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Studies on effect of storage on sensorial properties and spoilage of mandarin jam

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Abstract
An experiment entitled "Studies on effect of storage on sensorial properties and spoilage of mandarin jam" was carried out during year 2020-21 at Post Harvest Technology Laboratory, Horticulture Section, College of Agriculture, Nagpur with objective to study the effect of sugar and pectin levels on physicochemical and sensorial properties of mandarin jam and to find out the suitable combinations of sugar and pectin level(s) for preparation of mandarin jam. Where sensory evaluation and microbiological count were periodically recorded from samples that had been stored for 30, 60, 90, 120, 150, and 180 days, respectively. It was discovered that as storage got better, the overall ratings for flavor and color went up. However, as storage is increased, the texture and spreading qualities decline. The highest scores on sensory qualities were obtained with the treatment combinations S3P2 and S3P1, which contained 850 g of sugar and 2 g of pectin. All treatment combinations, with the exception of S1P1 (650 g sugar in pectin control), S1P2 (650 g sugar and 2 g pectin), and S1P3 (650 g sugar and 4 g pectin), are free from microbial deterioration.

Keywords: Mandarin, Jam, *Citrus reticulata*, Sensorial properties, Spoilage

Introduction
Citrus fruits are rich in nutrients and, thanks to their high flavonoid content, have positive benefits on human health. Mandarin (Citrus unshiu March) is a type of citrus fruit that is consumed as fresh juice, juice concentrate, or juice that has been processed. The purpose of this research was to make jam from inferior or unusable satsuma mandarins and assess its physical, chemical, and sensory properties. The jam was made using a conventional method in an open container with a 1:1 fruit to sugar ratio. According to the hedonic scale, the produced whole fruit mandarin jam had a respectable favor rating. Jams, which are made from fruit pulp, sugars, pectin, acid, and other components, are among the most popular food products with intermediate moisture. For marketing purposes, jam with a high fruit content is also referred to as preserver conserve. Jams that combine the qualities of two or more fruits produce a product with a better nutritional value and enticing sensory qualities.
By all respects, jam-bread is a dish that evokes memories. Many of us won't be surprised that there must be communities of jam enthusiasts. In Greece, jams are consumed by the spoonful from bowls and are called as glyko. Water is then consumed, and finally liqueur is consumed. They are delicious foods that were originally viewed as medical treatments. Jams, preserves, and marmalades are based on centuries-old methods for preserving fruit, if only to serve as a reminder to ourselves. Long-standing key issue is how the fruit, sugar, acid, and pectin interact when present in the proper ratios. The mixture gels because the ratios are just correct.

Materials and Methods
For the purpose of making jam, fully ripened Nagpur mandarin fruits are picked. Fruits are categorized according to color and maturity. Fruits without flaws were chosen. On the production day, the fruits were washed with portable running water and then immersed for 10 minutes. The segments were divided. The seeds and white fiberous pith are removed. Fruit pulp is produced by homogenizing cleaned section in a blender. Different levels of sugar and pectin were used in the creation of jam that had just been freshly extracted. According to the treatments, sugar comes in weights of 650 g, 750 g, 850 g, 950 g, 1050 g, and 1150g, and pectin weighs 2 g and 4 g. First, combine pulp, sugar, and pectin in an open container. The mixture continues to be stirred as the heating process begins. Then using a hand refractometer set to 70 °B to determine the end point.

Total jam solids were calculated by deducting moisture content from 100, and titratable acidity, reducing sugars, and total sugars were assessed in accordance with Ranganna's (1986) [12] description. The Srivastava and Kumar (1994) [13] titration method was used to determine the vitamin C concentration. Three duplicates of each experiment were conducted. The F.C.R.D. factorial experiment was used to conduct the statistical analysis of the data according to the procedure outlined by Panse and Sukhatme (1961) [10].

Result and Discussions

Physical Characteristics of Fresh Mandarin Fruits (At the time of preparation of jam)

For the purpose of making jam, fully ripened Nagpur mandarin fruits are picked. Fruits are categorized according to color and maturity. Fruits without flaws were chosen. The average in terms of volume, length, weight, and specific gravity.

