Development and Evaluation of Physico-chemical Properties of Moringa-Woodapple-KarondaMixed Jam

Abstract

The present investigation was conducted to develop mixed jam using moringa leaf powder, wood apple and karonda fruit pulp. This research focuses on the standardization and evaluation of a unique mixed fruit jam comprising wood apple, karonda, and fortified withmoringa leaf power.The study initially standardized the wood apple and karonda mixed jam by blending their pulps in different proportions. Organoleptic scores were used to determine the most favourable blend, with WK_4 (40% wood apple + 60% karonda) emerging as the preferred combination based on appearance, aroma, taste, mouthfeel, and overall acceptability. Subsequently, WK_4 was utilized as the control for the development of moringa-based mix jam. The organoleptic evaluation of the moringa-based jam revealed a decrease in appearance scores with an increase in moringa leaf powder. However, taste and mouthfeel exhibited favourable scores, with WKM_3 (95% Woodapple karonda blend + 5% Moringa leaf power) achieving the highest overall acceptability that include appearance, aroma, taste, mouth feel, texture and body of jam. The study also explored the physio-chemical properties of thetreatments, including total soluble solids, titratable acidity, pH, ascorbic acid, total phenol, and sugar content. The statistical analysis was used Complete Randomized Design with six treatments and three replications in each. Notably, WKM_6 (12.5% Moringa) demonstrated the highest gel and rupture strength, indicating a robust texture.The findings contribute to the development of innovative fruit-based products with enhanced nutritional profiles, emphasizing the potential of moringa as a valuable ingredient in mixed fruit jams.

Keywords: Moringa, value-added, textural properties, blend, Organoleptic

1. Introduction

Moringa (*Moringa oleifera*) is the most widely cultivated species of the Moringaceae family. Moringa is usually known as drumstick tree and also by different names in local languages like sahjan, moonga, benzolive tree, kelor, marango, mlonge, mulangay, sajna or Ben oil tree. Moringa is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and

Afghanistan [1]. India is the major producer of moringa crop, with an annual production of 2.2 million tonnes from an area of 38,000 hectares[2]. Among the major states in moringa production, Andhra Pradesh leads in both area and production followed by Karnataka and Tamil Nadu. Commercial production of the crop has also been adopted in Maharashtra and Gujarat. The plant adopts well to different soil conditions and has an incredible ability to survive in harsh weather and even to drought. It is therefore considered as a fast-growingdrought-resistant tree. The rainfed agriculture in arid and drought-prone areas of Bundelkhand could be rejuvenated with the commercial cultivation of moringa.

Moringa stands out as a remarkably versatile plant, offering diverse applications including food, natural medicine, animal feed, natural coagulants, forestry products, fertilizer, alley cropping, and fuel [3,4]. Its extensive utility stems from the fact that nearly every part of the tree holds value, making moringa renowned as one of the most multifunctional plants on the planet. The leaves, fruits, flowers and immature pods are edible and form part of traditional diets in tropical and subtropical nations [5]. The immature green pods called “drumsticks” are widely used as part of the tree. Drumsticks or pods have a slight asparagus taste and are commonly consumed in South India in vegetable preparation or sambar. The flowers of moringa are edible when cooked, and are said to taste like mushrooms and added in vegetable preparation. However, another edible part of the plant i.e. moringa leaves has found less commercial exploitation.

Moringa leaves possess remarkable nutritional and medicinal qualities. The plant has brought massive attention as the ‘natural nutrition of the tropics’ because it has the potential to enhance the consumption of essential nutrients and phytochemicals that promote health. Medicinal properties like anti-tumour, anti-inflammatory, anti-ulcer, anti-atherosclerotic and anti-convulsant activities are important [6,7,8). Moringa is also utilized for the treatment of home-scale medicine [9]. Moringa leaves are considered to be a causative factor in controlling cholesterol and blood glucose levels and therefore thought to be useful for glucose purification [10]. The leaves contain a high amount of vitamin C, which fights different illnesses including colds and flu. Carotenoids, serving as Vitamin A precursors in the leaves, protect against various diseases such as eye and skin conditions, heart ailments, and diarrhea. Additionally, the leaves contain abundant Calcium for building strong bones and teeth, preventing osteoporosis, and essential Potassium for proper brain and nerve function. Moringa leaves are rich sources of

protein and also contain all of the essential amino acids in a good proportion. For individuals lacking protein from animal sources, these leaves could be a valuable resource. The nutritional content is particularly high in dried leaves, with ten times the vitamin A of carrots, 17 times the calcium of milk, 15 times the potassium of bananas, 25 times the iron of spinach, and nine times the protein of yoghurt, as indicated by [11].

