**Nutritional, Sensory Quality and Antimicrobial Enhancement of Mango Ginger and Spices Fortified Tamarind Candies**

**Abstract**

Tamarind (*Tamarindus indica* L.) is a highly nutritious but underutilized fruit. Tamarind have a significant health benefits but till its potential remains largely unexploited. This present investigation is about the effects of incorporating natural ingredients like cumin (*Cuminum cyminum*), black cumin (*Nigella sativa*), fenugreek (*Trigonella foenum*-*graecum*), chilli powder (*Capsicum annuum*) and mango ginger (*Curcuma amada*) on the overall nutritional, sensory and microbial quality of tamarind candy. The entire study was conducted during the 12 months of storage. A Completely Randomized Design (CRD) consisting of four (04) treatments (control, spice mix, spice mix + chilli, spice mix + chilli + mango ginger) and five (05) replications was conducted. Results showed that total soluble solids (TSS), total sugar (TS) and reducing sugar (RS) gradually increased over time. The titratable acidity and ascorbic acid content declined during the storage which was irrespective of treatments. The firmness which was analyzed using texture analyzer was significantly higher in spice-enhanced candies. The Microbial analysis revealed that mango ginger significantly reduced the total plate count (TPC). This demonstrates a strong antimicrobial property of mango ginger. Sensory evaluation revealed that candies prepared with spices and mango ginger retained better flavor, texture and overall acceptability as compared to the control. The study concludes that incorporating traditional spices, particularly mango ginger, improved the physicochemical, microbial and sensory attributes of tamarind candy. Mango ginger is also known to extend the shelf life and improving consumer demand. These findings back the development of a quality enhanced tamarind candy with health-promoting spices..

**Keywords**: Mango ginger, microbial stability, functional candy, spice enrichment, mango ginger, shelf life, sensory quality.

1. **INTRODUCTION**

Tamarind (*Tamarindus indica* L.) is an underutilized yet highly nutritious fruit tree indigenous to tropical and subtropical regions. Tamarind is grown in almost every part of the tropics and sub-tropics and the processed products made of tamarind have a very high market demand. Tamarind is liked for its sour & acidic pulp and hence widely used in culinary applications. The mature tamarind fruit contains a brown to reddish-brown pulp with comprises of around 55% of the fruit weight. The seeds, the fibres and the brittle shell constitute of 31%, 5% and 9%, respectively (Zhang et al., 2024). In the Indian subcontinent, tamarind is vital ingredient for imparting tanginess and flavour in a variety of traditional dishes such as curries, sauces, chutneys and beverages. Tamarind pulp is a rich source of essential phytonutrients which includes dietary antioxidants, total phenolics, flavonoids and organic acids. All these factors contribute to the unique health-promoting properties of tamarind (Shankaracharya, 1998). These bioactive compounds are known to be associated with numerous health benefits, such as lipid lowering effects, cardiovascular disease protection, high blood sugar control and immunity boosting (Lim et al., 2013; Jindal et al., 2011). Tamarind is known for its digestive, anti-inflammatory, antimicrobial and antioxidant properties. The day to day use of tamarind is deeply rooted to our traditional herbal systems. According to Manjula et al. (2017) and Leung and Flores (1961), tamarind is a nutrient rich fruit, high in vitamins like thiamine and niacin; minerals like potassium, calcium, magnesium and phosphorus; dietary fiber and amino acids. These above nutritional properties and its delicate taste make tamarind an ideal candidate for the development of functional and health-oriented food products which can be liked by people of all ages.

There are different types of value-added and processed tamarind based products which include jam, jelly, fruit bar, puree, sauce, powder made of pulp, pickle, beverages and candy. Tamarind candy is one such important processed product which is very popular because of its natural sweet-sour taste and excellent aroma. Tamarind candy is prepared by boiling the fibre free tamarind pulp with sugar. The amount of sugar to be added depends on requirement and taste preferences. After achieving a certain stickiness and thick consistency, the tamarind is being shaped as per requirement and dried (Ravindran et al., 2002). The process of tamarind candy preparation with desirable consistency in texture, taste, and shelf life has been standardized (Mani et al., 2020).

The particular study is aimed towards understanding the effect of incorporating natural ingredients like cumin (*Cuminum cyminum*), black cumin (*Nigella* *sativa*), fenugreek (*Trigonella foenum-graecum*), chilli powder (*Capsicum annuum*) and mango ginger (*Curcuma amada*) on the overall nutritional, sensory and therapeutic properties of tamarind candy. These ingredients are a part of Indian household and possess desirable nutritional and medicinal benefits. Mixing these ingredients in the pulp is expected to enhance the quality of tamarind candy by improving its sensory quality like flavors, aromas and mouthfeel (Sowbhagya, 2019). These additives would also enrich the prepared candy with dietary fiber, essential oils, polyphenols, flavonoids and micronutrients (Johri, 2011; Neelakantan et al., 2014). These ingrediants also have desirable antimicrobial and antioxidant properties. For example thymoquinone in black cumin and capsaicin in chilli is known to extend shelf life by delaying microbial spoilage and oxidative rancidity (Ahmad et al., 2013; Ludy et al., 2012). Cumin and black cumin improves digestion (Gholamnezhad et al., 2016), controls diabetes (Neelakantan et al., 2014), reduces cholesterol and improves immunity (Prasad & Tyagi, 2015). Cumin is rich in iron, volatile oils and is known to enhance the flavor, antioxidant potential and antimicrobial properties (Sowbhagya, 2019). Cumin is known to improve digestion and stimulates the secretion of pancreatic enzymes (Johri, 2011).

Black cumin (*Nigella sativa*) is rich in thymoquinone which have antioxidant, anti-inflammatory and immunomodulatory properties (Ahmad et al., 2013). Black cumin improves the therapeutic value of tamarind candy and is traditionally used to support respiratory and digestive health (Gholamnezhad et al., 2016). Fenugreek seeds are rich in soluble fiber, saponins and flavonoids. Incorporating fenugreek is expected to improve the functional benefits of tamarind candy by reducing diabetes, balancing lipid metabolism and improving gut health (Neelakantan et al., 2014). Capsaicin is the main active compound of chilli powder that contributes to thermogenesis, appetite regulation and improvement in metabolism (Ludy et al., 2012). However mango ginger rhizomes is not that much available in a common Indian house hold but it is very much popular in villages and traditional household. Mango ginger is easy to grow in most type of soil and is gaining popularity world wide. Mango ginger imparts an unique aroma with mild pungency of some unripe mangoes (Policegoudra et al., 2011). Mango ginger possesses anti-inflammatory, anti-nausea and several other benefits (Prasad & Tyagi, 2015). The addition of mango ginger extract is expected to offers a refreshing flavour and enhances the nutraceutical profile of tamarind candy.

