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RESEARCH ARTICLE

Standardization of process technology for preparation of turmeric paste from fresh rhizomes

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Abstract

The process technology for preparation of turmeric paste from fresh turmeric rhizomes was standardized. The prepared turmeric paste is stored in glass bottles and retortable pouches. The fingers were blanched in water at 100 ºC± 5 ºC for 5 min. The fingers were peeled and water, starch, vinegar and sodium benzoate were added. The paste is prepared in wet grinder and after pasteurization packed in respective containers. The maximum average L*, a* and b* value, yellowing index was observed in sample packed in retortable pouches. The maximum consistency of turmeric paste was observed in glass bottles. The significantly maximum reducing sugar, total sugar, crude fiber, crude protein, crude fat and ash were recorded in the glass bottles followed by retortable pouches. The total plate count and yeast and mould count were lowest in retortable pouches after 180 days storage under refrigerated condition. The maximum B:C ratio (1.84) was recorded in the retortable pouches as compared to glass bottles with maximum net monetary returns. It can be concluded that to prepare turmeric paste by using 80.5 % fresh turmeric rhizomes, 15 % water, 4 % vinegar, 0.5 % starch and 250 ppm sodium benzoate of 1.23 Pa.s. The paste is best packed in retortable pouches and stored under refrigerated conditions for up to 180 days.

Keywords

fresh turmeric; turmeric paste; turmeric processing; value added products of turmeric

Introduction

Turmeric (*Curcuma longa* L.) belongs to the family Zingiberaceae (1). As a spice crop, it is used in various Indian foods. It also has medicinal value (2). Turmeric (*Curcuma longa* L.) is belongs to the family Zingiberaceae (1). Turmeric has a bright yellow colour mainly due to the presence of polyphenolic pigment curcuminoids (3). Indian turmeric is in high demand in the world market due to its high curcumin content (4). India has 244281 ha area with annual production of 2833462 MT during 2021-2022 under turmeric cultivation. In India, turmeric is mainly cultivated in various states including Maharashtra, Telangana, Karnataka, Tamil Nadu, Andhra Pradesh, West Bengal, Odisha, Assam, Gujarat and Haryana. The area under turmeric cultivation in Maharashtra is 60840 ha with 1216975 MT production (5).

Turmeric is mainly used as blood purification, as an anti-inflammatory agent and for treating digestive issues, dermatological disorders, liver

diseases, conjunctivitis, diabetic retinopathy and high cholesterol. It also functions as antioxidant, antimicrobial and anti-carcinogenic agent (6). Turmeric has potential to treat major chronic diseases like cardiovascular diseases, liver diseases, atherosclerosis, cancer and cataracts. Rheumatoid arthritis can be alleviated with antioxidants such as vitamin C, vitamin E and turmeric (7-9). Natural compounds make turmeric an ideal natural food colourant which leads to increase market demand for this food additive (10).

Fresh turmeric rhizomes contain approximately 84.25 %, 1.08 % fat, 9.10 % carbohydrate and 1.20 % protein. The total soluble solids (TSS) of fresh turmeric rhizomes were recorded as 7.80°B. The other parameters such as ash, acidity, pH and fibres recorded in the turmeric rhizomes were 0.66 %, 0.70 %, 5.7 % and 0.72 % respectively. The curcumin content of *Salem* variety rhizomes was recorded 5.1 % (11). The processed products of turmeric involve dehydrated turmeric powder, volatile oil, oleoresin, curcumin capsule, tonics, blended juices, turmeric crackers, turmeric milk and turmeric tea. The processing of turmeric after harvesting includes primary processing. Turmeric rhizomes were cleaned, graded, cured, dried, polished, coloured and sorted. During the curing of turmeric 27-53 % curcuminoids were lost. The maximum loss of curcuminoids was observed in pressure cooking for 10 min (12).

By keeping in view the wide medicinal uses, properties of turmeric, its use in food industry and loss of curcuminoids during processing of turmeric, the study was undertaken for development of the process technology of turmeric paste for retention of its properties and to evaluate its physico-chemical characters and storage stability of turmeric paste.

Materials and Methods

The experiment was conducted at the Department of Post -Harvest Management of Medicinal, Aromatic, Plantation, Spices and Forest Crops, Post Graduate Institute of Post-Harvest Technology and Management, Killa Roha, Maharashtra. The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with 2 main packaging materials namely, glass bottles and retortable pouches and 4 sub-treatments of storage period (0, 2, 4 and 6 months) along with 5 replications. Fresh turmeric rhizomes of the variety Pragati were collected from a farmer's field. The process technology for the preparation of turmeric paste from fresh turmeric rhizomes was standardized. (Fig. 1). The freshly harvested turmeric fingers (rhizomes) were thoroughly washed with potable water. Fingers affected by pests, disease infections or mechanical injuries were discarded. The fingers were blanched in water at 100 °C ± 5 °C for 5 minutes. The fingers were peeled and water, starch, vinegar and sodium benzoate were added. The paste was prepared in wet grinder and after pasteurization (80 °C ± 5 °C for 15 min) packed in respective containers. The prepared turmeric paste was stored in glass bottles and retortable pouches with a thickness of 200 microns. The paste was analyzed for the following physico-chemical properties.

