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# PEEL TO PERFECTION: UPCYCLING MANDARIN WASTE INTO DELECTABLE TREATS- MANDARIN CANDIED PEELS.

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***Abstract :*** The Citrus genus includes many different species and fruits such as oranges, grapefruits, lemons, and limes. These fruits are not only nutritious, but they also have distinct qualities like taste and colour. Citrus fruits contain beneficial compounds like vitamins, minerals and essential oils. The outer layer of citrus fruits is rich in polyphenols, which provide protection agai nst the sun and infections. However, the citrus processing industry creates a lot of waste, including peels, seeds and membrane residue. Despite this waste, citrus peels contain valuable compounds with health benefits. Candying, a traditional preservation method, involves soaking fruits in sugar syrup to prevent spoilage. The analysis of the sensory scores indicates that T2 performed the best among the treatments, as it received the highest scores in various categories. T2 had higher scores than the other treatments, with an overall acceptability score of 8.6±0.516. T3 had the second highest score of 8.2±0.632, followed by T1 with a score of 8.0±0.942. T2, which used 100% sugar, was the most preferred treatment in terms of overall acceptability and was selected for further analysis. The moisture content of the candied mandarin peels varied across the treatments, with T3 having the highest moisture content. The ash content was similar in all treatments, while the acidity and pH levels showed slight variations.

**Keywords:** Mandarin peels, Citrus fruits, Physiochemical Properties, Organoleptic Properties, Candying, Utilization of Waste.

## I. INTRODUCTION

The genus *Citrus*, belonging to the Rutaceae or Rue family, comprises of about 140 genera and 1300 species. *Citrus sinensis* (Orange), *Citrus paradise* (Grapefruit), *Citrus limon* (Lemon), *Citrus reticulate* (Tangerine), *Citrus grandis* (Shaddock),*Citrus aurantium* (Sour orange), *Citrus medica* (Citron), and *Citrus aurantifolia* (Lime) are some important fruits of genus *Citrus* (Yerou *et al*., 2017). The sensory attributes of fruits (color, sweet taste, bitterness, and astringency) constitute decisive organoleptic and commercial properties (Gracia *et al*., 2013).

Citrus fruits are good sources of nutrition with an ample amount of vitamin C. Besides, the fruits are abundant in other macronutrients, including sugars, dietary fiber, potassium, folate, calcium, thiamine, niacin, vitamin B6, phosphorus, magnesium, copper, riboflavin and pantothenic acid (Economus *et al*., 1999).

Citrus fruits are rich in various secondary metabolites, which are compounds produced by the fruit that are not directly involved in its growth or development. These metabolites, including flavonoids, alkaloids, coumarins, limonoids, carotenoids, phenol acids and essential oils, play a crucial role in promoting human health. They possess numerous bioactivities that are beneficial for our well-being, such as acting as antioxidants to combat oxidative stress, reducing inflammation, preventing cancer formation, protecting cardiovascular health and preserving brain function (Xinmiao *et al*., 2015).

A number of studies have recognized the presence of polyphenols, vitamins, minerals, dietary fibres, essential oils and carotenoid content which makes citrus a health-benefit promoting fruit (Shafiya *et al*., 2018). Citrus fruits have a protective outer layer that is rich in polyphenolic compounds, which can protect against sun rays and infections. These compounds include p-cinnamic acid, ferulic acid, isoferulic acid, 5-hydroxyvaleric acid, vanillic acid and 2-oxybenzoic acid. Sour oranges in particular are a good source of ferulic and sinapinic acids (Kavita *et al*., 2017).

The citrus processing industry produces a significant amount of waste in the form of citrus peels, seeds, and membrane residue. This waste accounts for around 50-60% of the total weight of the fruit (Mahato *et al*., 2019). Citrus peels are subdivided into the epicarp or flavedo (coloured peripheral surface) and mesocarp or albedo (white soft middle layer).

