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STUDIES ON DEVELOPMENT OF READY-TO-SERVE (RTS) BEVERAGES FROM WOOD APPLE (*LIMONIA ACIDISSIMA* L.), GUAVA (*PSIDIUM GUAJAVA* L.), GINGER (*ZINGIBER OFFICINALE* ROSCOE) AND CARDAMOM (*ELETTARIA CARDAMOMUM* MATON) BLEND

MOHAMMAD ISHAN*[1] AND BHAGWAN DEEN*[2]

[1]Research Scholar, Deptt. of Post Harvest Management, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya-224229 U.P., India.

[2]Professor and Head, Deptt. of Post Harvest Management, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya-224229 U.P., India.

Corresponding address- * ishannn09@gmail.com

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Ready-To-Serve(RTS), wood apple, guava, ginger, cardamom, blend combinations, storage, organoleptic quality.

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ABSTRACT

The present investigation was carried out at Post Graduate Laboratory, Department of Post-Harvest Technology, College of Horticulture & Forestry, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya-224229, U.P. India during 2025. Wood apple (*Limonia acidissima* L.), Guava (*Psidium guajava* L.), Ginger (*Zingiber officinale* Roscoe) & Cardamom (*Elettaria cardamomum* Maton) have nutritional, spicy, medicinal and therapeutic values. In the present studies, wood apple pulp, guava pulp, ginger juice and cardamom seed extract were blended in different ratios *viz*., 0:90:9:1 (T1), 10:80:9:1 (T2), 20:70:9:1 (T3), 30:60:9:1 (T4), 40:50:9:1 (T5), 50:40:9:1 (T6), 60:30:9:1 (T7), 70:20:9:1 (T8), 80:10:9:1 (T9), 90:0:9:1 (T10) for the preparation of RTS. Result appears that the treatment no. 4 containing 30% wood apple pulp + 60% guava pulp + 9% ginger juice + 1% cardamom seed extract was found to be best over other treatments for the preparation of palatable quality of RTS blend beverages. Therefore 10% blend with 13% Total Soluble Solids, 0.3% acidity and incorporated with 70 ppm SO_2 was used to prepare RTS for storage study. During the storage period TSS, acidity, reducing sugars, total sugars and browning increased whereas, ascorbic acid (Vitamin-C), non-reducing sugar, and organoleptic quality decreased with the advancement of storage period. The beverage was organoleptically acceptable upto 3 months of storage in ambient condition.

INTRODUCTION

Blended beverages, including Ready-To-Serve (RTS) drinks, squashes, and syrups, combine fruits, herbs, and spices to provide a healthy source of vitamins and minerals. These beverages have several health advantages, including better digestion, immunity, and hydration. They includes high levels of antioxidants, fiber, and energy-boosting chemicals. Blended drinks have a long shelf life and preserve nutritional integrity when handled and stored properly.

Wood apple (*Limonia acidissima* L.) is a fruit of the Rutaceae family, is one of the most resilient fruits cultivated in the semi-arid and arid areas of India. The pulp from wood apples is high in beta-carotene, which is a precursor to vitamin A. It also has a small quantity of ascorbic acid and a large amount of vitamin B, including riboflavin and thiamine (Kumar and Deen, 2017). The nutritional and chemical properties of fresh wood apple fruit pulp reveal that it comprises of 9.45-21.70 percent TSS, 1.98-3.80 percent titratable acidity, 4.77-5.71 percent TSS/acid ratio, 0.30-6.03 percent reducing sugars, 5.65-13.80 percent non reducing sugar, 7.95-19.83 percent total sugars, 3.86-6.82 mg/100g ascorbic acid, 21.50- 80.10 mg/100g total phenol, and 1.22-1.30 percent pectin (Kumar and Deen, 2017). Fruits have great medicinal value and are used as a liver and heart tonic in India,while unripe fruits are utilized in traditional remedies as an astringent to treat diarrhoea and dysentery, as well as effectively treating hiccups, sorethroat, and gum diseases (Kerkar *et al.*, 2020). A plentiful supply of wood apples, which are easily processed into various processed items, can be found in the majority of the tribal regions of central India.

