International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(10): 492-5001
www.biochemjournal.com
Received: 17-07-2025
Accepted: 20-08-2025

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Storage stability and sensory evaluation of value-added kokum candy developed from rind waste

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DOI: https://www.doi.org/10.33545/26174693.2025.v9.i10Sf.5880

Abstract
The experiment was conducted in Completely Randomized Design (CRD), with four major treatments and at ambient storage conditions *viz.*, 0, 30, 60, 90 and 120 days. Various changes in the physical, chemical, total plate count and sensory quality parameters of kokum candy were studied. It was observed that all the chemical parameters such as total soluble solids, protein, moisture contents exhibited a decreasing trend while increasing trend was observed in reducing sugar, total sugar, titratable acidity, ash, fat content of the kokum candy during 120 days of storage period. As regards the organoleptic evaluation the kokum candy prepared with (45% kokum rind and 25% jaggery) along with 30% constant: cumin powder (20%), sugar powder (75%), red chilli powder (2.0%), black salt (0.5%) obtained highest sensory score for colour (7.80), Taste (7.90), Texture (7.80) and Overall acceptability (7.88) at 120 days of storage.

Keywords: Kokum rind waste, candy, jaggery, rind, kokum candy

1. Introduction

India is the second-largest fruit grower in the world, after China, with an annual production of over 110.21 million tonnes (Anonymous, 2024) [6]. It has been reported that 5.53 million tonnes of smaller fruits are produced in the country each year. This group includes important fruits such as pomegranate (*Punica granatum*), cashew (*Anacardium occidentale*), karonda (*Carissa carandas*), kokum (*Garcinia indica*), jackfruit (*Artocarpus heterophyllus*), and aonla (*Emblica officinalis*).

Horticulture has always held an important place in the agricultural system. It thrives in arid climates that are influenced by weather patterns. Horticultural products such as fruits, vegetables, and processed foods significantly contribute to human nutrition and dietary needs. These crops also support the global economy. India's diverse tropical and subtropical agroclimatic conditions allow for the cultivation of a wide variety of fruits and vegetables. Consequently, horticultural crops occupy 15.07 percent of the country's total agricultural land and constitute a substantial component of the agricultural industry.

Both primary and secondary fruits are considered preventive foods due to their high vitamin and mineral content. However, they are classified as perishable items and differ from edible grains based on their short shelf life. Moreover, due to the limited harvest season, fruits are often rushed to the market, where facilities for handling, storing, and transporting produce are inadequate. In addition to these constraints, adverse weather during the main harvest season significantly affects fruit shelf life. These factors are believed to contribute to 25-30% of fruit spoilage. Furthermore, less than 1% of India's horticultural raw materials are processed compared to 40-60% in developed countries like the US, Brazil, Australia, and Israel.

Kokum (*Garcinia indica* L.), an indigenous tree of India, belongs to the Guttiferae family (Chandran, 1996; Padhye *et al.*, 2009) [10, 34]. It grows to a lesser extent in the forests of Assam, Meghalaya, and West Bengal, and more abundantly in the Konkan region of Maharashtra, Goa, Karnataka, Kerala, and the Surat district of Gujarat along India's west coast. Kokum cultivation is largely concentrated in Maharashtra's Konkan area, especially in the districts of Ratnagiri and Sindhudurg. According to Patil *et al.* (2012) [38], more than 108 hectares in Sindhudurg district are under kokum cultivation, typically located in valleys, along streams and riverbanks, backyard wastelands, and roadsides. Market trends and export data suggest kokum is steadily gaining importance as a crop, with an estimated 10,200 tonnes produced from 1,200 hectares in Goa (Korikanthimath and Desai, 2005) [22]. There are around 200 species in the genus *Garcinia*, with only 20 found in India. Of these, five species are commonly found in the Western Ghats: *G. gummigutta* (Kochampuli), *G. indica* (Kokum), *G. mangostana* (Mangosteen), *G. morella*, and *G. spicata*. The first two species are the most widely distributed in Goa, the Konkan belt, and the northern region of Kerala (Bhat *et al.*, 2005) [9].

According to Ayurveda, kokum is a medicinal herb used to treat various ailments such as sunstroke, diarrhoea, liver problems, cancer, and heart conditions (Deore *et al.*, 2011) [14]. Kokum acts as an appetizer and serves as a tonic for the liver and heart. The fruit infusion is used to treat burns, scalds, rashes, chafed skin, and allergies. It is also beneficial for treating heatstroke, diarrhoea, piles, heart disease, and dysentery. Kokum is commonly used for weight loss, as its hydroxycitric acid content helps increase fat oxidation, reduce weight, and boost serotonin levels in the body. Garcinol, another component of kokum, has demonstrated anti-oxidative, anti-cancer, anti-ulcer, and anti-glycation properties (Nayak *et al.*, 2010) [32]. Kokum fruit naturally has a cooling effect. A popular drink called *Amrit Kokum*, made from the rind, is rich in antioxidants and helps quench thirst during hot summers. Kokum juice is also used as a natural remedy for liver and stomach ailments (Mishra *et al.*, 2006) [30].

Ripe kokum fruits are sour and have a short shelf life of about a week. Chemical investigations reveal that approximately 25% of the fruit's weight consists of seeds, which contain 40-42% oil. The oil, known as kokum butter, is light grey to yellow, fatty in texture, bland in flavour, and remains solid at room temperature (Nayak *et al.*, 2010) [32]. After decorticating the seeds, the kernels are extracted and pressed in an expeller to obtain the oil. The remaining cake can be used as animal feed or organic manure for plantation crops (Korikanthimath and Desai, 2005) [22]. According to Krishnamurthy *et al.* (1982) [23], the fresh peel of kokum fruit accounts for 50-60% of the whole fruit. The rind of *G. indica* is rich in acids, predominantly hydroxycitric acid [(-)-HCA], also known as 1,2-dihydroxypropane-1,2,3-tricarboxylic acid. The dry weight content of (-)-HCA in kokum rinds ranges from 20-30% (Swami *et al.*, 2014) [47].

