Chemical-Free Tutti Frutti: A Green Approach Using Muskmelon Rinds

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ABSTRACT

This study investigates the proximate analysis and sensory evaluations and consumer preferences of tutti frutti made from muskmelon rind (Cucumis melo) using three distinct preparation methods: traditional sugar syrup, citric acid preservation, and natural colorants. The nutritional analysis reveals that while fresh muskmelon rind is low in calories and sugar, the sugar syrup method significantly increases these metrics, potentially deterring health-conscious consumers. In contrast, the citric acid and natural colorants methods provide moderate caloric increases while enhancing fiber and vitamin C content. Sensory evaluations indicate that the sugar syrup method is preferred for its sweetness (average score: 8.25), while the citric acid method excels in color and texture, receiving high scores as well. Consumer surveys show strong market potential, with 80% of participants indicating a willingness to purchase muskmelon rind tutti frutti, particularly favoring the sugar syrup method (60%). The findings suggest that muskmelon rind tutti frutti, especially when prepared using the sugar syrup method, holds substantial market potential and aligns with consumer preferences.

Muskmelon (*Cucumis melo* L.), also known as nutmeg melon or kharbooj, belongs to the Cucurbitaceae family and is valued for its unique flavor and taste. It is rich in vitamins A and C, composed of approximately 90% water and 9% carbohydrates, and grows best in well-drained loamy to sandy loamy soils. The fruit varies in size, shape, and rind texture, which can be smooth, ribbed, netted, or furrowed.

Food waste management is a growing concern, and utilizing fruit rinds for value-added products presents a sustainable solution. This study explores the potential of muskmelon rinds as a raw material for the production of tutti frutti without artificial colors or chemicals. The rinds were cleaned, cut into small cubes, and subjected to natural pre-treatment involving blanching, slow sugar infusion, and natural coloring from fruit and vegetable extracts. Various concentrations of sugar syrup were tested to determine the optimal formulation. Sensory evaluation was conducted using a panel to assess taste, texture, color, and overall acceptability. Physicochemical analyses, including moisture content, total soluble solids, and nutritional composition, were performed to compare the developed product with conventional tutti frutti.

The results demonstrated that muskmelon rind tutti frutti had excellent sensory properties and good nutritional value, making it a viable and eco-friendly alternative to traditional tutti frutti. This study highlights an innovative approach to food waste utilization while promoting sustainable and natural food processing practices.(e.g., Keywords: Muskmelon (Cucumis melo L.), Tutti Frutti, Sustainable Processing, Blanching, Natural food processing, Sugar infusion, Natural coloring, Value-added products, Food waste management, Cucurbitaceae family, Proximate analysis, Sensory evaluation, Nutmeg melon)

INTRODUCTION

Muskmelon, also known as Cantaloupe Melon, is a sweet and juicy fruit that is perfect when consumed during summer due to its high water content.

The health advantages of Muskmelon can be found in every part of the fruit.

It is widely grown in India and is popular in all of the country's regions. Muskmelon is high in minerals, antioxidants and other wholesome properties.

Nutritional Facts of Muskmelon

Muskmelon is water like any other melon. Over 90 percent of Muskmelon is water. This doesn't make them fall short of other vital nutrients.

The muskmelon nutrition content in 100 g is :

Calories - 25 Kcal

Carbohydrates - 4.64 gram

Protein - 0.48 gram

Fat - 0.37 gram

Dietary Fibre – 1.79 gram

Muskmelon rind contains a variety of nutrients, including fiber, vitamins, and minerals. It's particularly rich in vitamins A and C, and also contains potassium, magnesium, and folate. While less common to eat, the rind can be a source of these essential nutrients.

Nutritional Breakdown:

Fiber**:**

Muskmelon rind is a good source of dietary fiber, which is important for digestive health.

Vitamins**:**

It's rich in Vitamin A, which is important for vision and immune function, and Vitamin C, a powerful antioxidant.

Minerals**:**

Muskmelon rind contains potassium, which helps regulate blood pressure, and magnesium, which is important for muscle and nerve function.

Other Nutrients:

It also contains smaller amounts of folate, niacin, and other essential nutrients.

Benefits:

Digestive Health: Fiber helps to promote healthy digestion and regularity.

Immune System Support: Vitamins A and C can help strengthen the immune system.