Table 1.1: Nutritional content of fresh and dried *Moringa oleifera* leaves (per 100gm)

Nutrient	Unit	Fresh leaves	Oven-dried
Moisture	(%)	75.9	6
Energy	(Kcal)	92	271.54
Protein	(g)	6.7	23.78
Carbohydrates	(g)	12.5	28.32
Fat	(g)	1.7	7.014
Fiber	(g)	0.9	11.8
Vitamin C	(mg)	220	56
Calcium	(mg)	440	3467

[12]

To bring this crop intothe mainstream of food product categories, it needs to be supplemented with additional value and storability. The moringa leaf-based value-added product diversification can play a vital role in the increased consumption,and utilization of this nutritionally rich crop. These diversified value-added products developed from moringa leaves could help not only to alleviate malnutrition problems but also help to address micronutrient deficiency in the Indian population. Moringa leaves are suitable for consumption in either their fresh or dried form as part of a daily diet, with the advantage of extended storage for dried leaves. Various Moringa leaf products, including Moringa Tea, Moringa Tablets, Moringa Capsules, Moringa Leaf Powder, Moringa Soaps, and Moringa Face products, are commercially utilized as health foods and cosmetic items. Moringa leaves beverage is another consumable product that has potential as health food. So, it is necessary to develop new technologies/ products from Moringa leaves that could be hygienically processed and have extended shelf life for further uses. The main aim of the study was to standardize different Moringa leaves-based value-added products for commercial utilization. Products like Ready-to-serve beverages, instant

fruit drink powder and jam have potential to be incorporated with moringa leaves. These products need to be developed considering their palatability, appearance and storage life. Therefore, other fruits/medicinal crops in the arid region could be utilized with the moringa leaves to make it more attractive and increase consumer acceptance. Wood apple and Karonda are the other crops selected for blending with Moringa leaves for the development of different value-added convenience products.

Mix fruit jam is another value-added product having higher commercial value due to its appealing nature. Jam is generally consumed in breakfast food with bread or roti. In India, changes in lifestyle promote value-added products like jam. Although moringa has several nutritional benefits, its utilization in jam is challenging. Therefore, other fruits like wood apple and karonda were explored for the purpose.

Wood apple botanically known as *Feronia lemonia* belonging to the family Rutaceae is one of the hardiest fruits grown in semi-arid and arid regions of India. It is an acidic fruit in unripe condition but gives characteristic flavour when ripe. It contains sweet aromatic pulp, which has 74% moisture, 7.3 g protein, 15.5 g carbohydrates, 170 mg riboflavin, 2 mg vitamin C per 100 g of pulp and minerals, especially 0.17% calcium 0.08% phosphorus and 0.07% iron [13]. The fruit is considered to be a rich source of pectin and therefore found to be most suitable for the preparation of value-added products like jam or jelly. However, the characteristic taste of the fruit needs to be neutralized to make it more acceptable. Mixed fruit jam therefore could be a good alternative for the utilization of wood apples.

Karonda (*Carissa Carandas*) is anative fruit of India and belongs to the family Apocynaceae. This is a rich source of pectin and also minerals, especially iron and calcium. Karonda possesses a higher vitamin C content compared to apples and bananas. The ripe fruit having anti-scorbutic properties is reported to be cooling, acidic and useful in bilious [14]. Fruit is slightly sour and astringent in taste, therefore its cultivation is only confined as a fencing bush and it is not popular as dessert fruit. The fruit has a potential for processing but its commercial utilization was limited by the characteristic acidic taste of the fruit. However, the Fruit can be used for the preparation of mixed jam, jelly, pickle and preserves[15]. Moringa-Wood apple-Karonda mixed jam could thus be one of the nutritive value-added products having a delicious taste with higher consumer acceptability.

2. Materials and Methods

The experiment was conducted at the Post Harvest Technology Department, College of Horticulture, Banda University of Agriculture and Technology, Banda, Uttar Pradesh during the session 2021-2022 under Complete Randomized Design with six treatments and three replications in each.

Procurement of raw material

Moringa leaves, karonda and wood apple collected from the field of College of Horticulture, BUAT, Banda. Sugar and other ingredients required were procured from the local market of Banda.

