**ASSESSMENT OF PHYSICOCHEMICAL AND SENSORIAL STABILITY OF MANGO MARMALADE USING DIFFERENT MANGO VARIETIES**

 \*Muhammad Asif Khan1, Farrukh Faiz2, Allah Rakha3 Madhia Rohi3, Taqi Raza1, Yasmin Bano1, Muhammad Naveed4

University of Agriculture Faisalabad Sub Campus Burewala, Vehari, Pakistan1

Department of Agriculture and Food Technology, Karakoram International University, Gilgit, Pakistan2

Department of food Science and Technology Govt. College Women University Faisalabad3

Department of Environmental Science, Comsat University Vehari Campus4

**\*Corresponding author:** asifkhan.muhammad@gmail.com

**Abstract**

Every year, millions of tons of agriculture-based industrial waste is produced, which is creating major waste disposal problems as well as serious environmental issues. The waste which comes from vegetables and fruits is a rich source of bioactive components, dietary fibers, oils and these are used in the production of various valuable, healthy, nutritious and economical products. Among all the tropical fruits, mango is the most significant and known as the king of all fruits because of its flavor, nutritional and sensory qualities. In a mango waste, 15-20% is a peel waste, which comprises of a large amount of very important and useful antioxidants and phytonutrients. The following study will comprise checking the storage stability of mango peel and checking its nutritional profile in the developed functional product. The mango peel and pulp were evaluated for its proximate contents. Then we made marmalade using different mango varieties peel. Then the proximate test was done on developed mango marmalade. Phenolic contents of marmalades show a decreasing trend with maximum phenols present in T2=90.92 mg GAE/100g. Antioxidant activity of all treatments also shows the same behavior with maximum antioxidants present in T1=74.69 %. The prepared marmalade was then stored for 0, 30 and 60 days to evaluate its sensory and physicochemical behavior. During this span, its color and texture, pH, sugar contents, viscosity, total plate count and water activity were analyzed and sensory evaluation was done. Total sugar content of all treatments increases with time (T2=70.05> T1=52.66 > T4=44.73> T3=35.70). All treatments were liked by the panel but T2 was overall preferred. Their order of overall acceptance were T2=8.00> T1=7.00> T3=6.50> T4=6.00.

**Keywords:** Mango production and losses, Physicochemical and sensorial stability of mango, Antioxidant activity in mango

**INTRODUCTION**

In tropical fruits, Mango is most popular fruit in Asia. Production wise mango gets 5th position. Pakistan is the 5th largest mango producing country. Pakistan is producing 1,753,686 tons of mango by the record of year 2009. In Pakistan, we possess varieties which have a mesmerizing aroma and beautiful peel colors. Famous varieties of Pakistan are dusehri, chaunsa, Anwar Ratole, Sindhrietc (FAO, 2009). Mango contains significant amount of polyphenols. Which is known for its anticancerous and antioxidant activity. Along with phenolic compounds fruits also contains numerous amount of carotenoids, flavonoids, tocopherols, ascorbic acid and other many components which have a numerous health benefits to human (Leontowicz*et al*., 2003).

Fruit and vegetables industries are producing large amount of processing waste in Pakistan. These industries are facing many problems regarding management, processing of fruits and vegetables, pollution, environmental issues and economic issues. The waste created by these industries are rich in various valuable components such as, phenolic, flavonoids, anthocyanins etc. These components have a healthy effect on human health as well. If we take mango industry where peel and kernel of mango is wasted in large amount, these can be used to produce various valuable products. Peel is 15-20% and kernel is 9-24% of the total fruit, while the pulp varies from 33-85% (Ajila*et al*., 2007a).

According to the modern research, if we are not utilizing peel and kernel of mango then we are wasting round about 35-60% of fruit from the total mass of the fruit. As world is getting polluted day by day it is our moral duty to save this earth. Food is a blessing so we should not waste it like that, we came to see the importance of food from African people who are not even getting a slice of food. Also this large amount of food waste create many disposal problems. And it is also polluting water underneath. Many scientists are studying to utilize mango kernel as a fat replacer, an antioxidant, starch, in feeds etc (Arogba, 2002; Kaur *et al*., 2004).