1. **Materials and Methods**
	1. **Methodology for preparation of Tamarind Candy:** Tamarind candy is a very popular processed product. However a standardized method is followed for candy preparation (Mani et al., 2020).

**Chart 1: Flowchart for Candy Preparation**

Tamarind fruits

↓

Breaking the rind and Peeling

↓

Extraction of pulp

↓

Separation of fiber and seeds from pulp

↓

Wetting the pulp with little water

↓

Addition of natural herbs and products

↓

Mixing with ingredients thoroughly

↓

Heating / cooking of the tamarind pulp

↓

Mixing thoroughly the mixture

↓

Cooking till hardness is achieved

↓

Sanding sugar dust into the tamarind pulp

↓

Shaping candy/toffee in proper shape

↓

Tamarind candy ready after mixing with sugar powder

↓

Cooling of the cooked product

↓

Packing in Cellophane paper

↓

Storage of candy in air tight jars

**Table 1: Recipe charts for preparation of Tamarind candy** (Mani et al., 2020)

|  |  |
| --- | --- |
| **Ingredients (for 250 g pulp)** | **Quantity** |
| Cumin | 3 g |
| Red chilli powder | 10 g |
| Black Cumin seed | 2 g |
| Fenugreek  | 5 g |

* 1. **Experiment details:** The experiment was conducted during the year 2018–2019 in the Post Graduate Laboratory of the Department of Post-Harvest Technology at Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, using a Completely Randomized Design (CRD) comprising four treatments and five replications. Tamarind fruits & spices were purchased from Local Market. Mango ginger was collected from Jaguli farm located at BCKV. The highest and lowest atmospheric temperature during the year of study was 41OC and 7OC respectively. The relative humidity varied from 100% during monsoon to 60% during winter.
	2. **Treatment Details:** The candy was prepared by addition of spices and mango ginger. The treatment details are as follows:
1. Treatment 1 (T1): Control (no addition)
2. Treatment 2 (T2): Cumin, black cumin and fenugreek
3. Treatment 3 (T3): Cumin, black cumin, fenugreek and chilli powder
4. Treatment 4 (T4): Cumin, black cumin, fenugreek, chilli powder and mango ginger
	1. **Observation recorded:** The tamarind candy was analyzed for its quality, sensory and microbiological properties at an interval of 3 months up to 12 months of storage. TSS of the prepared candies was determined using a digital refractometer. Total sugar, reducing sugar, titratable acidity and ascorbic acid content of the prepared candy was determined according to the standard procedures (AOAC, 2012). pH value of the prepared candy was determined using a standard pH meter. The hardness or firmness (Newton) of tamarind candy during storage was analyzed using instrumental texture analyzer (Stable Microsystem; Model: TA.XT. Plus). . The pre-test speed was set at 1 mm/second, test speed at 2 mm/second, post-test speed at 5 mm/second. The distance of penetration at 5mm and trigger force at 5 g. Microbiological analysis for the candy was carried out by the method of Ranganna (2010). All the enumerations of Bacteria and *Lactobacillus* were carried out following serial dilution technique using specific media. Plates were incubated at 34±1 °C for 48 hours and colony forming units (CFU/g) were recorded. Observations for microbial count were made at prescribed intervals. The principle behind this is that the population of total bacterial population tends to decline with the decimal reduction in the concentration of the sample analyzed. Usually in a culture the microbial population was expected to be higher in 10-1 which tends to decline with 10-2, 10-3, 10-4, 10-5 and 10-6 sample concentration. Higher the sample concentration higher would be the expected microbial concentration. As the colonies tend to coalesce or merge at higher concentration hence the readings for Total Plate Count and Total Bacterial Population Count have been studied at 10-5 concentration. 9-point hedonic scale was used for the purpose of sensory evaluation of the prepared tamarind candy. Twenty judges of different age groups were asked to rate from 1 to 9 based on different columns like colour, texture, flavour, taste and overall organoleptic score (Peryam et al., 1957; Prescott, 2015).
5. **Results**

**Table 2: Physicochemical properties of Tamarind pulp used for candy preparation**

|  |  |
| --- | --- |
| **Attributes** | **Value per 100 gm** |
| Vitamin C | 0.841 mg/100g |
| TSS | 48 OB |
| Titratable acidity | 30.45 % |
| Moisture percent | 28.2% |
| Total sugar | 18.4 % |
| pH | 3.26 |

Table 2 highlights the physicochemical composition of fresh tamarind. Vitamin C content of fresh tamarind was 0.841 mg/100g. Titratable acidity was 30.45%. Moisture percent was 28.2% and total sugar content was 18.4 %. TSS was observed to be 48OB and pH was 3.26.

* 1. **Change in TSS (OB) of tamarind candy during storage**

Table 3 highlights the variation in TSS (OB) of tamarind candy prepared by different treatments during storage. At 0 days of storage, TSS was more or less same in tamarind candy prepared by different treatments. After 3 month, 6 months, 9 months and 12 months of storage, candy prepared with treatment 1 (T1) exhibit no variation from treatment 2 (T2), treatment 3 (T3) and treatment 4 (T4). However a steady increase in TSS (OB) has been observed. At 0 days of storage, The TSS in all the treatments was 85.15OB which increased up to 86.18OB in treatment 3 (T3), 86.17 OB in treatment 2 (T2) and treatment 4 (T4) and 86.15OB in treatment 1 (T1). But this increase is irrespective of the treatment. A steady increase in TSS might be due to loss in surface moisture. Moisture loss from the main product is a continuous process and the grinded sugar at the surface of the candy also gets partially absorbed by the candy. Due to these factors the TSS in all the treatments keeps increasing continuously.