Standardization of wood apple and karonda mixed jam

Wood apple and karonda pulp were blended in different proportions for the preparation of jam and the best proportion was selected based on a 9-point hedonic sensory score. The selected proportion was further blended with moringa leaf powder.

Table 2.1: Standardization of wood apple and karonda mixed jam

Treatments	Fruit pulp (Ratio)			TSS (^{0}Brix)
	Wood apple	:	Karonda	
WK_1	70	:	30	68%
WK_2	60	:	40	68%
WK_3	50	:	50	68%
WK_4	40	:	60	68%
WK_5	30	:	70	68%

(Key: **WK** =Wood apple and Karonda blend jam)

Standardisation of Moringa-Wood Apple- Karonda mixed jam

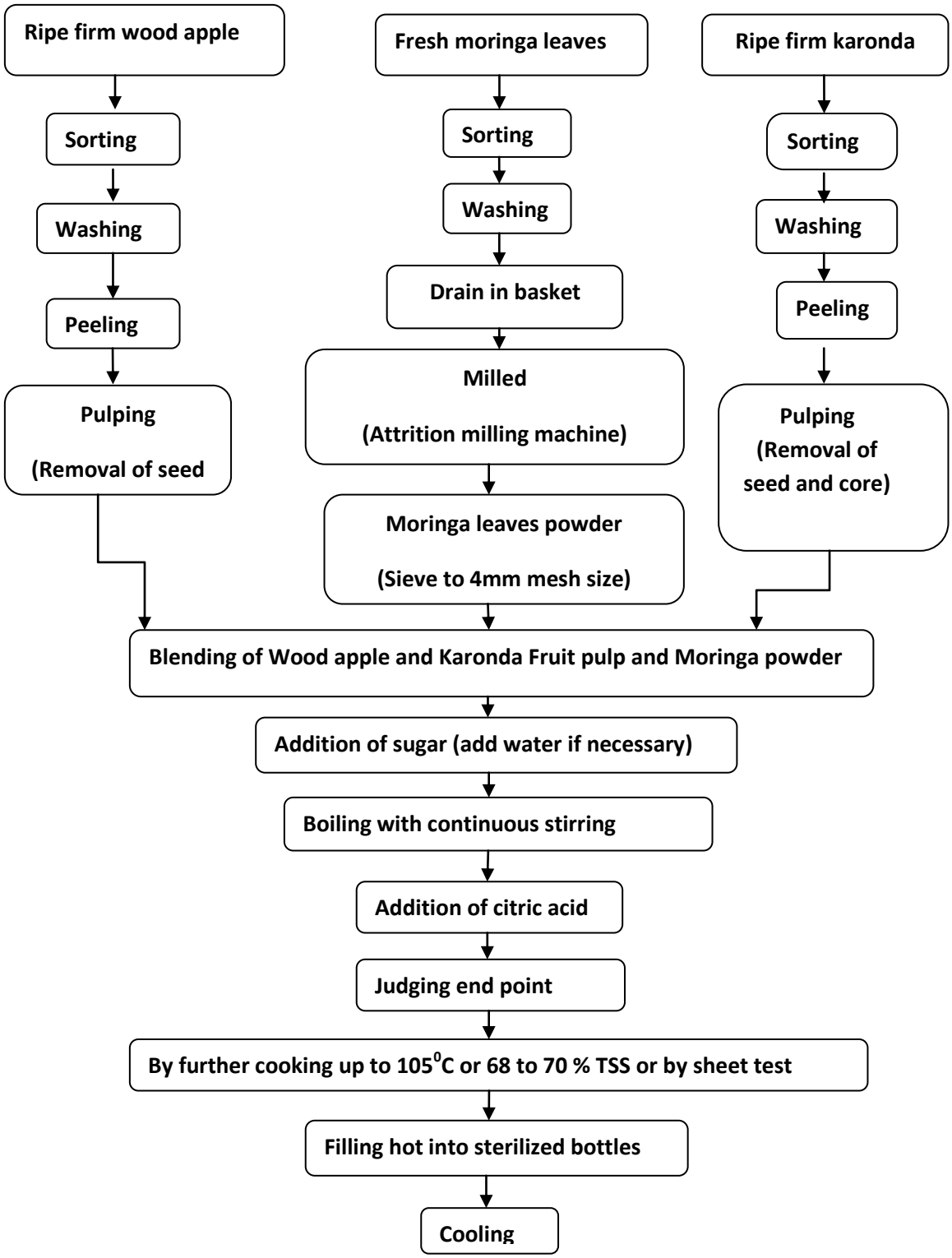
Table 2.2: Combination of mixed jam from moringa leaf powder, wood apple and karonda

