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STUDY ON PREPARATION OF WOOD APPLE (*LIMONIA ACIDISSIMA* L.) READY-TO-SERVE (RTS) BEVERAGE

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ABSTRACT

The study evaluated the biochemical and sensory qualities of Ready-to-Serve (RTS) beverages prepared from wood apple pulp, with a focus on variations observed across different treatment locations. The pulp was extracted using a threefold dilution method and was found to contain 8.00 °Brix of total soluble solids, 1.34% titratable acidity and 1.61 mg/100 mL of ascorbic acid. Reducing and non-reducing sugars contributed to a total sugar content of 3.56%, which played a crucial role in shaping the flavor and nutritional profile of the RTS. Throughout all sample locations, the TSS of the final product remained consistent at 14 °Brix, while acidity levels were maintained at the standard 0.3%, ensuring quality uniformity.

Significant differences were observed in sugar composition, vitamin C content and acidity among the treatments. Reducing sugars peaked at 6.91% in location 4, while the highest non-reducing sugars (5.75%) were found in location 7. Vitamin C content varied notably, with location 7 showing the highest level (10.78 mg/100 g), highlighting the influence of raw material and processing on nutrient retention. Color analysis revealed variation in lightness, redness and yellowness across locations, affecting visual appeal.

Sensory evaluation, conducted by a panel, assessed attributes such as texture, taste, flavor and overall acceptability. Location 9 consistently received the highest scores across most parameters, indicating strong consumer appeal. The study confirms that ingredient composition and processing conditions significantly influence the quality, nutritional value and consumer perception of wood apple-based RTS beverages.

Key words : Wood apple (*Limonia acidissima* L.), Ready-to-Serve (RTS), Beverage, Sensory evaluation.

Introduction

The wood apple (*Limonia acidissima* L.) is a tropical fruit tree and the sole species in its genus within the Rutaceae family (Allen, 1967). It's particularly well-suited for cultivation in wastelands, making it an ideal option for underutilized land. This fruit is known for its wide range of health benefits, which stem from its rich nutritional profile that includes essential nutrients, vitamins and organic compounds such as tannins, calcium, phosphorus, fiber, protein and iron (Minh, 2015). Additionally, wood apple is recognized as a natural source of antioxidants, largely due to the free radical scavenging activity of its diverse phytochemicals (Sivakkolundu and Loganathan, 2013).

The wood apple is not under regular orcharding, however along the border of fields, roads, railway lines and as a roadside tree, near villages and banks of the river are the common places, where the plants are found as stray plant. The fruit tree can be grown even on saline, marginal lands, waste and neglected lands normally unsuitable for cultivation of other fruit trees (Kumar and Deen, 2018).

Importance of wood apple fruit lies in its curative properties, which makes the tree as one of the useful medicinal plants of India. It is highly regarded as religious, cultural, nutritional and medicinal value fruit crop. The fruits are consuming as good source of juice during its harvesting season due to their low cost and thirst-quenching ability. People consume the raw fruit pulp as such with or without sugar or jaggery, or as a beverage after blending it with other ingredients (cardamom, salt, ginger *etc*.). A homemade drink popularly known as "*Sarbat*" is prepared from the wood apple fruits. Fruits have high medicinal value and used in India as a liver and cardiac tonic, while unripe fruits are used as an astringent means of treating diarrhea and dysentery in folk medicines. It is effective treatment for hiccough, sore throat and diseases of the gums (Vidhya and Narayin, 2011; Kumar and Udipi, 2004).

Wood apple, a fruit rich in nutrition and medicinal properties, is often underutilized and available seasonally. However, its potential can be harnessed by processing it into various food products, including juice, sherbet, nectar, jam, fruit bars, wine, chutneys and pulp powder, enabling its consumption even during the off-season.

Additionally, processed goods including juice, sherbet, nectar, jam, fruit bars, wine, chutneys and pulp powder benefit greatly from the pulp. Desserts, drinks, creams and jellies are all made with ripe fruit (Adikaram *et al*., 1989). Furthermore, the ripe fruit pulp can be eaten raw with sugar or used to make chutney (Veeraraghavathatham *et al*., 1996).

There is plenty of evidence from experiences suggesting that consuming *Limonia acidissima* could be beneficial for health issues. It is also commonly used in food production to create items like juice, flavourful chutneys, sweet treats and preserves. Since the peel of *L. acidissima* does not contain any substances, it can even be given to animals. These findings further reinforce the health benefits of this fruit.

Over time the texture and thickness of wood apple pulp stay the same after being stored for a time though its flavor may fade. The amount of ascorbic acid decreases because of oxidation, during storage leading to a drop, in calcium and phosphorus levels. It's safe to keep wood apples at room temperature. For longer preservation its best to refrigerate them. If you need to store them for a period taking out the pulp and mixing it with lemon juice before freezing can help maintain its quality.