Chemical Characteristics of fresh Mandarin fruits

Fresh mandarin fruits were tested for a number of chemical traits, and the results are shown in Table 4.1. The nutritional information for fruit that contains vitamin C, thiamin, riboflavin, niacin, calories, protein, carbohydrates, fiber, and sugar is shown in Table 4.1.

Changes in Proximate Composition of Mandarin Jam during storage

Appearance

Every food has a crucial sensory characteristic called appearance since it affects how well it is received. According to Table 4.2, appearance score declines as storage time increases from 0 to 180 days. The treatment combination S3P2 (850 g sugar and 2 g pectin) achieved the greatest appearance score at 0 days of storage, scoring 8.5, followed by S3P1 (850 g sugar and pectin control), scoring 8.2. While the lowest scores were 5.0 (650 grams of sugar and control pectin in treatment S1P1) and 5.1 (treatment S6P3), respectively. The trend continues in storage for 30, 60, 90, 120, 150, and 180 days.

Jams made with lower and greater levels of sugar and pectin received lower marks for aesthetics. This may be because sugar alters the texture, color, and flavor. therefore also have an impact on jam's look. This supports the findings in papaya jam from Pinandoyo *et al*. (2019) [11].

Colour

As the storage duration lengthens, the color score rises. S3P2 (850 g sugar and 2 g pectin) and S5P1 (1050 g sugar with no pectin) were found to have identical color scores at 0 days of storage, whereas S6P3 (1150 g sugar and 4 g pectin) had the lowest color score, registering 5.5. This pattern is consistent with the storage periods of 30, 60, 90, 120, 150, and 180 days shown in Table 4.3.

A decline in color score was seen during storage. Color shifts from orange brown to dark brown. The sugar's carmelization may be to blame for this. Islam *et al*. (2012) [3] and Akshay *et al*. (2018) report findings that are similar.

Taste

The treatment S3P2 (850 g sugar and 2 g pectin) received the greatest taste rating at 0 days of storage, while the treatment S3P1 (850 g sugar and control of pectin) received the lowest rating of 7.9. Where the flavor rating gradually rises after 30 days of storage as opposed to only one. At 90 to 180 days of storage, the taste score starts to decline. A minimum score of 5.2 was observed at 90 days for treatment S6P3 (1150 g sugar and 4 g pectin), while 5.2 was recorded for treatment S1P1 (650 g sugar and pectin control). The same pattern continued throughout the storage period, as shown in Table 4.4, at 30, 60, 90, 120, 150, and 180 days.

The jam with the highest rating contained 850 grams of sugar and 2 grams of pectin. In contrast, the score decreased for sugar and pectin concentrations that were lower and greater. This might be because the jam has the right amount of sugar and pectin because sugar is one of the key components to jam's flavor. Jam becomes overly sweet and sour, respectively, with lower and higher sugar levels. The outcomes are consistent with Khan's 2012 research on strawberry jam.

Microbial Spoilage

No colony forming units were found during the microbiological load testing of the mandarin jam, indicating that it is safe from a microbiological standpoint for storage for up to 90 days. After 90 days, the treatment combination S1P1, S1P2, and S1P3 began to show signs of spoiling.

Table 18 shows that all treatment combinations of mandarin jam, with the exception of treatments S1P1, S1P3, and S1P3 with low sugar concentration, have been shown to be free of microbial deterioration.

Due to the presence of preservation elements or barriers, food products are microbiologically stable and secure. Because the spoilage or pathogenic bacteria are unable to overcome all of the barriers currently in place, the diverse type and strength of these preservative elements work in concert to inhibit the growth or multiplication of these organisms. However, the typical combination of barriers would not be sufficient to prevent spoiling or poisoning if excessive quantities of microorganisms are present due to inadequate hygienic circumstances, as shown by Juvonen *et al*. (2011) [4].