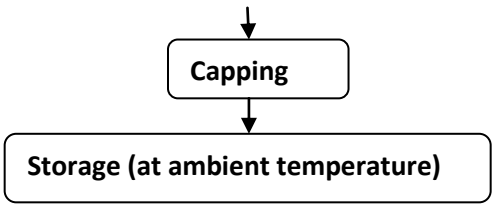
Treatments	Fruit Pulp (%)		TSS (^{0}Brix)
	WK	MLP	
WKM_1	100%	0% (control)	68%
WKM_2	97.5%	2.5%	68%
WKM_3	95%	5%	68%
WKM_4	92.5%	7.5%	68%
WKM_5	90%	10%	68%

WKM_6	88.5%	12.5%	68%

(Key:**WKM** =Wood apple, Karonda and Moringablend jam; **MLP:** Moringa Leaf Powder; **WK** =Wood apple and Karondablend)

Flow Chart for Preparation of Moringa-based mix jam:





3. Result and Discussion

Standardization of wood apple and karonda mixed jam

Wood apple and Karonda pulp were blended in different proportions for the preparation of jam and the best proportion was selected based on a 9-point hedonic organoleptic score. A significant difference was recorded among all the other formulations the detail given in table 3.1.

A gradual increase in appearance scores of all the formulations was recorded with an increase in the proportion of karonda pulp. The similar pattern was observed with the scores of taste and mouth feel. But in the case of aroma scores was decreased from all the formulations were recorded with increasing the proportion of karonda pulp. The highest overall acceptability score was recorded as 8.66 for the formulation WK_4 (40% wood apple and 60% karonda) followed by WK_3 (7.33). The minimum overall acceptability score was recorded in the jam WK_1 which contains 70% wood apple and 30% karonda pulp.WK_4 (40% wood apple and 60% karonda pulp) was adjudged best among all the combinations considering the higher overall acceptability. It was further used for the development of moringa based mix jam. The detailis given table in 3.2.

Table 3.1: Organoleptic evaluation of standardized wood apple and karonda mix jam

Parameter / Treatment	Appearance	Aroma	Taste	Mouth feel	Overall acceptability
WK_1	5.66	8.33	5.33	4.66	5.66
WK_2	6.66	7.66	6.33	5.66	6.33
WK_3	7.66	6.33	7.33	6.66	7.33
WK_4	8.33	7.66	8.66	8.33	8.66
WK_5	8.66	5.66	6.66	6.66	6.00
Mean	7.39	7.12	6.86	6.39	6.79
CD (0.05%)	**1.34**	**1.41**	**1.04**	**1.20**	**1.39**

(Key:**WK =**Wood apple and Karondablend jam)

Standardisation of Moringa-Wood Apple- Karonda mix jam

Wood apple: karonda pulp blend for mixed jam standardized in table (3.2) was further blended with moringa leaf powder in five different proportions using WK_4 (40:60) as control.

Organoleptic evaluation of developed moringa based mix jam

Appearance

A gradual decrease in the appearance scores of all the formulations for moringa based mix jam was recorded with an increasing proportion of moringa leaf powder and the observation given in Table No. 3.2. The maximum score was recorded in WKM_1 (8.30) followed by WKM_2 (7.60), WKM_3 (7.15), WKM_4 (6.31), WKM_5 (5.98) and WKM_6 (5.18). The appearance score was decreased significantly [16]and reported similar result in mixed fruit jam.A similar result was recorded by [17] in strawberry fruit jam.A similar result was reported by [18] in jamun fruit jam and [19] also reported in apple and pear mixed fruit jam.

Aroma

The aroma scores of developed moringa based mix jam have been given in Table3.2 and indicate that a significant difference in aroma scores was observed for all the treatments. The maximum score was recorded in WKM_3 (7.55) followed by WKM_4 (6.30), WKM_2 (5.33), WKM_5 (5.26) and WKM_1 (5.15) respectively, while the minimum value was recorded in WKM_6 (4.46). The aroma score was decreased significantly.A similar result was reported by [18] in jamun fruit jam and [19] also reported in apple and pear mixed fruit jam.

