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RR Gajera
Associate Professor, College of Horticulture, College of Food Processing Technology and Bio-energy, Anand Agricultural University, Anand, Gujarat, India

Anurag Nema
Assistant Professor and College of Food Processing Technology and Bio-energy, Anand Agricultural University, Anand, Gujarat, India

Harsh P Sharma
Assistant Professor and College of Food Processing Technology and Bio-energy, Anand Agricultural University, Anand, Gujarat, India

DC Joshi
Principal & Dean, College of Food Processing Technology and Bio-energy, Anand Agricultural University, Anand, Gujarat, India

Correspondence
RR Gajera
Associate Professor, College of Horticulture, College of Food Processing Technology and Bio-energy, Anand Agricultural University, Anand, Gujarat, India

Processing and quality evaluation of bottle gourd (*L. siceraria*) juice

RR Gajera, Anurag Nema, Harsh P Sharma and DC Joshi

Abstract
Bottle gourd (*Langenaria siceraria*) belongs to *Cucurbitaceae* family and locally known as Calabash, Doodhi, and Lauki in different parts of India. Fruit is rich in nutrients and is available at a cheaper rate. Bottle gourd contents 1.6% choline on a dry weight basis and is required for proper functioning of the central nervous system. Bottle gourd fruit have higher edible index which proves its importance for processing. Production of bottle gourd juice is mostly done manually in the household or at cottage level, which is less hygienic with high chances of degradation within few hours. To develop new acceptable bottle gourd juice; experiments were carried out for its juicing and to have shelf-life of few days. For this, bottle gourd were shredded to 5mm thickness and blanched in hot water at 85°C for 3 min for its juicing. 1% lemon juice, 1% ginger juice and 0.5% of rock salt were added to extracted bottle gourd juice to improve sensory quality. The juice was hot-filled in 200 ml glass bottles; crown corked and thermally processed at 85°C for 4 min and bottles were cooled and stored under ambient (30 ± 02 °C) and refrigerated (07 ± 02 °C) conditions. Quality characteristics were evaluated in line with FSSRs (2011). The total plate counts were not more than 50cfu/ml in juice up to 20 days at ambient and 35 days at refrigerated storage conditions hence juice was microbiologically safe up to this storage period.

Keywords: Bottle gourd, juice, blanching, thermal processing, quality, storage life

Introduction
Bottle gourd (*Langenariasiceraria)* is a vigorous annual climbing vine with large leaves, and belongs to *Cucurbitaceae* family. It is locally known as *Calabash, Doodhi, and Lauki* in different parts of India [1]. Among various vegetables grown in India, bottle gourd has a high place in diet. It is rich in nutrients, and is available at a cheap rate. A 100 g of edible portion of the bottle gourd contains 12.0 mg ascorbic acid, 87.0 mg potassium, 12.0 mg calcium, 37.0 mg phosphorus, and 0.3 mg niacin [2, 3]. Bottle gourd contains 1.6% choline on a dry weight basis [4]. Choline is required for proper functioning of the central nervous system and also for metabolism of folic acid and DNA synthesis [5]. Bottle gourd fruit is a potential source of natural antioxidants [1]. It contains cucurbitacins, polyphenols and two sterols, campesterol and sitosterol [6]. The fruits are traditionally used as a nutritive agent having cardio-protective, cardio-tonic, general tonic, diuretic, aphrodisiac, antidote to certain poisons, alternative purgative, and cooling effects [7]. A glass of bottle gourd juice taken daily is considered to prevent premature graying of hair [8].

Bottle gourd plant is seasonal, and supply of bottle gourd fruit is not uniform throughout the year. It is still an underutilized fruit in spite of higher edible index, which also highlights the need for its processing [3]. Production of juice is one way to make diversified processed product from the fruit. Production of bottle gourd juice is mostly done manually in the household or at cottage level by small venders for fresh use, and is less hygienic with chances of quality degradation within few hours.