Antioxidant Properties: Vitamin C and other antioxidants can help protect the body against damage from free radicals.

Hydration: Muskmelon's high water content helps with overall hydration.

Nutrient	**Amount**	**% Daily Value**	**Nutrient**
Calories	34 kcal	–	Calories
Total Fat	0.2 g	0%	Total Fat
– Saturated Fat	0.1 g	0%	– Saturated Fat
Cholesterol	0 mg	0%	Cholesterol
Sodium	16 mg	0%	Sodium
Potassium	267 mg	7%	Potassium
Total Carbohydrate	8 g	2%	Total Carbohydrate
– Dietary Fiber	0.9 g	3%	– Dietary Fiber
– Sugar	8 g	–	– Sugar
Protein	0.8 g	1%	Protein
Vitamin C	–	61%	Vitamin C
Calcium	–	0%	Calcium
Iron	–	1%	Iron
Vitamin D	–	0%	Vitamin D
Vitamin B6	–	5%	Vitamin B6
Cobalamin (Vitamin B12)	–	0%	Cobalamin (Vitamin B12)
Magnesium	–	3%	Magnesium

India is one of the world's leading producers of fruits, contributing significantly to global horticultural production. With the rapid expansion of the food processing industry, often regarded as a sunrise sector, the generation of fruit processing waste has become a critical

concern. The sector produces a wide range of processed products, but it also generates substantial solid and liquid waste, including peels, skins, seeds, stones, and pulp residues. If not managed properly, these byproducts result in economic losses for producers and contribute to environmental pollution through microbial spoilage and improper disposal.

Fruit processing industries discard a significant portion of raw materials, leading to high wastage rates in horticultural produce. For instance, muskmelon accounts for 40% waste, while mango, watermelon, pineapple, orange, and banana have wastage rates ranging between 30% and 50%. The accumulation of these organic wastes near processing units fosters unwanted microbial growth, emitting foul odors and posing a risk of pathogenic bacterial activity, which can further lead to health hazards and disease outbreaks. Conventional disposal methods, such as landfilling or incineration, are not sustainable due to their adverse environmental impact and contribution to greenhouse gas emissions.

However, fruit processing waste is rich in bioactive compounds and has significant potential for value-added applications. These discarded materials contain dietary fiber, antioxidants, pectin, enzymes, organic acids, essential oils, and food additives, which can be harnessed for commercial use in food, pharmaceutical, and cosmetic industries. Sustainable waste management strategies, including recycling, upcycling, and bio-conversion, can transform fruit processing byproducts into economically viable resources, reducing environmental burdens and promoting a circular economy.

In this context, utilizing muskmelon rinds for the production of tutti frutti presents a promising approach to minimize waste, enhance resource efficiency, and introduce a novel, natural, and cost-effective alternative to conventional tutti frutti. This study aims to develop a chemical-free, naturally processed tutti frutti from muskmelon rinds, thereby contributing to sustainable food processing practices while addressing the issue of fruit waste disposal.

REVIEW OF LITERTURE

History of Muskmelon

Muskmelon (Cucumis melo L.), belonging to the Cucurbitaceae family, has a history spanning over 4,000 years. It was first cultivated in ancient Egypt, Persia, and India, where it was valued for its sweet taste and refreshing qualities. The name "muskmelon" comes from the Latin word

"muscus," referencing its musky aroma. The fruit spread across the ancient world through trade routes, with early mentions by Theophrastus in ancient Greece. In the 16th century, it was introduced to the Americas by European colonists. Today, muskmelon is widely grown in warm climates across the globe, with major production in India, China, and the United States. The fruit is rich in vitamins A and C and has gained attention for its potential in sustainable agriculture and food waste management, particularly through the utilization of its rinds in value-added products like tutti frutti.

Muskmelon product

Muskmelon is used in various products due to its sweet flavor and high nutritional value. Common muskmelon products include fresh fruit slices, muskmelon juice, and dried muskmelon snacks. The fruit is also used to make canned products, jams, and sweets like tutti frutti and halwa. Muskmelon seeds are processed into oil or roasted for snacks, while the rinds can be pickled or dried into powder. These products highlight the versatility of muskmelon in both traditional and innovative food applications.