Taste

The taste scores of developed moringa based mix jam have been presented in Table3.2. Results indicated that the mean score for different jam varied from 5.33 to 8.33.the mean maximum score for taste was recorded as 8.50 for WKM_3followed by WKM2 (7.91), WKM_4 (7.56), WKM_1 (7.30), WKM_5 (6.66) and the minimum 5.33 was scored by WKM_6 respectively. The aroma score was decreased significantly. A similar result was recorded by [17] in strawberry fruit jam.A similar result was reported [18] in jamun fruit jam and [19] also reported in apple and pear mixed fruit jam.

Table 3.2: Organoleptic evaluation of developed moringa based mix jam

Parameter	Appearance	Aroma	Taste	Mouth feel	Texture and body	Overall acceptability

Treatment						
WKM_1 (100%)	8.30	5.15	7.30	6.65	7.06	6.33
WKM_2 (97WK.5:2.5M)	7.60	5.33	7.91	7.80	7.46	7.00
WKM_3 (95WK:5M)	7.15	7.55	8.50	8.60	8.61	7.91
WKM_4 (93WK:7.5M)	6.31	6.30	7.56	7.68	7.03	6.91
WKM_4 (93WK:7.5M)	5.98	5.26	6.66	6.26	6.15	5.91
WKM_6 (87.5WK:12.5M)	5.18	4.46	5.33	5.30	5.38	4.58
Mean	6.75	5.67	7.21	7.04	6.94	6.44
CD (0.05%)	**0.29**	**0.37**	**0.65**	**0.66**	**0.42**	**0.72**

(Key:**WKM =**Wood apple, Karonda and Moringablend jam; Values are expressed as mean ± standard deviation of triplicate readings means with different letters in the same column are significantly different in the same column at the $p \leq 0.05$ level.)

Mouth feel

The data presented in Table3.2 shows the effect of moringa leaf powder on all moringa based mix jam. The maximum mouth feel mean score was recorded as 8.60 for WKM_3 followed by WKM_2 (7.80), WKM_4 (7.68), WKM_1 (6.65), WKM_5 (6.26) and the minimum (5.30) was scored by WKM_6 respectively. The mouth feels score differed significantly in most of the different combinations of moringa based fruit jam. A similar result was reported by [18] in jamun fruit jam and [19] also reported in apple and pear mixed fruit jam.

Texture and body

The texture and body mean score of the developed moringa based mix jam was recorded and mentioned in Table3.2 The maximum score was recorded in WKM_3 (8.61) followed by WKM_2 (7.46), WKM_1 (7.06), WKM_4 (7.03), WKM_5 (6.15) and minimum score was recorded in WKM_6 respectively. The texture and body score was differ significantly. A similar result was

reported [18] in jamun fruit jam and [19] also reported a similar result in apple and pear mixed fruit jam.

Overall acceptability

The Overall acceptability mean score of different combinations of moringa based mix jam was found to range from 4.58 to 7.91 in Table3.2. Among the products studied, WKM_3 displayed the highest score for overall acceptability, closely followed by WKM_3, WKM_2, WKM_4, WKM_1 WKM_5 and WKM_6. In most of the jam combinations, overall acceptability score differed significantly. A similar result was recorded by [17] in strawberry fruit jam and [20] reported in pineapple and mango mixed fruit jam. [18] reported in jamun fruit jam and [19] also reported similar results in apple and pear mixed fruit jam.

Physico-chemical properties of moringa based mix jam

Total soluble solid (^{0}Brix)

The total soluble solids of the products are the index of sweetness. TSS of different combinations of the mix jam as determined by the refractometer was found to be in the range of 68.10 to 70.53 ^{0}Brix given in Table 3.3. Among the previously studied products, WKM_1 displayed maximum TSS content (70.53 ^{0}Brix), thoroughly followed by WKM_6 (70.06 ^{0}Brix), WKM_5 (68.33 ^{0}Brix), WKM_2 (68.26 ^{0}Brix), WKM_3 (68.1^{0}Brix) and WKM_4 (67.50 ^{0}Brix). In most of the treatment combinations, TSS content differed significantly. A similar result was reported by [21] in fruit jam [16] reported a similar result in mixed fruit jam and [19] also reported a similar result in apple and pear mixed fruit jam.

