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To study the changes in chemical and microbial quality parameters of the blended pineapple (*Ananas comosus* L.) and nutmeg (*Myristica fragrans* L.) rind jelly cubes during storage after product development

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Abstract
An experiment entitled, to study the "changes in chemical and microbial quality parameters of the blended pineapple (*Ananas comosus* L.) and nutmeg (*Myristica fragrans* L.) rind jelly cubes during storage after product development" was conducted in the Department of Post-Harvest Management of Fruit, Vegetable and Flower Crops, P.G. Institute of Post-Harvest Management., Killa- Roha during the year 2017-2018. It was aimed to develop the blended jelly cubes by using various proportions of pineapple and nutmeg rind fruit juices *viz.* 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50. The blended pineapple and nutmeg rind jelly cubes were evaluated for chemical and microbial quality parameters during 90 days of storage period.
The significantly increase was found in the Moisture, Total soluble solids, Reducing sugar and Total sugars content of jelly from 26.56 to 27.93 percent, 69.60 °B to 69.93 °B, 20.07 to 22.26 percent and 57.51 to 61.33 percent were as Titratable acidity of the jelly was decreased from 1.02 to 0.81 percent during storage.
Based on the Chemical quality parameters evaluation and economics of the jelly cubes, the blended pineapple and nutmeg rind jelly cubes could be prepared by blending pineapple and nutmeg rind juice in the ratio of 70:30 with optimum consumer acceptability upto 90 days of storage at ambient condition.

Keywords: Microbial quality parameters, blended pineapple, *Ananas comosus* L., rind jelly cubes

1. Introduction

1.1 Pineapple

Pineapple (*Ananas comosus*) is one of the most important horticultural crops and is the third most important tropical fruit in the world after banana and citrus in terms of production (Guin *et al.*,2010) [21].
The world total annual production of pineapple during 2016-2017 was 67,434 tonnes. The area of pineapple production in India is 89,000 ha, with a production of 1.42 million tonnes and a productivity of 15.9 tonnes/ha. (Bijaykumar, 2011) [22]. According to Samson (1986) [17], pineapple mainly contains water, carbohydrates, sugars, vitamin A, vitamin C and β carotene. It contains low amounts of protein, fat, ash, fiber and antioxidants namely flavonoids in addition to citric and malic acid and moderate amounts of ascorbic acid (Tochi *et al.*, 2008) [8].
Pineapple is cultivated predominantly for its fruit that is consumed fresh or as canned fruit and juice. Pineapple is the only source of bromelain, a complex proteolytic enzyme used in the pharmaceutical market and as a meat-tenderizing agent. The stems and leaves of pineapple plant are also a source of fibre that is white, creamy and lustrous as silk. Pineapple fibre has been processed into paper with remarkable qualities of thinness, smoothness and pliability. Parts of the plant are used for silage and hay for cattle feed. Processing wastes in the form of shell, core materials and centrifuged solids from juice production are also used as animal feed. Alcoholic beverages can also be made from juice. (International tropical fruit network, 2018)
Pineapple helps several enzymes present in the body to produce energy as it contains magnesium and vitamin B1, which are essential for the normal functioning of some enzymes. It is an excellent source of antioxidant vitamin C, which is required for the collagen synthesis in the body (MacDonald and Low, 1996) [23]. Pineapples can be consumed fresh, cooked, juiced or preserved. The edible portion of pineapple contains 81.2-86.2% moisture and 13-19% total solids.

1.2 Nutmeg

Nutmeg (*Myristica fragrans*) is unique among spices as it produces two spices, nutmeg and mace. It belongs to the myristicaceae family with about 18 genera and 300 species. Indonesia and Grenada are the major producers of nutmeg. Nutmeg was introduced in India for quite a long time. It is seen mainly in Kerala, Tamil Nadu and Karnataka (Purseglove *et al.*, 1981) [12]. The fruit is a fleshy drupe usually pendulous, broadly pyriform, yellow and smooth. It is 60-90 mm long. When ripe, the yellow pericarp splits open into two halves, exposing the shiny brown testa surrounded by a laciniate red aril. The testa contains a brown kernel, which is 20-30 mm long and 15-20 mm broad. The kernel is wrinkled and contains a lighter coloured endosperm and a small embryo (Purseglove *et. al.*, 1981) [12]. Fresh ripe pericarp has an acidic, astringent, aromatic juice. Fruit rind, contains 86.8% moisture, 1% protein, 0.4% ether extract, 11.2% carbohydrates, 0.6% mineral matter with 0.04% calcium, 0.01% phosphorous, 2 mg iron and 8 i.u/100 g carotene (Anon., 2017) [24].

Fruits, which are rich in nutrients but are not accepted due to high acidity or poor taste and flavour, can be blended with other fruits to improve their acceptability and make use of available nutrients (Khan *et al.*, 1988) [25].

Hence, blending vitamin rich pineapple juice with spicy flavour nutmeg juice may improve the nutritional quality and enhance taste of the pineapple: nutmeg blended jelly cubes. When pineapple is used as fruit base in the preparation of blended jelly.

Keeping this in view, the experiment entitled, to study the "changes in chemical and microbial quality parameters of the blended pineapple (*Ananas comosus* L.) and nutmeg (*Myristica fragrans* L.) rind jelly cubes during storage after product development" with following objectives-

1. To standardize the proportion of pineapple and nutmeg rind juice in the blended jelly.
2. To study the storage behavior of pineapple and nutmeg rind blended jelly.

2. Material and Methods

The present research entitled, to study the "changes in chemical and microbial quality parameters of the blended pineapple (*Ananas comosus* L.) and nutmeg (*Myristica fragrans* L.) rind jelly cubes during storage after product development" 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 2017-2018.

2.1 Experimental material

The mature fruits of pineapple local and nutmeg rind fruit were procured from local farmers of Raigad district (MS). After washing, fruits were used for the preparation of jelly. For making jelly, pectin, sugar and chemicals like citric acid and sodium benzoate were added. The above material was procured from the Department of Post- Harvest Management of Fruit, Vegetable and Flower Crops, Post Graduate Institute of Post-Harvest Management, Killa-Roha, and Dist-Raigad.