The high acidity of preserves is a characteristic that helps preserve the color and flavor of most fruits while also preventing the growth of bacteria that can cause food poisoning. However, some yeasts and molds can develop at high acidity levels, which can contaminate the food. By making sure that the preserve's sugar level is at least 68%, as recommended by Bourton and Dunsmore *et al*. (2015) [1], they are kept from ruining jams.

For the prepared items, microbial characteristics (bacteria, yeast, and mould) were investigated. According to a microbial analysis conducted by Gebrezgi Desalegn *et al*. (2016) [2], the product is safe to ingest for a period of four months after purchase. Jams and syrups were stable up to six months of storage for most of the parameters reported by Christine Mukantwali *et al*., (2017) [9].

Table 1: Chemical characteristics of fresh Mandarin fruit

Chemical parameters	Vitamin C	Thiamin	Riboflavin	Niacin	Calories	Protein	Carbohydrate	Fiber	Sugar
Observations	29.1 mg / 100 g	0.06 mg	0.04 mg	0.41 mg	47 cal	1 g	12 g	2 g	9 g

Table 2: Effect of sugar and pectin combinations on Appearance of mandarin jam

Treatments	Appearance						
	0 days	30 days	60 days	90 days	120 days	150 days	180 days
S_1P_1(650 g Sugar)	5.0	4.8	4.8	4.5	4.4	4.3	4.2
S_1P_2(650 g Sugar: 2 g Pectin)	5.0	5.0	5.3	5.0	4.9	4.8	4.5
S_1P_3(650 g Sugar:4 g Pectin)	5.8	5.5	5.5	5.5	5.4	5.3	5.2
S_2P_1(750 g Sugar)	7.9	7.9	7.9	7.9	7.8	7.7	7.6
S_2P_2(750 g Sugar:2 g Pectin)	7.8	7.5	7.3	7.0	6.9	6.8	6.7
S_2P_3(750 g Sugar:4 g Pectin)	7.5	7.0	7.0	7.0	6.9	6.8	6.7
S_3P_1(850 g Sugar)	8.2	8.2	8.0	7.8	7.7	7.6	7.5
S_3P_2(850 g Sugar:2 g Pectin)	8.5	8.5	8.5	8.4	8.3	8.2	8.1
S_3P_3(850 g Sugar:4 g Pectin)	8.1	8.1	8.0	8.0	7.9	7.8	7.7
S_4P_1(950 g Sugar)	7.5	7.4	7.5	7.5	7.4	7.3	7.2
S_4P_2(950 g Sugar:2 g Pectin)	7.0	7.1	7.2	7.4	7.3	7.2	7.1
S_4P_3(950 g Sugar:4 g Pectin)	7.5	7.0	7.1	7.3	7.2	7.1	7.0
S_5P_1(1050 g Sugar)	6.1	6.2	6.4	6.0	6.0	5.9	5.8
S_5P_2(1050 g Sugar:2 g Pectin)	6.0	6.2	6.1	6.0	5.9	5.8	5.7
S_5P_3(1050 g Sugar:4 g Pectin)	6.2	6.0	6.4	6.0	5.9	5.8	5.7
S_6P_1(1150 g Sugar)	5.2	5.1	5.0	5.0	4.9	4.8	4.7
S_6P_2(1150 g Sugar:2 g Pectin)	5.2	5.0	5.0	5.0	4.9	4.8	4.7
S_6P_3(1150 g Sugar:4 g Pectin)	5.1	5.0	5.0	5.0	4.8	4.7	4.5

All values are mean± SEM of three replicates.

The test values along the same column carrying different superscripts for each composition contents are significantly different ($p<0.05$) within days.

