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SS Lohakare
P.G Scholar, Department of Horticulture, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

VP Kamble
Assistant Professor, College of Agriculture, Ambajogai, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

SS Akale
P.G Scholar, Department of Horticulture, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

MM Magar
P.G Scholar, Department of Horticulture, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

VR Khandebharad
P.G Scholar, Department of Horticulture, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

MB Shinde
P.G Scholar, Department of Horticulture, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

SR Mane
P.G Scholar, Department of Horticulture, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

SN Wagatkar
P.G Scholar, Department of Horticulture, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
SS Lohakare
P.G Scholar, Department of Horticulture, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Optimization of nutritional and chemical stability of wood apple (*Limonia acidissima* L.) and Karonda (*Carissa carandas* L.) blended jelly during storage period

SS Lohakare, VP Kamble, SS Akale, MM Magar, VR Khandebharad, MB Shinde, SR Mane and SN Wagatkar

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Abstract
Underutilized and highly perishable, wood apple (*Limonia acidissima* L.) and karonda (*Carissa carandas* L.) offer significant potential for value-added processing to reduce postharvest losses. A study conducted in 2024-2025 at the Department of Horticulture, College of Agriculture, Latur, optimized blends of these fruits to develop nutritionally and chemically stable jelly. The objective was to evaluate the effects of pulp ratios (100:0, 80:20, 60:40, 40:60, 20:80, 0:100 wood apple:karonda) and sugar levels (800, 900, 1000 g/kg pulp) on Total Soluble Solids (TSS), pH, acidity, anthocyanin, and iron content over 60 days of storage. Karonda-rich blends exhibited higher TSS (up to 71.2 °Brix), anthocyanin (17.1 mg/100 g), and iron (2.9 mg/100 g) compared to wood apple-rich blends (67.2 °Brix, lower anthocyanin, and iron). TSS slightly increased during storage, more notably at higher sugar levels, while pH decreased and acidity increased, particularly in karonda-heavy blends (0.84% acidity vs. 0.68% in wood apple blends). Anthocyanin showed minor degradation, with lower sugar levels better preserving nutrient stability. Iron content remained largely stable across blends. These findings highlight the potential of karonda-rich blends for enhanced nutritional quality and stability, offering a scalable approach for commercializing jellies from underutilized regional fruits, thereby reducing waste and adding economic value.

Keywords: Wood apple, Karonda, Blended Jelly, Storage Stability, Nutritional Quality, Physio-chemical Properties

1. Introduction
The wood apple (*Limonia acidissima*. L) is an edible fruit from trees primarily in the *Limonia acidissima* genus. The inside contains brown, mealy, aromatic, resinous, and mildly sweet pulp filled with numerous small seeds (Pandey *et al*., 2014) [10]. Wood apple offers advantages in treating dysentery, diarrhea, piles, and scurvy. It is recognized as a tonic for both the liver and heart and is noted for its protective properties against skin cancer (Ahmed). The pulp of the wood apple is utilized in making items like jellies, jams, syrups, and beverages (Senthilkumar and Venkatesalu 2013) [14]. Karonda (*Carissa carandas* L.) is a well-known native evergreen shrub belonging to the Apocynaceae family, commonly referred to as “Christ’s thorn” this plant is an important fruit crop found in tropical and subtropical areas across the globe and is often cultivated as a protective bio-fencing hedge due to its thorns and dense foliage (Sturrock 1980) [16]. Additionally, it is appreciated as an ornamental plant because of its attractive, cherry-like fruits. The fruit of karonda possesses various medicinal properties; it is rich in iron, making it beneficial for treating anemia, serves as an astringent, and acts as a remedy for biliousness (Jadhav *et al.,* 2004) [6]. Karonda may not be widely appreciated as a fresh fruit because of its sour and astringent flavor; however, it holds significant promise for processing into various value-added products. These include appetizers, candies, chutneys, jams, jellies, pickles, squashes, sauces, tarts, and wines (Hayes, 1957) [5].

2. Materials and Methods

The experiment was conducted at the Department of Horticulture, College of Agriculture, Latur, Vasantrao Naik Marathwada Agricultural University, Parbhani, India. The chemical properties of Woodapple:Karonda jelly, including TSS, pH, titratable acidity (%), Anthocyanin content (mg/100 g) and Iron content (mg/100g), were analysed following the methods outlined by Ranganna (1986) [12]. Following treatment combinations were employed.