Guava (*Psidium guajava* L.), a species native to Tropical America and belonging to the Myrtaceae family, is cultivated successfully throughout the tropical and subtropical regions of India. According to NHB (2023), the area under this crop is 359 thousand hectares with a production of 5.59 million metric tons, with average productivity of 15.9 mt/ha. Guava serves as a good source of ascorbic acid (299 mg/100 g) and pectin (1.15%), with moisture content ranging from 74% to 84%, dry matter between 13% and 26%, protein content of 0.8% to 1.5%, fat ranging from 0.4% to 0.7%, and ash content of 0.5% to 1.0%. The fruit is rich in various vitamins such as niacin, thiamine, riboflavin, and vitamin A, as well as minerals like phosphorus (23-37 mg/100 g), calcium (14-30 mg/100 g), and iron (0.6-1.4 mg/100 g) (Bal *et al.*, 2014). Guavas have a total soluble solids (TSS) content between 8.2 to 10.4° Brix and are recognized as a nutritious, delicious, and juicy fruit. Guavas can be consumed fresh or processed into various items such as juice, nectar, pulp, jam, jelly, fruit bars, syrup slices, and dried foods. They can also be used to flavor other fruit juices and pulps (Leite *et al*. 2006).

Ginger (*Zingiber officinale* Rosc) is an ancient, spicy, and medicinal plant that belongs to the Zingiberaceae family. It is

native to Southeast Asia. The total area used for ginger cultivation in India was 175,000 hectares, resulting in a production of 1,451,000 metric tons during the 2018-19 period (NHB, 2020). For a long time, ginger has been recognized for its medicinal benefits, serving as a digestive aid, spiritual beverage, aphrodisiac, antiemetic, anticancer agent, anti- platelet, antimicrobial, anti-parasitic, antioxidant, anti-inflammatory, analgesic, hepatic protective, and immune-stimulating substance (Malhotra and Singh, 2003). Fresh ginger primarily consists of protein (2.3%), fat (0.9%), carbohydrates (12.3%), minerals (1.2%), fiber (2.4%), and moisture (80.9%). According to Deen and Kumar (2014), ginger has 1.80% total soluble solids, 0.08% acidity, and contains 1.90 mg of Vitamin C per 100 grams. Minerals such as Phosphorus, calcium, and iron are found in ginger. It also includes vitamins like thiamine, riboflavin, niacin, and vitamin C. Unique active components, such as gingerol, are present in ginger and contribute to improved digestion, acting as a trigger for this process. Fresh ginger is commonly utilized in making pickles and candies, whereas fresh ginger juice is used in the preparation of beverages. Ginger drinks not only provide a refreshing beverage but also promote health benefits.

Cardamom (*Elattaria cardamomum* maton) is a perennial herb that produces pale green to yellow fruits, as well as triangular brownish-black seeds. The dried fruits of cardamom emit a pleasant fragrance accompanied by a distinctively slightly spicy flavour, creating a warm sensation in the mouth. The current global market trend emphasizes the search for unique food ingredients and flavours with enhanced health benefits (Netzal *et al.*, 2007). Cardamom seeds are rich in volatile oil. Cardamom acts as a stimulant, carminative, and digestive aid. The monoterpenes present in the oil extracted from the seeds exhibit antibacterial, antifungal, antiviral, and spasmolytic properties, and are utilized for their carminative, antispasmodic, and expectorant effects (Srinivasan, 2004 Tapsell *et al.*, 2006). The nutritional profile and composition of cardamom (per 100 g) includes Energy 311 Kcal, Carbohydrates 68.47 g, Protein 10.76 g, Total Fat 6.7 g, Dietary Fiber 28 mg, Thiamin 0.198 mg, Vitamin C 21 mg, Copper 0.383 mg, Iron 13.97 mg, and Manganese 28 mg (Source: USDA National Nutrient Database).

2. MATERIALS AND METHODS

2.2 Raw Materials

Wood apple was collected from baraipara village of Milkipur Tehshil, Ayodhya, Uttar Pradesh. Guava was procured from Horticultural Main Experiment Station, Department of fruit science, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya. Ginger and Cardamom (Local variety) purchased from local market in Kumarganj.

2.2 Extraction of wood apple pulp, guava pulp, ginger juice and cardamom powder

The processes used for the extraction of wood apple pulp, guava pulp, ginger juice and cardamom powder are shown in Fig.-1, Fig.-2, Fig.-3 and Fig.-4, respectively.

2.3 Standardization of Blends for Ready-To-Serve (RTS) Beverages

For the preparation and evaluation of palatable RTS beverages, the squash comprising 10 % blends, 13 % TSS, 0.3 % acidity and 70 ppm SO2 were prepared from various combinations of wood apple pulp, guava pulp, ginger juice and cardamom powder to find out the best combination for the development of palatable quality of RTS beverages.

T1 - 10 % B.C. No.1 containing 90% guava pulp + 9% ginger juice + 1% cardamom powder + 13% Sugar + 0.3% acidity + 70 ppm SO2.