2.2 Experimental details

Experimental details

Crop	:	Pineapple (*Anana scomosus*L.) and Nutmeg (*Myristica fragrans* L.)
Cultivar	:	Pineapple Local and Nutmeg local Cultivar
Design	:	Factorial Completely Randomized Design (FCRD)
Number of treatment combinations	:	6 × 4 = 24
Replications	:	3

2.3 Treatment details

Main treatments

Treatments		Proportion of pineapple and nutmeg juice
T_1	:	100:00
T_2	:	90:10
T_3	:	80:20
T_4	:	70:30
T_5	:	60:40
T_6	:	50:50

Sub treatments

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

2.4 Methods

2.4.1 Physical parameters of pineapple and nutmeg rind:

2.4.1.1 Juice recovery

The consumable part of the fruit was weighted and known amount was taken for blending. The blended homogenized pulp was passed through a set of muslin cloth to separate the solid particles. The juice was collected in a measuring cylinder and recovery of juice content was given as follows:

$$\text{Juice recovery (\%)} = \frac{Volume\ of\ juice}{Weight\ of\ fruit} \times 100$$

2.4.1.2 Colour

The colour of pineapple and nutmeg fruit juices were measured by using colour reader (make Konica Minolta, Japan CR-400) and expressed as L*, a* and b* values.

2.4.2 Chemical parameters of pineapple and nutmeg rind:

2.4.2.1 Moisture

The moisture content was measured directly by using Contech moisture analyzer made in India (model CA-123) at 100 °C temperature and expressed as percent moisture content on electronic display directly.

2.4.2.2 Total Soluble Solids

The total soluble solids were determined by using Hand Refractometer (Atago Japan, 0-32 °B) and the values were corrected at 20 °C with the help of temperature correction chart (A.O.A.C., 1975) [1].

2.4.2.3 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) [1]. 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, 2003) [30]. The results were expressed as percent anhydrous citric acid.

$$\text{Titratable acidity}(\%) = \frac{\text{Normality of alkali X Titre reading X Volume made X Equivalent weight of acid}}{\text{Weight of sample taken X Volume of sample taken for estimation X 1000}} X100$$

2.4.2.4 Reducing sugars

The reducing sugars were determined by the method of Lane and Eynon (1923) [31] as described by Ranganna (2003) [30]. A known weight of sample was taken in 250 ml volumetric flask. To this, 100 ml of distilled water was added and the contents were neutralized by 1 N sodium hydroxide. Then 2 ml of 45 percent lead acetate was added to it. The contents were mixed well and kept for 10 minutes. Two ml of 22 percent potassium oxalate was added to it to precipitate the excess of lead. The volume was made to 250 ml with distilled water and solution was filtered through Whatman No. 4 filter paper. This filtrate was used for determination of reducing sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' solutions (5 ml each) using methylene blue as indicator to a brick red end point. The results were expressed on percent basis.

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

2.4.2.5 Total sugars

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

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

2.4.3 Preparation of jelly cubes

The product was prepared as per the steps given below

2.4.3.1 Extraction of juice

Fresh ripe pineapple fruits were crushed by mixer grinder. Then, the pulp was squeezed through muslin cloth for the juice extraction. Nutmeg rind cut into small pieces and crushed into mixer grinder then squeezed through muslin cloth for the juice extraction.

2.4.3.2 Straining of juice

The juice of both pineapple and nutmeg was strained by passing it through four fold muslin cloth to remove all colloidal particles and scum.

2.4.3.3 Addition of water

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

2.4.3.4 Blending of juices

The juices of pineapple (Cv. Local) and nutmeg were blended in different proportions as per the treatments.

2.4.3.5 Addition of sugar

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

2.4.3.6 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.

2.4.3.7 Addition of pectin

Out of the total required sugar, $1/10^{th}$ part of sugar was mixed with 2 percent pectin powder so as to dissolve the pectin easily in juice. After reaching 60 °B TSS, pectin extract was sprinkled on mixture with continuous stirring to avoid loss of jelly forming strength of pectin.

2.4.3.8 Addition of citric acid

Upon reaching 65 °B TSS, the citric acid was added @ 0.5 percent in order to prevent sucrose crystallization in the finished product and to establish the optimum gel formation. The citric acid was added at the end of cooking for proper sugar inversion.

2.4.3.9 Addition of sodium benzoate

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

2.4.3.10 Filling, packing and processing of jelly

When the TSS of jelly reached to 68 °B, the blended jelly was poured hot in the cube shape moulds and allowed the jelly to set for 15 minutes in moulds. After jelly was set, the blended jelly cubes were packed in the glass bottles. Glass bottles were processed for 10 minutes in boiling water and then the jelly cubes were stored in ambient condition for further investigation.

2.4.4 Changes in the chemical quality parameters of the blended pineapple and nutmeg rind jelly cubes during storage

The biochemical parameters like moisture, total soluble solids, titratable acidity, reducing and total sugars were analyzed with the methods described under 2.4.2. Initially (0 day) and thereafter at an interval of 30 days for a period of 90 days during storage at ambient condition

2.5 Microbial analysis

The microbial analysis of the blended pineapple and nutmeg

rind jelly cubes was carried out at 0 day and after 90 days of storage as per the method described by.

2.5.1 Bacteria
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 °C for 20 min. When the temperature of media reached to 40 °C, it was used for plating.
The plating was carried out with 0.1 ml sample in sterile petri plates under the Laminar Air Flow. The sample of each treatment was taken on a separate petri plate, followed by pouring of approximately 20 ml of media (35-40 °C) on the sample and mixing was done by tilting plate properly. Plates were sealed with para film and incubated at 37 °C for 48 hrs to check bacterial count. Total microbial plate count was measured in colony forming unit/gram (cfu/g).

2.5.2 Fungi
Potato dextrose agar media was prepared for the colony count of fungi. Plates were sealed with para film and incubated at 37 °C for 5-6 days for fungal count. The total microbial plate count was measured in colony forming unit/g initially and at the end of storage of period of 90 days.