When evaluating the assortment of beneficial chemicals found in citrus peels, it becomes evident that discarding them as waste is a significant economic disadvantage. Citrus peels contain an abundance of phenolic compounds, including phenolic acids and flavonoids, which possess bioactive properties. Moreover, these valuable compounds are predominantly concentrated in the peels compared to other sections of the fruit (Ademosun *et al*., 2018). In light of the abundance of polyphenolic compounds found in citrus peels and their potential for promoting health, numerous studies have been conducted in recent years to explore the properties and benefits of these peels (Ademosun *et al*., 2022).

The presence of flavonoids with hydroxyl structures in the B-ring of citrus peels allows them to effectively eliminate harmful free radicals. This is achieved by the flavonoids donating hydrogen and an electron to peroxyl, hydroxyl, and peroxynitrite radicals, thereby stabilizing them (Santos & Mira, 2004). Flavonoids found in the peel of citrus fruits are widely acknowledged for their significant contribution as dietary antioxidants. These compounds effectively shield cells from harm through a variety of mechanisms, including transferring hydrogen atoms, scavenging free radicals, and chelating divalent metal ions (Sarian et al., 2017). In addition to their role in regulating metabolic syndrome and type 2 diabetes, these compounds also contribute to the inhibition of α-glucosidase, sensitization of insulin, and reduction of blood lipid levels (Jia et al., 2019).

Candying, a technique that predates the production of refined sugar, has been used for centuries as a method of food preservation. The process involves slowly saturating fruits with a syrup made from sugar, gradually increasing the sugar concentration within the fruit's tissues. Once the sugar concentration reaches a certain level, it effectively inhibits the growth of harmful microorganisms that can cause food spoilage (Dhakal Drishti et al., 2017).

## II. OBJECTIVES

1. To create a delicious candied using the rinds of citrus fruits.
2. To ascertain the nutritional content using chemical techniques.
3. To determine the consumer acceptability by sensory evaluation.

## III. RESEARCH METHODOLOGY

### 3.1 Raw Materials

In this research work, fully matured and ripe mandarin fruits free from diseases and insect damages, transportation injuries and bruises were collected from the fruit Market of Guntur. Food additives such as sugar, salt and calcium carbonate were purchased from the local market.

### 3.2 Preparation of Candied Peels

Initially, the process involved washing and cutting citrus peels using a steel knife in order to obtain peel pieces that were about 0.5cm long. Next, 20g of these sliced citrus peels were immersed in a prepared solution consisting of 100ml of 1% calcium carbonate ($CaCO3$) for a duration of 45 minutes. Subsequently, the solution was filtered and the citrus slices were washed with water to eliminate any excess chemical residue. Afterwards, the citrus slices were subjected to blanching in hot water at a temperature of 100°C for a period of 10 minutes, until the peel achieved a translucent appearance. Following this, a steel pot containing 1 liter of water, 100gms of sugar and 0.5g of salt was cooked at a temperature of 70°C. Once the pot reached the desired temperature, the previously blanched citrus peels were added to the sugar syrup and stirred continuously stirred until they are transformed into translucent nature. Later the citrus peels were dried in an oven set at 70°C for a total of 6 hours. Finally, the dried peels were sprinkled with 50g of crystal sugar and the candies were packed into a plastic box.

Procurement of raw material

↓

Washing

↓

Cutting into pieces (0.5cm long)

