Lima *et al.* (2017) reported the moisture 7.83 per cent, protein content 8.28 per cent, ash content 7.77 per cent and total fiber 20.60 per cent in turmeric.

Nisar *et al.* (2015) studied estimation of total phenolics and free radical scavenging of turmeric which contains protein content 6.47 per cent, crude fat 2.7 per cent, crude fiber 4.80 per cent and ash 3.49 per cent.

Hirun *et al.* (2014) reported moisture content 91.5 per cent, total ash content 6.9 per cent and curcuminoid content 9.4 g/100 g dry basis during the study of microwave-vacuum drying of turmeric.

Kuttigounder *et al.* (2011) reported the moisture content in fresh, dried and cured-dried turmeric was 80.02 per cent, 8.26 per cent and 10.06 per cent respectively, protein content in fresh, dried and cured-dried turmeric was 2.07 per cent, 9.27 per cent and 9.12 per cent respectively, fat content in fresh, dried and cured-dried turmeric was 0.80 per cent, 3.62 per cent and 4.70 per cent respectively, crude fiber content in fresh, dried and cured-dried turmeric was 1.79 per cent, 3.41 per cent and 4.10 per cent, respectively, total ash content in fresh, dried and cured-dried turmeric was 1.83 per cent, 7.87 per cent and 6.95 per cent respectively and starch content in fresh turmeric rhizomes was 47 per cent.

Lim *et al.* (2011) observed the crude protein 2.85 per cent, crude fat 1.48 per cent, crude fiber 2.60 per cent and crude ash 1.84 per cent proximate composition of turmeric used in preparation of bread.

Govindarajan and Stahl, (1980) reported moisture content 13.1 per cent, starch content 69.4 per cent, protein content 6.3 per cent, fiber content 2.6 per cent, ash content 3.5 per cent and volatile oil content 5.8 per cent in turmeric rhizomes.

2.2 Standardization of blanching period.

Jayashree and Zachariah, (2016) studied processing of turmeric (*Curcuma longa*) by different curing methods and its effect on quality and observed quality aspects of cured dried rhizomes indicated that as the curing time increased a reduction in quality parameters like curcumin, starch, essential oil and oleoresin content.

Patil and Chhapkhane, (2013) studied large scale of turmeric boiling was use of conventional plants with multiple cooker and boiler assembly placed on trolley and observed that the traditional plants the boiling was done without maintaining the pressure in the vessel, so the boiling was inefficient. The efficiency of the actual processing plant was 13.19 per cent which was very less. This was due to the lot of losses from every part of the plant.

Shinde *et al.* (2011) studied the treatments during processing of turmeric by traditional and steam blanching methods. The loss of colour observed in curcumin was 1.5 to 2.5 per cent in steam cooking, whereas in boiling; it was 1.6 to 3.5 per cent.

Suresh *et al.* (2005) studied the heat treatments of turmeric, red pepper and black pepper. It was observed that the significant loss of active constituents of spices was subjected to heat processing. Curcumin loss due to heat processing in turmeric was 12.1-18.8 mg/g, with maximum loss in pressure cooking for 10 min.

2.3 Preparation of paste

2.3.1 Ginger paste

Devi *et al.* (2016) studied the physico-chemical characteristics

of ginger paste with microbiological characteristics during storage period with different packaging and temperature conditions. Shelf life of ginger paste and quality parameters were studied with three packaging materials [metalized poly-propylene (MPP), polyethylene terepthalate (PET) and high density polyethylene (HDPE)] and two storage temperatures i.e. 25°C and 5°C room temperature and cold room, respectively for 120 days. There was no significant change in acidity, pH, TSS and TS of the paste with packaging and storage temperatures, whereas a discolouration was observed significantly. Considering the discolouration, safety of food and nutritional quality throughout the storage, only the samples stored in MPP and PET at 5°C storage temperature were acceptable in view of microbiological load.

Unni *et al.* (2015) evaluated quality changes in ginger paste treated by thermal treatment and high hydrostatic pressure and storage at 6±1°C for a period of six months. After manually washing and peeling ginger was pulverized within the sort of smooth paste and was mixed with citric acid (100 mg/kg) and ascorbic acid (100 mg/kg) and subsequently paste was packed in polyethylene pouches (25 µm thickness, 50 g pack size). The pastes were processed in an isostatic high pressure system at a pressure of 200, 400 and 600 MPa at 30°C for 5 minutes. The thermal treated with high pressure samples were analyzed for various physico-chemical, enzymatic, sensory and microbiological parameters. The titratable acidity and pH were not significantly ($p<0.05$) affected by high pressure processing. Thermal treatment and high pressure were effective to keep microbial count under the permissible limit during complete storage period. In the treated sample during storage period phenolics, flavonoids and antioxidants were slightly decreased and total colour difference indicated significant differences ($p<0.05$) in colour between thermal and pressure treated samples. The lowest colour difference obtained for samples treated at 600 MPa. The ginger pastes treated at 600 MPa pressure for 5 minutes showed complete shelf-life of 180 days at low temperature (6±1°C, 80-85 % RH). The retention of physicochemical, sensory and microbiological parameters observed in storage study.

Ahmed, (2004b) prepared the ginger paste by adding common salt at 8 per cent (w/w). Fresh ginger puree had a pH of 6.38 and was adjusted to 4.05 by adding 30 per cent citric acid solution (w/v). The paste was therefore thermally processed at 80° C for 15 min and packaged immediately in selected containers. Storage of ginger paste for 120 days at 5°C and 25°C revealed that there was no significant effect of packaging materials but temperature affected L*,a* and b* values significantly. In the study of ginger paste its colour changed during storage with rheology.

Tripathi, (2003) manufactured a ginger paste with water in the proportion of 88:12 and stabilized its colour. The pH was fixed to 4.2 using citric acid (strength; 30 %). Different chemicals such as $CaCl_2$, SO_2, common salt, xanthan gum were assessed for their ability to check the problem of pink discolouration by measuring the optical density. Samples were packed and pasteurized in glass container. It was concluded that the colour of paste could be stabilized using 0.165 g $CaC1_2$, 333 ppm SO_2, 5.44 per cent common salt, 4.14 per cent sugar and 0.12 per cent xanthan gum. Storage at below temperature (5°C) increased the storage life of 120 days.

Baranowski, (1985) studied the storage stability of a processed ginger paste by blending the ginger with water in the ratio of 50:50, along with xanthan gum and citric acid. The blend was comminuted for 2 min in a food processor. The paste (pH 4.15) was heated in a steam kettle at 80°C for 12 min, cooled and stored. This product was found to have good shelf-life under refrigeration, but degradation of colour, odour and (6)-gingerol made the paste unacceptable after 8 week storage at 25°C or 37°C.

2.3.2 Garlic paste

Constenla and Lozano, (2005) assessed the effect of chemical additives namely potassium sorbate, citric acid and ascorbic acid on the physico-chemical characteristics, microbial analysis and sensory evolution of garlic paste and effect on storage temperature. Development of undesirable greenish pigment was avoided by storing fresh garlic rhizomes at 25 and 40°C, respectively. Moreover, bulbs are heated at 40°C for a few minutes before processing to facilitate skin removal and thermally treated paste at 55°C for 5 min was processed and packed. Colour of the garlic paste was affected by temperature, chemical treatments and storage period. The increase in rate of colour variation was separated into two linear periods with different slopes. Garlic paste showed pseudo plastic with yield, stress and flow sufficiently described by the Herschel—Bulkley model (r^2>0.990).

Ahmed and Shivhare, (2001a) prepared paste from fresh garlic by addition of common salt 10 per cent (w/w) and citric acid with total solids 33 per cent and pH value 4.1. Appearance of green pigment was noticed during preparation of the product. Thermal treatment was done on paste with three different temperatures 70, 8O or 90°C, respectively for fifteen min. The greening of paste decreased with increasing temperature. Rheological data exposed that garlic paste acted as a pseudo-plastic fluid with flow behaviour of 0.14 Pa.sn and consistency index of 279 Pa.sn. The paste was examined periodically for colour and microbiological counts for duration of at least 6 months at 25°C, the product was observed to be shelf stable. During storage, significant decrease ($p<0.05$) in green colouration was observed.

Ahmed and Shivhare, (2001b) studied the thermal kinetics of colour change, rheology and storage characteristics of garlic puree/paste. The prepared paste is characterized as the product obtained after addition of common salt and organic acid to the puree with addition of 10 per cent salt (w/w). pH of the paste was adjusted to 4.1 by adding 30 per cent citric acid (w/v) solution. The paste was, thereafter, thermally processed at 80°C for 15 min and packaged immediately in selected containers. The degreening in garlic paste was observed at 25°C and complete degreening was observed at about 48 to 52 days. Storage at 5°C improved greening during storage.

Sumi *et al.* (1987) patented process for the production of garlic paste. In their process the unpeeled garlic was blanched at 99°C to 120°C by hot water to inactivate allinase which would otherwise produce odorous and irritant compounds. The blanched garlic was crushed and garlic liquor were mixed with vitamin B_3, rice bran or yeast; heated in presence of cellulose and finally mixed with the soya flour.

2.3.3 Onion paste

Mu *et al.* (2010) in this study, used onion as the material for processing onion paste. Through a single-factor test and orthogonal test, the material, acid regulation, heating temperature, flavouring, and enzymatic hydrolysis related to processing were studied. The results showed that optimal treatment conditions during processing were pH adjusted to 4.4 - 4.6 with 0.25 per cent of citric acid and heating temperature of 85°C. For the maintenance of nutrition, the optimum proportion of MSG (monosodium glutamate), IMP (disodium inosinate) and GMP (disodium guanylate) was 1:1:7. For optimum enzymatic hydrolysis, the best processing conditions were 0.75 per cent compound enzyme, temperature 45°C, for 20 min. Under optimal conditions, the soluble solids content reached to 22 per cent.

Ahmed and Shivhare, (2001c) studied the kinetics of colour degradation at selected temperatures and effects of storage temperatures and packaging materials on colour of onion paste. Colour change during thermal processing of onion paste. pH of paste was adjusted to 3.9 by adding citric acid solution, acidity 0.41 per cent and TSS 16.5°B. Except colour of onion paste other parameter did not changed significantly with storage, temperature and packaging materials. Colour of the paste was found more stable at low temperature (5°C) than at higher temperatures (25°C) in a high-density polyethylene pouch with minimum colour degradation.

2.3.4 Ginger garlic paste

Akhtar *et al.* (2015) studied the effect on the quality attributes of developed ginger-garlic paste during storage. The prepared ginger paste and garlic paste were mixed in equal proportion (1:1 ratio) by weight. The sodium benzoate (150 ppm), citric acid (0.2 per cent w/w) and sodium chloride (1.5 per cent w/w) were added to the mixed ginger garlic paste and packed in glass bottles. The samples were treated with microwave and conventional heating and stored for 3 months at 30 to 38°C. During storage the paste was shelf stable and pH, moisture, acidity and ash content found significantly changed.

Topno *et al.* (2013) studied the quality of ginger–garlic paste stored in retort pouches. Ginger rhizomes were soaked for 12 hr in potassium metabisulphite solution (1 g/L) and washed thoroughly to remove the traces. The paste was prepared by mixing 1:1 (w/w) proportion of ginger and garlic with sodium chloride (1 per cent). By the addition of citric acid pH was adjusted to 4.0, 4.5 and 5.4, then by adding sodium benzoate (0.2 g/L) and Xanthan gum (2 g/L) paste filled in retort pouches. The pouches were thermally processed at 85°C for 2 and 5 min at 80°C at the centre of the paste, respectively. The paste was found shelf stable, with the delicate spice odour of fresh ginger and garlic stored in retort pouches.

Shaista *et al.* (2009) studied the effect of five stabilizers (citric acid, sodium metabisulfite, sodium benzoate, olive oil and ascorbic acid) in the ginger - garlic paste which was evaluated against pathogens. Antimicrobial activity of the paste was stabilized by various stabilizers when incorporated. Sodium metabisulfite, olive oil and ascorbic acid were found to be effective to stabilize the antibacterial activity of the paste considerably. In case of citric acid and sodium benzoate microbes showed resistance in the paste.

Giridhar *et al.* (1996) studied the method of preparation and storage of ginger-garlic paste. They mixed peeled ginger with garlic and common salt in the preparation of 55:35:10, respectively and ground the mix to paste form in wet grinder. The pH of resultant paste was adjusted to 4.0 by addition of an adequate amount of 30 per cent citric acid and 0.1 per cent sodium benzoate. The content was pasteurized and packed in containers. Glass containers found to be more stable for packaging ginger garlic paste, storing over 6 months at 5°C as well as ambient temperature of 25°C to 35°C.

2.3.5 Ginger garlic onion paste

Ahmed and Shivhare, (2002c) prepared a paste of onion, ginger and garlic with addition of citric acid and common salt (10 %). Paste was packed in two different packaging materials glass bottles and polyethylene terephthalate (PET) containers and stored at 5±1°C and 25±1°C for 123 days, respectively. The paste was thermally processed at 8O°C for 15 minutes. Then the paste was sampled periodically for physico-chemical characteristics. Colour degradation occurs as the temperature and duration of storage increases at 25±1°C for 123 days. The paste stored in polyethylene terephthalate (PET) containers was observed to be better packaging material.

2.3.6 Other paste

Priyadarshi *et al.* (2019) studied the effect of pre-treatment on colour, flavour and microbial profile of coriander paste. A shelf stable coriander paste was prepared by pre-treating fresh coriander foliage with 0.1 per cent Na_2CO_3 solution for 20 sec at 100±2°C. The prepared paste contains salt (3 %) and sodium benzoate (200 ppm). During storage at 27±1°C and 37±1°C, gradual changes in the colour profiles were observed. A shelf stable, microbiologically safe coriander paste retaining desirable colour, sensory and flavour characteristics with extended shelf life from one to seven days.

Ahmed *et al.* (2004c) studied the colour kinetics and rheology of coriander leaf puree and storage characteristics of the paste. Coriander puree converted to paste by addition of 2 per cent salt (w/w) and the required volume of 30 per cent (w/v) citric acid to adjust the pH to 4.2. After pasteurization at 80°C for 15 min the paste was hot-filled into pre-sterilized glass bottles. The bottles were cooled and stored at selected temperatures (5°, 25° and 36°C) for 6 months. The paste processed at 80°C for 30 min was shelf stable with insignificant change in physicochemical properties during storage and was microbiologically safe for human consumption.

Rajano *et al.* (1997) studied different processes such as water blanching and microwave blanching to increase storage stability of pickled garlic and its chemical characteristics using Sodium chloride (w/w). It was added to raise the total solids of content and the final pH was adjusted to 4.1 using 30 per cent citric acid solution (w/v). Blanching with hot water at 90°C for15 min and microwave at 90°C for 8 min was done. Product was pasteurized and packed. Most stable and best quality product resulted from water blanching.

2.4 Microbial analysis

Devi *et al.* (2016) studied the physico-chemical characteristics of ginger paste with microbiological characteristics during storage period with different packaging and temperature conditions. They reported that the low temperature was unfavourable for growth of bacteria but mould can favourably grow in the paste which might be due to the water activity (>0.7) of the samples. Low moisture, low temperature and high salt were unfavourable for the growth of bacteria, but it provides a conducive environment for the growth of yeast and moulds. Yeasts and moulds were also acid tolerant and can grow at pH (<0.4). The sample of ginger garlic paste stored at refrigerated condition were only found within the acceptable limit for mould and bacteria. However microbial activities increase with storage period.

According to Topno *et al.* (2013) total plate count (TPC) in fresh ginger–garlic paste was $2x10^2$ colony-forming unit (cfu)/g, whereas the coliform and yeast and mould counts were below 10 and 100 cfu/g, respectively. Thermal processing of paste at 85°C for 2 and 5 min, respectively reduced TPC to 65 while coliforms, yeast and mould were found to be nil. Addition of sodium benzoate (200 ppm) helped in controlling microbial load completely for duration of 6 months in storage. It can therefore be inferred that prepared ginger–garlic paste in retort pouches stored more than 6 months was microbiologically safe.

Ahmed *et al.* (2004c) concluded that the total plate counts (TPC) of the coriander paste before thermal treatment were $3x10^4$, while the yeast and mould counts were below 10 and 100, respectively. Thermal processing of paste reduced TPC to 100 while yeast and moulds were found to be negative. The TPC values increased from 100 to 950 cfu/g, while yeast and moulds nil till 6 months of storage. It can therefore be concluded that prepared paste stored up to 6 months was microbiologically safe.

Ahmed, (2002b) concluded that prepared red chilli paste was stored up to 6 months and it was microbiologically safe for human consumption for TPC and yeast and mould count.

Ahmed, (2002b) reported the red chilli puree was microbiologically stable up to 6 month storage.

Ahmed and Shivhare, (2001c) studied onion paste, the paste was microbiologically stable at low temperature (5± 3°C).

Baranowski, (1985) and Giridhar *et al.* (1996) recommended a process temperature of 80°C for ginger–garlic paste with a pH of approximately 4.0. The combination of antioxidant stabilizer and preservative was very important for the preparation of a high-quality ginger–garlic paste.

MATERIAL AND METHODS

CHAPTER III

MATERIAL AND METHODS

The present research entitled, “Development of process for preparation of turmeric paste.” was conducted at the Department of Post Harvest Management of Medicinal, Aromatic, Plantation, Spices and Forest Crops, Post Graduate Institute of Post-Harvest Management, Killa-Roha, Dist. Raigad, (18°42’5947” N, 73°17'9361" E) during the year 2019-2020.

3.1 Experimental materials

3.1.1 Turmeric rhizomes

The fresh turmeric rhizome (Cv. Pragati) was obtained from the farmers in Sangli District directly in the month of April, which corresponded to 9 months after planting.

3.1.2 Chemicals

Food grade and analytical grade chemicals were used for carrying out analysis of the samples.

3.1.3 Packaging Materials

The high-density polyethylene (HDPE) pouch and glass bottles packaging materials were obtained from the local market.

3.1.4 Equipment

The equipment used in this investigation was grinder, peeler, cutting knife, weighing balance, autoclave, hot water bath etc.

3.2 Experimental details

3.2.1 Standardization of blanching period

In traditional turmeric processing curing i.e. cooking resulted loss of curcumin. Hence to minimize losses of the curcumin blanching period was standardized. The details of experiments are given as follows.

