STUDIES ON PREPARATION OF POMEGRANATE (*Punica granatum* L.) : SAPOTA (*Manilkara achras* (MILL.) Fosberg) BLENDED JELLY

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JULY-2015

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A thesis submitted to the

DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH, DAPOLI

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

(POST HARVEST MANAGEMENT)

In

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CERTIFICATE

This is to certify that the thesis entitled **"Studies on preparation of pomegranate** (*Punica granatum* L.) **: sapota** (*Manilkara achras* (Mill.) Fosberg) **blended jelly"** *submitted to the Department of Post Harvest Management of Fruits,Vegetable and Flower Crops, Post Graduate Institute Of Post Harvest Management, Faculty of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, (Maharashtra State), in the partial fulfilment of the requirements for the degree of* **MASTER OF SCIENCE (POST HARVEST MANAGEMENT)** *in* **FRUIT, VEGETABLE AND FLOWER CROPS**, *embodies the results of a piece of bona-fide research carried out by* **MISS. RAUT PRIYANKA SHASHIKANT** *under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma. All the assistance and help received during the course of investigation and the sources of literature have been duly acknowledged by her.*

Place: Killa-Roha
Date: July, 2015

(P. P. RELEKAR)
Chairman,
Advisory Committee
and
Research Guide

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It is difficult to shape up emotions into words. My acknowledgements are many times higher than that which I am expressing in this note.

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There are no words to express my feelings of adoration, love, respect and obligation to my beloved parents, who moulded me to what I am. My dearest mother ***Ratna Raut*** *and my beloved father,* ***Shashikant Raut*** *taught me to lead an obedient, trustworthy and simple life, which constantly guided as a lighted lamp and their ambitious encouragement, continued calm endurance, constant support and affection showered on me throughout my educational endeavor.*

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

Place: Killa- Roha

Date: *(Priyanka S. Raut.)*

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DEDICATED TO
MY BELOVED
PARENTS
AAI & PAPPA

CANDIDATE'S DECLARATION

I hereby declare that the thesis or any part there of
has not been previously submitted by me or
other person to any other University or
Institute for a degree

Place: Killa-Roha **(P. S. Raut)**
Date: / / 2015

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DEPARTMENT OF POST HARVEST MANAGEMENT OF FRUIT, VEGETABLE AND FLOWER CROPS
POST GRADUATE INSTITUTE OF POST HARVEST MANAGEMENT, KILLA-ROHA
DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH, DAPOLI.

Title of Thesis	**:**	Studies on preparation of pomegranate (*Punica granatum* L.) : sapota (*Manilkara achras* (Mill.) Fosberg) blended jelly
Name of student	**:**	Miss Raut Priyanka Shashikant.
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Year of submission	**:**	2015

ABSTRACT

An experiment entitled, "Studies on preparation of pomegranate (*Punica granatum* L.) : sapota (*Manilkara achras* (Mill.) Fosberg) blended jelly" was conducted in the Department of Post Harvest Management of fruit, vegetable and flower crops, P.G. Institute of P.H.M., Killa- Roha during the year 2014-2015. It was aimed to develop the blended jelly by using various proportions of pomegranate and sapota fruit juices viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100. The pomegranate : sapota blended jelly was evaluated for physical, chemical and sensory quality parameters during 90 days of storage period.

Colour of the blended jelly was determined by recording L*, a* and b* value. L* value was decreased from 26.92 to 26.73 during storage indicating the increase in darkness of colour. However, an increase in a* (20.04 to 20.19) and b* (22.11 to 22.40) was observed in the blended jelly during storage.

An increase in moisture, T.S.S., reducing and total sugars and microbial count was observed during 90 days of storage period, whereas the titratable acidity in the blended jelly was decreased during 90 days of storage at ambient temperature.

Sensory evaluation of the pomegranate : sapota blended jelly showed that the sensory score for colour, flavour and texture decreased during storage. Based on the organoleptic evaluation and economics of the jelly the pomegranate : sapota blended jelly could be prepared by blending pomegranate and sapota in the ratio of 60:40 with optimum consumer acceptability of 90 days.

फळे,भाजीपाला आणि फुल पिके काढणी पश्चात व्यवस्थापन विभाग,
काढणी पश्चात व्यवस्थापन पदव्युत्तर संस्था,
डॉ. बाळासाहेब सावंत कोकण कृषी विद्यापीठ, दापोली-४१५ ७१२,
जि. रत्नागिरी, (महाराष्ट्र), भारत

प्रबंध शिर्षक	:	"डाळिंब (पुनिका ग्रानटम एल.) : चिकू (मॅनिलकारा अचरस (मिल.) फोसबेर्ग) मिश्रित जेली तयार करण्याचा अभ्यास करणे"
विद्यार्थीचे नाव	:	कु. प्रियांका शशिकांत राऊत.
नोंदणी क्रमांक	:	पी एच एम आर एम-१३७६
शैक्षणिक वर्ष	:	२०१४- २०१५
अभ्यासक्रम	:	एम् एस् सी (पी.एच.एम)
संशोधन मार्गदर्शकाचे नाव आणि हुद्दा	:	डॉ. पी. पी. रेळेकर. सहयोगी प्राध्यापक काढणी पश्च्यात व्यवस्थापन, पदयुत्तर संस्था, किल्ला रोहा , जि. रायगड

सारांश

"डाळिंब (पुनिका ग्रानटम एल.) : चिकू (मॅनिलकारा अचरस (मिल.) फोसबेर्ग) मिश्रित जेली तयार करण्याचा अभ्यास " या शिर्षकाखालील प्रयोग फळे, भाजीपाला आणि फुल पिके काढणी पश्च्यात व्यवस्थापन, पदयुत्तर संस्था, किल्ला रोहा येथे सन २०१४-२०१५ या कालावधीत घेण्यात आला. या प्रबंधाचा मुख्य उद्देश डाळिंब आणि चिकू रस वेगवेगळ्या प्रमाणात घेऊन मिश्रित जेली बनविणे हा होता. जसे की, १००:०, ८०:२०, ६०:४०,४०:६०, २०:८० आणि ०:१००. तयार डाळिंब : चिक्कू मिश्रित जेलीचे नव्वद दिवसाच्या साठवणूक काळामध्ये भौतिक , रसायनिक आणि इंद्रियग्राहय निर्देशांकासाठी मुल्यमापन करण्यात आले.

एल*, ए* आणि बी* या रंगनिर्देशांकाच्या नोंदी घेऊन डाळिंब : चिकू मिश्रित जेलीचा रंग ठरविण्यात आला. त्यापैकी एल* या रंगनिर्देशांक २६.९२ पासून २६.७३ पर्यंत कमी झाली.

यावरून जेलीच्या गडदपणात वाढ झालेली आढळली. तथापि , नव्वद दिवसांच्या साठवणूकीच्या काळात ए* (२०.०४ ते २०.१९) आणि बी* (२२.११ ते २२.४०) या रंगनिर्देशांकामध्ये वाढ झाली.

नव्वद दिवसांच्या साठवणूकीनंतर असे निदर्शनास आले की, मिश्र जेलीमध्ये एकुण विद्राव्य घटक, सापेक्ष शर्करा, असापेक्ष शर्करा व सूक्ष्मजंतूंची वाढ झाली तर आम्लता कमी झाल्याचे आढळून आले.

जेलीच्या इंद्रियग्राहय मुल्यमापनावरून असे दिसते की, रंग, स्वाद आणि पोत यासाठीचे गुण ९० दिवसांच्या साठवणूक काळात कमी झाले . डाळिंब व चिकू मिश्रित जेलीच्या स्विकार्हतेनुसार जेली तयार करताना डाळिंब व चिकू रस यांचे ६०: ४० असे प्रमाण वापरून तयार केलेली जेलीची स्विकार्हता जास्त आहे.

फल, सब्जी और फुल फसल कटाई पश्चात व्यवस्थापन विभाग,

कटाई पश्चात व्यवस्थापन पद्व्युत्तर संस्था,

डॉबाळासाहेब सावंत कोकण कृषी विद्यापीठ ., दापोली-४१५ ७१२, जि. रत्नागिरी,

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प्रबंध का नाम	:	"अनार (पुनिका ग्रानटम एल.) : चिकू (मॅनिलकारा अचरस (मिल.) फोसबेर्ग) मिश्रित जेली तैयार करने का अध्ययन"
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प्रबंध सार

"अनार (पुनिका ग्रानटम एल.) : चिकु (मॅनिलकारा अचरस (मिल.) फोसेबेर्ग) मिश्रित जेली तैयार करने का अध्ययन " फल सब्जी और फुल फसल कटाई ,पश्चात व्यवस्थापन विभागपश्चात पदव्युत्तर संस्था कटाई ,, किला रोहा, में सन २०१४-२०१५ में किया गया। इस अध्ययन का हेतु अनार और चिकू रस विविध मात्रा में लेकर मिश्रित जेली बनाने का था। जैसे की, १००:०, ८०:२०, ६०:४०,४०:६०, २०:८० आणि ०:१००। अनार : चिकू मिश्रित जेली का नब्बे दिनो के संचयन

कालावधी में भौतिक , रसायनिक और इंद्रियग्राहय निर्देशांको के लिए मुल्यांकन किया गया।

एल*, ए* और बी* या रंगनिर्देशांको के अनुसार जेली का रंग निर्धारित किया गया। एल* रंगनिर्देशांक में २६.९२ से २६.७३ तक कमी हुई इससे यह निर्देशित होता है कि जेली की रंगछटा नब्बे दिनो के संचयन कालावधी में बढ गई थी, किंतु , ए* (२०.०४ से २०.१९) और बी* (२२.११ से २२.४०) रंगनिर्देशांको में वृद्धी पायी गई।

अनार और चिकु मिश्रित जेली की एकुण विद्राव्य घन पदार्थ , सापेक्ष शर्करा, असापेक्ष शर्करा व सूक्ष्मजंतुका प्रमाण इस निर्देशांको में नब्बे दिनो के संचयन कालावधी में वृद्धी हो पाई गयी। बल्की आम्लता कम हो गई।

जेली के इंद्रियग्राहय मुल्यांकन से यह पता चलता है की, रंग, स्वाद और पोत के लिए मिले गुण ९० दिनों के संचयन में कम हो गये थे। अनार व चिकू मिश्रित जेली के स्विकार्हता के अनुसार अनार और चिकू रस का ६०: ४० यह प्रमाण इस्तमाल करके बनाई गयी जेली की स्विकार्हता उत्कृष्ट पायी गई।

CHAPTER I

INTRODUCTION

Pomegranate (*Punica granatum* L.) belongs to the family punicaceae and is one of the favourite table fruits of many tropical and sub-tropical regions of the world having great processing potential, grown especially in the moderate climates of Mediterranean countries.

Pomegranate is originated from Iran. It is cultivated in Spain, Egypt, Afghanistan, Pakistan, China, Japan, Russia, America and India. The area under this crop is 1,13,000 hectares with the production of 7,45,000 MT in year 2012-13 in India. (Anon., 2014). Maharashtra state is the leading producer of pomegranate. The area under this crop is 82,000 ha with the production of 492 MT in year 2010-11 in Maharashtra. (Anon., 2011). In Maharashtra, the pomegranate is cultivated in the districts of Solapur, Nasik, Ahmednagar, Pune, Sangli, Dhule, Latur, Usmanabad, Jalna, Parbhani, Aurangabad, Beed and Satara.

The pomegranate enjoys reputation for its healthy, dietetic and medicinal properties. It has better keeping quality, good market price and a high export potential. In recent years, the area under pomegranate in India has increased substantially, mainly because of its versatile adaptability, drought tolerance and high yields. Maximum yield is obtained when pomegranate is supplemeted with irrigation. The area under pomegranate in Maharashtra has been increasing year after year.

In India, the commercially grown pomegranate varieties are Ganesh, Bhagwa, Phule Arakta and Mridula. The varieties such as Bhagwa and Arakta have been recommended/released resepectively for cultivation in Maharashtra state by Mahatma Phule Krishi Vidyapith, Rahuri. Among these varieties, Bhagwa variety produces a glossy red coloured fruit with soft seeds and high

total soluble solids. The fruit are generally harvested fully ripe with a waxy skin surface of reddish yellow or greenish red colour, depending on the cultivar.

Pomegranate is not only used for consumption but also used as medicines. According to EL-Nemer *et al*,.(1990), the edible portion of pomegranate fruit was 52 per cent of total fruit weight which contained 78 per cent juice and 22 per cent seeds. The fresh juice contained 85.4 per cent moisture,10.6 per cent total sugars,1.4 per cent pectin 0.19 per cent total acidity and 19.6 mg free amino nitrogen per 100 ml juice.

Pomegranate is commercially grown for its sweet acidic taste. Fruits are mainly used for dessert purposes. The pomegranate also has wide consumer preference for its attractive, juicy, sweet, acidic and refreshing fruits. Fruits are used for fresh consumption and the aril portion of fruits is used in salad and processing. During seasonal glut, the fruit prices are fairly low and due to cracking problem the pomegranate fruits need to be processed and preserved. The pomegranate can be processed into products like juice, carbonated drinks, syrup, jelly, wine, anar-rub, anardana and canned beverages (Dhumal *et al.*, 2014). The pomegranate juice has attractive colour. However,the pomegranate juice has very poor flavour (Nakadi, 1998). Therefore, juice needs to be blended with some other juices having strong flavour and high nutritional value for consumer acceptance.

Sapota (*Manilkara achras* (Mill.) Fosberg) (Syn.: *Achras zapota* L.) is one of the most important tropical fruits, belonging to the family sapotaceae. It is native of Mexico in the Tropical America, fully domesticated by indigenous people. It is not known when the sapota was first introduced into India but its cultivation was first taken up in Maharashtra. The states which grow sapota on a commercial scale in India are Maharashtra, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Uttar Pradesh, West Bengal, Punjab and Haryana. It is also important fruit crop of the Konkan region of Maharashtra after mango, cashew nut and coconut.

India is the largest producer of sapota followed by Mexico. In India, it is cultivated on 1,64,000 hectare with annual production of 14,95,000 metric tonnes in the year 2012-2013 (Anon., 2014). Among the 41 varieties grown all over India, Kalipatti is an outstanding variety of sapota popularly cultivated in the Konkan region with a few other varieties like Bhuripatti, Dhola diwani and Cricket ball.

Sapota fruit is a good source of digestible sugar, which ranges from 12 to 18 per cent and it is virtually a treasure of minerals such as iron and calcium. The fruits have an appreciable amount of protein, fat, fiber, calcium, phosphorus, iron, carotene and vitamin C (Shanmugavelu and Srinivasan, 1973). It is also rich in bio-iron required for the formation of haemoglobin (Singh, 2001). It is commercially grown for the production of chickle i.e. a gum like substance obtained from the latex mainly used for the preparation of chewing gum.

Sapota is mainly valued for its sweet and delicious fruits. Sapota fruits are preferably consumed as fresh, although some studies have reported its use in preparation of jelly, jam, cheese and butter (Relekar et al., 2011). Products like sweet chutney, dried sapota pieces, sapota milk shake, nectar, blended sapota drinks, pickle, preserve and candy can also be prepared with good sensory quality (Sawant, 1989). Even wine can be prepared from sapota fruit (Gautam and Chundawat, 1998). It has been observed that when there is a bumper production of sapota, the fruit goes as waste for want of suitable preservation facilities. Thus, considering the fast increasing area under sapota cultivation, the preservation and processing technology needs to be developed in order to prevent huge post harvest losses and regulate prices during glut period and thereby protecting the interest of the growers. However, there are no popular commercial products of sapota in the market.