T2 - 10 % B.C. No.2 containing 10% wood apple pulp + 80% guava pulp + 9% ginger juice + 1% cardamom powder + 13% Sugar + 0.3% acidity + 70 ppm SO2.

T3 - 10 % B.C. No.3 containing 20% wood apple pulp + 70% guava pulp + 9% ginger juice + 1% cardamom powder + 13% Sugar + 0.3% acidity + 70 ppm SO2.

T4 - 10 % B.C. No.4 containing 30% wood apple pulp + 60% guava pulp + 9% ginger juice + 1% cardamom powder + 13% Sugar + 0.3% acidity + 70 ppm SO2

T5 - 10 % B.C. No.5 containing 40% wood apple pulp + 50% guava pulp +9% ginger juice + 1% cardamom powder + 13% Sugar + 0.3% acidity + 70 ppm SO2.

T6 - 10 % B.C. No.6 containing 50% wood apple pulp + 40% guava pulp + 9% ginger juice + 1% cardamom powder + 13% Sugar + 0.3% acidity + 70 ppm SO2.

T7 - 10 % B.C. No.7 containing 60% wood apple pulp + 30% guava pulp + 9% ginger juice + 1% cardamom powder + 13% Sugar + 0.3% acidity + 70 ppm SO2.

T8 - 10 % B.C. No.8 containing 70% wood apple pulp + 20% guava pulp + 9% ginger juice + 1% cardamom powder + 13% Sugar + 0.3% acidity + 70 ppm SO2.

T9 - 10 % B.C. No.9 containing 80% wood apple pulp + 10% guava pulp + 9% ginger juice + 1% cardamom powder + 13% Sugar + 0.3% acidity + 70 ppm SO2 .

T10 - 10 % B.C. No.10 containing 90% wood apple pulp + 9% ginger juice + 1% cardamom powder + 13% Sugar + 0.3% acidity + 70 ppm SO2.

Preparation of RTS: A panel of 10 semi-trained judges assessed each blend combinations organoleptically then determined the ideal combination of wood apple pulp, guava pulp, ginger juice and cardamom powder. The results indicate that blend combination No. 4, comprising 30% wood apple pulp, 60% guava pulp, 9% ginger juice and 1% cardamom powder, received the highest overall sensory scores compared to other combinations. Therefore, the optimal RTS beverage can be formulated using 10% blend juice containing 30% wood apple pulp, 60% guava pulp, 9% ginger juice and 1% cardamom powder with 13% total soluble solids (TSS), 0.3% acidity and 70 ppm SO_2. The technique used for RTS making is shown in Fig. 5.

2.4 Storage Studies

A total of 10 litres of RTS was prepared using the combinations (Combination - 4). The beverage was bottled in glass bottles with a 2 cm headspace, , sealed with crown corks, pasteurized and stored at room room temperature for storage evaluation. Observations were taken at monthly intervals over a three-month period to assess variation in total soluble solids (TSS), acidity, Vitamin-C content, reducing sugars, non-reducing sugar, total sugars, browning and sensory (organoleptic) qualities. The Total Soluble Solids (TSS) content of the samples was measured using 3 types of hand refractometer (Erma Inc., Tokyo, Japan) each with measurement ranges of 0–32 %, 28–62 % and 58–92 %. The TSS values obtained at ambient temperature were corrected to 20°C using a reference table and the average TSS content of the sample was expressed as a percentage. Acidity was determined by titrating a known volume of the sample with N/10 sodium hydroxide solution, using two to three drops of phenolphthalein as an indicator and the results were expressed as a percentage of anhydrous citric acid. Vitamin-C content was determined by preparing the sample in a 3% metaphosphoric acid solution and titrating it with 2,6- dichlorophenol indophenol dye until a light pink endpoint appeared. Reducing, non-reducing and total sugars were analyzed using Fehling's solutions A and B, with methyl blue as the indicator during boiling. For non-enzymatic browning estimation, the sample was mixed with 30 ml of 60% ethanol, centrifuged at 1500 rpm for 15 minutes and filtered through Whatman No. 1 filter paper. Absorbance was measured at 440 nm using a UV-Visable Double Beam spectrophotometer (Igene Labserve), with 60% ethanol as the blank. Browning was expressed as the increase in absorbance. Sensory evaluation of colour, flavour and texture was conducted by a panel of ten semi-trained judges using the 9-point Hedonic Scale.

2.5 Statistical analysis

The experiment was carried out using a completely randomized design (CRD) with three replications and observations were recorded on a monthly basis. The data collected were subjected to statistical analysis using OPSTAT software, based on the methodology outlined by Prof. O.P. Sheoran.

