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Research Article

Efficacy of Tamarind Pulp on Quality Assessment and Storage Stability of Brinjal Pickle

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ABSTRACT

The present study was to optimize the brinjal pickle development process and investigate the effect of tamarind pulp on the nutritional status, sensory qualities, and storage stability of brinjal pickles. The fresh brinjal and tamarind pulp were analyzed for nutritional composition. Developed brinjal pickles incorporation with tamarind pulp were analyzed for nutritional composition, sensory attributes, microbiological status, and overall storage stability. The nutritional compositions of the developed pickles were different depending on the processing ingredients. Chemical analysis of the developed pickles showed that the highest moisture content (60.23%) was obtained in sample A (500 g Brinjal + No tamarind pulp) followed by sample B (450 g Brinjal + 50 g tamarind pulp), sample C (400 g Brinjal + 100 g tamarind pulp), and sample D (350 g Brinjal + 150 g tamarind pulp). Other components, such as ash, protein, fat, fibre, vitamin C, magnesium, phosphorus, iron, and total carbohydrate content increased with an increasing amount of tamarind pulp with brinjal. The acceptability of prepared pickles was organoleptically evaluated by the panelists using a 1-9 hedonic scale. The sensory properties, more specifically overall acceptability, was in a rank like sample D>C>B>A. Storage studies were carried out for up to 4 months at room temperature (29°-30° C) at an interval of one month. The microbial load decreased with the increasing amount of tamarind pulp, salt, sugar, and mustard oil in brinjal pickles. It could be due to the antimicrobial activity of tamarind pulp, salt, sugar, and mustard oil. The color, flavor, and texture were unchanged up to 4 months of storage except slightly spoiled in samples A and B at the 4th month.

Introduction

The brinjal *(Solanum melongena),* commonly known as 'Begoon' (Rahman et al., 2016) in Bangladesh, a perennial herbaceous vegetable crop, which belongs to the family of Solanaceae*,* is a native of India (Liu et al., 2021;). Although brinjal may be produced all year round and is adaptable to various agro-climatic locations, it is mostly grown from December to April. (Timmareddygari et al., 2021; Sharma et al., 2016). The second-most significant vegetable farmed in Bangladesh is brinjal (Rahman et al., 2016). Due to its superior taste, easier cooking quality, and reduced market price, this vegetable crop has gained popularity. In Bangladesh, brinjal grows well all over the country (BBS, 2020) and during 2018-19, 170189 metric tons of brinjal (Kharif) were produced on 47213 acres and 360421 metric tons of brinjal (Robi) were produced on 82206 acres (BBS, 2020). Brinjals are not only high in nutrients like vitamins and minerals, but they also have high antioxidant content. (Akanitapichat et al., 2010; Meherunnahar et al., 2009; Das et al., 2011; Ghidelli et al., 2013). It aids in the prevention of heart disease, the regulation of blood sugar levels, and the promotion of weight loss **(**Siddhuraju, 2007; Singh et al., 2009; Dranca and Oroian, 2017**).** However, as brinjal contains about 80% moisture content (Prodhan et al., 2018; Khan and Isshiki, 2016) it is particularly vulnerable to losses after harvest. Since it is perishable in nature, brinjal cannot be kept for an extended period. It can be converted into several value-added products to minimize losses and maintain costs.

Tamarind (*Tamarindus indica*) a leguminous tree is a member of the Fabaceae family and the Caesalpiniaceae subfamily (Stege et al., 2011; Okello et al., 2018) which is found in tropical Africa and southern Asia (Asoiro et al., 2017). According to the BBS (2019)