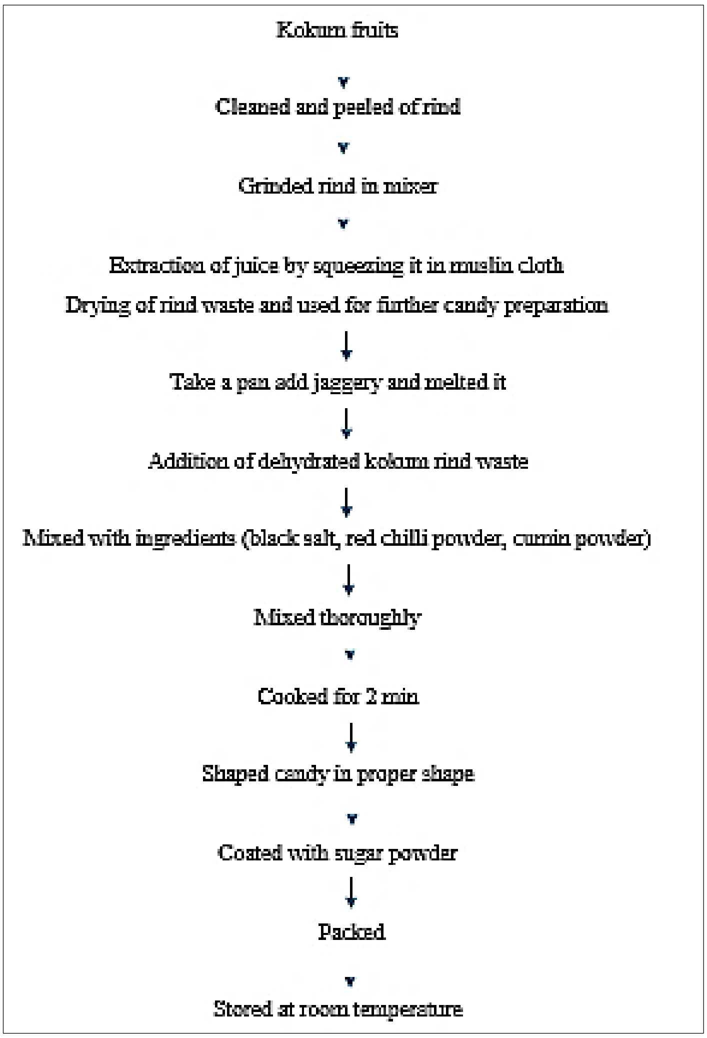
2. Material and Methods

2.1 Material Required

The kokum fruits were procured from Regional Fruit Research Station, Vengurla, other ingredients required such as jaggery, black salt, red chilli powder, cumin powder were procured from local market, Roha.

2.2 Methods Flow Chart

Preparation of kokum candy



2.3 Physical parameters of kokum candy
The kokum candy was analyzed for the physical parameters such as colour by using standard procedures as stated below.

2.3.1 Colour values
The colour values of kokum candy was measured using colour reader (make Konica Minolta Japan CR-10) and expressed as L* (light to dark), a* (red to green), b* (yellow to blue) values.

2.4 Chemical parameters of kokum candy
The kokum candy was analysed for the chemical parameters such as the moisture, ash, TSS, Titratable acidity, reducing sugar, total sugar, protein, fat, content by using standard procedures as stated below.

2.4.1 Moisture %
In order to estimate the moisture content, 5 g of the sample was dried in pre-weighed aluminium moisture boxes in a hot air oven set at 130 ± 1 °C for two hours until the weight remained constant. The dried samples were then allowed to cool to room temperature by placing the boxes in a desiccator before being weighed AOAC (2002) [3] and the weight difference was expressed as the percentage of moisture content using the following formula:

$$\text{Moisture Loss (\%)} = \frac{\text{Loss in weight (g)}}{\text{Weight of sample (g)}} \times 100$$

2.4.2 TSS (°B)
Total soluble solids (TSS) were measured by using hand refractometer (Erma, Japan) and the results were expressed as percent (ºB) according to standard procedure as given in Ranganna, (1986) [40]. The refractometer was calibrated with distilled water before use

2.4.3 Titratable acidity %
Titratable acidity was determined by titrating a known quantity of sample (10ml) against standard solution of 0.1 N Sodium hydroxide to a faint pink colour using phenolphthalein as an indicator. The results were expressed using per cent citric acid A.O.A.C. (1990) [1].

$$\text{Acidity (\%)} = \frac{\text{Normality of alkali} \times \text{Titre reading} \times \text{Volume made} \times \text{Equivalent weight of acid} \times 100}{\text{Weight of sample taken} \times \text{Volume of sample taken for estimation} \times 1000}$$

2.4.4 Sugar
2.4.4.1 educing sugars %
According to Ranganna (1986) [40] the reducing sugars were ascertained using the Lane and Eynon (1923) [25] approach. The material was weighed and placed in a 250 ml volumetric flask. After adding 100 milliliters of distilled water, 1 N sodium hydroxide was added to neutralize the contents. Two milliliters of 45% lead acetate were then added. After thoroughly mixing the ingredients, they were left for ten minutes. To precipitate the extra lead, two milliliters of potassium oxalate (22%), were added. The solution was filtered through Whatman No. 4 filter paper after the volume was adjusted to 250 ml using distilled water. Using methylene blue as an indicator to a brick red end point, this filtrate was titrated against the boiling mixture of Fehling "A" and Fehling "B" solutions (5 ml each) in order to determine the amount of reducing sugars. Percentage was used to express the results.

$$\text{Roughness (\%)} = \frac{\text{Factor} \times \text{Dilution}}{\text{Titre reading} \times \text{Weight of sample}} \times 100$$

2.4.4.2 Total sugars %: A 50 ml aliquot of clarified deluded solution was placed in a 250 ml volumetric flask for inversion at room temperature. Ten milliliters of 50% HCl were then added, and the mixture was left to stand at room temperature for twenty-four hours. A 40% NaOH solution was then used to neutralize it. Using distilled water, the neutralized aliquot's volume was increased to 250 ml. Using methylene blue as an indication to a brick red end point, this aliquot was titrated against the boiling mixture of Fehling "A" and Fehling "B" (5 ml each) in order to determine the total sugars. Percentage was used to express the results.

$$\text{Total Sugar (\%)} = \frac{\text{Factor} \times \text{Dilution} \times 5}{\text{Titre reading} \times \text{Weight of sample}} \times 100$$

