

Effect of Incorporating Beetroot on Shelf-Life Stability of Functional Pickles.

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Abstract: Beetroot pickles are a relatively new vegetable gaining market share in Bangladesh. It is a naturally growing root vegetable known for its health benefits due to its phytochemicals and bioactive compounds. Beetroot (***beta vulgaris***) has been shown to improve clinical and physiological conditions and promotes good health. And has become a potential functional food that can prevent disease. One of its compounds, betalaine, has shown chemo preventive, sedative, and disease-preventive activity. There is a fundamental difference between the newly developed pickled beet sample and the commercial one. The sample developed was 11.5° Brix, 55.5 mg (%) Vitamin C, 27.5% Moisture, 3.25% Dietary Fiber, 37.3 % Carbohydrate, 1.25% Protein, 2.7% Ash, 28%, 195 mg (%) Betalaine, pH 4. Microbiological analysis of samples after 270 days showed 5/g colony forming units (*cfu*), with an overall acceptance of 70% among trained panelists after 270 days of storage. Vitamin C and added salt prevent oxidative degradation and extend the shelf life of pickled beets.

Keywords: Pickle, Beetroot, Vitamin C, Betaine, Water Activity, pH and Sensory Evaluation

1. INTRODUCTION

Pickling is an ancient method of food preservation and is a popular technique among home canners due to its ability to extend the shelf life of food [1]. In Bangladesh, pickling plays a crucial role in enhancing the flavor of various dishes [2]. While beetroot pickles have been used in India, the United States, and Bangladesh, this study aims to improve the method for extending its shelf life [3]. Pickles are typically made from high-quality, nutritious ingredients that are soaked in a salty, alkaline solution to mature or under controlled conditions, with vinegar added to achieve a pH of 4.6 or less. The balanced pH value must be maintained throughout the useful life of the product, which can also be achieved through refrigeration or sterilization. Pickled goods may contain natural sugars, flavors, spices, and other acceptable additives. Although the term "pickle" refers to salted cucumbers in the United States and Canada, in other countries, it can refer to any product that involves curing [4]. In Bangladesh, beetroot pickles are made by preserving vegetables or natural ingredients in vinegar or salt water [5].

To prepare beetroot pickles, it is important to follow proper directions [6]. The spice blend used in Bangladesh for pickling beetroots is unique, and the pickles are often served as appetizers or as an accompaniment to meals [7]. Fermentation is a common method of making pickles, and it produces acid by beneficial bacteria that adhere to the surface of the vegetables [8]. Pickles made through natural fermentation in brine contain probiotics that are beneficial for gut health, unlike vinegar-made pickles. While pickled beets contain some vitamins and minerals, the concentrations are lower than those found in fresh beets [9]. However, pickled beets are a great source of probiotics that help regulate and maintain a healthy gut flora, which is essential for overall health [10].

Lactic acid bacterial fermented beetroot pickles offer numerous health benefits, including improved intestinal tract health, enhanced immune system function, relief from inflammation, and maintenance of gut flora that helps control weight gain and appetite, among other things [11]. Beetroots contain more than 50% water and are therefore semi-perishable [12]. There are various ways to preserve beets so that they can be enjoyed long after harvest season [13].

Increasing the shelf life of beetroot pickles through home preservation is a cost-effective option. Beets are among the healthiest vegetables, low in fat and protein, rich in nutrients such as folate, fiber, and antioxidants [16].

It is becoming increasingly popular as a healthy means of managing health. Supplementation with beetroot pickle has been shown to reduce circulatory stress, inflammation, oxidative pressure, and preserve endothelial function in human studies [30].

Some of the benefits of consuming beetroot pickle include cancer prevention, cardiovascular disease management, muscle strength enhancement, reduction of bad cholesterol, promotion of bone health, treatment of iron deficiency, mitigation of skin problems, and prevention of birth defects [31].

In Bangladesh, the demand for beetroot pickles varies seasonally, with supply often exceeding demand during peak harvest seasons [17]. To ensure proper preservation and marketing during these periods, it is necessary to take appropriate steps to maintain quality and increase shelf life [18]. The current study aims to improve the quality of beetroot pickles and extend their shelf life [19].

