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Sustainable Production of Tutti Frutti from Watermelon Rind (*Citrullus lanatus*)

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ABSTRACT

This study investigates the proximate analysis and sensory evaluations and consumer preferences of tutti frutti made from watermelon rind (*Citrullus lanatus*) using three distinct preparation methods: traditional sugar syrup, citric acid preservation, and natural colorants. The nutritional analysis reveals that while fresh watermelon 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 watermelon rind tutti frutti, particularly favoring the sugar syrup method (60%). The findings suggest that watermelon rind tutti frutti, especially when prepared using the sugar syrup method, holds substantial market potential and aligns with consumer preferences.

Keywords: Watermelon rind, Tutti frutti, Proximate analysis, Sensory evaluation

INTRODUCTION

Watermelon (Cucurbitaceae, *Citrullus lanatus*) is a popular tropical and subtropical fruit (Yamaguchi, 2006). Watermelon is a popular fruit in many countries, recognised for its high water content of more than 91% and carbohydrate content of up to 7%. Watermelon is a great source of vitamins, including vitamin A and other B-complex vitamins including thiamine, riboflavin, niacin, pantothenic acid, vitamin B6, and folate. It also contains a sufficient amount of vitamin C. Minerals such as calcium, iron, magnesium, phosphorus, potassium, and zinc are present. Aside from this, watermelon has a variety of bioactive components such as alkaloids, flavonoids, glycosides, saponins, tannins, and phenols, all of which help to promote health (Awad, 2017).

Watermelon rind is a thick white covering that lies between the outer green shell and the inner red core. It takes up around one-third of the overall fruit bulk. Watermelon rind is said to have a high concentration of phytochemicals. Watermelon contains pectin, lignin, celluloses, and hemicellulose, as well as entrapped sugars, carotenoids, polyphenolics, lycopene, citrulline, and proteins (Mustafa *et al.*, 2022). The rind contains essential vitamins and minerals such as vitamin A, C, and B6, as well as potassium and magnesium. The rind is primarily water (approximately 90%), which assists in hydration, an important component of a healthy diet (Kumar and Singh, 2019).

Watermelon rind is nutritionally healthy, although less nutritious than the meat. Watermelon rind, like meat, contains fewer calories but more fibre, according to USDA. A 100-gram watermelon rind has 30 calories, 0.6 grammes of protein, 0.1 grammes of fat, and 7.6 grammes of fibrous carbs. This high fibre content improves digestion, satiety, and blood sugar control.

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The vitamin C in watermelon rind improves immunity, skin health, and oxidative stress prevention (Salunkhe and Kadam, 1995). Citrulline, an amino acid found in higher amounts in the rind than in the flesh, has been researched for its potential to improve exercise performance and reduce muscular soreness (Siddiq *et al.,* 2007).

Innovative culinary dishes made from watermelon rind have emerged as part of a growing trend aimed at reducing food waste and improving sustainability. Food scientists and chefs have begun to experiment with making snacks and drinks from watermelon rind. Watermelon rind may also be used into smoothies or juices, increasing the nutritional content of these beverages while reducing waste. The usage of rind in culinary goods conforms to the principles of a circular economy, in which byproducts are repurposed to create value-added things (Baldwin *et al.,* 2020).

Integrating watermelon rind into modern health foods and beverages has substantially increased its use. Watermelon rind is frequently used to smoothies, drinks, and dry snacks due to its high fibre content and possible health advantages, such as aiding digestion and providing hydration (Davis and Nunn, 2019).

Processed watermelon rind products are not commonly found in the market. Moreover, no systematic research has been conducted on processing watermelon rind for preparing Tutti Frutti. In recent years, India's food processing industry has experienced significant growth, with an increasing demand for processed fruit products driven by changing lifestyles. While a wide variety of processed fruit products with diverse packaging options is now available, watermelon rind products remain notably absent. This highlights a significant opportunity to develop value-added products from watermelon rind. Such innovation could reduce fruit waste and contribute to substantial economic growth.