It is essential to produce value added products based on sapota, so that farmers can get an assured price for their produce all the time. Processed food items viz. jelly, jam, squashes and fruit drinks are produced from sapota after blending it with other fruits (Ghade, 2013 and Pawar, 2013).

Among these fruits, the pomegranate juice has poor flavour but excellent blood red colour. On the contrary sapota has excellent delicious taste and flavour. Therefore, blending of these fruits for jelly preparation would improve sensory quality of the product.

With this view the investigation on **"**Studies on preparation of pomegranate (*Punica granatum* L.) : sapota (*Manilkara achras* (Mill.) Fosberg) blended jelly" will be undertaken with the following objectives.

1) To standardize the proportion of pomegranate : sapota fruit juices in the blended jelly.

2) To study the storage behaviour of pomegranate : sapota blended jelly at ambient condition.

CHAPTER II

REVIEW OF LITERATURE

The research work done on "Studies on preparation of pomegranate (*Punica granatum* L.) : sapota (*Manilkara achras* (Mill.) Fosberg) blended jelly" is reviewed in the current chapter. The literature on pomegranate and sapota jelly is scanty, hence, the research work in this regard on other important fruit crops is also reviewed under the following headings.

2.1 Chemical composition of pomegranate and sapota fruit

2.2 Preparation of the pomegranate: sapota blended jelly

2.3 Changes in the physical quality parameters of the pomegranate: sapota blended jelly during storage

2.4 Changes in the chemical quality parameters of the pomegranate: sapota blended jelly during storage

2.5 Microbial count

2.6 Changes in the sensory quality parameters of the pomegranate: sapota blended jelly during storage**.**

2.1 Chemical composition of pomegranate and sapota fruit

2.1.1 Moisture

Pawar *et al*. (2011) studied the physico-chemical parameters of sapota fruit at different maturity stages and observed 75.80 per cent moisture content in sapota fruit.

Nwofia *et al*. (2012) studied chemical composition of some morphotypes of papaya. They recorded 90.33 per cent moisture content in papaya fruit.

Chopade *et al.* (2014) studied the preparation of powder from pomegranate juice by use of spray dryer and observed 85.4 per cent moisture in pomegranate.

2.1.2 Total soluble solids

Kumbhar *et al.* (2002) conducted an experiment on effect of methods of juice extraction on the quality of pomegranate wine and observed 14.6 °B total soluble solids by hand press method.

Zaman *et al*. (2006) evaluated the physicochemical composition of four papaya cultivars. They reported 11 °B total soluble solid content in cv Shahi yellow.

Pawar *et al.* (2011) evaluated physico-chemical parameters of sapota fruits at different maturity stages and reported 23.60 °B T.S.S at ripe stage.

Dhutade (2012) conducted an experiment on standardization of sapota juice powder and recorded 23 °B total soluble solids in sapota fruit.

Hiremath and Rokhade (2012) conducted an experiment on preparation and preservation of sapota juice and recorded 21.60 °B T.S.S. level in sapota fruit.

Dhumal *et al.* (2013) worked on the development of pomegranate juice processing technology and observed 14.80 °B total soluble solid contents in pomegranate juice.

Hire (2013) conducted an experiment on preparation of blended pomegranate and cashew apple nectar and recorded 14.4 °B total soluble solid content in pomegranate fruit.

Naktee (2013) conducted an experiment on preservation of sapota juice and recorded 23 °B total soluble solid content in sapota fruit.

2.1.3 Titratable acidity

Kumbhar *et al.* (2002) conducted an experiment to study the effect of methods of juice extraction on the quality of pomegranate wine and observed 0.35 per cent titratable acidity by hand press method.

Pawar *et al*. (2011) studied the physico-chemical parameters of sapota fruit at different maturity stages and reported 0.10 per cent titratable acidity at ripe stage.

Dhutade (2012) conducted an experiment on the standardization of sapota juice powder and recorded 0.12 per cent titratable acidity in sapota fruit.

Hiremath and Rokhade (2012) conducted an experiment on the preparation and preservation of sapota juice and recorded 0.214 per cent titratable acidity in sapota fruit.

Dhumal *et al.* (2013), while working on the development of pomegranate juice processing technology observed 0.46 per cent titratable acidity in pomegranate juice.

Hire (2013) conducted an experiment on the preparation of blended pomegranate and cashew apple nectar and recorded 0.39 per cent titratable acidity in pomegranate fruit.

Naktee (2013) conducted an experiment on the preservation of sapota juice and recorded 0.12 per cent titratable acidity in sapota fruit.

2.1.4 Reducing sugars

Zaman *et al*. (2006) recorded 5.68 per cent reducing sugar content in Deshi cultivar of papaya during evaluation of physicochemical composition of papaya.

Pawar *et al*. (2011) studied the physico-chemical parameters of sapota fruit at different maturity stages and reported 10.11 per cent reducing sugar content at ripe stage.

Dhutade (2012) conducted an experiment on standardization of sapota juice powder and recorded 8.3 per cent reducing sugar content in sapota fruit.

Hiremath and Rokhade (2012) conducted an experiment on preparation and preservation of sapota juice and observed 7.69 per cent reducing sugar content in sapota fruit.

Dhumal *et al.* (2013), while developing the pomegranate juice processing technology, observed 14.70 per cent reducing sugar content in pomegranate juice.

Hire (2013) conducted an experiment on the preparation of blended pomegranate and cashew apple nectar. They reported 12 per cent reducing sugar content in pomegranate cv Bhagwa.

Naktee (2013) conducted an experiment on the preservation of sapota juice and recorded 8.3 per cent reducing sugar content in sapota fruit.

2.1.5 Total sugars

Kumbhar *et al.* (2002) studied the effect of methods of juice extraction on the quality of pomegranate wine and observed 12.50 per cent total sugars by hand press method.

Zaman *et al*. (2006) evaluated physicochemical composition of four papaya cultivars and observed 8.85 per cent total sugar content in Deshi cultivar of papaya.

Pawar *et al*. (2011) studied the physico-chemical parameters of sapota fruit at different maturity stages and reported 18.20 per cent total sugar content at ripe stage.

Dhutade (2012) conducted an experiment on the standardization of sapota juice powder and recorded 17 per cent total sugar content in sapota fruit.

Hiremath and Rokhade (2012) conducted an experiment on the preparation and preservation of sapota juice and reported 13.54 per cent total sugar content in sapota fruit.

Dhumal *et al.* (2013) studied the pomegranate juice processing technology and observed 16.11 per cent total sugar content in pomegranate juice.

Hire (2013) conducted an experiment on the preparation of blended pomegranate and cashew apple nectar and recorded 13.31 per cent total sugar content in pomegranate fruit.

Naktee (2013) conducted an experiment on the preservation of sapota juice and recorded 17 per cent total sugar content in sapota fruit.

2.2 Preparation of the pomegranate : sapota blended jelly

Tomar *et al*. (1988) conducted an experiment to standardize a process for preparation of diabetic jelly. They prepared jelly by using different combinations of raw papaya and guava extracts. In treatment T_8, 50 per cent raw papaya extract and 50 per cent guava extract were used. It was selected as the best treatment as far as colour, flavour, taste and setting of jelly are concerned.

Poonam *et al*. (1997) prepared coloured jelly by using three grape cultivars namely 'Lomanto', 'Madeliene Royal' and 'Beauty seedless-ruby red hybrids'. It was observed that all the three cultivars separately as well as in mixed form were unable to form a desirable jelly due to inadequate pectin content and high acidity. Therefore, grape juice was mixed with guava extract in 20:80, 40:60 and 60:40 ratios. Among these blends, the ratio of 40:60 scored the highest for colour, flavour, consistency and overall acceptability after sensory evaluation.

Katoch *et al*. (2006) developed the blended jelly from seabuckthorn and guava fruit extracts in different proportions viz. (40:60), (50:50), (60:40) and (100:0). Jelly prepared with (50:50) proportion of seabuckthorn and guava fruit extracts was found the best with respect to proper setting, flavour, taste and colour.

Singh and Chandra (2012) conducted an experiment to develop the fruit jelly using various levels of guava extract and carrot juice content viz. 75:25, 50:50 and 25:75. It was concluded that fruit jelly prepared with guava extract

and carrot juice in the ratio of 75:25 was found to be superior for overall acceptability to those prepared with other ratios.

Ghade (2013) conducted an experiment to develop the fruit jelly using various proportions of sapota and papaya extracts viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100. It was concluded that fruit jelly prepared with sapota and papaya pectin extract in the ratio 40:60 was found to be superior for overall acceptability to those prepared with other ratios.

Pawar (2013) conducted an experiment to develop the fruit jam using various proportions of sapota and papaya pulp viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100. It was concluded that the fruit jam prepared with sapota and papaya pulp in the ratio 40:60 was found to be superior for overall acceptability to those prepared with other ratios.

2.3 Changes in the physical quality parameters of the pomegranate : sapota blended jelly during storage

2.3.1 Colour

Aleman *et al.* (2011) performed experiment on elaboration of blackberry jellies with native and modified banana starches.They recorded that the darkness of jelly decreased contiously with increase in the proportion of banana starch and b* value for colour increased during storage.

Moura *et al*. (2011) performed an experiment to follow-up colour changes in low-calorie strawberry and guava jellies during storage. Colour instrumental analyses (L*, a*, and b*) were performed after every 30 days. They recorded the changes in L* value for colour from 33.23 to 32.76, a* value for colour changed from 15.44 to 16.27 and b* value for colour changed from 25.39 to 25.81 during 90 days of storage period.

Abozeid and Nadir (2012) determined colour of loquat fruit jelly by recording L*=35.22, a*=15.51 and b*=19.66 values for colour after preparation of jelly.

Rababah *et al*. (2012) evaluated the colour of raisin jam by recording L*, a* and b* values for colour. The recorded value for L*, a* and b* was 19.8, 2.2 and 5.4, respectively in ground raisin jam.

2.4 Changes in the chemical quality parameters of the pomegranate : sapota blended jelly during storage

2.4.1 Moisture

Hossen *et al*. (2009) conducted the study on the processing of jelly from guava juice at different stages of extraction. Jelly prepared from composite of first and second extraction of guava juice was more acceptable than other which contained 21.53 per cent moisture.

Relekar *et al*. (2011) conducted the comparative studies on compositional changes in the value added sapota products such as sapota jam, butter, cheese and jelly. They reported that the sapota jelly did not exhibit variation in moisture content, recorded 23.08, 22.83 and 23.08 per cent moisture at 0, 30 and 60 days of storage period, respectively in sapota jelly.

Singh and Chandra (2012) developed the fruit jelly using various levels of guava extract and carrot juice content viz. 75:25, 50:50 and 25:75 and they reported 23.63, 24.02 and 23.73 per cent moisture content, respectively. However, it was decreased to 19.83, 21.58 and 19.88 per cent, respectively in 90 days of storage period.

Carvalho *et al*. (2012) developed sapota pulp jelly and found that the mean value of moisture content was 32.68 per cent.

Ghade (2013) conducted an experiment to develop the fruit jelly using various proportions of sapota and papaya extracts viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 and he reported 23.83, 23.03, 22.85, 23.91, 22.32 and 23.42 per cent moisture content, respectively. However, it was increased to 24.06, 23.72, 23.19, 25.12, 24.34 and 24.40 per cent, respectively in 90 days of storage at ambient condition.

Pawar (2013) conducted an experiment to develop the fruit jam using various proportions of sapota and papaya pulp viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 and he reported 28.48, 27.03, 26.79, 26.31, 26.70 and 26.06 per cent moisture content, respectively. However, it was decreased to 24.06, 25.83, 24.28, 24.50, 25.25, 24.80 and 25.29 per cent, respectively in 90 days of storage period.

2.4.2 Total soluble solids

Poonam *et al.* (1997) prepared coloured jelly by using three grape cultivars and recorded 10 °B total soluble solid content in grape jelly.

Hossen *et al.* (2009) studied the processing of jelly from guava juice at different stages of extraction and observed 67 °B total soluble solid content in the jelly.

Singh and Chandra (2012) conducted an experiment to develop the fruit jelly using various levels of guava extract and carrot juice viz. 75:25, 50:50 and 25:75. They recorded 68.10, 68.30 and 68.20 °B total soluble solid contents, respectively. It was observed that T.S.S. level was increased to 72.20, 72.20 and 77.10 °B respectively after 90 days of storage.

Relekar *et al.* (2011) reported that the T.S.S. level of sapota jelly increased significantly, irrespective of the treatments by the end of six months of storage period. They recorded 68.25, 68.65 and 68.85 °B at 0, 30 and 60 days of storage periods, respectively in sapota jelly.

Carvalho *et al.* (2012) developed sapota pulp jelly and found 66.04 per cent carbohydrates which were consistent to 61.06 °B T.S.S. level.

Deen and Singh (2013) studied the preparation of jelly from karonda fruits and observed that the T.S.S. content of jelly increased from 68.64 to 70.19 per cent during storage period of six months.

Ghade (2013) conducted an experiment to develop the fruit jelly using various proportions of sapota and papaya extracts viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 and he reported 69.03, 68.23, 67.98, 68.20, 67.90 and

68.55 °B total soluble solid content, respectively. However, it was increased to 69.18, 68.83, 68.35, 68.88, 68.45 and 69.18 °B, respectively in 90 days of storage period.

Pawar (2013) conducted an experiment to develop the fruit jam using various proportions of sapota and papaya pulp viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 and they reported 67.20, 67.55, 67, 67.60, 67.60 and 67.35 °B total soluble solid content, respectively. However, it was increased to 68.30, 68.48, 68.35, 68.40, 68.75 and 68.65 °B, respectively in 90 days of storage period.

2.4.3 Titratable acidity

Poonam *et al.* (1997) prepared coloured jelly by blending of grape and guava juice. They reported that the titratable acidity of the blended jelly varied in the range between 0.80 and 1.03 per cent.

Tomar *et al*. (1988) conducted an experiment to standardize a process for preparing diabetic jelly. They prepared diabetic jelly by using papaya and guava extracts. They found the highest 0.53 per cent acidity in jelly prepared from composition of raw papaya extract, guava extract, glycerol, calcium chloride and citric acid and it was decreased to 0.50 per cent after three months of storage period.

Masoodi *et al*. (2005) studied the use of carrot and tomato as biocolourant in guava jelly and observed 0.957 per cent titratable acidity in control treatment which was reduced to 0.785 per cent during two months of storage period.

Katoch *et al*. (2006) prepared jelly by blending seabuckthorn fruit with apple and guava in different proportions. They reported highest acid content in the seabuckthorn and guava blend which was 0.95 per cent, while seabuckthorn and apple blend showed lower acid content which was 1.1 per cent.

Deen and Singh (2013) prepared the jelly from karonda fruits and observed that the titratable acidity content of jelly increased from 1.51 to 1.82 per cent during storage period of six months.

Ghade (2013) conducted an experiment to develop the fruit jelly using various proportions of sapota and papaya extracts viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 and they reported 0.52, 0.54, 0.58, 0.56 , 0.57 and 0.60 per cent titratable acidity, respectively. However, it was decreased to 0.41, 0.39, 0.43, 0.39, 0.41 and 0.46 per cent, respectively in 90 days of storage period.