**Table 3: Effect of different recipe on TSS (OB) of tamarind candy during storage**

|  |  |
| --- | --- |
| **Treatment details** | **Months of storage** |
| **0** | **3** | **6** | **9** | **12** |
| Treatment 1 (Control) | 85.15 | 85.35 | 85.59 | 85.88 | 86.15 |
| Treatment 2 (Cumin, black cumin and fenugreek) | 85.15 | 85.35 | 85.59 | 85.88 | 86.17 |
| Treatment 3 (Cumin, black cumin, fenugreek and chilli powder ) | 85.14 | 85.35 | 85.58 | 85.89 | 86.18 |
| Treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) | 85.15 | 85.35 | 85.58 | 85.90 | 86.17 |
| S.Em. (±) | 0.011 | 0.008 | 0.004 | 0.012 | 0.012 |
| C.D. at 5% | 0.035 | 0.025 | 0.013 | N/A | N/A |

* 1. **Change in titratable acidity (%) of tamarind candy during storage**

Table 4 highlights the variation in titratable acidity (%) of tamarind candy prepared using different treatments. Throughout the storage period, there is an evident decline in titratable acidity of tamarind candy. The decline is gradual but is a continuous process. At 0 days of storage, titratable acidity was 0.537% which increased up to 0.505% at 12th month of storage. At 0 month, 3rd month, 6th month, 9th month and 12th month of storage, treatment 1 (T1) was at par with treatment 2 (T2), treatment 3 (T3) and treatment 4 (T4). This clearly indicates that throughout the storage period the treatments do not have any effect on titratable acidity of the tamarind candy. This implies that addition of natural products like spices and herbs does not have any significant effect on the titratable acidity even up to 12th month of storage.

**Table 4: Effect of different recipe on titratable acidity (%) of tamarind candy during storage**

|  |  |
| --- | --- |
| **Treatment details** | **Months of storage** |
| **0** | **3** | **6** | **9** | **12** |
| Treatment 1 (Control) | 0.537 | 0.533 | 0.523 | 0.516 | 0.505 |
| Treatment 2 (Cumin, black cumin and fenugreek) | 0.537 | 0.530 | 0.524 | 0.516 | 0.505 |
| Treatment 3 (Cumin, black cumin, fenugreek and chilli powder ) | 0.537 | 0.530 | 0.523 | 0.515 | 0.505 |
| Treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) | 0.537 | 0.532 | 0.525 | 0.516 | 0.505 |
| S.Em. (±) | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| C.D. at 5% | 0.002 | N/A | N/A | N/A | 0.002 |

* 1. **Change in total sugar (%) of tamarind candy during storage**

Table 5 highlights the variation in total sugar (%) of tamarind candy prepared from different treatments. At 0 days of storage, the total sugar content was 52.63% in treatment 1 (T1), 52.60% in treatment 2 (T2), 52.59% in treatment 4 (T4) and 52.58% in treatment 3 (T3). Throughout the storage, the total sugar content keeps on increasing steadily. The increase in total sugar content is irrespective of the treatments applied. Treatments do not have any significant effect on the increasing trend of total sugar. At 12th month of storage, total sugar content was 55.20% in treatment 3 (T3), 55.19% in treatment 1 (T1) and treatment 2 (T2), 55.17% in treatment 4 (T4). The steady increase in total sugar content throughout the storage might be due to the fact that, moisture is lost due to which the total amount of sugar gets increased per unit weight. Also some sugar gets uptake from the grinded sugar coating.

**Table 5: Effect of different recipe on total sugar (%) of tamarind candy during storage**

|  |  |
| --- | --- |
| **Treatment details** | **Months of storage** |
| **0** | **3** | **6** | **9** | **12** |
| Treatment 1 (Control) | 52.63 | 53.16 | 53.91 | 54.66 | 55.19 |
| Treatment 2 (Cumin, black cumin and fenugreek) | 52.60 | 53.19 | 53.90 | 54.63 | 55.19 |
| Treatment 3 (Cumin, black cumin, fenugreek and chilli powder ) | 52.58 | 53.18 | 53.88 | 54.56 | 55.20 |
| Treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) | 52.59 | 53.17 | 53.89 | 54.56 | 55.17 |
| S.Em. (±) | 0.016 | 0.010 | 0.016 | 0.032 | 0.022 |
| C.D. at 5% | N/A | 0.029 | 0.049 | N/A | N/A |

* 1. **Change in reducing sugar (%) of tamarind candy during storage**

Table 6 highlights the variation in reducing sugar (%) of tamarind candy prepared from different treatments. Just like in the case of total sugar, the reducing sugar also keeps on increasing throughout the storage period. The increase in reducing sugar content is irrespective of the treatment used. At 0 days of storage more or less similar reducing sugar was observed which was 18.34% in T1, 18.35% in T3 and T4 and 18.37% in T2. At 3rd month of storage, however there is not much variation in reducing sugar content but statistically significant variation was observed among the candy prepared by different treatments. Treatment 2 (T2) shows highest value of reducing sugar which was 19.13% followed by 19.10% in treatment 3 (T3) and treatment 4 (T4). At 3rd month of storage, least value of reducing sugar was observed in Treatment 1 (T1) which was 19.07%. But at 6th, 9th and 12th month of storage there is no effect of treatment on reducing sugar content of tamarind candy. The gradual increase in reducing sugar content is due to the loss in moisture of the product.

**Table 6: Effect of different recipe on reducing sugar (%) of tamarind candy during storage**

|  |  |
| --- | --- |
| **Treatment details** | **Months of storage** |
| **0** | **3** | **6** | **9** | **12** |
| Treatment 1 (Control) | 18.34 | 19.07 | 19.53 | 20.42 | 21.19 |
| Treatment 2 (Cumin, black cumin and fenugreek) | 18.37 | 19.13 | 19.51 | 20.32 | 21.16 |
| Treatment 3 (Cumin, black cumin, fenugreek and chilli powder ) | 18.35 | 19.10 | 19.43 | 20.38 | 21.17 |
| Treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) | 18.35 | 19.10 | 19.51 | 20.40 | 21.18 |
| S.Em. (±) | 0.037 | 0.014 | 0.066 | 0.031 | 0.036 |
| C.D. at 5% | N/A | N/A | N/A | N/A | N/A |