METHODOLOGY

The present experiment "Sustainable Production of Tutti Frutti from Watermelon Rind (*Citrullus lanatus*)" was carried out during August 2024 - October 2024 in the food processing laboratory of Department of Food Technology, PIT, Parul University, Vadodara, Gujarat, India. The primary ingredient for tutti frutti preparation is watermelon rind, chosen for its texture and nutritional benefits. Other ingredients are excluded to focus solely on the rind's potential.

Preparation Methods for tutti frutti:

Dehydrated watermelon rind tutti frutti was prepared following the method described by Dehydrated watermelon rind tutti frutti was made using the method revealed by Zainun (2007), with some changes. Fresh watermelons were completely cleaned and peeled, leaving just the rinds for candy manufacture and eliminating the meat. The green 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 watermelon rind:

Treatment 1(T_1): Traditional Sugar Syrup Method (70% Sugar):

Watermelon 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 (T_2): 1% Citric Acid and 60% Sugar Preservation Method:

The watermelon 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 (T_3): 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:

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

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 watermelon rind tutti fruttiwere recorded throughout all three trials. Parul University's Department of Food Technology has five semi-trained panellists.Vadodara 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 semi trained 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 watermelon rind Tutti Frutti:

The Proximate analysis of watermelon 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 watermelon rind and various tutti frutti formulations. Fresh watermelon rind is a low-calorie 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

Table 1 : Proximate analysis of watermelon rind Tutti Frutti

Treatment Symbol	Treatment Combination	Calories (Kcal)	Total Sugar (g)	Fiber (g)	Ascorbic Acid (mg)
T_0	Fresh Watermelon Rind	20	1	0.4	5
T_1	70 % Sugar Syrup	90	20	0.5	8
T_2	1 % Citric Acid and 60 % Sugar Syrup	70	15	0.6	7
T_3	10 % Beetroot Juice as a natural colorant and sweetener.	75	18	0.5	7