The pure juices and fruit beverages from many fruits and vegetables are available in the market with added class II preservatives, prepared with pasteurization process. Fresh bottle gourd juice is not commercially available, but has good potential for development. In order to produce pure juice with superior quality with minimal thermal exposure during processing and without addition of chemical preservatives; a scientific study was undertaken to develop an appropriate processing technology for production of stable, acceptable and quality juice from bottle gourd having adequate shelf–life of at least few days in line with food safety and standards regulations (FSSRs, 2011).

Materials and Methods

Raw material and chemicals

Tender bottle gourd (cv. ABG-1) fruits were procured from the Horticultural Farm, Anand Agricultural University, Anand, India. The fruits were cleaned to remove adhering soil and other extraneous matters, washed in 2 % diluted HCL solution and running tap water to remove residues of sprays of arsenic and lead [9].

Phenolphthalein (1%), Fehling's solutions (A+B), methylene blue indicator, neutral lead acetate (45%) and potassium oxalate (22%) were procured from Merck, Mumbai, India; Ascorbic acid standard (99%) from SD Fine Chemicals Mumbai, India; and plate count agar, VRBA and PDA were procured from Hi-Media Laboratories Pvt. Ltd., Mumbai. De-ionized distilled water was used for all assays.

Blanching and juice extraction

Bottle gourd fruits were shredded to 5 mm size using a stainless steel shredder (Sumeet), and blanched at 85°C for 2, 3 and 4 min using a constant temperature water bath (Electro equipment, New Delhi, India). Fruit to water ratio was maintained@1:4 w/v during blanching process. Juice from the blanched shreds was extracted using a centrifugal juicer (Rama Udyog, Jaipur, India).Lemon was cut into two halves and its juice was extracted by squeezing. Ginger juice was extracted by a domestic mixer-cum-grinder. Prepared juices were strained through muslin cloth. 1% of lemon juice, 1% of ginger juice and 0.5% of rock salt were added to the bottle gourd juice extracted from blanched shreds to improve its sensory quality.

Thermal processing and storage

The prepared juice was hot-filled in pr-sterilized 200 ml glass bottles; crown corked and autoclaved (Nova Instruments Pvt. Ltd., Ahmedabad) at 85°C and atmospheric pressure for 2, 3 and 4 min. The bottled juice thereafter was subsequently cooled and stored under ambient (30 ± 02 °C) and refrigerated (07 ± 02 °C) conditions in an incubator (Khera Instruments Pvt. Ltd., New Delhi) for further quality evaluation.

Quality Analysis

A total soluble solid (ºBrix) was measured using a pocket hand refractometer-PAL-1(ERMA, Japan) having measuring range 0-53 ºBrix. Titratable acidity (%) was determined by taking an aliquot of the sample diluted with distilled water and titrated with NaOH (0.1N) using phenolphthalein (1%) solution as indicator [10]. Dry matter (%) was determined using AOAC method [11]. Total sugar was determined using Lane and Eynon method. The ascorbic acid content (mg per 100ml) was determined by visual titration method using 2, 6-dichlorophenol-indophenol [10]. Microbiological analysis was carried out as per standard procedures in sterile environment using a laminar air flow chamber (Khera Instruments Pvt. Ltd., New Delhi). The juice samples were subjected to microbial analysis for total plate counts (TPC) using plate count agar, yeasts and moulds count using freshly prepared acidified (pH adjusted to 3.5 by sterile 10 % tartaric acid solution) PDA and coliform counts using VRBA (Macconkey agar) (Hi-Media Laboratories Pvt. Ltd., Mumbai). Sensory score were evaluated using a 9 point hedonic rating test where 9 is 'like extremely' and 1 is 'dislike extremely.' A panel of 7 semi trained tester among faculties of institute had carried out the acceptance tests [10].