Where kernel is being used as a fat replacer, the mango peel also has a tremendous benefits. Many scientists have reported mango peel significant as an antioxidant and is anticancer us. In Pakistan mango has a definite season in which it grows, that starts from april. According to the analysts, only 20% of the whole fruit mass of the mango it is used in making foodstuffs like canned mango slices, nectar, pickles, purees etc. These products are globally appreciated as well. In industries, mango peel is being wasted in a large amount. Peel disposal is also a major problem. We should promote new ways in which this waste can be utilized in such a way that it will benefit both industries and also human health. It will benefit human health in such a way as it contains many beneficial nutrients and vitamins such as vitamin E, ascorbic acid and also it has a redical scavenging potential in it (Ajila*et al*., 2007b).

From nutrition point of view mango is very good for health and have a plenty of health benefits. Such as it contain numerous natural antioxidants like ascorbic acid carotenoids. *B*-carotene is mostly abundant in mango varieties. It is a precursor of vitamin A. which we all know helps in vision, strengthen immunity and helps in production. As it is an antioxidant it helps in scavenging free oxygen redicals (Shieber*et al*., 2000). This type of action in body is helpful for prevention of cancer & various heart diseases (Kris-Etherton*et al*., 2002). Antioxidant activity of mango varies from each other due to various reason. These changes occur in mango because of varietal difference. Some other reason include genotypic difference, harvesting difference, farming practices or climate (Lee and Kader, 2000).

Phenolic compounds are present in all plants. These consist of phenolic acids, flavonoids, glycosides & anthocyanins. Polar substances increase fats and oil stability. For this purpose polar substance such as lignin or resins added in fat for heat stability. These polar substances prevents food from dispersions. In tea leave, cocoa beans high amount of phenolics are present. Many tries to increase blood antioxidant level but they fail. Because some of them are readily absorbed in intestinal walls already and became inactivated (Pakorny, 2006).

**Material and Methods**

**Procurement of Raw Material**

Fresh mangoes was collected from local market. All four varieties Anwar rataul, Sindhri, Chaunsa and Dasehri was collected from local market. They were checked for any physical damage also for any insect, pest attack. They were checked for any fungal attack also. To make mango marmalade mangoes selected should be close to their full ripeness, but not full ripe. Mangoes collected were then washed and dried. Then they were ground to obtain fine powder. Then we do the proximate analysis of all the four varieties of mango.

**Development of Mango Marmalade**

Pulper was used to make fine pulp of all the four varieties of mango. They were then pasteurized and then we add chemicals to preserve them. Citric acid was added in it to preserve it for longer period of time. Then to make marmalade in an open kettle we first add pulp, sugar and at the same time pectin was also added. Then it was allowed to cook. After some cooking we add shreds of mango peels. They were added earlier so that their density matches with the pulp. If they were added at last they will come at the top of the jar. While making, I keep checking the brix of the marmalade with refractometer. So that required brix can be achieved at the end which was 68-700 Brix. When we achieved the required brix we add sodium benzoate as a preservative, color and flavor at the end. Then we stop the heating and fill it in jars for further evaluation.

**Table No. 1.** Treatment Plan

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Varieties** | **Peel concentration (g)** |
| **T1** | Anwar Rataul | 20 |
| **T2** | Chaunsa | 20 |
| **T3** | Dasehri | 20 |
| **T4** | Sindhri | 20 |