Titratable acidity (%)

The examination of titratable acidity was undertaken to ascertain physico-chemical alterations during the preparation process. The titratable acidity of samples WKM_1, WKM_2, WKM_3, WKM_4, WKM_5 and WKM_6 were 1.10, 1.10, 1.16, 1.18, 1.07 and 1.12% respectively in Table 3.3. Maximum and minimum acidity were found to be in WKM_4 and WKM_5 (1.07% and 1.18%). In most of the treatment combinations acidity content differed non-significantly.A similar result was reported by [21] in strawberry jam [20] reported a similar result in pineapple and mango mixed fruit jam and [19] also reported a similar result in apple and pear mixed fruit jam.

pH

The pH measurement was conducted to determine if a consistently low pH was maintained, as it could serve as an effective preservation method and contribute to the textured gel structure of the jam. Maximum pH value was in WKM_6 (3.35) followed by WKM_5, WKM_4, WKM_3, WKM_2 and WKM_1, (3.34, 3.21, 3.11, 3.05, 3.04) respectively in Table 3.3. pH value differed significantly in most of the different combinations of moringa based mix jam. Similar result were reported by [22] in Mulberry and Roselle Mixed Fruits Jam and [23] reported similar result in fruit jam. [24] also reported similar result in moringa powder and apple mixed jam.

Table 3.4: TSS, titratable acidity and pH content of moringa based mix jam

Treatment	TSS (^{0}Brix)	Titratable Acidity (%)	pH
WKM_1	70.53±1.05	1.10±0.20	3.04±0.04
WKM_2	68.26±0.84	1.10±0.10	3.05±0.03
WKM_3	68.10±0.52	1.16±0.12	3.11±0.04
WKM_4	67.50±0.80	1.18±0.12	3.21±0.03
WKM_5	68.33±0.40	1.07±0.11	3.34±0.08
WKM_6	70.06±0.60	1.12±0.8	3.35±0.03
Mean	68.80	1.12	3.18
C.D.(0.05%)	**1.31**	**N/A**	**0.07**

(Key: **WKM** =Wood apple, Karonda and Moringablendjam; Values are expressed as mean ± standard deviation of triplicate readings means with different letters in the same column are significantly different in the same column at the $p \leq 0.05$ level, but not in titratable acidity.)

Ascorbic acid (mg/100g)

The ascorbic acid content of different combination of moringa based mix jam was found to be range from 7.59 to 11.14 mg/100g.Among the products studied, WKM_1 displayed highest ascorbic acid content (11.14mg/100g), closely followed by WKM_2 (9.24 mg/100g),WKM_3 (8.71 mg/100g), WKM_4 (8.30 mg/100g), WKM_5 (7.88 mg/100g) and WKM_6 (7.59 mg/100g) respectively in Table 3.4. In most of the treatment combinations, ascorbic acid content differed significantly. A similar result was recorded by [20] in pineapple and mango mixed fruit jam and [25] reported a similar result in mixed fruit jam.

Total phenol (mg/100g)

The total phenol content of different combination of moringa based mix jam was found to be range from 98.6 to 201.54 mg/100g given in Table 3.4. In most of the treatment combinations, total phenol content differed significantly. Among the products studied, WKM_6 displayed highest total phenol content (201.54 mg/100g), closely followed by WKM_5 (167.92 mg/100g), WKM_4 (153.71mg/100g), WKM_3 (118.75 mg/100g), WKM_2 (110.45 mg/100g) and WKM_1 (98.60 mg/100g) respectively. WKM_1 showed the lowest value of total phenol content 98.60 mg/100g.

Table 3.4: Ascorbic acid and Total phenol content of moringa based mix jam

Treatment	Ascorbic Acid (mg/100g)	Total phenol (mg/100g)
WKM_1	11.14±0.70	98.60±3.64
WKM_2	9.24±0.09	110.45±1.92
WKM_3	8.71±0.37	118.75±3.63
WKM_4	8.30±0.46	153.71±8.70
WKM_5	7.88±0.37	167.92±4.62
WKM_6	7.59±0.20	201.54±2.92
Mean	8.81	141.83
C.D.	**0.74**	**8.55**

(Key:**WKM =**Wood apple, Karonda and Moringablendjam;Values are expressed as mean ± standard deviation of triplicate readings means with different letters in the same column are significantly different in the same column at the p≤0.05 level.)