2.4.5protein %
Protein was calculated using the micro-Kjeldahl method, which converts nitrogen content into crude protein using a factor of 6.25 Sadasivam and Manickam (2008) [42]. A 2 g weighed sample was digested for 2 hours until it was carbon-free using 2 ml of concentrated sulphuric acid and 2 g of a catalyst mixture (K2SO4, CuSO4, and SeO2) in a long neck Kjeldahl flask. After cooling, the contents were moved to a 100 ml volumetric flask, and distilled water was added to get the volume down to 100 ml. The protein content was determined using the following equation after the measured aliquot was distilled with 40 percentage sodium hydroxide and the released ammonia was collected through a condenser in a flask containing 10 ml of 4 percentage boric acid solution and a few drops of mixed methyl red and bromocresol green indicator AOAC (2002) [3]. The aliquot was then titrated against standardised 0.1 N sulphuric acid. Alongside the sample, a blank sample was also run.

$$\text{Moisture (\%)} = \frac{\text{Titre value} \times 0.00014 \times \text{Volume made} \times 100}{\text{Aliquot taken (g)} \times \text{Weight of sample (g)}}$$

$$\text{Protein (\%)} = \text{Nitrogen (\%)} \times 6.25$$

2.4.6 Fat %
Crude ether extract of the dry material was used to quantify fat. After precisely weighing the 5 g dry sample, it was placed in the thimble and sealed with cotton. After that, the thimble was extracted for three hours using anhydrous ether in a Soxhlet device. Following the ether's evaporation, the flask containing the residue was dried in an oven set between 80 and 100 degrees Celsius, cooled in a desiccator, and weighed. According to AOAC (1975) [2] the fat content was stated as g/100 g.

$$\text{Fat }(\%) = \frac{\text{Weight of fat (g)}}{\text{Weight of sample (g)}} \times 100$$

2.4.7 Ash %

Ash was measured by placing 5 g of the sample in silica crucibles that had been previously weighed, burning it over a hot plate in an open atmosphere to remove any smoke, and then ashing it in a muffle furnace at 550 °C for 4-6 hours. Then let the crucibles cool down. The crucibles and ash were removed, placed in a desiccator, and weighed until they reached a steady weight. The amount of total ash was determined by comparing the weight of a silica crucible with and without ash AOAC (2002) [3]. The following calculation was used to determine the percentage of ash:

$$\text{Ash }(\%) = \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100$$

2.5 The microbial analysis of kokum candy

The total plate count of the kokum candy was carried out at 0 day initial up to 120 days of storage.

2.5.1 Total plate count (cfu/g)

According to APHA, 2001 [7], the total number of plates was calculated and represented as colony forming units (cfu/g). Samples were weighed aseptically and then transferred to 225 millilitres of physiological saline in a homogeniser. Physiological saline (2 percent) was employed as a diluent for the homogenate preparation. A mortar and pestle were used to homogenise the samples. Using normal saline, the homogenate was diluted appropriately, and the pour plate method was used to plate it on plate count agar. The sample-containing petri plates were incubated for 24 to 48 hours at 37 °C. We counted and calculated the colonies that grew on agar plates. Colonies with dilutions ranging from 30 to 300 were chosen. The data obtained were reported in cfu/g.

2.7 Sensory evaluation of kokum candy

The sensory quality of kokum candy in terms of colour, taste, texture and overall acceptability was studied immediately after preparation and at 0 days up to 120 days of storage by the semi- trained panel of 9-10 judges on a 9-point Hedonic scale (Amerine *et al.* 1965) [5].

2.8 Experimental details: The experiment was conducted using a Completely Randomized Design (CRD). Four treatments were applied, each with different proportions of kokum rind waste (%) and jaggery (%), and evaluated over a storage period of five months. Observations were recorded at 0, 30, 60, 90, and 120 days of storage, and the data were subjected to statistical analysis.

2.9 Storage behaviour of candy: The kokum candy was then stored at room temperature to study the storage behaviour of the candy with respect to the changes in chemical parameters during storage. The product was evaluated immediately after preparation and at an interval of 30, 60. 90, 120 days of storage.

2.10 Statistical analysis

The data collected on the physical parameters of kokum candy, such as colour (L*, a*, and b* values), and chemical parameters, including moisture, ash, sugars, fat, protein, titratable acidity, and total soluble solids (TSS), were expressed as mean values. Changes in physico-chemical parameters, microbial count, and sensory quality of kokum candy during the storage period were statistically analyzed using the standard procedures outlined by Panse and Sukhatme (1985) [35], under a Completely Randomized Design (CRD). Valid conclusions were drawn based on statistically significant differences between treatment means at the 5 percent level of significance.

3. Results and Discussion

3.1 Effect of different storage periods on physical parameters (L*a*b*) of kokum candy

3.1.1 Colour (L* a* b*) values for colour L* value for colour

During the 120-day storage period of kokum candy, treatment T_2 (45% kokum rind + 25% jaggery), as presented in Table 1, showed a decrease in the L* colour value from 55.38 to 51.34.

This reduction in lightness can be attributed to the presence of amino acids and reducing sugars in jaggery, which undergo Maillard reactions over time, especially at room temperature leading to the formation of brown-coloured melanoidins that darken the candy. Additionally, anthocyanins in kokum degrade with exposure to light, air, and fluctuating temperatures, contributing further to browning. Ingredients like black salt and cumin, which have naturally dark pigments, may also enhance the overall darkening effect during storage. Similar trends were reported by Choudhary (2020) [13], who observed a decline in L* values in stored pumpkin-mango blended toffee, and by Kamboj (2021) [21], who noted a significant decrease in the L* value of raw mango candy from 55.22 to 42.41 over time.

a* value for colour

As mentioned in Table 1, the a* value of kokum candy increased from 1.64 to 3.32 over the course of 120 days of storage.