* 1. **Change in ascorbic acid content of tamarind candy during storage**

Table 7 illustrates the variation in ascorbic acid content of tamarind candy prepared using different treatments. At 0 days of storage, the ascorbic acid content of the candy does not vary too much with the treatments. At 3rd month of storage, highest ascorbic acid was present in treatment 4 (T4) followed by treatment 3 (T3), treatment 2 (T2) and treatment 1 (T1) which was 0.390 mg/100 g, 0.378 mg/100 g, 0.377 mg/100 g and 0.377 mg/100 g respectively. At 6th month of storage, highest ascorbic acid was present in Treatment 4 (T4) followed by treatment 2 (T2), treatment 1 (T1) and treatment 3 (T3) which was 0.350 mg/100 g, 0.329 mg/100 g, 0.328 mg/100 g and 0.327 mg/100 g respectively. At 9th month of storage, highest ascorbic acid was present in Treatment 4 (T4) followed by treatment 3 (T3), treatment 2 (T2) and treatment 1 (T1) which was 0.299 mg/100 g, 0.232 mg/100 g, 0.231 mg/100 g and 0.230 mg/100 g respectively. At 12th month of storage, highest ascorbic acid was present in treatment 4 (T4) followed by treatment 1 (T1), treatment 2 (T2) and treatment 3 (T3) which was 0.265 mg/100 g, 0.174 mg/100 g, 0.169 mg/100 g and 0.168 mg/100 g respectively. It can be observed that ascorbic acid decline is a natural process in storage. But rate of decline is low in case of candy where mango ginger has been added along with different spice mixture. This might be due to the fact that mango ginger has better capacity to reduce loss of Vitamin C during storage as compared to the candy prepared without addition of mango ginger.

**Table 7: Effect of different recipe on ascorbic acid (mg/100 g) of tamarind candy during storage**

|  |  |
| --- | --- |
| **Treatment details** | **Months of storage** |
| **0** | **3** | **6** | **9** | **12** |
| Treatment 1 (Control) | 0.431 | 0.377 | 0.328 | 0.230 | 0.174 |
| Treatment 2 (Cumin, black cumin and fenugreek) | 0.432 | 0.377 | 0.329 | 0.231 | 0.169 |
| Treatment 3 (Cumin, black cumin, fenugreek and chilli powder ) | 0.433 | 0.378 | 0.327 | 0.232 | 0.168 |
| Treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) | 0.432 | 0.390 | 0.350 | 0.299 | 0.265 |
| S.Em. (±) | 0.001 | 0.002 | 0.003 | 0.003 | 0.005 |
| C.D. at 5% | N/A | 0.006 | 0.009 | 0.008 | 0.014 |

* 1. **Change in hardness/firmness (Newton) of tamarind candy during storage**

Table 8 illustrates the variation in hardness/firmness (N) of tamarind candy prepared using different treatments. At 0 days of storage, highest firmness was observed in Treatment 3 (T3) followed by Treatment 2 (T2), Treatment 4 (T4) and Treatment 1 (T1) which was 284.28 N, 282.84 N, 279.85 N and 247.00 N. Treatment 2 (T2), Treatment 3 (T3) and Treatment 4(T4) was at par with each other. At 3rd month of storage, highest firmness was observed in Treatment 3 (T3) followed by Treatment 4 (T4), Treatment 2 (T2) and Treatment 1 (T1) which was 301.21 N, 299.14 N, 293.16 N and 258.40 N respectively. Treatment 2 (T2), Treatment 3 (T3) and Treatment 4(T4) was at par with each other. At 6th month of storage, highest firmness was observed in Treatment 3 (T3) followed by Treatment 4 (T4), Treatment 2 (T2) and Treatment 1 (T1) which was 322.87 N, 321.41 N, 311.50 N and 273.88 N respectively. Treatment 2 (T2), Treatment 3 (T3) and Treatment 4(T4) was at par with each other. At 9th month of storage, highest firmness was observed in Treatment 3 (T3) followed by Treatment 4 (T4), Treatment 2 (T2) and Treatment 1 (T1) which was 343.44 N, 336.96 N, 336.63 N and 291.21 N respectively. Treatment 2 (T2), Treatment 3 (T3) and Treatment 4(T4) was at par with each other. At 12th month of storage, highest firmness was observed in Treatment 3 (T3) followed by Treatment 2 (T2), Treatment 4 (T4) and Treatment 1 (T1) which was 364.05 N, 357.73 N, 350.36 N and 303.15 N respectively. Treatment 4 (T4) and Treatment 3 (T3) was at par with Treatment 2 (T2) but not at par with each other. Clearly it can be observed that the addition of powdered spice significantly improved the firmness (N) of tamarind candy throughout the storage period. The hard particle of powdered spice might need more force for penetration of the probe.

**Table 8: Effect of different recipe on hardness/firmness (N) of tamarind candy during storage**

|  |  |
| --- | --- |
| **Treatment details** | **Months of storage** |
| **0** | **3** | **6** | **9** | **12** |
| Treatment 1 (Control) | 247.00 | 258.40 | 273.88 | 291.21 | 303.15 |
| Treatment 2 (Cumin, black cumin and fenugreek) | 282.84 | 293.16 | 311.50 | 336.63 | 357.73 |
| Treatment 3 (Cumin, black cumin, fenugreek and chilli powder ) | 284.28 | 301.21 | 322.87 | 343.44 | 364.05 |
| Treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) | 279.85 | 299.14 | 321.41 | 336.96 | 350.36 |
| S.Em. (±) | 4.092 | 4.159 | 3.851 | 2.472 | 2.632 |
| C.D. at 5% | 12.373 | 12.576 | 11.644 | 7.475 | 7.960 |

* 1. **Change in total plate count (10-5 log CFU) of tamarind candy during storage**