Results and Discussion

Effect on sensory characteristics

Table 1 represents the sensory scores of un-blanched and blanched at 85°C for 2, 3 and 4 min bottle gourd juice carried out on the basis of colour, flavour, consistency and overall acceptability (OAA) using a 9-point hedonic scale. Mean values of colour, flavour, consistency and OAA of juice ranged from 5.56 to 7.57, 5.54 to 7.65, 5.50 to 7.56, and 5.53 to 7.57, respectively. Treatment T_3 in terms of OAA of the juice had the highest sensory score of 7.57, while least score of 5.53was for the treatment T_1. Statistical analysis of sensory evaluation showed significant difference at 95 % confidence level for the colour, flavour, consistency, and overall acceptability of the juice. The increased in OAA of treatment $T_3$was 36.89% higher as compared to the treatment T_1, indicating that the blanching treatment was beneficial before juicing.

Table 1: Effect of blanching on sensory characteristics of bottle gourd juice

Treatment	Sensory characteristic			
	Colour	Flavour	Consistency	OAA
T_1	5.56	5.54	5.50	5.53
T_2	6.27	6.29	6.21	6.32
T_3	7.57	7.65	7.56	7.57
T_4	6.47	6.72	6.82	6.75
SEm ±	0.130	0.139	0.131	0.107
CV %	8.513	9.023	8.535	6.939
CD (P=0.05)	0.366*	0.394*	0.371*	0.302*

T_1 Un-blanched juice sample, T_2 Blanching at 85°C for 2 min, T_3 Blanching at 85°C for 3 min, T_4 Blanching at 85°C for 4 min
* Significant value

Effect on physico-chemical characteristics

TSS of bottle gourd juice at selected blanching time and temperature is shown in Table 2.TSS decreased with increase in blanching time and had direct variation with acidity might be due to direct variation of imbibitions of the blanching water. TSS changes during blanching indicated a progressive loss of total sugar and simultaneously increased imbibitions of water. Prolonged blanching increased the removal of total solids as exemplified by the change in sugar content, dry matter and brix/acid ratio of juice. The ascorbic acid content of un-blanched bottle gourds juice was 7.51 mg/100 ml and was decreased to 50.85 % after the blanching at 85°Cfor 4 min. Result revealed that prolonging the blanching time at constant blanching temperature increased the ascorbic acid losses more. Blanched juice TSS, acidity, ascorbic acid, total sugar and dry matter were highly significant at 5 % level of significance, while no significant effect was in brix/acid ratio.

Table 2: Effect of blanching on physicochemical characteristics of bottle gourd juice

Treatment	Physicochemical characteristic					
	TSS, °Brix	Acidity, %, as CA	Ascorbic acid, mg/100ml	Total sugar, %	Dry matter, %	Brix/Acid ratio
T_1	2.50	0.16	7.51	2.13	2.94	15.96
T_2	2.10	0.14	5.42	2.06	2.76	15.37
T_3	2.03	0.13	4.52	1.97	2.55	15.25
T_4	1.83	0.12	3.72	1.78	2.43	14.86

SEm ±	0.033	0.002	0.142	0.006	0.011	0.464
CV %	3.150	3.429	5.348	0.630	0.833	6.029
CD (P=0.05)	0.103*	0.007*	0.436*	0.019*	0.034*	NS

Effect on microbiological characteristics

The microbiological quality in terms of the total plate counts, yeast and mould counts, and coliform counts of blanched juice is presented in Table 3.Maximum total plate, yeast and mould counts were 2.34 $\times 10^2$ and 56cfu.ml^{-1}, respectively, in un-blanched sample. The total plate counts, yeast and mould counts of blanched juice were significantly lower ($P<0.05$) during the treatments T_1 toT_4. This might be due to the inhibitory effect of thermophilic temperature of blanching rather than mesophilic towards the total plate counts and yeast and mould counts. The initial coli form counts were nil (cfu.ml^{-1}) in the un-blanched juice, and were also nil after the blanching process.