The deep purplish-red colour of kokum rind is primarily due to its high anthocyanin content. During storage, factors such as light, oxygen, pH, and heat can lead to partial degradation of anthocyanins, shifting the colour from purple toward red and thus increasing the a* value. Additionally, jaggery contains amino acids and reducing sugars that undergo Maillard reactions over time, forming reddish-brown melanoidins which contribute to a rise in the a* value. Moisture loss during storage may also concentrate these pigments, enhancing the intensity of red tones. As darker pigments fade or stabilize, the red hues become more prominent. Moreover, phenolic compounds and minerals present in cumin and black salt may interact with anthocyanins to stabilize or intensify the red-coloured forms, further contributing to the increase in a* value. Similar findings were reported by Kamboj (2021) [21], where the mean a* value of raw mango blended candy increased from 4.11 to 5.26 during 90 days of storage.

b* value for colour

During 120 days of storage, the b* value of kokum candy increased from 1.46 to 3.52, as shown in Table 1. Proteins or amino acids undergo the Maillard reaction with jaggery, which is rich in reducing sugars. In the early stages of this reaction, yellowish intermediate compounds (such as dicarbonyls) are formed before the development of darker melanoidins. These intermediates contribute to an increase in the b* (yellowness) value. Kokum's anthocyanins, which provide purple to crimson hues, degrade during storage into colorless or yellow-brown compounds. This degradation reduces bluish tones and enhances yellow hues, thereby increasing the b* value. Phenolic compounds present in jaggery, cumin powder, and kokum rind can also oxidize over time to form yellow-brown pigments, further raising the b* value.

Additionally, moisture loss during storage may concentrate yellowish pigments, intensifying the yellow appearance and contributing to a higher b* value. Cumin naturally contains yellowish-brown pigments, which may become more prominent or diffuse into the candy matrix over time, leading to an increase in b* value. These findings are consistent with those of Haseeba (2020) [19], who studied the effect of packaging material and storage on the color (b*) value of honey- based carrot candy and reported a similar increase in b* value during storage.

3.2 Effect of different storage periods on chemical parameters of kokum candy

3.2.1 Moisture (%)

As seen in Table 2, the moisture content in treatment T_2 (45% kokum rind + 25% jaggery) drops from 7.92% to 7.06% over 120 days of storage. Particularly in low-moisture systems, the porous nature of kokum rind can eventually promote surface water loss. Water activity (aw), which tends to stabilize through moisture diffusion out of the product, is impacted by this. During storage, water may become more firmly bonded to solids (such as sugar and fibers), rendering it insoluble or undetectable in standard moisture measurements. Even if water isn't completely evaporated, this can still appear as a "loss" in quantifiable moisture. The decrease in moisture content in kokum candy after 120 days can be attributed to water desorption, the hygroscopic and crystalline behavior of ingredients, and environmental storage conditions. These changes are common in semi-moist or dry confectionery items stored over extended periods.

Gupta *et al.* (1980) [17] observed a decrease in moisture content in ber candy after storage. Gharate (1984) [16] reported similar outcomes. Rani and Bhatia (1985) [41] reported a moisture content reduction in pear candy from 20.1% to 12.9% at high storage temperature over 24 weeks. Candy's moisture content significantly decreased during storage. Similar findings were reported by Mai (2006) [27]. Tulsi (2017) [49] observed a dramatic drop in moisture content in sweet orange peel candy over a 120-day storage period. This may be due to moisture evaporation during storage. Higher sugar concentrations tend to reduce moisture content because, when peels are soaked in sugar solution, osmotic pressure develops as water from the peel cells moves out and sugar moves in. The resulting structural changes make the peel harder due to this water-sugar exchange.

3.2.2 Total soluble solids (°B)

Over a storage duration of 120 days, the total soluble solids (TSS) in treatment T_2 (45% kokum rind + 25% jaggery) of kokum candy, as shown in Table 2, decreased from 24.6°Brix to 16.4°Brix. Black salt, sugar powder, and jaggery are hygroscopic in nature, meaning they tend to absorb moisture from the air, especially under high humidity conditions. This absorption increases the candy's water content and dilutes its soluble solids, thereby lowering its °Brix value.

The natural acids in kokum, such as hydroxycitric acid, can promote sugar inversion between the jaggery and sugar, particularly in acidic environments. This process breaks down sucrose into glucose and fructose, which may further react or degrade, thereby affecting the TSS. Additionally, the reducing sugars and amino acids in the candy may undergo Maillard browning during storage, especially at room temperature. Over time, components of sucrose and jaggery may begin to crystallize, contributing to changes in texture and TSS. Similar contradictory findings were reported in previous studies. Manshi *et al.* (2010) [28] observed a significant decrease in the TSS content of jamun cheese and toffee with increasing storage duration, possibly due to increased acidity. Choudhary (2020) [13] also reported a similar decline in the TSS content of blended pumpkin-mango toffee during storage. Likewise, Norzom (2018) [33] found a decreasing trend in TSS in strawberry-bottle gourd blended toffee.

3.2.3 Titratable acidity (%)

Over a storage duration of 120 days, the titratable acidity of kokum candy in treatment T_2 (45% kokum rind + 25% jaggery), as shown in Table 2, increased from 2.10% to 5.96%.

Kokum rind contains glycosides, organic acids (such as hydroxycitric acid), and polyphenols. These compounds can hydrolyze (break down) into simpler organic acids over time, particularly in moist or mildly acidic conditions, leading to an increase in titratable acidity. Free organic acids are released when complex polyphenols or esters degrade during storage.

Additionally, jaggery, which is rich in reducing sugars, along with amino acids from the rind or added spices, may undergo Maillard browning during storage especially under warm conditions. This reaction can result in the formation of low molecular weight acids, contributing further to the rise in titratable acidity.

Furthermore, oils and polyphenols present in cumin and kokum rind can gradually oxidize over time, releasing acidic compounds such as carboxylic acids. Even in trace amounts, these substances contribute to the increase in titratable acidity.

Similar findings were reported by Sandhu (1994) [43], who observed a rising trend in acidity in papaya candy during storage. Muzzaffar *et al.* (2016) [31] also reported an increase in titratable acidity in pumpkin candy stored at room temperature, attributing this to the breakdown of cell wall components and the subsequent release of organic acids. These results are consistent with those of Sakhare *et al.* (2019) [44], who observed a slight increase in acidity over the storage period, possibly due to moisture loss or degradation of cell wall materials that resulted in the production of organic acids.