Reducing sugars (%)

The reducing sugars of developed products were the index of sweetness. Reducing sugar of different blends of moringa based mix jam was found to be ranged from of 34.74 to 43.27 percent given in Table 3.5. Amongst the developed products studied, WKM_6 displayed the lowest reducing sugar content (34.74%), closely followed by WKM_5 (35.42%), WKM_4 (37.29%), WKM_3 (39.47%) and WKM_2 (41.80%) respectively in Table 3.5. WKM_1 showed the highest value of reducing sugars content 43.27 per cent. In most of the treatment combinations, total sugar content different significantly. A similar result was reported by [18] in jamun fruit jam and [25] also reported similar result in black-plum fruit jam.

Non-reducing sugars(%)

Non-reducing sugars of different combinations of moringa based mix jam were found to be ranged from 18.62 to 20.02 percent given in Table 3.5. Among the products studied, WKM_6 displayed the lowest non-reducing sugar content (18.62%), closely followed by WKM_3 (19.04%), WKM_2 (19.07%), WKM_4 (19.41%) and WKM_5 (19.88%) respectively. WKM_1 showed the highest value of non-reducing sugar content 20.02 percent. In most of the treatment combinations total sugar content is different non-significantly. A similar result was reported by [18] in jamun fruit jam and [25,26] also reported a similar result in black-plum fruit jam.

Total sugars (%)

The total sugars of developed products were the index of sweetness. Total sugars of different blends of moringa based mix jam were found to be a range of 63.51 to 67.36 per cent given in Table 3.5. Amongst the products studied, WKM_4 existing lowest total sugar content (63.40%), closely followed by WKM_3 (63.51%), WKM_2 (64.52%), WKM_5 (65.64%) and WKM_1 (67.29%) respectively. WKM_6presentedthe maximum value of total sugar content of 67.36 percent. In most of the treatment combinations total sugar content different significantly. A similar result was also reported by [23] in fruit jam [16] reported similar result in mixed fruit jam and [19,26,27] also reported similar result in apple and pear mixed fruit jam.

Table 3.5: Reducing, non-reducing and total sugar content of moringa based mix jam

Treatment	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)
WKM_1	43.27±1.07	20.02±0.1	67.29±0.88
WKM_2	41.80±0.55	19.07±1.0	64.52±1.15
WKM_3	39.47±1.07	19.04±0.3	63.51±1.17
WKM_4	37.29±0.46	19.41±0.7	63.40±0.89
WKM_5	35.42±0.89	19.88±1.6	65.64±1.06
WKM_6	34.74±0.96	18.62±0.2	67.36±0.71
Mean	38.66	19.34	65.29
CD(0.05%)	1.55	N/A	1.78

(Key: **WKM** =Wood apple, Karonda and Moringablendjam; Values are expressed as mean ± standard deviation of triplicate readings means with different letters in the same column are significantly different in the same column at the p≤0.05 level, but not in reducing sugar)

Textural properties of developed moringa based mix jam

Analysis of jam texture was performed, using a TA-XT-plus texturometer (Stable Micro Systems, at Banda University of Agriculture and Technology, Banda). The following conditions were applied: Return to Start (Set Dist), Test Mode: Compression, Pre-Test Speed: 3.00 mm/sec, Test Speed: 2.00 mm/sec, Post-Test Speed: 10.00 mm/sec, T.A. Variable No: 5: 0.0 g, Target Mode: Distance, Distance: 10.000 mm, Strain: 10.0 %, Trigger Type: Auto (Force), Trigger Force: 10.0 g, Probe: SMS P/36R; P/36R, Batch: TEST, Points per second: 500. Prior to the analyses, the samples were acclimated at room temperature. Each sample underwent analysis in ten repetitions. Jam texture was established using the following texture parameters: gel strength (force at a point in the initial stage of penetration, where little deformation has occurred), rupture strength (the rupture point of the gel), brittleness (mm) and adhesiveness (area under the negative region of the curve). The results were calculated using Texture Exponent software (Stable Micro Systems, Banda University of Agriculture and Technology, Banda).

Pectin is the main factor analyzing jam consistency and its content and type have an effect on gel strength (g), jam rapture strength (g) and brittleness (mm), which were measured, along with adhesiveness (g.sec.).

Gel strength (g)

Right after production, the gel strength values for the examined jam ranged from 127.09 to 561.85g (see Table 3.6).Among the all jam studied, WKM_2 displayed the highest value of gel strength (561.85g), closely followed by WKM_4 (429.18g), WKM_3 (342.81g), WKM_1 (145.89g) and WKM_5 (134.63g). WKM_6 showed the lowest value of gel strength 127.09g. In most of the treatment combinations gel strength differed significantly.