A significant portion around 25 to 30 percent of harvested wood apple fruits is lost before consumption due to limited awareness of fruit processing technologies and a lack of processing infrastructure (Namdev and Singh, 2015). The fruit is rarely eaten fresh because of its acidic and astringent taste. Despite its high nutritional and medicinal value, wood apple has low consumer demand in both fresh and processed markets. This is largely due to limited public awareness of its health benefits (Johari and Kawatra, 2016). These challenges highlight the need to explore its processing potential. This study was designed to address that gap by utilizing wood apple's health-promoting qualities to develop a Ready-to-Serve (RTS) beverage. Creating such a value-added product could pave the way for the commercial use of this underutilized but highly beneficial fruit.

Materials and Methods

Preparation of processed product RTS

Based on the survey conducted across 11 different locations, among 201 genotypes best 9 genotypes were selected from different districts for further evaluation. Each selected location was treated as an individual treatment, with three replications for accuracy. Ready-to-Serve (RTS) beverages were then prepared using samples from each of these locations to assess their quality and performance.

Extraction of wood apple juice

Ripe, healthy, and uniformly mature wood apple fruits were carefully selected for the process. After thorough washing and peeling, the fruits were manually opened to remove the pulp. Only fully mature fruits were used to ensure the best quality. To extract the pulp, it was mixed with water in a 1:2 ratio and boiled at 60 °C for 40 minutes. Once the mixture cooled, the juice was obtained by filtering the boiled pulp through a clean muslin cloth, following the method described by Khan *et al*. (2019a).

Preparation of RTS

To prepare the Ready-to-Serve (RTS) beverage, total soluble solids (TSS) and titratable acidity were first measured in the extracted juice using a hand refractometer and titration method, respectively. Based on these values, the sugar and acid content of the pulp were calculated, along with the required amounts of citric acid, potassium metabisulphite and water needed for final RTS preparation at each location.

The juice was then filtered and pasteurized. A sugar syrup was prepared by dissolving the calculated amount of sugar in pre-boiled water. After cooling slightly, citric acid was added and the syrup was filtered through a muslin cloth to ensure clarity. Once completely cooled, potassium metabisulphite was added at 70 ppm as a preservative.

The RTS was prepared using wood apple juice as the base, strictly following FSSAI guidelines, which include a minimum of 10 % juice or pulp, TSS above 10 °Brix, 0.3% acidity and 70 ppm preservative. The beverage was filled into sterilized 200 ml glass bottles, leaving a 2 cm headspace before sealing. These bottles were stored at room temperature for further biochemical analysis, Srivastava and Kumar (1993).

Biochemical analysis

The biochemical characteristics of wood apple fruits and the prepared RTS products were analyzed using standard procedures. Total soluble solids (TSS) were measured with a hand refractometer (QA Supplies, LLC) ranging from 0 to 45°Brix. A few drops (1-2) of the sample were placed on the prism, and the TSS was recorded in °Brix. Titratable acidity was estimated following the AOAC method (1994).

To determine the total phenolic content, the Folin-Ciocalteu reagent was used as described by Rathod et al. (2014). Ascorbic acid (Vitamin C) content was measured using the visual titration method with 2,6-dichlorophenolindophenol, based on the technique outlined by Johnson and Dana (1948).

A Lovibond colour meter (Lovibond RT300, Portable spectrophotometer, The Tintometer Limited, Salisbury, UK) with an 8mm aperture was used to determine the colour values (L^*. a^*, b^*). In addition to biochemical analysis, sensory evaluation was carried out to assess the overall quality of the RTS beverages. A panel of semi-trained judges evaluated attributes such as colour, appearance, aroma, flavour, taste and texture using a 9-point Hedonic Rating Scale (Amerine *et al.*, 1965). This approach provided insight into the acceptability of the product from a consumer perspective. The data collected on the physico-chemical and sensory characteristics were analyzed statistically using a Completely Randomized Design (CRD).

Results and Discussion

Chemical characteristics of wood apple pulp

Table 1 outlines the chemical composition of wood apple pulp. The pulp was extracted by adding three times its volume of water. The analysis showed that it contained 8.00 °Brix total soluble solids, 1.34% titratable acidity, and 1.61 mg/100 mL of ascorbic acid. In terms of sugars, it had 1.30% reducing sugars, 2.32% non-reducing sugars and a total sugar content of 3.56%. These characteristics played an important role in determining the taste, nutritional value and overall quality of the RTS beverage made from the pulp.

Table 1 : Chemical characteristics of wood apple pulp extracted with (1:2) water.

