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Storage Studies in Culinary Paste Prepared from Underutilized Medicinal Spice, Mango Ginger (*Curcuma mangga* Val. et Zijp.)

SUSANSKRITI GUPTA[1], POOJA BOHRA[2], AJIT ARUN WAMAN[2]* and SAVITA BUDHWAR[1]

[1]Department of Nutrition Biology, Central University of Haryana, Mahendergarh, Haryana, India.
[2]Division of Horticulture and Forestry, ICAR-Central Island Agricultural Research Institute, Sri Vijaya Puram, Andaman and Nicobar Islands, India.

Abstract

Mango ginger (*Curcuma mangga* Val. et Zijp.) is an underutilized spice, rhizomes of which possess raw mango-like aroma. Product diversification is one of the important aspects for the promotion of underutilized species. In the present study, culinary paste was prepared from mango ginger rhizomes, and shelf stability over a period of three months was studied at two different storage conditions, viz. ambient (26 ± 2 °C) and low temperature (4 ± 2 °C). No significant change was observed in the total soluble solids content, whereas pH increased after two months of storage at low temperature. Ascorbic acid content decreased sharply from 52.57 mg/100 g to 39.21mg/ 100 g after three months of storage at low temperature. No significant variations ($p \leq 0.05$) were observed in the essential oil and ash content of the product at room temperature or low temperature after three months of storage. However, after three months of storage at room temperature, a significant decrease in moisture content (74.20%) was noticed. A significant change was observed in total phenolic content during the experimental period. Mango ginger paste stored at low temperature showed maximum retention of product quality after three months of storage based on physico-chemical, biochemical analyses, sensory evaluation, and microbial assessment.

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Introduction

The genus *Curcuma* consists of more than 80 species and is known for its versatile uses, viz. culinary, pharmaceutical, cosmetic, dye, as tropical ornamentals, etc.[1] *Curcuma mangga* Val. et Zijp. (mango ginger) is a perennial herb indigenous to Java and is widely distributed in the Andaman and Nicobar Islands (India), Malaysia, Thailand, and Indonesia.[2-4] Its rhizomes are fleshy, yellowish-brown from the outside and citron yellow from the inside.

CONTACT Ajit Arun Waman ajit.arun@icar.gov.in Division of Horticulture and Forestry, ICAR-Central Island Agricultural Research Institute, Sri Vijaya Puram, Andaman and Nicobar Islands, India.

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Rhizomes impart a raw mango-like aroma when cut, and hence, it is popularly known as mango ginger. Rhizomes are primarily used as a spice and salad in fresh form,[5] apart from their use as a vegetable and raw material for the preparation of pickles, candies, and sauces.

Traditionally, the rhizomes have stomachic properties and are used against chest pain, gastric ulcers, fever, and general debility.[6-7] Essential oils are found to be present in the primary, secondary, and mother rhizomes of C. *mangga*[5] and are known to possess antimicrobial activity.[8] Beta-Myrcene and Cyclofenchene have been identified as the prime constituents of the essential oil of this species.[5] This makes them a suitable candidate for flavouring of culinary preparations. Further, curcumin- an important, versatile bioactive molecule occurring in *Curcuma* species, has also been reported to be present in the rhizomes in small quantities.[5] Fresh rhizomes of *C. mangga* are perishable in nature. Postharvest shriveling and sprouting of rhizomes are the major concerns during prolonged storage. Despite its high medicinal and nutritional value, no reports are available describing the processing of this species as a ready-to-use paste for prolonging its storage. Therefore, the aim of the present study was to determine the storage stability of its culinary paste at two different conditions: ambient (26 ± 2 °C) and refrigerated (4 ± 2 °C).

Materials and Methods

Experimental Material

Rhizomes of *Curcuma mangga* were procured from the experimental fields of ICAR – Central Island Agricultural Research Institute, Sri Vijaya Puram, India and were used after curing.