2. MATERIALS AND METHODS

The beetroot pickle was formulated with different food grade ingredients, were purchased from local market of Dhanmondi, Dhaka, Bangladesh

Table 1: Formulation value of the pickle samples

Ingredients	BRPS	OPS	MPS
Beetroot, Olive, Mango	2.5 kg	1 kg	1.5 kg
Carrot, Green Chile,	1.5 kg	0.5 kg	0.5 kg
Capsicum	500 gm	300 gm	500 gm
Sugar	250 gm	200 gm	200 gm
Salt	100 gm	50 gm	100 gm
Chile Powder	5gm	3gm	3gm
Card amine	100gm	50gm	50gm
Spice mix	500 gm	300 gm	400 gm
Mustard oil	800 ml	500 ml	500 ml
Vinegar	500mg/kg	300mg/kg	400mg/kg
Sodium Benzoate	0.6%	0.2%	0.3%
Potassium Sorbet	2.5 kg	2.0 kg	2.5 kg

2.1 Methods

The beetroots were thoroughly washed and the skin was removed using a vegetable peeler. They were then cut into small pieces and put in a cooking pot with the formulated ingredients including vinegar, water, salt, spices, and sugar. The mixture was brought to a boil and once boiling, the paste form of garlic, ginger, and hot peppers were added. The mixture was cooked on low heat for 45 minutes until the beetroots were tender. It was then removed from heat and cooled down to room temperature. The sample was transferred to a clean and sterilized glass jar, making sure that the beetroot pieces were fully covered with the liquid. The jar was sealed and stored in a cool and dry place for at least 2-3 days before consuming the beetroot pickles, which can last for several months.

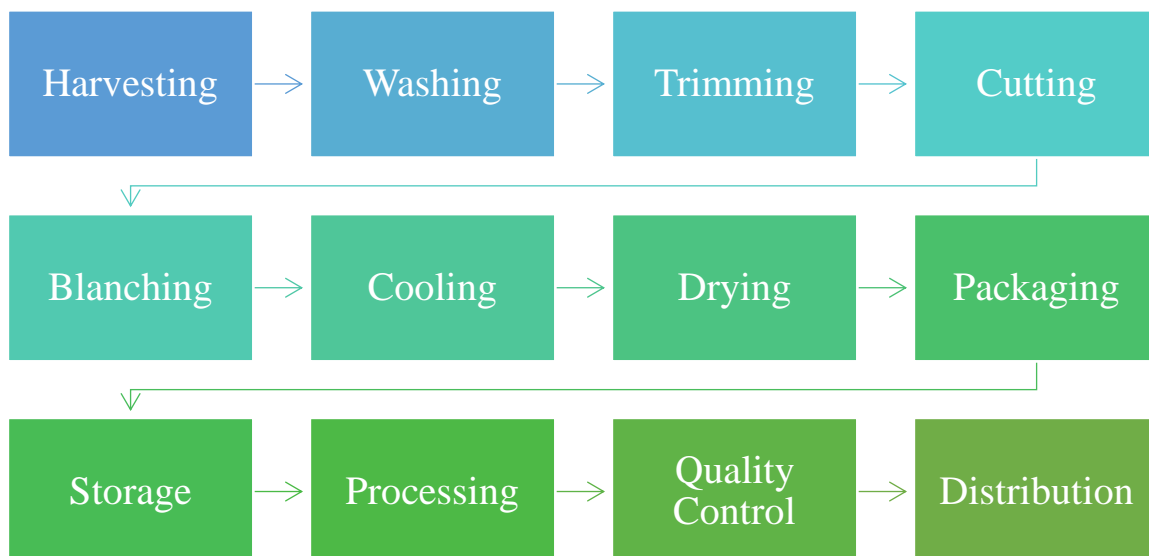


Figure 1: Flow Chart diagram for preparation of Beetroot Pickle.

In the figure 1, final pickle sample was prepared and stored in sterile glass container in dry and cool place [20, 21, 22, 23].

2.2 Proximate Data

Proximate composition including pH, Brix, moisture content, protein, fiber, ascorbic acid (Vitamin C) and carbohydrate was determined using AOAC (2005) method [32].