3.2.4 Sugars (%)

3.2.4.1 Reducing sugars (%)

The reducing sugar content in treatment T_2 (45% kokum rind + 25% jaggery) of kokum candy, as shown in Table 2, increased from 4.02% to 6.02% during the 120-day storage period.

Jaggery (25%) and sugar powder (7.5%) contain a significant amount of sucrose, a non- reducing sugar. Over time, sucrose may undergo acid-catalyzed hydrolysis (inversion), particularly in the presence of acidic compounds found in kokum, which is rich in hydroxycitric acid. This process results in the breakdown of sucrose into reducing sugars such as glucose and fructose.

The acidic nature of kokum rind, along with the candy's moisture content and storage conditions, facilitates the hydrolysis of sucrose into reducing sugars. This is the primary reason for the observed increase in reducing sugar content during the storage period.

Similar observations have been reported in earlier studies. Rani and Bhatia (1985) [41] noted a greater degree of sugar inversion at higher storage temperatures. Tripathi *et al.* (1988) [48] reported a significant increase in sugar content during the storage of amla candy, which was attributed to the inversion of non-reducing sugars into reducing sugars. Sandhu (1994) [43] also observed an increase in reducing sugars in candy samples stored at ambient temperature, with the rise being significantly influenced (P<0.05) by variety, treatment (with and without papain), and duration of storage. Muzzaffar *et al.* (2016) [31] reported similar results in aonla candy. Likewise, Kumar *et al.* (2022) [24] found that the reducing sugar content in orange peel candy significantly increased during storage.

3.2.4.2 Total sugars (%)

The total sugar content in treatment T_2 (45% kokum rind + 25% jaggery) of kokum candy, as shown in Table 2, increased from 8.08% to 9.26% during the 120-day storage period.

Jaggery and kokum rind contain complex carbohydrates, including polysaccharides such as pectin and starch. During storage, these polysaccharides may break down into simple sugars (e.g., glucose and fructose) due to the action of hydrolytic enzymes (such as amylase) or under acidic conditions. This breakdown contributes to an increase in measurable total sugars.

Additionally, the acidity from kokum and black salt facilitates the inversion of sucrose present in jaggery and added sugar into glucose and fructose. These reducing sugars are also accounted for in total sugar estimation, further contributing to the rise. Over time, these reducing sugars may react with amino acids in Maillard browning reactions. However, before degradation occurs, more sugars are released or become detectable, especially in the early stages of storage.

Similar findings were reported by Prasad *et al.* (1968) [39] during the storage of candy. Tripathi *et al.* (1988) [48] also observed an increase in total sugars, likely due to a higher degree of sugar inversion. Sandhu (1994) [43] noted a significant impact of storage duration on total sugar content, reporting an increase from 71.5% to 93.5% after five weeks of ambient storage. Contributing factors may include moisture loss, sugar conversion, and the hydrolysis of starch and pectin into simpler sugars.

Comparable results were reported in aonla sweet and IMF aonla products by Panwar (2014) [36]. Chaurasiya *et al.* (2014) [11] found that total sugar content in palm toffee increased gradually and significantly with prolonged storage. Similar trends were observed by Chavan *et al.* (2015) [12] in guava and strawberry toffee. These findings are in agreement with those of Norzom (2018) [33], who attributed the increase in total sugars to starch hydrolysis under high-temperature and acidic conditions in mixed toffees. Patel *et al.* (2022) [37] also reported a significant increase in total sugar content over time in guava candy.

3.2.5 Protein (%)

As seen in Table 2, the protein content in treatment T_2 (45% kokum rind + 25% jaggery) of kokum candy decreased from 1.52% to 1.12% over the 120-day storage period.

Variations in texture or changes in the uniformity of the candy's composition during storage may affect the efficiency of protein extraction during testing, potentially leading to an apparent reduction in measured protein content. Additionally, increased rates of oxidative and Maillard reactions during storage may impair protein stability. Moisture migration within the product can further interfere with protein extraction, contributing to the observed decline.

Hasanuzzaman *et al.* (2014) [18] reported a similar trend in tomato candies, noting that protein content tended to decrease with increasing sugar solution concentration. Their findings indicated that the higher the concentration of sugar solution used, the lower the resulting protein content, and vice versa.

Sandhu (1994) [43] also observed a declining trend in the protein content of candy stored at both ambient and refrigerated temperatures. Specifically, the protein content decreased significantly from 0.41% to 0.18% after five weeks of ambient storage.

3.2.6 Fat (%)

The fat content increased from 0.76% to 0.84% in treatment T_2 (45% kokum rind + 25% jaggery) of kokum candy, as shown in Table 2.

During storage, the fat content in kokum candy appeared to increase. This is primarily due to moisture loss caused by environmental factors. As the water content decreases, the proportion of remaining solids such as fat in the overall weight of the product increases. Although the absolute amount of fat remains unchanged, this shift gives the impression of an increased fat content.

A similar trend was observed by Jothi *et al.* (2014) [20] in pineapple candy, where the fat content significantly increased from 0.72% to 0.77% during storage.

3.2.7 Ash (%)

Over the course of 120 days of storage, the ash content in treatment T_2 (45% kokum rind + 25% jaggery), as shown in Table 2, increased from 1.66% to 2.70%.

On a total mass basis, the proportion of ash increases as the amount of organic matter decreases while the mineral content (ash) remains constant. In candies, particularly those containing reducing sugars, crystallization or breakdown of sugars may occur over time. These processes reduce the overall bulk of organic components, thereby increasing the relative proportion of ash.

A similar trend was reported by Sandhu (1994), who observed a significant increase in ash content from 0.38% to 0.61% in candies stored at ambient temperature for five weeks. Akhter *et al.* (2022) [4] also noted that in carambola candy, the sample containing 80% molasses had the highest ash content, while the sample with 80% corn syrup had the lowest value (0.15%).

3.3 Effect of different storage periods on total plate count of kokum candy.

3.3.1 TPC (Total plat count) (cfu/g)

Table 3 provides information on the total plate count of kokum candy throughout the storage period. The data show that no microbial growth was detected in the kokum candy neither during its manufacture nor after 120 days of storage at room temperature.

his absence of microbial growth can be attributed to the candy's high sugar (or jaggery) content, which results in low water activity. Microorganisms require available (free) water to grow, and most bacteria and fungi cannot survive if the water activity is below approximately 0.6 cfu/g. Jaggery-based candies generally fall within this safe range, particularly when properly dried.