2.1 Treatment details

Factor A: Ratio of Wood apple: Karonda pulp

S. No	Treatment	Symbol
1	100% Wood apple + 0% Karonda	F_1
2	80% Wood apple + 20% Karonda	F_2
3	60% Wood apple + 40% Karonda	F_3
4	40% Wood apple + 60% Karonda	F_4
5	20% Wood apple + 80% Karonda	F_5
6	0% Wood apple + 100% Karonda	F_6

Factor B: Recipes (Quantity of sugar)

S. No	Recipes	Symbol
1	800g of sugar / kg pulp	S_1
2	900g of sugar / kg pulp	S_2
3	1000g of sugar / kg pulp	S_3

2.2 Treatment Combination

S. No	Symbol	Details of Treatment Combination
1	F_1S_1	100% Wood apple + 0% Karonda X 800 gm of sugar / kg pulp
2	F_1S_2	100% Wood apple + 0% Karonda X 900 gm of sugar / kg pulp
3	F_1S_3	100% Wood apple + 0% Karonda X 1000 gm of sugar / kg pulp
4	F_2S_1	80% Wood apple + 20% Karonda X 800 gm of sugar / kg pulp
5	F_2S_2	80% Wood apple + 20% Karonda X 900 gm of sugar / kg pulp
6	F_2S_3	80% Wood apple + 20% Karonda X 1000 gm of sugar / kg pulp
7	F_3S_1	60% Wood apple + 40% Karonda X 800 gm of sugar / kg pulp
8	F_3S_2	60% Wood apple + 40% Karonda X 900gm of sugar / kg pulp
9	F_3S_3	60% Wood apple + 40% Karonda X 1000 gm of sugar / kg pulp
10	F_4S_1	40% Wood apple + 60% Karonda X 800 gm of sugar / kg pulp
11	F_4S_2	40% Wood apple + 60% Karonda X 900 gm of sugar / kg pulp
12	F_4S_3	40% Wood apple + 60% Karonda X 1000 gm of sugar / kg pulp
13	F_5S_1	20% Wood apple + 80% Karonda X 800 gm of sugar / kg pulp
14	F_5S_2	20% Wood apple + 80% Karonda X 900 gm of sugar / kg pulp
15	F_5S_3	20% Wood apple + 80% Karonda X 1000 gm of sugar / kg pulp
16	F_6S_1	0% Wood apple + 100% Karonda X 800 gm of sugar / kg pulp
17	F_6S_2	0% Wood apple + 100% Karonda X 900 gm of sugar / kg pulp
18	F_6S_3	0% Wood apple + 100% Karonda X 1000 gm of sugar / kg pulp

2.3 Methodology Followed for the Preparation of jelly

The fresh and uniform size of pink coloured Karonda fruits were collected from the Yashvante Farm, Vasmat (Hingoli) and fruits of Wood apple were procured from Fruit Market, Pune. Mature and ripe pink coloured fruits of Karonda and mature fruits of Wood apple were used for preparation of jelly.

2.4 Extraction of pulp from Karonda and Wood apple:

The Karonda fruits were sorted, cut in half, and seeds were removed. They were cooked in water until soft. The wood apple fruits were broken into small pieces with a small hammer, and the pulp was scooped out with a spoon, then cooked in water until very soft. The pulp from both fruits was collected, carefully strained, and stored in bottles.

2.5 Procedure for preparation of mixed fruit jelly

The stored Wood apple and karonda pulp were used for preparation of mixed fruit jelly as per their treatment combinations. Six ratio of both fruit pulp combinations (F_1 - F_6) each were taken with three different recipes (S_1, S_2 and S_3) and replicated three times.