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data, tamarind was grown on 14804 acres in Bangladesh, producing 11657 metric tons in 2017–18. However, 30 to 50% of ripe fruits are made up of pulp, while 11 to 30% are made up of the fruit's shell and fiber, and 20 % are made up of the fruit's seed (Abdelrahman and Mariod, 2019; Yusuf et al., 2007). Tamarind paste is used in numerous dishes, including chutneys, curries, and the traditional drink known as sharbat syrup (Bhusari et al., 2014.). It is rich in a variety of essential elements. Tamarind is a great source of B vitamins, vitamin C, magnesium, potassium, phosphorus, iron, riboflavin, thiamine, and fibre (Doughari, 2006; Adekunle and Adenike, 2012; Okello et al., 2017). Tamarind pulp helps treat stomach ailments, liver and gallbladder issues, and constipation (Havinga et al., 2010). It is also employed to treat fever and colds. Polyphenols and antioxidants found in tamarind may aid to reduce inflammation in the body (Sulieman et al., 2015; Chimsah et al., 2020). If stored in sealed containers and kept in a cold, dry environment, the pulp can be effectively preserved for 6–8 months without any additional treatment because of having antimicrobial activity (Kuru, 2014).

One of the most well-known techniques for processing and preserving food is called pickling (Shikha et al., 2018; Ranganna, 2005). Pickles are prepared by processing and preserving any type of food (fruit, vegetable, fish, or meat) utilizing fermentation, vinegar, natural salt, oil, and spices (Srivastava and Kumar, 2002). In the Indian subcontinent, pickle is widely used as a delicious condiment food (Bhuiyan, 2012). The popular common pickles manufactured in Bangladesh by various industries available in the market are mango pickles, chalta pickles, olive pickles, mixed fruit pickles, and so on. Since Bangladesh has a greater rate of brinjal production and spoilage (Rahman et al.,2016), efforts have been made to reduce rotting and maximize the use of these cheap, widely available brinjal. The addition of tamarind with brinjal may act as a preservative because of having an antimicrobial effect and makes the pickles more delicious and enhances consumers' acceptability with health benefits. Although a lot of information on making pickles from various fruits and vegetables has previously been published (Rahman et al., 2014; Shanta et al., 2014; Rathore et al., 2021; Sawada et al., 2021), data on Bangladeshi variations of mixed pickles made from brinjal and tamarind are still incredibly rare. So, standardization and formulation of mixed pickles prepared from brinjal, and tamarind may help to enhance the sensory characteristics of pickles and will be more economical as well. Considering all these standpoints, the goal of this study was to optimize the brinjal pickle development process and investigate the effect of tamarind pulp on the nutritional, sensory qualities, and storage stability of brinjal pickles.

Materials and Methods

This study was carried out in the laboratory of the Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh.

Materials

Brinjal and the required species were collected from the local market. The laboratory's apparatus and equipment were used for the research work.

Formulation of brinjal pickles

The basic formulation for brinjal pickles is presented in Table 1.

Table 1. Formulation of brinjal pickles

Ingredients	A	B	C	D
Brinjal(g)	500	450	400	350
Dry chili powder(g)	10	10	10	10
Garlic(g)	5	5	5	5
Ginger(g)	20	20	20	20
Turmeric powder(g)	5	5	5	5
Mustard powder(g)	5	5	5	5
Cumin powder(g)	1.25	1.25	1.25	1.25
Green chili(g)	15	15	15	15
Fenugreek powder(g)	2.5	2.5	2.5	2.5
Salt(g)	10	15	20	25
Sugar(g)	50	50	100	150
Mustard oil(ml)	100	100	100	200
Acetic acid(ml)	50	50	50	50
Tamarind(g)	-	50	100	150

Preparation of brinjal pickle

At first, the brinjal was washed and cut into pieces. Chili, turmeric powder, mustard powder, fenugreek powder, cumin powder, salt, sugar, and mustard oil were weighted and garlic, ginger, green chili & tamarind were pasted separately. The mustard oil was heated till smoking and the pieces of brinjal were fried and removed from the oil. The oil was then filled with all the spices and cooked continuously until a brown color developed. After that, the fried brinjal was added and fried for a short while. Later, the oil was heated with sugars and vinegar until the oil began to float to the top. Afterward, it was taken out of the fire and given time to cool. Then it had the preservative put to it. When everything was ready, brinjal pickles were poured into clean bottles and sealed tightly.

Proximate composition analysis

According to the AOAC methodology, moisture, ash, crude protein, and fat were all measured using the hot air oven, muffle furnace, Kjeldahl, and Soxhlet apparatus, respectively (AOAC, 2019a–d).