Glassware, Chemicals, and Reagents

Glassware were procured from Borosil Glass Works Limited, Mumbai, India. Chemicals (AR grade) were procured from HiMedia Laboratories Pvt. Ltd., Mumbai, India, and Sisco Research Laboratories Pvt. Ltd., Mumbai, India.

Preparation and Storage

Rhizomes were washed under running tap water, followed by peeling and slicing using a stainless steel knife to *ca.* 6-8 mm thickness. Sliced rhizomes were blanched and ground into a thin paste using a laboratory electric grinder. The paste was mixed with sodium chloride (10%, w/w), citric acid (0.02%, w/w) and sodium benzoate (0.015%, w/w) followed by packing in autoclaved glass jars (8 cm × 8 cm × 8 cm, 200 ml). These glass jars were sealed and stored at room temperature (RT; 26 ± 2 °C), and low temperature (LT; 4 ± 2 °C) in a refrigerator (Whirlpool, FP 263D Protton Roy, India) for three months.

Biochemical Analysis

The product was analyzed at monthly intervals for various biochemical parameters. The TSS was measured using a hand refractometer (Optics Technology, Delhi, India), while pH was determined using a benchtop digital pH meter (Hanna Instruments, HI 2211). For determination of moisture content, the samples were accurately weighed using an analytical balance (CY-104, Citizen, India) and dried in a hot air oven at 105 °C (Deep Vision, India) until the weight became constant.[9] For ash content determination, pre-weighed samples were kept in a muffle furnace (Omron, India) at 550 °C till white ash was obtained. They were then shifted to a desiccator before recording the final weights.[9] For determination of essential oil content, 50 g of paste was added to 200 ml of deionized water, and hydro-distillation was carried out for 6 h using Clevenger apparatus. Collected oil was dried using anhydrous sodium sulphate and content (v/w) was calculated.[5] Ascorbic acid content was determined using the dichlorophenolindophenol titration method.[10] Total phenolic content was determined using the Folin-Ciocalteau (FC) method with gallic acid as a standard.[11]

Microbial Analysis

Microbiological evaluations of the samples were carried out for total bacterial and total fungal count. Different concentrations (10^{-1}, 10^{-2}, and 10^{-3}) were made from each treatment, and the sample was spread over Petri dishes containing NA and PDA media. Samples were then incubated for 48 h at 37 ± 2 °C before recording observations.[12] For determination of psychrophiles in the LT-stored samples, incubation in NA medium was done at 7 °C for 7 days.

Statistical Analysis

The experimental design used was completely randomized design. Statistical analysis of the data collected from various experiments was carried out by one-way ANOVA using the Web Agri Stat Package

Ver. 2.0 (ICAR-CCARI, Ela, India) with the least significant difference ($p \leq 0.05$). All the experiments were performed in triplicates, whereas essential oil estimation was performed in duplicate.

Results and Discussion

Value addition not only provides an opportunity for improving the availability of the produce during off-season in the local markets, but also paves way for increasing the reach of the product to non-native areas for better marketing. Mango ginger in the present study was processed into ready-to-use culinary paste, and results of the storage study have been presented hereunder.

pH and Total Soluble Solids

pH is an important factor that influences the food quality mainly through various chemical reactions.[13] The fresh product had a pH of 5.08. It remained stable for two months and increased slightly after three months of storage at LT. However, at RT, a continuous increase in pH from 5.08 to 5.56 was observed (Fig. 1). An increment in temperature might have resulted in increased pH due to dissociation of molecules.