3.2.1.1 Treatment details

Product	:	Turmeric paste.
Treatments	:	7 (blanching period)
Replications	:	3
Statistical design	:	CRD

Treatments	**Blanching period**
T_1:	0 min blanching period
T_2:	5 min blanching period
T_3:	10 min blanching period
T_4:	15 min blanching period
T_5:	20 min blanching period
T_6:	25 min blanching period
T_7:	30 min blanching period

3.2.2 Storage of turmeric paste

Product	:	Turmeric paste.
Main treatments	:	2 (Packaging materials: glass bottles and HDPE pouches)
Sub Treatments	:	4 (Storage period: 0, 60, 120, 180 days)
Treatment combinations	:	8
Replications	:	5
Statistical design	:	FCRD

3.2.2.1 Treatment details

A. Main treatments

Treatments	**:**	**Details**
T_1	:	Glass bottles
T_2	:	HDPE pouches with 240 µ thickness

B. Sub treatments

Sub treatments	**:**	**Storage period (Days)**
S_1	:	0
S_2	:	60
S_3	:	120
S_4	:	180

3.3 Method

3.3.1 Standardization of blanching period

Turmeric rhizomes were sorted and washed before blanching to avoid contamination. Selected rhizomes dipped in boiling water using muslin cloth as per the treatments. Best treatment was selected on a basis of statistical analysis to further study. The impact of packaging material during storage period on quality of turmeric was studied.

3.3.2 Physical parameters of turmeric during blanching period

3.3.2.1 Colour

(a) L*, a* and b* colour value

The colour of turmeric paste was measured by using colour reader (make Konica Minolta, Japan CR-400) and expressed as L*, a* and b* values. To evaluate the difference between samples, the yellowness index parameter was calculated according to the following equation (Neves *et al.,* 2020).

(b) Yellowing index

To evaluate the difference between samples, the yellowness index parameter was calculated (Neves *et al.*, 2020).

$$\textbf{Yellowing index} = 142.86\left(\frac{b*}{L}\right)$$

Plate 1: Colour analyzer (M/s Konica Minolta, Japan)

3.3.2.2 Viscosity (Pa.sn)

The viscosity of turmeric paste was determined after using Brookfield Viscometer RVDV II+ Pro (M/s Brookfield's Viscometer RVDV II+ Pro using spindle No. 7 at 12 and 30 rpm. The viscometer gives digital reading in Centipoises'. Brookfield Viscometer RVDV II+ Pro (M/s Brookfield's Engineering Lab., USA) and spindle number S7 was used for this study.

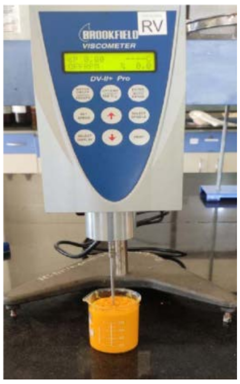


Plate 2: Viscometer

3.3.3 Chemical parameters of turmeric during blanching period

3.3.3.1 Moisture content (%)

The initial moisture content of the paste was determined by using the hot air oven method. The 1 g paste was kept in the tared metal dish. The metal dish was kept in a hot air oven at 100°C for 4 hr. The final weight of paste was recorded till constant weight. The moisture content of the paste was determined by using the following formula (Ranganna, 1986).

$$\textbf{Moisture Content}\ (\%) = \left(\frac{\mathrm{Wm} - \mathrm{Wd}}{\mathrm{Wm}}\right) \times 100$$

Where, W_m= initial weight of sample, g; W_d= weight of dry sample, g.

3.3.3.2 Curcumin content (%)

About 1g of the sample was refluxed with 75 ml acetone for 1 hr after which it was filtered and volume made up to 200 ml. From this further 1ml was taken and volume made up to 100 ml in a standard flask. The UV spectral reading for this solution was recorded at 420 nm. A UV spectrum was recorded for standard curcumin. Percentage curcumin in samples was calculated using the formula: (Geethanjali *et al.,* 2016).

$$\textbf{Curcumin}\ (\%) = \left[\mathrm{Ds} \times \frac{\mathrm{As}}{100} \times \mathrm{Ws} \times 1650\right] \times 100$$

Where, Ds -dilution volume of the sample; Ws -weight of the sample taken in grams; As -absorbance of the sample; 1650 - calculated standard value.

$$\textbf{Curcumin dry basis}(\%) = \left(\frac{\text{curcumin}\ \%}{100 - \text{moisture}\ \%}\right) \times 100$$

3.3.3.3 Total soluble solids (°B)

The total soluble solids were determined by using Hand Refractometer (Atago Japan, 0-32°B) and the values were corrected at 20°C with the help of temperature correction chart (A.O.A.C., 1990).

3.3.3.4 pH

pH is defined as the logarithm of the reciprocal of hydrogen ion concentration in g/l. It is important as it measures the active acidity which influences the flavour or palatability of a product and affects the processing requirements (Ranganna, 1986).

3.3.3.5 Titrable acidity (%)

A 10 g quantity of paste sample was blended in mortar and pestle with 20-25 ml distilled water. It was then transferred to a 100 ml volumetric flask, made up the volume and filtered. A 10 ml volume of aliquot was titrated against 0.1 N sodium hydroxide (NaOH) solutions. Use phenolphthalein as an indicator. The acidity were calculated as given below and the results was expressed as percent ascorbic acid (Ranganna, 1986).

Titratable acidity (%)

$$= \frac{\text{Titrate} \times \text{Normality of alkali} \times \text{volume made up} \times \text{Equivalent wt. of acid}}{\text{volume of sample taken for estimation} \times \text{Wt. of sample taken} \times 1000} \text{ x } 100$$

3.3.3.6 Starch (%)

Extract about 3 g of the ground sample accurately weighed with five parts of 10 ml portions of ether on a filter paper that will retain completely the smallest starch granules. Evaporate the ether from the residue and wash with 150 ml of 10 per cent ethyl alcohol. Carefully wash off the residue from the filter paper with 200 ml of cold water.

Heats the un-dissolved residue with 200 ml of 2.5 per cent dilute HCl in a flask equipped with reflux condenser for two and half hours. Cool and neutralise with Sodium carbonate solution and transfer quantitatively to 250 ml volumetric flask and make up volume. Determine reducing sugars in the solution by Lane and Eynon Volumetric method using Fehling solution and methylene blue as internal indicator. Express the result as Dextrose (Ranganna, 1986).

$$\textbf{Starch content}\ (\%) = \text{Dextrose x 0.9}$$

3.3.3.7 Sugars

(a) Reducing sugar (%)

A known weight of sample was taken in 250 ml volumetric flask. To this, 100 ml of distilled water was added and the contents were neutralized by 1 N sodium hydroxide. Then 2 ml of 45 per cent lead acetate was added to it. The contents were mixed well and kept for 10 minutes. Two ml of 22 per cent potassium oxalate was added to it to precipitate the excess of lead. The volume was made to 250 ml with distilled water and solution was filtered through Whatman No. 4 filter paper. This filtrate was used for determination of reducing sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' solutions (5 ml each) using methylene blue as an indicator to a brick red end point. The results were expressed on percent basis. The reducing sugar was calculated as below (Ranganna, 1986).

$$\textbf{Reducing sugar}\ (\%) = \frac{\text{Factor x Dilution}}{\text{Titre reading x Weight of sample}} \text{ x 100}$$

(b) Total sugar (%)

Take a 50 ml aliquot of clarified filtrate solution was transferred to 250 ml volumetric flask, to which, 10 ml of 50 per cent HCl was added and then allowed to stand at room temperature for 24 hrs. It was then neutralized with 40 per cent NaOH solution. The volume of neutralized aliquot was made to 250 ml with distilled water. This aliquot was used for determination of total sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' (5ml each) using methylene blue as indicator to a brick red end point. The results were expressed on per cent basis and the procedure as suggested by (Ranganna, 1986). Total sugar was calculated and expressed in per cent.

$$\textbf{Total sugar}\ (\%) = \frac{\text{Factor x Dilution}}{\text{Titre reading x Weight of sample}} \text{x } 100$$

3.3.3.8 Crude fibers (%)

Extract 2 g of ground sample with ether or petroleum ether to remove fat. Then boil the dried sample mix in 200 ml of sulphuric acid for 30 min with bumping chips. Filter through muslin cloth and wash with boiling water until washing was free of acid. Boil residue with NaOH for 30 min again filter and wash with 25 ml of boiling sulphuric acid, three times 50 ml of water and 25 ml of alcohol. Remove the residue and transfer to ashing dish. Dry the residue for 2 hr at 130±2°C, cool in desiccators and weigh it. Ignite for 30 min at 600±15°C cool in desiccators and weigh. (Thimmaiah, 2004).

$$\textbf{Crude fiber}\ (\%) = \frac{\text{Loss in weight}}{\text{Wt. of sample(g)}} \text{x } 100$$

3.3.3.9 Crude protein (%)

Protein in the paste sample was determined by a Micro-Kjeldahl distillation. The samples were digested by heating with concentrated sulphuric acid (H_2SO_4) in the presence of digestion mixture, potassium sulphate (K_2SO_4) and copper sulphate ($CuSO_4$). The mixture was then made alkaline with 40 per cent NaOH. Ammonium sulphate thus formed. Released ammonia which was collected in 4 per cent boric acid solution and titrated again standard HCl. The percent nitrogen content of the sample was calculated by the formula given below. Total protein was calculated by multiplying the amount of percent nitrogen with appropriate factor (Thimmaiah, 2004).

$$\mathbf{N\%} = \frac{1.4 \times (\text{ml of HCl}) \times \text{Normality of acid} \times 14.01 \times 100}{\text{Weight of sample (g)}}$$

$$\textbf{crude protein}\ (\%) = \%\text{N x } 6.26$$

3.3.3.10 Crude fat (%)

Crude fat of the paste sample was estimated as crude ether extract of the dry material. The dry sample 5 g was weighed accurately into a thimble and plugged with cotton. The thimble was then placed in a soxhlet apparatus and extracted with anhydrous ether for 3 hrs, cooled in a desiccator and weighed. The fat content was expressed as g/100 g (Thimmaiah, 2004).

$$\textbf{Crude fat}\ (\%) = \frac{\text{Weight of dried ether soluble material} \times 100}{\text{Weight of sample (g)}}$$

3.3.3.11 Total ash (%)

The ash content of the paste sample was determined by a method suggested by Ranganna (1986). The tare weight of three silica dishes (7-8 cm dia) was noted and 5 g of the sample was weighed into each silica dish. The contents were ignited on a Bunsen burner and the material was ashed at not more than 525°C for 4 to 6 hr, in a muffle furnace. The dishes were cooled and weighed. The difference in weights represented the total ash content and was expressed as percentage.

$$\textbf{Totla Ash}\ (\%) = \frac{\text{Weight of crucible with ash (g)} - \text{Weight of crucible(g)}}{\text{Weight of sample (g)}} \times 100$$

3.3.3.12 Statistical analysis of turmeric during blanching period

Data collected on chemical parameters of turmeric paste such as moisture, TSS, titratable acidity and sugars were represented as mean values. The data collected on the changes in physico-chemical parameters of turmeric paste during blanching period were statistically analyzed by the standard procedure given by Panse and Sukhatme (1985) and Amdekar (2014) using Completely Randomized Design with three replication and valid conclusions were drawn only on significant differences between treatment mean at 5 per cent level of significance.

3.3.4 Preparation of turmeric paste and storage study

The turmeric paste was prepared as per the standard procedure followed to prepare ginger paste with slight modification. The paste was prepared by adding 50.5 per cent turmeric, 25 per cent water (w/w), 24 per cent vinegar (w/w), 0.5 per cent starch and 250 ppm sodium benzoate. The turmeric rhizomes were washed under tap water to remove the adhering soil materials. Fully matured secondary rhizomes of turmeric were selected for preparation of turmeric paste. Then turmeric rhizomes were washed thoroughly and blanched at 100°C for 5 minutes. Blanched rhizomes were peeled with the help of peelers and ground fine into puree using a commercial wet grinder. The chemical preservatives i.e. sodium benzoate at 250 ppm was used as a preservative to avoid discolouration of the paste and vinegar to maintain pH 4 to 4.5 was added to the finely ground turmeric puree. Corn starch was added to avoid water separation from the paste and maintain flow behaviour index and consistency i.e. viscosity of the paste and mixed well. The prepared paste filled in the pre sterilized packaging materials i.e. glass bottle and HDPE pouch and sealed.

Before storage, paste was thermally pasteurized using a hot water bath at 80°C for 15 min to avoid microbial contamination.

To study the effect of packaging materials on the shelf life of turmeric paste, the paste was stored at refrigerated temperature (5±1°C). The two types of packaging materials, viz. glass bottles and HDPE pouches for the study was used so as to recommend the most cost effective packages to the small entrepreneurs. The storage was continued for 180 days and the samples were analysed for different quality parameters at 60 days interval. The experiments were done with five replications.

One side open HDPE pouches and glass bottle were brought from the market. A hand operated sealing machine was used to seal the HDPE pouches. The 250 g turmeric paste sample was filled in each of the selected packaging materials. The preparation of turmeric paste given in flow chart (1).

3.3.5. Physical parameters of turmeric paste during storage period

3.3.5.1 Colour

The colour value L*, a* and b* and yellowing index of turmeric paste analysed during storage period according to treatment at 60 days interval as per the procedure discussed in section 3.3.2.1.

3.3.5.2 Viscosity (Pa.sn)

The viscosity of turmeric paste analysed during storage period according to treatment at 60 days interval as per the procedure discussed in section 3.3.2.2.

3.3.6 Chemical parameters of turmeric paste during storage period

3.3.6.1 Moisture content (%)

The moisture content of turmeric paste analysed during storage period according to treatment at 60 days interval as per the procedure discussed in section 3.3.3.1.

3.3.6.2 Curcumin content (%)

The curcumin content of turmeric paste analysed during storage period according to treatment at 60 days interval as per the procedure discussed in section 3.3.3.2.

3.3.6.3 Total soluble solids (°B)

The TSS content of turmeric paste analysed during storage period according to treatment at 60 days interval as per the procedure discussed in section 3.3.3.3.

3.3.6.4 pH

The pH of turmeric paste analysed during storage period according to treatment at 60 days interval as per the procedure discussed in section 3.3.3.4.

3.3.6.5 Titrable acidity (%)

The titratable acidity of turmeric paste analysed during storage period according to treatment at 60 days interval as per the procedure discussed in section 3.3.3.5.

3.3.6.6 Starch (%)

The starch content of turmeric paste analysed during storage period according to treatment at 60 days interval as per the procedure discussed in section 3.3.3.6.

3.3.6.7 Sugars

(a) Reducing sugar (%)

The reducing sugar content of turmeric paste analysed during storage period according to at 60 days interval as per the procedure discussed in section 3.3.3.7 (a).

(b) Total sugar (%)

The total sugar content of turmeric paste analysed during storage period according to treatment at 60 days as per the procedure discussed in section 3.3.3.8 (b).

3.3.6.8 Crude fibers (%)

The crude fiber content of turmeric paste analysed during storage period according to treatment at 60 days interval as per the procedure discussed in section 3.3.3.8.

3.3.6.9 Crude protein (%)

The crude protein content of turmeric paste analysed during storage period according to treatment at 60 days interval as per the procedure discussed in section 3.3.3.9.

3.3.6.10 Crude fat (%)

The crude fat content of turmeric paste analysed during storage period according to treatment at 60 days interval as per the procedure discussed in section 3.3.3.10.

3.3.6.11 Total ash (%)

The total ash content of turmeric paste analysed during storage period according to treatment at 60 days interval as per the procedure discussed in section 3.3.3.11.

3.3.7 Microbial analysis of turmeric paste during storage period

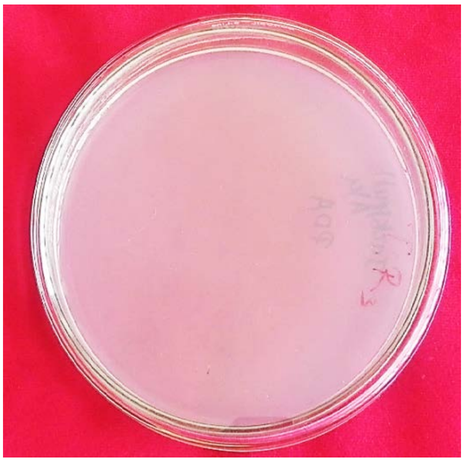
The microbial analysis of the turmeric paste was carried out from 0 day to 180 days of storage as per the method described.

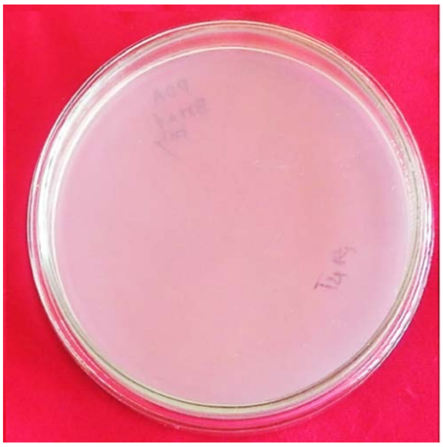
3.3.7.1 Total plate count

Using separate sterile pipettes, prepare decimal dilutions of 10^{-1} to 10^{-6} and others as appropriate, of food homogenate by transferring 10 ml of previous dilution to 90 ml of diluents. Shake all dilutions well. Pipette 1 ml of each dilution into separate, duplicate, appropriately marked petri dishes. Add 12-15 ml plate count agar (cooled to 45±1°C) to each plate within 15 min of original dilution. Pour agar and diluents in control plates for each series of samples. Immediately mix sample dilutions and agar medium thoroughly and uniformly by alternate rotation and back-and-forth motion of plates on flat level surface. Let agar solidify. Invert solidified petri dishes and incubates promptly for 48 ± 2 hr at 35°C. Do not stack plates when pouring agar or when agar is solidifying (Maturin and Peeler, 2001).

3.3.7.2 Yeast and mould count

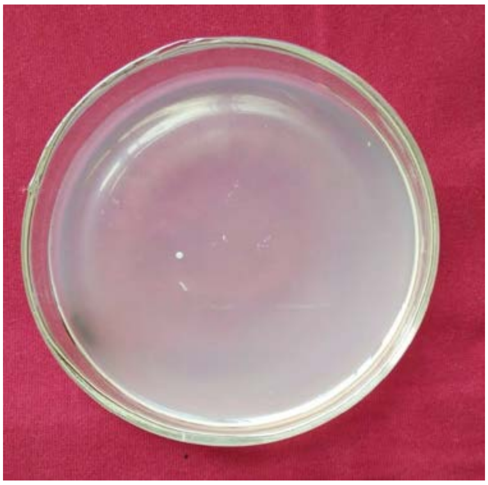
Prepare dichloran 18 per cent glycerol (DG18) agar (cooled to 45±1°C) and add 12-15 ml agar to each plate within 15 min of original dilution. Pour agar and diluents in control plates for each series of samples. Immediately mix sample dilutions. Let agar solidify. Incubate plates in the dark at 25°C. Do not stack plates higher than 3 and do not invert (Tournas *et al.,* 2001).