Pawar (2013) conducted an experiment to develop the fruit jam using various proportions of sapota and papaya pulp viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 and they reported 0.47, 0.48, 0.48, 0.48, 0.49 and 0.51 per cent titratable acidity content, respectively. However, it was increased to 24.06, 23.72, 23.19, 25.12, 24.34 and 24.40 per cent, respectively in 90 days of storage period.

2.4.4 Reducing sugars

Tomar *et al*. (1988) observed the highest amount of reducing sugar content in control treatment which was 3.86 per cent and it increased to 3.98 per cent in three months of storage of jelly.

Katoch *et al*. (2006) prepared jelly by blending seabuckthorn fruit with apple and guava in different proportions. They found 22.5 per cent reducing sugar content in seabuckthorn and guava (40:60) blend.

Relekar *et al.* (2011) conducted the comparative studies on compositional changes in sapota products and observed that the reducing sugar content was continuously increased from 29.11 to 49.15 per cent in two months of storage period, in sapota jelly.

Carvalho *et al*. (2012) observed small amount of reducing sugar content in sapota pulp jelly which was 4.05 per cent.

Deen and Singh (2013) prepared the jelly from karonda fruits and observed that reducing sugar content of jelly increased from 35.36 to 42.60 per cent during storage period of six months.

Ghade (2013) conducted an experiment to develop the fruit jelly using various proportions of sapota and papaya extracts viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 and they reported 22.28, 32.56, 33.56, 34.97, 33.36 and 33.41 per cent reducing sugar content, respectively. However, it was increased to 52.49, 65.99, 59.96, 59.54, 59.93 and 63.27 per cent, respectively in 90 days of storage period.

Pawar (2013) conducted an experiment to develop the fruit jam using various proportions of sapota and papaya pulp viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 and they reported 11.80, 16.25, 16.15, 18.57, 17.47 and 14.98 per cent reducing sugar content, respectively. However, it was increased to 42.11, 41.73, 35.02, 33.64, 33.87 and 29.87 per cent, respectively in 90 days of storage period.

2.4.5 Total sugars

Masoodi *et al.* (2005) studied the use of carrot and tomato as biocolourant in guava jelly and observed that the total sugar content of jelly varied from 67.98 to 73.20 per cent.

Katoch *et al.* (2006) reported 70.4 per cent total sugar content in jelly prepared from seabuckthorn and guava blend. Amount of total sugar content was reduced to 66.8 per cent in seabuckthorn, guava and apple blend.

Hossen *et al.* (2009) observed that amount of total sugar was consistent in all five composition, used for jelly making. It changed in the range of 63.20 to 64.40 per cent in guava jelly.

Relekar *et al.* (2011) estimated total sugar content in sapota jelly which increased from 62.97 to 63.59 per cent in two months of storage period.

Deen and Singh (2013) studied the preparation of jelly from karonda fruits and observed that the total sugar content of jelly increased from 65.24 to 68.69 per cent during storage period of six months.

Ghade (2013) conducted an experiment to develop the fruit jelly using various proportions of sapota and papaya extracts viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 and they reported 63.45,65.28, 65.97, 65.63, 65.64 and 66.85 per cent total sugar content, respectively. However, it was increased to 66.32, 67.40, 67.95, 67.39, 67.94 and 69.07 per cent, respectively in 90 days of storage period.

Pawar (2013) conducted an experiment to develop the fruit jam using various proportions of sapota and papaya pulp viz. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 and they reported 38.03, 45.18, 51.74, 52.45, 50.43 and 49.04 per cent total sugar content, respectively. However, it was increased to 58.02, 57.71, 60.20, 58.30, 58.21 and 56.07 per cent, respectively in 90 days of storage period.

2.5 Microbial count

Shakir *et al*. (2009) studied the microbial analysis of apple and pear mixed fruit jam. Results regarding the total fungal count showed a gradual increase from 42.14 to 57.7 during storage.

Cravalho *et al*. (2012) observed that sapota pulp jelly was not infected with the thermotolerant coliform, mould and yeast.

Safdar *et al*. (2012) reported that no detectable yeast and mould was observed during 150 days of storage period. However, total viable count of mango jams were within permissible limits which is 10,000 cfu/g.

2.6 Changes in the sensory quality parameters of the pomegranate: sapota blended jelly during storage

2.6.1 Colour

Migual *et al*. (2008) observed that the mean sensory score for colour of the strawberry jelly was increased from 9.33 to 10.00 during 180 days of storage period.

Singh and Chandra (2012) conducted an experiment to develop the fruit jelly using various levels of guava extract and carrot juice content. They observed 7.60 mean sensory score for colour of the jelly.

2.6.2 Flavour

Singh and Chandra (2012) recorded 7.70 mean score for flavour of guava-carrot jelly which was decreased to 5.20 during 90 days of storage period.

Rababah *et al*. (2012) observed that the mean score for flavour was 7.1 for raisin jam.

2.6.3 Texture

Singh and Chandra (2012) developed the fruit jelly by using various levels of guava extract and carrot juice content. They observed 7.80 score for texture. It was decreased to 5.60 during 90 days of storage period.

Shakir *et al*. (2009) recorded 7.8 mean score for the texture of apple and pear mixed fruit jam.

2.6.4 Overall acceptability

Shakir *et al*. (2009) prepared mixed fruit jam with apple: pear blend. They observed that the mean score for overall acceptability was 8.4.

Singh and Chandra (2012) conducted an experiment to develop the fruit jelly using various levels of guava extract and carrot juice content and observed 7.70 score for overall acceptability which was decreased to 5.40, during 90 days of storage period.

CHAPTER III

MATERIAL AND METHODS

The present investigation entitled, "Studies on preparation of pomegranate (*Punica granatum* L.) : sapota (*Manilkara achras* (Mill.) Fosberg) blended jelly" was conducted at the Department of Post Harvest Management of Fruit, Vegetable and Flower Crops, Post Graduate Institute of Post Harvest Management, Killa-Roha, Dist. Raigad, during the year 2014-2015.

3.1 Experimental material

The mature fruits of pomegranate (*Punica granatum* L.) cv Bhagwa and sapota cv Kalipatti were procured from local market. After washing, fruits were used for the preparation of jelly. Pectin, sugar and chemicals like citric acid, sodium benzoate were available in the Department of Post Harvest Management of Fruit, Vegetable and Flower Crops, Post Graduate Institute of Post Harvest Management, Killa-Roha, Dist. Raigad.

3.1.1 Experimental details

Crop : Pomegranate (*Punica granatum* L.) and sapota (*Manilkara achras* (Mill.) Fosberg)

Cultivar : Pomegranate cv Bhagwa and sapota cv Kalipatti.

Design: Factorial Completely Randomized Design (FCRD)

Number of treatment combinations : $6 \times 4 = 24$

Replications : Three

3.1.2 Treatment details

Main treatments

Treatments		Proportions of pomegranate and sapota juice
T_1	:	100:0
T_2	:	80:20
T_3	:	60:40

T_4	:	40:60
T_5	:	20:80
T_6	:	0:100

Sub treatments

Sub treatments		Storage period (Days)
S_1	:	0
S_2	:	30
S_3	:	60
S_4	:	90

3.2 Methods

3.2.1 Chemical composition of pomegranate and sapota fruit

3.2.1.1 Moisture

Moisture content was measured directly by using Contech moisture analyzer (model CA-123) at 100^0C temperature and expressed as per cent moisture content on electronic display directly.

3.2.1.2 Total soluble solids

Total soluble solids were determined by using Hand Refractometer (Atago Japan, 0-32 ^{o}B) and the values were corrected at 20 ^{o}C with the help of temperature correction chart (A.O.A.C., 1975).

3.2.1.3 Titratable acidity

A known quantity of sample was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator (A.O.A.C., 1975). The sample of known quantity with 20 ml distilled water was transferred to 100 ml volumetric flask, made up the volume and filtered. A known volume of aliquot (10 ml) was titrated against 0.1N sodium hydroxide (NaOH) solution using phenolphthalein as an indicator (Ranganna, 1997). The results were expressed as per cent anhydrous citric acid.

$$\textbf{Titrable acidity}(\%) = \frac{\textbf{Normality of alkali X Titre. reading X Volume made X Equivalent weight of acid}}{\textbf{Weight of sample taken X Volume of sample taken for estimation X 1000}} \boldsymbol{X\ 100}$$

3.2.1.5 Reducing sugars

The reducing and total sugars were estimated by using Lane and Eynon method (1923) with modifications suggested by Ranganna, (2003). A known weight of sample was blended with distilled water using lead acetate (45 %) for precipitation of extraneous material and potassium oxalate (22 %) to de-lead the solution. This lead free extract was used to estimate reducing sugars by titrating against standard Fehling's mixture (Fehling A and B in equal proportion) using methylene blue as an indicator to a brick red end point.

$$\textbf{Reducing sugars}\ (\%) = \frac{\textbf{Factor X Dilution X 100}}{\textbf{Titre reading X Weight of sample}}$$

3.2.1.6 Total sugars

Total sugars were estimated by the same method after acid hydrolysis of an aliquot of de-leaded sample with 50 per cent hydrochloric acid followed by neutralization with 40 per cent sodium hydroxide.

$$\textbf{Total sugars}\ (\%) = \frac{\textbf{Factor X Dilution}}{\textbf{Titre reading X Weight of sample}}\textbf{X 100}$$

3.2.2 Preparation of jelly

The product was prepared as per the steps given below

3.2.2.1 Extraction of juice

Fresh ripe sapota fruits were peeled and cut into small pieces with a stainless steel knife. Pomegranate fruits were peeled and the arils were separated manually. Then, the juice was extracted by squeezing the sapota pulp in double fold muslin cloth.

3.2.2.2 Straining of juice

The juice of both pomegranate and sapota was strained by passing it through four fold muslin cloth. Clear sapota juice was obtained by heating the juice for few minutes and straining the juice through muslin cloth to remove all colloidal particals and scum.

3.2.2.3 Addition of water

The water was added in both juices in 1:1 proportion.

3.2.2.4 Blending of juices

Juices of pomegranate cv Bhagawa and sapota cv Kalipatti were blended in different proportions as per the treatments.

3.2.2.5 Addition of sugar

About 750g of blended juice of pomegranate and sapota was used in each replication for the preparation of jelly. The sugar was added in 1:1 proportion in the juice.

3.2.2.6 Boiling

After addition of the sugar, the mixture was boiled as rapidly as possible to avoid destruction of pectin as well as to maintain the colour and flavour of the jelly. The scum was removed with the help of spoon as and when it appeared.

3.2.2.7 Addition of pectin

Out of the total required sugar, the $1/10^{th}$ part of sugar was mixed with 0.5 per cent pectin powder so as to dissolve the pectin easily in juice. After reaching 60°B TSS it was sprinkled on the pectin extract with continuous stirring to avoid loss of jelly forming strength of pectin.

3.2.2.8 Addition of citric acid

Upon reaching 65 ^{0}B TSS, the citric acid was added @ 0.5 per cent in order to prevent sucrose crystallization in the finished product and to establish the optimum gel formation. Citric acid was added at the end of cooking for proper sugar inversion.

3.2.2.9 Addition of Sodium benzoate

After reaching 65°B TSS, the sodium benzoate was also added @ 200 ppm at the end as a chemical preservative.

3.2.2.1 Filling, packing and processing of jelly

When the TSS of jelly reached to 68 ºB, the blended jelly was filled hot in the presterilized, wide mouthed glass bottles and capped air tight. Packaged jelly was then processed in boiling water for a period of ten minutes. After processing, the blended jelly was stored at ambient condition for further investigation.

3.2.3 Changes in the physical quality parameters of the pomegranate : sapota blended jelly during storage

3.2.3.1 Colour

The colour of pomegranate and sapota blended jelly was measured by using colour reader (make Konica Minolta, Japan) and expressed as L*, a* and b* values.

3.2.4 Changes in the chemical quality parameters of the pomegranate : sapota blended jelly during storage

The biochemical parameters like moisture, total soluble solids, titratable acidity, reducing and total sugars except microbial analysis were evaluated with the methods described under 3.2.1 at an interval of 30 days for a for period of 90 days during storage at ambient condition.

3.2.5 Microbial count

Nutrient Agar media was prepared by weighing required quantity of nutrient agar and diluted with double distilled water to a known volume. The media was then autoclaved at 121 ^{0}C for 20 min. When the temperature of media lowered to 40^0 C, it was used for plating.

The plating was carried out with 0.1g sample in sterile petriplate under the Laminar Air Flow. The sample of each treatment was taken on a separate petriplate, followed by pouring of approximately 20 ml of media (35-40 ^{0}C) on the sample and mixing was done by tilting plate properly. Plates were sealed with parafilm and incubated at 37 ^{0}C for 48 hrs to check the bacterial count and kept it for 5-6 days at room temperature for fungal count. The total microbial plate count was measured in colony forming unit/gram.

3.2.6 Changes in sensory quality parameters of the pomegranate : sapota blended jelly

Pomegranate and sapota blended jelly was evaluated for their organoleptic qualities like colour, flavour, texture and overall acceptability on a hedonic scale (Amerine *et al*., 1965) as given below.

Organoleptic Score	Rating
9	Like extremely
8	Like very much
7	Like moderately

6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

The overall rating was obtained by averaging the score for colour, flavour and texture of pomegranate and sapota blended jelly. The samples with score of 5.5 and above were rated as acceptable.

3.2.7 Statistical analysis of the pomegranate: sapota blended jelly

The data collected on chemical parameters of pomegranate and sapota juice such as moisture, T.S.S., titratable acidity and sugars were represented as mean values. The data collected on the changes in physico-chemical and sensory quality parameters during storage were statistically analyzed by the standard procedure given by Panse and Sukhatme (1985) using Factorial Completely Randomized Design and valid conclusions were drawn only on significant differences between treatment mean at 5 per cent level of significance.

3.2.8 Economics of the pomegranate: sapota blended jelly

The economics of the product was worked out by considering existing rates of various inputs such as cost of raw material (Fruits), labour, fuel, chemical, packaging, depreciation (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 adding 20 per cent profit margins to the cost of product for different treatments of the experiments.

FLOW SHEET - I

Preparation of pomegranate and sapota blended jelly

Selection of sapota and pomegranate fruits

↓

Washing, peeling and cutting of fruits

↓

Extraction of juice using muslin cloth

↓

Straining through four fold muslin cloth

↓

Seperation of clear juice of pomegranate

↓

Heating the sapota juice and removing its scum

↓

Straining the sapota juice through muslin cloth.

↓

Addition of water in juice in 1:1 proportion

↓

Mixing the pomegranate and sapota juice in different ratios as per the treatment

↓

Addition of sugar in 1:1 proportion

↓

Heating the mixture upto TSS level 60° Brix

↓

Addition of pectin @ 0.5 %

↓

Heating the mixture upto TSS level 65° Brix

↓

Addition of citric acid @ 0.5 % and sodium benzoate @ 200 ppm

↓

Heating mixture upto TSS level of 68 °Brix.

↓

Hot filling in the jam bottles

↓

Capping

↓

Processing of bottles for 10 minutes.

↓

Labelling

↓

Storing.

CHAPTER IV

RESULTS AND DISCUSSION

The present investigation entitled, "Studies on preparation of pomegranate (*Punica granatum* L.) : sapota (*Manilkara achras* (Mill.) Fosberg) : blended jelly" was undertaken in the Department of Post Harvest Management of Fruit, Vegetable and Flower Crops, Post Graduate Institute of Post Harvest Management, Killa-Roha, during the year 2014-2015.