Preservation

Preservation by Acids:

Low acid foods are spoilt rapidly. Highly acidic environment inhibits the growth of food spoilage organisms. Lowering the protein of certain foods by anaerobic fermentation, action on carbohydrates producing lactic acid is one of the methods of food preservation. The same spoilage inhibitory effects can be produced by acidic additives such as vinegar or citric acid. Nutrients losses through fermentation are small. In fact, in certain cases, the nutrient levels are increased particularly through microbial vitamin and protein synthesis.

Acid conditions inhibit the growth of many microorganisms hence organic Acids are added to or allowed to form in goods to preserve them. Acetic (vinegar) citric (lime juice) and lactic many products. Onions are bottled in vinegar with a little salt. Vinegar is also added to pickles, chutneys, sauces and prevent mold growth.

Preservation by Drying

This process is analogous to the concentration process it is done in the same way as milk drying. The juice is sprayed in the form of a very tine mist into an evaporating chamber through which hot air is passed. The temperature of the chamber and the blast of the air are so regulated

that only dry juice falls on the floor of the chamber in the form of a fine powder. The powder is collected and packed in dry containers which are then closed air- tight. The powder when dissolved in water make a pleasant fruit drink practically similar to the original fresh juice. Fruit juice powders are highly hygroscopic and require special care in packing. All juice powders are highly hygroscopic and require special care in packing. All juice do not, however dry readily without special treatment Siddappa and Girdhari Lal have developed and patented a process for the preparation of fruit juice powders. In the case of orange juice, the powder which is prepared according to this process, it should be packed in free flowing powder form in hermetically sealed container with in package desiccant to prolong shelf-life of the product. Freeze drying, foam-mat drying etc. Is other recent method of preparing fruit juice powder. Fruit flavors also can be prepared in free flowing powder form using materials such as gums, sorbitol etc; to seal the flavor in tiny globules. The free flowing flavor powders can be mixed with fruit juice powders to enhance their taste and flavor there has been in recent years consider able interest in the manufacturing of fruit juice powder.

MATERIAL

4.1.1.Ingredients

Muskmelon rind: The inner lining of the rind is green and the flesh of the ripe fruit is orange. Rind is rich in beta-carotene, which our bodies change into vitamin A. vitamin A is needed to keep our eyes and skin healthy and our immune system working efficiently.

Muskmelon rinds are also an excellent source of vitamin C. vitamin C help ti maintain healthy skin and gums, stimulates wound healing, enables the body to make the collagen found in muscles and skin, and helps iron to be absorbed in the small intestine. It may also improve the functioning of the immune system, although evidence for this is mixed. Vitamin A and C are antioxidants present in the rind.

Sugar:

Botanical name is Saccharum officinarum

Sugar is the generic name for sweet-tasting, soluble carbohydrates many of which are used in food. The various types of sugar are derived from different sources. Simple sugars are called monosaccharides and include glucose, fructose and galactose. "Table sugar" or "granulated

sugar" refer to sucrose, a disaccharide of glucose and fructose. In the body. sucrose is hydrolysed into fructose and glucose.

Citric acid:

Citric acid anhydrous or monohydrate, the most widely used acidulant to give a sour taste in food and beverage, also acts as a preservative, PH buffer, antioxidant and chelating agent. The European food additive number for it is E330. China is the biggest manufacturer of citric acid in the world and exported around 1 million tons in 2019.

COSTING INTRODUTION

Product cost refers to the costs incurred to create a product. These cost include direct labor direct materials, consumable production supplies and foory overhead The product cost can also be considered the cost of the labor required to deliver a service to a customer In the latter case, product cost should include all costs related to a sevice, such as compensation, payroll taxes and employee benefits.

The cost of a product on a unit basis is typically derived by compiling the costs associated with a batch of units that were produced as a group and dividing by the number of units manufactured. The calculation is:

(Total direct labor + Total direct materials + Consumable sur plies + Total allocated overhead) + Total number of units = Product unit cost)

METHODOLOGY

Preparation Methods for tutti frutti: Dehydrated muskmelon rind tutti frutti was prepared following the method described by Dehydrated muskmelon rind tutti frutti was made using the method revealed by Zainun (2007), with some changes. Fresh muskmelons were completely cleaned and peeled, leaving just the rinds for candy manufacture and eliminating the meat. The yellow outer covering of the rinds was removed, and the white inside meat was sliced into pieces 2 cm long and 1 cm wide. The rind pieces were blanched in boiling water for 1 minute before being soaked in sugar syrup, which impregnated the tissues with sugar at a high concentration to avoid microbiological deterioration. The procedure began with a sugar concentration of 50 °Brix, which was raised by 5 °Brix each day until a final concentration of 70 °Brix was achieved.Each time the syrup concentration was adjusted, it was drained, cooked, and sugar was added to get the required amount. Natural food colours and flavours were added.