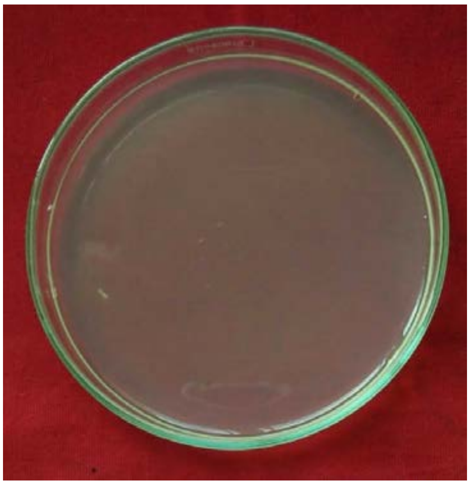




(a) T1 **(b) T2**

Plate 3: TPC





(a) T1 **(b) T2**

Plate 4: Yeast and mould

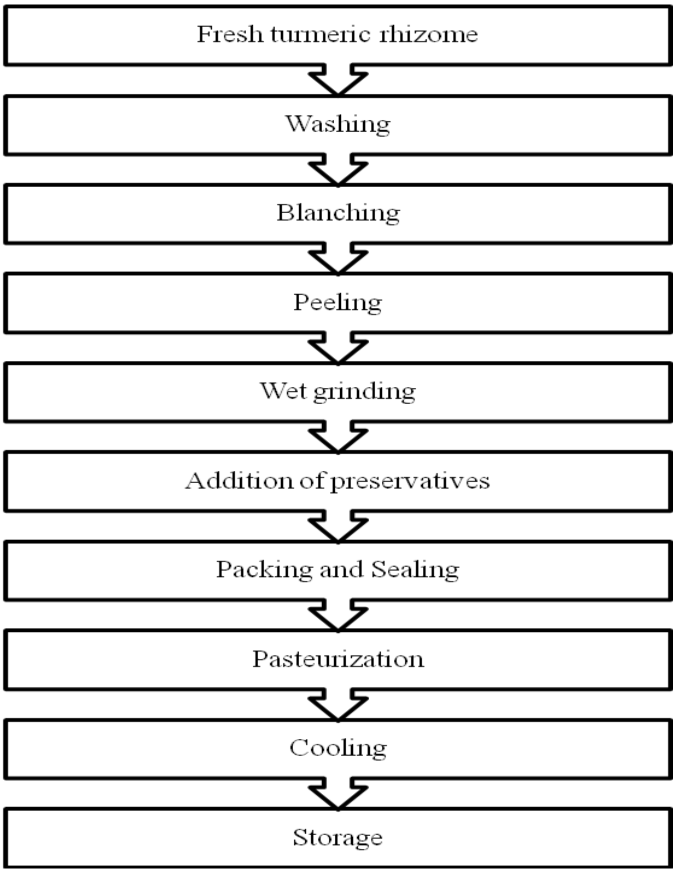
3.3.8 Statistical analysis of turmeric paste during storage period

Data collected on chemical parameters of turmeric paste such as moisture, TSS, titratable acidity and sugars were represented as mean values. The data collected on the changes in physico-chemical parameters of turmeric paste storage at 60 days interval up to 180 days. The experiment was statistically analyzed by the standard procedure given by Panse and Sukhatme (1985) and Amdekar (2014) using Factorial Completely Randomized Design with five replications and valid conclusions were drawn only on significant differences between treatment mean at 5 per cent level of significance.

3.4 Economics of the turmeric paste

The economics of the product was worked out by considering existing rates of various inputs such as cost of raw material (rhizomes), labour, fuel, chemicals, packaging materials, depreciation charges (repairing charge) and interest on the fixed capital. The gross returns as per the treatments were worked out by considering prevailing market price. The sale price of the product was calculated by considering the market value of various pastes available in market.

Flow chart- 1
Process flowchart for preparation of turmeric paste



(a) 0 min blanching

(b) 5 min blanching

(c) 10 min blanching

(d)15 min blanching

(e)20 min blanching

(f) 25 min blanching

(g) 30 min blanching

Plate 5: Turmeric paste prepared with different blanching period.

(a) 0 days

(b) 60 day

(c) 120 days

(d) 180 days

Plate 6: Turmeric paste with different packaging and storage period.

RESULT AND DISCUSSION

CHAPTER IV

Result and discussion

The present investigation entitled, "Development of process for preparation of turmeric paste" was undertaken in the Department of Post-Harvest Management of Medicinal, aromatic, plantation, spices and forest crops, Post Graduate Institute of Post-Harvest Management, Killa-Roha, during the year 2019-2020.

The fresh turmeric rhizomes were selected for the present investigation which was undertaken to standardize the process for preparation and to study storage behaviour of turmeric paste. The experimental data was analysed statistically using Completely Randomized Design (CRD) and Factorial Completely Randomized Design (FCRD). The observations on the changes in physical, chemical and microbial parameters of turmeric paste during blanching and storage were recorded at 0, 60, 120 and 180 days of refrigerated storage. The results obtained from the investigation are presented and discussed in this chapter.

4.1 Changes in the physical quality parameters of the turmeric paste during blanching period

4.1.1 Colour

4.1.1.1 L* value for colour

The data for L* value for colour of turmeric paste during blanching period are presented in Table 4.1 and graphically depicted in Fig 4.1. L* value was recorded to determine lightness of turmeric paste which decreased with corresponding increase in blanching period.

Highest mean L* value for lightness of turmeric paste was found in the treatment T_1 (77.74) which was at par with T_2 (77.13) followed by the treatment T_3 (75.60). The lowest mean L* value was observed in the treatment T_7 (71.69) which was at par with T_6 (72.42). It was noticed from the data that the darkness of turmeric paste increased continuously with increase in the blanching period in the turmeric paste.

This decrease in L* value of colour occurred due to browning of paste during blanching period which was the result of loss of yellow colour pigment i.e. curcumin due to prolonged heating. Rocha and Morais, (2001) reported that the higher the degree of browning encountered, L* value lowered. Pradeep *et al.* (2016) reported the decrease in L* value of turmeric rhizome after drying affected due to pre-treatment (blanching).

4.1.1.2 a* value for colour

The data for a* value for colour of turmeric paste during blanching period are presented in Table 4.1 and graphically depicted in Fig 4.1. The a* value was recorded to determine redness of turmeric paste which increased with corresponding increase in blanching period.

Highest mean a* value for redness of turmeric paste was found in the treatment T_7 (13.16) followed by the treatment T_6 (12.92) and T_5 (12.27). The lowest mean a* value was observed in the treatment T_1 (10.42) which was at par with T_2 (10.63). It was noticed from the data that the redness of turmeric paste increased continuously with increase in blanching period in the turmeric paste.

This increase in a* value of colour occurred due to browning of paste during blanching period which was the result of loss of yellow colour pigment i.e. curcumin due to prolonged heating similar trend of increase in a* colour value in ginger paste from brown to yellow during storage was observed by Ahmed, (2004b).

Table 4.1: Changes in the colour of the turmeric paste during blanching period.

Parameter		Colour			Yellowing index
		L*	a*	b*	
Treatments	T_1 (0 min)	77.74	10.42	91.46	168.07
	T_2 (5 min)	77.13	10.63	92.06	170.51
	T_3 (10 min)	75.60	11.39	90.72	169.19
	T_4 (15 min)	74.56	12.03	88.10	168.07
	T_5 (20 min)	72.65	12.27	84.97	167.09
	T_6 (25 min)	72.42	12.92	84.44	166.56
	T_7 (30 min)	71.69	13.16	82.94	165.29
S.Em±		0.26	0.08	0.07	0.64
CD AT 5 %		0.76	0.22	0.20	1.81

4.1.1.3 b* value for colour

The data for b* value for colour of turmeric paste during blanching period are presented in Table 4.1 and graphically depicted in Fig 4.1. b* value was recorded to determine yellowness of turmeric paste which decreased with corresponding increase in blanching period.

Highest mean b* value for yellowness of turmeric paste was found in the treatment T_2 (92.06) followed by the treatment T_1 (91.46) and T_3 (90.72). The lowest mean b* value was observed in the treatment T_7 (82.94). It was noticed from the data that the yellowness of turmeric paste decreased continuously with increase in blanching period in the turmeric paste.

This decrease in b* value of colour occurred due to browning of paste during blanching period which was result of loss of yellow colour pigment i.e. curcumin due to prolonged heating. Similar trend of decrease in b* colour value in ginger paste was observed by Ahmed, (2004b) as ginger paste turns brown to yellow during storage. Pradeep *et al.* (2016) reported the decrease in b* value of turmeric rhizome after drying affected by pre- treatment (blanching).

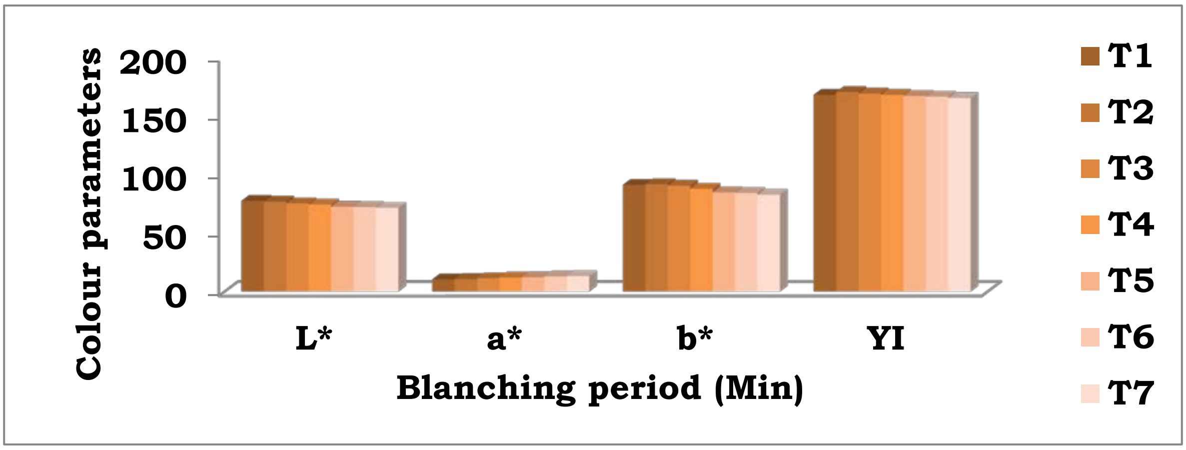


Fig 4.1: Changes in the colour of the turmeric paste during blanching period.

4.1.1.4 Yellowing index

The data for yellowing index for colour of turmeric paste during blanching period are presented in Table 4.1 and graphically depicted in Fig 4.1. Yellowing index was recorded to determine yellowness of turmeric paste which decreased with corresponding increase in blanching period.

Highest mean yellowing index for yellowness of turmeric paste was found in the treatment T_2 (170.51) which was at par with T_3 (169.19) followed by the treatment and T_1 (168.07) and T_4 (168.07). The lowest mean yellowing index was observed in the treatment T_7 (165.29) which was at par with T_6 (166.56) and T_5 (167.09). It was noticed from the data that the yellowness of turmeric paste decreased continuously with increase in blanching period in the turmeric paste.

This decrease in YI value of colour occurred due to browning of paste during blanching period which was the result of loss of yellow colour pigment i.e. curcumin due to prolonged heating. Similar observations were recorded by Ahmed *et al.* (2000). They reported blanching resulted in a loss of green pigment in green chilli puree and colour degradation observed due to thermal process in onion paste was noticed by Ahmed and Shivhare, (2001c). Similarly, in green chilli puree Ahmed *et al.* (2002a) reported the colour degradation during thermal processing. Total colour degradation in red chilli puree was recorded by Ahmed *et al.* (2002b). Neves *et al.* (2020) found the similar results in turmeric biomass. In onion paste colour degradation was observed by Ahmed *et al.* (2001d). Ahmed *et al.* (2004) observed the rate of colour degradation was more at higher temperature in coriander leaf puree.

4.1.2 Viscosity (Pa.sn)

The data related to the changes in the flow behaviour index (n) and consistency index (k) of the turmeric paste during blanching period are presented in Table 4.2 and graphically depicted in Fig 4.2 observed that there was decreasing trend of flow behaviour index and increasing trend of consistency index as blanching period increased.

It was observed from the data that the flow behaviour index of turmeric paste significantly varied due to the treatments. The treatment T_1 (0.1501) showed significantly highest mean value for flow behaviour index which was followed by the treatments T_2 (0.1369) and T_3 (0.1117). The lowest flow behaviour index was recorded by the treatment T_7 (0.0586) at par with T_6 (0.0710). It was observed that there was decreasing trend of flow behaviour index with increase in blanching period.

Table 4.2: Changes in the viscosity of the turmeric paste during blanching period.

Parameter		Viscosity	
		N	K
Treatments	T_1 (0 min)	0.1501	1.1349
	T_2 (5 min)	0.1369	1.2365
	T_3 (10 min)	0.1117	1.4253
	T_4 (15 min)	0.0793	1.8562
	T_5 (20 min)	0.0759	1.9199
	T_6 (25 min)	0.0710	2.0213
	T_7 (30 min)	0.0586	2.3437
S.Em±		0.004	0.034
CD AT 5 %		0.013	0.102

It was observed from the data that the consistency index of turmeric paste significantly varied due to the treatments. The treatment T_7 (2.3437 Pa.sn) showed significantly highest mean value for consistency index which was followed by the treatments T_6 (2.0213 Pa.sn) and T_5 (1.9199 Pa.sn). The lowest consistency index was recorded by the treatment T_1 (1.1349 Pa.sn). It was observed that there was an increasing trend of consistency index during increase in blanching period.

Similar observations for ginger paste have been reported by Ahmed, (2004a) and the consistency index decreases and flow behaviour index increases with increase in temperature observed in ginger paste by Ahmed, (2004b). In coriander leaf puree by Ahmed *et al.* (2004) and onion puree by Ahmed *et al.* (2001d) while decrease in consistency index with increase in temperature was observed in garlic paste by Constenla and Lozano, (2005). Fagbemi, (1999). Reported the blanching considerably reduced the viscosity of plantain flour.

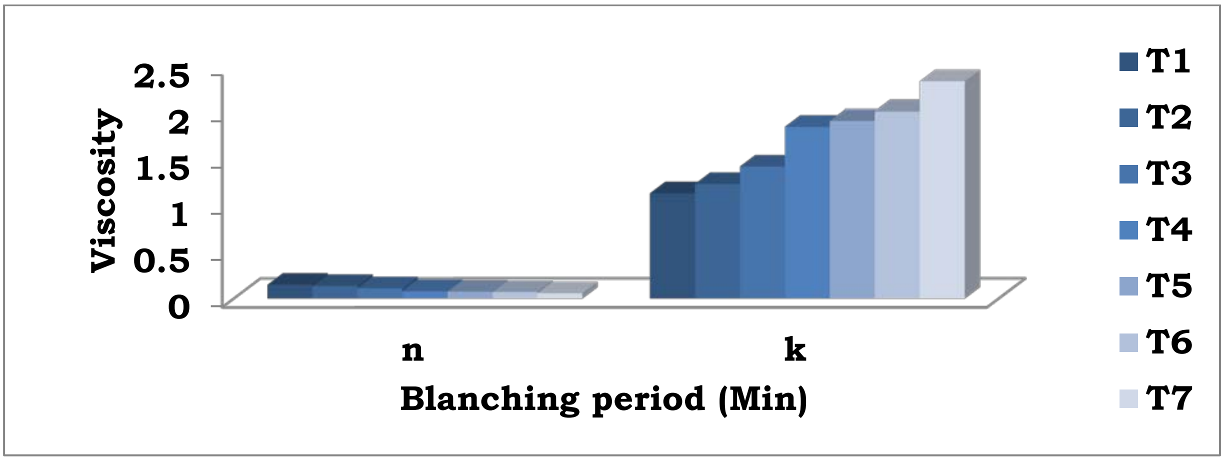


Fig 4.2: Changes in the viscosity of the turmeric paste during blanching period.

4.2 Changes in the chemical quality parameters of the turmeric paste during blanching period

4.2.1 Moisture (%)

The data related to the changes in the moisture content of the turmeric paste due to blanching period are presented in Table 4.3 and graphically depicted in Fig 4.3 observed that there was decreasing trend of moisture content during increase in blanching period.

It was observed from the data that the moisture content of turmeric paste varied due to the treatments. The treatment T_1 (87.73 per cent) showed the highest mean value for moisture content which was at par with T_2 (86.34 per cent), T_3 (85.59 per cent) and T_4 (84.75 per cent) followed by T_5 (82.76 per cent). The lowest moisture content was recorded by the treatment T_7 (80.64 per cent) which was at par T_6 (80.66 per cent). It was observed from the data that the moisture content in turmeric paste was decreased with increase in blanching period.

Moisture loss during blanching period might have occurred due to prolonged periods of heat and modification of starches due to heat. Giridhar *et al.* (1996) reported 71.80 per cent moisture content in ginger-garlic paste. Ghodke *et al.* (2014) reported 75.8 per cent moisture content in ginger-garlic-chilli paste, Topno *et al.* (2013) reported 75.10 per cent in ginger-garlic paste. Akter *et al.* (2010) observed the decreasing trend of moisture content after blanching in dried persimmons peel powder.

4.2.2 Curcumin (%)

The data related to the changes in the curcumin content of the turmeric paste during blanching period are presented in Table 4.3 and graphically depicted in Fig 4.3 observed that there was loss of curcumin content with increase in blanching period.

It was observed from the data that the curcumin content of turmeric paste varied due to the treatments. The treatment T_2 (5.16 per cent) showed the highest mean value for curcumin content which was superiorly significant, followed by the treatments T_1 (4.53 per cent). The lowest curcumin content was recorded by the treatment T_7 (4.06 per cent).

Curcumin concentration decreased as the boiling time increased. Curcumin undergoes hydrolytic degradation under thermal processing conditions thus the loss of curcumin content rapidly increased with temperature, indicating its instability at high temperatures. It was observed from the data that the curcumin content of turmeric paste declined significantly with increase in blanching period. Curcumin content of turmeric paste decreased with increase in blanching period. It was observed from the data that curcumin content of turmeric paste decreased significantly with increase in blanching period.

Mane *et al.* (2018) reported the curcumin content of fresh turmeric was 5.1 per cent. Curcumin loss from heat processing of turmeric was 27–53 per cent, with maximum loss in pressure cooking for 10 min was stated by Suresh *et al.* (2007). Shinde *et al.* (2011) reported a similar trend of decrease in curcumin content during boiling of turmeric for 15, 20, 25 and 30 minutes resulted in curcumin concentration 4.25 per cent, 4.21 per cent, 3.91 per cent, and 2.29 per cent, respectively. Jayashree and Zachariah, (2016) reported that increase in curing time of turmeric rhizomes resulted in significant reduction in curcumin content. The curcumin content first increased and then decreased with increase in temperature was observed by Sogi *et al.* (2010). Patil *et al.* (2015) reported the decrease in curcumin content with increase in blanching period.