2.6 Statistical analysis of the blended pineapple and nutmeg rind jelly cubes
The data collected on chemical parameters of pineapple and nutmeg rind such as moisture, TSS, titratable acidity and sugars were represented as mean values. The data collected on the changes in chemical and biological quality parameters of blended pineapple and nutmeg jelly cubes during storage were statistically analyzed by the standard procedure given by Amdekar (2014) [27] using Factorial Completely Randomized Design and valid conclusions were drawn only on significant differences between treatment mean at 5 percent level of significance.

2.7 Economics of the blended pineapple and nutmeg rind jelly cubes
The economics of the product was worked out by considering existing rates of various inputs such as cost of raw material (fruits), labour, fuel, chemicals, packaging material, depreciation charges (repairing charge) and interest on the fixed capital. The gross returns as per the treatments were worked out by considering prevailing market price. The sale price of the product was calculated by adding 20 percent profit margins to the cost of product for different treatments of the experiment.

Flow chart-I
Extraction of pineapple and nutmeg rind juice

1. Extraction of pineapple juice

Selection of fruits
↓
Washing and cleaning of fruits
↓
Peeling and cutting

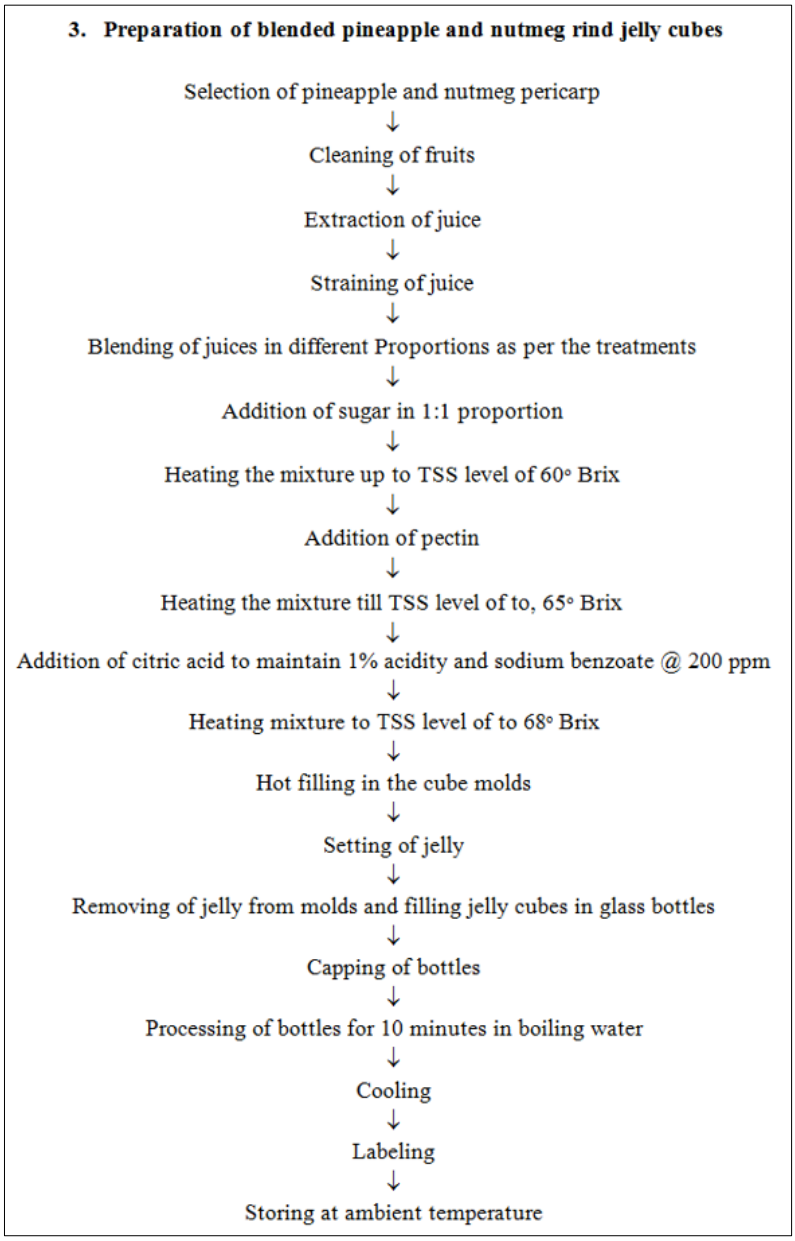
Homogenizing in the mixer
↓
Squeezing the pulp through muslin cloth for juice extraction

2. Extraction of nutmeg rind juice

Selection of fruitpericarp
↓
Cleaning of pericarp
↓
Blanching in 2% brine solution for 10 min.

Peeling
Cutting into pieces and crushing in grinder
↓
Extraction of juice by squeezing the pulp through muslin cloth

Flow Sheet-II



3. Results and Discussion

The present investigation entitled, to study the "changes in chemical and microbial quality parameters of the blended pineapple (*Ananas comosus* L.) and nutmeg (*Myristica fragrans* L.) rind jelly cubes during storage after product development" 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 2017-2018.

The local cultivar of pineapple and nutmeg rind fruit were selected standardize the proportion of pineapple and nutmeg rind juices in the preparation of jelly and to study storage behaviour of blended pineapple and nutmeg rind jelly cubes. The experiment consisted of six treatments, comprising different proportions of pineapple and nutmeg rind juices i.e. 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50. The experimental data was analysed statistically using Factorial Completely Randomized Design (FCRD). The observations on the changes in chemical and biological quality parameters of blended pineapple and nutmeg rind jelly cubes 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.

3.1 Chemical parameters of pineapple and nutmeg rind:

The data related to the chemical parameters of local types of pineapple fruit and nutmeg rind are presented in Table 1.

Table 1: Chemical parameters of pineapple and nutmeg rind juice:

Sr. No.	Parameters	Pineapple	Nutmeg rind
1	Moisture content (%)	84.00	91.24
2	Total soluble solids (°B)	12.00	4.00
3	Titratable acidity (%)	0.51	2.30
4	Reducing sugars (%)	8.22	1.30
5	Total sugars (%)	10.90	2.55
6	Juice recovery (%)	71.10	67.70
7	Colour Value L*	35.85	-
8	Colour Value a*	-1.73	-
9	Colour Value b*	3.68	-

*Values are the average (mean) of three observations.