↓

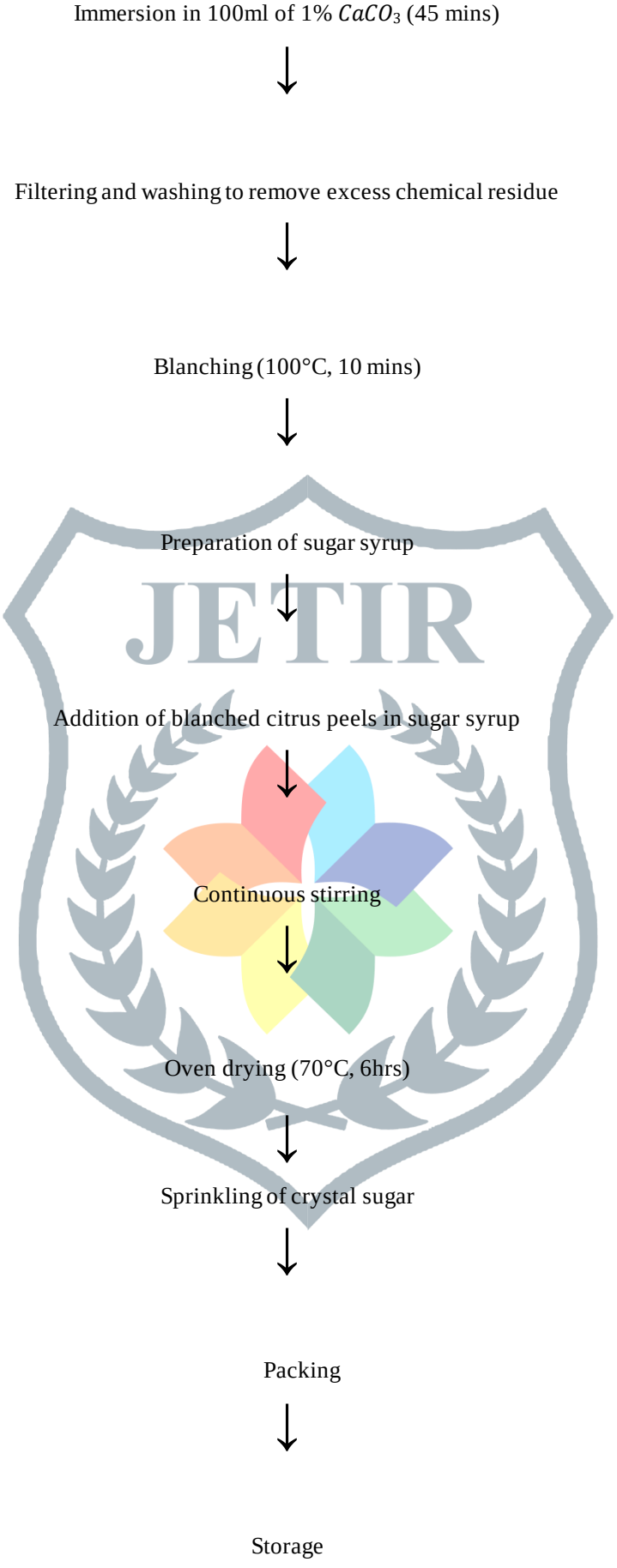


Fig.1 Flowchart of Candied Mandarin Peels Production Process

Table 1 variations with details of ingredients to prepare candied mandarin peel

| S.No | Ingredients | Treatment-1 | Treatment-2 | Treatment-3 |
|---|---|---|---|---|
| 1. | Mandarin peels(gm) | 25 | 25 | 25 |
| 2. | 1% Calcium carbonate(ml) | 100 | 100 | 100 |
| 3. | Sugar(gm) | 50 | 100 | 150 |

### 3.3 Physico-chemical Properties

The physico-chemical properties of preserve citrus peel such as moisture content, ash content, acidity and pH were determined by AOAC official methods.

**Moisture content:** Moisture content was determined using approximately 3.0 g of the citrus peels in an oven at 105ºC until the weight constant (AAOC,1984).

**Ash content:** The ash content of citrus peels was determined by muffle furnace (AAOC, 1984).

**Determination of pH:** pH was determined in ten milliliters of the juice dispensed into a beaker after calibration with phosphate buffer of pH 4.0 and 7.0 (Adubofuor et al., 2010).