**Functional Assessment**

**Total Phenolic Content (TPC)**

Folin-Ciocalteu method was used to calculate total phenols in our marmalade sample of four different varieties (Morelli and Prado, 2009). 1 ml of sample was taken and it was added with 1% 5ml Folin-Ciocalteu and 20% 4ml sodium carbonate. It was then incubated for 1 hour. Absorbance of results was measured at 765 nm with the appearance of blue color on UV visible spectroscopy. Standard is galic acid in this procedure. We quantify the results by calibrating our sample results with the curve of our standard galic acid. To make calliberated curve of galic acid 1 ml aliquots of galic acid ranging from 0.01 to 0.10 mg/ml were added with methanol. They were then mixed with 5ml ten times diluted Folin-Ciocalteu and 20% of 4 ml sodium carbonate. Then its absorbance was measured at 765 nm at spectroscopy after 60 minutes. Its absorbance was calculated as reference to concentration of total phenolic contents in sample. The concentration measured was referred as a galic acid equivalent and calculated by the formula given below

T = C × V / M

**DPPH**

Thaipong*et al*., (2006) protocol was used in our experiment to calculate the free antioxidant activity of sample. DPPH assay were used. We dissolve it in freshly made methanol solution. Then we take 0.004% of 1 ml DPPH solution and mixed with 3 ml of our sample. It was mixed in different concentration and then held in dark for about 30 minutes. Its absorbance was checked at 517 nm using spectroscopy. Its absorbance at this range indicates the presence of its radical scavenging phenomenon. Then we found out the radical scavenging activity of butylated hydroxyl toluene and of ascorbic acid by taking them as standard. Callibration was done by taking them as a standard and perform the reaction without our sample. They were taken as a control readings or as a blank sample. It is then calculated by formula given below

DPPH Inhibition (%) = Absorbance of blank - Absorbance of Sample/Absorbance of blank ×100

**pH Determination**

pH meter was used to find out the pH value of our mango marmalade. We follow the protocol of Touati*et al*., (2014). pH was found out during first day of making then after 30 and 60 days later. Buffer solution of pH 4 and pH 7 were taken as a standard for pH meter. Then we take our marmalade sample in a beaker which was well mixed and representative. The electrode of pH meter which comes in contact with our sample is first cleaned by dipping it in distilled water for some time to neutralize it. Then we dip this electrode in our sample and check the readings.

**Viscosity**

In jams, jellies and marmalades pectin is used in their making. Which is the main ingredient needed for binding of materials. So in marmalades the degree of viscosity depends on pectin esterification ability, its pH conditons and third on the type of pectin used for the process. We follow the protocol given by AOAC (2006) to found out the viscosity of marmalade sample. Viscometer is used for this purpose. Round about 200g of marmalade sample was taken in container and spindle is immersed in sample. Then the other spindle is inserted in sample and readings were recorded.

**Total Plate Count**

To check out the presence of microbes present in food we perform this test. Microorganism produce severe health problems in humans and also spoils the food if they are not controlled and checked. We determine the microorganisms in our marmalade at different storage intervals so that it will be controlled and our product be saved. It produces foul smelling, changes color, taste and mould growth on product. Similarly in humans they cause problems like food poisoning and diarrhea and other fatal diseases. Microorganism not all the times are dangerous. In some cases it is needed to produce very beneficial and healthy products such as cheese, pickles, yoghurt and sausages.

Total plate count was determined by following the protocol of AOAC (2006). In this we took 1g of sterile sample. It was placed in sterile paper with the help pf sterile spoon. Then it was transferred to sterile blender. Buffered phosphate diluent (9ml) was added in it. It was then mixed in blender for about 60 to 120 seconds until it was thoroughly mixed. After this decimal dilution process was performed by transferring the 1ml of previous dilution to the next 9 ml dilution tube. All tubes were well shaken. The material which was settled during this process, was again suspended by performing agitation. Then after agitation, we transfer 1ml of dilution from each tube to its duplicate named petri dish. About 15 ml of agar was poured in to these plates and and then allowed to solidify. Then we pour dilution to each plate. Then we mixed dilution and agar on plate’s surface. Petri dishes were then inverted and incubated for 2 days at 350c temperature. Then we count colonies on these plates ranging from 30 to 300 colonies. They were then multiplied by dilution factor and then average was concluded.