Table 9 illustrates the variation in total plate count (10-5 log CFU) of tamarind candy prepared using different treatments. At 0 days of storage, the total plate count (10-5 log CFU) was very high in case of treatment 1 (T1) which was 17.40. Significantly low TPC was observed in treatment 2 (T2) and treatment 3 (T3) which was 8.20 and 7.20 respectively. Very low TPC was observed in case of candy prepared from treatment 4 (T4) which was just 1. Treatment 3 and treatment 2 was at par with each other. Similar trend was observed after 3rd, 6th, 9th and 12th month of storage. At 3rd month of storage, total plate count showed a gradual increase which was 32.20 in treatment 1 (T1), 15.80 and 15.00 in treatment 2 (T2) and treatment 3 (T3), 5.40 in treatment 4 (T4). Treatment 3 and treatment 2 was at par with each other. At 6th month of storage, a further increase in TPC was observed which was 45.60 in treatment 1 (T1), 24.40 and 22.00 in treatment 2 (T2) and treatment 3 (T3), 9.80 in treatment 4 (T4). Treatment 3 and treatment 2 was at par with each other. At 9th month of storage, highest TPC was observed in treatment 1 (T1) followed by treatment 2 (T2), treatment 3 (T3) and treatment 4 (T4) which was 62.60, 30.60, 27.00 and 13.80. At 12th month of storage highest TPC was observed in treatment 1 (T1) followed by treatment 2 (T2), treatment 3 (T3) and treatment 4 (T4) which was 99.40, 38.60, 34.20 and 19.20. Spice addition in candy (T2 and T3) seems to reduce the total bacterial population as compared to that of the candy prepared without any addition (T1). In candy where mango ginger has been added along with spice, the bacterial population is very low. This highlights that mango ginger is capable to reduce bacterial population up to several times. Throughout the storage, candy where mango ginger is added seems to be significantly reducing the bacterial population. Anti-bacterial property of mango ginger was also reported by Annapurnaet al., (2021) and Siddaraju and Dharmesh, (2007).

**Table 9: Effect of different recipe on total plate count (10-5 log CFU) of tamarind candy during storage**

|  |  |
| --- | --- |
| **Treatment details** | **Months of storage** |
| **0** | **3** | **6** | **9** | **12** |
| Treatment 1 (Control) | 17.40 | 32.20 | 45.60 | 62.60 | 99.40 |
| Treatment 2 (Cumin, black cumin and fenugreek) | 8.20 | 15.80 | 24.40 | 30.60 | 38.60 |
| Treatment 3 (Cumin, black cumin, fenugreek and chilli powder ) | 7.20 | 15.00 | 22.00 | 27.00 | 34.20 |
| Treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) | 1.00 | 5.40 | 9.80 | 13.80 | 19.20 |
| S.Em. (±) | 0.954 | 1.495 | 1.471 | 1.136 | 1.549 |
| C.D. at 5% | 2.885 | 4.521 | 4.449 | 3.434 | 4.684 |

* 1. **Change in flavour of tamarind candy during storage**

Table 10 highlights the variation in flavour of tamarind candy prepared using different treatments. At 0 days of storage the treatments showed negligible effect on flavour of the candy. Flavour of all candy was liked very much and was given a score of 8.80 in T1, 9.00, 9.00 and 9.00 in T2, T3 and T4 respectively. After 3rd month of storage, the score given to treatment 1 (T1) was 8.20 whereas treatment 2 (T2), treatment 3 (T3) and treatment 4 (T4) was given a score of 9.0. T2, T3 and T4 were at par with each other during 3rd month of storage. After 6th month of storage, maximum score of 9.0 was given to Treatment 4 (T4) followed by 8.60 in Treatment 3 (T3), 8.40 in Treatment 2 (T2) and 7.60 in Treatment 1 (T1). Treatment 4 (T4) and Treatment 2 (T2) was at par with Treatment 3 (T3). After 9th month of storage, best flavour was observed in Treatment 4 (T4) which was 8.80 followed by Treatment 2 (T2) and Treatment 3 (T3) which was 8.0. Minimum score in terms of flavour was observed in Treatment 1 (T1) which was 7.0. Treatment 2 (T2) and Treatment 3 (T3) was at par with each other. After 12th month of storage, best score in terms of flavour was given to Treatment 4 (T4), Treatment 3 (T3), Treatment 2 (T2) and Treatment 1 (T1) which was 8.40, 8.00, 7.80 and 6.80 respectively. Flavour of spices and flavour of mango ginger in tamarind candy was liked by the scorer. Even after 12th month of storage, the candy retained flavour of spice and mango ginger and hence Treatment 4 (T4) and Treatment 3 (T3) were considered best in terms of flavour. The exquisite flavour of unripe mango and ginger is due to presence of cis- and trans-hydroocimene, ocimene and myrcene (Rao et al., 1989). There are reports of flavour improvement of pickles, candies, preserves and sauces by Verghese, (1990) and Shankaracharya, (1982) as well.

**Table 10: Effect of different recipe on flavour of tamarind candy during storage (9 point hedonic scale)**

|  |  |
| --- | --- |
| **Treatment details** | **Months of storage** |
| **0** | **3** | **6** | **9** | **12** |
| Treatment 1 (Control) | 8.80 | 8.20 | 7.60 | 7.00 | 6.80 |
| Treatment 2 (Cumin, black cumin and fenugreek) | 9.00 | 9.00 | 8.40 | 8.00 | 7.80 |
| Treatment 3 (Cumin, black cumin, fenugreek and chilli powder ) | 9.00 | 9.00 | 8.60 | 8.00 | 8.00 |
| Treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) | 9.00 | 9.00 | 9.00 | 8.80 | 8.40 |
| S.Em. (±) | 0.100 | 0.100 | 0.212 | 0.100 | 0.187 |
| C.D. at 5% | NS | 0.302 | 0.641 | 0.302 | 0.566 |

* 1. **Change in texture/mouth feel of tamarind candy during storage**

Table 11 highlights the variation in texture/mouth feel of tamarind candy prepared using different treatments. Texture of candy is the perception when the candy is placed in the mouth. At 0 days of storage the treatments showed negligible effect on texture of the candy. The candy prepared with Treatment 1 (T1) was given a score of 8.60. Significantly better texture score of 9.00 was given to Treatment 2 (T2), Treatment 3 (T3) and Treatment 4 (T4). At 3rd month of storage, highest score was observed in Treatment 3 (T3) and Treatment 4 (T4) followed by Treatment 2 (T2) and Treatment 1 (T1) which was 9.00, 9.00, 8.80 and 8.60 respectively. At 6th month of storage, 9.00 score was given to candy prepared with treatment 3 (T3) and treatment 4 (T4). A low score of 8.80 and 8.60 was given to Treatment 2 (T2) and Treatment 1 (T1) respectively. At 9th month of storage, highest score was given to candy prepared with treatment 4 (T4) followed by treatment 3 (T3), treatment 2 (T2) and treatment 1 (T1) which was 9.00, 8.60, 8.40 and 8.00. Treatment 3 (T3) is at par with treatment 4 (T4). Treatment 2 was at par with treatment 1 (T1) and treatment 3 (T3). After 12th month of storage, best score of 9.0 was observed in treatment 4 (T4) followed by considerably good score in all other treatment which was 8.0. Clearly it can be observed that addition of mango ginger along with spice improved the mouth feel or the texture to a significant extent even after 12th month of ambient storage.