3. RESULTS AND DISCUSSION

3.1 Chemical attributes of wood apple pulp, guava pulp, ginger juice and cardamom powder

Table-1 provides an overview of the chemical attributes of wood apple pulp, guava pulp, ginger juice and cardamom powder. Wood apple pulp contains 10.72% TSS, 1.99% acidity, 5.47 mg/100g Vitamin- C, 1.43% reducing sugars, 5.75% non-reducing sugar and 7.18% total sugars. Guava pulp contains 12.9% TSS, 0.94% acidity, 221 mg/100g Vitamin-C, 3.55% reducing sugars,

6.15% non-reducing sugar, and 9.70% total sugars. Ginger juice contains 2.21% TSS, 0.29% acidity, 1.94 mg/100g Vitamin-C, 0.62% reducing sugars, 1.15% non-reducing sugar and 1.77% total sugars. Cardamom powder contained 1.5% TSS, 0.24% acidity, 2.0 mg/100g Vitamin-C, 0.50% reducing sugars, 1.23% nonreducing sugar and 1.73% total sugars. Similar to the present results, Kumar and Deen (2017) reported that wood apple fruits contains 9.45 to 21.70% TSS, 1.98 to 3.80% acidity, 3.86 to 6.82 mg/100g ascorbic acid, 0.30 to 6.03% reducing sugars, 5.65 to 13.80% non-reducing sugar, 5.95 to 19.83% total sugars. Ghosh *et al*. (2010) also revealed that wood apple pulp contains 11.56% TSS, 1.94% acidity, 7.00 mg/100g ascorbic acid and 3.72 pH. Wazed *et al*. (2021) found that guava juice contains 12% TSS, 28.87 mg/100g ascorbic acid, 0.51% acidity. Kumar *et al*. (2020) also found that guava pulp cv. Lucknow-49 contains 12.80% TSS, 0.44% acidity, 220.00mg/100g ascorbic acid, 6.47% reducing sugars, 3.08% non-reducing sugar and 9.55% total sugars. . Harendra and Deen (2022) also noticed that ginger juice contains 2.20 % TSS, 0.26 % acidity, 1.90 mg/100g Vitamin-C, 0.63 % reducing sugars, 1.12 % non- reducing sugar and 1.75 % total sugars which supports the present findings.

3.2 Standardization of the Blends

3.2.1 Organoleptic quality of RTS prepared from different blends of wood apple pulp, guava pulp, ginger juice and cardamom powder

Table-2 presents the organoleptic evaluation results of RTS beverages prepared using various combinations of wood apple pulp, guava pulp, ginger juice and cardamom powder. Among the different treatments, Treatment No. 4 comprising 30% wood apple pulp, 60% guava pulp, 9% ginger juice and 1% cardamom powder, emerged as significantly superior in sensory quality. Therefore, 10% blend beverage containing 30% wood apple pulp, 60% guava pulp, 9% ginger juice and 1% cardamom powder, with 13% TSS, 0.3% acidity and 70 ppm SO_2, is recommended for producing a high-quality, palatable RTS beverage. Likewise, Verma and Deen (2024) also developed blended beverages RTS from Guava *(Psidium gujava* L.),wood apple (*Limonia acidissima* L.) and ginger (*Zingiber officinale* Rosc.) in different ratios viz., 100:0:0 (T1), 0:100:0 (T2), 0:0:100 (T3), 33.33:33.33:33.33 (T4), 40:30:30 (T5), 50:25:25 (T6), 60:20:20 (T7), 70:15:15 (T8), 80:10:10 (T9), and 90:5:5 (T10) to get the best blend combination for the preparation of RTS. The blend comprises of 60% guava pulp, 20% wood apple and 20% ginger juice was found to be best over other treatments for the preparation of palatable quality of RTS.