Total soluble solids content of fresh culinary paste was found to be 12 °Brix. There was no significant difference in TSS of product stored at LT (Fig. 2). However, an increment was observed after three months of storage at RT. The increase in TSS may be due to depolymerization or cleavage of polysaccharides (starch and soluble pectin) into their simplest forms. Moreover, non-carbohydrate compounds such as organic acids and salts might have also contributed in increased TSS content. A similar increasing trend in TSS was observed in ginger paste stored in different packaging materials at ambient as well as low temperature.[12]

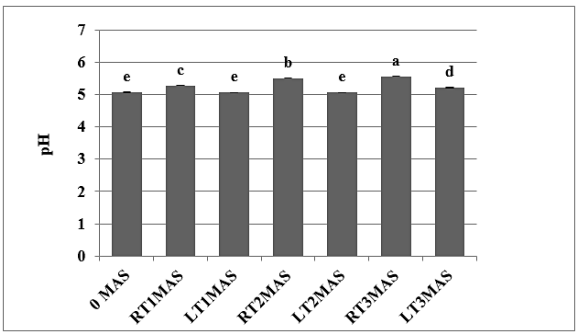

Fig. 1: Effect of storage temperature and storage period on pH of mango ginger paste. RT: Room temperature; LT- Low temperature; 0 MAS: 0 month after storage; 1MAS: 1 month after storage; 2MAS: 2 months after storage; 3MAS: 3 months after storage. Bars with different alphabet are significantly different at 5% level of significance.

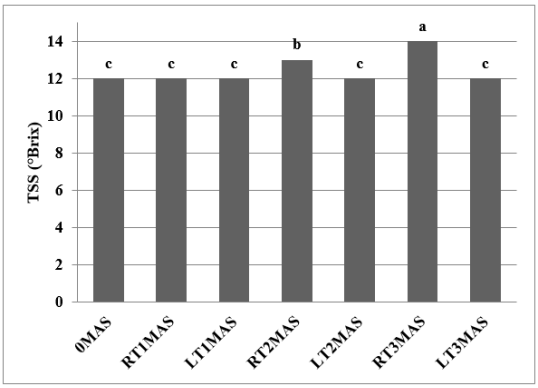

Fig. 2: Effect of storage temperature and storage period on TSS content of mango ginger paste.

Moisture and Ash Content

Moisture content of a product influences its texture, taste, colour, freshness, microbial safety, etc.[14] The initial moisture content of paste was 76.57%, which did not differ significantly during three months of storage at LT (Table 1). However, after three months of storage at RT, significant decrease in moisture content (74.20%) was reported. The present findings are in conformity with those reported by Gamli and Hayoglu,[15] who observed that pistachio nut paste stored at 4°C retained higher moisture content than that stored at 20°C. Ash content determination is important in nutritional evaluation of food, as ash contains the inorganic residues, mainly minerals. The ash content of fresh product was 9.71%, which did not differ statistically at LT and RT during three months of storage (Table 1). On the contrary, garlic paste stored at 25°C had significantly higher ash content (4.06%) than that stored at 40°C (3.82%).[16]

Table 1: Effect of storage temperature and storage period on moisture and ash content of mango ginger paste

Particulars	Moisture (%)	Ash (%)
0 MAS: 0 month after storage	76.57 a	9.714 a
RT1MAS: Room temperature; 1 month after storage	76.54 a	9.690 a
LT1MAS: Low temperature; 1 month after storage	76.11 a	9.702 a
RT2MAS: Room temperature; 2 months after storage	76.46 a	9.709 a
LT2MAS: Low temperature; 2 months after storage	76.30 a	9.697 a
RT3MAS: Room temperature; 3 months after storage	74.20 b	9.686 a
LT3MAS: Low temperature; 3 months after storage	76.17 a	9.695 a

Values followed by similar alphabets in a column are statistically similar

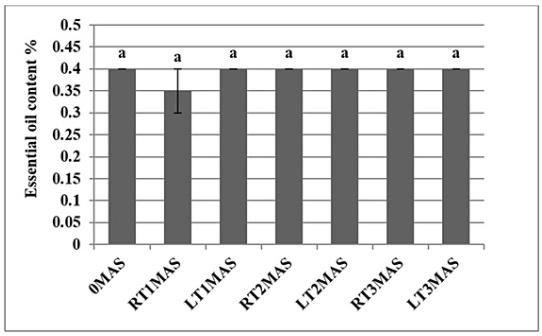

Fig. 3: Effect of storage temperature and storage period on essential oil content (%) of the mango ginger paste