Rupture strength (g)

After preparing mixed jam the values of rapture strength were recorded within the range of 435.86 to 2021.52g (Table 3.6). Among all jam studied WKM_2 displayed the highest value of rapture strength (2021.52g), closely followed by WKM_4 (1032.79g), WKM_1 (969.92g), WKM_3 (888.61g) and WKM_5 (635.78g). WKM_6 Showed the lowest value of rapture strength 435.86g. in most of the treatment combinations rapture strength value differed significantly.

Brittleness (mm)

In the present study brittleness value was recorded in different combinations of mixed fruit jam result showed that the brittleness value was 10 mm for all jam except WKM_3 9.65 mm. Brittleness differed significantly in most of the different combinations of moringa leaves-based jam. The detail given in Table3.6.

Adhesiveness (g.sec)

Adhesiveness of different combinations of mixed jam as determined by the texturometer was found to be range of -1130.72 to -369.22g.sec in table 4.26. Among the all jam studied WKM_2 displayed lowest adhesiveness (-1130.72g.sec), closely followed by WKM_4 (-531.16g.sec), WKM_1 (-499.25g.sec), WKM_5 (-414.97g.sec), WKM_3 (-410.03g.sec) and WKM_6 showed highest value of adhesiveness. In most treatment combinations adhesiveness differed significantly. A similar result was reported by [27] in strawberry jam.

Table 3.6: Textural properties of developed moringa based mix jam

Parameters / Treatments	Gel strength (g)	Rupture strength (g)	Brittleness (mm)	Adhesiveness (g.sec)
WKM_1 (Control)	145.89	969.92	10	-499.25
WKM_2 (2.5%)	561.85	2021.52	10	-1130.72
WKM_3 (5%)	342.81	888.61	9.65	-410.03
WKM_4 (7.5%)	429.18	1032.79	10	-531.16
WKM_5 (10%)	134.63	635.78	10	-414.97
WKM_6 (12.5%)	127.09	435.86	10	-369.22
Mean	290.24	997.41	9.94	-550.89
S.D. (±)	167.09	501.46	0.31	264.02
C.V.	57.57	50.28	1.31	-47.93

(Key: WKM =Wood apple, Karonda and Moringablend jam)

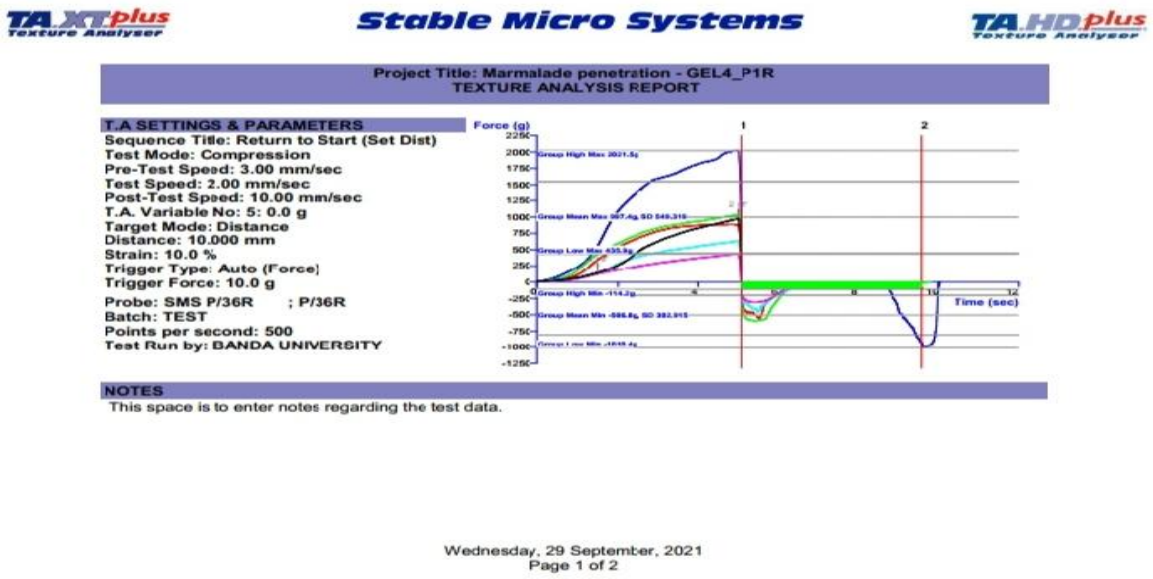


Fig 3.1: Textural properties of developed moringa based mixed jam

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