The pomegranate cv Bhagwa and sapota cv Kalipatti were selected for the present investigation which was undertaken to standardize proportion of pomegranate and sapota fruit juices in the jelly and to study storage behaviour of pomegranate and sapota blended jelly. The experiment consisted of six treatments, comprising different proportions of pomegranate and sapota juices i.e. 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100. The experimental data was analysed statistically using Factorial Completely Randomized Design (FCRD). The observations on the changes in physical, chemical and sensory quality parameters of pomegranate and sapota and blended jelly during storage were recorded at 0, 30, 60 and 90 days of storage. The results obtained from the investigation are presented and discussed in this chapter.

4.1 Chemical composition of pomegranate and sapota fruit

The data related to the chemical composition of pomegranate cv Bhagwa and sapota cv Kalipatti fruit are presented in Table 1.

Table 1: Chemical composition of pomegranate and sapota juice

Sr. No.	Parameters	Pomegranate	Sapota
1	**Moisture content (%)**	85.1	76.06
2	**Total soluble solids (^{0}Brix)**	14.2	21.4
3	**Titratable acidity (%)**	0.42	0.09
4	**Reducing sugars (%)**	12.29	7.61
5	**Total sugars (%)**	13.27	13.20

4.1.1 Moisture

Moisture content of pomegranate was recorded as 85.1 per cent. Chopade *et al.* (2014) also recorded 85.4 per cent moisture.

It could be observed from the data presented in Table 1 that the moisture content of sapota cv Kalipatti was recorded as 76.06 per cent. Similar result for moisture content of sapota fruit was observed by Pawar *et al.* (2011). They recorded 75.80 per cent moisture content in sapota fruit.

4.1.2 Total soluble solids

The total soluble solid content of pomegranate cv Bhagwa was 14.2 °B. Identical finding was observed by Dhumal *et al*. (2013) in Bhagwa cultivar of pomegranate.

The perusal of data regarding the total soluble solid content of sapota presented in Table 1 indicates that the sapota cv Kalipatti fruit recorded average T.S.S. of 21.4 °B. Similar result for the T.S.S. (21.6 °B) of sapota was recorded by Hiremath and Rokhade (2012).

4.1.3 Titratable acidity

The data regarding titratable acidity of sapota presented in Table 1 revealed that the average acidity of sapota fruit was 0.09 per cent. The result in similar line was reported by Hiremath and Rokhade (2012) in sapota. They recorded 0.10 per cent titratable acidity at ripe stage in sapota fruit.

The titratable acidity for pomegranate was recorded as 0.42 per cent. Similar observation (0.46 %) was also reported by Dhumal *et al.* (2013) in pomegranate.

4.1.4 Reducing sugars

The reducing sugar content of pomegranate cv Bhagwa fruit was 12.29 per cent. The similar observation (12 %) was also recorded by Hire (2013) in Bhagwa cultivar of pomegranate.

The data with respect to reducing sugars of sapota cv Kalipatti fruit are presented in Table 1. The per cent reducing sugars of sapota fruit was recorded as 7.61. Similar result for the reducing sugar content (7.69 %) of sapota fruit was reported by Hiremath and Rokhade (2012).

4.1.5 Total sugars

The data with respect to total sugars of sapota cv Kalipatti fruit presented in Table 1 reveals that the per cent total sugar of sapota cv Kalipatti fruit was 13.20. Hiremath and Rokhade (2012) also recorded 13.54 per cent total sugar content in sapota fruit.

It is also observed from the data that the total sugar content of pomegranate was 13.27 per cent. The observation in accordance with this finding (13.31 %) was reported by Hire (2013) in Bhagwa cultivar of pomegranate fruit.

4.2 Changes in the physical quality parameters of the pomegranate : sapota blended jelly during storage

4.2.1 Colour

Colour of jelly was evaluated by recording L* value for lightness, a* value for redness and b* value for yellowness with digital colorimeter (make Konica Minolta, Japan).

4.2.1.1 L* value for colour

The data for L* value for colour of pomegranate and sapota blended jelly during storage are presented in Table 2 and depicted in Fig 1.

L* value was recorded to determine lightness of jelly which increased significantly with corresponding increase in the amount of sapota juice in the blended jelly.

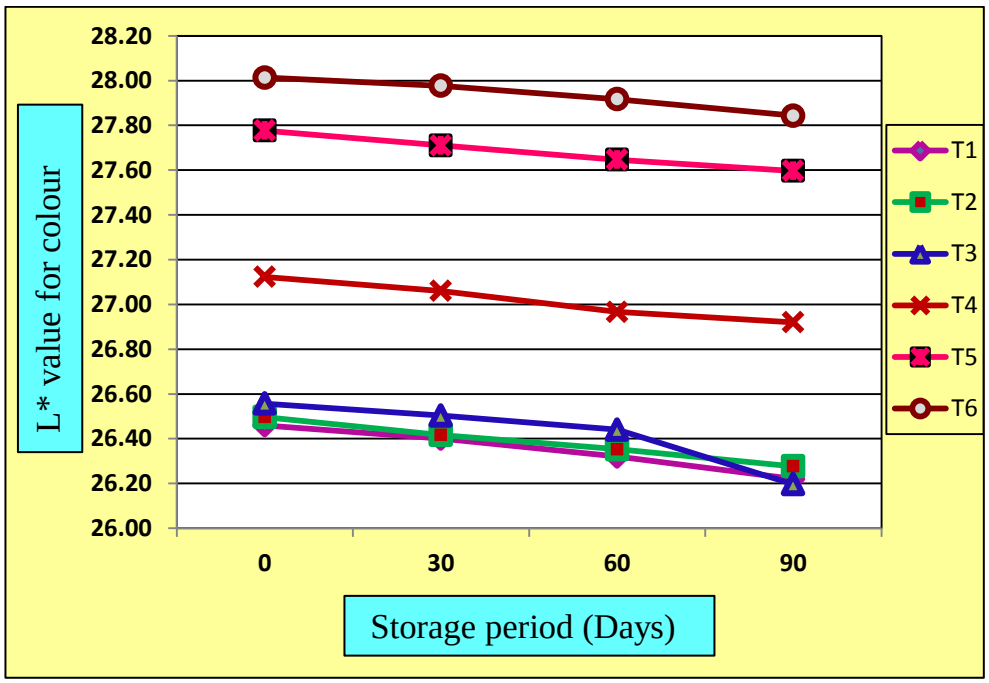
Highest (27.94) mean L* value for lightness of jelly was found in the treatment T_6 (0:100) which was significantly different from all other treatments. The lowest (26.35) mean L* value was observed in the treatment T_1 (100:0) which was at par with the T_2 , followed by the treatment T_3 which was at par with T_2. It was noticed from the data that the darkness of jelly decreased continuously with increase in the proportion of sapota juice in the blended jelly. Similar observations were recorded in blackberry jelly by Aleman *et al*. (2011).

A significant decline was recorded for mean L* values of jelly during the storage period of 90 days. It was decreased from 27.07 to 26.84 up to 90 days of storage.Thus, it can be concluded that darkness in colour of jelly increased with increase in storage period. It might be due to accumulation of carotenoid pigments. The results in accordance with these findings were also reported by Moura *et al*. (2011) in strawberry and guava jelly.

Table 2 : Effect of different proportions of pomegranate and sapota fruit juices on L* value for colour of blended jelly during storage

Treatments	L* value for colour				Mean
	Storage period (Days)				
	0	30	60	90	
T1	26.46	26.40	26.32	26.22	26.35
T2	26.50	26.42	26.35	26.28	26.39
T3	26.56	26.50	26.44	26.20	26.42
T4	27.12	27.06	26.97	26.92	27.02
T5	27.78	27.71	27.65	27.60	27.68
T6	28.01	27.98	27.92	27.84	27.94
Mean	27.07	27.01	26.94	26.84	
		S.Em ±		CD at 5%	
Treatments (T)		0.01		0.04	
Storage (S)		0.01		0.03	
Interaction (T×S)		0.03		0.08	

Fig. 1 : Effect of different proportions of pomegranate and sapota fruit juices on L* value for colour of blended jelly during storage



T_1: Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

4.2.1.2 a* value for colour

The data pertaining to a* value for colour of the pomegranate : sapota blended jelly during storage are presented in Table 3 and illustrated graphically in Fig 2.

The redness of the blended jelly was determined from a* value for colour of jelly which was found to be significantly varied due to the treatments.

Maximum (36.28) mean a* value for colour of jelly was observed in the treatment T_1 (100:0) which was significantly different from the rest of the treatments, followed by the treatment T_2 and T_3. Minimum (2.95) mean a* value for colour of the jelly was observed in the treatment T_6 (0:100) which was also significantly different from all other treatments, followed by T_5 and T_4. It is obvious from the data that redness of jelly increased due to increase in the proportion of pomegranate juice in the blended jelly which contained maximum red coloured pigments. Similar result was recorded by Rababah *et al*. (2012) in raisin jam for a* value of colour.

Data on a* value for colour revealed that the redness of jelly increased significantly during storage period of 90 days. At the time of preparation, mean a* value for colour was 20.04 which was increased significantly to 20.19 at 90 days of storage period. Similar findings for a* value were recorded by Moura *et al*. (2011) in strawberry jelly.

The interactions between treatments and storage period were found to be non-significant for a* value of colour in pomegranate and sapota blended jelly at 5 per cent level of significance.

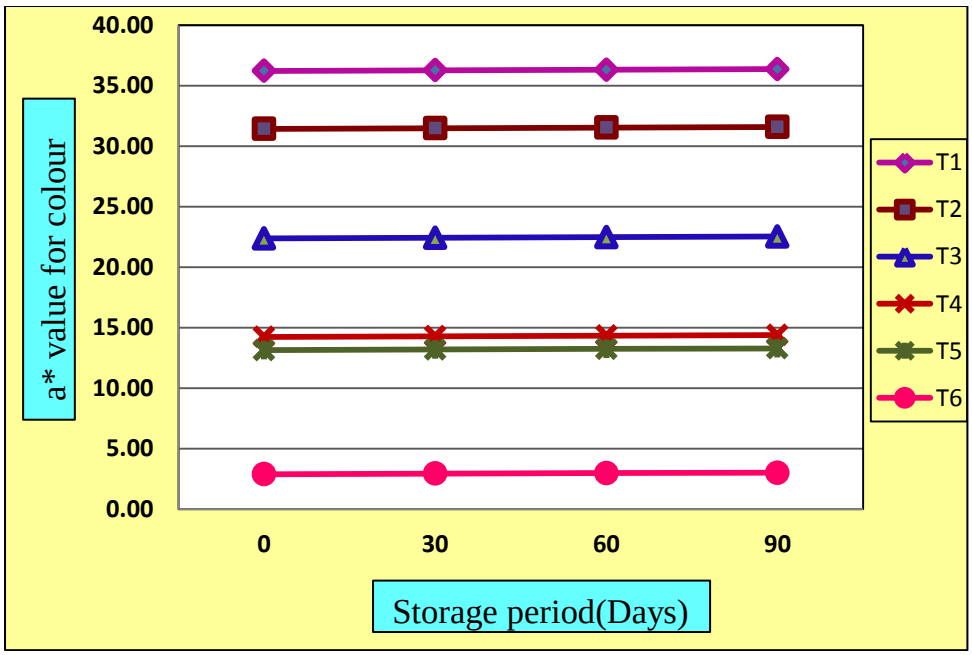
4.2.1.3 b* value of colour

The data related to the b* value for colour of pomegranate and sapota blended jelly during storage are presented in Table 4 and illustrated in Fig 3.

Table 3 : Effect of different proportions of pomegranate and sapota fruit juices on a* value for colour of blended jelly during storage

Treatments	a* value for colour				Mean
	Storage period (Days)				
	0	30	60	90	
T1	36.21	36.26	36.31	36.36	36.28
T2	31.43	31.48	31.53	31.59	31.51
T3	22.37	22.42	22.47	22.52	22.45
T4	14.23	14.28	14.33	14.39	14.31
T5	13.13	13.19	13.24	13.29	13.21
T6	2.89	2.93	2.98	3.01	2.95
Mean	20.04	20.10	20.14	20.19	
		S.Em ±		CD at 5%	
Treatments (T)		0.07		0.019	
Storage (S)		0.06		0.016	
Interaction (T×S)		0.14		N.S.	

Fig. 2 : Effect of different proportions of pomegranate and sapota fruit juices on a* value for colour of blended jelly during storage



T_1: Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

Yellowness of jelly was determined from b* value for colour. The present data explicit that the yellowness of pomegranate and sapota blended jelly changed significantly due to the treatments as well as storage period.

Maximum (24.96) mean b* value for colour was recorded in the treatment T_6 (0:100) which was significantly different from all other treatments, followed by T_5 and T_4. Minimum (20.70) mean b* value for yellowness was recorded in the treatment T_1 (100:0) which was significantly different from all other treatments. It is clear from the data that the b* value for colour also increased with corresponding increase in the proportion sapota juice in the blended jelly. Similar result was observed by Rababah *et al.* (2012) in raisin jam.

A continuous increasing trend with significant differences was observed in mean b* value for colour during storage. It was 22.11 at the time of preparation which increased to 22.40 at 90 days which was at par with the b* value for 60 days of storage .The b* value at 30 days storage was at par with the b* value at 60 days storage. The observation in accordance with this finding was recorded by Moura *et al.* (2011) in guava and strawberry jelly and similar b* values for colour were also recorded by Aleman *et al.* (2011) in blackberry jelly.

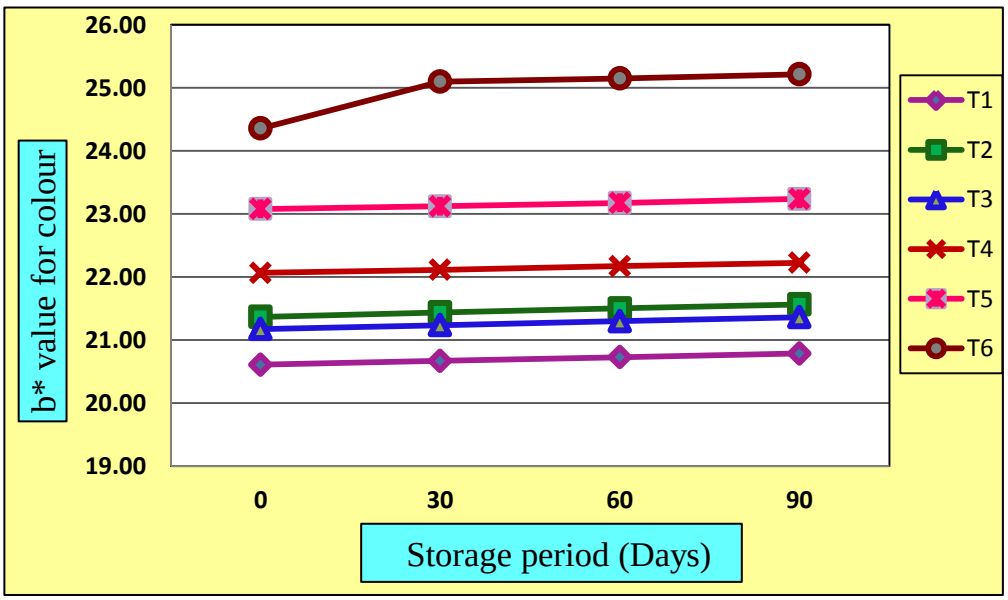
The interactions between different proportions of pomegranate and sapota fruit juices in the jelly and storage period were found to be significant for b* value for colour of the blended jelly at 5 per cent level of significance. Highest (25.22, 25.15 and 25.10, respectively) mean b* value for colour of jelly

was found in the treatment T_6 (0:100) after 90, 60 and 30 days of storage. Lowest mean b* value for colour of jelly was observed in the treatment T_1 (100:0) throughout the storage period of 90 days. Similar results were observed by Moura *et al*. (2011) in guava and strawberry jelly.