2.3 Microbiological Assay

For microbiological assay for *cfu/g*, representative sample of the newly developed BRPS (Beetroot pickles), and commercial sample OPS (Olive Pickles) & MPS (Mango Pickles) were homogenize to obtain a uniform mixture. After dilute the sample in a suitable diluent to obtain a range of dilutions, preparing culture media for plating, incubation for colony counting, and interpret the results of the assay [24, 25].

2.4 Shelf-life Study

The shelf-life study of beetroot pickles involves analyzing the changes in the quality and safety of the product over time. To establish the baseline quality and safety of the beetroot pickles, the product's pH, water activity, salt content, microbiological count²⁶ and other relevant parameters were analyzed. The expected storage conditions of the product on store shelves, including temperature, humidity, and packaging, were also considered. The collected data was evaluated to determine the product's shelf life by analyzing the trends in the quality and safety parameters over time and identifying when they reach unacceptable levels. The expiration date of the product was established based on the collected data to ensure the product remains safe and of good quality throughout its shelf life with a conservative date. In addition to the analytical measurements, sensory evaluation was conducted to assess the product's flavor, aroma, taste, appearance, and overall acceptability, which was done by a panel of trained sensory evaluators.

2.5 Sensory Evaluation

Sensory evaluation analysis was conducted among 50 semi-trained panelists at NFE (Nutrition and Food Engineering), Daffodil International University, hedonic rating scales of 9-Points (Extremely like-9 to Extremely dislike-1) according to the method reported by Saeid et al., (2020). The sensory characteristics of pickles were evaluated in terms of Appearance, flavor, texture, taste and Overall acceptability.

2.6 Statistical Analysis

Analyzes were performed at least in triplicate. All data represent the means of at least three measurements, and results are expressed as mean \pm standard deviation (SD). Comparison of means was performed using analysis of variance (ANOVA).

3. RESULT AND DISCUSSIONS

The proximate analysis of pickles typically includes the following components and is presented in the table below:

Table 2: Data of proximate value of the pickle samples

Sample	Ash (%)	Fiber (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Vitamin C (mg/100g)	Bataline (mg/100g)
BRPS	2.7	3.25	1.25	28.0	37.3	55.5	195
OPS	2.9	1.80	0.85	31.0	35.65	0.9	0
MPS	2.5	2.25	0.56	26.5	39.19	3.0	0

In the table the proximate value results the percentage of ash is lowest in MPS (2.5%) and highest in OPS (2.9%); percentage of fiber is highest in BRPS (3.25%) and lowest in OPS (1.8%); percentage of protein is highest in OPS (31%) and lowest in MPS (0.56%); percentage of fat is highest in OPS (31%) and lowest in MPS (26.5%); percentage of carbohydrates is highest in BRPS (37.3%) and lowest in OPS (35.65%); the highest amount of vitamin C is found in BRPS (55.5 mg/100g), and the lowest is found in OPS (0.9 mg/100g) and Bataline is a compound that is found in some plants and is believed to have antioxidant and anti-inflammatory properties. In the Beetroot sample having only 195 mg/100g *respectively*. Overall, the nutritional composition of the three samples varies significantly, with each having its unique composition.

For assuring the quality as functional food of Beetroot pickle sample comparing other two commercial pickles, different parameters are conducted round the year specially stability and acceptability of newly devolved vegetable pickle.

Table 3: Moisture content for BRPS, OPS, MPS.

Samples	Temperature	% moisture		Time
		0 Days	270 days	
BRPS	105 ⁰ C	27.5	27.3	90 mins
OPS	105 ⁰ C	27.8	27.4	90 mins
MPS	105 ⁰ C	29.0	28.9	90 mins

The moisture content of the samples at 0 days' ranges from 27.5% for BRPS (Beetroot pickles sample) to 29.0% for MPS (Mango pickles sample). After 270 days, there is a slight reduction in the moisture content of all samples, with BRPS having the highest reduction in moisture content, from 27.5% to 27.3%. OPS (Olive pickles sample) and MPS also show a slight reduction in moisture content from 27.8% to 27.4% and from 29.0% to 28.9%, respectively. The reduction in moisture content of the samples over time indicates that there has been some degree of drying, which is expected as the samples age. However, the reduction is not significant, and it is unlikely to affect the overall

quality or safety of the samples. The processing temperature of 105^o C is relatively high, and it may have contributed to the slight reduction in moisture content.

Table 4: Data of water activity and humidity of the samples at 0 and 270 days.