**Determination of total titratable acidity (TTA):** For the measurement of the titratable acidity the standard method of (Talasila et al., 2012) was used. Five grams of concentrated fruit juice was diluted with distilled water (20ml) and filtered using filter paper (Whatman No. 1). The indicator (two drops of phenolphthalein) was added to 20ml of the filtrate and titrated against 0.05 M NaOH. The Total Titratable Acidity was calculated.

### 3.4 Organoleptic Properties

The sensory evaluation of candied orange peel was conducted to determine the level of acceptance for three different variations of the sample. A group of ten semi-trained panelists participated in the evaluation and assessed various parameters including taste, aroma, colour, texture, appearance, and overall acceptability. The parameters were evaluated using a Hedonic scale method developed by Larmond (1997), which consists of a 9-point scale ranging from the highest score of 9 indicating extreme satisfaction to extreme displeasure.

## IV. Results And Discussion

### 4.1 Sensory Analysis

The results of the sensory evaluation conducted on candied citrus peels with different levels of sugar are presented in table-2. The scores obtained from this assessment suggest that the ten semi trained judges had a favorable opinion of the candied citrus peels, rating them as either "liked very much" or "liked moderately".

Table 2 Sensory Evaluation of Candied Citrus Peels

| Sensory Parameters | Treatment-1 | Variation-1 | Variation-2 |
|---|---|---|---|
| **Color** | 8.6±0.516 | 8.7±0.483 | 8.6±0.516 |
| **Taste** | 7.6±0.966 | 8.5±0.527 | 8.1±0.737 |
| **Texture** | 8.1±0.737 | 8.5±0.527 | 8.0±0.942 |
| **Flavour** | 7.8±0.63 | 7.9±0.994 | 7.8±0.788 |
| **Appearance** | 7.9±0.994 | 8.1±0.737 | 8±0.666 |
| **Overall acceptability** | 8.0±0.942 | 8.6±0.516 | 8.2±0.632 |

values are mean ± sd, analysed individually in triplicate, and expressed as g/100 g