Table 3: Effect of blanching on microbiological characteristics of bottle gourd juice

Treatment	Total plate count, Cfu.ml^{-1}	Yeast andmould count, Cfu.ml^{-1}	Coliform count, Cfu.ml^{-1}
T_1	2.34 x10^2	56	0
T_2	93	25	0
T_3	79	18	0
T_4	56	12	0
SEm ±	5.244	2.475	0
CV %	9.074	17.999	0
CD (P=0.05)	16.160*	7.626*	0

Standardization of blanching process

Hot water blanching was considered suitable for bottle gourd shreds, and the process was optimized on the basis of the maximum retention of sensory, physico-chemical and microbiological quality in the juice produced after blanching the shreds. The best blanching treatment of bottle gourd shreds (5 mm) was found to be at treatment with hot water at 85°C temperature for 3 min. At this combination, bottle gourd juice had 7.57 overall acceptability score, TSS of 2.03 ºBrix, titratable acidity of 0.13%, ascorbic acid of 4.52 mg/100 ml, total sugar of 1.97%, 2.55% dry matter, brix/ acid ratio of 15.25, total plate counts of 79cfu.ml^{-1}, and yeast and mould counts of18cfu.ml^{-1}. This process parameters combination was thus considered to be standardized, as it satisfied the required sensory, physico-chemical and microbiological criteria.

To further improve the sensory quality of optimized blanched bottle gourd juice along with overall acceptability; 1% lemon juice, 1% ginger juice and 0.5% rock salt were added. Prepared juice was hot-filled in 200 ml glass bottles at 85°C and crown corked. Filled glass bottles were immediately autoclaved at 85 °Cfor2, 3 and 4 min; and subsequently cooled at room temperature. Cooled bottles were stored at ambient (30± 02 °C) as well as at refrigerated (07± 02 °C) temperature for 40 days, and microbiological characteristics were evaluated in line with FSSRs (2011).

Microbiological characteristics during storage

The microbiological characteristics data of thermally processed juice at ambient and refrigerated storage temperatures are presented in Table 4.

Table 4: Microbiological characteristics of thermally processed juice during storage

Parameters	Storage period (days)																				
	0			5			10			15			20			25			30	35	40
	*	#	@	*	#	@	*	#	@	*	#	@	*	#	@	*	#	@	@	@	@
Ambient condition (30 ± 02 °C)																					
Total plate count (cfu.ml^{-1})	15	10	7	37	15	10	103	36	18	-	67	34	-	-	48	-	-	61			
Yeasts andmoulds count (cfu.ml^{-1})	6	5	2	3	3	1	0	1	1	-	0	0	-	-	0	-	-	0			
Coli form count (cfu.ml^{-1})	0	0	0	0	0	0	0	0	0	-	0	0	-	-	0	-	-	0			
Refrigerated condition (07 ± 02 °C)																					
Total plate count (cfu.ml^{-1})	15	10	7	22	13	9	41	27	11	78	46	16	-	60	21	-	-	28	34	45	57
Yeasts andmoulds count (cfu.ml^{-1})	6	5	2	4	2	2	2	2	2	1	0	1	-	1	1	-	-	1	1	1	0
Coli form count (cfu.ml^{-1})	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	-	0	0	0	0

Juice processed: * At 85 °C for 2 min, # At 85 °C for 3 min, @ At 85 °C for 4 min

Note: Missing data in table indicates that experiments were discarded because of spoilage of samples

Mean values of total plate counts of the thermally processed juice at 85 °C for 2, 3 and 4 min were initially 15, 10 and 7cfu.ml^{-1}; and increased to 1.03 x10^2, 67and61cfu.ml^{-1} after 10, 15 and 25 days at ambient temperature; and 78, 60 and 57cfu.ml^{-1} after 15, 20 and 40 days at refrigerated temperature, respectively. The increase in the total plate counts at both storagetemperatures was followed by decrease in yeast and mould counts. However, the increases in total plate counts were lower at refrigerated storage condition than at ambient, and an inverse trend was observed in yeasts and mould counts. The coli form counts (cfu.ml^{-1}) in the juice were initially nil, and were also nil during ambient and refrigerated storages. Thermally processed bottle gourd juice at 85 °C for 4 min was microbiologically safe up to 20 days at ambient and 35 days at refrigerated storage conditions, and was in conformity with FSSRs (2011) [12]. Total plate counts at ambient and refrigerated condition increased beyond prescribed limit of 50 cfu.ml^{-1}after storage period of 20 days and 35 days, respectively. Hence, further studies were limited up to the safe period of 20 days at ambient and 35 days at refrigerating conditions.