S1P1(650 g Sugar), S1P2(650 g Sugar: 2 g Pectin), S1P3(650 g Sugar:4 g Pectin), S2P1(750 g Sugar), S2P2(750 g Sugar:2 g Pectin), S2P3(750 g Sugar:4 g Pectin), S3P1(850 g Sugar) , S3P2(850 g Sugar:2 g Pectin) , S3P3(850 g Sugar:4 g Pectin), S4P1(950 g Sugar) , S4P2(950 g Sugar:2 g Pectin), S4P3(950 g Sugar:4 g Pectin), S5P1(1050 g Sugar), S5P2(1050 g Sugar:2 g Pectin), S5P3(1050 g Sugar:4 g Pectin), S6P1(1150g Sugar), S6P2(1150 g Sugar:2 g Pectin), S6P3(1150 g Sugar:4 g Pectin

Table 3: Effect of sugar and pectin combinations on Colour of mandarin jam

Treatments	Color						
	0 days	30 days	60 days	90 days	120 days	150 days	180 days
S_1P_1(650 g Sugar)	5.8	5.4	5.4	5.1	5.0	4.9	4.5
S_1P_2(650 g Sugar: 2 g Pectin)	5.9	5.8	5.8	5.2	5.1	5.0	4.8
S_1P_3(650 g Sugar:4 g Pectin)	5.1	5.7	5.5	5.5	5.4	5.3	5.2
S_2P_1(750 g Sugar)	6.8	6.9	6.9	7.0	6.8	6.5	6.2
S_2P_2(750 g Sugar:2 g Pectin)	6.9	6.9	7.0	7.2	7.0	6.8	6.6
S_2P_3(750 g Sugar:4 g Pectin)	7.0	7.1	7.2	7.3	7.2	7.1	7.0
S_3P_1(850 g Sugar)	7.8	7.5	7.5	7.4	7.3	7.2	7.1
S_3P_2(850 g Sugar:2 g Pectin)	8.8	8.8	8.8	8.5	8.4	8.3	8.3
S_3P_3(850 g Sugar:4 g Pectin)	8.3	8.3	8.2	8.0	7.9	7.8	7.5
S_4P_1(950 g Sugar)	8.0	8.1	8.2	7.2	7.1	7.0	6.8
S_4P_2(950 g Sugar:2 g Pectin)	7.9	7.9	7.7	7.5	7.4	7.3	7.2
S_4P_3(950 g Sugar:4 g Pectin)	8.1	8.2	8.1	8.0	7.9	7.8	7.5
S_5P_1(1050 g Sugar)	8.3	8.4	7.6	7.2	7.0	6.9	6.5
S_5P_2(1050 g Sugar:2 g Pectin)	7.4	7.5	7.6	7.5	7.4	7.3	7.3
S_5P_3(1050 g Sugar:4 g Pectin)	7.7	7.8	7.7	7.2	7.0	6.9	6.7
S_6P_1(1150 g Sugar)	6.2	5.0	5.9	4.8	4.7	4.6	4.5
S_6P_2(1150 g Sugar:2 g Pectin)	5.5	5.5	5.3	5.1	5.0	4.9	4.5
S_6P_3(1150 g Sugar:4 g Pectin)	5.5	5.1	5.1	4.8	4.5	4.4	4.3

Table 4: Effect of different sugar and pectin combination on Taste of mandarin jam