S. no.	Chemical characteristics	Pulp (mean value)
1	Total soluble solids (°B)	8.00
2	Acidity (%)	1.34
3	Ascorbic acid (mL/100 g)	1.61
4	Reducing sugars (%)	1.30
5	Non-reducing sugar (%)	2.32
6	Total sugars (%)	3.56

TSS and acidity (°B and %)

As shown in Table 2, the Total Soluble Solids (TSS) of the product remained consistent at 14 °Brix across all locations. Similarly, acidity levels were carefully standardized to meet the permissible limit of 0.3%. Table 2 further confirms that the titratable acidity was maintained within this acceptable range at every location, ensuring uniformity and compliance with quality standards throughout the samples. Acidity plays a key role in shaping both the taste and overall quality of Ready-to-Serve (RTS) beverages. It provides the distinct tanginess that enhances the flavor, while also affecting the color, aroma and shelf life of the product. The organic acids found in ingredients like fruit pulp, sugar and added acids each bring their own unique characteristics, which together determine the final titratable acidity of the RTS.

In this study, the titratable acidity of the fruit pulp varied notably across different treatments, averaging 0.30% (Table 2). Location 5 recorded the highest acidity at 0.45 %, whereas Location 1 had the lowest at 0.27%. These results are in line with earlier studies by Jain and Nema (2007), Elbelazi *et al.* (2015), Asghar *et al.* (2016), Bhatt and Verma (2016), Chauhan *et al.* (2016), Abhangrao *et al.* (2017) and Bisen *et al.* (2017), all of which highlighted how factors like pulp content and sugar levels significantly affect the titratable acidity in fruit-based value-added products.

Reducing, non-reducing and total sugars (%)

According to the data presented in Table 2, the sugar composition of the Ready-to-Serve (RTS) beverage varied across different locations. Location 4 recorded the highest reducing sugar content at 6.91%, with location 1 close behind at 6.42%. On the lower end, location 2 had the least reducing sugars at 4.81%, followed by location 5 at 5.25%. For non-reducing sugars, location 7 stood out with the highest value of 5.75%, while location 8 also showed a relatively high content at 5.52%. The lowest non-reducing sugar levels were found in location 3 (3.83%)

Table 2 : Changes in physio-chemical attributes of wood apple RTS.

S. no.	Location	TSS (ºB)	Acidity (%)	Ascorbic acid (mg/100 g)	Reducing sugars (%)	Non-reducing sugar (%)	Total sugars (%)
1	Location-1	14	0.27	9.36	6.42	5.48	11.9
2	Location-2	14	0.32	7.47	4.81	5.23	10.04
3	Location-3	14	0.29	7.15	6.84	3.83	10.67
4	Location-4	14	0.3	8.29	6.91	4.23	11.14
5	Location-5	14	0.33	7.97	5.25	4.34	9.59
6	Location-6	14	0.28	9.43	6.16	5.34	11.50
7	Location-7	14	0.28	10.78	5.97	5.75	11.72
8	Location-8	14	0.3	8.23	6.03	5.52	11.55
9	Location-9	14	0.31	8.87	5.87	4.20	10.07
S. Em±		0.203	0.004	0.114	0.062	0.061	0.192
CD at (1%)		0.838	0.017	0.464	0.253	0.247	0.783

Table 3 : Changes in L*, a*, b* values wood apple of RTS.

S. no.	Location	l*	a*	b*
1	Location-1	19.86	3.07	9.67
2	Location-2	20.19	5.56	13.26
3	Location-3	22.71	-0.29	4.23
4	Location-4	24.43	0.19	9.31
5	Location-5	21.35	-0.72	4.68
6	Location-6	23.81	-0.35	7.10
7	Location-7	21.82	0.12	4.97
8	Location-8	21.33	7.78	13.41
9	Location-9	25.89	2.21	10.99
S. Em±		0.59	0.07	0.05
CD at (1%)		2.38	0.27	0.20

and location 4 (4.23%). When it came to total sugar content, location 7 again led with 11.72 %, followed by location 1 at 11.19%, indicating a sweeter profile in those samples.

The total sugar content in Ready-to-Serve (RTS) beverages is largely influenced by the natural sugar levels present in the individual ingredients used during preparation.

In this study, noticeable differences in sugar content were observed across the various treatments, as presented in Table 2. Reducing sugar levels were highest in location 4 at 6.91%, while location 2 showed the lowest at 4.81%. For non-reducing sugars, location 7 stood out with 5.75%, whereas location 3 had the lowest at 3.83%. When it came to total sugar content, location 5 recorded the highest value at 24.34%, while the lowest was also observed in location 5 at 22.18%, possibly due to variation across replications. These results are consistent with findings from Asghar *et al*. (2016), who studied functional bael jam and Chauhan *et al*. (2016), who worked on bael vermouth both studies highlighted how the composition of ingredients can significantly influence the total sugar content in processed fruit products.