Table 4: Effect of different proportions of pomegranate and sapota fruit juices on b* value for colour of blended jelly during storage

Treatments	b* value for colour				Mean
	Storage period (Days)				
	0	30	60	90	
T1	20.61	20.67	20.73	20.78	20.70
T2	21.37	21.44	21.50	21.56	21.47
T3	21.17	21.23	21.30	21.36	21.27
T4	22.06	22.11	22.17	22.22	22.14
T5	23.08	23.12	23.17	23.24	23.15
T6	24.36	25.10	25.15	25.22	24.96
Mean	22.11	22.28	22.34	22.40	
		S.Em ±		**CD at 5%**	
Treatments (T)		0.03		0.09	
Storage (S)		0.03		0.07	
Interaction (T×S)		0.06		0.18	

Fig. 3 : Effect of different proportions of pomegranate and sapota fruit juices on b* value for colour of blended jelly during storage



T_1: Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

4.3 Changes in the chemical quality parameters of the pomegranate : sapota blended jelly during storage

4.3.1 Moisture

The data related to the changes in moisture content of the pomegranate : sapota blended jelly during storage are presented in Table 5 and illustrated graphically in Fig 4.

The maximum moisture content was recorded in the treatment T_3 (23.32) which was significantly more than remaining treatments. The minimum moisture content was recorded in the treatment T_4 which is at par with treatment T_5.

Moisture content of jelly changed significantly during 90 days of storage period. Maximum mean value for moisture content was observed at 90 days of storage period which was 23.53 per cent. Minimum (22.17%) mean value for the moisture content was observed at the time of preparation. The significant increase was observed in the moisture content of jelly from 22.17 to 23.53 per cent during 0 to 90 days of storage periods. This effect was related with the increase in water activity and microbial count after 90 days of storage period. Similar trends were reported by Relekar *et al.* (2011) in sapota jelly.

The interaction effect of different proportions of pomegranate : sapota fruit juices in blended jelly and storage periods was found to be statistically significant for moisture content of the jelly at 5 per cent level of significance.The moisture content was highest (24.25 %) in the treatment T_3 at 90 days and the lowest (21.25 %) in the treatment T_4 at the time of preparation.

4.3.2 Total soluble solids

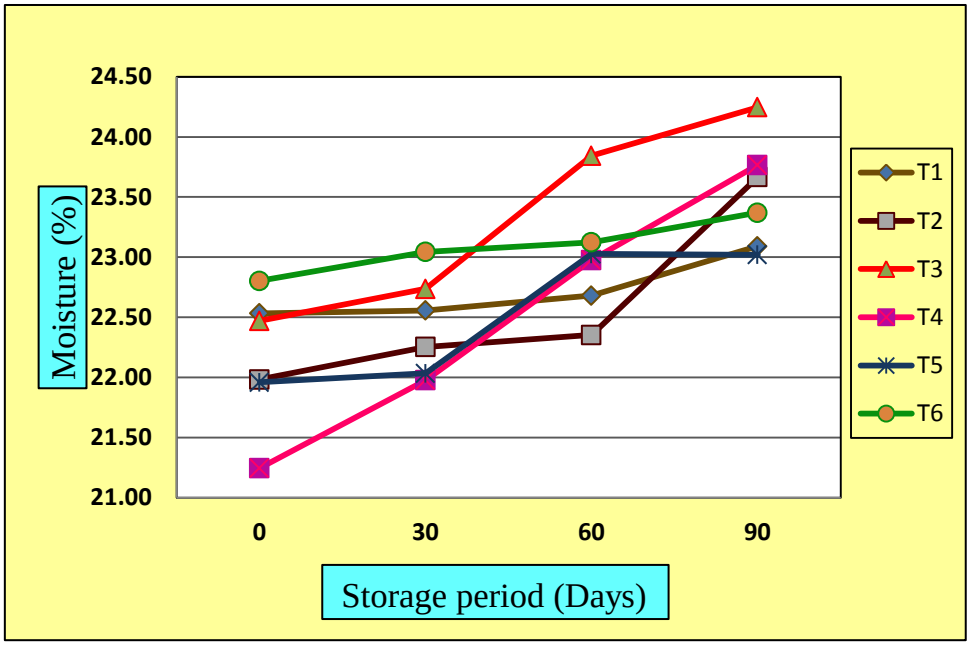
The data on the changes in the total soluble solid contents of pomegranate : sapota blended jelly during storage are presented in Table 6 and depicted in Fig 5.

Data recorded for total soluble solid contents of the blended jelly exhibited significant differences among the treatments. The mean value for total soluble solid content was maximum (68.97 ºB) in the treatment T_5 (20:80) which was significantly different from all other treatments. The treatment T_1 (100:0) showed minimum (68.22 ºB) mean value for the total soluble solid content which was at par

Table 5 : Effect of different proportions of pomegranate and sapota fruit juices on the moisture content of blended jelly during storage

Treatments	Moisture (%)				Mean
	Storage period (Days)				
	0	30	60	90	
T1	22.53	22.56	22.68	23.09	22.72
T2	21.98	22.25	22.35	23.67	22.56
T3	22.47	22.74	23.84	24.25	23.32
T4	21.25	21.98	22.98	23.77	22.49
T5	21.96	22.03	23.03	23.02	22.51
T6	22.80	23.04	23.12	23.37	23.09
Mean	22.17	22.43	23.00	23.53	
		S.Em ±		CD at 5%	
Treatments (T)		0.05		0.14	
Storage (S)		0.04		0.11	
Interaction (T×S)		0.10		0.28	

Fig. 4 : Effect of different proportions of pomegranate and sapota fruit juices on the moisture content of blended jelly during storage



. **T_1:** Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

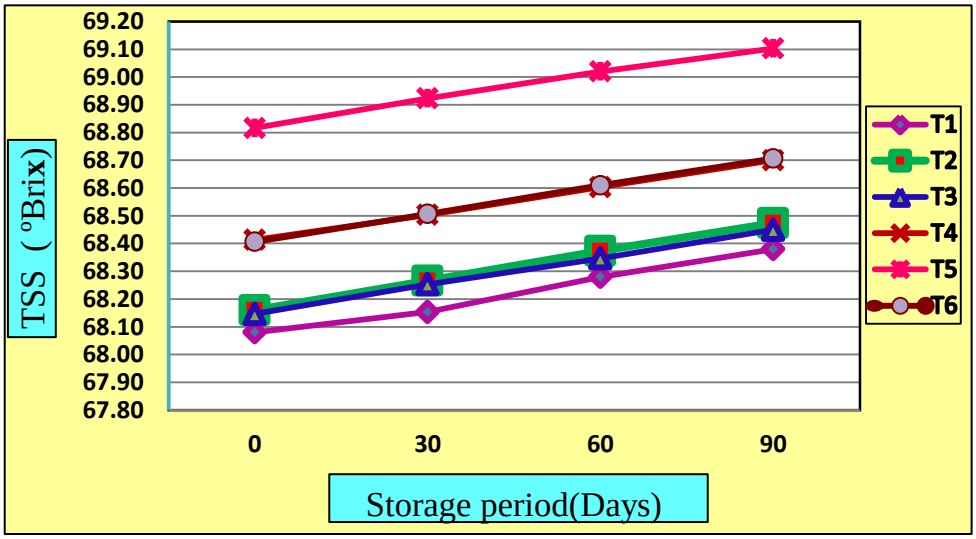
T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

Table 6: Effect of different proportions of pomegranate and sapota fruit juices on the total soluble solid content of blended jelly during storage

Treatments	Total soluble solids (°B)				Mean
	Storage period (Days)				
	0	30	60	90	
T1	68.08	68.15	68.28	68.38	68.22
T2	68.16	68.27	68.37	68.47	68.32
T3	68.15	68.25	68.35	68.45	68.30
T4	68.41	68.50	68.60	68.70	68.56
T5	68.82	68.92	69.02	69.10	68.97
T6	68.41	68.51	68.61	68.71	68.56
Mean	68.34	68.43	68.54	68.64	
		S.Em ±		**CD at 5%**	
Treatments (T)		0.08		0.23	
Storage (S)		0.07		0.19	
Interaction (T×S)		0.16		NS	

Fig.5 : Effect of different proportions of pomegranate and sapota fruit juices on the total soluble solid content of blended jelly during storage



T_1: Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

with the treatments T_2 and T_3. It was observed from the data that the total soluble solid contents varied significantly in between the range of 68.22 and 68.97 ºB due to the treatments. The variation in T.S.S. content of the blended jelly due to the treatments might be due to varied T.S.S. level of the jelly retained initially at jelly setting stage. Poonam *et al.* (1997) found similar results for total soluble solid content during standardization of jelly from grape and guava blends. Identical observations were also recorded by Tomar *et al.* (1988). They observed mean T.S.S. level at 68°B in diabetic jelly prepared from guava and papaya extract.

The observations recorded on the total soluble solid contents of jelly during storage period were significantly different. Increasing trend was found in total soluble solid contents of the pomegranate : sapota blended jelly from

68.34 to 68.64 ºB during 90 days of storage period. An increasing trend in the total soluble solid content was noticed with the advancement of the storage period. Relekar *et al*. (2011) observed that T.S.S. level of sapota jelly increased significantly by the end of six months of storage period. Singh and Chandra (2012) also noticed an increase in total soluble solid contents of mixed fruit guava and carrot jelly during 90 days of storage.

The interactions between different proportions of pomegranate and sapota fruit juices in the blended jelly and storage period on total soluble solid content was statistically non-significant at 5 per cent level of significance.

4.3.3 Titratable acidity

The data related to the changes in the titratable acidity of the pomegranate : sapota blended jelly during storage period are presented in Table 7 and graphically illustrated in Fig 6.

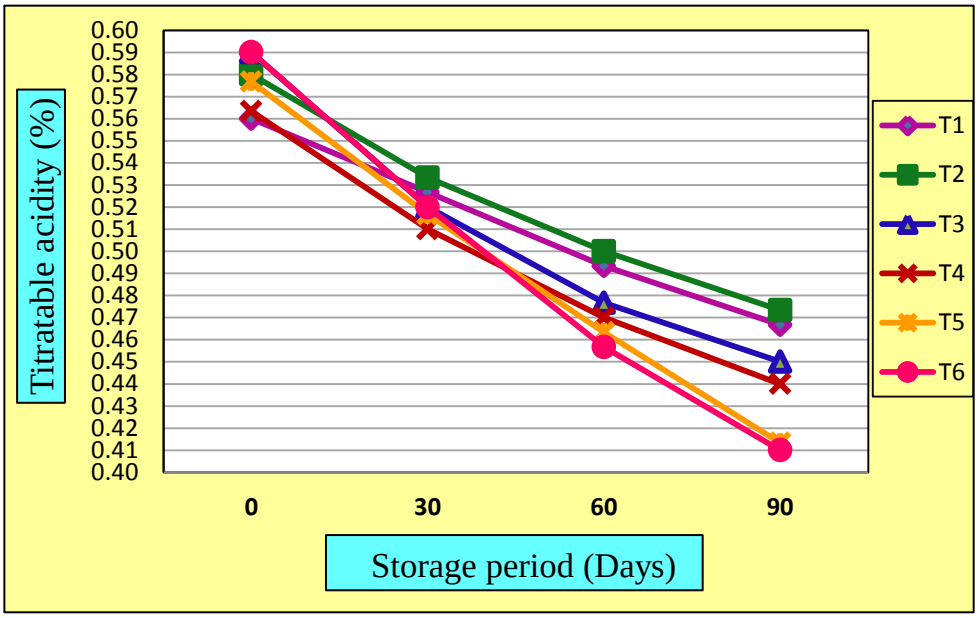
It is observed from the data that the titratable acidity of pomegranate : sapota blended jelly varied significantly due to the treatments. The treatment T_2 (80:20) showed highest mean value for titratable acidity which was 0.52 per cent which is at par with the treatments T_1 and T_3. The treatments T_5 and T_6 showed lowest (0.49 %) mean value for the titratable acidity. However, it was at par with T_4. The treatment T_4 was at par with the treatments T_1 and T_3. It is clearly noticed

Table 7: Effect of different proportions of pomegranate and sapota fruit juices on the titratable acidity of blended jelly during storage

Treatments	Titratable acidity (%)				Mean
	Storage period (Days)				
	0	30	60	90	
T1	0.56	0.53	0.49	0.47	0.51
T2	0.58	0.53	0.50	0.47	0.52
T3	0.59	0.52	0.48	0.45	0.51
T4	0.56	0.51	0.47	0.44	0.50
T5	0.58	0.52	0.46	0.41	0.49
T6	0.59	0.52	0.46	0.41	0.49
Mean	0.58	0.52	0.48	0.44	

	S.Em ±	CD at 5%
Treatments (T)	0.00	0.01
Storage (S)	0.00	0.01
Interaction (T×S)	0.01	0.02

Fig. 6 : Effect of different proportions of pomegranate and sapota fruit juices on the titratable acidity of blended jelly during storage



T_1: Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

from the data that the titratable acidity of jelly changed irrespective of the treatments. All the values for titratable acidity were close to the adjusted level of acidity initially for optimum gel formation which was 0.5 per cent. Tomar *et al.* (1988) revealed that the titratable acidity changed irrespective of the treatments in the range of 0.53 to 0.39 per cent in diabetic jelly which was prepared by using papaya and guava extracts. Hossen *et al.* (2009) also observed similar observations for titratable acidity in guava jelly.

Significant differences were recorded for titratable acidity of pomegranate and sapota blended jelly during 90 days of storage. A linear decline in mean values of titratable acidity of blended jelly was noticed from 0.58 per cent initially to 0.44 per cent after 90 days of storage and results were statistically significant. This might be attributed to the chemical reactions between organic constituents of fruit induced by temperature and action of enzyme during storage. Tomar *et al*. (1988) observed a decreasing trend in the titratable acidity during three months of storage period in diabetic jelly prepared from guava and papaya extracts. Masoodi *et al*. (2005) also found a decreasing trend for titratable acidity in guava jelly during storage.

Significant effect was observed in the interactions between storage period and different proportions of pomegranate : sapota juices for titratable acidity of the blended jelly at 5 per cent level of significance. The significantly maximum titratable acidity was observed in the treatments T_6, T_3, T_5 and T_2 at 0 day of storage where it was minimum in the treatments T_5 and T_6 after 90 days of storage of the product at ambient conditions.

4.3.4 Reducing sugars

The data related to the changes in reducing sugar content of the pomegranate : sapota blended jelly during storage are presented in Table 8 and depicted graphically in Fig 7. It can be observed from the data that reducing sugar content of pomegranate and sapota blended jelly varied significantly due to the treatments as well as the storage period.

The mean value for reducing sugar content of the blended jelly in the treatment T_1 (100:0) was highest (48.10%), followed by T_2 which was significantly different from all other treatments. Lowest (44.04%) mean value for reducing sugar content was observed in the treatment T_1 (100:0) which was significantly different from rest of the treatments, followed by T_5 . Katoch *et al*. (2006) recorded similar findings for reducing sugar content in seabuckthorn jelly and Relekar *et al*. (2011) in sapota jelly.