Moisture content

For determining moisture content, the oven drying method was used. An empty, dry crucible was weighed using an electric balance. 5 g of sample was later added to the dry crucible and weighed in the digital balance. The sample was then placed in a crucible, which was maintained in an oven overnight to dry at 100 to 105°C. The crucible containing the sample was removed from the oven after dehydration and cooled in the desiccators. Once it had cooled, the moisture dish containing the sample was weighed. Using equation (i), the sample's moisture content was calculated. For accuracy, a set of three samples was dried in an oven, and the mean moisture content was determined.

$$\%\ Moisture = \frac{(W - X)}{Z} \times 100 \ \ldots\ldots\ldots\ldots\ldots\ldots (i)$$

Where, W = Crucible + sample weight (g); X = Crucible + dry sample weight (g); Z = sample weight (g)

Ash content

Moisture-free 5 g sample was taken in a porcelain crucible and burned in a gas burner to avoid loss of sample into muffle furnace at high temperature. After that, the crucible was placed in a muffle furnace and heated to 550°C for 6 hours. The crucible was removed from the hot air furnace and placed in a desiccator to cool for five minutes. The following equation had been used to calculate the ash content:

$$\%\ Ash = \frac{(X - Y)}{W} \times 100 \ \ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

where, X = ashed weight (g, Y = crucible weight (g) and W = sample weight (g)

Protein content

In a Kjeldahl flask, 3 g of sample and 5 g of the digesting mixture were added. In a flask, 25 ml of concentrated H_2SO_4 was added. Digesting continued until the issue was resolved. A distillation flask was filled with an aliquot (5 ml) and 40 ml of a 40 percent NaOH solution. A 100 ml conical flask was set up in a distillation unit with 15 ml of a 2 percent boric acid solution, 10 ml of ammonia-free water, and two drops of the mixed indicator added. The distillation process took 40 minutes, and 0.1 N HCl was used to titrate it. Additionally, a blank titration was established and inferred from titration. The amount of crude protein was calculated by multiplying by 6.25. The following is the formula:

$$\%\ \text{Nitrogen} = \frac{(\text{Titre value} - \text{blank titre}) \times \text{N of HCL} \times 14 \times \text{volume made up} \times 100}{\text{Aliquot taken for estimation} \times \text{sample taken} \times 100} \ \ldots (iii)$$

% Protein = % nitrogen × conversion factor (6.25).

Fat content

To assess the samples' fat content, solvent extraction was performed. Two grams of the sample were placed in each thimble. The fat extraction tube of the Soxhlet device received the thimbles. The Soxhlet flask was attached to the ends of the tubes. Through the sample in the tube, approximately 75 ml of anhydrous ether was added to the flask. The top of the fat extraction tubes was attached to the condenser. The samples were extracted for roughly 16 hours on a heater set at 70°C-80°C. When ether has volatilized, the heater is placed to a temperature where it condenses and drips constantly over the sample with no discernible loss. At the end of the extraction phase, the thimbles were removed from the apparatus, and most of the ether was distilled off by allowing it to collect in the Soxhlet tube. Whenever the tube was nearly full, the ether was spilled out. Once the ether had reached a small volume, it was transferred through a small funnel into a tiny, dry (already weighted) beaker. The flasks were thoroughly rinsed and filtered with several minuscule amounts of ether. The ether was dried at 100°C for an hour after being evaporated over a low heat steam bath and it was then chilled and weighted. The fat-soluble substance present in the samples was determined by the difference in weights, and the percent fat content was calculated by using equation *iv*.

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

Total carbohydrate

The total carbohydrate content was calculated using the Food and Agriculture Organization's (FAO) methodologies (FAO, 2003). The carbohydrate content had not been directly determined. It was computed by deducting the entire amount of moisture, fat, protein, and ash percentage from 100.

Vitamin-C content (Ascorbic acid)

Vitamin-C content was determined following the methodology described by Sahoo and Prakash (2017).

Determination of crude fiber

Crude fiber was determined according to the method elucidated in AOAC (2010).