3.1.1 Juice recovery (%)
The data regarding juice recovery of pineapple fruit presented in Table 1 revealed that the average juice recovery of pineapple fruit was 72 percent. The similar result 72.20 percent was reported by Khalid *et al*. (2015) [10] in pineapple fruit juice. The recovery of nutmeg rind juice was recorded as 67.70 percent.

3.1.2 Colour
The mean colour in terms of tri-stimulus values of L*, a* and b* of pineapple fruit juice was recorded as 35.85, -1.73 and 3.68, respectively. Similar 36.28, -1.80 and 3.84 results are recorded by the Assawarachan, R.,and Noomhorm, A. (2010) [2] in pineapple juice.

3.2 Nutmeg rind
3.2.1 Moisture
Moisture content of nutmeg was recorded as 91.24 percent. Closely related result for moisture content of nutmeg fruit was observed by Simenthy (2015) [19], Gopal krishnan (1992) [8]. They recorded 88.4 and 88 percent moisture content in nutmeg fruit, respectively. The slight variation in the moisture content was due to variation in the sample for study by various worker.

3.2.2 Total Soluble Solids
The total soluble solid content of nutmeg was 4 °Brix. Identical result for the TSS i.e. 3.8 °Brix of nutmeg fruit was recorded by Simenthy (2015) [19].

3.2.3 Titratable acidity
The data regarding titratable acidity of nutmeg presented in Table 1 revealed that the average acidity of nutmeg fruit was 2.3 percent. The result in similar line was reported by Gopalkrishnan (1992) [8]. They recorded 2.5% acidity in nutmeg fruit rind.

3.2.4 Reducing sugars
The data with respect to reducing sugars of nutmegfruit was presented in Table 1. The percent reducing sugars of nutmeg fruit rind was recorded as 1.3 percent. Closely related result for the reducing sugar content (1.58 percent) of nutmeg fruit rind was reported by Gopalkrishnan (1992) [8].

3.2.5 Total sugars
The data with respect to total sugars of nutmeg fruit presented in Table 1 reveals that the percent total sugars of nutmeg fruit was 2.55 percent. Similarly Simenthy (2015) [19] recorded 2.69 percent total sugar in nutmeg fruit.

3.3 Pineapple
3.3.1 Moisture
Moisture content of pineapple was recorded as 84 percent. Closely related result for moisture content of pineapple fruit was observed by Hossain *et al* (2015) [9]. They recorded 81 to 85 percent moisture content in pineapple fruit, respectively.

3.3.2 Soluble Solids
Total soluble solids content of the pineapple fruit juice was recorded about 12 °B similar results are observed by Balaswamy (2012) [3] reported that ripe pineapple fruits with total soluble solid content 12º Brix.
Expedito *et al.,* (1996) [5] reported that fully ripe, medium sized Queen variety fruits, with soluble solid content from 10 to 12 ºBrix, were used in these experiments.

3.3.3 Titratable acidity
0.51 percent titratable acidity was recorded into the pineapple fruit juice, similar results are recorded by, Balaswamy (2012) [3] reported that ripe pineapple fruit juice acidity content 0.46 percent and Khurdiya (1987) [11] reported the acidity of pineapple juice in the range of 0.3 to 0.8 percent.

3.3.4 Reducing sugars
Reducing sugar content 8.22 percent was recorded into the pineapple fruit, similar results are recorded by the Balaswamy (2012) [3] reported that ripe pineapple fruit juice reducing sugar content 8.4 percent.

3.3.5 Total sugars
10.90 percent total sugar content was observed into the pineapple similar results are recorded by, Balaswamy (2012) [3] reported that ripe pineapple fruit juice total sugar content 10.6 percent.

3.4 Changes in the chemical quality parameters of the blended pineapple and nutmeg rind jelly cubes during storage
3.4.1 Moisture
The data related to the changes in moisture content of the blended pineapple and nutmeg rind jelly cubes during storage are presented in Table 2 and illustrated graphically in Fig 1.

Table 2: Effect of different proportions of pineapple and nutmeg rind juices on the Moisture of blended jelly cubes during storage

Treatments	Moisture (%)				Mean
	Storage period (Days)				
	0	30	60	90	
T1	25.57	25.69	26.19	27.20	26.16
T2	26.19	26.23	26.88	27.6	26.73
T3	26.64	26.80	27.64	28.13	27.30
T4	26.99	27.52	27.69	28.17	27.60
T5	27.39	28.13	28.59	28.57	28.17
T6	27.82	28.27	28.84	28.90	28.46
Mean	26.56	26.88	27.40	27.93	27.19
		S.Em ±		CD at 5%	
Treatments (T)		0.06		0.18	
Storage (S)		0.05		0.14	
Interaction (T×S)		0.12		NS	

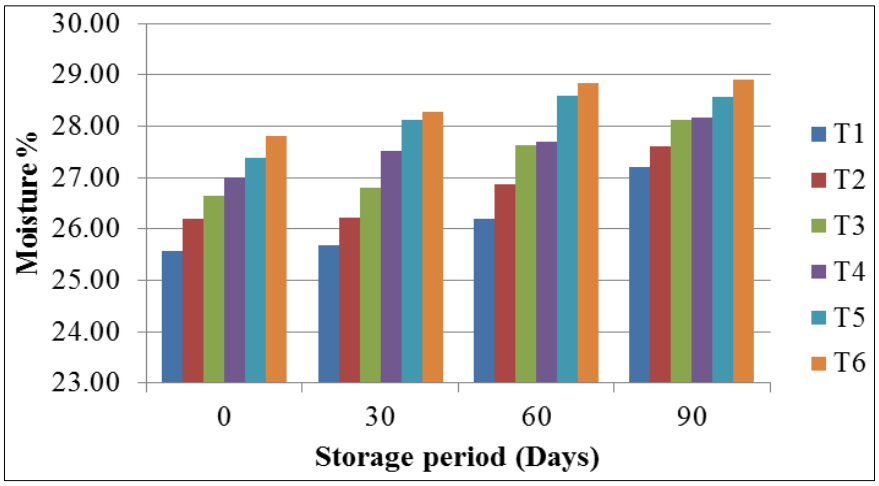


Fig 1: Effect of different proportions of pineapple and nutmeg rind juices on the moisture percent of blended jelly cubes during storage

The maximum moisture content (28.46%) was recorded in the treatment T_6 [pineapple (50%): nutmeg rind (50%)].Which is significantly superior over all the treatment followed by T5 [pineapple (60%): nutmeg rind (40%)], T4 [pineapple (70%): nutmeg rind (30%)] and T3 [pineapple (80%): nutmeg rind (20%)] in that order however, minimum moisture content (26.16%) was recorded in the treatment T_1 [pineapple (100%): nutmeg rind (0%)].Similar findings were also recorded by Gaikwad (2016) [6] in sapota and beetroot blended jelly and Deokar (2017) [4] for moisture content.