Significant difference was observed in the mean values of reducing sugar content of pomegranate and sapota blended jelly during 90 days of storage period. Lowest (32.84 %) mean value for reducing sugar content was observed at the time of preparation while highest (59.60 %) mean value for reducing sugar content was recorded at 90 days of storage period. Thus, a significant increase in reducing sugar content of the blended jelly was found throughout the storage period of 90 days. This might be due to inversion of non-reducing sugars to reducing sugars after acid hydrolysis of polysaccharides. Tomar *et al*. (1988) recorded an increase in reducing sugar content of diabetic jelly during three months of storage period. Similar trend of increase in reducing sugar content of sapota jelly was observed by Relekar *et al*. (2011).

Interaction between different proportions of pomegranate and sapota fruit juices on storage period was also found to be significant at 5 per cent level of significance. The maximum (61.09 %) reducing sugar content was recorded in the treatment T_2 (80:20) after 90 days of storage while it was minimum (28.45 %) in the treatment T_6 (0:100). Similar trend for reducing sugar content during storage was observed by Masoodi *et al*. (2005) in guava jelly.

4.3.5 Total sugars

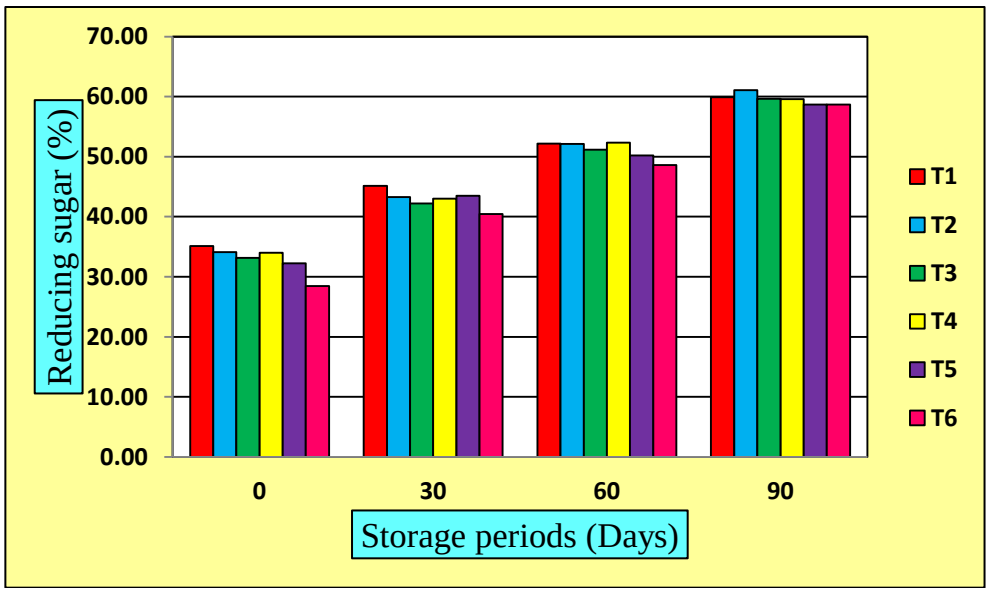
The data pertaining to the changes in the total sugar content of pomegranate and sapota jelly during storage are presented in Table 9 and depicted graphically in the Fig 8.

Table 9: Effect of different proportions of pomegranate and sapota fruit juices on reducing sugar content of blended jelly during storage

Treatments	Reducing sugars (%)				Mean
	Storage period (Days)				
	0	30	60	90	
T1	35.14	45.16	52.16	59.91	48.10

T2	34.12	43.25	52.11	61.09	47.64
T3	33.14	42.20	51.14	59.64	46.53
T4	33.98	42.99	52.35	59.57	47.22
T5	32.22	43.47	50.22	58.70	46.15
T6	28.45	40.44	48.59	58.67	44.04
Mean	32.84	42.92	51.09	59.60	
		S.Em ±		**CD at 5%**	
Treatments (T)		0.10		0.28	
Storage (S)		0.08		0.23	
Interaction (T×S)		0.20		0.57	

Fig. 8 : Effect of different proportions of pomegranate and sapota fruit juices on reducing sugar content of blended jelly during storage



T_1: Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

A significant difference was found in the total sugar content of pomegranate and sapota jelly among the treatments. The treatment T_5 (20:80)

recorded the highest (66.68 %) mean value for total sugar content, which was at par with the T_5. Lowest (64.76 %) mean value for total sugar content was observed in the treatment T_1 (100:0). The higher proportion of the sapota juice in the blended jelly exhibited rise in the total sugar content of the product. This could be due to more conversion of complex polysaccharides present in the sapota juice into soluble sugars during storage. The analogous results to the present findings were recorded by Hossen *et al*. (2009) in guava jelly and Relekar *et al*. (2011) in sapota jelly.

It is clearly noticed from the data that the total sugar content of pomegranate and sapota blended jelly significantly increased with increase in the storage period.

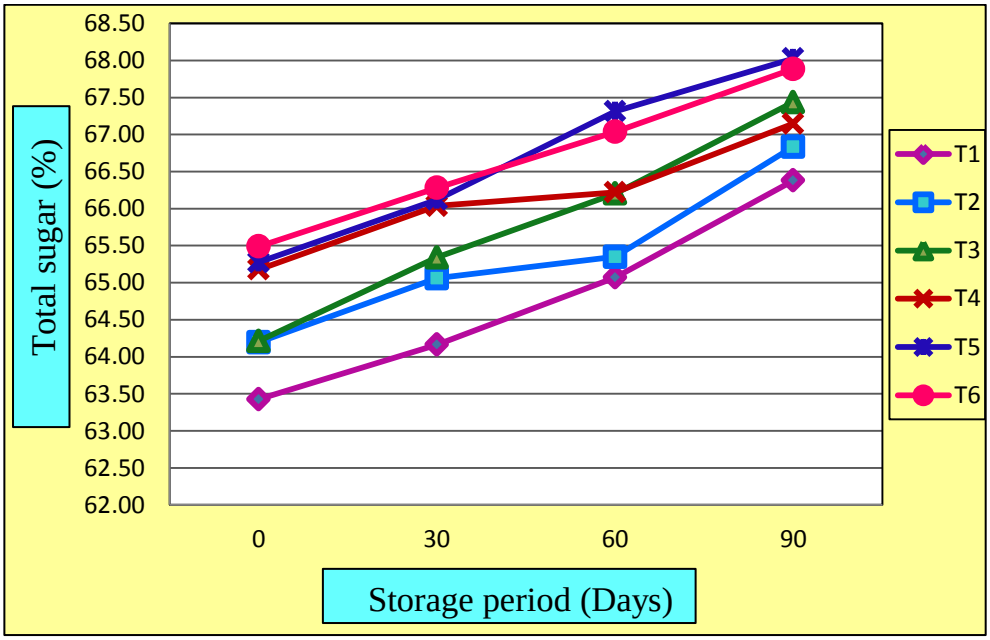
The total sugar content of the blended jelly increased significantly from 64.63 per cent initially to 67.29 per cent after a storage period of 90 days at ambient conditions. The increase in total sugar content might be due to breakdown of insoluble polysaccharide in simple sugars. Masoodi *et al*. (2005) found similar results for total sugar content during storage in guava jelly. The identical increasing trend in total sugar content was also recorded in sapota jelly by Relekar *et al*. (2011).

The interaction effect between treatments and storage period was found to be significant for total sugar content of pomegranate and sapota blended jelly at 5 per cent level of significance. The maximum (68.03 and 67.89 %, respectively) total sugar content was observed in the treatments T_5 and T_6 after 90 days of storage, while it was minimum in the treatment T_1 initially, at the time of preparation of the product.

Table 9: Effect of different proportions of pomegranate and sapota fruit juices on total sugar content of blended jelly during storage

Treatments	Total sugars (%)				Mean
	Storage period (Days)				
	0	30	60	90	
T1	63.43	64.16	65.07	66.38	64.76
T2	64.20	65.06	65.35	66.84	65.36
T3	64.21	65.34	66.20	67.44	65.80
T4	65.18	66.04	66.22	67.15	66.15
T5	65.28	66.12	67.31	68.03	66.68
T6	65..49	66.28	67.04	67.89	66.67
Mean	64.63	65.50	66.20	67.29	
		S.Em ±		**CD at 5%**	
Treatments (T)		0.08		0.23	
Storage (S)		0.07		0.19	
Interaction (T×S)		0.16		0.46	

Fig. 10: Effect of different proportions of pomegranate and sapota fruit juices on total sugar content of blended jelly during storage



T_1: Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

4.4 Microbial count

The data related to the microbial count of pomegranate and sapota blended jelly during storage periods are presented in Table 10 and depicted graphically in Fig 9.

The effect of different proportions of pomegranate and sapota juices on microbial count was found non-significant at 5 per cent level of significance.

No microbial infection was observed initially i.e. immediately after preparation . However, the mean microbial count of 0.89 cfu/g was recorded in the pomegranate : sapota blended jelly after 90 days of storage at ambient conditions. The increase in the microbial count was statistically non-significant at 5 per cent level of significance, but the microbial infection in the jelly was negligible and microbial count was far below the permissible safety limit. Similar findings were also observed by Safdar *et al*. (2012) in mango jam and Carvalho *et al*. (2012) in sapota pulp jelly.

The interaction effect due to combination of treatments and storage period was found to be statistically non-significant for microbial counts at 5 per cent level of significance.

4.5 Changes in the sensory quality parameters of the pomegranate : sapota blended jelly during storage

4.5.1 Colour

The data pertaining to the changes in the sensory score for colour of pomegranate and sapota blended jelly during storage are presented in Table 11 and illustrated in the Fig 10. It is evident from the data that the sensory score for colour of the pomegranate and sapota blended jelly varied significantly due to the treatments as well as storage period.

Maximum (8.33) mean score for colour of jelly was observed in the treatment T_1 (100:0), which was at par with the treatment T_2. The treatment T_3

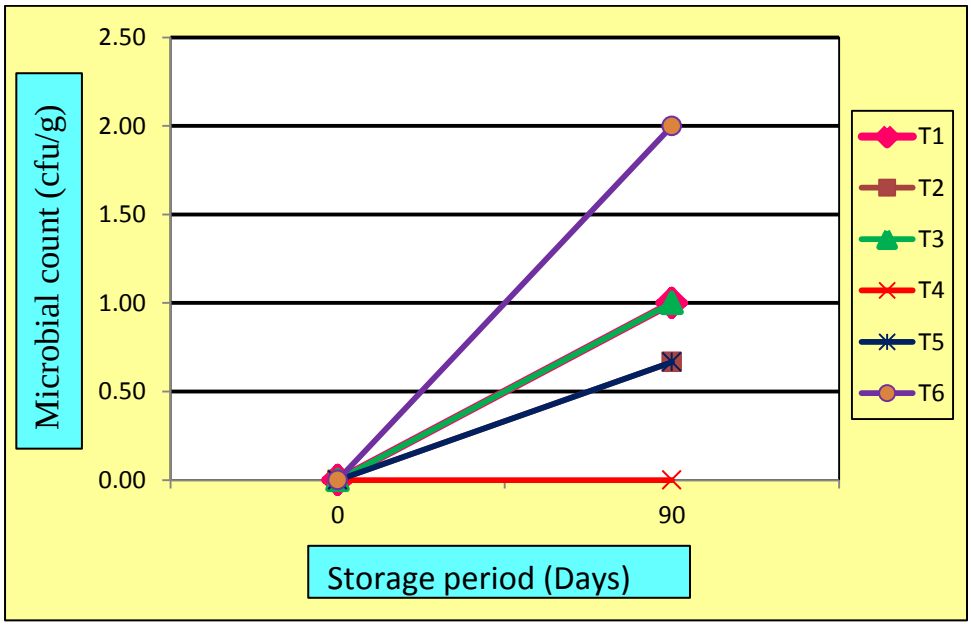
was superior to the treatment T_4 in colour. Minimum (7.13) mean score for colour of

Table 10: Effect of different proportions of pomegranate and sapota fruit juices on microbial count of blended jelly during storage

Treatments	Microbial count (cfu/g)		Mean
	Storage period (Days)		
	0	90	
T1	0.00	1.00	0.50
T2	0.00	0.67	0.33
T3	0.00	1.00	0.50
T4	0.00	0.00	0·00
T5	0.00	0.67	0.33
T6	0.00	2.00	1.00
Mean	0.00	0.89	

	S.Em ±	CD at 5%
Treatments (T)	0.66	N.S.
Storage (S)	0.38	N.S.
Interaction (T×S)	0.94	N.S.

Fig. 9: Effect of different proportions of pomegranate and sapota fruit juices on microbial count of blended jelly during storage



T_1: Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

jelly was obtained by the treatment T_5 (20:80), but it was at par with the treatment T_6. Thus, it is clear from the data that the sensory score for colour of blended jelly increased with increase in the proportion of pomegranate juice in the jelly which imparted attractive red colour to the product. Singh and Chandra (2012) observed similar results in the guava-carrot blended jelly.

The mean sensory score for colour varied significantly during storage period of 90 days. It was highest (8.06) at the time of preparation and lowest (7.33) at the 90 days of storage. It is revealed from the data that the likeness for colour of jelly decreased during storage period of 90 days. It might be due to accumulation of colour pigments resulted into slight browning of the jelly during storage. Similar trend of decrease in sensory score for colour was observed by Safdar *et al*. (2012) in mango jam.

The interaction effect between treatments and storage period was found to be non-significant at 5 per cent level of significance.

4.5.2 Flavour

The data related to the sensory score for flavour of pomegranate and sapota blended jelly during storage are presented in Table 12 and graphically illustrated in the Fig 11.

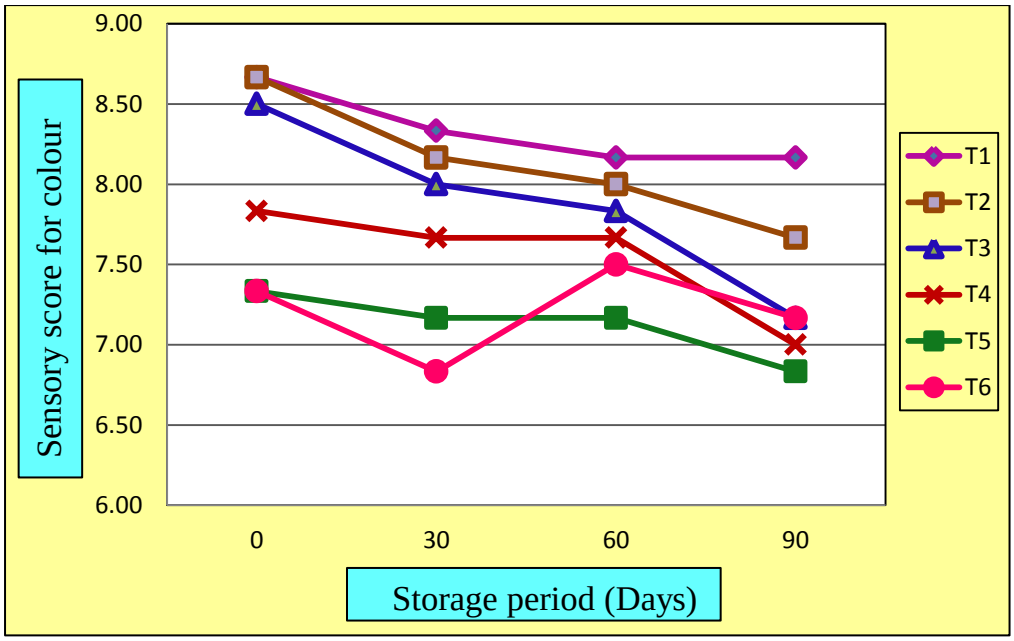
It is apparent from the results that the mean sensory score for flavour was varied significantly due to the treatments and storage period. Maximum (8.00) mean score for flavour of the blended jelly was obtained by the treatment T_6 (0:100) , but it was at par with the treatment T_3, T_4 and T_2. The treatment T_1 (0:100) showed minimum (7.42) mean score for flavour, but it was at par with the treatments T_2 and T_5. The treatments T_2, T_3, T_4 and T_5 were at par with each

other with respect to the sensory score for flavour of the jelly. This clearly indicates that addition of 20 per cent sapota juice was sufficiant to improve the flavour of the pomegranate : sapota blended jelly. Rababah *et al*. (2012) observed similar result for sensory score of flavour in raisin jam.