3.2.2 Biochemical changes during storage of RTS blend beverage

The biochemical changes in RTS during storage are summarized in Table 3. The results indicate that total soluble solids (TSS) gradually increased from 13.00 % to 13.42 % over a three months period, likely due to the breakdown of polysaccharides into simpler sugars. Similar results that an increase in total soluble solids content during storage of products were reported by Bharati *et al*. (2023) who observed that sweet orange and guava RTS preparation enhanced the value of TSS during storage of beverage. Harendra and Deen (2021) noticed similar change in mango, kagzi lime, ginger and aloe vera based blended RTS. Similarly, total acidity increased from 0.30% to 0.56% at the end of stoarge. An rise in acidity levels may appear from the breakdown of pectic substances and the production of organic acids (Conn and Stumf, 1976). Similar results that an increase in acidity content during storage of products were found by Kumar *et al*. (2024) analyzed that the total acidity increased in RTS during storage condition. Similarly, Harendra and Deen (2021) noticed in mango, kagzi lime, aloe vera and ginger based blended RTS beverages. Vitamin-C content declined steadily from 33.48 mg/100ml to 33.20 mg/100ml, likely due to oxidation of ascorbic acid into dehydro- ascorbic acid by oxygen (O2) trapped inside containers and in the intramolecular spaces of the product. The present results on changes in Vitamin-C content during storage of beverages are also supported by the findings of Kumar *et al*. (2024) that analyzed that the total ascorbic acid decreased in RTS during storage condition, Bharati *et al*. (2023) also observed that sweet orange and guava RTS preparation show that the total ascorbic acid decreased during storages of beverage. Reducing sugars levels rose from 1.10 % to 2.36 % at the end of the storage. This might be due to conversion of non reducing sugar into reducing sugars. Similar elements were also mentioned by Kumar *et al*. (2024) analyzed that the reducing sugar content increased in RTS during storage condition, Bharati *et al*. (2023) observed that sweet orange and guava RTS preparation, the value of reducing sugar increased during storages of beverage. Non reducing sugar level dropped from 11.06 % to 10.41% , attributed to its transformation into reducing sugars. The results are similar with the prior results of Harendra and Deen (2022) in mango, citrus, aloe vera and ginger syrup, Harendra and Deen (2021) in mango, aloe vera, kagzi lime, and ginger based blended RTS beverages. Browning increases from 0.23 % to 0.44 %, this increase in browning is primarily due to non-enzymatic reactions, particularly the Millard reaction, which involves the reaction between organic acids, sugars and amino acids, which produces brown pigments. The organoleptic quality decreased from the hedonic scale reading of 8.50 to 7.20. which was found to be acceptable for up to three months. This decline in scale is might be due to temperature, as it plays a significant part in biochemical alterations that causes beverages to become more off-flavored and discolored. Similarly, Pandian *et al*. (2023) observed same decreasing pattern in aonla, ginger and sour orange based blend beverge, and Verma and Deen (2024) in guava, wood apple and ginger RTS bevegares.

CONSLUSION

It can be concluded that a 10 % beverage blend comprising 30 % wood apple pulp, 60 % guava pulp, 9% ginger juice and 1% cardamom was rated highest on the Hedonic Scale by a panel of semi-trained judges for its palatable quality. The optimal RTS formulation was standardized to 13 % TSS, 0.3 % acidity and 70 ppm SO_2. During storage at ambient temperature, TSS, acidity, reducing sugars, total sugars and browning increased, while Vitamin-C, non-reducing sugar and sensory quality declined gradually. Despite these changes, the RTS beverage maintained acceptable quality for up to three months under ambient conditions.

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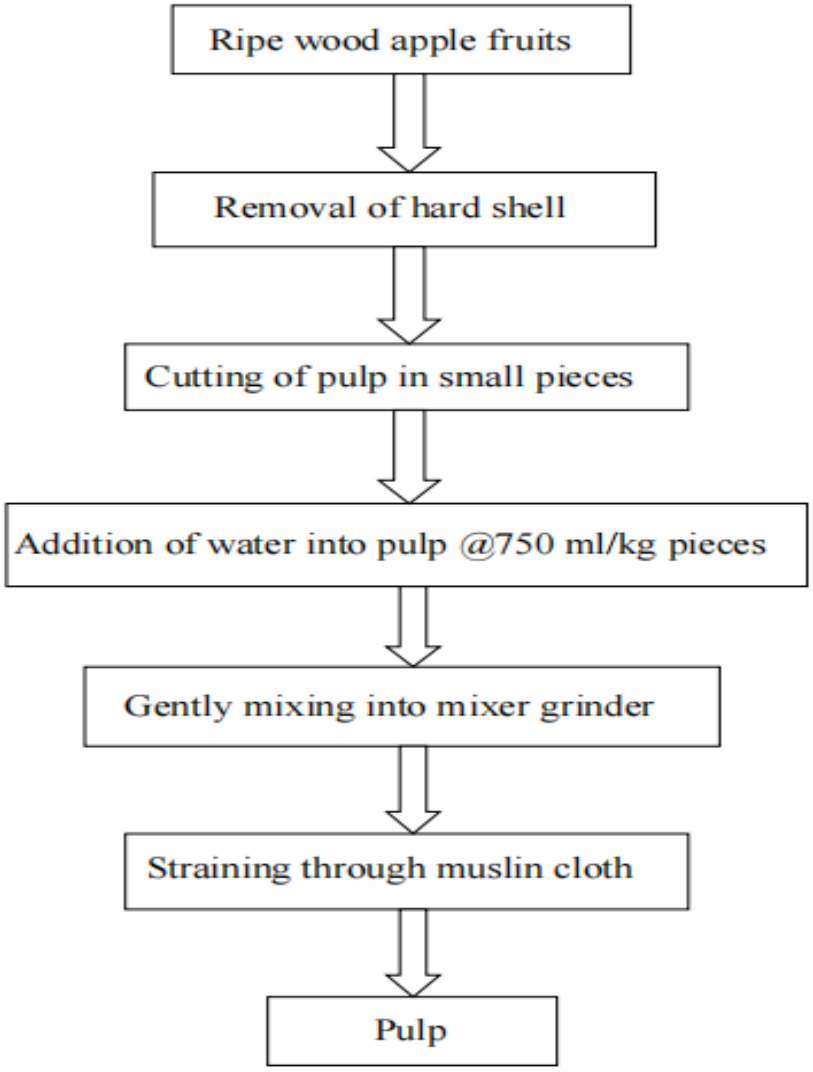