Moisture content of jelly cubes changed significantly during 90 days of storage period. Maximum mean value for moisture content was observed at 90 days of storage period which was 28.46 percent. Minimum mean value for the moisture content was observed 26.16 percent at the time of preparation. The significant increase was observed in the moisture content of jelly cubes from 25.57 to 28.90 percent during 0 to 90 days of storage periods. This effect was related with the increase in water activity and temperature during 90 days of storage period. Similar trends were reported by Raut (2015) [14] in pomegranate and sapota juice blended jelly.

3.4.2 Total Soluble Solids

The data on the changes in the total soluble solid contents of blended pineapple and nutmeg rind jelly cubes during storage are presented in Table 3 and depicted in Fig 2.

Table 3: Effect of different proportions of pineapple and nutmeg rind juices on the TSS of blended jelly cubes during storage

Treatments	TSS (°B)				Mean
	Storage period (Days)				
	0	30	60	90	
T1	69.83	69.98	70.04	70.16	70.00
T2	69.71	69.88	69.94	70.05	69.90
T3	69.64	69.70	69.80	69.97	69.78
T4	69.47	69.53	69.60	69.80	69.60
T5	69.37	69.43	69.53	69.67	69.50
T6	69.33	69.40	69.47	69.57	69.44
Mean	69.60	69.71	69.78	69.93	69.76
		S.Em ±		CD at 5%	
Treatments (T)		0.02		0.07	
Storage (S)		0.02		0.06	
Interaction (T×S)		0.05		NS	

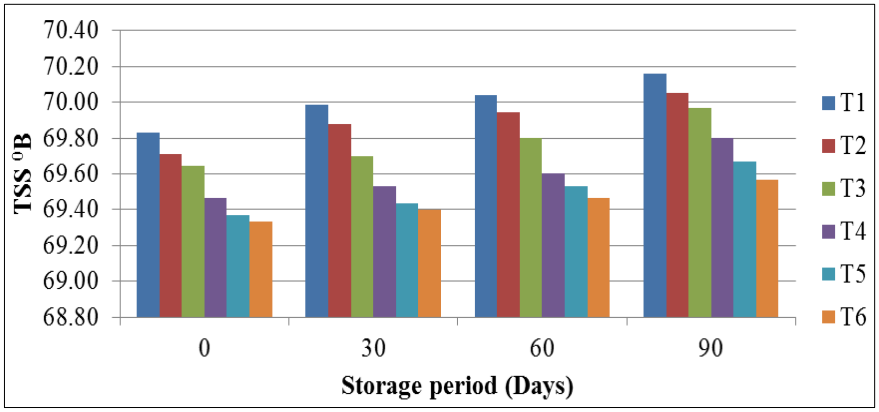


Fig 2: Effect of different proportions of pineapple and nutmeg rind juices on the TSS of blended jelly cubes during storage

Data recorded for total soluble solid contents of the blended jelly cubes indicated that the mean value for total soluble solid content was maximum (70.00 °B) in the treatment T_1 [pineapple (100%): nutmeg rind (0%)].Which was significantly superior over rest of the treatments. The treatment T_6 [pineapple (50%): nutmeg rind (50%)] showed minimum (69.44 °B) mean value for the total soluble solid content and it was at par with the treatments T_5 [pineapple (60%): nutmeg rind (40%)].

It is observed from the data that the total soluble solid contents of jelly cubes declined significantly with decrease in the proportion of pineapple juice in the blended jelly cubes. Poonam *et al*. (1997) [28] found similar results for total soluble solid content during standardization of jelly from grape and guava blends.

3.4.3 Titratable acidity

The data related to the changes in the titratable acidity of the blended pineapple and nutmeg rind jelly cubes during storage period are presented in Table 4 and graphically illustrated in Fig 3.

Table 4: Effect of different proportions of pineapple and nutmeg rind juices on the titratable acidity of blended jelly cubes during storage

Treatments	Titratable acidity (%) Storage period (Days)				Mean
	0	30	60	90	
T1	1.00	0.94	0.86	0.76	0.89
T2	1.02	0.96	0.88	0.80	0.91
T3	1.03	0.97	0.89	0.82	0.93
T4	1.03	0.98	0.91	0.84	0.94
T5	1.04	0.99	0.92	0.85	0.95
T6	1.06	1.00	0.92	0.86	0.96
Mean	1.02	0.97	0.89	0.81	0.92
		S.Em ±		CD at 5%	
Treatments (T)		0.003		0.010	
Storage (S)		0.002		0.008	
Interaction (T×S)		0.006		NS	

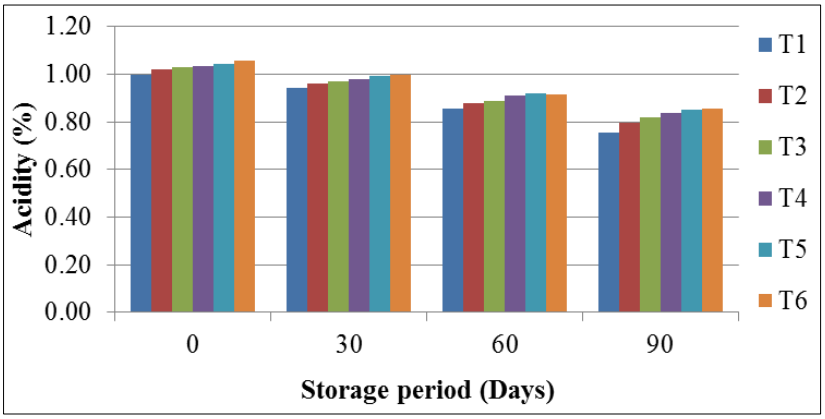


Fig 3: Effect of different proportions of pineapple and nutmeg rind juices on the titratable acidity of blended jelly cubes during storage