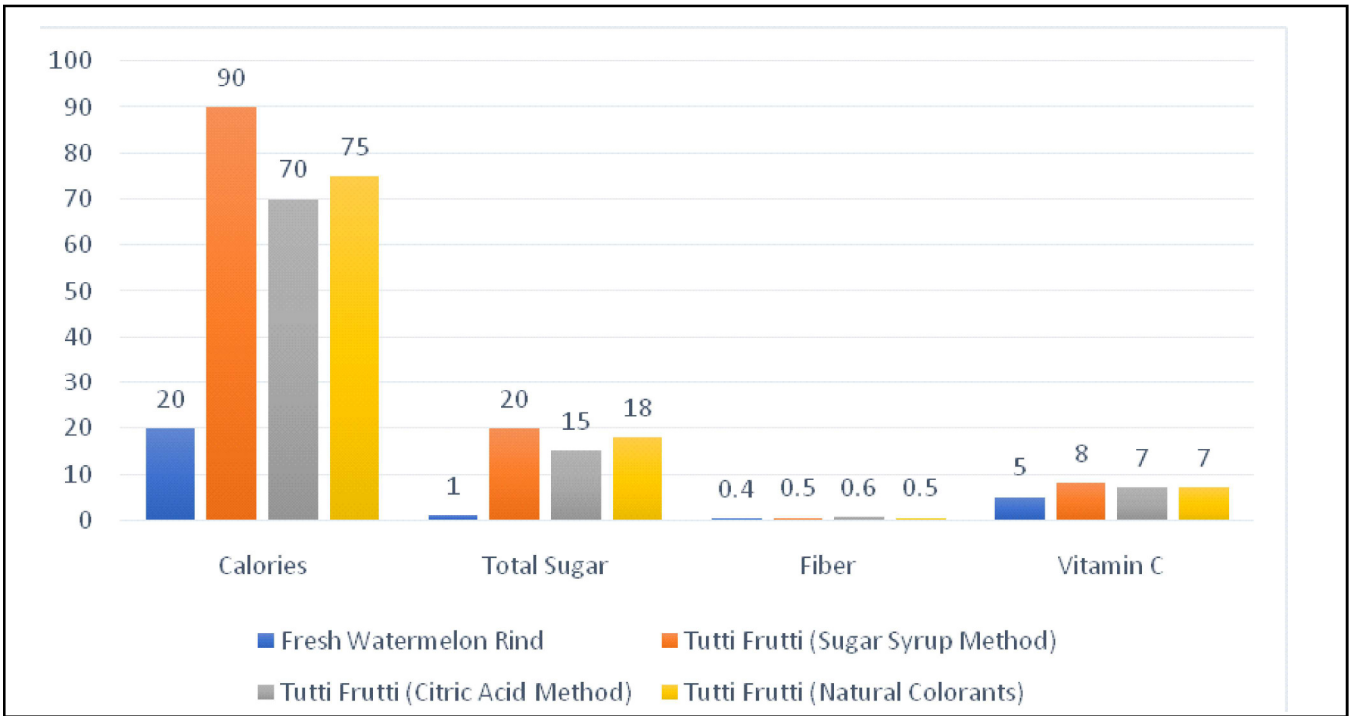

Fig. 1 : Visual Comparison of Proximate composition of tutti frutti made from all 3 treatments

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.

Sensory Evaluation of Watermelon rind tutti frutti:

Sensory evaluation of prepared Watermelon rind tutti frutti was done by 9 point hedonic scale, 10 semi trained 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 T_1 (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 (T_2), 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 (T_3) 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

Table 2 : Sensory evaluation of Watermelon rind tutti frutti

Sr. No.	Treatment	Flavor	Color	Texture	Aroma	Overall Acceptability
1.	T_1	8	8	8	9	8.25
2.	T_2	8	8	8	7	7.75
3.	T_3	7	9	7	7	7.5

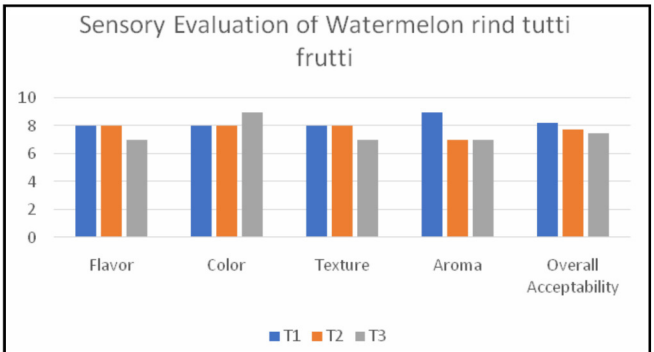

Fig. 2 : Illustration of the average sensory evaluation scores for each preparation method across different attributes (Flavor, Color, Texture, Aroma, Overall Acceptability)

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 watermelon rind tutti frutti aligns with consumer expectations.

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 watermelon 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 flavor profile.

Table 3: Consumer survey responses of all three treatments

Survey Question	Response Percentage
Would you purchase watermelon 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 Colorants Method	15%
Purchase Frequency of Similar Products	
- Weekly	50%
- Monthly	30%
- Rarely	20%

When it comes to preparation methods, the Sugar Syrup Method emerged as the clear favorite, 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 flavor

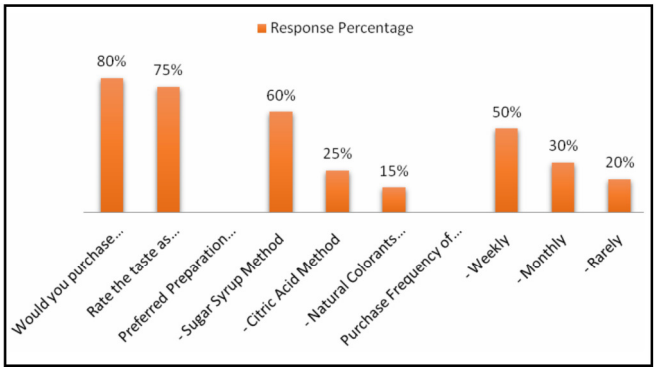

Fig. 3 : Illustration of consumer survey responses, showing 80% purchasing intent, 75% positive taste ratings, preferences for the Sugar Syrup Method (60%), and weekly purchase frequency at 50%

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, favorable taste ratings, and strong preference for the Sugar Syrup Method. These findings indicate a promising opportunity for watermelon rind tutti frutti in the market, emphasizing the importance of flavor and preparation method in driving consumer choices.

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.

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