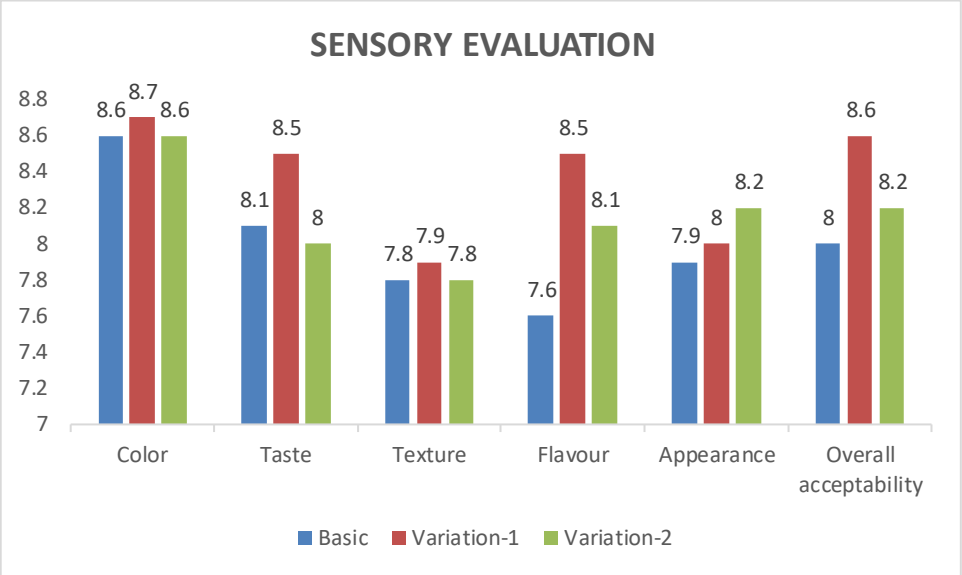


Fig. 2 Examination of Sensory Parameters Using Bar Graphs

After analyzing the sensory scores presented in both the table and the figure, it is clear that T2, which consisted of 100% sugar, achieved the highest scores across various categories. In terms of color, it received a score of 8.7±0.483, for taste it received a score of 8.5±0.527, for texture it received a score of 8.5±0.527, for flavor it received a score of 7.9±0.994, for appearance it received a score of 8.1±0.737 and for overall acceptability it received a score of 8.6±0.516, all of which were higher than the scores obtained by the other treatments. The data also reveals that T2 had the highest overall acceptability score of 8.6±0.516, followed by T3 (150% sugar) with a score of 8.2±0.632, and T1 (50% sugar) with a score of 8.0±0.942. These results indicate that T2 was the most preferred treatment in terms of overall acceptability, while T1 received the lowest score. Therefore, T2, which involved the use of 100% sugar in the preparation of candied citrus peels, was selected for further analysis. These findings are somewhat consistent with the research conducted by Phyoe (2020), who also utilized 100% sugar in the preparation of candied lime peels.

Table 3 Nutrients and Nutritional Value of Candied Mandarin Peels (100g)

| **Proximate composition (g/100gm)** | **Treatment-1** | **Treatment-2** | **Treatment-3** |
|---|---|---|---|
| Moisture content (gm) | 9.61±0.026 | 9.76±0.025 | 9.95±0.02 |
| Ash content (gm) | 0.8±0.210 | 1.2±0.2 | 1.6±0.2 |
| Titrable Acidity (%) | 0.87±0.02 | 0.91±0.02 | 1.03±0.02 |
| pH | 1.96±0.03 | 3.07±0.017 | 5.06±0.03 |

values are mean ± sd, analysed individually in triplicate, and expressed as g/100 g

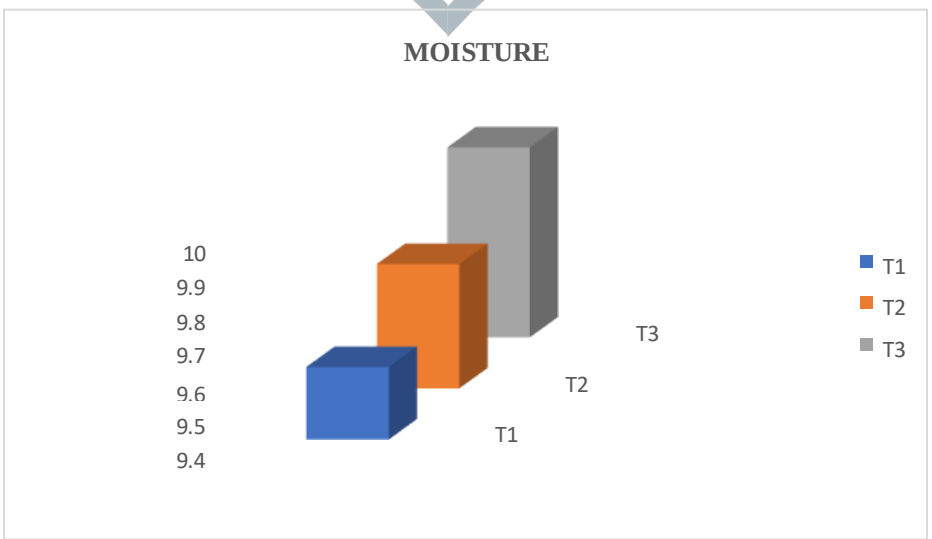


Fig. 3 Nutrition-Related Claims in Candied Mandarin Peels (Moisture)

The moisture content of candied mandarin peels was investigated in three different treatments. The moisture content was determined to be 9.61±0.026, 9.76±0.025 and 9.95±0.02 in treatments 1, 2 and 3, respectively (Figure-3). It was observed that the highest moisture content was recorded in treatment 3. These findings are consistent with a previous study conducted by (Sulekha*et al.*, 2018), where they reported a moisture content of 9.2% in orange peels.