Table 11: Effect of different proportions of pomegranate and sapota fruit juices on sensory score for colour of blended jelly during storage

Treatments	Sensory score for colour				Mean
	Storage period (Days)				
	0	30	60	90	
T1	8.67	8.33	8.17	8.17	8.33
T2	8.67	8.17	8.00	7.67	8.13
T3	8.50	8.00	7.83	7.17	7.88
T4	7.83	7.67	7.67	7.00	7.54
T5	7.33	7.17	7.17	6.83	7.13
T6	7.33	6.83	7.50	7.17	7.21
Mean	8.06	7.69	7.72	7.33	
		S.Em ±		**CD at 5%**	
Treatments (T)		0.10		0.29	
Storage (S)		0.08		0.24	
Interaction (T×S)		0.21		N.S.	

Fig. 10 : Effect of different proportions of pomegranate and sapota fruit juices on sensory score for colour of blended jelly during storage



T_1: Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

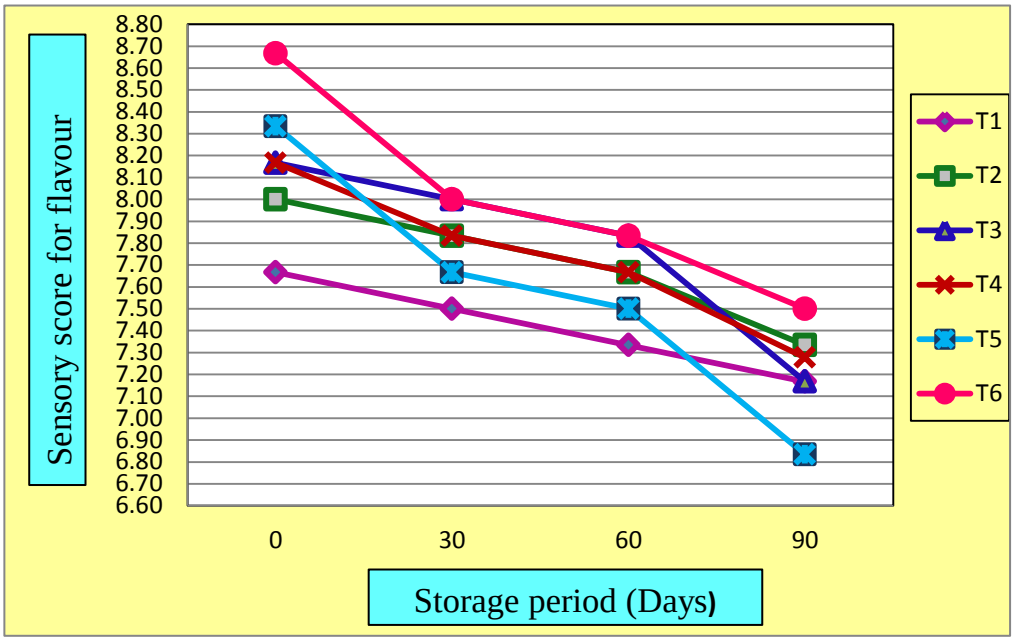
T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

Table 12 : Effect of different proportions of pomegranate and sapota fruit juices on senory score for flavour of blended jelly during storage

Treatments	Sensory score for flavour				Mean
	Storage period (Days)				
	0	30	60	90	
T1	7.67	7.50	7.33	7.17	7.42
T2	8.00	7.83	7.67	7.33	7.71
T3	8.17	8.00	7.83	7.17	7.79
T4	8.17	7.83	7.67	7.28	7.74
T5	8.33	7.67	7.50	6.83	7.58
T6	8.67	8.00	7.83	7.50	8.00
Mean	8.17	7.81	7.64	7.21	
		S.Em ±		**CD at 5%**	
Treatments (T)		0.11		0.31	
Storage (S)		0.09		0.25	
Interaction (T×S)		0.21		N.S.	

Fig. 11: Effect of different proportions of pomegranate and sapota fruit juices on sensory score for flavour of blended jelly during storage



T_1: Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

As regards storage, the mean score for flavour of the blended jelly was decreased significantly with increase in the storage period. It was maximum (8.17) at the time of preparation which decreased to 7.21 at 90 days of storage period. Singh and Chandra (2012) recorded similar results for flavour of guava-carrot jelly.

The interactions between treatments and storage period were found to be non- significant at 5 per cent level of significance.

4.5.3 Texture

The data related to the changes in sensory score for texture of pomegranate and sapota blended jelly during storage are presented in Table 13 and depicted graphically in Fig 12.

The statistical analysis of sensory score for texture of blended jelly reveals that there was a significant difference in mean score for texture among the treatments. Maximum (8.25) mean score for texture was obtained by the treatment T_3 (60:40) which was at par with the treatments $T_{2,}$. The treatment T_4 was at par with the treatments T_5, T_6 and T_2 . Minimum (7.38) mean score for texture of jelly was obtained by the treatment T_1. It is also noticed from the data that blending pomegranate and sapota juice improved the texture of the blended jelly and had better texture than that of straight jelly.

The statistical analysis of sensory score for texture of blended jelly reveals that there was a significant difference in mean score for texture among the storage period.The mean score for texture of the blended jelly was decreased significantly with increase in the storage period. Maximum (8.14) mean score for texture was obtained at the time of preparation which was decreased to 7.72 at 90 days of storage period.

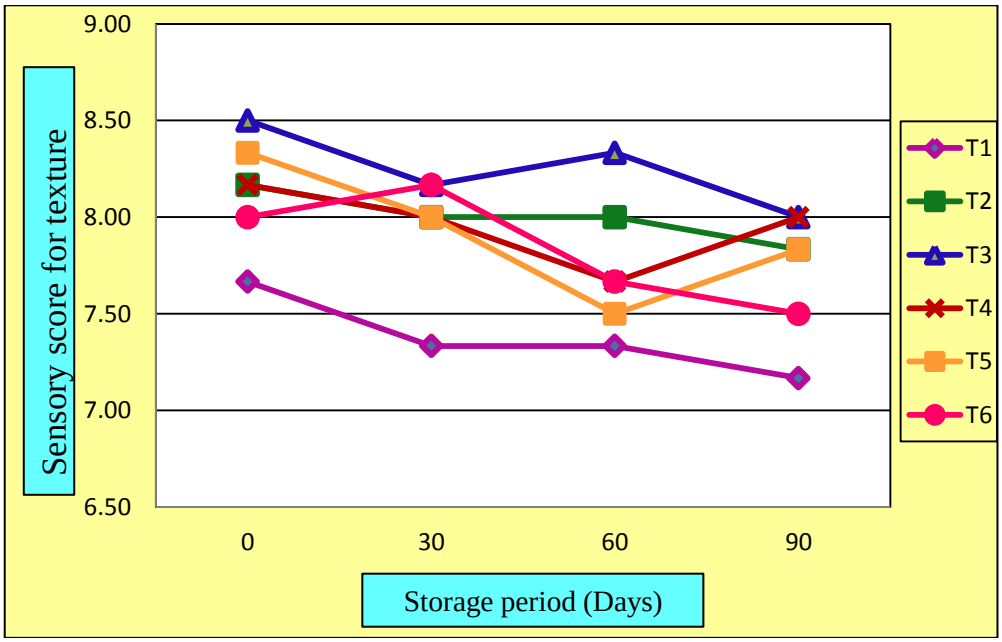
Non significant effect was observed for interaction between storage period and different proportions of pomegranate and sapota fruit juices for texture of the blended pomegranate : sapota jelly at 5 per cent level of significance.

Table 13: Effect of different proportions of pomegranate and sapota fruit juices on sensory score for texture of blended jelly during storage

Treatments	Sensory score for texture				Mean
	Storage period (Days)				
	0	30	60	90	
T1	7.67	7.33	7.33	7.17	7.38
T2	8.17	8.00	8.00	7.83	8.00
T3	8.50	8.17	8.33	8.00	8.25
T4	8.17	8.00	7.67	8.00	7.96
T5	8.33	8.00	7.50	7.83	7.92
T6	8.00	8.17	7.67	7.50	7.83
Mean	8.14	7.94	7.75	7.72	
		S.Em ±		**CD at 5%**	
Treatments (T)		0.09		0.26	

Storage (S)	0.07	0.21
Interaction (T×S)	0.18	NS

Fig. 12 : Effect of different proportions of pomegranate and sapota fruit juices on sensory score for texture of blended jelly during storage



T_1: Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

4.5.4 Overall acceptability

The data on the changes in the sensory score for overall acceptability of pomegranate and sapota blended jelly during storage period are presented in Table 14 and illustrated graphically in the Fig 13.

It is evident from the data that the mean sensory score for overall acceptability of the pomegranate : sapota blended jelly varied significantly due to the treatments. The maximum (7.97) mean score for overall acceptability was obtained by the treatment T_3 (60:40) which was at par with the treatment

T_2. The lowest (7.52) mean score for overall acceptability of the blended jelly was observed in the treatment T_5 (20:80) which was at par with the treatment T_1 and T_6 . It is clear from the data that the treatments T_2 i.e. 80:20 and T_3 i.e. 60 : 40 ratio of pomegranate and sapota juices was preferred as the best treatments among the six treatments comprising different proportion of pomegranate and sapota juices. It might be due to optimum colour, flavour and texture quality characteristics in the blended jelly prepared with 80:20 and 60:40 ratio of pomegranate and sapota fruit juices. The higher ($\geq$ 60 %) levels of sapota juice improved strong sapota flavour to the blended jelly which was not liked by the sensory panel, the treatments T_4 (40:60) and T_5 (20:80) recorded less sensory score for overall acceptability of the blended jelly. Shakir *et al*. (2009) observed similar result for mean score of overall acceptability in the blended apple: pear jam.

Significant differences were observed in the mean sensory score for overall acceptability of pomegranate and sapota blended jelly during 90 days of storage period. The mean score for overall acceptability of the blended jelly was decreased significantly with increase in the storage period. Maximum (8.00) mean score for overall acceptability was obtained at the time of preparation and which was decreased to 7.47 at 90 days of storage period.

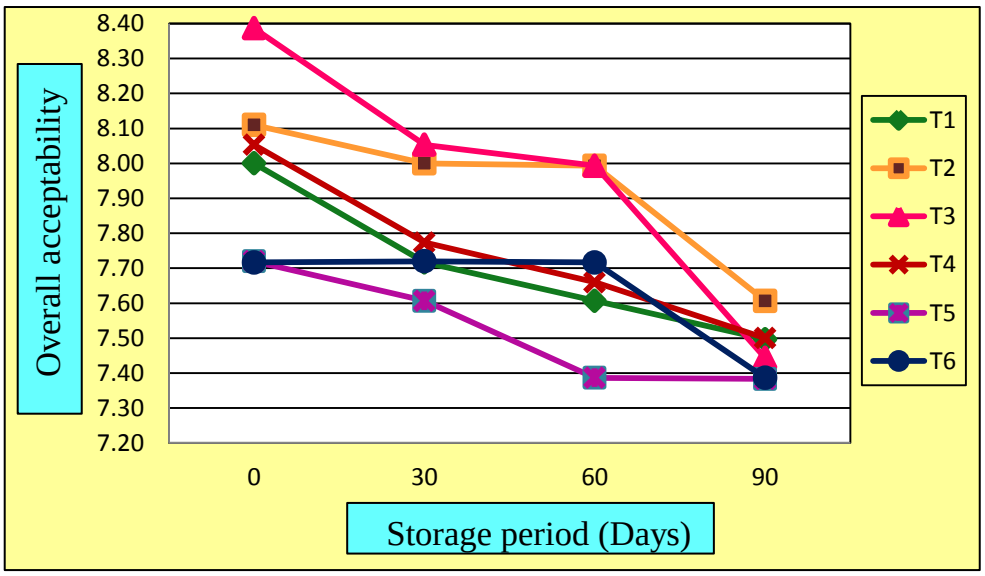
The interaction effect of different proportions of pomegranate and sapota juices and storage periods was also found statistically non-significant for the mean score of overall acceptability of pomegranate and sapota blended jelly.

Table 14 : Effect of different proportions of pomegranate and sapota fruit juices on overall acceptability of blended jelly during storage

Treatments	Sensory score overall acceptability				Mean
	Storage period (Days)				
	0	30	60	90	
T1	8.00	7.72	7.61	7.50	7.71
T2	8.11	8.00	7.99	7.61	7.93
T3	8.39	8.05	7.99	7.44	7.97
T4	8.05	7.77	7.66	7.50	7.75

T5	7.72	7.61	7.39	7.38	7.52
T6	7.72	7.72	7.72	7.39	7.64
Mean	8.00	7.81	7.73	7.47	
		S.Em ±		**CD at 5%**	
Treatments (T)		0.07		0.21	
Storage (S)		0.06		0.17	
Interaction (T×S)		0.15		N.S.	

Fig. 13 : Effect of different proportions of pomegranate and sapota fruit juices on sensory score for overall acceptability of blended jelly during storage



T_1: Pomegranate (100%) + Sapota (0%), **T_2:** Pomegranate (80%) + Sapota (20%),

T_3: Pomegranate (60%) + Sapota (40%), **T_4:** Pomegranate (40%) + Sapota (60%),

T_5: Pomegranate (20%) + Sapota (80%), **T_6:** Pomegranate (0%) + Sapota (100%) .

4.6 Economics of pomegranate : sapota blended jelly

The data related to the economics of 100 kg pomegranate and sapota blended jelly with Rs 10,000/- fixed capital are presented in Table 19.

The total cost of production of 100 Kg jelly was maximum (Rs. 20090.58/-) in the treatment T_1 i.e. 100:0 pomegranate and sapota fruit juices, followed by the treatment T_2. It might be due to higher price of pomegranate

fruit and more labour requirement for the preparatory operations of the jelly. The lowest (Rs. 15904.98/-) cost of production of 100 Kg jelly was observed in the treatment T_6 (0:100) due less price of fruits and labour requirement for preparatory operations of sapota fruit. It is clear from the economics of 100 kg jelly production that the increasing the proportions of sapota juices in the jelly decreased the total cost production of the pomegranate and sapota blended jelly.

Sale price of the pomegranate : sapota blended jelly was evaluated by adding 20 per cent margin to the cost of production. It is observed from the data that the maximum (Rs.48.217/- per 500 g) sale price was rated in for the treatment T_1. However, sale price of the jelly prepared from the treatment T_6 was Rs.38.17/-

Highest net profit (Rs.4018.12/-) was observed in the treatment T_1 (100:0) while lowest net profit (Rs. 3180.99/-) was observed in the treatment T_6 (0:100).