Samples	Temperature	0 Days		270 days	
		aw	% humidity	aw	% humidity
BRPS	34 ^o C	0.7	84	0.65	92
OPS	34 ^o C	0.8	84	0.75	95
MPS	34 ^o C	0.95	84	0.90	94

Based on the provided data in the table 3, revealed that the samples were tested at two different time points, i.e., 0 days and 270 days. The samples were tested for their water activity (aw) and humidity at both time points. The temperature of the samples was constant at 34^o C. The water activity of the samples at 0 days' ranges from 0.7 for BRPS to 0.95 for MPS. After 270 days, there is a reduction in the water activity of all the samples, with BRPS having the highest reduction in water activity, from 0.7 to 0.65. OPS and MPS also show a reduction in water activity from 0.8 to 0.75 and from 0.95 to 0.90, *respectively*. The % humidity of the samples at 0 days' ranges from 84% for all the samples. After 270 days, there is a slight increase in % humidity for BRPS and OPS, while MPS shows a slight reduction in % humidity. Overall, observation that there is a reduction in water activity for all the samples after 270 days, which indicates that the samples have become less moist over time. However, there is not much change in % humidity for most of the samples.

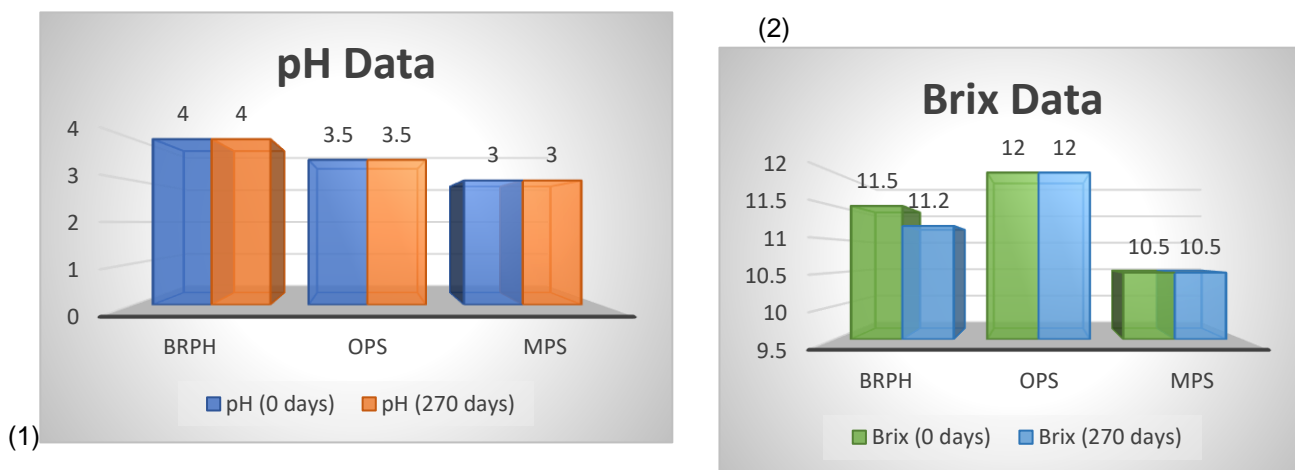


Figure 2: pH (1) & Brix (2) values of pickle samples.

From the figure 2- shows that the pH values of all three samples remained constant at both 0 day and 270 days. This indicates that there was no significant change in the acidity level of the samples over time.

Regarding the Brix values, the OPS sample remained constant at both 0 day and 270 days, indicating good stability over time. On the other hand, the BRPS sample showed a slight decrease in Brix value after 270 days, which indicates that the sugar content in the sample may have decreased slightly over time. The MPS sample showed no change in Brix value between 0 day and 270 days, indicating good stability over time.

Overall, the data suggest that all three pickle samples showed good stability in terms of pH and Brix values over the 270-day period. However, further analysis would be required to determine other factors affecting the quality and shelf life of the pickle samples.

Table 5: Data of Microbial Assay.