Essential Oil Content

Essential oil of the genus *Curcuma* is of great importance because of its uses in cosmetics, pharmaceutical industries, and in food as additives. Essential oil obtained from the genus is categorized as 'Generally Regarded as Safe'. Essential oil content of fresh product in the present investigation was 0.4%. No significant differences were observed at RT and LT after three months of storage (Fig. 3). Several authors have reported the essential oil of *C. mangga* to possess antioxidant, anti-allergic, and antimicrobial properties.[8,17] Further, retention of essential oil content in mango ginger paste during storage revealed its potential to impart the characteristic aroma of the species in the cuisines.

Ascorbic Acid Content

Ascorbic acid content of freshly prepared product was 52.57 mg/100 g (Fig. 4). Progressive decrease in vitamin C content was observed with increasing storage duration. Ascorbic acid content decreased gradually from 52.57 to 49.01 mg/100 g after three months of storage at RT. In tomato paste stored at room temperature, degradation of ascorbic acid content with time was evident, and about 68% ascorbic acid remained in the product after three months of storage.[18] The decrease in degradation of vitamin C content at RT compared to LT in processed mango ginger paste might be due to increased TSS of samples stored at RT for three months. Robertson and Samaniego-Esguerra[19] reported that at constant temperature, an increase in TSS in lime juice could reduce the ascorbic acid degradation process. Rapid

deterioration of vitamin C content was observed from 52.57 to 41.38 mg/100 g after one month of storage at LT. It further degraded in a slow manner from 41.38 mg/ 100 g to 39.21 mg/ 100 g. Several studies have reported that aerobic degradation of vitamin C was more rapid during the initial period of product storage and this loss might be due to trapped air within the storage container.[19,20] This noticeable difference in ascorbic acid degradation at the studied temperatures is a matter of further investigation.

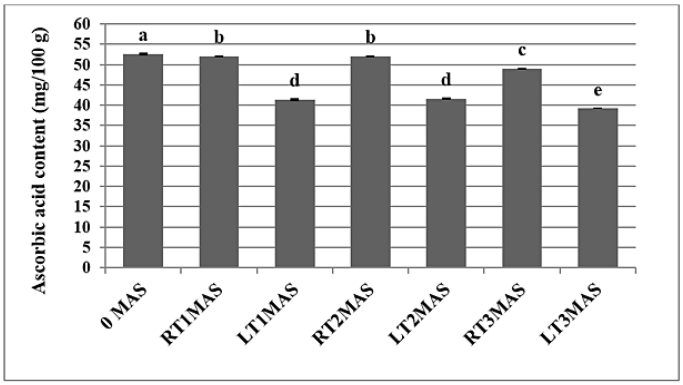

Fig. 4: Effect of storage temperature and storage period on ascorbic acid content of the mango ginger paste

Total Phenolic Content

Phenolic compounds are known to contribute to the sensory and nutritional quality of fresh and processed plant foods. Several studies have reported that phenolic compounds act as natural antioxidants.[21-23] Various phenolic compounds found in *C. mangga* are gallic acid, epigallocatechin, gallocatechingallate, epigallocatechingallate, catechin, and epicatechin. In the present study, the total phenolic content of fresh product was 3.211 mg GAE/ 100 g, which decreased to 2.786 mg GAE/ 100 g in product stored at RT for three months (Fig. 5). The decrease might be due to the non-enzymatic browning reaction of phenolic compounds.[21] Friedman and Jurgens[24] reported that degradation of polyphenolic compounds was higher when exposed to high pH. Low temperature induced a dual effect on the total phenolic content of product with an initial decrease to 3.015 mg GAE/ 100 g after one month of storage, which increased to 3.335 mg GAE/ 100 g three months after storage. The increase might be due to the conversion of polyphenolic compounds into simple phenols.[25]