The syrup was chilled to 60 degrees Celsius before the rinds were reintroduced. The rinds were steeped in the final concentration for three days before being drained. Approximately 500 g of the prepared rind samples were arranged on stainless steel perforated trays and dried in a cabinet dryer at 60 °C for durations of 6 hours. Three distinct treatment methods are employed for preparing tutti frutti using muskmelon rind:

Treatment 1(T1): Traditional Sugar Syrup Method (70% Sugar): muskmelon rind is diced and cooked in a sugar syrup until tender. This method creates a sweet and sticky texture through the heating of the rind in a mixture of sugar and water.

Treatment 2 (T2): 1% Citric Acid and 60% Sugar Preservation Method: The muskmelon rind is blanched briefly and mixed with a sugar-citric acid solution, enhancing its flavor and preservation while creating a slightly tangy tutti frutti.

Treatment 3 (T3): Natural Colorants Method: This variation involves adding natural colorants i.e. 10% beetroot juice to enhance the visual appeal of the tutti frutti without using artificial dyes, maintaining a natural ingredient profile

Determination of Energy by calculation:

Energy is evaluated by formula. Energy (kcal) = Protein (g)x4 + Fat(g) + Carbohydrate (g)x 4 (1 gm of carbohydrate gives 4 calories)

Fiber Content:

Total fibre content of water melon rind was determined by AOAC method.

Estimation of total acidity (% citric acid):

The total acidity tutti frutti was estimated as per the procedure described by Ranganna (2004). Aliquot of the sample was diluted with distilled water and titrated with NaOH (0.1N) using phenolphthalein (1%) solution as indicator. The per cent anhydrous citric acid was computed using following equation:

$$\text{Acidity \%} = \frac{\text{Titre x normality of alkali x volume made up x equi. of acid}}{\text{Volume of aliquot taken for estimation x Volume of sample taken for estima}} \text{ x } 100$$

Estimation of ascorbic acid:

The 2,6 dichlorophenol titrimetric method as described by AOAC was used. 2 ml of the sample was extracted by homogenizing sample in acetic acid solution. The standard solution was prepared by dissolving 50 mg of ascorbic acid in 100 ml of water. The solution was filtered to get a clear solution. Then, 10 ml of the filtrate was added into a flask in which 2.5 ml acetone had been added. This was titrated with indophenols solution (dye 2,6, dichlorophenol indophenols) to a faint pink color which persisted for 115 seconds. The standard was treated identically. Calculation mg ascorbic acid/ml = C × V × DF/WT, where; C = mg ascorbic acid ml dye; V = volume of dye used for titrate of diluted sample; DF = Dilution factor; WT = volume of sample in ml.

Estimation of total sugar content:

50 g of the sample was ground using a blender or pestle and mortar and then transferred to a 500 mL beaker, and 400 mL of water was added. The sample was neutralised with 1N NaOH using phenolphthalein indicator. After that it was gently boiled with occasional stirring. After cooling, it was transferred to a 500 mL volumetric flask. After that, 100 mL of aliquot was pipetted into another 500 mL volumetric flask, and then 2 mL of neutral lead acetate was added. After that it was allowed to stand for 10 minutes, then the excess of lead was precipitated with potassium oxalate solution. Total sugar was determined by inverting 25 mL of the clarified solution in a 250 mL volumetric flask with HCl in a water

bath at 70°C. Then it was cooled and neutralised with NaOH and made up to volume. Total sugar was determined by the Lane and Eynon volumetric method.