Sample	1st Petridis		2nd Petridis		3rd Petridis		Average	
	(0 day)	(270days)	(0 day)	(270days)	(0 day)	(270days)	(0 day)	(270days)
BRPS	5	6	7	7	2	3	4.5 cfu/g	5 cfu/g
OPS	7	8	5	6	4	5	5.5 cfu/g	5.5 cfu/g
MPS	9	8	8	9	5	6	7 cfu/g	7.3 cfu/g

The data provided for microbiological assay of three different types of pickles - BRPS, OPS, and MPS. The assay was conducted using three Petri dishes for each sample at 0 days and 270 days after inoculation. The average **cfu/g** for each sample was calculated by taking the average of the three media.

For the Beetroot pickle sample (BRPS), the average **cfu/g** was 4.5 at 0 days and 5 at 270 days. This indicates that there was a slight increase in the number of viable microorganisms in the sample over the storage period. However, the increase was not significant, and the sample can still be considered safe for consumption.

For the OP₂ sample, the average **cfu/g** was 5.5 at 0 days and 5.5 at 270 days. This indicates that there was no significant change in the number of viable microorganisms in the sample over the storage period. The sample can still be considered safe for consumption.

For the MPS sample, the average **cfu/g** was 7 at 0 days and 7.3 at 270 days. This indicates that there was a slight increase in the number of viable microorganisms in the sample over the storage period. However, the increase was not significant, and the sample can still be considered safe for consumption.

The results of the assay used to assess the effectiveness, stability and storage of preserved methods used for developed beetroot pickle shelf life.

3.1 Sensory Quality

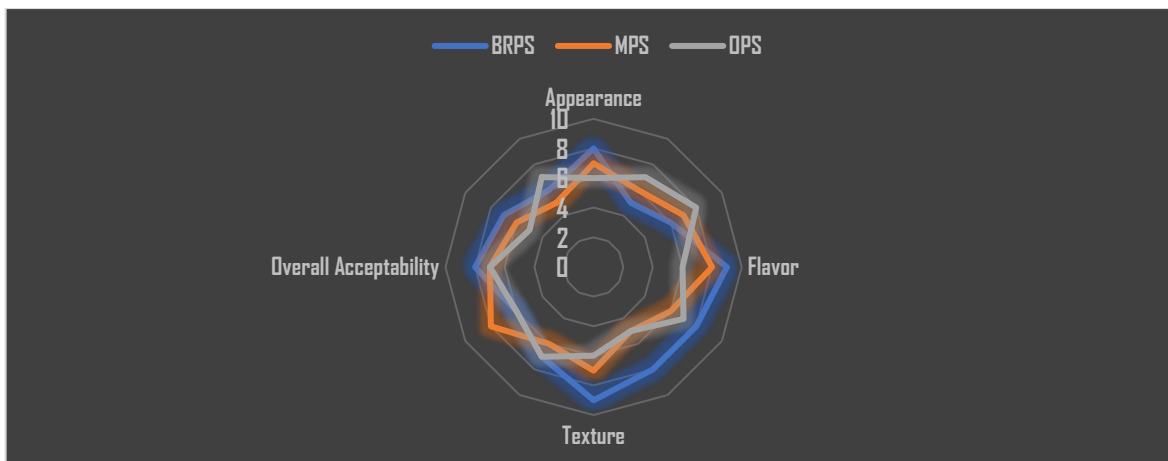


Figure 3: Sensory Attributes of BRPS (Beetroot Pickles), MPS (Mango Pickles), OPS (Olive Pickles)

The data presented shows the evaluation of sensory attributes for three different types of pickles: Beetroot Pickles (BPRS), Mango Pickles (MPS), and Olive Pickles (OPS). The sensory attributes evaluated as appearance, flavor, texture, and overall acceptability after 9 months. Each attribute has been rated on a scale of 1 to 10, with 10 being the highest score. Looking at the appearance ratings, it appears that bright red colored peels for BRPS received the highest score of 8, followed by brown yellowish stick peels for MPS with a score of 7

6. OPS received the lowest score of 6 for appearance, indicating that the appearance of these pickles may not be as visually appealing as the other two. Moving on to the flavor ratings, it can be seen that the soft flavor for BRPS received the highest score of 9, followed by mushy flavor for MPS with a score of 8. OPS received the lowest score of 6 for flavor, indicating that these pickles may not be as flavorful as the other two. The texture ratings show that BRPS with tangy and sweet with a hint of spice received the highest score of 9, followed by MPS with a score of 7. OPS received the lowest score of 6 for texture, indicating that these pickles may not have the desired texture as compared to the other two.