Fig. 1 Flow chart of pulp extraction from wood apple fruits

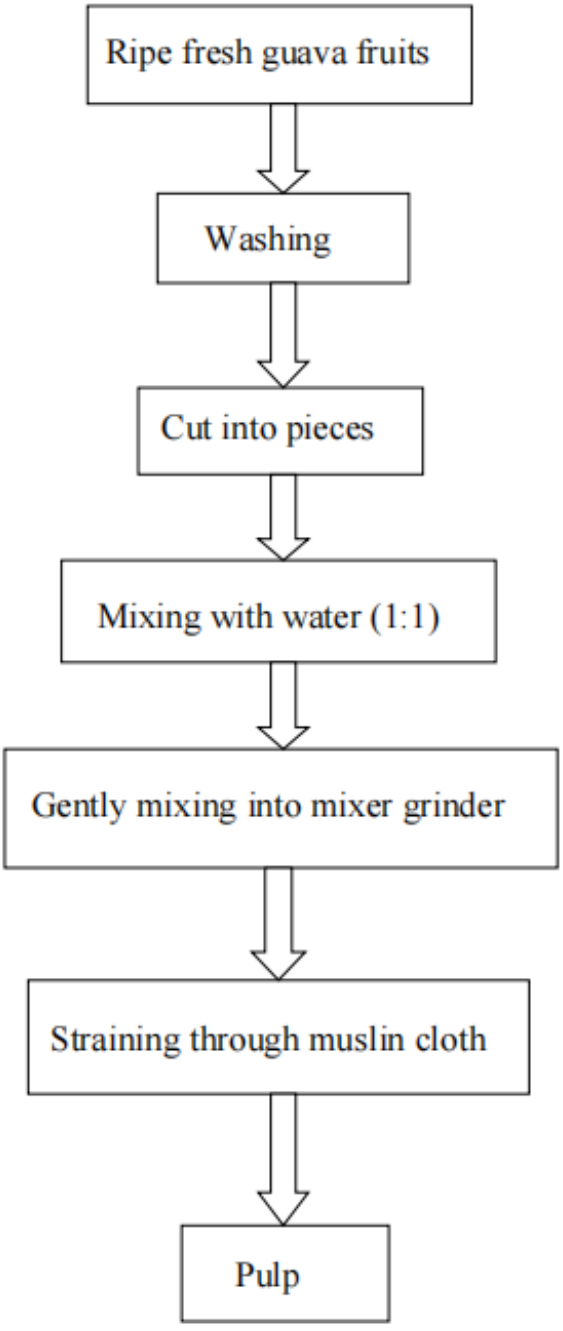

Fig. 2 Flow chart of pulp extraction from guava fruits

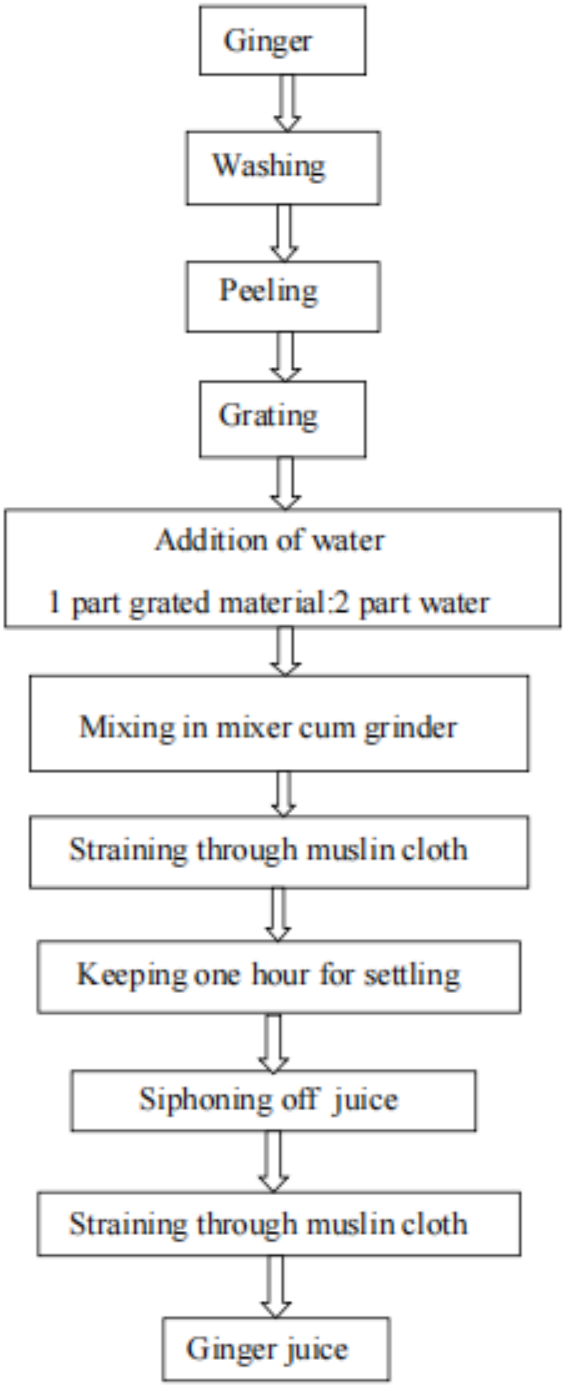

Fig. 3 Flow chart of juice extraction from ginger rhizomes

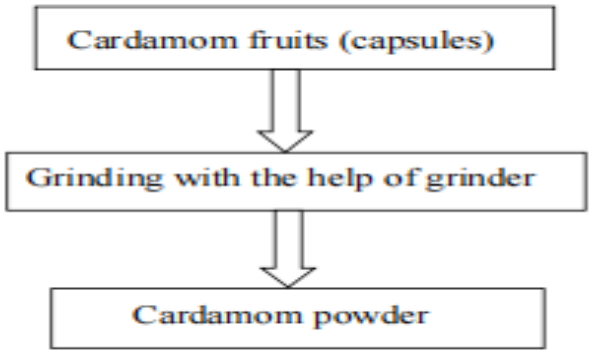

Fig. 4 Flow chart of powder extraction from cardamom seeds

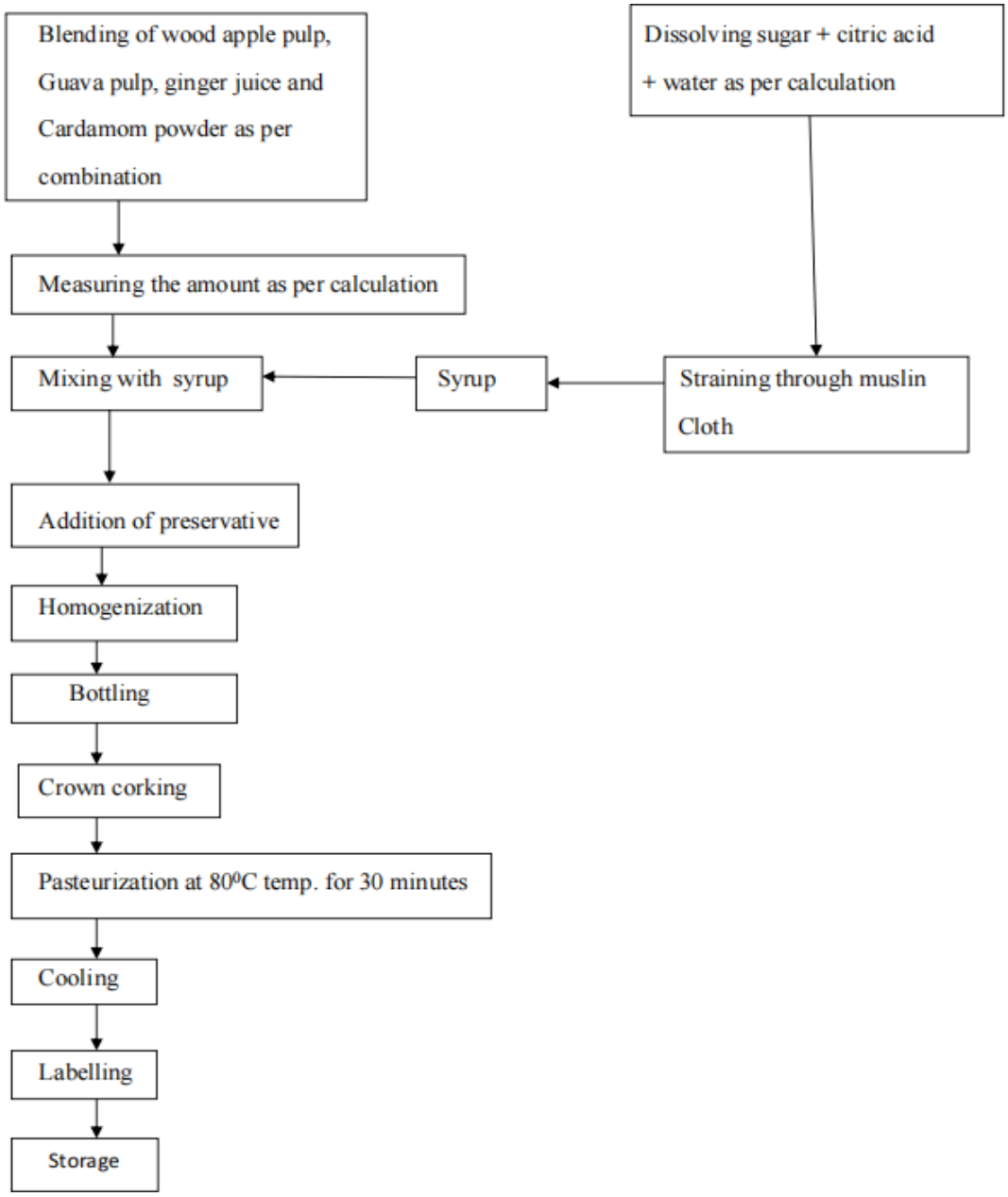

Fig. 5 Flow chart for preparation of blend RTS

Table-1 Chemical attributes of wood apple pulp, guava pulp, ginger juice and cardamom powder

Raw materials	Chemical attributes					
	Mean Values					
	TSS (%)	Acidity(%)	Vitamin-C (mg/100g)	Reducing sugars(%)	Non - reducing sugar(%)	Total sugars(%)