Mineral content analysis

Mineral concentrations in samples of brinjal, tamarind, and mixed pickles were estimated using the dry digestion technique. Important minerals such as magnesium (Mg) were evaluated using an AOAC (2016b) approved method, whilst macronutrients such as iron (Fe) were assessed using an ISO (2007) method (Model: AA-7000; Shimadzu, Japan). Using an Elisa Reader (Infinite 200 Pro Nano Quant), absorbance was read at 820 nm to estimate the amount of phosphorus (P) (ISO, 2006).

pH

The pH meter was first standardized using a buffer of pH 7.00. Then for determining the pH of all the samples, a buffer of pH 4.00 was sufficient. Again, the p^H meter was standardized using this buffer, and checked the pH of the sample.

Sensory evaluation

Ten semi-trained panellists selected from the students, teachers, and employees of the department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh assessed the sensory qualities of prepared brinjal pickles, including color, flavor, texture, and overall acceptability, using a 9-point hedonic rating scale (Amerine, 1965). The hedonic rating scale was set up with the following values: 9 for exceedingly like, 8 for greatly like, 7 for like moderately, 6 for like slightly, 5 for neither like nor a dislike, 4 for slightly dislike, 3 for fairly dislike, 2 for considerably dislike, and 1 for excessively dislike.

Shelf-life studies of brinjal pickles

The pickles were stored at room temperature. The different parameters such as color, flavor, texture, and fungal growth were observed at an interval of 30 days.

Microbiological quality assessment

Microbiological quality assessment of the developed samples was carried out by determining the standard plate count as per the AOAC (2000).

Standard plate count

The plate count technique was used for the detection of viable bacteria in developed samples. The Standard Plate Count (SPC) or aerobic plate count is an indicator of the overall degree of microbial contamination of food. 1 ml of 10^{-1} and dilution up to 10 folds of the samples were inoculated using the pour plate method. The plates were then incubated at 37°C for 24 hours. After 24 hours of incubation in nutrient agar media, visible bacterial colonies were counted and expressed as cfu/g. A calculation was made for the number of cfu per gram as follows:

Standard plate count (cfu/gm) = Average number of colonies x Reciprocal of dilution used

Statistical analysis

The results were statistically evaluated using Stat View (Abacus Concepts Inc., Berkeley, CA, USA) software utilizing Fisher's least significant difference (LSD) and ANOVA (analysis of variance) methods to determine whether there were any substantial variations at the 5% level of significance.

Results and Discussion

Chemical and nutritive characteristics of fresh brinjal and tamarind pulp

Table 2 shows the nutritional composition of fresh brinjal and tamarind pulp. Fresh brinjal contained moisture, protein, fat, ash, fiber, and total carbohydrate content of 92.7, 1.4, 0.1, 0.8, 2.52 and5% respectively. On the other hand, tamarind pulp contained moisture (32.80%), protein (3.10%), fat (0.58%), ash (3.25%), fiber (3.61%), and total carbohydrate (60.27%). Also, it contained 42 mg per 100 g of vitamin C while fresh brinjal had 28 mg per 100 g. Fresh brinjal and tamarind pulp contained pH of 4.83 and 2.94 respectively.

Table 2. Chemical and nutritive characteristics of fresh brinjal and tamarind pulp

Parameters	Fresh brinjal (%)	Tamarind pulp (%)
Moisture content	92.7 ± 0.1^a	32.80± 0.01^b
Ash	0.8 ± 0 .2^a	3.25± 0.15^b
Protein	1.4 ± 0.3^a	3.10± 0.2^b
Fat	0.1± 0.01^a	0.58± 0.02^b
Fiber	2.52± 0.2^a	3.61± 0.1^b
Vitamin-C (mg/l00 g)	28 ± 1.5^a	42± 2.0^b
Total Carbohydrate	5.0±0.2^a	60.27± 0.1^b
Magnesium (mg/l00 g)	12± 0.1^a	31± 0.2^b
Phosphorus (mg/l00 g)	18± 0.1^a	55± 1.0^b
Iron (mg/l00 g)	0.23± 0.1^a	0.6± 0.05^b
pH	4.83± 0.05^a	2.94± 0.01^b

Mean ± SD, for each assessment, the mean of three trials is used. Means with various superscripts in the same row proved different significantly ($p \leq 0.05$).