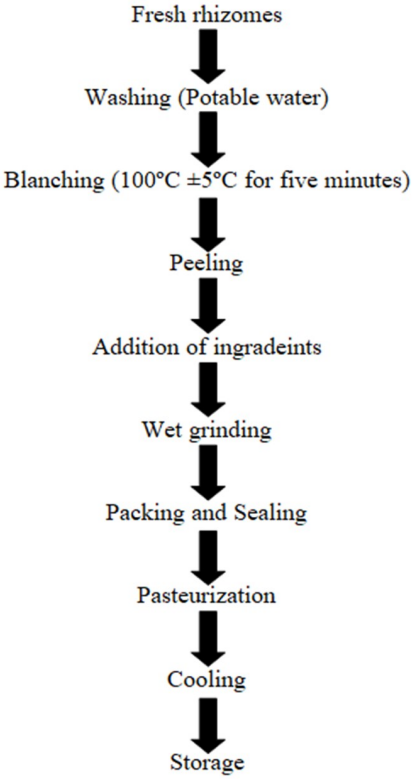

Fig. 1. Process flowchart for preparation of turmeric paste.

Physico-chemical parameters of turmeric during storage period

Colour- colour values i.e. L*, a* and b* of turmeric paste was measured by using colour reader (make Konica Minolta, Japan CR-400)

Yellowing index- To evaluate the difference between samples, the yellowness index parameter was calculated (13).

Viscosity- The viscosity of turmeric paste was determined using Brookfield Viscometer RVDV II+ Pro (M/s Brookfield's Viscometer RVDV II+ Pro using spindle No. 7 at 12 and 30 rpm.)

Moisture content (%) - The initial moisture content of the paste was determined by using the hot air oven method. The 1 g paste was kept in the tared metal dish. The metal dish was kept in a hot air oven at 100 °C for 4 h. The final weight of paste was recorded till constant weight. The moisture content of the paste was determined by using the following formula

$$Moisture\ content\ (\%) = \frac{(Wm - Wd)}{(Wm)} \times 100$$

Where, Wm= initial weight of sample, g; Wd= weight of dry sample, g. (14)

Curcumin content (%) - About 1 g of the sample was refluxed with 75 mL acetone for 1 h after which it was filtered and volume made up to 200 mL. From this filtrate

further 1 mL was taken and volume made up to 100 mL in a volumetric flask. The UV spectral reading for this solution was recorded at 420 nm. A UV spectrum was recorded for standard curcumin. % curcumin in samples was calculated using the formula:

$$Curcumin\ (\%) = \frac{Ds \times As}{100 \times Ws \times 1650} \times 100$$

Where, Ds-dilution volume of the sample, Ws-Weight of the sample taken in grams, As-absorbance of the sample, 1650 -Calculated standard value

$$Curcumin\ (db)\ basis = \frac{Curcumin\ \%}{100 - moisture\ \%} \times 100 \quad (15).$$

Total soluble solids (°B) - The total soluble solids were recorded by using Hand Refractometer (Atago Japan) and the values were corrected at 20 °C with the help of temperature correction chart (16).

pH - It is important as it measures the active acidity which influences the flavour or palatability of a product and affects the processing requirements. The method of pH was determined with digital pH meter (14).

Titrable acidity (%) - Titrable acidity was determined by using the methods (14). A 10 g quantity of paste sample was blended in mortar and pestle with 20-25 mL distilled water. It was then transferred to a 100 mL volumetric flask, made up the volume and filtered. A 10 mL volume of aliquot was titrated against 0.1 N sodium hydroxide (NaOH) solutions. Use phenolphthalein as an indicator. The acidity was calculated as given below and the results was expressed as percent ascorbic acid

$$Titrable\ acidity\ (\%) = \frac{(Titrate \times Normality\ of\ alkali \times volume\ madeup \times Equivalent\ weight\ of\ Acid)}{(Volume\ of\ sample\ taken \times Weight\ of\ sample\ taken \times 1000)} \times 100$$