Vitamin C (mL/100 g)

Further analysis from Table 2 highlighted noticeable differences in Vitamin C content among the various locations. Location 7 had the highest level, measuring 10.78 mg per 100 g, followed by location 6 with 9.43 mg per 100 g. On the lower end, location 3 showed the least vitamin C content at 7.15 mg per 100 g, while location 2 was slightly higher at 7.47 mg per 100 g. These variations reflect how growing conditions or processing methods might have influenced the nutritional profile of the final RTS product.

Ascorbic acid (vitamin C) is an essential nutrient that enhances both the nutritional quality and sensory appeal of Ready-to-Serve (RTS) beverages. The final vitamin C content in these drinks can be influenced by various ingredients used in their preparation, such as fruit pulp, sugar and other added components.

In this study, the ascorbic acid levels varied significantly across the different treatments, as shown in Table 2. The highest content was observed in location 7, with 10.78 mg/100 ml, while location 5 had the lowest at 7.15 mg/100 ml. These results are consistent with earlier findings by Jain and Nema (2007) and Abhangrao *et al*. (2017), who also reported that factors like the type of fruit used and the processing techniques applied have a notable effect on the ascorbic acid content in fruit-based value-added products.

Color analysis

Table 3 shows that the color values of the RTS product varied across different locations. Location 9 had the highest L* value at 25.89, indicating the lightest appearance, followed by location 4 at 24.43. In terms of

Table 4 : Organoleptic quality of RTS.

S. no.	Location	Colour and appearance	Texture	Taste	Flavour	Over all acceptability
1	Location-1	6.94	7.28	6.94	6.89	7.00
2	Location-2	7.44	7.06	7.06	6.89	6.83
3	Location-3	7.50	7.78	7.50	7.72	7.67
4	Location-4	7.17	7.33	7.28	7.83	7.50
5	Location-5	7.50	7.00	6.89	6.89	7.11
6	Location-6	7.06	6.89	7.11	7.33	7.28
7	Location-7	6.94	7.11	7.17	7.28	7.22
8	Location-8	7.94	7.22	7.11	7.33	7.67
9	Location-9	8.22	8.00	8.06	8.28	8.39
S. Em±		0.36	0.48	0.54	0.44	0.46
CD at (1%)		1.45	1.95	2.21	1.77	1.86
		*NS	*NS	*NS	*NS	*NS

redness, location 8 showed the highest a* value at 7.78, while locations 3 and 6 had negative values, suggesting a greenish tint. For b* values, which represent yellowness, location 8 again topped the list at 13.41. The lowest b* value was recorded in location 3 (4.23), followed by location 7 (4.97).

Sensory evaluation

As shown in Table 4, sensory evaluation of specific attributes revealed notable differences across locations. For texture, location 8 received the highest score of 8.00, with location 3 following closely at 7.78. In terms of taste, location 9 led with a score of 8.06, while location 3 scored 7.50. The lowest taste scores were seen in locations 5 and 1. Location 9 also topped the flavour category with 8.28, followed by location 4 at 7.83, whereas locations 1, 2 and 5 received the lowest flavour scores (6.89). Overall acceptability was highest in location 9 (8.39), and lowest in location 2 (6.83).

Sensory evaluation, often referred to as sensory analysis, is a scientific approach that uses human senses, such as sight, smell, taste, touch and even hearing to assess the quality of consumer products. This method involves a panel of individuals who sample the product and share their feedback. By applying statistical methods to their responses, meaningful insights can be gathered about the product's specific characteristics (Table 4).

This type of evaluation is especially important because it reflects how consumers perceive the product, making it a vital part of quality assessment. Sensory analysis mainly focuses on key attributes like color, flavor, taste, texture and overall acceptability, helping ensure that the final product meets consumer expectations.

Conclusion

In summary, the product maintained consistent quality across all locations in terms of key parameters such as Total Soluble Solids (14 °Brix) and acidity (0.3%), ensuring standardization and compliance with permissible limits. The sugar composition varied slightly across regions, with location 4 recording the highest level of reducing sugars and location 7 leading in both non-reducing and total sugars. Vitamin C content also showed regional differences, with location 7 having the highest concentration, indicating better nutritional retention, while location 3 had the lowest. Color analysis highlighted location 9 as the brightest, while location 8 exhibited the most vibrant red and yellow hues. From a sensory standpoint, location 9 consistently outperformed others in taste, flavour and overall acceptability, making it the most favored among consumers. On the other hand, location 2 showed lower performance in several sensory parameters. Overall, while the product quality was uniformly maintained in terms of core standards, regional differences in composition and sensory attributes offered useful insights into consumer preferences and product performance.

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