Additionally, black salt contains sulfur compounds such as iron sulphide and hydrogen sulphide, which possess known antibacterial properties. Cumin powder also contributes to microbial inhibition through compounds like cumin aldehyde and essential oils that exhibit antifungal and antibacterial activity. The kokum rind itself contains organic acids and polyphenols (e.g., garcinol) with strong antioxidant and antimicrobial effects.

Moreover, the high sugar content in jaggery acts as a natural preservative by creating osmotic pressure that draws water out of microbial cells, thereby inhibiting or killing them. Kokum's naturally acidic pH (ranging from 2.5 to 3.5) further prevents the growth of microorganisms, particularly bacteria, which typically thrive in near-neutral pH environments.

These results align with those of Sandhu (1994) [43], who found that pumpkin-based sweets remained safe for consumption for up to three months when properly preserved. The inhibitory effect of high sugar content, which limits the availability of water for microbial activity, was similarly reported by Hasanuzzaman *et al.* (2014) [18] in tomato candy and Muzzaffar *et al.* (2016) [31] in pumpkin candy.

3.4 Effect of different storage periods on sensory parameters of kokum candy

3.4.1 Colour

Table 3 displays the sensory evaluation results for colour changes in kokum candy (treatment T_2: 45% kokum rind + 25% jaggery) over a 120-day storage period. The colour score decreased from

7.80 to 6.18, indicating a noticeable decline in visual appeal. The deep reddish-purple colour of kokum rind is primarily due to anthocyanins, especially cyanidin-3-glucoside. However, anthocyanins are highly sensitive to environmental factors such as light, oxygen, temperature, and pH. Their gradual degradation into colourless or brownish compounds leads to visible colour fading or darkening over time.

Additionally, oxidation of phenolic compounds in kokum and added spices (such as cumin) during storage contributes to colour dulling. These phenols can undergo enzymatic or non-enzymatic oxidation, leading to the formation of brown pigments. This process is exacerbated by exposure to oxygen during storage.

Moreover, black salt, sugar, and jaggery used in the formulation are hygroscopic, meaning they absorb moisture from the air. This can result in stickiness, surface discoloration, and texture changes, making the candy appear duller and less visually appealing.

These findings are consistent with previous studies. Muzzaffar *et al.* (2016) [31] reported similar results in pumpkin candy, and Mir *et al.* (2015) [29] found comparable colour degradation in quince candy. Ghanwat (2017) [15] also noted that non-enzymatic browning during storage could significantly impact the colour of candies. Similarly, Shamrez *et al.* (2013) [46] observed colour deterioration in candies made from citron peel. Tulsi (2017) [49] reported a noticeable decline in the mean colour score of sweet orange peel candy after 120 days of storage, attributing it to non-enzymatic browning. In that case, the candy developed a chocolate-like hue, likely due to sugar caramelization during storage.

3.4.2 Taste

The results of the sensory evaluation for taste in kokum candy (treatment T_2: 45% kokum rind + 25% jaggery) over a 120-day storage period are shown in Table 3, where the taste score decreased from 7.90 to 6.16.

Jaggery and sugar powder are highly hygroscopic, meaning they absorb moisture from the air. This can lead to textural changes such as stickiness or lumping, which negatively affect mouthfeel and taste perception. Additionally, volatile compounds present in cumin, kokum, and jaggery are sensitive to oxygen and prone to oxidative degradation during storage. As these compounds break down, there is a noticeable loss of aroma and flavor. Specifically, unsaturated fatty acids and essential oils in cumin may oxidize, leading to the development of off-flavors.

Similar results were reported by Ghanwat (2017) [15], who observed a significant decrease in the average taste score of aonla candy from 8.3 to 7.1 over a 120-day storage period, likely due to chemical changes. Tulsi (2017) [49] also found a considerable drop in the flavour score of sweet orange peel candy during the same storage duration, attributing the decline to oxidative and physicochemical changes.

It is important to note that taste is a sensory attribute influenced by human perception, and thus even minor changes in composition or texture can significantly impact its evaluation. Similar declining trends in taste scores during storage have also been reported in orange peel candy by Kumar *et al.* (2022) [24] and in mango candy by Sehrawat *et al.* (2023) [45].

3.4.3 Texture

The sensory score for texture of treatment T_2 (45% kokum rind + 25% jaggery) decreased from

7.80 to 6.22 over the 120-day storage period, as shown in Table 3.

The acidic nature of kokum and its salt content can interact with proteins and sugars during storage, leading to protein-sugar interactions or Maillard reactions that result in a harder texture.

Additionally, lipids and other bioactive compounds in kokum and spices (such as cumin) may undergo enzymatic degradation or oxidation, further affecting texture.

Similar outcomes were reported by Shamrez *et al.* (2013) [46] during the production and evaluation of candies made from citron peel. Ghanwat (2017) [15] also observed a significant decline in the average texture score of aonla sweets, dropping from 8.4 to 6.7, which was attributed to moisture loss during storage. The texture of the candy significantly

deteriorated over time, partly due to the prolonged dipping process and the high concentration of sugar solution used.
Tulsi (2017) [49] reported a marked decrease in the mean texture score of sweet orange peel candy over a 120-day storage period. Similar findings were noted by Kumar *et al.* (2022) [24] in orange peel candy and Sehrawat *et al.* (2023) [45] in mango candy.

3.4.4 Overall acceptability
Table 3 indicates the sensory score for the overall acceptability of treatment T_2 (45% kokum rind+ 25% jaggery), which decreased from 7.88 to 6.18 over the storage period.
The deep red colour of kokum rind is due to anthocyanins, which are sensitive to heat, oxygen, and light. The fading of this vibrant red colour reduces both the overall acceptability and visual appeal of the candy. Over time, volatile oils present in spices such as red chili powder and cumin powder oxidize or degrade, leading to a loss of flavour and aroma. Additionally, interactions between sugars and amino acids from kokum rind and jaggery occur during storage at room temperature, causing changes in colour, flavour, and sometimes bitterness, further decreasing the candy's attractiveness.