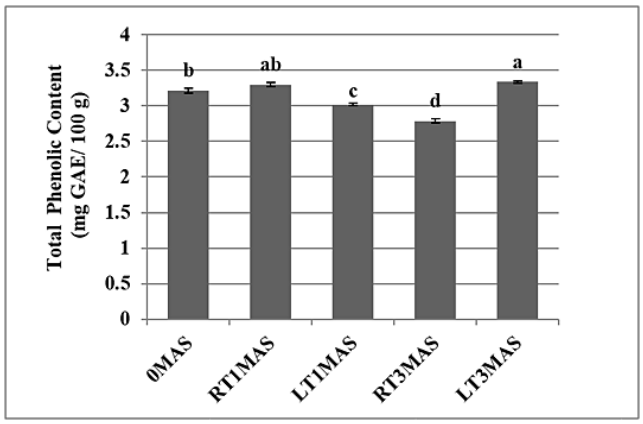

Fig. 5: Effect of storage temperature and storage period on total phenolic content of the mango ginger paste

Microbial Evaluation

In the present study, microbiological assessment showed that the product was safe, irrespective of the storage temperatures and period. Thermal processing of mango ginger paste might have proved to be effective against the growth of food spoilage bacteria, yeasts, and molds. The addition of citric acid helped in lowering the pH of the product, thereby inhibiting the growth of food spoilage microorganisms. Further, the addition of common salt (NaCl) reduces the water activity of the food and retards the growth of microorganisms by causing osmotic shock, limiting oxygen solubility, or interfering with cellular enzymes. Yigit and Korukluoglu[26] reported that usage of 10% NaCl as a preservative reduced the growth of *Aspergillus niger.* Moreover,[27] reported that the addition of sodium benzoate (200 ppm) in ginger-garlic paste helped in the eradication of microbial load completely. In the case of ginger paste, thermal treatment was found to be effective against microbial counts after six months of storage in refrigerated condition.[28] Similar positive results of the combined effect of thermal treatment and added preservatives were also recorded in the present study. Additionally, the essential oil retained in the product throughout the storage duration could have also contributed to avoiding the spoilage.

Sensory Evaluation

Sensory evaluation is important for studying the consumer behavior and attitude towards a new product. The seven-point hedonic scale has been used for testing the consumer preference of processed products.[29-30] Scores of sensory parameters of mango ginger paste after storage for 3 months at different temperatures are presented in Table 2. In general, mean sensory scores of product stored at low temperature were higher than those of product stored at room temperature. However, the differences were not significant and hence, both the products were equally acceptable. Aroma was a key characteristic of the product. Unchanged concentration of essential oil content in mango ginger paste, both at RT and LT, might be the reason of good scores of aroma even after three months of storage. A product is said to have market potential if the acceptability scores are more than 70%[31] and thus, the present product (both stored at LT and RT) could be considered as a candidate product for commercialization.

Table 2: Mean sensory scores of mango ginger paste after three months of storage at different temperatures

Treatments	Color	Flavor	Aroma	Overall acceptability
RT	5.85 ± 0.279	6.10 ± 0.179	6.15 ± 0.258	6.15 ± 0.211
LT	6.10 ± 0.179	6.35 ± 0.211	6.45 ± 0.216	6.35 ± 0.150

Conclusion

The present report was an attempt to popularize an underutilized medicinal spice through value addition. The product was shelf-stable and acceptable after three months of storage at ambient as well as low temperature. The product would be of great use in restaurants, institutional catering, and in processing industries to impart the characteristic mango ginger aroma to the cuisines.

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Conflict of Interest

The authors do not have any conflict of interest.

Data Availability Statement

All the relevant data has been presented in the manuscript.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Author Contributions

- **Susanskriti Gupta:** methodology, writing first draft.
- **Pooja Bohra:** conceptualization, methodology, supervision, final review and editing.
- **Ajit Arun Waman:** methodology and editing of drafts during different stages of reviewing
- **Savita Budhwar:** editing first draft.

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