Starch (%) - Starch was determined by using the methods (14). Extract about 3 g of the ground sample accurately weighed with 5 parts of 10 mL portions of ether on a filter paper that will retain completely the smallest starch granules. Evaporate the ether from the residue and wash with 150 mL of 10 % ethyl alcohol. Carefully wash off the residue from the filter paper with 200 mL of cold water. Heats the un-dissolved residue with 200 mL of 2.5 % dilute HCl in a flask equipped with reflux condenser for 2 and half hours. Cool and neutralise with Sodium carbonate solution and transfer quantitatively to 250 mL volumetric flask and make up volume. Determine reducing sugars in the solution by Lane and Eynon Volumetric method using Fehling solution and methylene blue as internal indicator. Express the result as Dextrose

Starch content (%) = Dextrose × 0.9

Reducing sugar and Total sugar (%) - Reducing sugar and Total sugar was determined by using the methods (14).

Reducing sugar: A known weight of sample was taken in 250 mL volumetric flask. To this, 100 mL of distilled water was added and the contents were neutralized by 1 N sodium hydroxide. Then 2 mL of 45 % lead acetate was added to it. The contents were mixed well and kept for 10 min. 2 mL of 22 % potassium oxalate was added to it to precipitate the excess of lead. The volume was made to 250 mL with distilled water and solution was filtered through Whatman No. 4 filter paper. This filtrate was used for determination of reducing sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' solutions (5 mL each) using methylene blue as an indicator to a brick red end point. The results were expressed on percent basis. The reducing sugar was calculated as below

$$Reducing\ sugar\ (\%) = \frac{Factor \times Dilution}{Titrate\ reading \times Weight\ of\ sample} \times 100$$

Total sugar: Take a 50 mL aliquot of clarified filtrate solution was transferred to 250 mL volumetric flask, to which, 10 mL of 50 % HCl was added and then allowed to stand at room temperature for 24 h. It was then neutralized with 40 % NaOH solution. The volume of neutralized aliquot was made to 250 mL with distilled water. This aliquot was used for determination of total sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' (5 mL each) using methylene blue as indicator to a brick red end point. The results were expressed on % basis

$$Total\ sugar\ (\%) = \frac{Factor \times Dilution}{Titrate\ reading \times Weight\ of\ sample} \times 100$$

Crude fiber (%) - The method of crude fibre estimation was determined (17). Extract 2 g of ground sample with ether or petroleum ether to remove fat. Then boil the dried sample mix in 200 mL of sulphuric acid for 30 min with bumping chips. Filter through muslin cloth and wash with boiling water until washing was free of acid. Boil residue with NaOH for 30 min again filter and wash with 25 mL of boiling sulphuric acid, 3 times 50 mL of water and 25 mL of alcohol. Remove the residue and transfer to ashing dish. Dry the residue for 2 h at 130 ± 2 °C, cool in desiccators and weigh it. Ignite for 30 min at 600 ± 15 °C cool in desiccators and weigh.

$$Crude\ fiber\ (\%) = \frac{weight\ loss\ of\ sample}{Weight\ of\ sample} \times 100$$

Crude protein (%) - Crude protein was processed by using Micro-Kjeldahl distillation. This method of crude protein estimation was determined (17). The samples were digested by heating with concentrated sulphuric acid (H2SO4) in the presence of digestion mixture, potassium sulphate (K2SO4) and copper sulphate (CuSO4). The mixture was then made alkaline with 40 % NaOH.

Ammonium sulphate thus formed. Released ammonia which was collected in 4 % boric

acid solution and titrated again standard HCl. The % nitrogen content of the sample was calculated by the formula given below. Total protein was calculated by multiplying the amount of % nitrogen with appropriate factor.

Crude protein (%) = % N × 6.25

$$N\ (\%) = \frac{1.4 \times mL\ of\ HCl \times Normality\ of\ acid \times 14.01}{Weight\ of\ sample} \times 100$$

Crude fat (%) - Crude fat of samples were estimated by using Soxhlet apparatus with petroleum ether as a solvent. This method of crude fat estimation was determined (17). The dry sample 5 g was weighed accurately into a thimble and plugged with cotton. The thimble was then placed in a soxhlet apparatus and extracted with anhydrous ether for 3 h, cooled in a desiccator and weighed. The fat content was expressed as g/100 g.

$$Crude\ fat\ (\%) = \frac{Weight\ of\ dried\ material}{Weight\ of\ sample} \times 100$$

Total ash (%) - The tare weight of 3 silica dishes (7-8 cm diameter) was recorded and 5 g of the sample was weighed into each silica dish. The contents were ignited on a Bunsen burner and the material was ashed after the completely burning of the sample at a temperature of 550 °C in a muffle furnace, an inorganic residue is remained which is recorded as total ash. It is the aggregate of all non -volatile inorganic elements. The method of total ash estimation was determined (14).