4.2.3 TSS (°B)

The data related to the changes in the TSS of the turmeric paste during blanching period are presented in Table 4.3 and graphically depicted in Fig 4.3 observed that there was a decreasing trend of TSS with increase in blanching period.

It was observed from the data that the TSS of turmeric paste varied due to the treatments. The treatment T_2 (6.73) showed the highest mean value for TSS followed by the treatments T_3 (6.57) and T_4 (6.43). The lowest TSS was recorded by the treatment T_7 (5.87) which was at par with T_5 (5.97). It was observed from the data that TSS of turmeric paste declined significantly with increase in blanching period.

TSS decreased due to hydrolysis of sugars and prolonged heating during blanching period. Mane *et al.* (2018) reported the TSS of fresh turmeric was 7.8°B. Kumar *et al.* (2018) reported that TSS of ginger candy increased with increase in blanching period up to some extent but later it was decreased. Mate *et al.* (1998) reported that the longer blanching of potato slices leads to the leaking out of glucose and glucose was measured as an indicator of soluble solids.

4.2.4 pH

The data related to the changes in the pH of the turmeric paste during blanching period are presented in Table 4.3 and graphically depicted in Fig 4.3 observed that there was an increasing trend of pH as blanching period was increased.

It was observed from the data that the pH of turmeric paste varied due to the treatments. The treatment T_7 (4.80) showed significantly highest mean value for pH which was followed by the treatment T_6 (4.75). The minimum pH was recorded by the treatment T_3 (4.03). It was observed from the data that the pH of turmeric paste slightly decreased but with increase in blanching it was increased.

As pH value increases, acidity decreases, and vice versa. Akhtar *et al.* (2015) reported decrease in pH of ginger garlic paste with increase in microwave power and heating timing. By lowering the pH more stability against microbial spoilage was achieved. Similarly, Ahmed, (2004b) adjusted the pH 4.05 of ginger paste, Ahmed, (2002b) 4.02 in garlic paste, Ahmed *et al.* (2004) 4.5 in coriander leaf puree, Mu *et al.* (2010) was maintained pH 4.4- 4.6 in onion paste, Ahmed *et al.* (2002a) pH 5.08 in green chilli puree, Ahmed and Shivhare, (2001c) was reduced pH 3.9 in onion paste, Ahmed and Shivhare, (2001b) observed pH 4.1 in garlic paste and Giridhar *et al.* (1996) adjusted pH to 4 in ginger-garlic paste.

4.2.5 Titratable acidity (%)

The data related to the changes in the titratable acidity of the turmeric paste during blanching period are presented in Table 4.3 and graphically depicted in Fig 4.3. It was observed that there was first increasing and then decreasing trend of titratable acidity during increase in blanching period.

It was observed from the data that the titratable acidity of turmeric paste varied due to the treatments. The treatment T_3 (1.03 per cent) showed significantly highest mean value for titratable acidity which was followed by the treatments T_2 (0.99 per cent). The minimum acidity was recorded by the treatment T_7 (0.68 per cent). It was observed that there was increasing trend of acidity during the blanching period up to some extent but later it was decreased.

Titratable acidity reduced during blanching period due to loss of ascorbic acid. Nath *et al.* (2013) observed a similar trend of increase in blanching period caused increase in acidity in ginger candy from 0.68 per cent to 1.43 per cent, it may be due to thickness of ginger slices and blanching period. Kumar *et al.* (2018) reported that titratable acidity of ginger candy increased with increase in blanching period up to some extent but later it decreased. Blanching period (from 7.50 to 10 min) might affect the semi-permeability of the cell walls, causing a reduction in rate of osmosis leading to a decrease in titratable acidity.

4.2.6 Starch (%)

The data related to the changes in the starch content of the turmeric paste during blanching is presented in Table 4.3 and graphically depicted in Fig 4.3 observed that there was a decreasing trend of starch content during increase in blanching period.

It was observed from the data that the starch content turmeric paste varied due to the treatments. The treatment T_2 (30.42 per cent) showed significantly highest mean value for starch content which was followed by the treatments T_3 (28.14 per cent) and T_4 (26.05 per cent). The minimum starch content was recorded by the treatment T_7 (23.10 per cent) which was at par T_6 (23.99 per cent). It was observed that there was a decreasing trend of starch content during the increase in blanching period.

Starch gets swelled and gelatinized (dissolving the starch molecule in water) in presence of heat and water makes the starch digestible or to thicken/bind water. Jayashree and Zachariah, (2016) reported that increase in curing time of turmeric rhizomes resulted in significant reduction in starch content. Chen *et al.* (2017) reported the blanching samples of yam flour presented lower starch content.

4.2.7 Sugars

4.2.7.1 Reducing sugar (%)

The data related to the changes in the reducing sugar content of the turmeric paste during blanching period are presented in Table 4.3 and graphically depicted in Fig 4.3 observed that there was a decreasing trend of reducing sugar content with increase in blanching period.

It was observed from the data that the reducing sugar content in turmeric paste varied significantly due to the treatments. The treatment T_1 (7.58 per cent) showed significantly highest mean value for reducing sugar content which was at par with T_2 (7.55 per cent) followed by the treatments T_3 (7.13 per cent). The minimum reducing sugar content was recorded by the treatment T_7 (5.38 per cent). It was observed that there was a decreasing trend of reducing sugar content during increase in blanching period.

Reducing sugar dissolve in the water during blanching period. Similar results were observed by Singh and Madan, (2019) and Madan, (2014). They observed the decrease in reducing sugar as increased the temperature in turmeric. Braga *et al.* (2003) reported 7.008 per cent of reducing sugar in turmeric. Akter *et al.* (2010) reported sugars might be lost from the plant cells into the blanching water, in dried persimmons peel powder. Wennberg *et al.* (2006) reported the greater diffusion of reducing sugars during blanching of cabbage.

4.2.7.2 Total sugar (%)

The data related to the changes in the total sugar content of the turmeric paste during blanching period are presented in Table 4.3 and graphically depicted in Fig 4.3 observed that there was a decreasing trend of total sugar content with increase in blanching period.

It was observed from the data that the total sugar content turmeric paste varied significantly due to the treatments. The treatment T_1 (29.43 per cent) showed significantly highest mean value for total sugar content which was followed by the treatments T_2 (28.22 per cent) and T_3 (27.12 per cent). The minimum total sugar content was recorded by the treatment T_7 (21.64 per cent. Decreasing trend of total sugar content was observed with increase in blanching period.

Total sugar dissolved in the water during blanching period. Singh and Madan, (2019) and Madan, (2014) observed that there was decrease in total sugar as increase in the temperature in turmeric. Akter *et al.* (2010) reported sugars might be lost from the plant cells into the blanching water, in dried persimmons peel powder.

4.2.8 Crude fiber (%)

The data related to the changes in the fiber content of the turmeric paste during blanching period are presented in Table 4.3 and graphically depicted in Fig 4.3 observed that there was a decreasing trend of fiber content with increase in blanching period.

It was observed from the data that the fiber content of turmeric paste varied due to the treatments. The treatment T_1 (0.72 per cent) showed highest mean value for fiber content which was at par with T_2

(0.70 per cent) followed by the treatments T_3 (0.69 per cent). The minimum fiber content was recorded by the treatment T_7 (0.50 per cent). It was observed that there was a decreasing trend of fiber content during the increase in blanching period.

Decomposition of crude fiber due to increased temperature leads to the breakage of weak bonds and makes it easier for digestion. Mane *et al.* (2018) reported the fiber content of fresh turmeric was 0.72 per cent. Svanberg *et al.* (1997) reported the total fiber content decreased during boiling of carrot. Harijono *et al.* (2013) reported the effect of blanching treatment decreased fiber content in purple yam and yellow yam. Bao and Chang, (1994) noted the loss of dietary fiber during blanching in carrot.

4.2.9 Crude protein (%)

The data related to the changes in the protein content of the turmeric paste during blanching period are presented in Table 4.3 and graphically depicted in Fig 4.3 observed that there was a slight increase and then decreasing trend of protein content with increase in blanching period.

It was observed from the data that the protein content of turmeric paste varied due to the treatments. The treatment T_2 (8.57 per cent) showed the highest mean value for protein content which was at par with T_3 (8.38 per cent) and T_1 (8.30 per cent) followed by the treatments T_4 (8.18 per cent). The minimum protein content was recorded by the treatment T_7 (5.46 per cent). It was observed that there was a slight increase and then decreasing trend of protein content during the increase in blanching period.

Heat can be used to disrupt hydrogen bonds and non-polar hydrophobic interactions. This occurs because heat increases the kinetic energy and causes the molecules to vibrate so rapidly and violently that the bonds were disrupted. The proteins in turmeric rhizomes denature and coagulate during cooking and denature the proteins to make it easier for enzymes to digest them.

Similar protein 8.28 per cent in turmeric was reported by Madhusankha *et al.* (2019) and 8.43 per cent was reported by De Lima *et al.* (2017). Chen *et al.* (2017) reported that during the blanching and heating of yam flour caused the proteins loss in water. Harijono *et al.* (2013) reported the effect of blanching treatment resulted in a decrease in protein content in purple yam and yellow yam.

4.2.10 Crude fat (%)

The data related to the changes in the fat content of the turmeric paste during blanching period are presented in Table 4.3 and graphically depicted in Fig 4.3. Decreasing trend of fat content was observed with increase in blanching period.

It was observed from the data that the fat content of turmeric paste varied significantly due to the treatments. The treatment T_1 (7.88 per cent) showed significantly highest mean value for fat content which was followed by the treatments T_2 (7.36 per cent) and T_3 (6.88 per cent). The minimum fat content was recorded by the treatment T_7 (4.28 per cent). It was observed that there was a decreasing trend of fat content during the increase in blanching period.

Crude fat content decreased during blanching period might be due to leaching in water. Harijono *et al.* (2013) reported the effect of blanching decreases fat content in purple yam and yellow yam. Athmaselvi, (2009) reported the decrease in the essential oil content in the conventional processing was due to the leaching of oil in water. In the pressure boiled process, the essential oil content decreased as the pressure was increased in turmeric.

4.2.11 Total ash (%)

The data related to the changes in the ash content of the turmeric paste during blanching period are presented in Table 4.3 and graphically depicted in Fig 4.3. It was observed that ash content decrease with increase in blanching period.

It was observed from the data that the ash content of turmeric paste varied due to the treatments. The treatment T_1 (1.92 per cent) showed the highest mean value for ash content which was at par with T_2 (1.91 per cent) and T_3 (1.86 per cent) followed by the treatments T_4 (1.78 per cent). The minimum ash content was recorded by the treatment T_7 (1.48 per cent). It was observed that there was a decreasing trend of ash content during the increase in blanching period.

Ash content decreased during blanching period may be due to leaching of minerals in blanching water. Similar ash content was observed by Kuttigounder *et al.* (2011). Mane *et al.* (2018) reported the total ash content of fresh turmeric was 0.66 per cent. Akter *et al.* (2010) observed the decreasing trend of ash contents after blanching in dried persimmons peel powder. Harijono *et al.* (2013) reported the effect of blanching treatment resulted decrease in ash content of purple yam and yellow yam. Chantaro *et al.* (2008) reported ash content was decreased due to blanching in carrot. Akhtar *et al.* (2015) reported increase in ash content during storage which was affected by heating treatment in ginger-garlic paste.

Table 4.3: Changes in the chemical quality parameters of the turmeric paste during blanching period

Parameter		Moisture (Wb)	Curcumin (Wb)	TSS	pH	Acidity (Wb)	Starch (Wb)	Sugars		Crude fiber (Wb)	Crude protein (Wb)	Crude fat (Wb)	Total ash (Wb)
								Reducing sugar (Wb)	Total sugar (Wb)				
Treatments	T_1 (0 min)	87.73	4.53	6.07	4.50	0.83	24.52	7.58	29.43	0.72	8.30	7.88	1.92
	T_2 (5 min)	86.34	5.16	6.73	4.30	0.99	30.42	7.55	28.22	0.70	8.57	7.36	1.91
	T_3 (10 min)	85.59	4.28	6.57	4.03	1.03	28.14	7.13	27.12	0.69	8.38	6.88	1.86
	T_4 (15 min)	84.75	4.23	6.43	4.47	0.80	26.05	6.75	25.77	0.64	8.18	5.17	1.78
	T_5 (20 min)	82.76	4.21	5.97	4.50	0.82	24.67	6.29	24.78	0.60	7.65	4.70	1.66
	T_6 (25 min)	80.66	4.18	6.03	4.75	0.70	23.99	5.87	23.23	0.56	6.92	4.44	1.60
	T_7 (30 min)	80.64	4.06	5.87	4.80	0.68	23.10	5.38	21.64	0.50	5.46	4.28	1.48
S.Em±		1.99	0.01	0.04	0.005	0.005	0.33	0.04	0.10	0.009	0.10	0.04	0.02
CD AT 5 %		5.69	0.03	0.12	0.013	0.013	0.99	0.13	0.33	0.029	0.31	0.13	0.06

Note-

*Wb- observations are recorded on wet basis

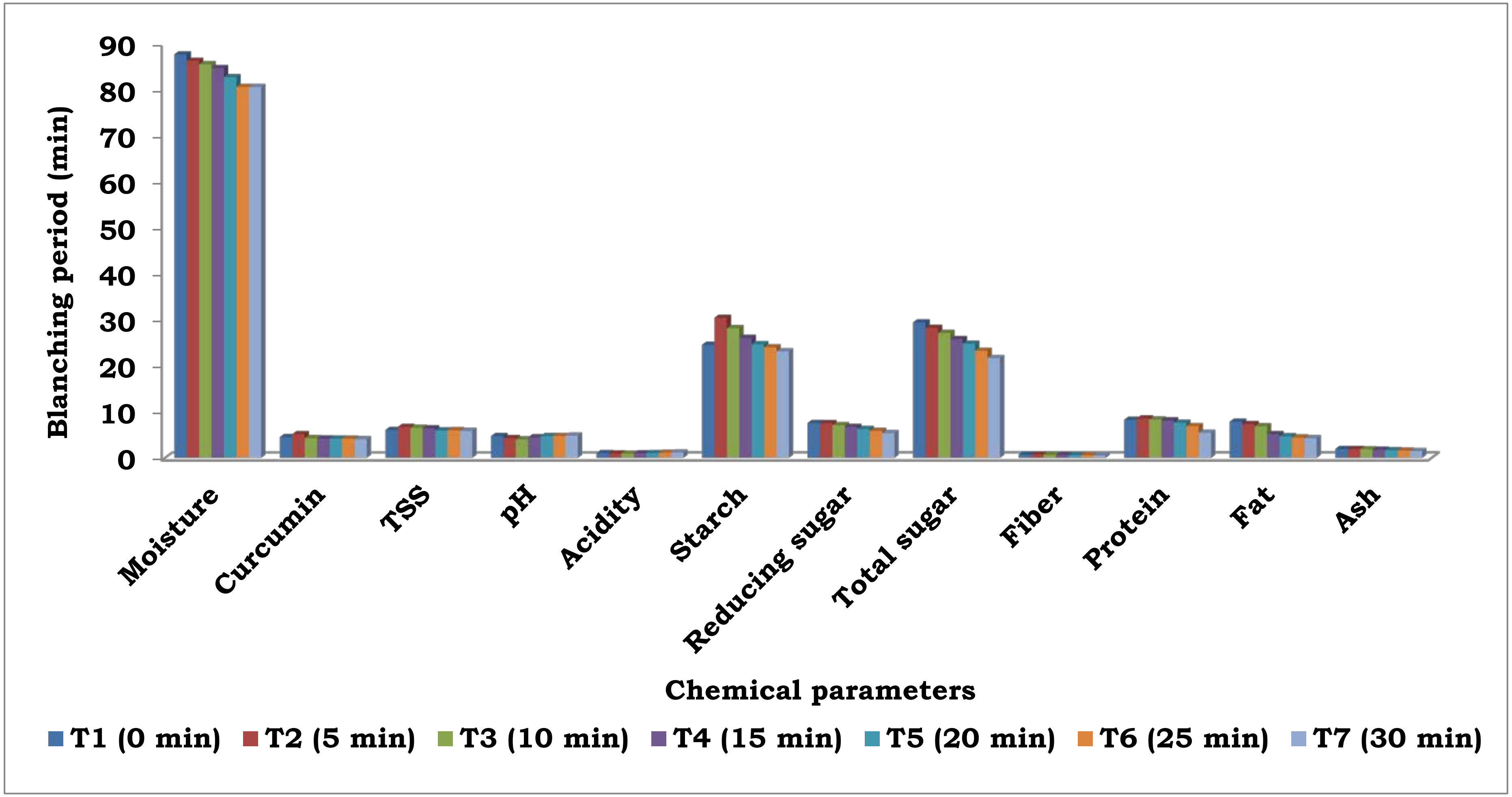


Fig 4.3: Changes in the chemical quality parameters of the turmeric paste during blanching period

4.3 Changes in the physical quality parameters of the turmeric paste during storage period

4.3.1 Colour value

4.3.1.1 L* value

The data for L* value for colour of turmeric paste during storage period is presented in Table 4.4 and graphically depicted in Fig 4.4.

The treatment T_1 (74.77) recorded the highest mean L* value for colour which decreased from 76.18 to 73.35 in glass bottle and 76.18 to 73.61 in HDPE pouch up to 180 days of storage. The L* value of colour during storage of 0 to 180 days also decreased significantly from 76.18 to 72.40 Thus, it can be concluded that darkness of the colour in turmeric paste decreased with increase in storage period.

Table 4.4: Effect of different packaging materials on the L* value of turmeric paste during storage.

Treatments (T)	Storage period				Mean.
	0 day	60 day	120 day	180 day	
T_1	76.18	75.10	73.61	71.44	74.08
T_2	76.18	75.41	74.14	73.35	74.77
Mean	76.18	75.25	73.88	72.40	
	Treatments (T)		Storage (S)		Interactions (TxS)
S.Em±	0.14		0.20		0.03
CD at 5 %	0.41		0.58		0.086

T_1: glass bottle T_2: HDPE pouch

Interaction effect between storage period and different packaging materials was found to be statistically significant for

mean L* value for colour of the turmeric paste at 5 per cent level of significance.

The decrease in L* value of colour occurred due to an increase in browning of turmeric paste during storage of 180 days in both the packaging. Ginger paste turns brown to yellow during storage and decrease in L* colour value was recorded by Ahmed, (2004b). Pradeep *et al.* (2016) reported the decrease in L* value of turmeric rhizome after drying affected by pre-treatment (blanching). In ginger garlic paste increasing trend of L* value of colour recorded by Topno *et al.* (2013). There were reports that the higher the degree of browning encountered, the lower the L* value of the apple samples by Rocha and Morais, (2001).