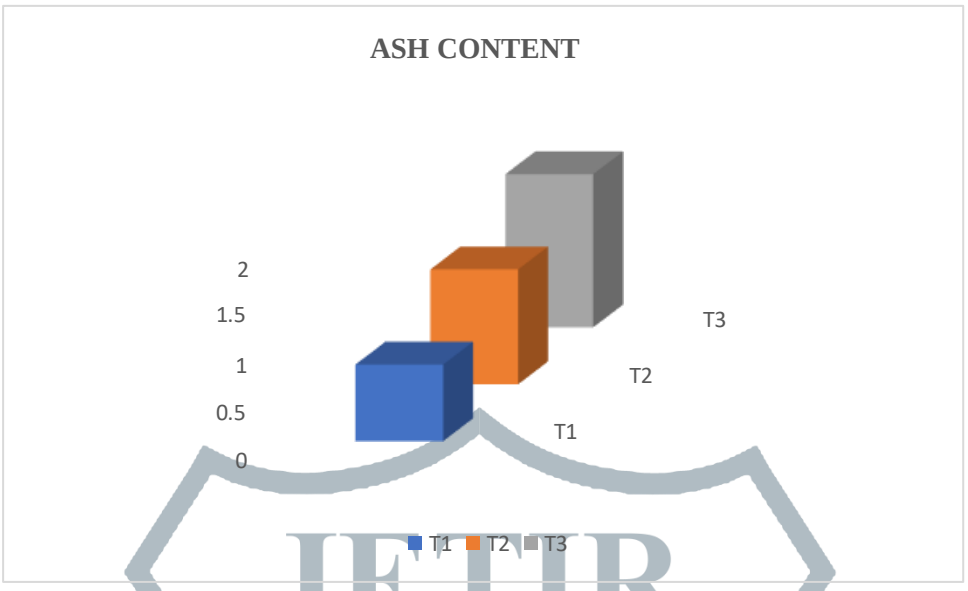


Fig. 4 Nutrition-Related Claims in Candied Mandarin Peels (Ash)

The analysis results indicate that the ash content in all the treatments was nearly identical, with only a slight variation of 0.8±0.210, 1.2±0.2 and 1.6±0.2 respectively (Figure- 4). These findings are consistent with a previous study conducted by (Islam *et al.*, 2023) where they discovered an ash content of 1.36% in orange peels.

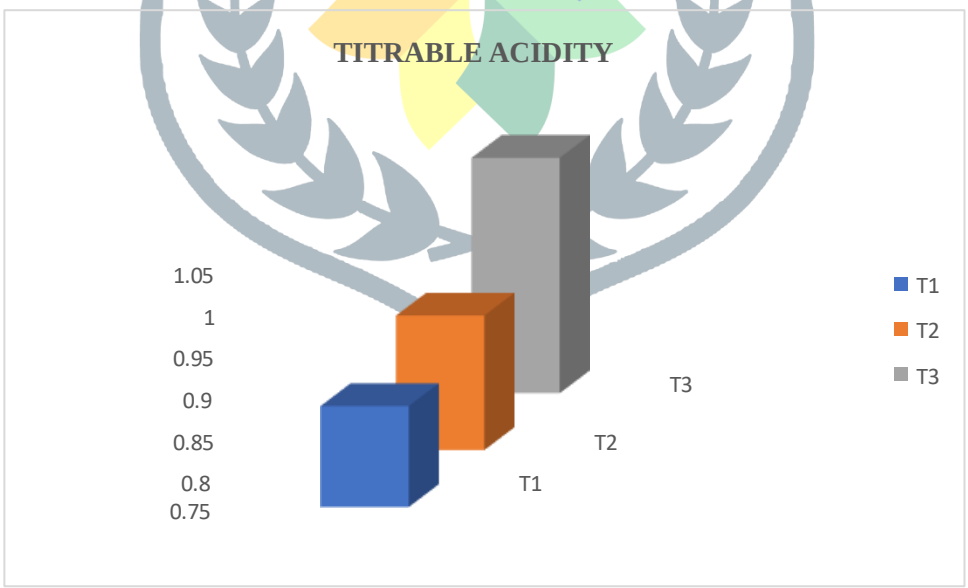


Fig.5 Nutrition-Related Claims in Candied Mandarin Peels (Titrable Acidity)