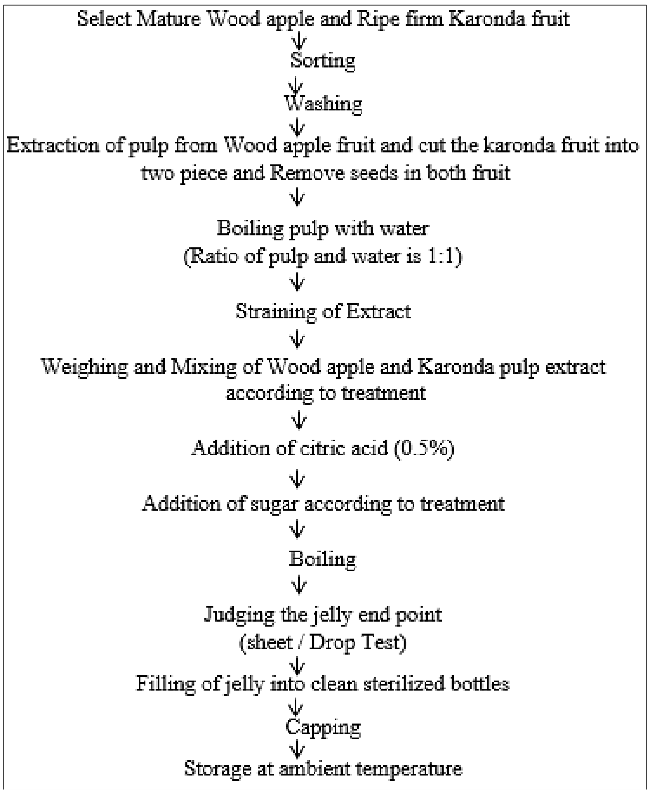
2.6 Determination of jelly end point

The jelly end point was determined by one of the following methods to stop further cooking:

1. **Drop test:** A drop of the concentrated mass is poured into a glass containing water. Setting of the drop without disintegration denotes the end point of jelly.
2. **Sheet or flake test:** A small portion of jelly is taken out during boiling in a spoon or wooden ladle and allowed to fall freely. If it falls in the form of a sheet or flakes, instead of flowing in a continuous stream or syrup, it means that the end point has been reached and the product is ready, otherwise boiling is continued till the sheet test is positive.

Both the methods were adopted to judge the end point of mixed fruit jelly.

2.6 Technological flow sheet for preparation of wood apple - karonda mixed fruit jelly



3. Results and Discussion

3.1 Chemical Characteristics

3.1.1 Total Soluble Solid (TSS)

Total Soluble solid of prepared products shows increasing trend during storage (Table 2). Among all the treatments, the highest TSS (71.20 °Brix) was found in treatment F_6, which was made with 100% Karonda pulp and 0% Wood apple, the lowest TSS was noted in treatment F_1 (67.23 °Brix), likely due to its greater proportion of Wood apple. In terms of sugar addition per kilogram of pulp, recipe S_3, which included 1000g of sugar, produced the highest TSS at 69.55 °Brix. This was significantly higher than the TSS for S_1 and S_2, which had a smaller amount of sugar. The TSS of the jelly showed a slight increase with longer storage times across all treatments. The total soluble solids (TSS) levels increased significantly until 60 days of storage. This rise in TSS within the jelly may be attributed to the transformation of polysaccharides into soluble sugars. Similar conclusions were reached in the research conducted by Manivasagan *et al.* (2004) [8] on karonda jam, and by Chauhan *et al.* (2008) [4] regarding guava pulp.

Table 2: Effect of pulp ratio and quantity of sugar on TSS of mixed fruit jelly at 0 day and 60 day of storage

S. No	Treatments Ratio of fruit pulp (Woodapple% + Karonda%) (Factor A)		0 DAS: Quantity of sugar per liter of pulp (Factor B)			Mean	60 DAS: Quantity of sugar per liter of pulp (Factor B)			Mean
			S_1 (800 gm)	S_2 (900 gm)	S_3 (1000 gm)		S_1 (800 gm)	S_2 (900 gm)	S_3 (1000 gm)	
1.	100%+0%	F_1	66.20	67.40	68.10	67.23	68.50	69.90	70.23	69.54
2.	80%+20%	F_2	68.50	67.30	67.70	67.83	70.60	68.90	69.20	69.57
3.	60%+40%	F_3	66.80	68.00	70.20	68.33	69.60	69.10	72.40	70.37
4.	40%+60%	F_4	67.10	69.30	70.40	68.93	70.40	69.90	72.30	70.87
5.	20%+80%	F_5	69.70	68.40	68.80	68.97	70.20	71.60	71.87	71.22
6.	0%+100%	F_6	70.20	71.30	72.10	71.20	71.90	72.67	73.33	72.63
Mean			68.08	68.62	69.55	68.75	70.20	70.34	71.56	70.70
Factor			A (F)	B (S)	AB (FxS)		A (F)	B (S)	AB (FxS)	
SEm±			0.27	0.19	0.48		0.31	0.22	0.54	
CD at 5% level			0.80	0.56	1.38		0.90	0.64	1.57	