It was observed from the data that the titratable acidity of blended pineapple and nutmeg rind jelly cubes varied significantly due to the treatments. The treatment T_6 [pineapple (50%): nutmeg rind (50%)] showed highest mean value (0.96%) for titratable acidity which was significantly superior over all other treatments, followed by the treatments T_5 [pineapple (60%): nutmeg rind (40%)] and T_4 [pineapple (70%): nutmeg rind (30%)] in that order. The minimum acidity (0.89%) was recorded by the treatment T_1 [pineapple (100%): nutmeg rind (0%)], followed by T_2 [pineapple (90%): nutmeg rind (10%)]. It is observed from the data that the titratable acidity of jelly cubes declined significantly with increase in the proportion of pineapple juice in the blended jelly cubes. This might be attributed to the chemical reactions between organic constituents of fruit induced by temperature and action of enzyme during storage. Hossen *et al*. (2009) [26] observed similar observations for titratable acidity in guava jelly. Identical result was also reported by Deokar (2017) [4] in sapota and tamarind blended jelly for titratable acidity.

Significant differences were recorded for titratable acidity of blended pineapple and nutmeg rind jelly cubes during 90 days of storage. A linear decline in the mean values of titratable acidity of blended pineapple and nutmeg rind jelly cubes was noticed from 1.00 percent initially to 0.86 percent after 90 days of storage and results were statistically significant. This decrease might be due to acid hydrolysis of polysaccharides and non-reducing sugars to their simpler components where the acid is utilized for converting them to hexose sugars or complexes in the presence of metal ions (Archana and Laxman, 2015). Tomar *et al*. (1988) [20] observed a decreasing trend in the titratable acidity during three months of storage period in diabetic jelly prepared from guava and papaya extracts. Deokar (2017) [4] also found a decreasing trend for titratable acidity in sapota and tamarind juice blended jelly during three months of storage.

3.4.4 Reducing sugars

The data related to the changes in reducing sugars content of the blended pineapple and nutmeg jelly cubes during storage are presented in Table 5 and depicted graphically in Fig 4.

Table 5: Effect of different proportions of pineapple and nutmeg rind juices on the Reducing sugar of blended jelly cubes during storage

Treatments	Reducing sugar (%) Storage period (Days)				Mean
	0	30	60	90	
T1	22.08	22.16	23.17	23.99	22.85
T2	21.43	21.63	22.49	23.36	22.23
T3	21.42	21.39	22.20	21.91	21.98
T4	20.24	20.65	21.29	22.15	21.08
T5	19.01	19.74	20.51	21.80	20.27
T6	18.22	19.37	20.35	21.10	19.36
Mean	20.07	20.56	21.37	22.26	
		S.Em ±		CD at 5%	
Treatments (T)		0.07		0.21	
Storage (S)		0.06		0.17	
Interaction (T×S)		0.15		NS	

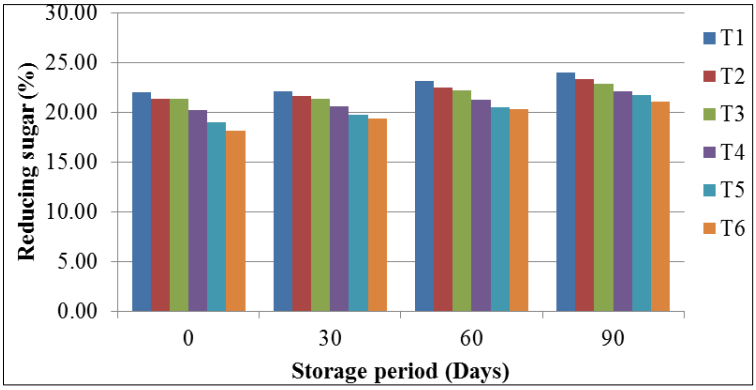


Fig 4: Effect of different proportions of pineapple and nutmeg rind juices on the reducing sugar percent of blended jelly cubes during storage

It can be observed from the data that reducing sugars content of blended pineapple and nutmeg rind jelly cubes varied significantly due to the treatments as well as the storage period.

The mean value for reducing sugars content of the blended jelly cubes in the treatment T_1 [pineapple (100%): nutmeg rind (00%)] was highest (22.85%) which was superior over all other treatments, followed by T_2 [pineapple (90%): nutmeg rind (10%)]. The lowest (19.36%) mean value for reducing sugars content was observed in the treatment T_6 [pineapple (50%): nutmeg rind (50%)] which was followed by the treatment T_5 [pineapple (60%): nutmeg rind (40%)]. Decreasing the proportion of pineapple juice to nutmeg rind from 100:00 to 50:50 resulted into significant fall in the reducing sugar content of the blended jelly cubes. Higher level of nutmeg juice increased the acidity of the blended jelly that resulted into more conversion of non-reducing sugars into reducing sugars due to acid hydrolysis. Relekar *et al*. (2011) [16] recorded similar findings for reducing sugars content in sapota jelly.

Significant difference was observed in the mean values of reducing sugars content of blended pineapple and nutmeg jelly cubes during 90 days of storage period. Lowest mean value for reducing sugars content (18.22%) was observed at the time of preparation, while highest mean value for reducing sugars content (23.99%) was recorded at 90 days of storage. 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) [20] 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) [16], Gaikwad (2016) [6] in sapota and beetroot blended jelly.

3.4.5 Total sugars

The data pertaining to the changes in the total sugar content of blended pineapple and nutmeg rind jelly cubes during storage are presented in Table 6 and depicted graphically in the Fig 5.