**Table 11: Effect of different recipe on texture/mouth feel of tamarind candy during storage (9 point hedonic scale)**

|  |  |
| --- | --- |
| **Treatment details** | **Months of storage** |
| **0** | **3** | **6** | **9** | **12** |
| Treatment 1 (Control) | 8.60 | 8.60 | 8.60 | 8.00 | 8.00 |
| Treatment 2 (Cumin, black cumin and fenugreek) | 9.00 | 8.80 | 8.80 | 8.40 | 8.00 |
| Treatment 3 (Cumin, black cumin, fenugreek and chilli powder ) | 9.00 | 9.00 | 9.00 | 8.60 | 8.00 |
| Treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 |
| S.Em. (±) | 0.122 | 0.158 | 0.158 | 0.173 | 0.158 |
| C.D. at 5% | N/A | N/A | N/A | 0.524 | 0.478 |

* 1. **Change in consistency of tamarind candy during storage**

Table 12 highlights the variation in consistency of tamarind candy prepared using different treatments. Consistency of candy is the perception when the candy is placed in the mouth and it does not break apart easily. At 0 days of storage, the treatments showed negligible effect on consistency of the candy. Treatment 2 (T2), Treatment 3 (T3) and Treatment 4 (T4) shows a score of 9.00. Treatment 1 (T1) showed a consistency of 8.80. At 3rd month of storage, similar trend was observed. Highest score was given to Treatment 2 (T2), Treatment 3 (T3) and Treatment 4 (T4) which were 9.0. Comparatively lower score of 8.80 was observed in Treatment 1 (T1). At 6th month of storage, low consistency was observed in treatment 1 (T1) which is 8.6 whereas treatment 2 (T2), treatment 3 (T3) and treatment 4 (T4) shows a higher consistency of 9.0. At 9th month of storage, highest score was given to candy prepared with treatment 2 (T2), treatment 3 (T3) and treatment 4 (T4) which was 9.00, 8.60, 8.60 respectively. Treatment 1 (T1) shows minimum consistency of 8.0. Treatment 2 (T2), treatment 3 (T3) and treatment 4 (T4) is at par with each other. After 12th month of storage, best score of 9.0 was observed in treatment 4 (T4) followed by considerably good score in Treatment 3 (T3) and Treatment 2 (T2) which was 8.60 and 8.60 respectively. Significantly lower consistency was observed in Treatment 1 (T1) which was 8.0. Addition of spice and mango ginger significantly improves the consistency of the candy. This was quite evident at 9th and 12th month of storage.

**Table 12: Effect of different recipe on consistency of tamarind candy during storage (9 point hedonic scale)**

|  |  |
| --- | --- |
| **Treatment details** | **Months of storage** |
| **0** | **3** | **6** | **9** | **12** |
| Treatment 1 (Control) | 8.80 | 8.80 | 8.60 | 8.00 | 8.00 |
| Treatment 2 (Cumin, black cumin and fenugreek) | 9.00 | 9.00 | 9.00 | 8.60 | 8.60 |
| Treatment 3 (Cumin, black cumin, fenugreek and chilli powder ) | 9.00 | 9.00 | 9.00 | 8.60 | 8.60 |
| Treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 |
| S.Em. (±) | 0.100 | 0.100 | 0.122 | 0.173 | 0.173 |
| C.D. at 5% | N/A | N/A | N/A | 0.524 | 0.524 |

* 1. **Change in taste of tamarind candy during storage**

Table 13 highlights the variation in taste of tamarind candy prepared using different treatments during ambient storage for 12 months. At 0 month and after 3rd month of storage, the hedonic score in terms of taste of the candy was uniform. The treatments do not have significant effect on the score during 0 month and 3rd month. Similar trend was also observed in the 6th month of ambient storage as well. But at the 9th month of storage, the effect of treatments on the taste of the candy was prominent. Treatment 3 (T3) and Treatment 4 (T4) exhibited a score of 9.00 at 9th month of storage followed by Treatment 2 (T2) and Treatment 1 (T1) which was 8.20 and 8.00 respectively. At 12th month of storage, Treatment 4 (T4) exhibited the highest score followed by Treatment 3 (T3), Treatment 2 (T2) and Treatment 1 (T1) which was 8.80, 8.40, 8.00 and 7.60 respectively. Quite clearly the effect of mango ginger and spice in improving the taste of the candy was improved. Mango ginger along with spices mixture helped improve the taste throughout the storage period.

**Table 13: Effect of different recipe on taste of tamarind candy during storage (9 point hedonic scale)**

|  |  |
| --- | --- |
| **Treatment details** | **Months of storage** |
| **0** | **3** | **6** | **9** | **12** |
| Treatment 1 (Control) | 8.80 | 8.80 | 8.60 | 8.00 | 7.60 |
| Treatment 2 (Cumin, black cumin and fenugreek) | 9.00 | 9.00 | 8.40 | 8.20 | 8.00 |
| Treatment 3 (Cumin, black cumin, fenugreek and chilli powder ) | 9.00 | 9.00 | 9.00 | 9.00 | 8.40 |
| Treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) | 9.00 | 9.00 | 9.00 | 9.00 | 8.80 |
| S.Em. (±) | 0.100 | 0.100 | 0.173 | 0.187 | 0.200 |
| C.D. at 5% | N/A | N/A | N/A | 0.566 | 0.605 |