3.1.2 pH

pH of prepared products shows decreasing trend during storage (Table 3). The highest pH value (3.39) was recorded in treatment F_1 (100% Wood apple + 0% Karonda), which was statistically similar to F_2 (3.34), the lowest pH (3.14) was observed in F_6 (0% Wood apple + 100% Karonda). In terms of sugar addition per liter of pulp, it was noted that an increase in sugar content a rise in pH, while the pH values decreased significantly over the storage period. The highest pH (3.32) was observed in recipe S_3, which used 1000g of sugar per liter of pulp. The mixed fruit jelly was found to have an overall pH score of less than 7.0, indicating that it is acidic. Analyzing the pH data reveals that a higher proportion of karonda pulp in the treatment combinations a decrease in pH values. Additionally, there was a slight reduction in pH values as the storage duration extended, potentially due to an increase in acidity. Pandey and Singh (1999) [9] reported that elevated acidity could contribute to the lower pH values. The decrease in pH might result from the production of organic acids through the degradation of ascorbic acid (Baramanray *et al.*, 1995) [2]. Chauhan *et al.* (2008) [4] similarly reported a reduction in pH during the storage of guava pulp.

Table 3: Effect of pulp ratio and quantity of sugar on pH of mixed fruit jelly at 0 day and 60 day of storage

S. No	Treatments Ratio of fruit pulp (Woodapple% + Karonda%) (Factor A)		0 DAS Quantity of sugar per liter of pulp (Factor B)			Mean	60 DAS Quantity of sugar per liter of pulp (Factor B)			Mean
			S_1 (800 gm)	S_2 (900 gm)	S_3 (1000 gm)		S_1 (800 gm)	S_2 (900 gm)	S_3 (1000 gm)	
1.	100%+0%	F_1	3.27	3.42	3.47	3.39	3.08	3.24	3.28	3.20
2.	80%+20%	F_2	3.25	3.42	3.35	3.34	3.07	3.22	3.16	3.16
3.	60%+40%	F_3	3.19	3.31	3.38	3.29	3.01	3.13	3.20	3.11
4.	40%+60%	F_4	3.18	3.25	3.32	3.25	3.00	3.06	3.14	3.07
5.	20%+80%	F_5	3.12	3.18	3.26	3.19	2.94	3.00	3.08	3.00
6.	0%+100%	F_6	3.10	3.14	3.17	3.14	2.92	2.96	2.99	2.95
Mean			3.18	3.29	3.32	3.27	3.00	3.11	3.14	3.08
Factor			A (F)	B (S)	AB (FxS)		A (F)	B (S)	AB (FxS)	
SEm±			0.015	0.011	0.026		0.010	0.007	0.018	
CD at 5% level			0.044	0.031	0.076		0.029	0.021	0.051	

3.1.3 Acidity (%)

Titratable acidity of prepared products shows increasing trend during storage (Table 4). The maximum mean score for acidity (0.84) was observed in F_6 (0% Wood apple +100% Karonda) which was at par with F_5 (0.81). The lowest acidity value (0.68) was found in treatment F_1, which had 100% Wood apple and 0% karonda. It was further noticed that the acidity of jelly gradually increased with the increasing storage period under all the treatment. In this case, acidity may increase due to the breakdown of ascorbic acid into organic acids, as noted by Pandey and Singh (1999) [9]. The different recipes have much influence on the acidity of mixed fruit jelly. The acidity of the jelly was seen to rise slightly during the storage period. Increase in acidity during storage was also reported by Baramanray *et.al.* (1995) [2] in guava nectar.

Table 4: Effect of pulp ratio and quantity of sugar on Acidity of mixed fruit jelly at (0) day and 60 day of storage

S. No	Treatments Ratio of fruit pulp (Woodapple% + Karonda%) (Factor A)		0 DAS Quantity of sugar per liter of pulp (Factor B)			Mean	60 DAS Quantity of sugar per liter of pulp (Factor B)			Mean
			S_1 (800gm)	S_2 (900gm)	S_3 (1000gm)		S_1 (800gm)	S_2 (900gm)	S_3 (1000gm)	
1.	100%+0%	F_1	0.69	0.68	0.66	0.68	0.74	0.73	0.71	0.73
2.	80%+20%	F_2	0.76	0.71	0.69	0.72	0.81	0.76	0.75	0.77
3.	60%+40%	F_3	0.78	0.76	0.74	0.76	0.83	0.81	0.78	0.81
4.	40%+60%	F_4	0.80	0.79	0.77	0.79	0.85	0.84	0.82	0.84
5.	20%+80%	F_5	0.83	0.82	0.78	0.81	0.88	0.87	0.83	0.86
6.	0%+100%	F_6	0.86	0.83	0.82	0.84	0.91	0.88	0.87	0.89
Mean			0.79	0.76	0.74	0.77	0.84	0.81	0.79	0.82
Factor			A (F)	B (S)	AB (FxS)		A (F)	B (S)	AB (FxS)	
SEm±			0.004	0.003	0.007		0.004	0.003	0.008	
CD at 5% level			0.011	0.008	0.019		0.013	0.009	0.022	