Wood apple pulp	10.70	1.99	5.47	1.41	5.71	7.12
Guava pulp	12.90	0.94	221	3.56	6.12	9.65
Ginger juice	2.21	0.29	1.93	0.62	1.15	1.77
CardamomPowder	1.50	0.24	2.00	0.50	1.23	1.73

Table-2 Organoleptic quality of RTS prepared from different blend combinations of guava pulp, wood apple pulp, ginger juice and cardamom powder

Blend Combinations (No.)	Different combinations of Blends (RTS)					Organoleptic quality	
	Wood apple pulp (%)	Guava pulp (%)	Ginger juice (%)	Cardamom powder (%)	Sugar(%)	Score	Rating
1	0	90	9	1	13	7.8	LM
2	10	80	9	1	13	7.6	LM
3	20	70	9	1	13	7.8	LM
4	30	60	9	1	13	8.5	LVM
5	40	50	9	1	13	8.1	LVM
6	50	40	9	1	13	7.5	LM
7	60	30	9	1	13	7.1	LM
8	70	20	9	1	13	7.0	LM
9	80	10	9	1	13	7.2	LM
10	90	0	9	1	13	7.7	LM
SE.m ±						0.1	
CD at 5%						0.2	

Table-3 Changes during storage life of prepared RTS

Storage Period (months)	T.S.S. (%)	Acidity (%)	Vitamin-C (mg/100ml)	Reducing sugars (%)	Non-Reducing Sugar(%)	Total sugars (%)	Browning (O.D.)	Organoleptic quality	
								Score	Rating
0	13	0.30	33.48	1.10	11.06	12.16	0.23	8.50	LVM

1	13.16	0.36	33.41	1.47	10.87	12.34	0.27	8.00	LVM
2	13.30	0.45	33.33	1.95	10.59	12.54	0.34	7.65	LM
3	13.42	0.56	33.20	2.36	10.41	12.77	0.44	7.20	LM
SE. m±	0.03	0.06	0.06	0.06	0.06	0.06	0.06	0.06	
CD at 5%	0.20	0.19	0.13	0.19	0.19	0.19	0.19	0.19	

LVM:Like very much, LM:Like moderately