Similar results were reported by Balaji *et al.* (2014) [8] in a comparative study of varieties, honey coating, and storage duration on aonla candy. Ghanwat (2017) [15] also found lower overall acceptability ratings in aonla candy, which corresponded to declines in texture, flavour, colour, and appearance. These changes may be attributed to chemical alterations or specific enzymatic and non-enzymatic modifications in the product during storage.
The findings are consistent with those of Tulsi (2017) [49], who observed a decline in overall acceptability scores of sweet orange peel candy during storage. Similar results were also reported by Kumar *et al.* (2022) [24] in orange peel candy, Muzzaffar *et al.* (2016) [31] in pumpkin candy, and Mahato *et al.* (2020) [26] in unripe mango candy

Table 1: Effect of different storage periods on colour values (L*a*b*) of kokum candy

Storage period (Days)	L*	a*	b*
0	55.38	1.64	1.46
30	54.42	1.92	1.96
60	53.36	2.44	2.48
90	52.38	2.82	2.94
120	51.34	3.32	3.52
S.E. m ±	0.10	0.08	0.12
C.D. at 5%	0.31	0.26	0.36

Table 2: Effect of different storage periods on chemical parameters of kokum candy

Storage period (days)	Moisture (%)	Total soluble solids (°B)	Titratable acidity (%)	Reducing sugars (%)	Total sugars (%)	Protein (%)	Fat (%)	Ash (%)
0	7.92	24.6	2.10	4.02	8.08	1.52	0.76	1.66
30	7.72	23.2	2.60	4.52	8.54	1.40	0.78	1.88
60	7.52	20.6	3.06	5.02	9.04	1.32	0.80	2.08
90	7.32	18.6	3.56	5.52	9.14	1.22	0.82	2.40
120	7.06	16.4	5.96	6.02	9.26	1.12	0.84	2.70
S.E. m ±	0.09	1.24	0.91	0.18	0.08	0.12	0.07	.10
C.D. at 5 %	0.27	3.70	NS	0.54	0.24	NS	S	0.30

Table 3: Effect of different storage periods on sensory parameters and total plate count of kokum candy

Storage period	Colour	Taste	Texture	overall acceptability	Total plate count cfu/100g
0	7.80	7.90	7.80	7.88	ND
30	7.08	7.80	7.66	7.66	ND
60	6.68	7.46	7.28	7.26	ND
90	6.26	6.26	6.58	6.48	ND
120	6.18	6.16	6.22	6.18	ND
S.E. m ±	0.22	0.21	0.22	0.30	--
C.D. at 5%	0.67	0.64	0.65	0.91	--

4. Conclusion
It can be concluded from the present investigation that the kokum candy prepared with 45% kokum rind and 25% jaggery and 30% constant: cumin powder (20%), sugar powder (7.5%), red chilli powder (2.0%), Black salt (0.5%) was found to be best with 120 days storage.

Acknowledgments
We are grateful to the Associate Dean, Post Graduate Institute of Post-Harvest Technology and Management, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India for offering facilities and resources for this project. Their support facilitated the smooth execution of the research.

References
1. Association of Official Analytical Chemists (AOAC). Official methods of analysis. 15th ed. Washington, D.C.: AOAC; 1990.
2. Association of Official Analytical Chemists (AOAC). Official methods of analysis. 12th ed. Washington, D.C.: AOAC; 1975.
3. Association of Official Analytical Chemists (AOAC). Official methods of analysis. 16th ed. Washington, D.C.: AOAC; 2002.
4. Akhter MJ, Hosain MM, Halim MA, Prabin M, Parvin S, Siddika A, *et al.* Consumer acceptance and physicochemical properties of developed carambola (*Averrhoa carambola*) candy. World J Eng Technol. 2022;10(2):458-471.