Table 19: Economics of pomegranate and sapota blended jelly (100 kg)

Sr. No.	Particulars	T_1	T_2	T_3	T_4	T_5	T_6
1	Pomegranate fruit @ Rs. 100 / kg	7611	6111	4566	3044	1522	---
2	Sapota fruit @ Rs. 40 /kg	---	684.8	1370	2055	2740	3425
3	Labour charges @ Rs. 150/ labour	1800	1800	1800	1800	1800	1800
4	Sugar @ Rs. 38/kg	2602.62	2602.62	2602.62	2602.62	2602.62	2602.62
5	Citric acid @ Rs. 258/500g	176.70	176.70	176.70	176.70	176.70	176.70
6	Sodium benzoate @ Rs.312/500g	12.68	12.68	12.68	12.68	12.68	12.68
7	Jelly bottles @ Rs. 8/bottles	4000	4000	4000	4000	4000	4000
8	Pectin @ Rs.636/100g	2177.98	2177.98	2177.98	2177.98	2177.98	2177.98
9	Fuel charges @ Rs. 2.1/Kg	210	210	210	210	210	210

Cost of production

1	Working capital (1 to 9)	18590.58	17775.78	16915.98	16078.98	15241.98	14404.98
2	Supervision charges @ 10% of working capital	1859.05	1777.57	1691.59	1607.89	1524.19	1440.49
3	Depreciation charges of the fixed capital 2% on Rs. 10000	200	200	200	200	200	200
4	Interest on the fixed capital @ 13% on Rs.10000	1300	1300	1300	1300	1300	1300
5	Total cost of production (A)	20090.58	19275.78	18415.98	17578.98	16741.98	15904.98
6	Gross production (No. of bottles)	500	500	500	500	500	500
7	Gross returns (B)	24108.7	23130.93	22099.17	21094.77	20090.37	19085.97
8	Net profit (B-A)	4018.12	3855.15	3683.19	3515.79	3348.39	3180.99
9	Sale price/Bottle (Rs.)	48.217	46.26	44.20	42.19	40.18	38.17

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted under the title, "Studies on preparation of pomegranate (*Punica granatum* L.) : sapota (*Manilkara achras* (Mill.) Fosberg) blended jelly" in the Department of Post Harvest Management of Fruit, Vegetable and Flower Crops, Post Graduate Institute of Post Harvest Management, Killa-Roha, Dist. Raigad, during the year 2014-2015.

This research was aimed to standardize proportion of pomegranate cv Bhagwa and sapota cv Kalipatti juices in the blended jelly and to study the storage behaviour of pomegranate : sapota blended jelly. Six treatments comprising different proportions were selected for standardization with three replications. Sapota and papaya blended jelly was analyzed for physical, chemical and sensory quality parameters at 0, 30, 60 and 90 days of storage. The research data was subjected to the statistical analysis with Factorial Completely Randomized Design (FCRD). The research findings are summarized under the following headings.

5.1 Summary

5.1.1 Chemical composition of pomegranate and sapota fruit

Initially, pomegranate and sapota fruits were evaluated for chemical composition and observed 85.1 per cent moisture content in pomegranate fruit and 76.06 per cent moisture in sapota fruit. Total soluble solid content of pomegranate cv Bhagwa and sapota cv Kalipatti was 14.2 and 21.4 ^{0}B, respectively. It was observed that the pomegranate fruit contained 0.42 per cent titratable acidity while sapota fruit had 0.09 per cent titratable acidity. Pomegranate fruit showed 12.29 per cent reducing sugar content whereas it was 7.61 per cent in sapota. However, total sugar content of pomegranate and sapota fruit was 13.27 and 13.20 per cent, respectively.

5.1.2 Changes in the physical quality parameters of the pomegranate : sapota blended jelly during storage

Regarding the physical quality parameters of the blended jelly, it is observed that the L* value for colour varied in the range of 26.35 to 27.94 among the treatments and decreased continuously from 27.07 to 26.84 during storage. Thus, it is concluded that the darkness of colour increased with increase in the storage period. Maximum (36.28) a* value for colour was recorded in the treatment T_1 (100:0) and minimum (2.95) a* value for colour in the T_6 (0:100). During storage, a* value for colour was significantly increased from 20.04 to 20.19. It indicates that redness of jelly was increased with corresponding increase in the amount of pomegranate juice. The treatment T_6 (0:100) exhibited highest (24.96) b* value for colour whereas lowest (20.70) b* value for colour was noticed in the treatment T_1 (100:0). A significant increase from 22.11 to 22.40 was observed during 90 days of storage period.

5.1.3 Changes in the chemical quality parameters of the pomegranate : sapota blended jelly during storage

Moisture content of the pomegranate and sapota blended jelly varied in the range of 22.49 to 23.32 per cent with significant differences among the treatments. The significant increase was observed in the moisture content of jelly from 22.17 to 23.53 per cent during 0 to 90 days of storage periods. Total soluble solid content was found to be maximum (68.97 ^{o}B) in the treatment T_5 (20:80) and minimum (68.22 ^{o}B) in the treatment T_1 (100:0). It was increased from 68.34 to 68.64 ^{o}B during 90 days of storage period. The mean value for titratable acidity was highest (0.52 %) in the treatment T_2 (80:20) and lowest (0.49 %) in the treatment T_5 and T_6 equally. Titratable acidity of the jelly was decreased from 0.58 to 0.44 per cent during storage. The reducing sugar content varied significantly due to the treatments. Highest mean value (48.10 %) for reducing sugars content was observed in the treatment T_1 (100:0). However, lowest mean value (44.04 %) was recorded in the treatment T_6 (0:100).The

reducing sugar content was increased from 32.84 to 59.60 per cent during 90 days of storage period. Maximum (66.68 %) total sugar content was recorded in the treatment T_5. Similar increasing trend was also observed for total sugar content during storage. It was increased from 64.63 to 67.29 per cent during 90 days of storage.

5.1.4 Microbial count

Initially, at the time of preparation no microbial count was observed in the pomegranate : sapota blended jelly. At 90 days of storage period, the maximum (1 cfu/ml) mean value for microbial count was recorded in the treatment T_6 (0:100) and minimum (0) was observed in the treatment T_4 (40:60).

5.1.5 Changes in the sensory quality parameters of the pomegranate : sapota blended jelly during storage

The sensory quality parameters of the pomegranate: sapota blended jelly viz. colour, flavour and texture, were evaluated by nine points hedonic rating test method. The sensory score for colour of the jelly was highest (8.33) in the treatment T_1 (100: 0) and lowest (7.13) in the treatment T_5 (20:80). A decrease was observed in sensory score for colour of the blended jelly from 8.06 to 7.33 during 90 days of storage period at ambient conditions. The mean score for flavour of the jelly was highest for the treatment T_6 (8.00). Lowest (7.42) mean score for flavour was observed in the treatment T_1 (100:0). The mean score for flavour was decreased from 8.17 to 7.21 during 90 days of storage. The mean score (8.25) for texture (firmness) of the blended jelly obtained by the treatment T_3 (60:40) was the highest. Lowest (7.38) mean sensory score was observed in the treatment T_1 (100:0). An increase was noticed from 8.14 to 7.72 during the 90 days of storage.

Based on mean score for overall acceptability, the treatments T_2 (80:20) and T_3 (60:40) were rated as the best treatments with maximum (7.93 and 7.97 respectively) mean sensory score for overall acceptability due to its attractive red colour, optimum pomegranate and sapota flavour and moderately firm texture. However, minimum (7.52) mean score for overall acceptability was observed in the treatment T_5 (20:80).

5.1.6 Economics of the pomegranate : sapota blended jelly

Economics for the production of 100 kg pomegranate and sapota blended jelly of each treatment was estimated with Rs. 10,000/- fixed capital. Total cost of production of 100 Kg jelly in Treatment T_1 (100:0) was maximum (Rs. 20090.58/-). Minimum (Rs. 15904.98/-) total cost was noticed for the production of 100 Kg jelly in the treatment T_6 (0:100) due less fruit price and labour requirement for preparatory operations of the jelly. Sale price for the pomegranate and sapota and blended jelly (500g bottle) was Rs. 48.217/- for the jelly prepared from the treatment T_1. It was estimated by adding the 20 per cent marginal cost in the total cost of production. Highest net profit (Rs. 4018.12/-) was observed in the treatment T_1 (100:0) while lowest net profit (Rs. 3180.99/-) was rewarded in treatment T_6 (0:100).

5.2 Conclusion

It is observed from the data that the pomegranate ; sapota blended jelly was acceptable during three months of storage at ambient conditions. Blending of pomegranate and sapota improved physical, chemical and sensory quality characteristics of the jelly.

The sensory evaluation of jelly revealed that the colour, flavour and firmness of the jelly retained after 90 days of storage period and the jelly was acceptable even after 90 days of storage at ambient conditions. Blending of pomegranate with sapota improved colour and flavor of the blended jelly. Based on the organoleptic evaluation and economics of the jelly it is concluded that the pomegranate : sapota blended jelly could be prepared successfully by blending pomegranate and sapota juice in the ratio of 60:40 with 0.5 per cent acidity and 0.5 per cent pectin content at commercial level with good net profit.

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Original not seen *

APPENDIX I

Weekly Weather Data Roha Center, Year - 2015

Period	Ambient storage conditions			
	Temperature (°C)		Relative humidity (%)	
	Max.	Min.	Max.	Min.
02.11 – 08.11	37.0	21.5	60.4	32
09.11 – 15.11	34.1	25.0	84.0	51
16.11 – 22.11	34.8	24.2	89.4	52
23.11 – 29.11	33.5	16.2	88.3	41
07.12 – 13.12	33.4	18.2	78.0	58
14.12 – 20.12	29.8	14.3	88.4	54
21.12 – 27.12	32.9	16.9	94.0	62
28.12 – 03.01	26.6	12.4	55.0	22
04.01 – 10.01	27.7	14.4	88.0	42
11.01 – 17.01	25.3	13.4	77.0	32
18.01 – 24.01	26.0	11.3	72.4	30
25.01 – 31.01	26.6	11.7	67.7	42
01.02 – 07.02	26.0	11.1	82.6	45
08.02 – 14.02	30.1	13.5	60.4	42
15.02 – 21.02	37.1	17.3	73.4	45
22.02 – 28.02	31.6	16.4	69.3	35
01.03 – 07.03	33.8	25.1	89.1	76
08.03 – 14.03	31.0	23.9	91.4	91
15.03 – 21.03	37.0	17.0	73.0	54
22.03 – 28.03	31.5	16.0	69.0	24
29.03 – 04.04	34.0	19.5	78.0	23

APPENDIX II

ABBREVATIONS

%	:	per cent
(TxS)	:	Interaction of treatments and storages
/	:	Per
@	:	At the rate of
°B	:	Degree Brix
°C	:	Degree Celsius
a*	:	Redness
A.O.A.C.	:	Association of Official Analytical chemists
Anon.	:	Anonymous
b*	:	Yellowness
C.D.	:	Critical difference
cv	:	Cultivar
et al.	:	and others
FCRD	:	Factorial Completely Randomized Design
Fig.	:	Figure
g	:	Gram (s)
ha		Hectare
Hrs	:	Hours
i.e.	:	that is
Kg	:	Killo grams
L*	:	Lightness

M.S.	:	Maharashtra State.
Mg	:	Milligram
Ml	:	Milliliter
MT	:	Metric tonnes
N	:	Newton
NS	:	Non-significant
ppm	:	Parts per million
RH	:	Relative humidity
S.Em.	:	Standard error of mean
Sig.	:	Significant
T	:	Treatments
TSS	:	Total soluble solids
viz	:	Namely

VITAE

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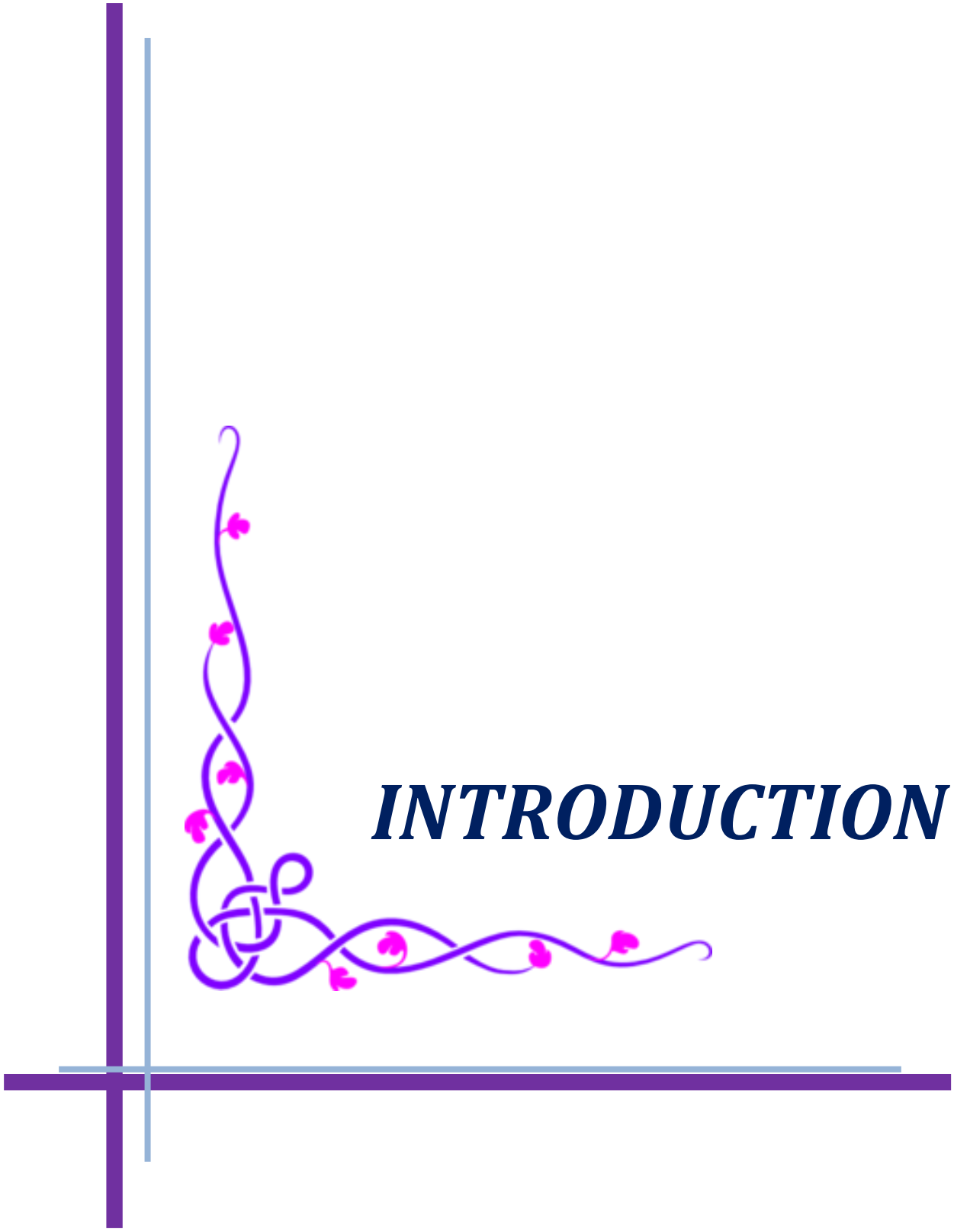

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