**Water Activity**

We follow the procedure given by Piga*et al*., (2005) to determine the water activity of our marmalade sample. As marmalades have a high amount of moisture content but their moisture is usually bound to the sugar and hence it becomes unavailable to microorganism. So to determine the water activity of our sample we use hygropalm water activity meter. It was first calibrated with the standard before using it to marmalade sample. The readings of our sample will be seen on digital display of machine at room temperature.

**Sensory Evaluation**

Sensory analysis is a vital tool in food technology, it can be used for the development of new product. It is a scientific discipline which measures and evaluate the human reaction to the composition of food or drink. Other than taste sensory properties of product include its smell, color, texture and how it appears. These all attributes plays vital role in consumer liking. It helps the retailer and manufacturer to know what consumer think of their product. It also ensure the our production line was carried out in line.

For sensory evaluation of mango marmalade we used bread as a carries for our marmalade. Bread was chosen because people likes it more with the bread as spread. All the four samples were then introduced to 10 experienced panelist who were consumer of jams or marmalades. All panelist were served with four sample which were spread on single slice of plain bread. All the panelist were given sensory evaluation performa. They checked the sample one by one with no restriction of rechecking. Sensory attributes included in our performa were marmalade color, texture, its spreadability and marmalade overall acceptability. It was a nine point scale system which ranges from extremely dislike at no. 1 to extremely like at no. 9 (Meilgaard*et al*., 2007).

**Statistical Analysis**

All the test of our marmalade samples were carried out in triplicates. Data was then statistically analyzed using ANOVA table. Mean comparison was taken using Least Significance Difference test with level of significance 5% (Masson *et al*., 2003).

**Results and Discussion**

**Total phenolic content (TPC)**

The mean values of four marmalades were T1= 88.61 mg GAE/100g, T2 = 90.92 mg GAE/100g, T3 = 87.98 mg GAE/100g and of T4 = 83.57 mg GAE/100g. It is evident from the results that the treatment T2 has highest amount of total phenolic content present in it as compared to other treatments. While T4 has the minimum amount of phenolic content present in it.

Mean values of total phenolic content present in mango marmalade decreased from 91.73 mg GAE/100g at 0 day to 83.99 mg GAE/100g at 60 day. It is found that total phenolic content present in mango fruit is more than it is present in mango marmalade. This is due to the fact that when we cook mango for marmalade due to heating many cell structures damage which cause reduction on total phenols present in marmalade.

The results which we obtained found relatively close with the results found by Rababah et al., (2011) who discovers that strawberry fruit contain more amount of TPC which is 1693.55 mg GAE/100g than its jam. In jam after processing its total phenolic content reduced to 848.86 mg GAE/100g. After being stored for 60 days it further reduced to 77.825 mg GAE/100g.

**Table No. 2.** Means of TPC of Different Treatments during Storage

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Day 0** | **Day 30** | **Day 60** | **Treatment mean** |
| **T1** | 91.52 | 88.18 | 86.12 | 88.61 |
| **T2** | 93.07 | 91.28 | 88.41 | 90.92 |
| **T3** | 92.12 | 88.54 | 83.27 | 87.98 |
| **T4** | 90.21 | 82.33 | 78.17 | 83.57 |
| **Days mean** | 91.73 | 87.58 | 83.99 |  |

**DPPH**

Mean value of treatment T1 is 74.69%, T2 71.65%, T3 68.74 and of T4 63.79%. It is clear from the table 4.9b that T1 has maximum amount of radical scavenging activity present in it. While T4 which is Sindhri variety has the lowest amount of antioxidant activity present in it. From the table it may be noted that the mean values for antioxidant activity during storage interval is decreasing from 77.13% at 0 day to 61.30 at 60 day. It was due to the fact that antioxidant activity of fresh fruit is higher than the processed item. Temperature has a main role in reduction of antioxidant activity after storage. Antioxidant activity is lost during marmalade formation due to heating. Heating cause development of Millard product.