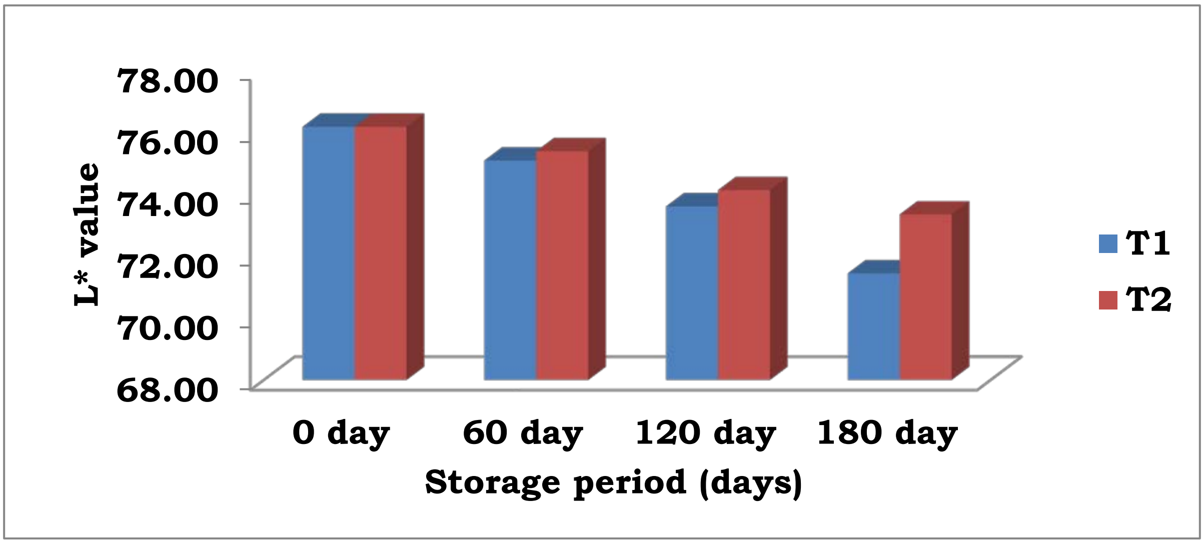


Fig 4.4: Effect of different packaging materials on the L* value of turmeric paste during storage.

4.3.1.2 a* value

The data for a* value for colour of turmeric paste during blanching period are presented in Table 4.5 and graphically depicted in Fig 4.5. a* value was recorded to determine redness of turmeric paste which increased significantly with corresponding increase in the storage period.

The treatment T_2 (11.83) recorded the highest mean a* value for colour which increased from 10.66 to 12.13 in glass bottle and 10.66 to 12.93 in HDPE pouch up to 180 days of storage. The a* value of colour during storage of 0 to 180 days also increased significantly from 10.66 to 12.53. Thus, it can be concluded that redness of the colour in turmeric paste increased with increase in storage period which resulted in increase of browning.

Table 4.5: Effect of different packaging materials on the a* value of turmeric paste during storage.

Treatments (T)	Storage period				Mean.
	0 day	60 day	120 day	180 day	
T_1	10.66	11.12	11.59	12.13	11.38
T_2	10.66	11.35	12.39	12.93	11.83
Mean	10.66	11.24	11.99	12.53	
	Treatments (T)		Storage (S)		Interactions (TxS)
S.Em±	0.02		0.03		0.0005
CD at 5 %	0.06		0.08		0.014

T_1: glass bottle T_2: HDPE pouch

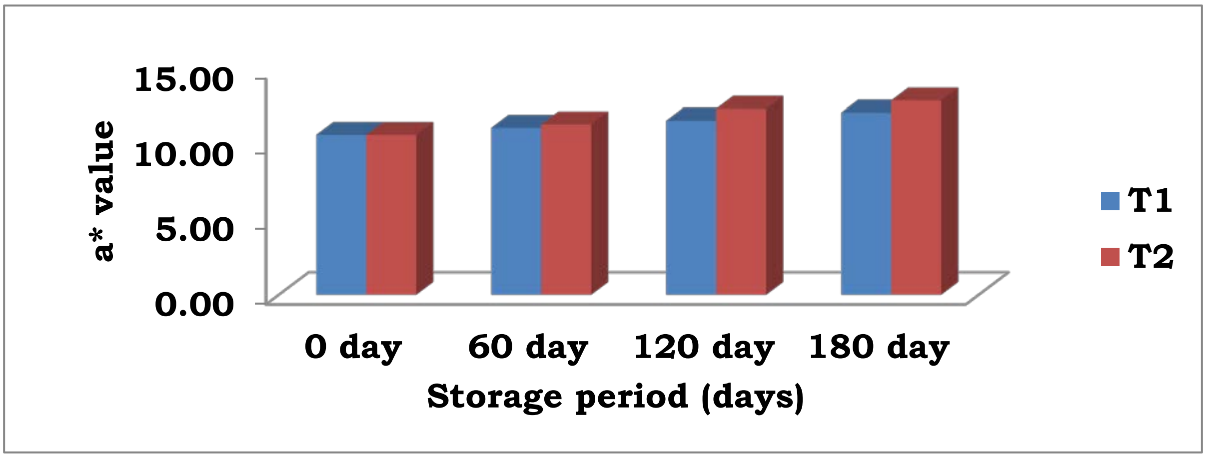


Fig 4.5: Effect of different packaging materials on a* value of turmeric paste during storage.

Interaction effect between storage period and different packaging materials was found to be statistically significant for mean a* value for colour of the turmeric paste at 5 per cent level of significance.

The increase in a* value of colour occurred due to an increase in browning of turmeric paste during storage of 180 days in both the packaging materials. Pradeep *et al.* (2016) reported the decrease in a* value of turmeric rhizome after drying affected by pre-treatment (blanching). Dhanya *et al.* (2009) reported the a* value of turmeric remains unchanged due to irradiation and storage. Ginger paste turns brown to yellow during storage Ahmed, (2004b).

4.3.1.3 b* value

The data for b* value for colour of turmeric paste during blanching period are presented in Table 4.6 and graphically depicted in Fig 4.6. b* value was recorded to determine yellowness of turmeric paste which decreased significantly with corresponding increase in the storage period.

The treatment T_2 (82.27) recorded significantly highest mean b* value for colour which decreased from 91.06 to 71.76 in glass bottle and 91.06 to 75.64 in HDPE pouch up to 180 days of storage. The b* value of colour during storage of 0 to 180 days also decreased significantly from 91.06 to 73.70. Thus, it can be concluded that yellowness of the colour in turmeric paste decreased with increase in storage period which resulted in increase of browning.

Interaction effect between storage period and different packaging materials was found to be statistically significant for mean b* value for colour of the turmeric paste at 5 per cent level of significance.

The decrease in b* value of colour occurred due to an increase in browning of turmeric paste during storage of 180 days in both the packaging materials. Pradeep *et al.* (2016) reported the decrease in b* value of turmeric rhizome after drying was affected by pre-treatment (blanching). Dhanya *et al.* (2009) reported the decrease in b* value of turmeric rhizome during storage. Similar decreasing trend of b* value of colour recorded by Topno *et al.* (2013) in ginger garlic paste.

Table 4.6: Effect of different packaging materials on the b* value of turmeric paste during storage.

Treatments (T)	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	91.06	79.70	76.57	71.76	79.77
T_2	91.06	82.57	79.83	75.64	82.27
Mean	91.06	81.14	78.20	73.70	
	Treatments (T)		Storage (S)		Interactions (TxS)
S.Em±	0.11		0.16		0.02
CD at 5 %	0.33		0.46		0.057

T_1: glass bottle T_2: HDPE pouch

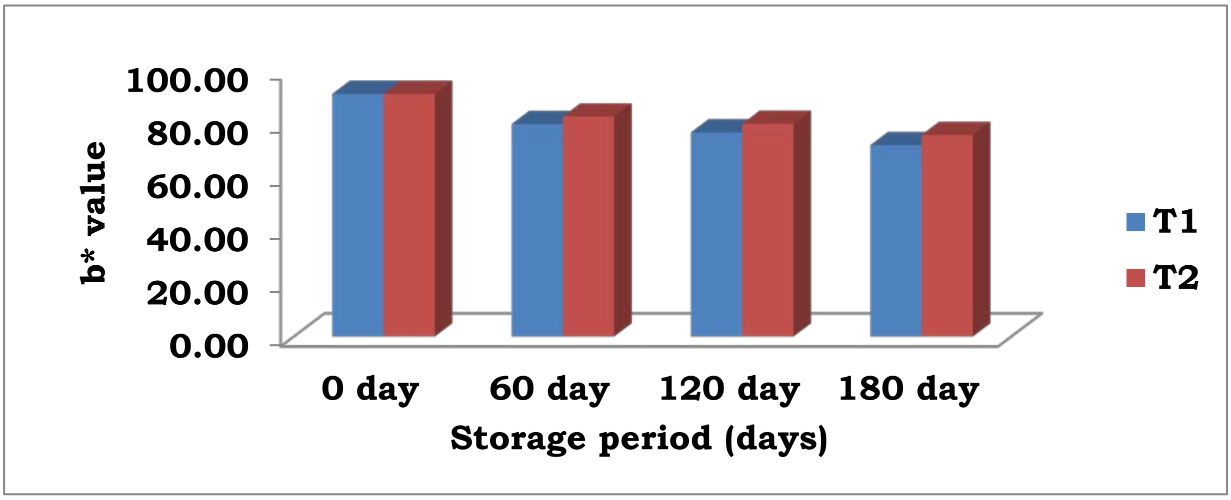


Fig 4.6: Effect of different packaging materials on the b* value of turmeric paste during storage.

4.3.1.4 Yellowing index

Table 4.7 and graphically depicted in Fig 4.7 shows colour value YI content of the turmeric paste during storage period with respect to different packaging materials changes in colour during storage of turmeric paste.

The treatment T_2 (157.09) recorded the highest mean YI. The colour value was decreased from 170.77 to 147.31 in HDPE pouch and from 170.77 to 143.50 in glass bottle up to 180 days of storage period. The YI during storage of 0 to 180 days also decreased significantly from 170.77 to 145.40. YI in storage period decreased. Thus, it can be concluded that yellowness of the YI in turmeric paste decreased with increase in storage period.

Table 4.7: Effect of different packaging materials on the yellowing index of turmeric paste during storage.

Treatments	**Storage period**				**Mean**
	0 day	**60 day**	**120 day**	**180 day**	
T_1	170.77	151.68	148.61	143.50	153.64
T_2	170.77	156.44	153.83	147.31	157.09
Mean	170.77	154.06	151.22	145.40	
	Treatments		**Storage (S)**		**Interactions (TxS)**
S.Em±	0.39		0.55		0.22
CD at 5 %	1.12		1.58		0.63

T_1: glass bottle T_2: HDPE pouch

Interaction effect between storage period and different packaging materials was found to be statistically significant for mean YI of the turmeric paste at 5 per cent level of significance.

The decrease in yellowing index occurred due to increase in browning of turmeric paste during storage of 180 days in both the packaging materials. Similar observations were observed by Baranowski, (1985) in ginger paste samples stored at -10 to 37°C for a period of 24 weeks as colour changed due to browning. The colour value of stored samples decreased with time observed by Ahmed, (2001a) in garlic paste. Similar observations recorded by

Ahmed, (2004b) in ginger paste and Ahmed *et al.* (2004) in coriander leaf paste. Ahmed, (2002b) in garlic paste and also noted that colour change was minimum at 5±1°C temperature storage. Similar observations recorded by Devi *et al.* (2016) in ginger paste. The minimum colour changes in paste observed by Ahmed and Shivhare, (2001c) in onion paste when stored in HDPE pouch. Ibarz and Garza, (2000) observed that the effect of thermal treatments resulting in nonenzymatic browning and discolouration could lead to several reactions inducing destruction of pigment which lowers the colour quality.

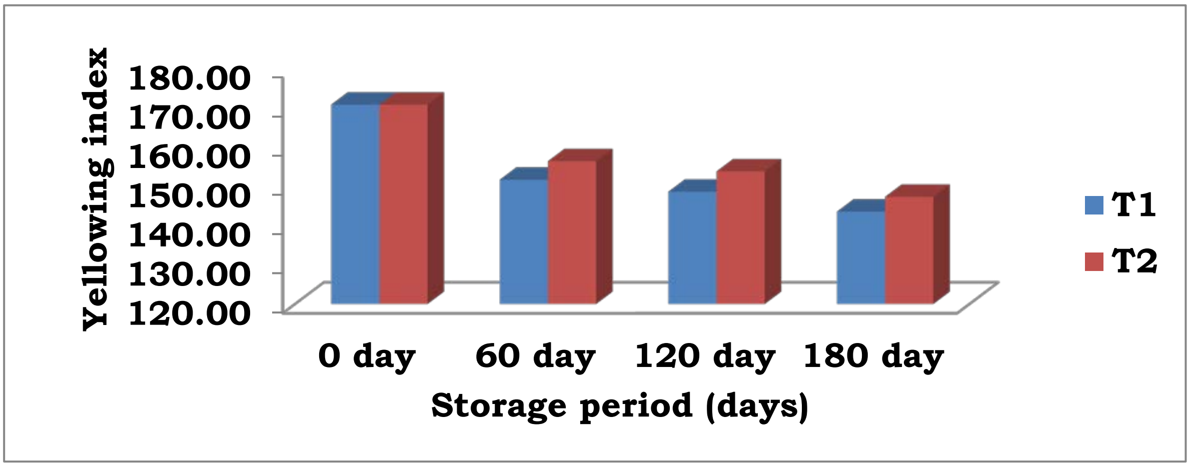


Fig 4.7: Effect of different packaging materials on the yellowing index of turmeric paste during storage.

4.3.2 Viscosity (Pa.sn)

Table 4.8 and graphically depicted in Fig 4.8 shows flowing behaviour index of the turmeric paste during storage period with respect to different packaging materials.

The treatment T_2 (0.1168) recorded significantly highest mean and gradually decrease in flow behaviour index was observed from 0.1333 to 0.0767 with T_1 (glass bottle) and from 0.1333 to 0.0963 with T_2 (HDPE pouch). The flow behaviour index during storage of 0 to 180 days also decreased significantly from 0.1333 to 0.0865. It showed that flow behaviour index decreased more with storage in glass bottle as compared to HDPE pouches.

Table 4.8: Effect of different packaging materials on the flow behaviour of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	0.1333	0.1220	0.0967	0.0767	0.1072
T_2	0.1333	0.1273	0.1100	0.0963	0.1168
Mean	0.1333	0.1247	0.0995	0.0865	
	Treatments		Storage (S)		Interactions (TxS)
S.Em±	0.0006		0.0008		0.0011
CD at 5 %	0.0017		0.0024		0.0033

T_1: glass bottle T_2: HDPE pouch

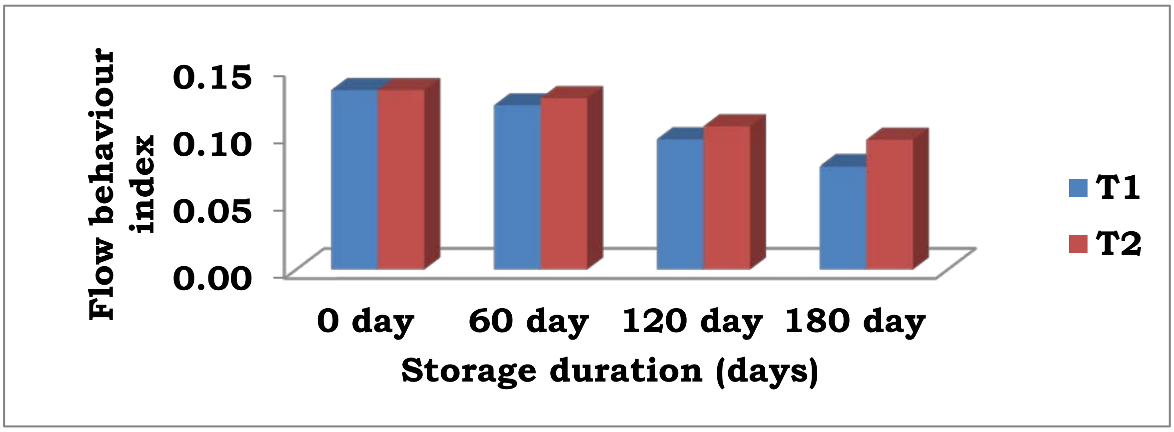
Table 4.9: Effect of different packaging materials on the consistency of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	1.2353	1.5223	1.7563	1.9893	1.6258
T_2	1.2353	1.4313	1.6273	1.6957	1.4974
Mean	1.2353	1.4768	1.6918	1.8425	
	Treatments		Storage (S)		Interactions (TxS)
S.Em±	0.01		0.01		0.015
CD at 5 %	0.02		0.03		0.042

T_1: glass bottle T_2: HDPE pouch

Table 4.9 and graphically depicted in Fig 4.9 shows consistency index of the turmeric paste at storage with respect to different packaging materials.

The treatment T_1 (1.6258 Pa.sn) recorded the highest mean and consistency index significantly increased from 1.2353 Pa.sn to 1.9893 Pa.sn in glass bottle and from 1. 2353 Pa.sn to 1.6957 Pa.sn in HDPE pouch in 180 days of storage period. The flow consistency index during storage of 0 to 180 days also increased significantly from 1.2353 Pa.sn to 1.8425 Pa.sn. It showed that consistency increased with storage period more rapidly in glass bottle as compared to HDPE pouches.



Interaction effect between storage period and different packaging materials was found to be statistically significant for mean flowing behaviour index and consistency index of the turmeric paste at 5 per cent level of significance.

Fig 4.8: Effect of different packaging materials on the flow behaviour of turmeric paste during storage.