Treatments	Taste						
	0 days	30 days	60 days	90 days	120 days	150 days	180 days
S_1P_1(650 g Sugar)	5.5	5. 6	5.6	5.3	5.0	4.8	4.4
S_1P_2(650 g Sugar: 2 g Pectin)	5.5	5.8	5.9	5.2	5.0	4.6	4.5
S_1P_3(650 g Sugar:4 g Pectin)	5.3	5.5	5.5	5.1	5.0	4.7	4.6
S_2P_1(750 g Sugar)	6.5	6.6	6.7	6.5	6.4	6.3	6.2
S_2P_2(750 g Sugar:2 g Pectin)	6.5	6.5	6.8	6.3	6.2	6.1	6.0
S_2P_3(750 g Sugar:4 g Pectin)	6.6	6.8	6.5	6.2	6.1	6.0	5.9
S_3P_1(850 g Sugar)	7.8	7.8	7.5	7.3	7.2	7.1	7.0
S_3P_2(850 g Sugar:2 g Pectin)	8.5	8.5	8.4	8.4	8.3	8.2	8.0
S_3P_3(850 g Sugar:4 g Pectin)	8.0	8.0	7.9	7.7	7.6	7.5	7.4
S_4P_1(950 g Sugar)	7.5	7.5	7.5	7.2	7.1	7.0	6.9
S_4P_2(950 g Sugar:2 g Pectin)	7.6	7.7	7.7	7.5	7.4	7.3	7.2
S_4P_3(950 g Sugar:4 g Pectin)	7.4	7.6	7.5	7.3	7.2	7.1	7.0
S_5P_1(1050 g Sugar)	6.7	6.9	6.7	6.5	6.4	6.2	6.1
S_5P_2(1050 g Sugar:2 g Pectin)	6.6	6.8	6.8	6.6	6.5	6.4	6.3
S_5P_3(1050 g Sugar:4 g Pectin)	6.3	6.5	6.4	6.2	6.1	6.0	5.9
S_6P_1(1150 g Sugar)	5.0	5.1	5.0	5.0	4.9	4.8	4.7
S_6P_2(1150 g Sugar:2 g Pectin)	5.3	5.2	5.0	5.0	4.9	4.8	4.7
S_6P_3(1150 g Sugar:4 g Pectin)	5.2	5.2	5.0	5.0	4.8	4.7	4.5

Table 5: Effect of different sugar and pectin combination of Mandarin Jam on Spoilage

Treatments	Microbial spoilage						
	Storage in days						
	0 days	30 days	60 days	90 days	120 days	150 days	180 days
S_1P_1(650 g Sugar)	×	×	×	✓	✓	✓	✓
S_1P_2(650 g Sugar: 2 g Pectin)	×	×	×	✓	✓	✓	✓
S_1P_3(650 g Sugar:4 g Pectin)	×	×	×	✓	✓	✓	✓
S_2P_1(750 g Sugar)	×	×	×	×	×	×	×
S_2P_2(750 g Sugar:2 g Pectin)	×	×	×	×	×	×	×
S_2P_3(750 g Sugar:4 g Pectin)	×	×	×	×	×	×	×
S_3P_1(850 g Sugar)	×	×	×	×	×	×	×
S_3P_2(850 g Sugar:2 g Pectin)	×	×	×	×	×	×	×
S_3P_3(850 g Sugar:4 g Pectin)	×	×	×	×	×	×	×
S_4P_1(950 g Sugar)	×	×	×	×	×	×	×
S_4P_2(950 g Sugar:2 g Pectin)	×	×	×	×	×	×	×
S_4P_3(950 g Sugar:4 g Pectin)	×	×	×	×	×	×	×
S_5P_1(1050 g Sugar)	×	×	×	×	×	×	×
S_5P_2(1050 g Sugar:2 g Pectin)	×	×	×	×	×	×	×
S_5P_3(1050 g Sugar:4 g Pectin)	×	×	×	×	×	×	×
S_6P_1(1150 g Sugar)	×	×	×	×	×	×	×
S_6P_2(1150 g Sugar:2 g Pectin)	×	×	×	×	×	×	×
S_6P_3(1150 g Sugar:4 g Pectin)	×	×	×	×	×	×	×

Conclusion

A sensory investigation of 18 different combinations of mandarin jam revealed that the 850g sugar and 2g pectin mandarin orange jam was judged to be appropriate for storage for up to 90 days. In terms of organoleptic evaluation, the treatment combination S3P2 (sugar 850 g + pectin 2 g) received the greatest score for overall acceptability score for appearance, taste, and color. Jam's sensory qualities were unchanged throughout storage for up to 60 days. At 90 days to 180 days, there was a reduction in look, texture, taste, color, and general acceptability. All jam that had been stored for 90 days or more was perfectly OK. Microbial deterioration was discovered in treatment combinations S1P1, S1P2, and S1P3 with 650 g of sugar concentration after 90 days of storage, but other treatment combinations remained spoilage-free for up to 180 days. According to organoleptic features, particularly flavor and color formed in jam, jam prepared with (850 g:2 g) sugar and pectin ratio was found to be most acceptable.

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