Table 6: Effect of different proportions of pineapple and nutmeg rind juices on the Total sugar of blended jelly cubes during storage

Treatments	Total sugar (%) Storage period (Days)				Mean
	0	30	60	90	
T1	60.04	60.80	62.22	62.83	61.47
T2	58.25	59.53	60.87	61.58	60.06
T3	57.82	59.41	60.75	60.82	59.70
T4	56.09	57.91	58.65	60.74	58.25
T5	55.35	56.45	57.99	60.68	57.62
T6	54.29	55.86	58.00	60.14	57.08
Mean	57.91	58.74	60.10	61.33	59.42
		S.Em ±		CD at 5%	
Treatments (T)		0.11		0.32	
Storage (S)		0.09		0.26	
Interaction (T×S)		0.22		NS	

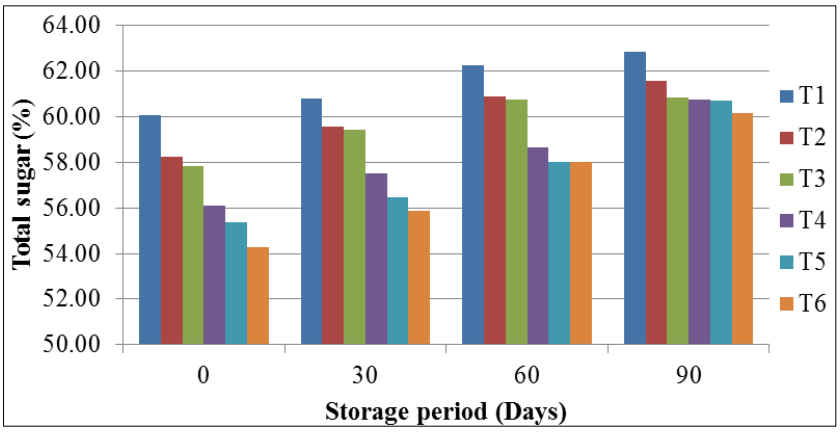


Fig 5: Effect of different proportions of pineapple and nutmeg rind juices on the total sugar percent of blended jelly cubes during storage

A significant difference was found in the total sugar content of blended pineapple and nutmeg rind jelly cubes in all the treatments. The treatment T_1 [pineapple (100%):nutmeg rind (0%)] recorded the highest (61.47%) mean value for total sugar content and significantly superior over all the treatments, followed by treatments T_2[pineapple (90%): nutmeg rind (10%)] and T_3 [pineapple (80%): nutmeg rind (20%)].The lowest (57.08%) mean value for total sugar content was observed in the treatment T_6[pineapple (50%): nutmeg rind (50%)]. The higher proportion of the pineapple juice in the blended jelly exhibited rise in the total sugar content of the product. The analogous results to the present findings were recorded by *Hossen et al.* (2009) [26] in guava jelly and *Relekar et al.* (2011) [16] in sapota jelly.

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

The total sugar content of the blended jelly increased significantly from 57.91 percent initially to 61.33 percent after a storage period of 90 days at ambient conditions. The increase in total sugar content might be due to the acid hydrolysis of polysaccharide in soluble or simple sugars. Masoodi *et al.* (2005) [29] reported 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) [16].

3.5 Microbial analysis

The data related to the microbial count of blended pineapple and nutmeg rind jelly cubes during storage periods are presented in Table 7. As regards microbial analysis of the product, it is observed that there was no microbial growth observed in blended pineapple and nutmeg jelly cubes at initial as well as at 90 days of storage at ambient conditions. Similar result was recorded by Cravalho *et al.* (2012) [32] for sapota pulp jelly and Sharma (2014) [27] for pineapple and mango jam.

Table 7: Effect of different proportions of pineapple and nutmeg rind juices on microbial analysis of blended jelly cubes during storage

Treatments	Microbial count (cfu/g)	
	Storage period (Days)	
	0	90
T1	ND	ND
T2	ND	ND
T3	ND	ND
T4	ND	ND
T5	ND	ND
T6	ND	ND
*ND – Not detected		

4. Economics of blended pineapple and nutmeg rind jelly cubes: The total cost of production of 100 kg jelly cubes was maximum (Rs. 27710.40) in the treatment T_1 [pineapple (100%): nutmeg rind 0%)], followed by the treatment T_2 [pineapple (90%): nutmeg rind (10%)].It might be due to higher quantity of costlier pineapple juice required for the preparation of the jelly. The lowest (Rs. 26052.70) cost of production of 100 kg jelly was observed in the treatment T_6 [pineapple (50%): nutmeg rind (50%)] due to low quantity of pineapple juice required for preparation of jelly cubes. It is clear from the economics of 100 kg jelly production that increasing the proportions of pineapple juices in the jelly increased the total cost of production of the blended pineapple and nutmeg jelly cubes.

Sale price of the blended pineapple and nutmeg jelly cubes was evaluated by adding 20 percent margin to the cost of production. It was observed from the data that the maximum (Rs.66.50 per bottle) sale price was for the treatment T_1 [pineapple (100%): nutmeg rind (0%)]. However, sale price of the jelly prepared from the treatment T_6 [pineapple (50%): nutmeg rind (30%)] was Rs.62.53 per bottle.

Highest net profit (Rs.5542.08) was observed in the treatment T_1 [pineapple (100%): nutmeg rind (0%)] while lowest net profit (Rs. 5210.54) was observed in the treatment T_6 [pineapple (50%): nutmeg rind (50%)].

For the treatment T_4 [pineapple (70%): nutmeg rind (30%)] which was mostly rate by the organoleptically, net profit of (Rs.5290.33) was observed.

T_1: pineapple (100%) + nutmeg (0%)

T_2: pineapple (90%) + nutmeg (10%)

T_3: pineapple (80%) + nutmeg (20%)

T_4: pineapple (70%) + nutmeg (30%)

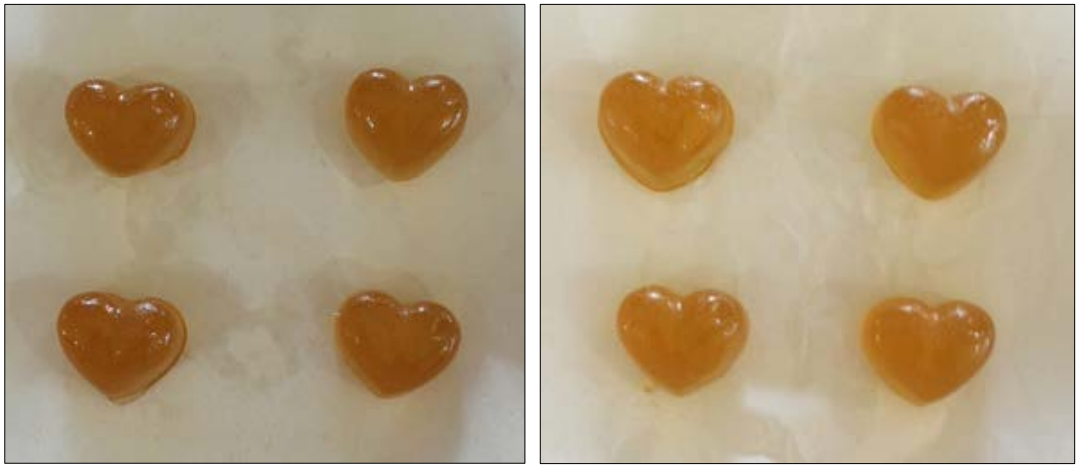
T_5: pineapple (60%) + nutmeg (40%)