$$Total\ ash\ (\%) = \frac{Weight\ of\ cricible\ with\ ash - Weight\ of\ crucible}{Weight\ of\ sample} \times 100$$

Microbial analysis - Total Plate Count estimation was determined (18). Using separate sterile pipettes, prepare decimal dilutions of 10-1 to 10-6 and others as appropriate, of food homogenate by transferring 10 mL of previous dilution to 90 mL of diluents. Shake all dilutions well. Pipette 1 mL of each dilution into separate, duplicate, appropriately marked petri dishes. Add 12-15 mL plate count agar (cooled to 45 ± 1 °C) to each plate within 15 min of original dilution. Pour agar and diluents in control plates for each series of samples. Immediately mix sample dilutions and agar medium thoroughly and uniformly by alternate rotation and back-and-forth motion of plates on flat level surface. Let agar solidify. Invert solidified petri dishes and incubates promptly for 48 ± 2 h at 35 °C.

To determine the yeast and mould count prepare dichloran 18 % glycerol (DG 18) agar (cooled to 45 ± 1 °C) and added 12-15 mL agar to each plate within 15 min of original dilution. Pour agar and diluents in control plates for each series of samples. Immediately mix sample dilutions. Let the agar solidify After that plates were incubate in the dark at 25 °C (19).

Results and Discussion

Colour value

L value*

Treatment T_1 (74.77) recorded the highest mean L* value for colour which decreased from 76.18 to 73.35 in glass bottles and 76.18 to 73.61 in retortable pouches up to 180 days of storage. The L* value of colour decreased significantly from 76.18 to 72.40 during storage of 0 to 180 days (Table 1). The L* value of colour was decreased due to an increase in browning of turmeric paste during storage period. Ginger paste turns brown to yellow during storage and decrease in L* colour value was recorded (20). The decrease in L* value of turmeric rhizome after drying was affected by pre-treatment (blanching) (21).

a value*

The treatment T_2 (11.83) recorded the highest mean a* value for colour which increased from 10.66 to 12.13 in glass bottles and 10.66 to 12.93 in retortable pouches up to 180 days of storage. The a* value of colour during storage of 0 to 180 days also increased significantly from 10.66 to 12.53 (Table 1). As there is increase in browning of turmeric paste during storage period, increase in a* value of colour was occurred. The decrease in a* value of turmeric rhizome after drying was affected by blanching (21).

b value*

Treatment T_2 (82.27) recorded highest mean b* value for colour which decreased from 91.06 to 71.76 in glass bottles and 91.06 to 75.64 in retortable pouches up to 180 days of storage. The b* value of colour decreased significantly from 91.06 to 73.70 during storage of 0 to 180 days (Table 1). As there is increase in browning of turmeric paste during storage period, increase in a* value of colour was occurred. The decrease in b* value of turmeric rhizome after drying was affected by pre-treatment (21).

Yellowing index

Fresh samples of treatment T_2 (170.77) was recorded the highest mean yellowness index. The yellowness index was decreased from 170.77 to 147.31 in retortable pouches i.e. T2 samples and from 170.77 to 143.50 in glass bottles i.e. T1 Sample stored for 180 days. Yellowness index decreased significantly from 170.77 to 145.40 during storage of 0 to 180 days (Table 2). The decrease in yellowing index may be occurred due to increase in browning of turmeric paste during storage period. Similar observations were observed by in ginger paste samples stored at -10 to 37 °C for a period of 24 weeks as colour changed due to browning (22). The colour value of stored samples decreased with increasing storage was observed in garlic paste (23). The effect of thermal treatments resulting in nonenzymatic browning and discolouration could lead to several reactions inducing destruction of pigment which lowers the colour quality (24).

Table 1. Effect of different packaging materials on the L*, a* and b* value of turmeric paste during storage.

Treatments (T)	L* colour value					a* colour value					b* colour value				
	Storage period (days)					Storage period (days)					Storage period (days)				
	Initial	60	120	180	Mean	Initial	60	120	180	Mean	Initial	60	120	180	Mean
T1	76.18	75.10	73.61	71.44	74.08	10.660	11.120	11.590	12.130	11.380	91.06	79.70	76.57	71.76	79.77
T2	76.18	75.41	74.14	73.35	74.77	10.660	11.350	12.390	12.930	11.830	91.06	82.57	79.83	75.64	82.27
Mean	76.18	75.25	73.88	72.40		10.660	11.240	11.990	12.530		91.06	81.14	78.20	73.70	
	Treatments (T)	Storage (S)	Inter-action (T x S)	Treatments (T)	Storage (S)	Inter-action (T x S)	Treatments (T)	Storage (S)	Inter-action (T x S)						
S. Em±	0.14	0.20	0.03	0.02	0.03	0.005	0.11	0.16	0.02						
CD at5 %	0.41	0.58	0.09	0.06	0.08	0.014	0.33	0.46	0.06						

T1: glass bottle T2: Retortable pouch

Table 2. Effect of different packaging materials on the yellowing index, consistency and moisture percentage of turmeric paste during storage.