3.1.4 Anthocyanin content (mg/100 g)

The study investigated how different pulp ratios of Wood apple and Karonda, along with varying sugar quantities, affected the anthocyanin content in mixed fruit jelly. The results, presented in Table 5. The jelly with 100% Wood apple (F_1) had the lowest anthocyanin content at (0.53 mg/100g), while the jelly with 100% Karonda (F_6) had the highest at (17.11 mg/100 g). The amount of sugar added to the jelly also influenced anthocyanin levels. Jelly made with the lowest sugar quantity S_1 (800g sugar per liter of pulp) had the highest anthocyanin content at (8.19 mg/100g). This trend suggests that higher sugar levels may cause anthocyanin degradation, possibly due to increased soluble solids, as noted by Cemeroglu *et al.* (1994) [3]. Rhim (2002) [13] reported that higher soluble solids in jam processing can accelerate anthocyanin breakdown. Rafique *et al.* (2023) [11] found that fresh Karonda fruit contains high anthocyanin content

3.1.5 Iron content (mg/100 g): The iron content of mixed fruit jelly made from wood apple and karonda was significantly influenced by pulp ratio, sugar quantity, and their interaction, as shown in Table 5. Jelly with 100% wood apple (F_1) had the lowest iron content at (0.29 mg/100 g), while 100% karonda (F_6) had the highest at (2.89 mg/100 g). Karonda significantly increased the iron content of the jelly, with 100% karonda jelly (F_6) having nearly ten times more iron than 100% wood apple jelly (F_1). Tripathi *et al.* (2014) [17] also noted karonda's high iron content, ideal for nutrient-rich products like jellies. Sugar levels affected iron content. Jelly with 800 g sugar per liter of pulp (S_1) had the highest iron content at 1.78 mg/100 g, followed by 1.61 mg/100 g (S_2, 900 g) and 1.53 mg/100 g (S_3, 1000 g). Wani *et al.* (2013) [18] found that high sugar in karonda jam slightly lowered nutritional quality. Singh *et al.* (2021) [15] noted that sugar addition can affect mineral retention in karonda products. Krishna *et al.* (2017) [7] reported that karonda's iron enhances processed foods, but sugar levels can reduce nutrient retention.

Table 5: Effect of pulp ratio and quantity of sugar on Anthocyanin content and Iron content of mixed fruit jelly

S. No	Treatments Ratio of fruit pulp (Woodapple% + Karonda%) (Factor A)		Anthocyanin content Quantity of sugar per liter of pulp (Factor B)			Mean	Iron content Quantity of sugar per liter of pulp (Factor B)			Mean
			S_1 (800 gm)	S_2 (900 gm)	S_3 (1000 gm)		S_1 (800 gm)	S_2 (900 gm)	S_3 (1000 gm)	
1.	100%+0%	F_1	0.66	0.51	0.42	0.53	0.39	0.23	0.26	0.29
2.	80%+20%	F_2	1.67	1.11	1.06	1.28	0.93	0.80	0.72	0.81
3.	60%+40%	F_3	4.62	3.01	1.34	2.99	1.53	1.43	1.24	1.40
4.	40%+60%	F_4	7.63	4.73	5.51	5.96	2.12	1.74	1.93	1.93
5.	20%+80%	F_5	16.36	12.36	11.08	13.27	2.68	2.54	2.31	2.51
6.	0%+100%	F_6	18.20	17.09	16.03	17.11	3.02	2.92	2.73	2.89
Mean			8.19	6.47	5.91	6.86	1.78	1.61	1.53	1.64
Factor			A (F)	B (S)	AB (FxS)		A (F)	B (S)	AB (FxS)	
SEm±			0.050	0.035	0.087		0.021	0.015	0.037	
CD at 5% level			0.143	0.101	0.248		0.061	0.043	0.106	

4. Conclusion

It can be concluded from the present investigation that varying pulp ratios and sugar levels significantly affect the nutritional and chemical stability of wood apple and karonda blended jelly during storage. Jellies stored for 60 days effectively maintained their physico-chemical quality, with higher karonda proportions enhancing Total Soluble Solids (TSS), acidity, anthocyanin, and iron content. Lower sugar levels (800 g/kg pulp) supported better nutrient retention. These findings demonstrate the potential for producing stable, nutrient-rich jelly, promoting the utilization of underused fruits and reducing post-harvest losses.

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