* 1. **Change in overall acceptability of tamarind candy during storage**

Table 14 highlights the variation in overall quality of tamarind candy prepared using different treatments as felt by respondent after consumption. At 0 days of storage, the treatments had no significant effect on overall quality of the tamarind candy. The score given to candy prepared by all the treatments was 9. No significant variation among the treatment was also observed at 3rd month of storage where Treatment 1 (T1) had a score of 8.80 whereas treatment 2 (T2), treatment 3 (T3) and treatment 4 (T4) had a score of 9.0. At 6th month of storage, highest score of 9.00 was observed in treatment 3 (T3) and treatment 4 (T4). Treatment 2 (T2) have a score of 8.60 in treatment 2 (T2) and 8.00 in treatment 1 (T1). At 9th month of storage, similar trend was observed. Highest score of 9.00 was observed in treatment 3 (T3) and treatment 4 (T4). Treatment 2 (T2) shows a high score of 8.6. A significantly lower score was observed in 7.40. At 12th month of storage, highest score was observed in Treatment 3 (T3) and Treatment 4 (T4) which was 8.80. Comparatively lower overall acceptability score was given to Treatment 2 (T2) which 8.00. A very low score was observed in Treatment 1 (T1) which was 7.0. Clearly, it can be observed that addition of spice and mango ginger enhances the flavour, improves the consistency and texture and hence the overall acceptability score is also more.

**Table 14: Effect of different recipe on overall quality of tamarind candy during storage (9 point hedonic scale)**

|  |  |
| --- | --- |
| **Treatment details** | **Months of storage** |
| **0** | **3** | **6** | **9** | **12** |
| Treatment 1 (Control) | 8.80 | 8.80 | 8.00 | 7.40 | 7.00 |
| Treatment 2 (Cumin, black cumin and fenugreek) | 9.00 | 9.00 | 8.60 | 8.60 | 8.00 |
| Treatment 3 (Cumin, black cumin, fenugreek and chilli powder) | 9.00 | 9.00 | 9.00 | 9.00 | 8.80 |
| Treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) | 9.00 | 9.00 | 9.00 | 9.00 | 8.80 |
| S.Em. (±) | 0.100 | 0.100 | 0.122 | 0.173 | 0.141 |
| C.D. at 5% | N/A | N/A | 0.370 | 0.524 | 0.428 |

1. **Discussions**

A steady increase in TSS (OB) has been observed in the tamarind candy throughout the storage. But this increase is irrespective of the treatment. A steady increase in TSS might be due to loss in surface moisture. Moisture loss from the main product is a continuous process and the grinded sugar at the surface of the candy also gets partially absorbed by the candy. Due to these factors the TSS in all the treatments keeps increasing continuously. Throughout the storage period, there is an evident decline in titratable acidity of the tamarind candy. The decline is gradual but is a continuous process. This clearly indicates that the treatments do not have any effect on titratable acidity of the tamarind candy. This implies that addition of natural products like spices and herbs does not have any significant effect on the titratable acidity even up to 12th month of storage. The total sugar content, reducing sugar content and ascorbic acid content of the tamarind candy keeps on increasing steadily throughout the storage. The increase in total sugar content is irrespective of the treatments applied. Treatments do not have any significant effect on the increasing trend of total sugar. The steady increase in total sugar content throughout the storage might be due to the fact that, moisture is lost due to which the total amount of sugar gets increased per unit weight. Also some sugar gets uptake from the grinded sugar coating.

The hardness/firmness (N) of tamarind candy showed a steady increase throughout the storage. Clearly it was observed that the addition of powdered spice significantly improved the firmness (N) of tamarind candy throughout the storage period. The hard particle of the powdered spice might need more force for penetration of the probe. Very low TPC was observed in case of candy prepared from treatment 4 (Cumin, black cumin, fenugreek, chilli powder and mango ginger) which was just 1. Treatment 3 (Cumin, black cumin and fenugreek) and treatment 2 (Cumin, black cumin and fenugreek). Spice addition in candy (T2 and T3) seems to reduce the total bacterial population as compared to that of the candy prepared without any addition (T1). In candy where mango ginger has been added along with spice, the bacterial population is very low. This highlights that mango ginger is capable to reduce bacterial population up to several times. Throughout the storage, candy where mango ginger is added seems to be significantly reducing the bacterial population. Anti-bacterial property of mango ginger was also reported by Annapurnaet al. (2021) and Siddaraju and Dharmesh, (2007).

At the 12th month of storage, the candy retained flavour of spice and mango ginger and hence Treatment 4 and Treatment 3 were considered best in terms of flavour. The exquisite flavour of unripe mango and ginger is due to presence of cis- and transhydroocimene, ocimene and myrcene (Rao et al., 1989). There are reports of flavour improvement of pickles, candies, preserves and sauces by Verghese, (1990) and Shankaracharya, (1982) as well. After 12th month of storage, best score of 9.0 was observed in treatment 4 followed by considerably good score in all other treatment which was 8.0. Clearly it can be observed that addition of mango ginger along with spice improved the mouth feel or the texture to a significant extent even after 12th month of ambient storage. Mouth feel and consistency is an important attribute for processed product like tamarind candy. Significantly lower consistency was observed in Treatment. Addition of spice and mango ginger significantly improves the consistency of the candy. This was quite evident at 9th and 12th month of storage. During the 12th month of storage the effect of mango ginger and spice in improving the taste of the candy was clearly visible. Clearly it can be observed that addition of spice and mango ginger enhances the flavour, improves the consistency and texture and hence the overall acceptability score is also more.

1. **CONCLUSION**

The research revealed that the total soluble solids (TSS) of tamarind candy increased consistently throughout the storage period. There was no significant influence of the treatments on the TSS as the value remained similar across all treatments. A continuous and treatment-independent decline in titratable acidity was recorded throughout the storage. Both the total and reducing sugar contents increased irrespective of the treatments applied. The ascorbic acid content decreased steadily throughout the storage. But this decline was more pronounced in treatments without mango ginger. Firmness of the candy continuously increased in all the treatments over time. The highest firmness was observed in the candy where spices mixture was used. The presence of powdered spices was found to enhance the firmness. This might be due to increased resistance to probe penetration of the texture analyzer. Microbial analysis using total plate count revealed that the highest total plate count was observed in candy prepared without any spice or mango ginger. The minimum value of total plate count was observed in the candy prepared with mango ginger and spices. This clearly validates the anti-microbial potential of mango ginger. The tamarind candy prepared with a mixture of spices and mango ginger was found to be the best in term of organoleptic properties like flavour, consistency, taste, texture and overall acceptability. These findings clearly indicate that the incorporation of spices significantly improves the physicochemical, microbial and sensory attributes of the tamarind candy. This is very useful during the extended storage making it a highly effective additive for enhancing product shelf life and consumer acceptability.