Treatments (T)	Yellowing index					Consistency					Moisture (%)				
	Storage period (days)					Storage period (days)					Storage period (days)				
	Initial	60	120	180	Mean	Initial	60	120	180	Mean	Initial	60	120	180	Mean
T1	170.77	151.68	148.61	143.50	153.64	1.2353	1.5223	1.7563	1.9893	1.6258	86.62	84.46	81.49	74.12	81.67
T2	170.77	156.44	153.83	147.31	157.09	1.2353	1.4313	1.6273	1.6957	1.4974	86.62	85.49	84.37	81.14	84.40
Mean	170.77	154.06	151.22	145.40		1.2353	1.4768	1.6918	1.8425		86.62	84.98	82.93	77.63	
	Treatments (T)	Storage (S)	Interaction (T x S)	Treatments (T)	Storage (S)	Interaction (T x S)	Treatments (T)	Storage (S)	Interac-tion (T x S)						
S.Em±	0.39	0.55	0.22	0.01	0.01	0.0001	0.07	0.10	0.01						
CD at5 %	1.12	1.58	0.63	0.02	0.03	0.0003	0.20	0.28	0.03						

T1: glass bottle T2: Retortable pouch

Viscosity (Pa. s)

Treatment T_2 (0.1168) recorded significantly highest mean and gradually decrease in flow behaviour index was reported from 0.1333 to 0.0767 with T_1 (glass bottles) and from 0.1333 to 0.0963 with T_2 (retortable pouches). Flow behaviour index decreased significantly from 0.1333 to 0.0865 during storage of 0 to 180 days. Treatment T_1 (1.6258 Pa.s) recorded the highest mean and consistency index significantly increased from 1.2353 Pa.s to 1.9893 Pa.s in glass bottles and from 1. 2353 Pa.s to 1.6957 Pa.s in retortable pouches in 180 days of storage period. Flow consistency index during storage of 0 to 180 days also increased significantly from 1.2353 Pa.s to 1.8425 Pa.s (Table 2). This decreased flow behaviour index and increased consistency index occurs due to loss of moisture due to low temperature in storage period. All rheological parameters increased with the addition of hydrocolloid and decreased with increasing storage duration. These results are found in tomato ketchup in agreement with those obtained (25). The consistency of tomato ketchup was decreased and flow behaviour index increased during 120 days of storage (26). The decrease in viscosity with increase in storage time in mint sauce was recoded (27).

Moisture (%)

Treatment T_2 (84.40 %) recorded the highest mean and gradual decrease in moisture content from 86. 62 % to 74.12 % in glass bottles (T_1), while from 86.62 % to 81.14 % in retortable pouches was (T_2) observed during storage of 180 days. The moisture content decreased significantly from 86.62 % to 77.63 % during storage of 0 to 180 days (Table 2). This decrease in moisture content of paste was observed primarily due to packaging materials and water condensation in refrigerated condition. Similar trend of decrease in moisture content in ginger garlic paste during storage period (28-30).

Curcumin (%)

Treatment T_1 (6.98 %) recorded significantly highest mean curcumin content which increased from 5.35 % to 9.22 % in glass bottles (T_1) and from 5.35 % to 6.84 % in retortable pouches (T_2). Curcumin content during storage of 0 to 180 days also increased significantly from 5.35 % to 8.03 % (Table 3). Among the different packaging materials effect on dry weight basis curcumin content of turmeric paste

Table 3. Effect of different packaging materials on the curcumin (%) fresh, curcumin (%) dry weight basis and totals soluble solids (°B) of turmeric paste during storage.