Minerals for instance magnesium, phosphorus, and iron were measured in fresh brinjal and tamarind pulp. Table 2 depicts, that minerals were higher in tamarind pulp than that in fresh brinjal for all the cases. The chemical and nutritive characteristics of fresh brinjals are more or less similar to those reported by Naeem and Ugur (2019) who observed the composition of fresh brinjal as moisture, protein, fat, ash, fiber, and total carbohydrate content 92.13, 1.01, 0.18, 0.8, 2.82 and 5.88% respectively. They also found magnesium, phosphorus, iron, and vitamin C content with values of 13.5, 22.5, 0.2, and 16.75 mg per 100 g respectively. The variation in composition between these two findings may be attributed to varietals differences; variation in the stage of maturity, the time elapsed between harvesting & analysis & the growing condition. The chemical and nutritive characteristics of tamarind pulp are close to those reported by Okello et al. (2017).

Effect of tamarind pulp on chemical and nutritive characteristics of brinjal pickles

The brinjal pickles were analyzed immediately after processing for Chemical and nutritive characteristics. The composition of brinjal pickles varies a little bit depending on ingredients such as tamarind and processing methods. The effect of tamarind pulp on the chemical and nutritive characteristics of brinjal pickles is shown in the following (Table 3).

Table 3. Effect of tamarind pulp on chemical and nutritive characteristics of brinjal pickles

Parameters	A	B	C	D
Moisture content	60.23 ± 0.1^{a}	56.5± 0.1^{b}	54.16± 0.15^{c}	51.3 ± 0.01^{d}
Ash	2.33 ± 0 .2^{a}	2.52± 0.1^{a}	2.98± 0.16^{b}	3.37± 0.15^{c}
Protein	3.11± 0.3^{a}	3.24± 0.1^{a}	3.44± 0.01^{b}	3.60± 0.2^{c}
Fat	4.87 ± 0.01^{a}	5.33± 0.1^{a}	6.32± 0.11^{c}	7.08± 0.02^{d}
Fiber	2.92± 0.2^{a}	3.31± 0.15^{b}	3.66± 0.18^{c}	3.81± 0.01^{d}
Vitamin-C (mg/l00 g)	18 ± 1.5^{a}	21± 0.2^{b}	24± 0.01^{c}	27± 2.0^{d}
Total Carbohydrate	29.46±0.2^{a}	32.41± 0.2^{b}	33.10± 0.11^{bc}	34.65± 0.1^{d}
Magnesium (mg/l00 g)	9± 0.15^{a}	11± 0.21^{b}	13± 0.1^{c}	16± 0.2^{d}
Phosphorus (mg/l00 g)	19± 0.15^{a}	24± 0.17^{b}	31± 0.21^{c}	37± 1.0^{d}
Iron (mg/l00 g)	0.26± 0.1^{a}	0.34± 0.2^{b}	0.39± 0.1^{c}	0.43± 0.05^{d}
pH	4.05± 0.05^{a}	3.5± 0.01^{b}	3.38± 0.03^{c}	3.10± 0.05^{d}

Mean ± SD, for each assessment, the mean of three trials is used. Means with various superscripts in the same row proved different significantly ($p \leq 0.05$). Sample A= 500 g Brinjal + No tamarind pulp, Sample B= 450 g Brinjal + 50 g tamarind pulp, Sample C= 400 g Brinjal + 100 g tamarind pulp, Sample D= 350 g Brinjal + 150 g tamarind pulp.

The results shown in Table 3 reveal that the highest moisture content (60.23%) is given in sample A (500 g Brinjal + No tamarind pulp) whereas the lowest amount of moisture content (51.3%) was found in sample D (350 g Brinjal + 150 g tamarind pulp). The decrease in moisture content may be due to the incorporation of tamarind pulp (Table 3) as it has much lower moisture content than fresh brinjal (Table 2). In contrast, other nutritional components such as ash, protein, fat, fiber, vitamin C, magnesium, phosphorus, and iron& total carbohydrate content increased with the increasing amount of tamarind pulp salt, sugar, and mustard oil (Table 3). These all could be the effect of tamarind pulp, salt, sugar, and mustard oil incorporation.