The levels of acidity found in candied mandarin peels were measured to be 0.87±0.02, 0.91±0.02 and 1.03±0.012, as shown in Figure-5. A study conducted by (Phyoe *et al.*, 2020) also reported that citrus lime peels have acidity levels ranging from 0.99 to 2.98, which aligns with the findings of our research.

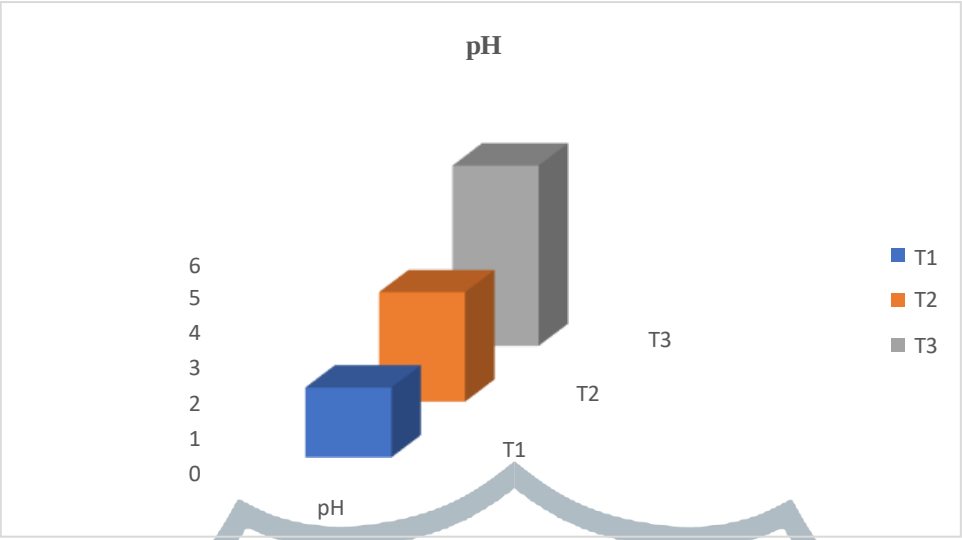


Fig. 6 Nutrition-Related Claims in Candied Mandarin Peels (pH)

The pH levels of candied mandarin peels were measured and found to be 1.96±0.03, 3.07±0.017 and 5.06±0.03. Theseresults align with the findings of (Fahmi *et al*., 2020), who also reported a pH level of approximately 3.8 for orange peels.

## V. CONCLUSION

The primary focus of this research was to explore the potential use of discarded mandarin fruit peels in the production of candies. These peels were subjected to both chemical analysis and sensory evaluation to ensure the development of a high-quality product that would meet consumers' needs. By offering a healthier alternative to unhealthy junk food, these candies have the ability to instantly encourage individuals to make better dietary choices. The results of the study indicated that all of the candy samples created were rated as "good" on the Hedonic Scale Score, demonstrating their overall positive reception. Furthermore, these candies are suitable for consumption by individuals of all age groups, as they provide a significant portion of the daily nutrient requirements. This is particularly advantageous as candies are a convenient and pleasurable way to ensure nutrient availability. The sensory evaluation test confirmed that the taste, aroma, colour, appearance and overall quality of the candies were well-received by the panel members. Based on these findings, it can be concluded that the formulated Orange Peel Candies are not only nutrient-enriched but also have potential industrial applications, making them economically viable. Consequently, theutilization of orange peels as a raw material in food processing industries holds significant promise.

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