5. Amerine MA, Pangborn RM, Rosseler EB. Principles of sensory evaluation of foods. New York: Academic Press; 1965. p. 350-376.
6. Anonymous. Area and production of horticultural crops for 2023-25. Ministry of Agriculture and Farmers' Welfare, Government of India; 2024. Available from: https://agriwelfare.gov.in
7. American Public Health Association (APHA). Compendium of methods for microbiological examination of foods. Downes FP, Ito K, editors. Washington: APHA; 2001.
8. Balaji V, Prasad VM, Saroj PL. Comparative study of varieties, honey coating and storage durations on aonla candy. Indian J Hortic. 2014;71(1):104-108.
9. Bhat DJ, Kamat N, Shirodhkar A. Compendium and proceedings of 2nd National Seminar on Kokum (*Garcinia indica*). 2005. p. 4-5.
10. Chandran MS. Nature watch: The kokum tree. Resonance. 1996;1(1):86-9.
11. Chaurasiya AK, Chakraborty I, Saha J. Value addition of Palmyra palm and studies on the storage life. J Food Sci Technol. 2014;51(4):768-773.
12. Chavan UD, Pawar UB, Pawar GH. Studies on preparation of mixed toffee from guava and strawberry. J Food Technol. 2015;52(10):6791-6797.
13. Choudhary A. Utilization of pumpkin (*Cucurbita moschata*) for the development of blended toffee [M.Sc. thesis]. Jammu: Sher-e-Kashmir Univ. Agric. Sci. Technol.; 2020.
14. Deore AB, Sapakal VD, Naikwade NS. Antioxidant and hepatoprotective activity of *Garcinia indica* Linn fruit rind. Int J Compr Pharm. 2011;2(6):23-26.
15. Ghanwat AB. Studies on preparation of aonla candy [doctoral dissertation]. Parbhani: Vasantrao Naik Marathwada Krishi Vidyapeeth; 2017.
16. Gharate AN. Studies on preparation of candy from ber [M.Sc. (Agri.) thesis]. Rahuri: Mahatma Phule Krishi Vidyapeeth; 1984. p. 1-35.
17. Gupta OP, Kainsa RL, Chauhan KS. Post-harvest studies on ber fruits. I. Preparation of candy. Haryana Agric Univ J Res. 1980;10(2):163-165.
18. Hasanuzzaman MD, Kamruzzaman M, Islam MM, Khanom SAA, Rahman MM, Lisa LA, *et al.* A study on tomato candy prepared by dehydration technique using different sugar solutions. Food Nutr Sci. 2014;5(13):1261-1271.
19. Haseeba M. Evaluation and standardization of process for development of carrot candy [doctoral dissertation]. Srinagar: Sher-e-Kashmir Univ. Agric. Sci. Technol. Kashmir; 2020.
20. Jothi JS, Islam M, Islam MS, Rahman MRT, Akther S. Development and shelf-life prediction of pineapple (*Ananas comosus*) preserve and candy. Int J Innov Sci Res. 2014;10:77-82.
21. Kamboj S. Development and evaluation of candy prepared from raw mango [doctoral dissertation]. Jammu: Sher-e-Kashmir Univ. Agric. Sci. Technol.; 2021.
22. Korikanthimath VS, Desai AR. Status of kokum (*Garcinia indica* Choisy) in Goa. In: Proc 2nd Natl Seminar on Kokum (*Garcinia indica* Choisy). Goa: Univ. of Goa; 2005. p. 75-78.
23. Krishnamurthy N, Lewis YS, Ravindranath B. Chemical constituents of kokum fruit rind. J Food Sci Technol. 1982;19(3):97-100.
24. Kumar R, Awasthi P, Mishra V, Chugh V, Singh SC. Effect of different packaging materials on quality during storage of kinnow mandarin (*Citrus reticulata* Blanco). Pharma Innov J. 2022;11(3):1137-1141.
25. Lane JH, Eynon L. Determination of reducing sugars by means of Fehling's solution with methylene blue as internal indicator. J Soc Chem Ind. 1923;17:32-37.
26. Mahato A, Chakraborty I, Baidya BK. Preparation and evaluation of fruit candy from unripe mango. Int J Chem Stud. 2020;8(1):2727-2731.
27. Mai Kiran E. Value addition to tamarind (*Tamarindus indica* L.) [M.Sc. thesis]. Hyderabad: Post Graduate and Research Centre, Acharya N.G. Ranga Agricultural University; 2006. p. 92-96.
28. Manshi, Gehlot R, Singh R, Siddiqui S. Development and quality evaluation of jamun (*Syzygium cumini* L.) cheese and toffee. Haryana J Hortic Sci. 2010;39(2):145-147.
29. Mir SA, Wani SM, Ahmad M, Wani TA, Gani A, Mir SA, *et al.* Effect of packaging and storage on the physicochemical and antioxidant properties of quince candy. J Food Sci Technol. 2015;52:7313-7320.
30. Mishra A, Bapat MM, Tilak JC, Thomas PA. Antioxidant activity of *Garcinia indica* L. (kokum) and its syrup. Curr Sci. 2006;91(1):90-93.
31. Muzzaffar S, Baba WN, Nazir N, Masoodi FA, Bhat MM, Bazaz R. Effect of storage on physicochemical, microbial and antioxidant properties of pumpkin (*Cucurbita moschata*) candy. Cogent Food Agric. 2016;2(1):1163650.
32. Nayak CA, Srinivas P, Rastogi NK. Characterization of anthocyanin from *Garcinia indica* Choisy. Food Chem. 2010;118:719-724.
33. Norzom T, Bandral JD, Sood M, Jan A. Quality of bottle gourd-strawberry blended toffee during storage. Appl Biol Res. 2018;20(2):193-199.
34. Padhye S, Ahmad A, Oswal N, Sarkar FH. Emerging role of Garcinol, the antioxidant chalcone from *Garcinia indica* Choisy and its synthetic analogs. J Hematol Oncol. 2009;2:1-13.
35. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. New Delhi: Indian Council of Agricultural Research; 1985. p. 70-72.
36. Panwar S. Development of intermediate moisture food segments and candy from aonla (*Phyllanthus emblica* L.) [Ph.D. thesis]. Hisar: CCS Haryana Agricultural University; 2014.
37. Patel A, Patel D, Sharma GL, Saxena RR, Nayak V, *et al.* Standardization of recipe of different guava (*Psidium guajava* L.) varieties for candy preparation. Pharma Innov J. 2022;11(1):932-936.
38. Patil SK, Manjunatha GO, Hegde H, Channabasappa KS. Diversity in germplasm of *Garcinia indica* (Choisy) in Karnataka. In: National symposium on Garcinia genetic resources: linking diversity, livelihood and management. Sirsi: College of Forestry; 2012. p. 53-59.
39. Prasad PSR, Rao SP, Nageswar PV, Giridhar G. Indian Food Packer. 1968;22(6):8-11.

40. Ranganna S. Handbook of analysis and quality control for fruits and vegetables. New Delhi: Tata McGraw Hill; 1986. p. 9-10.
41. Rani U, Bhatia BS. Studies on pear candy processing. Indian Food Packer. 1985;39(5):40-46.
42. Sadasivam S, Manickam A. Biochemical methods. New Delhi: New Age International (P) Ltd; 2008.
43. Sandhu GS. Development of sugar-coated candied products [M.Sc. thesis]. Ludhiana: Punjab Agricultural University; 1994.
44. Sakhare KS, Sawate AR, Kshirsagar RB, Taur AT. Studies on technology development, organoleptic evaluation and proximate composition of beetroot candy by using different sweeteners. J Pharmacogn Phytochem. 2019;8(2):766-769.
45. Sehrawat A, Bahadur V, Prasad VM, Joseph AV, Topno SE, *et al.* Standardisation of recipe with value addition for mango candy (*Mangifera indica* Linn). Int J Plant Soil Sci. 2023;35(15):288-295.
46. Shamrez B, Aftab S, Junaid M, Ahmed N, Ahmed S. Preparation and evaluation of candies from citron peel. IOSR J Environ Sci Toxicol Food Technol. 2013;7(1):21-24.
47. Swami BS, Thakor NJ, Patil SC. Kokum (*Garcinia indica*) and its many functional components as related to human health: a review. J Food Res Technol. 2014;4:130-142.
48. Tripathi VK, Singh MB, Singh S. Studies on comparative compositional changes in different preserved products of aonla (*Emblica officinalis* Gaertn.) var. Banarasi. Indian Food Packer. 1988;42(4):60-66.
49. Tulsi B. Studies on standardisation of sweet orange peel candy [doctoral dissertation]. Parbhani: Vasantrao Naik Marathwada Krishi Vidyapeeth; 2017.