Finally, the overall acceptability ratings indicate that BRPS with Liked it a lot received the highest score of 8, followed by MPS and OPS with scores of 7 and 7, respectively. However, the mixed feelings rating for OPS was higher than the other two, indicating that there may be some variability in how people perceive the overall acceptability of this type of pickle.

Overall, the data presented suggests that BRPS is the most preferred type of pickle based on the evaluated sensory attributes, followed by MPS and OPS. However, it is important to keep in mind that taste preferences can vary greatly among individuals, and the results of this evaluation may not be applicable to everyone.

Table 6: Data Analysis Using ANOVA method for Sensory Evaluation

Sensory Attribute	Sources	DF	SS	MS	F-State	P-Value
Appearance	Between group	2	2	1	1	0.4219
	Within group	6	6	1		
	Total	8	8			
Favor	Between group	2	4.22	2.11	1	0.4219
	Within group	6	12.66	2.11		
	Total	8	16.88			
Texture	Between group	2	0.888	0.444	0.33	0.729
	Within group	6	8	1.33		
	Total	8	8.88			
Overall Acceptability	Between group	2	3.55	1.77	2.285	0.1828
	Within group	6	4.66	0.777		
	Total	8	8.22			

The table shows the results of a sensory evaluation of beetroot pickle, which was evaluated based on four sensory attributes: Appearance, Favor, Texture, and Overall Acceptability. The evaluation was done by a panel of judges (N=8) who tasted the pickle and gave their ratings on a scale for each attribute.

Based on the results, the p-values for Appearance, Flavor, Texture, and Overall Acceptability are all greater than 0.05, which means that there is no significant difference between group means for these attributes. Therefore, we can conclude that the judges did not perceive any significant differences in the appearance, flavor, texture, or overall acceptability of the beetroot pickle. All data analysis using ANOVA indicates that Beet Root Pickle sample is the same liking by the trained panelists.

Table7: Statistical Analysis for Proximate values.

Sample	ASD	FSD	PSD	FASD	CSD	VSD	BSD
BRPS	0.21	0.18	0.09	1.45	1.13	3.88	9.71
OPS	0.23	0.17	0.17	2.25	2	0.14	0
MPS	0.1	0.23	0.07	1.14	1.27	0.51	0

The table 7- shows that the results of Standard deviation of BRPS, OPS, MPS, which was evaluated based on Ash Standard deviation (ASD), Fiber Standard deviation (FSD), Protein Standard deviation (PSD), Fat Standard deviation (FASD), Carbohydrate Standard deviation (CSD), Vitamin C Standard deviation (VSD and Bataline Standard deviation (BSD).

3.2 Storage Stability

Results for the developed products' color, flavor and texture are displayed in Table no.6. Up to 9 months of storage did not alter the pickle's color, taste, or texture and flavor thus it was acceptable to eat. A significant change was observed after 9 months of preservation, and the pickle was deemed unsafe for ingestion. The pickle was still good in terms of color, taste, and flavor after being preserved for up to 12 months. Upon discovering a significant change in the pickle after 12 months of storage, it was deemed unsafe for human consumption. Total plate count for microbes are the most common organisms responsible for decaying vegetables; hence, the changes may have been the consequence of fermentation with these organisms present (Table. 4). It was clear from a comparison of cooked pickle and fermented pickle that was more stable during storage than fermented was, and that both condiments' storage lifetimes were well within the ranges specified in.

Table 8: Effect of storage on the quality of pickle.

Storage (Time of month)	Color	Flavor	Texture	Remarks
1	Brown	Satisfactory	Firm	Acceptable
2	Brown	Satisfactory	Firm	Acceptable
3	Brown	Satisfactory	Firm	Acceptable
4	Brown	Satisfactory	Firm	Acceptable
5	Brown	Satisfactory	Firm	Acceptable
6	Brown	Satisfactory	Firm	Acceptable
7	Brown	Satisfactory	Firm	Acceptable
8	Semi Light Brown	Light flavor	Firm	Acceptable
9	Semi Light Brown	Light flavor	Firm	Acceptable
10	Light Brown	Light off flavor	Firm	Tolerable
11	Light Brown	Light off flavor	Firm	Tolerable
12	Light Brown	Off flavor	Firm	Not acceptable

CONCLUSIONS

Based on the evidence, beetroot pickle appears to be a significant dietary source of health-boosting agents with therapeutic potential for several medical conditions due to its high antioxidant activities. In addition, it has a unique flavor that can compete with other pickles on the market. When compared to other pickles with a similar pH range, beetroot pickle is safe to consume, as its microbial count is 5 *cfu/g*. The storage and stability of the developed beetroot pickles have shown better attributes for up to 12 months while considering human safety levels comparatively.