For ash, protein, and fat; there was no significant difference ($p>0.05$) between sample A (500 g Brinjal + No tamarind pulp) and B 450 g Brinjal + 50 g tamarind pulp). It is also seen from Table 3 that the pH value is highest in sample A (4.05) whereas the lowest in sample D (3.10).

Sensory Evaluation of Brinjal pickles

Table 4 displays the sensory characteristics (color, flavor, texture, and overall acceptability) of developed brinjal pickles.

Table 4. Sensory evaluation of brinjal pickles

Sample code	Sensory attributes			
	Color	**Flavor**	**Texture**	**Overall Acceptability**
A	5.5± 0.15^{c}	5.4± 0.25^{c}	5.3± 0.15^{c}	5.4± 0.12^{c}
B	5.8± 0.11^{bc}	5.9± 0.05^{bc}	5.5± 0.10^{bc}	5.8± 0.12^{bc}
C	6.1± 0.14^{b}	6.4± 0.15^{b}	6.2± 0.05^{b}	6.2± 0.15^{b}
D	7.5± 0.10^{a}	7.3± 0.13^{a}	7.5± 0.11^{a}	7.4± 0.13^{a}

Mean ± SD, for each assessment, the mean of three trials is used. Means with various superscripts in the same column proved different significantly ($p \leq 0.05$). Sample A= 500 g Brinjal + No tamarind pulp, Sample B= 450 g Brinjal + 50 g tamarind pulp, Sample C= 400 g Brinjal + 100 g tamarind pulp, Sample D= 350 g Brinjal + 150 g tamarind pulp.

An analysis of variance (ANOVA) was carried out for color, flavor, texture, and overall preferences. The result for color reveals that the sample was more acceptable than the other sample. The lowest score was for sample A (5.5) and the highest was for D (7.5). In case of flavor, the result reveals that sample D was more acceptable than the other sample. The lowest score was A (5.4) and the highest score was D (7.3). Textural property shows that sample D was more acceptable (7.5) followed by sample C (6.2), B (5.5), and A (5.3). It is apparent from the results of the ANOVA that there was a significant difference in the overall acceptability of the sample tasted. This indicates that all the samples were not equally accepted. It can be seen from Table 4 that sample D was the most acceptable product securing 7.4 compared to other samples. It could be due to the addition of more tamarind pulp, sugar, salt, and mustard oil than in other samples. Sample A was a less acceptable sample securing 5.4.

Storage stability of brinjal pickles

Effects of tamarind pulp on the growth of bacteria at different storage periods

Table 5 represents the effect of tamarind pulp on the storage stability of brinjal pickles. Brinjal pickles were observed for microbiological load after 30 days, 60 days, and 120 days storage.

Table 5. Effect of tamarind pulp on the growth of bacteria at different storage periods

Storage periods (months)	A	B	C	D
1	$70x10^2 \pm 15^a$	$44x10^2 \pm 10^b$	$38x10^2 \pm 12^c$	$35x10^2 \pm 14^d$
2	$90x10^2 \pm 15^d$	$68x10^2 \pm 20^c$	$61x10^2 \pm 13^b$	$58x10^2 \pm 13^a$
4	$130x10^2 \pm 20^a$	$101x10^2 \pm 18^c$	$90x10^2 \pm 24^d$	$85x10^2 \pm 18^b$

Mean ± SD, for each assessment, the mean of three trials is used. Means with various superscripts in the same row proved different significantly ($p \leq 0.05$). Sample A= 500 g Brinjal + No tamarind pulp, Sample B= 450 g Brinjal + 50 g tamarind pulp, Sample C= 400 g Brinjal + 100 g tamarind pulp, Sample D= 350 g Brinjal + 150 g tamarind pulp

Sample D was figured out with a minimum count in which tamarind pulp was maximum (Table 5). On the other side, maximum count was found in sample A where no tamarind pulp had been used followed by samples B, C, and D. It is clear from the findings that microbial load decreased with the increasing amount of tamarind pulp, salt, sugar, and mustard oil in brinjal pickles. It could be due to the antimicrobial activity of tamarind pulp, salt, sugar, and mustard oil (Kuru, 2014). The total viable bacteria increased with increasing storage periods for all samples following the same chronology.