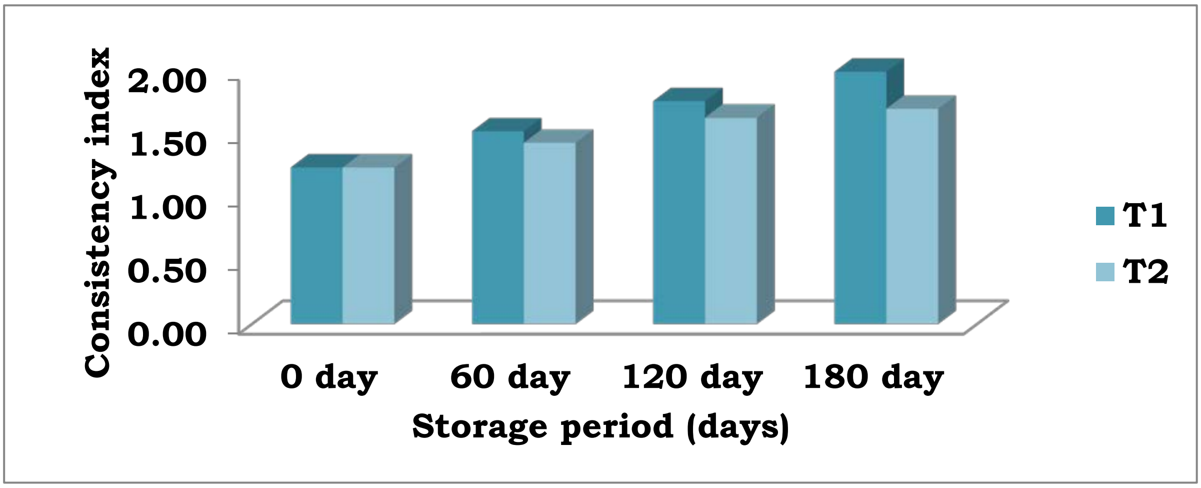


Fig 4.9: Effect of different packaging materials on the consistency of turmeric paste during storage.

This decreased flow behaviour index and increased consistency index occurs due to loss of moisture due to low temperature in 180 days of storage in both packaging materials.

All rheological parameters increased with the addition of hydrocolloid and decreased with increasing storage duration. These results are found in tomato ketchup in agreement with those obtained by El-Desouky, (2016). Gujral *et al.* (2002) reported the tomato ketchup consistency decreased and flow behaviour index increased during 120 days of storage. Aggarwal, (2016) observed the decrease in viscosity with increase in storage time in mint sauce.

4.4 Changes in the chemical quality parameters of the turmeric paste during storage period

4.4.1 Moisture (%)

The data of moisture content was influenced by the different packaging materials and storage period is presented in Table 4.10 and Fig 4.10.

The treatment T_2 (84.40 per cent) recorded the highest mean and gradual decrease in moisture content from 86. 62 per cent to 74.12 per cent in glass bottle, while from 86.62 per cent to 81.14 per cent in HDPE pouch was observed during storage of 180 days. The moisture content during storage of 0 to 180 days also decreased significantly from 86.62 to 77.63. The maximum moisture content was observed in paste packed in HDPE pouch. This loss in moisture content of turmeric paste was primarily due to different packaging materials.

Interaction effect between storage period and different packaging materials was found to be statistically significant for

mean moisture content of the turmeric paste at 5 per cent level of significance.

Table 4.10: Effect of different packaging materials on the moisture (%) of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	86.62	84.46	81.49	74.12	81.67
T_2	86.62	85.49	84.37	81.14	84.40
Mean	86.62	84.98	82.93	77.63	
	Treatments		**Storage (S)**		**Interactions (TxS)**
S.Em±	0.07		0.10		0.01
CD at 5 %	0.20		0.28		0.03

T_1: glass bottle T_2: HDPE pouch

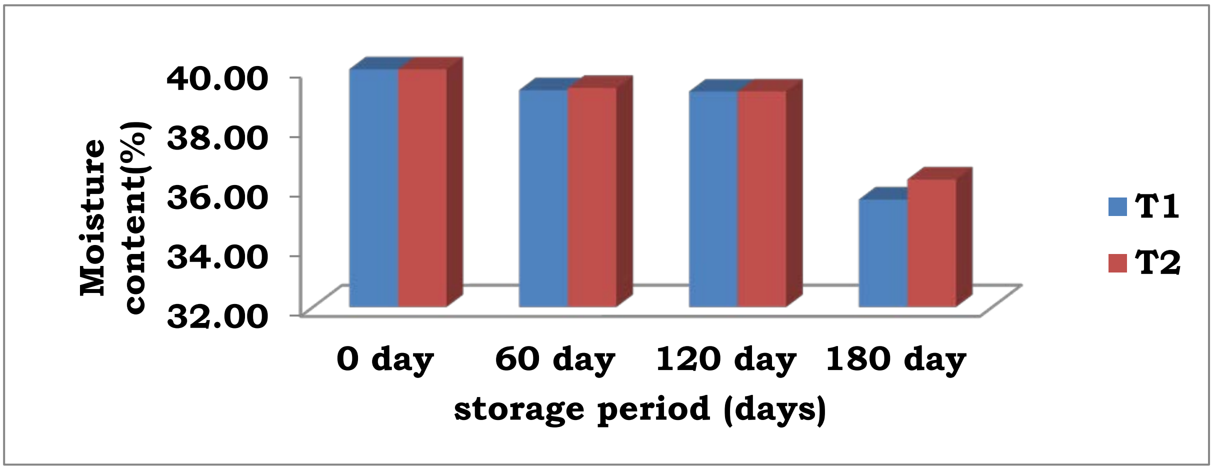


Fig 4.10: Effect of different packaging materials on the moisture (%) of turmeric paste during storage.

This decrease in moisture content of paste was observed primarily due to packaging materials and water condensation in refrigerated condition. Algadi *et al.* (2014), Akhtar *et al.* (2015) and Mane, (2018) reported similar trend of decrease in moisture content in ginger garlic paste during storage period. Ghodke *et al.* (2014) reported that moisture was decreased during storage period in ginger-garlic-chilli paste. Similar observations recorded by Doutaniya, (2018) in ginger-garlic-onion paste.

4.4.2 Curcumin (%)

Table 4.11 and graphically depicted in Fig 4.11 shows curcumin content in turmeric paste during storage period with respect to different packaging materials.

The treatment T_1 (6.98 per cent) recorded significantly highest mean curcumin content which increased from 5.35 per cent to 9.22 per cent in glass bottle and from 5.35 per cent to 6.84 per cent in HDPE pouch. The curcumin content during storage of 0 to 180 days also increased significantly from 5.35 to 8.03.

Table 4.11: Effect of different packaging materials on the curcumin (%) of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	5.35	6.10	7.25	9.22	6.98
T_2	5.35	5.71	6.13	6.84	6.01
Mean	5.35	5.91	6.69	8.03	
	Treatments		Storage (S)		Interactions (TxS)
S.Em±	0.04		0.06		0.002
CD at 5 %	0.12		0.17		0.006

T_1: glass bottle T_2: HDPE pouch

Table 4.12 and graphically depicted in Fig 4.12 shows curcumin content on dry weight basis in turmeric paste at storage period with respect to different packaging materials.

The effect of different packaging materials on dry weight basis curcumin content of turmeric paste during storage found to be non-significant. The treatment T_2 (38.71 per cent) recorded highest mean curcumin content which decreased from 39.99 per cent to 35.60 per cent in glass bottle and from 39.99 per cent to 36.28 per cent in HDPE pouch. The curcumin content on dry weight basis during storage of 0 to 180 days also decreased from 39.99 to 35.94.

Table 4.12: Effect of different packaging materials on the dry weight basis curcumin (%) of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	39.99	39.28	39.23	35.60	38.53
T_2	39.99	39.35	39.24	36.28	38.71
Mean	39.99	39.32	39.23	35.94	
	Treatments		Storage (S)		Interactions (TxS)
S.Em±	0.22		0.31		0.07
CD at 5 %	0.63		0.88		Non Sig

T_1: glass bottle T_2: HDPE pouch

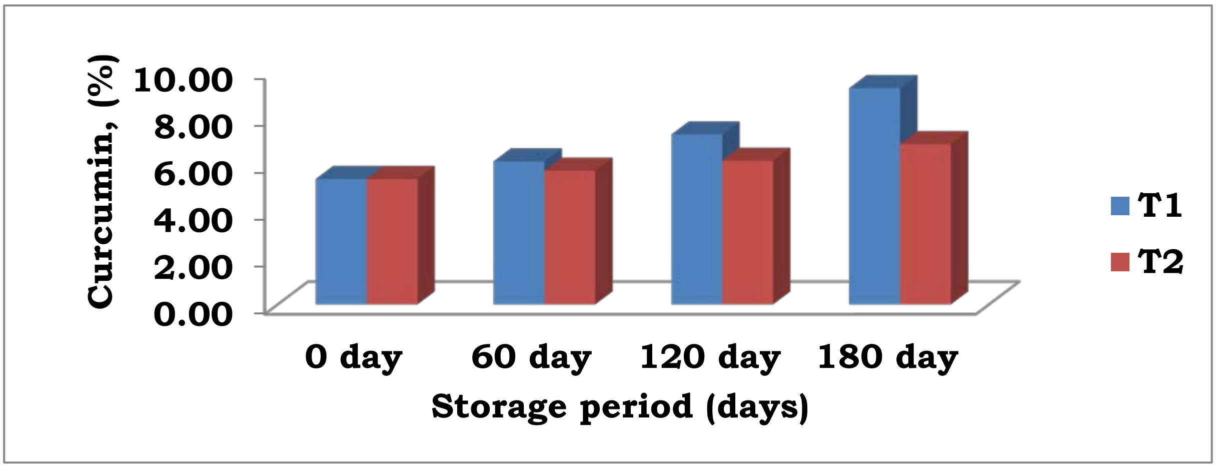


Fig 4.11: Effect of different packaging materials on the curcumin (%) of turmeric paste during storage.

Interaction effect between storage period and different packaging materials was found to be statistically non-significant for mean curcumin content on dry basis of the turmeric paste at 5 per cent level of significance. Curcumin concentration increased during storage period due to reduction in moisture content.

It showed that curcumin content increased with storage period more rapidly in glass bottle. As the moisture content decreased by using different packaging materials curcumin content was increased.

The storage period and different packaging materials have significant influence on curcumin content of turmeric paste on wet weight basis. However on dry weight basis it was found to be non-significant. This might be due to degradation of curcumin in storage.

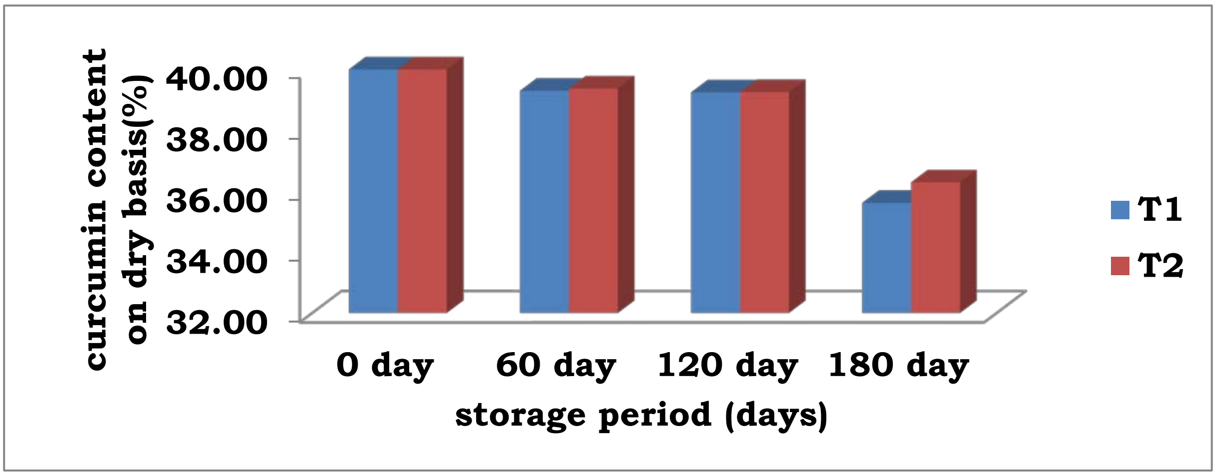


Fig 4.12: Effect of different packaging materials on the dry wt. basis curcumin (%) of turmeric paste during storage.

Bambirra *et al.* (2002) reported that lower the moisture content, higher the levels of curcuminoid pigments. Lahari *et al.* (2020) reported the increase in moisture content from 14.60 per cent (db) to 16.98, curcumin content decreased from 2.816 per cent to 0.526 per cent during storage of 180 days.

4.4.3 Total soluble solids (°B)

The data of TSS content as influenced by the different packaging materials and storage period is presented in Table 4.13 and graphically depicted in Fig 4.13.

The treatment T_1 (7.24 per cent) recorded significantly highest mean; TSS value during storage increased from 6.50 per cent to 7.94 per cent in glass bottle, while it was increased from 6.50 per cent to 7.64 per cent in HDPE pouch was observed during storage of 180 days. The TSS value during storage of 0 to 180 days also increased significantly from 6.50 to 7.79. There was an increase in TSS during storage of paste might be due to decrease in moisture content during storage period in both packaging materials.

Table 4.13: Effect of different packaging materials on the total soluble solids (°B) of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	6.50	6.98	7.54	7.94	7.24
T_2	6.50	6.82	7.20	7.64	7.04
Mean	6.50	6.90	7.37	7.79	
	Treatments		Storage (S)		Interactions (TxS)
S.Em±	0.01		0.02		0.0003
CD at 5 %	0.04		0.06		0.0009

T_1: glass bottle T_2: HDPE pouch

Interaction effect between storage period and different packaging materials was found to be statistically significant for mean TSS of the turmeric paste at 5 per cent level of significance.

There was an increase in TSS during storage of paste might be due to decrease in moisture content in both packaging material during 180 days of storage.

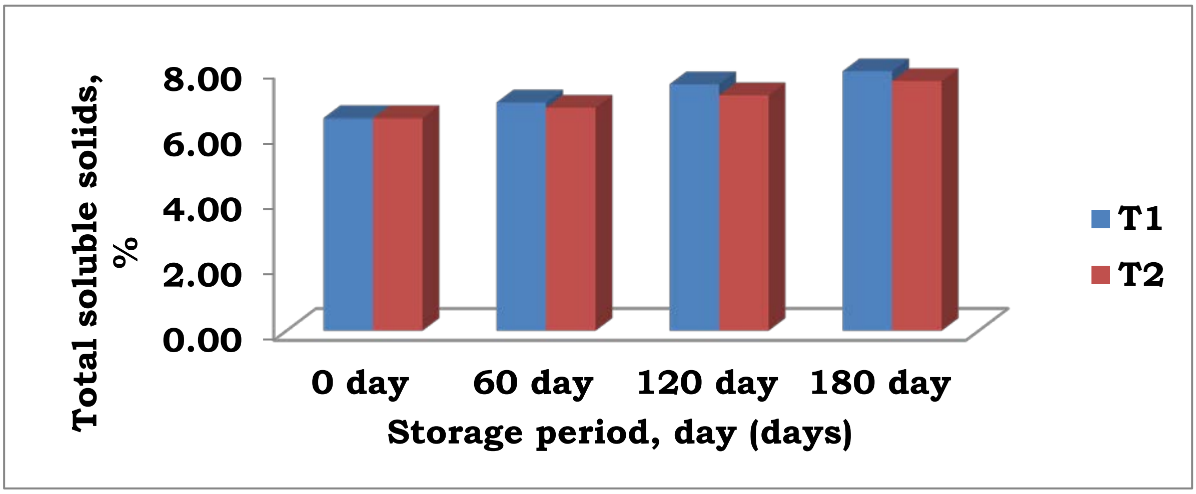


Fig 4.13: Effect of different packaging materials on the total soluble solids (°B) of turmeric paste during storage.

Similar results were recorded for ginger garlic paste by Devi *et al.* (2016). They reported TSS of ginger garlic paste increased in different packaging materials in 120 days of storage due to decrease in moisture content. Topno *et al.* (2013) and Mane, (2018) reported similar results for ginger garlic paste. Akinwande and Olatunde, (2015) observed that TSS of peeled garlic slightly increased with storage duration and Doutaniya, (2018) reported the same results in ginger-garlic-onion paste. Bhagwan and Awadhesh, (2014) reported an increase in TSS in mango ginger juice during storage for 120 days. Policegoudra and Aradhya, (2007) reported first decrease and then increasing trend of TSS in mango ginger during storage. Jayashree *et al.* (2012) reported the increase of TSS during storage period in ginger based spice sauces.

4.4.4 pH

The data of changes in pH as influenced by different packaging materials and storage period is presented in Table 4.14 and graphically depicted in Fig 4.14.

Table 4.14: Effect of different packaging materials on the pH of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	4.27	4.64	5.04	5.64	4.90
T_2	4.27	4.43	4.64	4.74	4.52
Mean	4.27	4.53	4.84	5.19	
	Treatments		Storage (S)		Interactions (TxS)
S.Em±	0.03		0.04		0.01
CD at 5 %	0.09		0.12		0.03

T_1: glass bottle T_2: HDPE pouch

The treatment T_1 (4.90) recorded the highest mean and there was a slight increase in the pH from 4.27 to 5.64 in HDPE pouch and from 4.27 to 4.74 in glass bottle different packaging till 180 days. The pH during storage of 0 to 180 days also increased significantly from 4.27 to 5.19. The storage period and different packaging materials have significant influence on pH of turmeric paste.

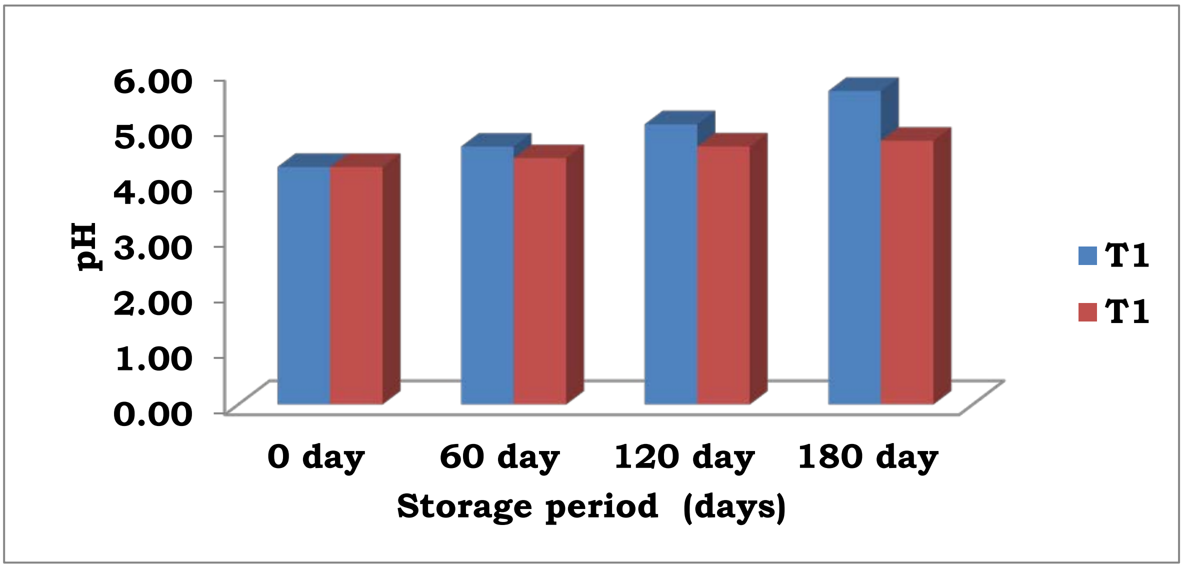


Fig 4.14: Effect of different packaging materials on the pH of turmeric paste during storage.