Treatments	Curcumin (%)					Curcumin (%) dry weight basis					Totals soluble solids (°B)				
	Storage period (days)					Storage period (days)					Storage period (days)				
(T)	Initial	60	120	180	Mean	Initial	60	120	180	Mean	Initial	60	120	180	Mean
T1	5.350	6.100	7.250	9.220	6.980	39.99	39.28	39.23	35.60	38.53	6.50	6.98	7.54	7.94	7.24
T2	5.350	5.710	6.130	6.840	6.010	39.99	39.35	39.24	36.28	38.71	6.50	6.82	7.20	7.64	7.04
Mean	5.350	5.910	6.690	8.030		9.99	39.32	39.23	35.94		6.50	6.90	7.37	7.79	
	Treatments (T)		Storage (S)		Interaction (T x S)	Treatments (T)		Storage (S)		Interaction (T x S)	Treatments (T)		Storage (S)		Interac-tion (T x S)
S.Em±	0.04		0.06		0.002	0.42		0.91		0.07	0.01		0.02		0.0003
CD at5 %	0.12		0.17		0.006	NS		NS		NS	0.04		0.06		0.0009

T1: glass bottle T2: Retortable pouch

during storage found to be non-significant. Treatment T_2 (38.71 %) recorded highest mean curcumin content which decreased from 39.99 % to 35.60 % in glass bottles (T_1) and from 39.99 % to 36.28 % in retortable pouches (T_2). Curcumin content on dry weight basis during storage of 0 to 180 days also decreased from 39.99 % to 35.94 % (Table 3). Curcumin concentration increased during storage period due to reduction in moisture content. It showed that curcumin content increased with storage period more rapidly in glass bottle. As the moisture content decreased by using different packaging materials curcumin content was increased. The storage period and different packaging materials have significant influence on curcumin content of turmeric paste on wet weight basis. However, on dry weight basis it was found to be non-significant. This might be due to degradation of curcumin in storage. It was reported that lower the moisture content, higher the levels of curcuminoid pigments (31). The increase in moisture content from 14.60 % (db) to 16.98 %, curcumin content decreased from 2.816 % to 0.526 % during storage of 180 days (32).

Total soluble solids (°B)

Treatment T_1 (7.24 %) recorded significantly highest mean; TSS value during storage increased from 6.50 % to 7.94 % in glass bottles (T_1), while it was increased from 6.50 % to 7.64 % in retortable pouches (T_2) was observed during storage of 180 days. The TSS value during storage of 0 to 180 days also increased significantly from 6.50 % to 7.79 % (Table 3). There was an increase in TSS during storage of paste might be due to decrease in moisture content in storage period. Similar results were recorded for ginger garlic paste (33). They reported TSS of ginger garlic paste increased in different packaging materials in 120 days of storage due to decrease in moisture content. Studies reported similar results for ginger garlic paste (30, 34).

pH

Treatment T_1 (4.90) recorded the highest mean and there was a slight increase in the pH from 4.27 to 5.64 in retortable pouches (T_2) and from 4.27 to 4.74 in glass bottles (T_1) different packaging till 180 days. The pH during storage of 0 to 180 days also increased significantly from 4.27 to 5.19 (Table 4). Increase in pH was observed due to decreased titratable acidity during storage period. Similar increasing trend of pH in garlic paste during storage was reported by (23, 29, 30, 35).

Titratable acidity (%)

Treatment T_2 (0.92 %) recorded significant highest mean. The initial value of the acidity was 0.99 % which was decreased to 0.68 % in glass bottles (T_1), while it was decreased from 0.99 % to 0.84 % in retortable pouches (T_2) during storage of 180 days. The acidity during storage of 0 to 180 days also decreased significantly from 0.99 % to 0.76 % (Table 4). The loss of acidity may be due to browning reaction during storage. Similarly, observations were recorded during storage of ginger-garlic paste (30). Sample stored in refrigerated conditions titratable acidity of peeled garlic was found to be slightly decreased (36, 37).

Starch (%)

Treatment T_2 (28.82 %) recorded significantly highest mean and starch content was decreased from 30.57 % to 25.57 % in glass bottles (T_1) and from 30.57 % to 27.29 % in retortable pouches (T_2). The starch content during storage of 0 to 180 days also decreased significantly from 30.57 % to 26.43 % (Table 4). Starch content decreased due to conversion of starch into sugars at low temperature in storage period. The starch content on a dry weight basis was decreased with storage (38). This decrease of starch content could be due to conversion of starch to sugars in cassava. The greater reduction of starch content at 0 °C storage was recorded in the potato tuber (39).

Reducing sugar (%)

Treatment T_1 (7.91 %) recorded significantly highest mean. Reducing sugar content increased from 7.48 % to 8.32 % in glass bottles (T_1) and from 7.48 % to 8.11 % in retortable pouches (T_2). The reducing sugar content during storage of 0 to 180 days also increased significantly from 7.48 % to 8.21 % (Table 5). Reducing sugar increased due to break down of non-reducing sugars and starch during the storage period. Increase of glucose and fructose in carrot during storage was recorded (40). reported Increase in reducing sugar in mango ginger due to conversion of starch into sugar was noted (41).

Table 4. Effect of different packaging materials on the pH, acidity (%) and starch (%) of turmeric paste during storage.