Sensory characteristics during storage

Sensory scores of juice having maximum acceptability score was in glass bottle thermally processed at 85°C for 4 min and stored at ambient and refrigerated temperatures are shown in Table 5. Mean values for bottle gourd juice colour ranged from 7.73 to 7.57, flavor 7.85 to 7.69, consistency 7.55 to 7.40 and overall acceptability 7.71 to 7.55 after ambient storage period of 20 days. Flavour of the juice had highest sensory score of 7.69, while least score was 7.40 for consistency at the end of 20 days storage at an ambient condition. Mean values for bottle gourd juice colour ranged from 7.73 to 7.52, flavor 7.85 to 7.59, consistency 7.55 to 7.40 and overall acceptability 7.71 to 7.50 after refrigerated storage period of 35 days. Flavour of the juice had highest sensory score of 7.59, while least score was 7.40 for consistency at the end of 35 days storage at refrigerated conditions.

Table 5: Sensory characteristics of juice during storage

Parameter	Storage period (days)							
	0	5	10	15	20	25	30	35
Ambient conditions (30 ± 02 °C)								
Colour	7.73	7.69	7.66	7.61	7.57	-	-	-
Flavour	7.85	7.82	7.78	7.73	7.69	-	-	-
Consistency	7.55	7.52	7.47	7.43	7.40	-	-	-
Overall acceptability	7.71	7.68	7.64	7.59	7.55	-	-	-
Refrigerated condition (07 ± 02 °C)								
Colour	7.73	7.71	7.67	7.63	7.60	7.58	7.55	7.52
Flavour	7.85	7.84	7.80	7.75	7.71	7.68	7.64	7.59
Consistency	7.55	7.55	7.50	7.50	7.47	7.46	7.43	7.40
Overall acceptability	7.71	7.70	7.66	7.63	7.59	7.57	7.54	7.50

Note: Missing data in table indicates that experiments were discarded because of spoilage of samples

Sensory scores of colour and overall acceptability were good during both the storage conditions. The overall acceptability gradually decreased along with advancement of storage period under both storage conditions. The decreased in overall acceptability at the end of storage period were 2.07 % and 2.72 % at ambient (30 ± 02 °C) and refrigerated (07 ± 02 °C) conditions, respectively, indicating good overall acceptability of the juice. Result revealed that the juice was stable for 20 and 35 days at ambient and refrigerated conditions, respectively.

Physico-chemical characteristics during storage

The physico-chemical values of the juice in terms of the TSS, titratable acidity, brix/acid ratio, total solids, total sugars and ascorbic acid during ambient and refrigerated storage conditions are shown in Table 6.

Table 6: Physicochemical characteristics of juice during storage

Parameters	Storage period (days)							
	0	5	10	15	20	25	30	35
Ambient condition (30 ± 02 °C)								
TSS(^{0}Brix)	2.13	2.16	2.20	2.23	2.26	-	-	-
Total acidity (%)	0.19	0.21	0.24	0.28	0.34	-	-	-
Brix/acid ratio	11.21	10.29	9.17	7.96	6.65	-	-	-
Total solids (%)	2.59	2.58	2.56	2.56	2.55	-	-	-
Total sugars (%)	2.01	2.01	2.03	2.03	2.04	-	-	-
Ascorbic acid (mg/100ml)	4.63	4.44	4.13	3.65	3.06	-	-	-
Refrigerated condition (07 ± 02 °C)								
TSS(^{0}Brix)	2.13	2.15	2.18	2.21	2.21	2.23	2.24	2.24
Total acidity (%)	0.19	0.20	0.23	0.25	0.28	0.30	0.33	0.35
Brix/acid ratio	11.21	10.75	9.48	8.84	7.89	7.43	6.79	6.40
Total solids (%)	2.59	2.59	2.57	2.57	2.57	2.57	2.56	2.56
Total sugars (%)	2.01	2.01	2.03	2.03	2.05	2.06	2.06	2.06
Ascorbic acid (mg/100ml)	4.63	4.50	4.45	4.14	3.98	3.77	3.43	3.16