Interaction effect between storage period and different packaging materials was found to be statistically significant for mean pH of the turmeric paste at 5 per cent level of significance.

Increase in pH was observed due to decreased titratable acidity during 180 days of storage in both packaging materials. Similar increasing trend of pH in garlic paste during storage was reported by Ahmed and Shivhare, (2001a), Sontakke and Roul, (2007), Mane, (2018) and Akhtar *et al.* (2015) and Doutaniya, (2018) in ginger-garlic-onion paste recorded the decreasing trend of pH. Priyadarshi *et al.* (2019) reported the pH of the coriander paste increased significantly during storage. Jayashree *et al.* (2012) reported the increase of pH during storage in ginger based spice sauces.

4.4.5 Titratable acidity (%)

The data in titratable acidity content as influenced by the different packaging materials and storage period is presented in Table 4.15 graphically depicted in Fig 4.15.

The treatment T_2 (0.92 per cent) recorded significant highest mean. The initial value of the acidity was 0.99 per cent which was decreased to 0.68 per cent in glass bottle, while it was decreased from 0.99 per cent to 0.84 per cent in HDPE pouch during storage of 180 days. The acidity during storage of 0 to 180 days also decreased significantly from 0.99 to 0.76. The loss of acidity may be due to browning reaction during storage.

Table 4.15: Effect of different packaging materials on the acidity (%) of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	0.99	0.93	0.88	0.68	0.87
T_2	0.99	0.94	0.91	0.84	0.92
Mean	0.99	0.94	0.90	0.76	
	Treatments		Storage (S)		Interactions (TxS)
S.Em±	0.006		0.008		0.000
CD at 5 %	0.017		0.024		0.0001

T_1: glass bottle T_2: HDPE pouch

Interaction effect between storage period and different packaging materials was found to be statistically significant for mean acidity of the turmeric paste at 5 per cent level of significance.

Similarly observations were recorded by Mane, (2018) during storage of ginger-garlic paste. Dronachari *et al.* (2010) and De Castro *et al.* (1998) reported that in refrigerated storage conditions titratable acidity of peeled garlic was found to be slightly decreased. Famurewa *et al.* (2013) reported the decrease in acidity as storage progressed in tomato sauces.

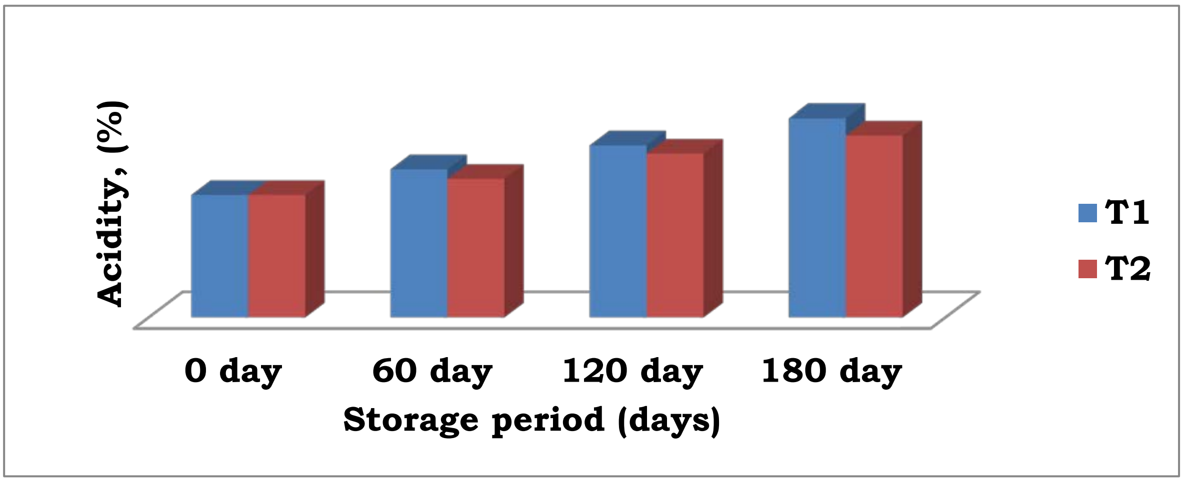


Fig 4.15: Effect of different packaging materials on the acidity (%) of turmeric paste during storage.

4.4.6 Starch (%)

Table 4.16 and graphically depicted in Fig 4.16 shows starch content in turmeric paste during storage period with respect to different packaging materials.

The treatment T_2 (28.82 per cent) recorded significantly highest mean and starch content was decreased from 30.57 per cent to 25.57 per cent in glass bottle and from 30.57 per cent to 27.29 per cent in HDPE pouch. The starch content during storage of 0 to 180 days also decreased significantly from 30.57 to 26.43. It was showed that starch content decreased with increase in storage period more rapidly in glass bottles.

Interaction effect between storage period and different packaging materials was found to be statistically significant for mean starch content of the turmeric paste at 5 per cent level of significance.

Table 4.16: Effect of different packaging materials on the starch (%) of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	30.57	28.39	26.73	25.57	27.82
T_2	30.57	29.08	28.33	27.29	28.82
Mean	30.57	28.74	27.53	26.43	
	Treatments		Storage (S)		Interactions (TxS)
S.Em±	0.09		0.13		0.01
CD at 5 %	0.27		0.39		0.03

T_1: glass bottle T_2: HDPE pouch

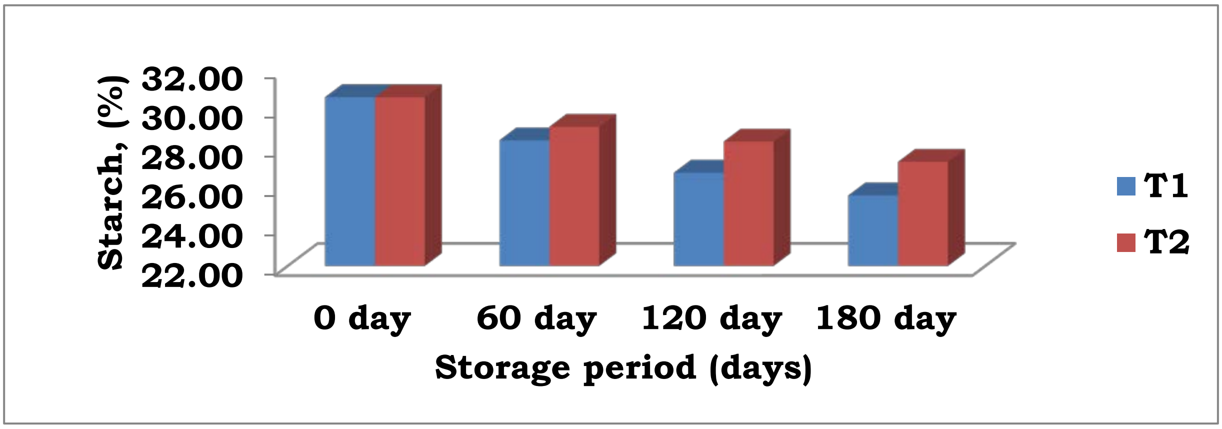


Fig 4.16: Effect of different packaging materials on the starch (%) of turmeric paste during storage.

Starch content decreased due to conversion of starch into sugars at low temperature in 180 days of storage in both packaging materials. Osunsami *et al.* (1989) reported the starch content on a dry weight basis was decreased with storage. This decrease of starch content could be due to conversion of starch to sugars in cassava. Murata *et al.* (2000) observed the greater reduction of starch content at 0°C storage in the potato tuber. Panneerselvam and Abdul, (2008) reported the loss of starch content was found from the time of storage till sprouting of turmeric.

4.4.7 Sugar

4.4.7.1 Reducing sugar (%)

Table 4.17 and graphically depicted in Fig 4.17 shows the data of reducing sugar content in turmeric paste during storage period with respect to different packaging materials.

The treatment T_1 (7.91 per cent) recorded significantly highest mean. Reducing sugar content increased from 7.48 per cent to 8.32 per cent in glass bottle and from 7.48 per cent to 8.11 per cent in HDPE pouch. The reducing sugar content during storage of 0 to 180 days also increased significantly from 7.48 to 8.21. It showed that reducing sugar content increased with storage period more rapidly in glass bottle.

Interaction effect between storage period and different packaging materials was found to be statistically significant for mean reducing sugar content of the turmeric paste at 5 per cent level of significance.

Table 4.17: Effect of different packaging materials on the reducing sugar (%) of turmeric paste during storage.

Treatments	Storage period				Avg.
	0 day	60 day	120 day	180 day	
T_1	7.48	7.71	8.15	8.32	7.91
T_2	7.48	7.65	7.90	8.11	7.78
Mean	7.48	7.68	8.02	8.21	
	Treatments		Storage (S)		Interactions (TxS)
S.Em±	0.02		0.02		0.0004
CD at 5 %	0.05		0.07		0.001

T_1: glass bottle T_2: HDPE pouch

Reducing sugar increased due to break down of non reducing sugars and starch during the storage period of 180 days in both packaging materials. Svanberg *et al.* (1997) reported that increase of glucose and fructose in carrot during storage. Policegoudra and Aradhya, (2007) reported increase of reducing sugar in mango ginger due to conversion of starch into sugar. Jayashree *et al.* (2012) reported an increase of reducing sugar during storage period in ginger-based spice sauces may be due to reduction in sucrose into stable glucose.

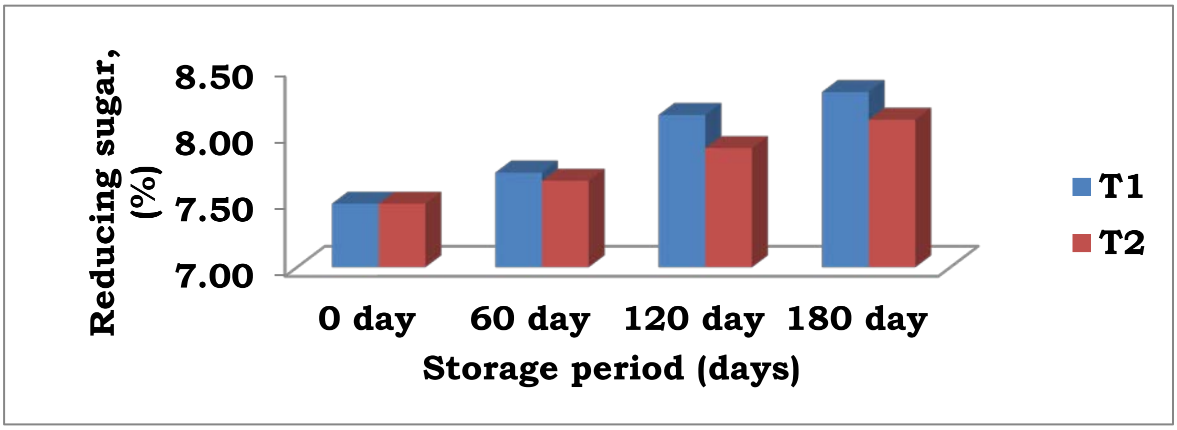


Fig 4.17: Effect of different packaging materials on the reducing sugar (%) of turmeric paste during storage.

4.4.7.2 Total sugar (%)

The data of total sugar content as influenced by the different packaging materials and storage period is presented in Table 4.18 and graphically depicted in Fig 4.18.

The treatment T_1 (29.55 per cent) recorded significantly highest mean. The totals sugar content of the paste increased from 28.23 per cent to 30.79 per cent in glass bottle, while from 28.23 per cent to 29.96 per cent in HDPE pouch on 180 days of storage. The total sugar content during storage of 0 to 180 days also increased significantly from 28.23 to 30.38.

Interaction effect between storage period and different packaging materials was found to be statistically significant for

mean total sugar content of the turmeric paste at 5 per cent level of significance.

Table 4.18: Effect of different packaging materials on the total sugar (%) of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	28.23	29.17	30.00	30.79	29.55
T_2	28.23	28.92	29.48	29.96	29.15
Mean	28.23	29.04	29.74	30.38	
	Treatments		Storage (S)		Interactions (TxS)
S.Em±	0.05		0.07		0.003
CD at 5 %	0.13		0.19		0.009

T_1: glass bottle T_2: HDPE pouch

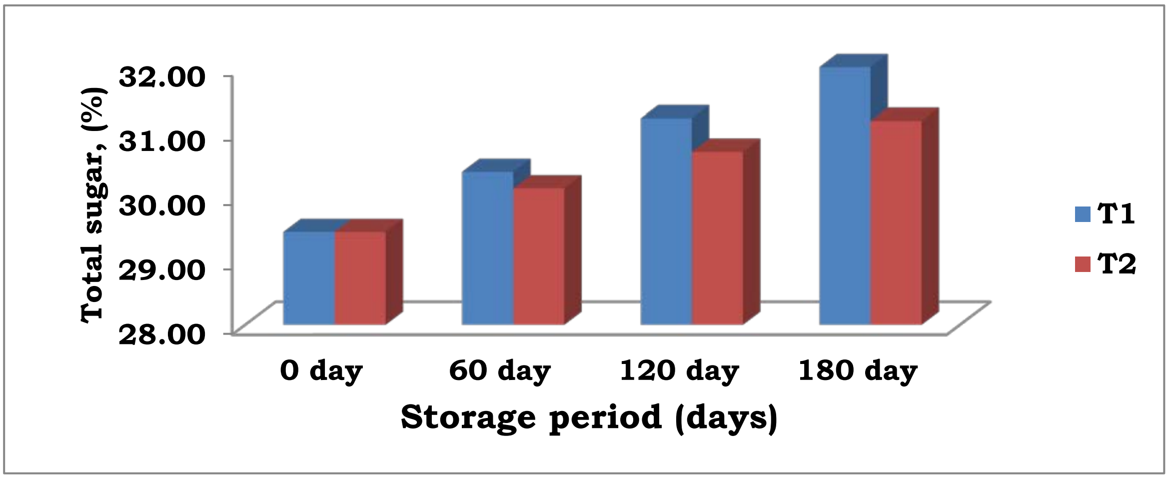


Fig 4.18: Effect of different packaging materials on the total sugar (%) of turmeric paste during storage.

Total sugar increased due to break down of starch during the storage period of 180 days in both packaging materials. Bhagwan and Awadhesh, (2014) reported an increase in total sugars in mango ginger juice during storage for 120 days. Policegoudra and Aradhya, (2007) reported the increasing trend of total sugar in mango ginger. Jayashree *et al.* (2012) reported that effect of storage period on total sugar was found to be non-significant in ginger based spice sauces.

4.4.8 Crude fiber (%)

Table 4.19 and graphically depicted in Fig 4.19 shows the data of crude fiber content in turmeric paste during storage period with respect to different packaging materials.

The treatment T_1 (1.15 per cent) recorded significantly highest mean. Crude fiber content increased from 0.71 per cent to 1.57 per cent in glass bottle and from 0.71 per cent to 1.24 per cent in HDPE pouch. The crude fiber content during storage of 0 to 180 days also increased significantly from 0.71 per cent to 1.41 per cent. It was showed that crude fiber content increased with storage period more rapidly in glass bottles.

Table 4.19: Effect of different packaging materials on the crude fibre (%) of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	0.71	1.05	1.28	1.57	1.15
T_2	0.71	0.99	1.10	1.24	1.01
Mean	0.71	1.02	1.19	1.41	
	Treatments		Storage (S)		Interactions (TxS)
S.Em±	0.01		0.02		0.0003
CD at 5 %	0.04		0.06		0.0009

T_1: glass bottle T_2: HDPE pouch

Interaction effect between storage period and different packaging materials was found to be statistically significant for mean crude fiber content of the turmeric paste at 5 per cent level of significance.

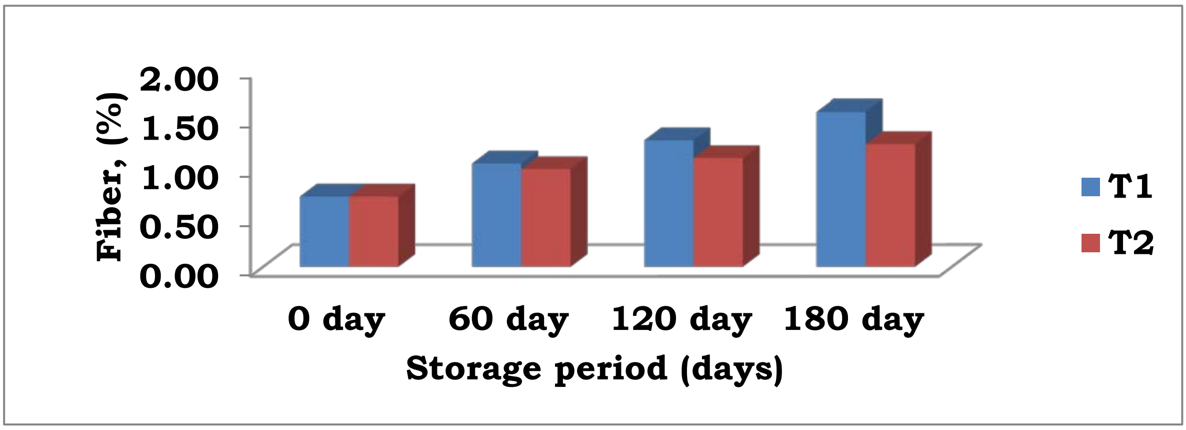


Fig 4.19: Effect of different packaging materials on the crude fibre (%) of turmeric paste during storage.

Crude fiber content increased might be due to loss of moisture content during the storage period of 180 days in both packaging materials. Algadi *et al.* (2014) observed the fiber content of garlic paste increased with the increase of the storage period. Svanberg *et al.* (1997) reported the small influence of storage on total fiber content in carrot. Olaniran *et al.* (2013) reported the increase in fiber content with the storage time in tomato paste.

4.4.9 Crude protein (%)

Table 4.20 and graphically depicted in Fig 4.20 shows crude protein content in turmeric paste during storage period with respect to different packaging materials.

The treatment T_1 (9.09 per cent) recorded significantly highest mean. Crude protein content increased from 8.69 per cent to 9.52 per cent in glass bottle and from 8.69 per cent to 9.35 per cent in HDPE pouch. The protein content during storage of 0 to 180 days also increased significantly from 8.69 to 9.44. It was showed that crude protein content increased with storage period more rapidly in glass bottles.

Interaction effect between storage period and different packaging materials was found to be statistically significant for mean crude protein content of the turmeric paste at 5 per cent level of significance.