Treatments (T)	pH					Acidity (%)					Starch (%)				
	Storage period (days)					Storage period (days)					Storage period (days)				
	Initial	60	120	180	Mean	Initial	60	120	180	Mean	Initial	60	120	180	Mean
T1	4.27	4.64	5.04	5.64	4.90	0.99	0.93	0.88	0.68	0.87	30.57	28.39	26.73	25.57	27.82
T2	4.27	4.43	4.64	4.74	4.52	0.99	0.94	0.91	0.84	0.92	30.57	29.08	28.33	27.29	28.82
Mean	4.27	4.53	4.84	5.19		0.99	0.94	0.90	0.76		30.57	28.74	27.53	26.43	
	Treatments (T)		Storage (S)		Interaction (T x S)	Treatments (T)		Storage (S)		Interaction (T x S)	Treatments (T)		Storage (S)		Interaction (T x S)
S.Em±	0.03		0.04		0.01	0.006		0.008		0.001	0.09		0.13		0.01
CD at5 %	0.09		0.12		0.03	0.017		0.024		0.003	0.27		0.39		0.03

T1: glass bottle T2: Retortable pouch

Table 5. Effect of different packaging materials on the reducing sugar (%), total sugar (%) and crude fiber (%) of turmeric paste during storage.

Treatments (T)	Reducing sugar (%)					Total sugar (%)					Crude fiber (%)				
	Storage period (days)					Storage period (days)					Storage period (days)				
	Initial	60	120	180	Mean	Initial	60	120	180	Mean	Initial	60	120	180	Mean
T1	7.48	7.71	8.15	8.32	7.91	28.23	29.17	30.00	30.79	29.55	0.710	1.050	1.280	1.570	1.150
T2	7.48	7.65	7.90	8.11	7.78	28.23	28.92	29.48	29.96	29.15	0.710	0.990	1.100	1.240	1.010
Mean	7.48	7.68	8.02	8.21		28.23	29.04	29.74	30.38		0.710	1.020	1.190	1.410	
	Treatments (T)		Storage (S)		Interaction (T x S)	Treatments (T)		Storage (S)		Interaction (T x S)	Treatments (T)		Storage (S)		Interaction (T x S)
S. Em±	0.02		0.02		0.0004	0.05		0.07		0.003	0.01		0.02		0.003
CD at5 %	0.05		0.07		0.001	0.13		0.19		0.009	0.04		0.06		0.009

T1: glass bottle T2: Retortable pouch

Total sugar (%)

Treatment T_1 (29.55 %) recorded significantly highest mean. The totals sugar content of the paste increased from 28.23 % to 30.79 % in glass bottles (T_1), while from 28.23 % to 29.96 % in retortable pouches (T_2) on 180 days of storage. The total sugar content during storage of 0 to 180 days also increased significantly from 28.23 % to 30.38 % (Table 5). Total sugar increased due to break down of starch during the storage period. The total sugars were increased in mango ginger juice during storage for 120 days (41, 42).

Crude fiber (%)

Treatment T_1 (1.15 %) recorded significantly highest mean. Crude fiber content increased from 0.71 % to 1.57 % in glass bottle (T_1) and from 0.71 % to 1.24 % in retortable pouches (T_2). The crude fiber content during storage of 0 to 180 days also increased significantly from 0.71 % to 1.41 % (Table 5). Crude fiber content increased might be due to loss of moisture content during the storage period. The fiber content of garlic pastes increased with the increase of the storage period (28). The small influence of storage on total fiber content in carrot was recorded (40).

Crude protein (%)

Treatment T_1 (9.09 %) recorded highest mean. Crude protein content increased from 8.69 % to 9.52 % in glass bottles (T_1) and from 8.69 % to 9.35 % in retortable pouches (T_2). The protein content during storage of 0 to 180 days also increased significantly from 8.69 % to 9.44 % (Table 6). Crude Protein content increased might be due to loss of moisture content during the storage period. Increase in protein content during storage period in ginger -based spice sauces (43). The increase in crude protein during the storage time in tomato paste due to use of ginger powder as a preservative (44).

Crude fat (%)

Treatment T_1 (7.71 %) recorded significantly highest mean. The crude fat content was increased from 7.33 % to 7.93 % in glass bottle (T_1) and from 7.33 % to 7.74 % with retortable pouches (T_2). The crude fat content during storage of 0 to 180 days also increased significantly from 7.33 % to 7.84 % (Table 6). Crude fat content increased might be due to loss of moisture content during the storage period. Fat content of garlic paste increased with the increase of storage period (28). The fat content was increased during the storage time in tomato paste due to use of ginger powder as a preservative (44).