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REFERENCES

- [1] A. N. R. Hamid A. Abdulmumeen, "Food: Its preservatives, additives and applications," *International Journal of Chemical and Biochemical Sciences*, pp. 36-47, 2011.
- [2] P. C. I. D. B. D. Tom Deliens, "Determinants of eating behaviour in university students: a qualitative study using focus group discussions," *BMC Public Health*, pp. 2-12, 2014.
- [3] A. B. V. A. I. A. P. L. B. Mihai FRÎNCU, "PROCESSING METHODS USED FOR ORGANIC VEGETABLE CHIPS -REVIEW," *Scientific Papers. Series B, Horticulture*, vol. LXVI, pp. 384-391, 2022.
- [4] F. Francis, "In a century of food science Chicago: Institute of Food," *Pioneer in Food Science and Quality Technologist*, pp. 13-14, 2000.
- [5] U. D. Corato, "Improving the shelf-life and quality of fresh and minimally-processed fruits and vegetables for a modern food industry: A comprehensive critical review from the traditional technologies into the most promising advancements,," *Critical Reviews in Food Science*, vol. 60:6, pp. 940-975, 2020.
- [6] Z.-e.-H. M. K. Farid Chemat, "Applications of ultrasound in food technology: Processing, preservation and extraction," *Ultrasonics Sonochemistry*, pp. 813-835, 2011.
- [7] S.-Y. Le, "Microbial Safety of Pickled Fruits and Vegetables and Hurdle Technology," *Internet Journal of Food Safety*, vol. 4, pp. 21-32, 2004.
- [8] G. H. D. J. W. E. J. S. Tom Clifford, "The Potential Benefits of Red Beetroot Supplementation in Health and Disease," *Nutrients*, pp. 2801-2822, 2015.
- [9] K. T. P. B. K. R. K. P. M. G. Ł. W. A. G.-M. Emilia Janiszewska-Turak, "The Impact of the Fermentation Method on the Pigment Content in Pickled Beetroot and Red Bell Pepper Juices and Freeze-Dried Powders," *Applied Sciences*, pp. 1-16, 2022.
- [10] E. Janiszewska-Turak, M. Walczak, K. Rybak, K. Pobiega, M. Gniewosz, Ł. Woźniak and D. Witrowa-Rajchert, "Influence of Fermentation Beetroot Juice Process on the Physico-Chemical Properties of Spray Dried Powder,," *Molecules*, 2022.
- [11] S. Khubber, F. Marti-Quijal, I. Tomasevic, F. Remize and F. Barba, "Lactic acid fermentation as a useful strategy to recover antimicrobial and antioxidant compounds from food and by-products,," *Food Science*, vol. 43, p. 189–198, 2022.
- [12] "Microbiological and Chemical Properties of Chokeberry Juice Fermented by Novel Lactic Acid Bacteria with Potential Probiotic Properties during Fermentation at 4 degrees C for 4 Weeks,," *Foods*, vol. 10, p. 768, 2021.
- [13] T. A. Jiang, "Health Benefits of Culinary Herbs and Spices," *AOAC INTERNATIONAL*, vol. 102, no. 2, p. 395–411, 2019.
- [14] M. Z., A. A. M. S. I. J. J. R. J. W.-S. M. B.-F. K. R. P. P. D. B. a. B. B. Ewelina Maślak, "Isolation and Identification of *Lactococcus lactis* and *Weissella cibaria* Strains from Fermented Beetroot and an Investigation of Their Properties as Potential Starter Cultures and Probiotics,," *Foods*, pp. 2-26, 2022.
- [15] G. W. S. H. P. U. P. L. U. M. O. H. J. W. Jürgen Wruss, "Compositional characteristics of commercial beetroot products and beetroot juice prepared from seven beetroot varieties grown in Upper Austria," *Food Composition and Analysis*, vol. 42, pp. 46-55, 2015.