Table 4.20: Effect of different packaging materials on the crude protein (%) of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	8.69	8.93	9.22	9.52	9.09
T_2	8.69	8.81	9.05	9.35	8.97
Mean	8.69	8.87	9.13	9.44	
	Treatments		**Storage (S)**		**Interactions (TxS)**
S.Em±	0.02		0.02		0.0004
CD at 5 %	0.05		0.07		0.001

T_1: glass bottle T_2: HDPE pouch

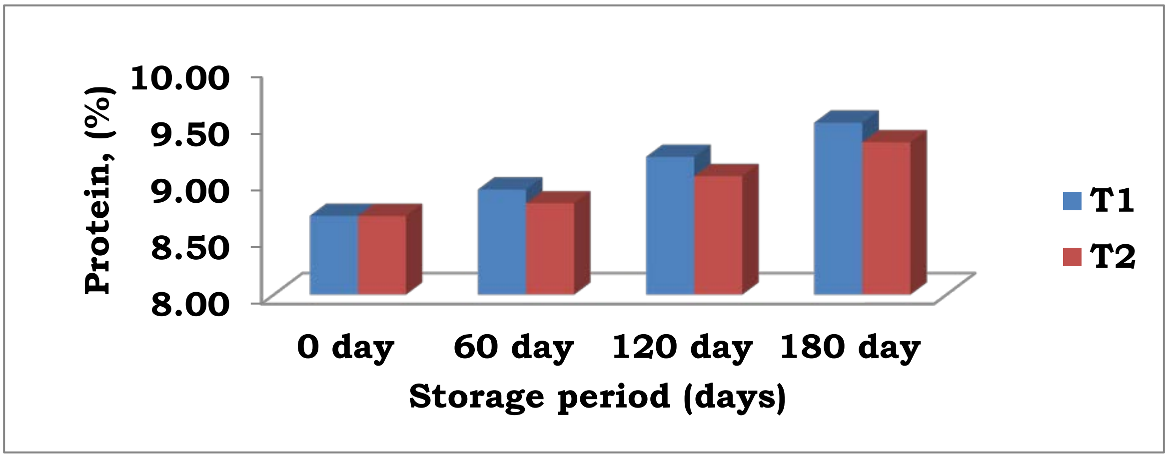


Fig 4.20: Effect of different packaging materials on the crude protein (%) of turmeric paste during storage.

Crude Protein content increased might be due to loss of moisture content during the storage period of 180 days in both packaging materials. Jayashree *et al.* (2012) reported increase in protein content during storage period in ginger based spice sauces. Olaniran *et al.* (2013) reported the increase in crude protein during the storage time in tomato paste due to use of ginger powder as a preservative.

4.4.10 Crude fat (%)

Data presented in Table 4.21 and graphically depicted in Fig 4.21 shows crude fat content in turmeric paste during storage with respect to different packaging materials.

The treatment T_1 (7.71 per cent) recorded significantly highest mean. It increased from 7.33 per cent to 7.93 per cent in glass bottle and from 7.33 per cent to 7.74 per cent with HDPE pouch. The crude fat content during storage of 0 to 180 days also increased significantly from 7.33 to 7.84. It was observed that crude fat content increased in storage more rapidly in glass bottle. The increase in crude fat (%) at all intervals (7.33 to 7.84) was showing significant difference.

Table 4.21: Effect of different packaging materials on the crude fat (%) of turmeric paste during storage.

Treatments	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	7.33	7.77	7.80	7.93	7.71
T_2	7.33	7.62	7.70	7.74	7.60
Mean	7.33	7.69	7.75	7.84	
	Treatments		**Storage (S)**		**Interactions (TxS)**
S.Em±	0.01		0.02		0.0003
CD at 5 %	0.04		0.06		0.0009

T_1: glass bottle T_2: HDPE pouch

Interaction effect between storage period and different packaging materials was found to be statistically significant for mean crude fat content of the turmeric paste at 5 per cent level of significance.

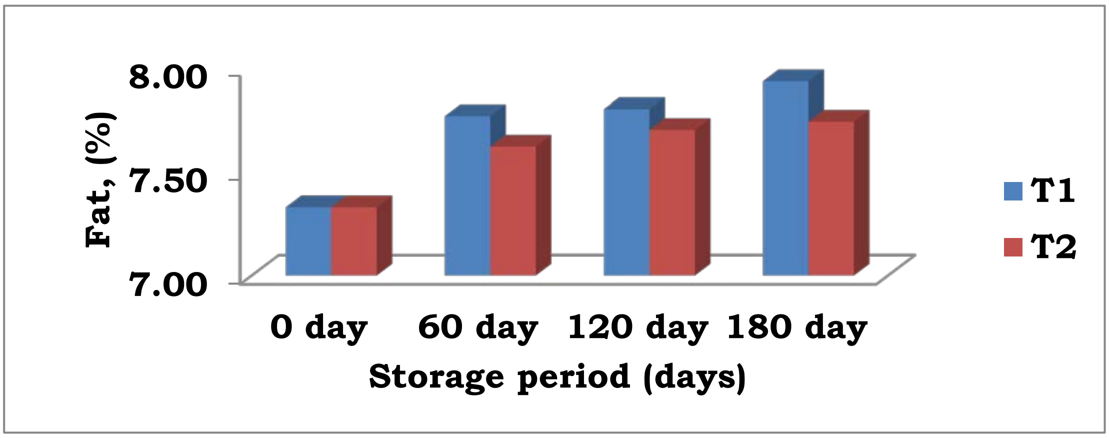


Fig 4.21: Effect of different packaging materials on the crude fat (%) of turmeric paste during storage.

Crude fat content increase might be due to loss of moisture content during the storage period of 180 days in both packaging materials. Algadi *et al.* (2014) observed the fat content of garlic paste increased with the increase of storage period. Olaniran *et al.* (2013) reported the increase in fat content during the storage time in tomato paste due to use of ginger powder as a preservative.

4.4.11 Total ash (%)

The data on changes in ash content as influenced by different packaging materials and storage period is presented in Table 4.22 and graphically depicted in Fig 4.22.

The treatment T_1 (2.21 per cent) recorded significantly highest mean. In general there was increase in the ash content from 1.87 per cent to 2.72 per cent in glass bottle and from 1.87 per cent to 2.29 per cent in HDPE pouch during storage of 180 days. The ash content during storage of 0 to 180 days also increased significantly from 1.87 to 2.51. At every interval of observation significant difference in ash content was observed.

Interaction effect between storage period and different packaging materials was found to be statistically significant for

mean ash content of the turmeric paste at 5 per cent level of significance.

Table 4.22: Effect of different packaging materials on the ash (%) of turmeric paste during storage.

Treatments.	Storage period				Mean
	0 day	60 day	120 day	180 day	
T_1	1.87	2.03	2.20	2.72	2.21
T_2	1.87	1.98	2.14	2.29	2.07
Mean	1.87	2.01	2.17	2.51	
	Treatments.		Storage (S)		Interactions (TxS)
S.Em±	0.03		0.05		0.001
CD at 5 %	0.09		0.14		0.003

T_1: glass bottle T_2: HDPE pouch

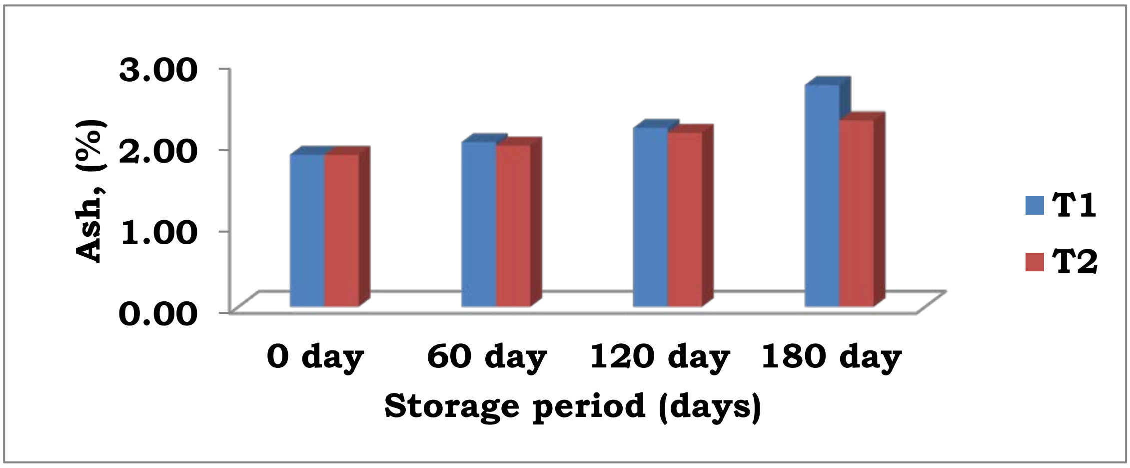


Fig 4.22: Effect of different packaging materials on the ash (%) of turmeric paste during storage.

Crude ash content increase might be due to loss of moisture content during the storage period of 180 days in both packaging materials. Similar results were observed for ginger-garlic paste by Akhtar *et. at.* (2015) and Mane, (2018). They reported that the ash per cent of ginger-garlic paste increased over storage time of 90 days due to heating. Algadi *et al.* (2014) reported the ash content of garlic paste increased with the increase of the storage period similar results were reported by Doutaniya, (2018) in ginger garlic onion paste. Ehsanullah *et al.* (2013) reported the increase in ash content during storage period because of less moisture content and high total solids in ginger garlic paste.

4.4.12 Microbial Count (CFU)

The recorded data of total plate count are presented in Table 4.23 and yeast mould count in Table 4.24 which was influenced by the different packaging materials and storage period.

Yeast and mould count in T_1 (glass bottle) increased from nil to 1.300×10^5 CFU/g and nil to 1.200×10^5 CFU/g in T_2 (HDPE pouches) whereas TPC count increased from nil to 4.600×10^5 CFU/g in T_1 (glass bottle) and nil to 4.000×10^5 CFU/g in T_2 (HDPE pouches). In general it was observed that both total plate count and yeast mould count increased with the storage period. All the samples stored at 5°C temperature for 180 days of storage period with different packaging materials were found within the acceptable microbial limit. Microbial load increased during storage period might be due to change in acidity during the storage period of 180 days in both packaging materials.

Devi *et al.* (2016) reported that the low temperature was unfavourable for growth of bacteria and samples of ginger garlic paste stored at refrigerated condition were found only in acceptable limits for mould and bacteria. However microbial activities increased with storage period. Topno *et al.* (2013) reported that the spices and herbs used in food need further cooking before consumption as the acceptable limit of the total plate count was 5×10^5 cfu/g. Ahmed *et al.* (2004) reported that the coriander leaf paste stored for 6 months was microbiologically safe. Ahmed, (2002b) concluded that prepared red chilli paste was stored up to 6 months and it was microbiologically safe for human consumption for TPC and yeast and mould count. Ahmed and Shivhare, (2001c) reported that onion paste was microbiologically stable at low temperature (5± 3°C) Ahmed, (2002b) reported the red chilli puree was microbiologically stable up to 6 months of storage.

Table 4.23: Effect of different packaging materials on the total plate count of turmeric paste during storage.

Storage period	Treatments	
	T_1	T_2
0 day	Not detected	Not detected
60 day	Not detected	Not detected
120 day	Not detected	Not detected
180 day	4.600×10^5 CFU/g	4.000×10^5 CFU/g

T_1: glass bottle T_2: HDPE pouch

Table 4.24: Effect of different packaging materials on the yeast mould count of turmeric paste during storage.

Storage period	Treatments.	
	T_1	T_2
0 day	Not detected	Not detected
60 day	Not detected	Not detected
120 day	Not detected	Not detected
180 day	1.300×10^5 CFU/g	1.200×10^5 CFU/g

T_1: glass bottle T_2: HDPE pouch

4.5 Economics of turmeric paste

The economics for the production of turmeric paste is shown in Table 4.25. From the table, it was clear that the total expenditures for 100 kg of turmeric paste was highest for treatment T_1 i.e. Rs. 12,581 and least in the treatment T_2 i.e. Rs. 8,181.

Highest gross return of was found in the treatment T_1 of Rs. 24,000 and the least in treatment T_2 of Rs. 20,000. However the highest net profit Rs.11,818 was recorded in treatment T_2 and lowest in treatment T_1Rs. 11,418. Benefit to cost ratio was found in T_1 (1.51) and T_2 (2.44) as the sales price was decided by considering the market value of various pastes available in market. The sale price Rs. 50/250 g of T_2 (HDPE pouch) was lowest and in treatment T_1 (glass bottle) Rs. 60/250 g was the highest as cost of glass bottle was more as compared to HDPE pouches.

As far as physico-chemical quality of turmeric paste was significantly superior in T_2 i.e. storage of turmeric paste in HDPE pouch. Sale price for the treatment T_2 for 250 g. HDPE pouch was Rs. 50 which was comparatively lower than the treatment T_1 i.e. Rs. 60.

Table 4.25: Economics of turmeric paste (100 Kg)

Sr. No.	Particulars	T_1	T_2
1	Turmeric rhizome @ Rs.15/kg	1080	1080
2	Labour charge @ Rs 300/labour	600	600
3	Vinegar @Rs.39/lit	923	923
4	Starch @ Rs. 25/100gm	125	125
5	Sodium benzoate @ Rs.4/2.50 gm	4	4
6	Glass bottle @ Rs.15/bottle or HDPE pouch @ Rs. 5/ pouch	6000	2000
7	Fuel charges @ Rs.3/kg	300	300
8	Total	9032	5032
Cost of production			
1	Working capital (1-7)	9032	5032
2	Supervision charges @10 % of working capital	903.2	503.2
3	Depreciation charges of the fixed capital @ 2 % on Rs. 17400	384	384
4	Interest on the fixed capital @ 13 % on Rs. 17,400	2,262	2,262
5	Total cost of production (A)	12,581.2	8,181.2

6	Gross production (no. of pouches and glass bottle)	400	400
7	Gross returns (B)	24,000	20,000
8	Net profit (B-A)	11,418	11,818.80
9	Sale price of pouch and glass bottle	60	50

T_1: glass bottle T_2: HDPE pouch

Note-

To prepare 100 kg paste rhizome quantity required 72 kg

72 kg turmeric rhizomes recovery after peeling 50.5 kg

For reference: Cost of ginger garlic paste Rs 30 / 100 gm

SUMMARY AND CONCLUSION

CHAPTER V

Summary and conclusion

The present study "**Development of process for preparation of turmeric paste**" was carried out at Dr. B.S.K.K.V., Dapoli Uniersity, Post Graduate Institute of Post Harvest Management, Department of Post Harvest Management of Medicinal, Aromatic, Plantation, Spices and Forest Crops. During the year 2019-2020.

5.1 The study is summarized as under:

The main objectives of the study were to optimize the blanching period for production of turmeric paste with evaluates physico-chemical and characters of turmeric paste and to evaluate storage stability of turmeric paste. In the process of standardization of blanching period, it was observed that turmeric paste had moisture 86.34 per cent, TSS 6.73°B, titratable acidity 0.99 per cent, pH 4.30, total sugars 28.22 per cent, reducing sugar 7.55 per cent, starch 30.42 per cent, total ash 1.91 per cent, curcumin 5.16 per cent, fiber 0.70 per cent, flow behaviour index 0.1369, consistency index 1.2365 Pa.sn, colour value for L*, a* and b* was 77.13, 10.63 and 92.06 respectively, yellowing index 170.51 and fat 7.36 per cent.

Standardized paste was packed in HDPE pouches and glass bottles. Product was kept at refrigerated temperature (5±2°C) for further storage studies after packaging and pasteurization. Analysis of paste for different quality parameters during blanching period and storage studies were conducted at 0, 60, 120 and 180 days. During the storage period moisture content decreased which resulted in increase of wet basis curcumin content however on dry weight basis curcumin content was found to be non-significant. The pH, total soluble solids, reducing sugar, total sugar, protein, fiber, fat, total ash and flow behaviour index increased with storage period. Although some parameters like starch content, titratable acidity, consistency index and colour decreased with increase in storage period. All the parameters were significantly influence.

Thus the scientific data of the present investigation, it may be concluded that the 50.5 per cent raw turmeric, 25 per cent water, 24 per cent vinegar, 0.5 per cent starch and 250 ppm sodium benzoate can be used successfully in preparation of paste without any undesirable changes in chemical attributes of paste. The prepared paste can be stored for 6 months in a refrigerated condition at (5±2°C) in a HDPE pouch for storage stability.

5.2 Conclusion

1. Blanching period affect the curcumin content as well as other parameters, hence 5 min blanching treatment was found to be best.
2. The good quality turmeric paste can be prepared by using 50.5 per cent raw turmeric, 25 per cent water, 24 per cent vinegar, 0.5 per cent starch and 250 ppm sodium benzoate that were blanched for 5 min without affecting their overall quality.
3. Packaging material and storage temperature showed significant overall changes in quality of turmeric paste but the quality retention was more in HDPE pouches.
4. The turmeric paste was stored for 180 days at refrigerated conditions (5±2°C) without affecting its quality and also found acceptable for microbiologically safe for human consumption.

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CHAPTER VI

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APPENDIX

APPENDIX – I

Meteorological information (Standard Meteorological Week) during the course of investigation (Sep. 2019- Feb 2020) at Roha, Raigad (MH.)

Sr. No.	SMW	Ambient temperature conditions			
		Temperature (˚C)		Humidity (%)	
		Max	Min	Max	Min
1.	36	29.14	24.85	99.14	79.85
2.	37	29.57	24.14	99.14	80.43
3.	38	30.57	24.71	96.71	72.43
4.	39	31.85	24.85	94.29	69.00
5.	40	32.28	24.42	89.57	65.00
6.	41	34.28	24.42	89.00	54.43
7.	42	34.14	24.28	76.86	47.57
8.	43	30.28	23.85	94.28	63.28
9.	44	34.43	24.43	83.57	49.00
10.	45	32.57	24.14	91.29	59.86
11.	46	34.00	23.14	84.00	41.14
12.	47	34.57	22.71	73.43	38.00
13.	48	34.28	22.00	75.71	36.00
14.	49	33.71	23.43	76.00	39.43
15.	50	33.14	21.00	75.14	47.29
16.	51	32.86	20.43	74.43	40.43
17.	52	32.57	21.57	74.43	40.43
18.	1	29.14	17.57	74.43	43.71
19.	2	32.28	19.43	68.14	41.29
20.	3	28.86	16.86	75.00	40.57
21.	4	33.57	18.57	71.71	35.86
22.	5	29.57	17.43	73.71	36.71
23.	6	29.85	17.14	76.86	36.43
24.	7	34.57	21.28	57.86	31.86
25.	8	35.00	20.28	67.71	27.29
26.	9	35.28	19.57	51.71	18.14

SMW- Standard Meteorological Week

VITAE

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A candidate for the degree of

M.Sc. (Post Harvest Management)

Title of thesis	Development of process for preparation of turmeric paste
Major Field	Post Harvest Management of medicinal, aromatic, plantation, spices and forest crops.

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