Total ash (%)

Treatment T_1 (2.21 %) recorded significantly highest mean. In general, there was increase in the ash content from 1.87 % to 2.72 % in glass bottles (T_1) and from 1.87 % to 2.29 % in retortable pouches (T_2) during storage of 180 days. The ash content during storage of 0 to 180 days also increased

Table 6. Effect of different packaging materials on the crude protein (%), crude fat (%) and ash (%) of turmeric paste during storage.

Treatments (T)	Crude protein (%)					Crude fat (%)					ash (%)				
	Storage period (days)					Storage period (days)					Storage period (days)				
	Initial	60	120	180	Mean	Initial	60	120	180	Mean	Initial	60	120	180	Mean
T1	8.69	8.93	9.22	9.52	9.09	7.33	7.77	7.80	7.93	7.71	1.87	2.03	2.20	2.72	2.21
T2	8.69	8.81	9.05	9.35	8.97	7.33	7.62	7.70	7.74	7.60	1.87	1.98	2.14	2.29	2.07
Mean	8.69	8.87	9.13	9.44		7.33	7.69	7.75	7.84		1.87	2.01	2.17	2.51	
	Treatments (T)	Storage (S)	Interaction (T x S)	Treatments (T)	Storage (S)	Interaction (T x S)	Treatments (T)	Storage (S)	Interaction (T x S)						
S. Em±	0.02	0.02	0.0004	0.01	0.02	0.001	0.03	0.05	0.001						
CD at5 %	0.05	0.07	0.001	0.04	0.06	0.003	0.09	0.14	0.003						

T1: glass bottle T2: retortable pouch

significantly from 1.87 % to 2.51 % (Table 6). Crude ash content increased might be due to loss of moisture content during the storage period. Similar results were observed for ginger-garlic paste (29, 30). They reported that the ash per cent of ginger-garlic paste increased over storage time of 90 days due to heating. The ash content of garlic pastes increased with the increase of the storage period (28).

Microbial Analysis (Cfu/g)

Yeast and mould count in of sample T_1 (glass bottles) was increased to 1.300×10^2 cfu/g and 1.200×10^2 cfu/g in sample T_2 (retortable pouches) whereas TPC count increased to 4.600×10^3 cfu/g in T_1 (glass bottles) and 4.000×10^3 cfu/g in T_2 (retortable pouches) (Table 7) after 180 days storage. In general, it was observed that both total plate count and yeast mould count increased with the storage period. All the samples stored at 5 °C temperature for 180 days of storage period with different packaging materials were found within the acceptable microbial limit. Microbial load increased during storage period might be due to change in acidity during the storage period of 180 days in both packaging materials. It was reported that the low temperature was unfavourable for growth of bacteria and samples of ginger garlic paste stored at refrigerated condition were found only in acceptable limits for mould and bacteria. However microbial activities increased with storage period (33). It was also reported that the spices and herbs used in food need further cooking before consumption as the acceptable limit of the total plate count was 5×10^5 cfu/g (34). It was concluded that prepared red chilli paste was stored up to 6 months and it was microbiologically safe for human consumption for TPC and yeast and mould count (45). The maximum B:C ratio (1.84) was recorded in the retortable pouches as compared to glass bottles (Table 7).

Conclusion

The process technology is recommended to prepare turmeric paste by using 80.5 % fresh turmeric rhizomes, 15 % water, 4 % vinegar, 0.5 % starch and 250 ppm sodium benzoate of 1.23 Pa Sec consistency packed in retortable pouches and stored in refrigerated conditions up to 180 days.

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Authors' contributions

JHK made substantial contribution to conception and designing of the experiment, overall guidance to conduct of the experiment, involved in drafting the manuscript critically for important intellectual content, SSJ conducted of the experiment and acquisition of data, analysis and interpretation of the data, GDS involved in statistical analysis and providing laboratory facilities and RCR involved in the time-to-time guidance during the conduct of experiment and revising the manuscript

Compliance with ethical standards

Conflict of interest: All the authors of manuscript entitled 'Standardization of process technology for preparation of turmeric paste from fresh rhizomes' are hereby declared that we do not have any conflict of interests to declare.

Ethical issues: None

Table 7. Effect of different packaging materials on total plate count, yeast mould count and B; C ratio of turmeric paste during storage.

Treatments (T)	Total plate count (cfu/g)				Yeast mould count (cfu/g)				B:C ratio
	Storage period (days)				Storage period (days)				
	Initial	60	120	180	Initial	60	120	180	
T1	ND	ND	ND	4.600×10^5	ND	ND	ND	1.300×10^5	1.38
T2	ND	ND	ND	4.000×10^5	ND	ND	ND	1.200×10^5	1.84

T1: glass bottle T2: retortable pouch ND –Not Detected

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