**Disclaimer (Artificial intelligence):** Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript

**Competing Interests**

Authors have declared that no competing interests exist

**REFERENCES**

1. AOAC. (2012). Official methods of analysis of AOAC International (19th ed.). AOAC International.
2. Ahmad, A., Husain, A., Mujeeb, M., Khan, S. A., Najmi, A. K., Siddique, N. A., Damanhouri, Z. A., & Anwar, F. (2013). A review on therapeutic potential of Nigella sativa: A miracle herb. Asian Pacific Journal of Tropical Biomedicine, 3(5), 337–352. [https://doi.org/10.1016/S2221-1691(13)60075-1](https://doi.org/10.1016/S2221-1691%2813%2960075-1)
3. Annapurna, A. S., Abhirami, D., & Umesh, T. G. (2021). Comparative study of phytochemicals and bioactivities of the leaf extracts of Curcuma amada and Curcuma karnatakensis. South African Journal of Botany, 142, 441–450. <https://doi.org/10.1016/j.sajb.2021.06.032>
4. Gholamnezhad, Z., Havakhah, S., & Boskabady, M. H. (2016). Preclinical and clinical effects of Nigella sativa and its constituent, thymoquinone: A review. Journal of Ethnopharmacology, 190, 372–386. <https://doi.org/10.1016/j.jep.2016.06.061>
5. Jindal, V., Dhingra, D., Sharma, S., Parle, M., & Harna, R. K. (2011). Hypolipidemic and weight reducing activity of the ethanolic extract of Tamarindus indica fruit pulp in cafeteria diet- and sulpiride-induced obese rats. Journal of Pharmacology & Pharmacotherapeutics, 2(2), 80–86.
6. Johri, R. K. (2011). Cuminum cyminum and Carum carvi: An update. Pharmacognosy Reviews, 5(9), 63–72. <https://doi.org/10.4103/0973-7847.79101>
7. Leung, W. T., & Flores, M. (1961). Food composition: Tables for use in Latin America. National Institute of Health.
8. Lim, C. Y., Mat Junit, S., Abdulla, M. A., & Abdul Aziz, A. (2013). In vivo biochemical and gene expression analyses of the antioxidant activities and hypocholesterolaemic properties of tamarind (Tamarindus indica L.) fruit pulp extract. PLoS ONE, 8(7), e70058. https://doi.org/10.1371/journal.pone.0070058
9. Ludy, M. J., Moore, G. E., & Mattes, R. D. (2012). The effects of capsaicin and capsiate on energy balance: Critical review and meta-analyses of studies in humans. Chemical Senses, 37(2), 103–121. <https://doi.org/10.1093/chemse/bjr100>
10. Mani, A., Kuchi, V. S., Mitra, S., Banik, A. K., Chakraborty, I., Bauri, F. K., & Das, S. (2020). Recipe standardization for preparation of tamarind candy. The Pharma Innovation Journal, 9(5), 166–170.
11. Manjula, B., Arun, R., Prasanna, N. S., & Ramana, C. (2017). Studies on physical and biochemical analysis of value added products developed from tamarind pulp. International Journal of Processing and Post Harvest Technology, 8(2), 99–103.
12. Neelakantan, N., Narayanan, M., de Souza, R. J., & van Dam, R. M. (2014). Effect of fenugreek (Trigonella foenum-graecum L.) intake on glycemia: A meta-analysis of clinical trials. Nutrition Journal, 13, 7. https://doi.org/10.1186/1475-2891-13-7
13. Peryam, D. R., & Pilgrim, F. J. (1957). Hedonic scale method of measuring food preferences. Journal of Food Technology, 14, 9–14.
14. Prescott, J. (2015). Multisensory processes in flavour perception and their influence on food choice. *Current Opinion in Food Science*, 3(1): 47-52.
15. Prasad, S., & Tyagi, A. K. (2015). Ginger and its constituents: Role in prevention and treatment of gastrointestinal cancer. Gastroenterology Research and Practice, 2015, 1–11. <https://doi.org/10.1155/2015/142979>
16. Policegoudra, R. S., Aradhya, S. M., & Singh, L. (2011). Mango ginger (Curcuma amada Roxb.) – A promising spice for phytochemicals and biological activities. Journal of Biosciences, 36(4), 739–748.
17. Ranganna, S. (2010). Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw-Hill Education Pvt. Ltd.
18. Rao, A. S., Rajanikanth, B., & Seshadri, R. (1989). Volatile aroma components of Curcuma amada Roxb. Journal of Agricultural and Food Chemistry, 37(3), 740–743. https://doi.org/10.1021/jf00087a036
19. Zhang, H., Cui, H., Xie, F., Song, Z., & Ai, L. (2024). Tamarind seed polysaccharide: Structure, properties, health benefits, modification and food applications. Food Hydrocolloids, 155, 110222. <https://doi.org/10.1016/j.foodhyd.2024.110222>
20. Ravindran, P. N., Johny, A., & Nirmal, B. K. (2002). Tamarind – A tree of untapped potential. Indian Spices, 39(3), 4–7.
21. Shankaracharya, N. B. (1982). Mango ginger. Indian Cocoa, Arecanut and Spices Journal, 5, 78–80.
22. Shankaracharya, N. B. (1998). Tamarind chemistry, technology and uses – A critical appraisal. Journal of Food Science and Technology, 35(3), 198–208.
23. Siddaraju, M. N., & Dharmesh, S. M. (2007). Inhibition of gastric H+,K+-ATPase and Helicobacter pylori growth by phenolic antioxidants of Curcuma amada. Journal of Agricultural and Food Chemistry, 55, 7377–7386.
24. Sowbhagya, H. B. (2013). Chemistry, technology, and nutraceutical functions of cumin (Cuminum cyminum L.): An overview. Critical Reviews in Food Science and Nutrition, 53(1), 1–10. https://doi.org/10.1080/10408398.2010.500223
25. Verghese, J. (1990). Mango ginger – An exotic flavourant. Indian Spices, 27, 15–16.