The data which I collected from this research was closely related with research of Rababah*et al*., (2011) who also noted the difference in radical scavenging activity of strawberry fruit 84.91%. Which after processing in to jam reduced to about 59.38%. After the storage interval of 15 days at different temperature he noted values as at 250C 55.13% at 450C 29.82% and at 550C 16.95%.

Wicklund*et al*., (2005) found out that the main factor in reduction of antioxidant activity is temperature. He analyzed strawberry jam for 3 months at 4 and 200C. Similarly, Scibisz and Mitek (2009) found out that during jam formation antioxidant activity of fruit was lost to about 13-19 %. Kim and Zakour (2004) reported that antioxidant activity of cherry and raspberry was reduced after jam formation.

**Table No. 3.** Means of DPPH of Different Treatments during Storage

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Day 0** | **Day 30** | **Day 60** | **Treatment mean** |
| **T1** | 79.18 | 76.48 | 68.41 | 74.69 |
| **T2** | 81.57 | 73.21 | 60.18 | 71.65 |
| **T3** | 75.32 | 69.68 | 61.21 | 68.74 |
| **T4** | 72.45 | 63.55 | 55.38 | 63.79 |
| **Days mean** | 77.13 | 70.73 | 61.30 |  |

**PH**

Mean values related to the pH of mango marmalade for treatments varies from 3.22 to 3.75. Mean values for different treatment of mango marmalade are as for T1 3.75, T2 3.58, T3 3.40 and for T4 3.22. T1 has the highest value of mean which is 3.75 while T4 has the lowest value. Mean values of pH decreased during storage time from 3.56 at 0 day to 3.41 at 60 day. This change is associated with the change in acidity of sample during storage. As acidity increases during storage time and acidic compounds are formed.

The results which I conducted from my research is in accordance with the Hussain and Shakir (2010), according to them pH values of apricot and apple jam was decreased during storage from 3.75 to 3.10 at 60 day. Shakir*et al*., (2007) reported same results for mixed fruit jam of apple and pear. He reported that the pH decreased from 3.54 to 3.45 during 90 days interval. Mango jam made with different mango varieties show similar behavior of reduction in pH during 150 days of storage (Safdar*et al*., 2012). Diet apple jam made by Muhammad *et al*., (2008) noted the decline in pH from 4.34 to 3.00 in 90 day interval. My present research is closely matches with the research of Bajwa*et al*., (2003) who noticed reduction in pH of grapefruit apple marmalade from 3.26 to 3.18 in 60 days.

**Table No. 4.** Means of pH of Different Treatments during Storage

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Day 0** | **Day 30** | **Day 60** | **Treatment mean** |
| **T1** | 3.89 | 3.76 | 3.59 | 3.75 |
| **T2** | 3.62 | 3.58 | 3.55 | 3.58 |
| **T3** | 3.43 | 3.40 | 3.38 | 3.40 |
| **T4** | 3.31 | 3.25 | 3.10 | 3.22 |
| **Days mean** | 3.56 | 3.50 | 3.41 |  |

**Viscosity**

Mean values regarding the treatments are as follows 124.22, 131.35, 131.56 and 146.66 for T1, T2, T3 and T4 respectively. T4 has the maximul mean value of viscosity while T1 has the lowest mean value. Storage mean values showed that there is a gradual increase in viscosity of marmalade during storage time. Which can be seen in table 4.16b. It increases from 119.66 at 0 day to 154 at 60 days. It is due to the cross linking of of carboxyl group with adjacent polyuronide through calcium ions. Which ultimately increases the viscosity of marmalade with time.

The results obtained from present research was closely matches with the research of Rababah*etal*., (2011). Who found an incline in viscosity of strawberry jam during storage from 0.55 to 0.69 in 2 months. The main fact of increasing of viscosity with time is that with time moisture content of marmalade decreases as a result viscosity increases.