Visual observation of yeast and mold in developed brinjal pickles.

The fungal growth in developed brinjal pickles at different storage periods was examined through visual observation for up to 4 months. No fungal growth was obtained in samples during storage periods apart from sample A. This could be due to the absence of tamarind pulp which could have acted as a preservative (Gupta et al., 2014). The results are shown in Table 6.

Table 6. Visual observation of yeast and mold in developed brinjal pickles

Storage periods (months)	Samples	Fungal growth
0	A	No growth
	B	No growth
	C	No growth
	D	No growth
1	A	No growth
	B	No growth
	C	No growth
	D	No growth
2	A	No growth
	B	No growth
	C	No growth
	D	No growth
4	A	White mold
	B	No growth
	C	No growth
	D	No growth

Sample A= 500 g Brinjal + No tamarind pulp, Sample B= 450 g Brinjal + 50 g tamarind pulp, Sample C= 400 g Brinjal + 100 g tamarind pulp, Sample D= 350 g Brinjal + 150 g tamarind pulp

Visual observation of color, flavor, and texture changes in developed brinjal pickles

The color, flavor & texture change was examined by visual observation for up to four months. The results found are shown in Table 7. The color, flavor & texture were unchanged up to 4 months of storage except samples A and B in the fourth month (Table 7).

Table 7. Visual observation of color, flavor and texture change in developed brinjal pickles

Storage periods (months)	Samples	Color	Flavor	Texture	Remarks
0	A	No change	No change	No change	Good
	B	No change	No change	No change	Good
	C	No change	No change	No change	Good
	D	No change	No change	No change	Good
1	A	No change	No change	No change	Good
	B	No change	No change	No change	Good
	C	No change	No change	No change	Good
	D	No change	No change	No change	Good
2	A	No change	No change	No change	Good
	B	No change	No change	No change	Good
	C	No change	No change	No change	Good
	D	No change	No change	No change	Good
4	A	No change	Slightly change	Slightly change	Slightly spoiled
	B	No change	Slightly change	No change	Slightly spoiled
	C	No change	No change	No change	Good
	D	No change	No change	No change	Good

Sample A= 500 g Brinjal + No tamarind pulp, Sample B= 450 g Brinjal + 50 g tamarind pulp, Sample C= 400 g Brinjal + 100 g tamarind pulp, Sample D= 350 g Brinjal + 150 g tamarind pulp.

Tamarind had been utilized as a preservative because of having an antimicrobial activity (Kuru, 2014). Since there was no tamarind pulp in sample A and only 50 g in sample B, microorganisms could grow there and affect on flavor and texture of the pickles.

Conclusion

As brinjal is widely available with high palatability and nutrient content, it can be utilized to make a value-added product. Moreover, because of having high moisture content brinjal has been considered a highly perishable vegetable. On the other hand, tamarind is popular for its taste, nutritional, medicinal, and antimicrobial value. So, the experiment implied the prospect of processing and preservation of brinjal pickles incorporation with tamarind pulp as well as investigated the nutritional aspect of brinjal pickles. Sensory properties followed the rank in a way such that sample D>C>B>A. As brinjal pickles mixed with tamarind pulp are nicely accepted through sensory evaluation, it can be concluded that processing and preservation of brinjals by pickling may be used for industrial trials. Commercial or home-scale processing by pickling may also be effective with the use of tamarind pulp as a flavor enhancer and preservative. Thus, many skilled and semiskilled, even unskilled persons would be employed in the relevant industries, which will help to remove the unemployment problem of any country.

Authors contributions

Md. Ahmadul Islam conceptualized and supervised the work. K. M. Mahdiuzzaman Sayed, Lopa Aunsary and Md. Tanvir Islam were involved in manuscript writing, editing, and data analysis. Farzana Akter performed laboratory experiments and data collection.

Competing interests

The authors have declared that no competing interests exist.

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