Note: Missing data in table indicates that experiments were discarded because of spoilage of samples

Mean values of TSS of the juice was 2.13˚Brix at the 0 day of storage, and increased to 2.26ºBrixat the end of 20 days of storage at ambient condition and 2.24°Brixat the end of 35 days at refrigerated storage. The increase in TSS during storage might be due to the hydrolysis of complex carbohydrates present in the juice. A gradual increase in acidity and TSS in juice over the storage periods were observed at both storage temperatures. Increased acidity from 0.19% to 0.34%during storage at ambient temperature for 20 days, and from 0.19% to 0.35% at refrigerated temperature for 35 days might be due to decrease in pH content, and conversion of sugars to acid inherently present in the juice. The result revealed that the slight variation in TSS and acidity did not affect the juice quality or acceptance, which was reflected in the sensory evaluations.

The initial Brix/acid ratio of the juice was 11.21 and decreased to 6.65 and 6.40 at the end of storage period 20 days at ambient and 35 days at refrigerated temperatures, respectively, and showed that the increase in acidity of the juice during storage was higher than TSS. Initial total solids of the juice were 2.59%, and decreased to 2.55% and 2.56% during storage at ambient temperature for 20 days and refrigerated temperature for 35 days, respectively. This decrease might be due to increase in TSS of juice during storage. The mean values of total sugars of the blend juice were found to be in the range 2.01% to 2.04%, and 2.01% to

2.06%after the above storage periods at ambient and refrigerated temperatures, respectively. The changes were less at refrigerated storage temperature than at ambient temperature after the same period of storage.

The initial ascorbic acid content of the juice was 4.63 mg/100 ml, and decreased to 1.95 mg/100 ml and 2.71 mg/100 ml during storage at ambient temperature for 20 days and refrigerated temperature for 35 days, respectively. Decrease in ascorbic acid was 33.9% at ambient (30±2°C) and 31.75 % at refrigerated (7±2°C) storage temperature at the end of 20 and 35 days, respectively. The decrease in ascorbic acid content in the juice might be due to the fact that ascorbic acid being more sensitive at higher temperature was easily oxidized by both enzymatic and non-enzymatic reactions.

Storage study was important to check the quality and shelf-life of thermally processed juice as per Food Safety and Standards Regulations (2011). Physico-chemical quality as TSS, total acidity, brix/acid ratio, total solids, total sugars and ascorbic acid of the juice were stable for 35 days at refrigerated, and 20 days at ambient storage temperature. These physico-chemical qualities did not affect the sensory attributes. The total plate counts in the juice were not more than 50cfu.ml^{-1} during the respective storage periods at different temperatures, and were in line with FSSRs (2011) standards. These storage conditions of the juice, therefore, satisfied the sensory, physicochemical and required microbiological criteria.

Conclusions

Blanching, accompanied by initial microbial load reduction, is an important unit operation prior to processing of fruits and vegetables for its juicing. Blanching of 5 mm bottle gourd shred at 85 °C for 3 min was found to be the best for its juicing. The sensory quality of extracted blanched bottle gourd juice could be increased by addition of 1% lemon juice, 1% ginger juice and 0.5% rock salt. Thermally processed bottle gourd juice at 85 °C for 4 min was found to be microbiologically safe up to 20 days at ambient (30 ± 02 °C) and 35 days at refrigerated (7 ±02°C) storage temperature, and satisfied food safety and standard regulations (FSSRs, 2011). The processors can modulate their process according to time–temperature-shred thickness conditions for large scale industrial juice production from bottle gourd.

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