- [16] L.-S. W. C. M. R. B. L. C. H. C. M. M. K. M. R. S. J. S. a. G. D. S. John F. Lechner, "Drinking Water with Red Beetroot Food Color Antagonizes Esophageal Carcinogenesis in N-Nitrosomethylbenzylamine-Treated Rats," *Medicinal Food*, Vols. 13, no.3, 2010.
- [17] P. Kavalcová, J. Bystrická, J. Tomáš, J. Karovičová, J. Kovarovič and M. Lenková, "The content of total polyphenols and antioxidant activity in red beetroot,," *Scientific Journal for Food Industry*, vol. 9, no. 1, pp. 77-83, 2015.
- [18] S. T. P. K. a. C. N. Murlidhar Ingle, "Nutritional assessment of beetroot (*Beta vulgaris* L.) powder cookies," *AGRICULTURAL RESEARCH COMMUNICATION CENTRE*, vol. 36, no. 3, pp. 222-228, 2015.
- [19] L. R. Peter C. Wootton-Beard, "A beetroot juice shot is a significant and convenient source of bioaccessible antioxidants," *Functional Foods*, vol. 3, no. 4, pp. 329-334, 2011.
- [20] N. S. a. A. S. Dorcus Masih, "Red beetroot: A source of natural colourant and antioxidants: A review," *Pharmacognosy and Phytochemistry*, vol. 8, no. 4, pp. 162-166, 2019.
- [21] C. P. b. c. A. H.-M. a. d. F. X. M. Cátia M. Peres a b, "Review on fermented plant materials as carriers and sources of potentially probiotic lactic acid bacteria – With an emphasis on table olives," *Trends in Food Science & Technology*, vol. 26, no. 1, pp. 31-42, 2012.
- [22] C. Wesley, "Blessed Be God for Food and Feast," *Liturgy*, vol. 15, no. 2, pp. 35-51, 2011.
- [23] A. C. S. E. D. A. Amanda Foster, "A Recipe for Healthy Communities," *Grand Valley State University*, 2014.
- [24] B. Çetin, "Production of probiotic mixed pickles (Tursu) and microbiological properties," *Academic Journals*, vol. 10 (66), pp. 14926-14931, 2011.
- [25] S. A. C. K. M. A. Y. Nihat Akın, "Changes of free fatty acid contents and sensory properties of white pickled cheese during ripening," *Food Chemistry*, vol. 80, no. 1, pp. 77-83, 2003.
- [26] N. J. d. A. F. J. V. P. S. C. C. B. C. G. F. R. Patrícia Dolabela Costa, "ATP - bioluminescence as a technique to evaluate the microbiological quality of water in food industry," *Food Science and Technology*, vol. 47, no. 3, pp. 399-405, 2004.
- [27] X. X. S. G. H. Liu, "Rheological, texture and sensory properties of low-fat mayonnaise with different fat mimetics," *LWT - Food Science and Technology*, vol. 40, no. 6, pp. 946-954, 2007.
- [28] B. T. C. G. V. C. Morten C. Meilgaard, *Sensory Evaluation Techniques*, Third Edition, 1999, p. 416.

- [29] X. G. C. D. N. D. K. D. Sara De Pelsmaeker, "Consumer-driven product development and improvement combined with sensory analysis: A case-study for European filled chocolates," *Food Quality and Preference*, vol. 41, pp. 20-29, 2015.
- [30] Halliwell B. Free radicals, antioxidants, and human disease: Curiosity, cause, or consequence? *Lancet*. 1994;344:721–724.
- [31] Bell P.G., Walshe I.H., Davison G.W., Stevenson E., Howatson G. Montmorency cherries reduce the oxidative stress and inflammatory responses to repeated days high-intensity stochastic cycling. *Nutrients*. 2014;6:829–843.
- [32] Lee, J., Durst, R. O. B. E. R. T., & Wrolstad, R. O. N. A. L. D. (2005). AOAC official method 2005.02: total monomeric anthocyanin pigment content of fruit juices, beverages, natural colorants, and wines by the pH differential method. Official methods of analysis of AOAC International, 2.

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