Sensory Evaluation:

Sensory evaluations for muskmelon rind tutti Frutti were recorded throughout all three trials. BAMU University's Department of Food Technology has five panellists. Chhatrapati Sambhajinagar used a 9-point hedonic scale to evaluate sensory experiences, ranging from 1 (very dislike/unwanted) to 9 (highly like/wanted). Panellists were presented with a test proforma during assessment. The scale for like is as follows: 9 = exceedingly, 8 = very much, 7 = moderately, 6 = somewhat, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = detest excessively. Assess factors like as

appearance, texture, taste, consistency, and acceptability. The recipe was finalized on the basis of sensory evaluation. Sensory evaluation was carried out by 10 panellist members by using 9 point hedonic scale.

Consumer Survey:

A diverse group of 100 consumers is selected to represent various demographics, including age, gender, and culinary preferences, ensuring a broad spectrum of consumer opinions and preferences.

RESULTS AND DISCUSSION

Proximate Analysis of Muskmelon rind Tutti Frutti:

The Proximate analysis of Muskmelon rind Tutti Frutti was determined by physicochemical parameters *viz.,* Calories, Acidity, Total Sugars and Fiber (Table 1 and Fig. 1). The nutritional profile analysis reveals significant differences between fresh muskmelon rind and various

tutti frutti formulations. Fresh Muskmelon rind is a lowcalorie option, containing only 20 calories and 1g of total sugar, making it a healthy snack choice. In contrast, the sugar syrup method significantly increases the caloric content to 90 calories and adds 20g of sugar, which may be concerning for health-conscious consumers. The citric acid and natural colorants methods offer a moderate caloric increase, with 70 and 75 calories, respectively, while also reducing sugar content to 15g and 18g. All formulations show a slight increase in fiber, with the citric acid method providing the highest at 0.6g, contributing positively to digestive health. Additionally, vitamin C levels are maintained or slightly enhanced in the tutti frutti products, ranging from 7 to 8mg, compared to 5mg in fresh rind. The visual comparison underscores these differences, particularly highlighting the dramatic rise in calories and sugar due to processing. While the tutti frutti formulations offer some nutritional benefits, particularly in fiber and vitamin C, consumers should be mindful of the increased caloric and sugar content when making dietary choices.

Table 1 : Proximate analysis of muskmelon rind Tutti Frutti					
Treatment Symbol	Treatment Combination	Calories (Kcal)	Total sugar(g)	Fiber (g)	Ascorbic acid (mg)
T0	Fresh muskmelon rinds	20	1	0.4	5
T1	70% sugar syrup	90	20	0.5	8
T2	1% citric acid and 60% sugar sytrup	70	15	0.6	7
T3	10% beetroot juice as a natural colorant and sweetener	75	18	0.5	7

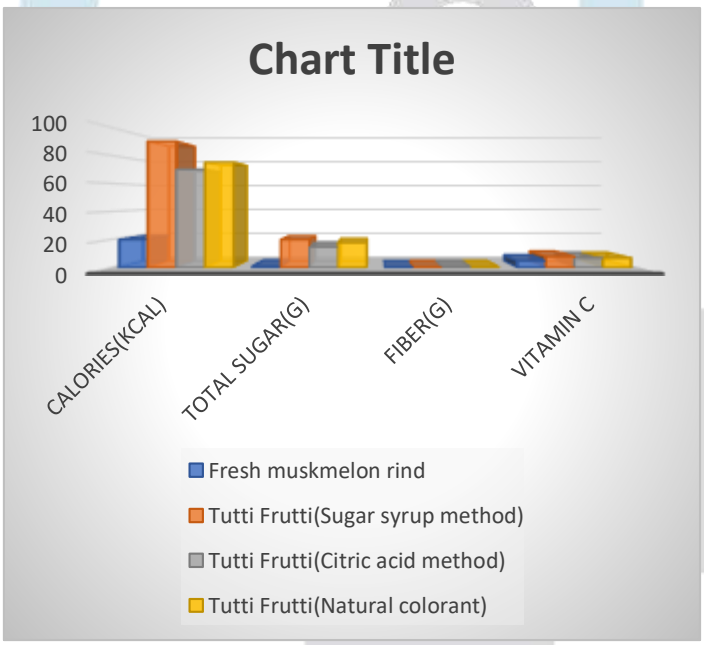

Fig. 1 : Visual Comparison of Proximate composition of tutti frutti made from all 3 treatments

Sensory Evaluation of muskmelon rind tutti frutti:

Sensory evaluation of prepared muskmelon rind tutti frutti was done by 9 point hedonic scale, 10 panel members were employed for this sensory evaluation. The product was evaluated on the basis of colour, taste, texture, flavour, appearance and overall acceptability. According to result among three different formulations the maximum overall acceptability score was found in the third variation that is T1 (Table 2 and

Fig. 2). The sensory evaluation scores provide valuable insights into consumer preferences for the different tutti frutti preparation methods. The Sugar Syrup Method scored the highest in flavor at 8.25, indicating a strong preference for its sweetness, which enhances its overall

appeal. The Citric Acid Method (T2), with a score of 7.75, offers a favorable balance of sweetness and acidity, suggesting that consumers appreciate its tangy notes. However, the Natural Colorants Method (T3) scored at 7.5, indicating that it may not provide the same intensity of flavor as the other methods. In terms of color, the Citric Acid Method excelled with a score of 8.0, highlighting its ability to create a visually appealing product, while the Natural Colorants Method also performed well with 9. The Sugar Syrup Method received a score of 8.0, which, although positive, suggests it might not be as vibrant. Regarding texture, the Citric Acid Method again led with 8.0, indicating a pleasing mouthfeel, while the Sugar Syrup Method scored 8, possibly due to a stickier texture from the syrup. The aroma of the Citric Acid Method scored 7.5, enhancing its overall appeal, whereas the Natural Colorants Method scored the lowest at 7. the Sugar Syrup Method achieved the highest acceptability score of 8.25, reflecting its broad consumer appeal, while the Citric Acid Method followed closely at 7.75. The Natural Colorants Method, while slightly less favored at 7.5, still demonstrated acceptable sensory qualities. These findings underscore the strengths and weaknesses of each preparation method and provide a roadmap for product development and marketing strategies, ensuring that muskmelon rind tutti frutti aligns with consumer expectations.

Table 2 : Sensory evaluation of Muskmelon rind tutti frutti

Sr No	Treatment	Flavour	Color	Texture	Aroma	Overall Acceptability
1	T1	8	8	8	9	8.25
2	T2	8	8	8	7	7.25
3	T3	7	9	7	7	7.5

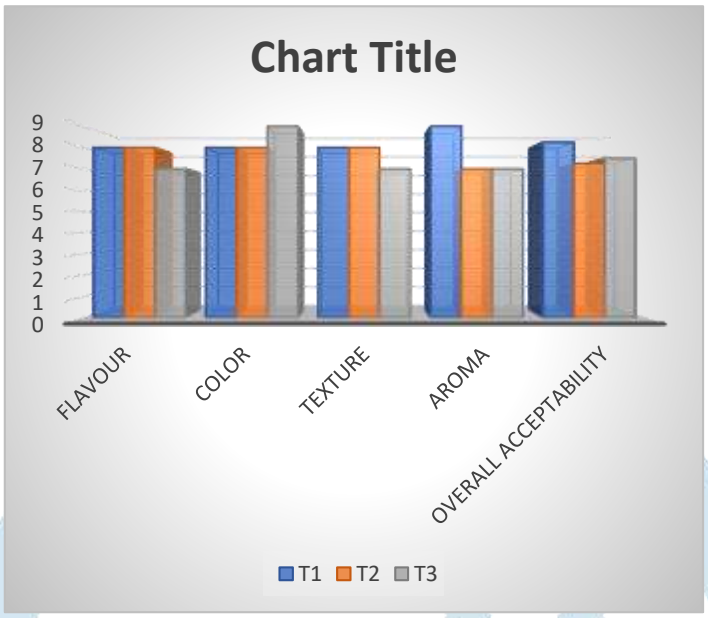

Fig. 2 : Illustration of the average sensory evaluation scores for each preparation method across different attributes (Flavour, Color, Texture, Aroma, Overall Acceptability)

Consumer Survey:

A diverse group of 100 consumers is selected to represent various demographics, including age, gender, and culinary preferences, ensuring a broad spectrum of consumer opinions and preferences. The consumer survey responses in Table 3 provide compelling insights into the acceptance and preferences surrounding muskSSmelon rind tutti frutti. A notable 80% of respondents indicated that they would purchase this product, demonstrating strong market potential and consumer interest. 75% of participants rated the taste as “excellent” or “very good,” reinforcing the positive reception of the product’s flavour profile. When it comes to preparation methods, the Sugar Syrup Method emerged as the clear favourite, with 60% of consumers preferring it over the Citric Acid Method (25%) and the Natural Colorants Method (15%). This preference aligns with the sensory evaluation findings, where the sugar syrup preparation scored highly in flavour and overall acceptability. Regarding purchase frequency of similar products, 50% of respondents indicated they buy such products weekly, while 30% reported a monthly purchase, and 20% claimed to buy them rarely. This data suggests a robust market for tutti Frutti, particularly for those that appeal to consumers’ taste preferences. Fig. 3 visually illustrates these responses, highlighting the high purchasing intent, favourable taste ratings, and strong preference for the Sugar Syrup Method. These findings indicate a promising

opportunity for MuslmelonSSSS rind tutti Frutti in the market, emphasizing the importance of flavour and preparation method in driving consumer choices.

Table 3: Consumer survey responses of all three treatments

Survey Question	Response Percenyage
Would you purchase muskmelon rind tutti frutti?	80%
Rate the taste as "excellent" or "very good"	75%
Preferred Preparation Method	
- Sugar Syrup Method	60%
- Citric Acid Method	25%
- Natural Colorant Method	15%
Purchase Frequency of Similar Products	
-Weekly	50%
-Monthly	30%
-Rarely	20%

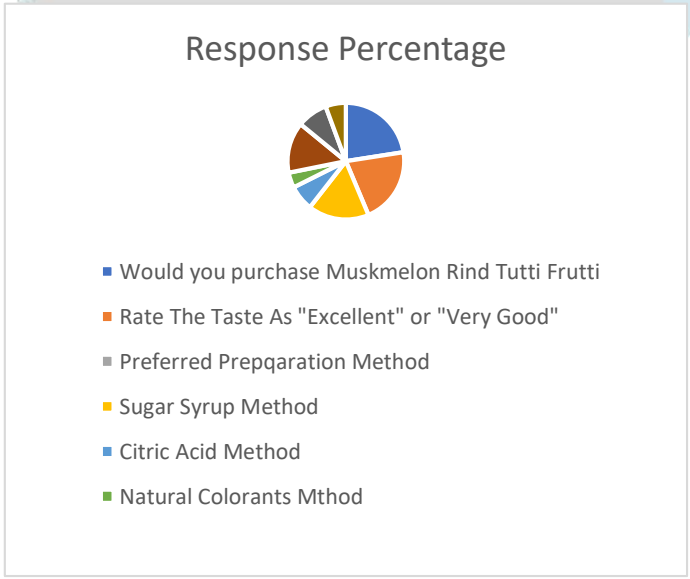

Fig. 3 : Illustration of consumer survey responses, showing 80% purchasing intent, 75% positive taste ratings, preferences for the Sugar Syrup Method (60%), and weekly purchase frequency at 50%

Conclusion:

The results revealed that the treatment T1 excelled in terms of acidity, total sugar, ascorbic acid, and organoleptic parameters. Consumer surveys highlighted a strong purchasing intent,

with 80% of respondents indicating a willingness to buy the product, particularly favoring the Sugar Syrup Method (60%). As a result, it was finally concluded that Tutti Frutti prepared using the treatment combination (70% sugar), i.e., the treatment T1, is economically viable and thus can be commercially processed on a large scale.

The waste from the fruit processing industry is a rich source of many utilizable components. This has become a serious prom as the production of fruits and vegetables increases, they influence the environment and pollute it. Therefore, it needs to be managed and utilized in a proper way. The combined effort of waste minimization and sustainable utilization of the by-products would substantially reduce the large quantities of fruit wastes accumulated globally. It has also proven by many researchers that a number of food products can be manufactured from various types of fruit waste, besides reducing pollution problems. Most of the Fruit wastes like citrus pulp, banana and mango peels etc are a rich source of nutrients. Hence, utilization of fruit waste gives another source of income to industries so it helps to increase economic productivity. So, the various products described above are will help to utilize the maximum wastage of fruits of industries.

- Some of the advantages of waste utilization concluded from the report are:
- Prevention of environmental pollution Good supplement of nutrition for the human population.
- Different types of products can be prepared
- Help in solving the problem of food scarcity Solve the problems of salinity hazards.
- Can increase economic returns of the industry.

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