**Table No. 5.** Means of Viscosity of Different Treatments during Storage

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Day 0** | **Day 30** | **Day 60** | **Treatment mean** |
| **T1** | 121.00 | 101.66 | 150.00 | 124.22 |
| **T2** | 117.00 | 134.67 | 142.37 | 131.35 |
| **T3** | 110.67 | 130.33 | 153.67 | 131.56 |
| **T4** | 129.97 | 140.00 | 170.00 | 146.66 |
| **Days mean** | 119.66 | 126.67 | 154.01 |  |

**Total Plate count**

Mean values of total plate count of T1 is 1654.50, T2 has 1777.33, T3 has 1769.17 and T4 has 1677.80 total plate count mean. It can be noted from table 4.17b that mean values of treatment during storage changes gradually from 1629.00 at 0 day to 1826.48 at day 60.

Results from present research matches with the results founded by Al-Hooti*et al*., (2000). Who studied chutney by using dates. He reported that total plate count increases from 2.70 to 24.71 log10 CFU/g. Dalton *et al*., (2006) made microbiologically and sensorial wise acceptable sandwich spread SFSS. Its total plate count was determined after 20 days at 50C and 150C. They were found quite acceptable.

**Table No. 6.** Means of Total Plate Count of Different Treatments during Storage

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Day 0** | **Day 30** | **Day 60** | **Treatment mean** |
| **T1** | 1567.30 | 1623.80 | 1772.40 | 1654.50 |
| **T2** | 1665.40 | 1794.30 | 1872.30 | 1777.33 |
| **T3** | 1695.30 | 1757.00 | 1855.20 | 1769.17 |
| **T4** | 1588.00 | 1639.40 | 1806.00 | 1677.80 |
| **Days mean** | 1629.00 | 1703.63 | 1826.48 |  |

**Water activity**

Mean values related to treatment of water activity of mango marmalade were 0.61 for T1, 0.63 for T2, 0.58 for T3 and 0.61 for T4. It can be noted from table 4.18b that T2 has the maximul value of water activity among all. It can be seen from table 4.18b that there was a reduction in water activity means value of different treatment during storage. It decreases from 0.63 at 0 day to 0.60 at day 60. This effect may be noticed because of moisture loss during storage. Or may be because of decline in moisture content, TSS or total sugar which bind water. As a result water activity decreases.

The data collected from recent research is closely related with the findings of Howard *et al*., (2010). Who noticed the water activity of blueberry sugar free jam was 0.998 while of blueberry sugar jam was 0.850. According to the research by Menezes *et al*., (2011) water activity of guava preserve was remain unchanged during storage.

**Table No. 7.** Means of Water Activity of Different Treatments during Storage

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Day 0** | **Day 30** | **Day 60** | **Treatment mean** |
| **T1** | 0.61 | 0.61 | 0.60 | 0.61 |
| **T2** | 0.63 | 0.63 | 0.63 | 0.63 |
| **T3** | 0.61 | 0.57 | 0.57 | 0.58 |
| **T4** | 0.64 | 0.60 | 0.59 | 0.61 |
| **Days mean** | 0.63 | 0.60 | 0.60 |  |

**Sensory Evaluation**

Mango marmalade was assessed through 9 point hedonic scale system. Mango marmalade samples were tested by random peoples. Flavor is the combination of essence and mouth feel of the product. T2 showed the maximum acceptability out of all treatments.

**Table No. 8.** Means for Sensory Evaluation of Overall Acceptability

|  |  |
| --- | --- |
| **Treatments** | **Means** |
| **T1** | 7.00 |
| **T2** | 8.00 |
| **T3** | 6.50 |
| **T4** | 6.00 |

**Conclusion**

The present research shows that the mango marmalade is healthy and nutrient rich product. The storage study of mango marmalade was done after 0, 30, and 60 days interval at room temperature. It is clearly be seen from research that all treatment were made from different mango variety. These all treatments were found acceptable after 60 days interval but overall T2 was the most appreciable treatment among all. Which was made from Chaunsa variety.

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