T_6: pineapple (50%) + nutmeg (50%)

Plate 1: Effect of pineapple and nutmeg juices on the blended jelly cubes at 30 day of storage

T_1: pineapple (100%) + nutmeg (0%) T_2: pineapple (90%) + nutmeg (10%)

T_3: pineapple (80%) + nutmeg (20%) T_4: pineapple (70%) + nutmeg (30%)



T_5: pineapple (60%) + nutmeg (40%) T_6: pineapple (50%) + nutmeg (50%)

Plate 2: Effect of pineapple and nutmeg juices on the blended jelly cubes after 60 days of storage

T_1: pineapple (100%) + nutmeg (0%)

T_2: pineapple (90%) + nutmeg (10%)

T_3: pineapple (80%) + nutmeg (20%)

T_4: pineapple (70%) + nutmeg (30%)

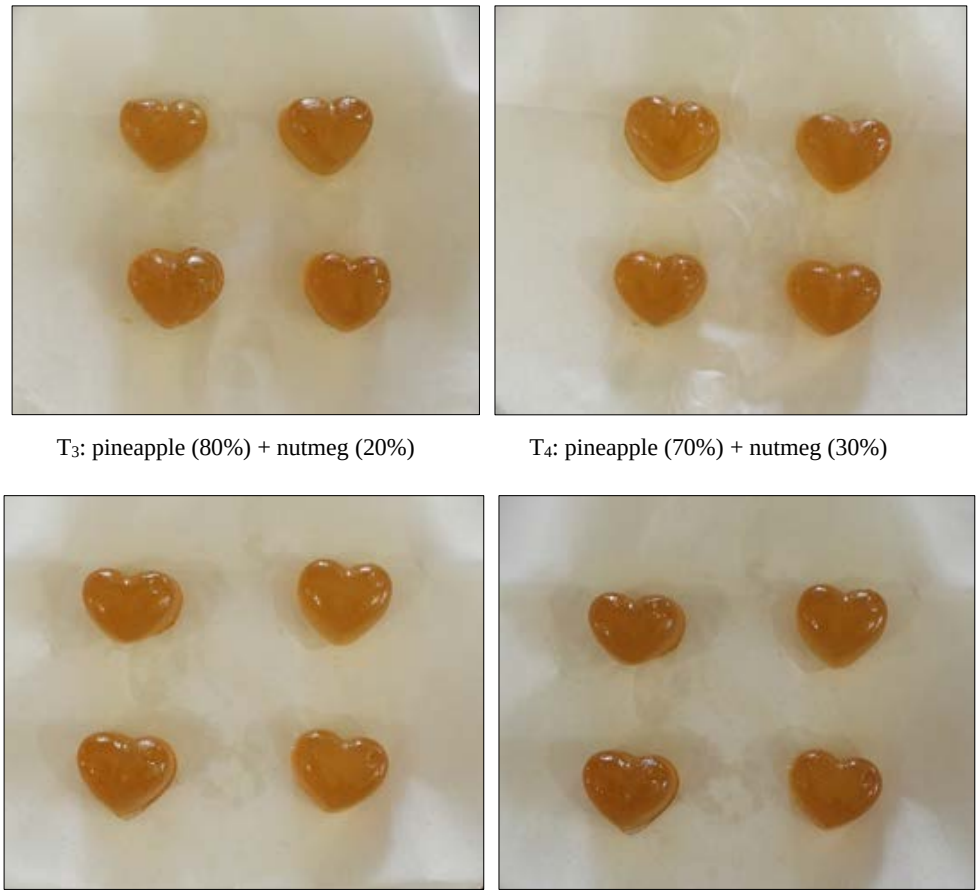
T_5: pineapple (60%) + nutmeg (40%)

T_6: pineapple (50%) + nutmeg (50%)

Plate 3: Effect of pineapple and nutmeg juices on the blended jelly cubes after 0 days of storage

T_1: pineapple (100%) + nutmeg (0%)

T_2: pineapple (90%) + nutmeg (10%)



T_3: pineapple (80%) + nutmeg (20%) T_4: pineapple (70%) + nutmeg (30%)

T_5: pineapple (60%) + nutmeg (40%) T_6: pineapple (50%) + nutmeg (50%)

Plate 4: Effect of pineapple and nutmeg juices on the blended jelly cubes after 90 days of storage

5. Conclusion

It was observed from the data that the blended pineapple and nutmeg rind jelly cubes irrespective of ratios were acceptable during three months of storage at ambient conditions. Blending of pineapple and nutmeg rind improved chemical and biological quality characteristics like colour, flavour, etc. of the jelly. The significantly increase was found in the Moisture, Total soluble solids, Reducing sugar and Total sugars content of jelly from 26.56 to 27.93 percent, 69.60 °B to 69.93 °B, 20.07 to 22.26 percent and 57.51 to 61.33 percent were as Titratable acidity of the jelly was decreased from 1.02 to 0.81 percent during storage. Based on the chemical quality evaluation and economics of the jelly, it is concluded that the blended pineapple and nutmeg rind jelly cubes could be prepared successfully by blending pineapple and nutmeg rind juice in the ratio of T_4[pineapple (70%): nutmeg rind (30%)]. Future scope for blended pineapple and nutmeg rind jelly cubes was also that helps whole utilization of wasted nutmeg rinds with increasing value addition of pineapple juice which helps to increases nutritional value as well as farmers income.

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