



Valorization of mini orange (*Citrus Sinensis*) peels through the development and evaluation of seasoning powders

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Abstract

The study aims to valorize mini orange peel by developing value added seasoning products from using the Albedo and Flavedo of the fruit. Four seasonings were prepared: T₁-Salt-Vinegar Mini Orange Seasoning, T₂-Jaggery Brine Mini Orange Seasoning, T₃-Mini Orange Peel Karampodi Seasoning, T₄-Sweet-and-Salty Mini Orange Peel Seasoning. The whole peel (including the flavedo and attached albedo) was washed and then manually separated, blanched for 3 minutes, brined according to the formulation, sun-dried, ground and stored. A Sensory evaluation was carried out with 32 semi trained panelists and with a 9-point hedonic scale. T₃ recorded the highest overall acceptability score (8.38 ± 0.66), followed by T₂ (8.31 ± 0.64), T₄ (8.25 ± 0.88) and T₁ (7.56 ± 0.91). ANOVA revealed significant differences between the formulations in appearance, aroma, taste, aftertaste and overall acceptability whereas the colour and texture of the formulations were not significantly different. The moisture content varied between 7.5% and 10.1%, whereas the ash content was between 43.19% and 51.87%. Ashing was not performed for T₂ due to caramelized jaggery sticking to the crucible. The TSS values were 7.8 °Brix for T₂ and 4.0 °Brix for T₄. T₁ and T₃ do not contain sugar compounds therefore, TSS was not done. The study is useful for food waste reduction by valorizing citrus peels.

Keywords: Mini orange peel, citrus peel valorization, seasoning, sensory evaluation, physicochemical analysis

Introduction

Citrus fruits are among the most important horticultural crops cultivated worldwide because of their high nutritional value, economic significance, and extensive industrial applications. Citrus fruits are one of the oldest fruit crops that are cultivated and have been an important part of human civilization for thousands of years. Citrus belongs to the genus *Citrus* of the family Rutaceae and is thought to have originated in Southeast Asia before spreading to other regions of the world via migration, trade and agriculture. Commercial species include sweet orange (*Citrus sinensis*), mandarin (*Citrus reticulata*), lemon (*Citrus limon*), lime (*Citrus aurantiifolia*), grapefruit (*Citrus paradisi*), pummelo (*Citrus maxima*) and sweet lime (*Citrus limetta*).

India is the third largest producer of citrus fruits in the world which allows for the mass production of juices, cakes and many other products but these products do not utilize the peel, seeds and pulp in most cases. Mini Orange peels contain high amounts of dietary fiber, pectin, phenolic substances, flavonoids, and essential oils, enhancing its nutritional and functional value. Specifically, it has bioactive substances like hesperidin, naringin, narirutin, and eriocitrin, as well as volatile compounds that contribute to its distinctive aroma and taste.

Using orange peels as food ingredients has not been explored to its fullest potential because the major drawback of using peels is the bitterness and astringency found in the peels. Bitterness is due to naringin and limonin present in the albedo and the astringency is due to the presence of tannins and other phenolic compounds that give dry, puckering mouthfeel when peels are tasted. Hence why different processing techniques are required to make the peels acceptable. One such method includes the brining of

peels. Using brining as a pretreatment allows for the salts and sugars to penetrate the peels and reduces the bitterness and astringency of the peels. The mechanism involves the diffusion of salts and sugars from the brine into the peel and in turn some soluble compounds leach out into the solution. This process may contribute to the reduced bitterness in the peels.

While orange peel has been used in baked goods, drinks, and other functional foods, its use in seasoning products is still relatively restricted. Orange zest is made of the flavedo of the peel. It is often used in small amounts to add citrus fragrance and taste, while the inner white albedo is usually discarded because of its notable bitterness. There is limited information related to Citrus Peel Seasoning Products.

Seasonings are blends of various spices, pulses and other ingredients that are versatile food products that can enhance bland foods. It enhances palatability and gives a complex flavour profile. Seasonings can be sweet, salty, spicy, sour, umami, tangy etc. A Mini Orange peel seasoning can be a modest step in introducing citrus peel-based food products to the consumer.

This study aims to develop different formulations of mini orange peel seasonings using easy to procure ingredients and to evaluate their sensory acceptability. Sensory evaluation is important for understanding consumer-related attributes such as appearance, colour, aroma, taste, texture, aftertaste and overall acceptability and selected physicochemical properties are performed which provide additional information about properties of the peel seasonings. The incorporation citrus peels into seasonings is an alternative method to utilize both the Albedo and Flavedo of the Citrus fruit and through the brining process the bitterness of the peels can be reduced significantly which

provides the consumer with a natural flavoring agent. Additionally, it promotes waste valorization and reduce environmental pollution.

Materials and methods

Materials

Mini Oranges procured from Raithu bazar

Ingredients for four formulations

Equipment used like Grinder, sieve, drying setup, Weighing balance, Moisture Analyzer, Refractometer, Muffle Furnace

Method of preparation

- The fruit is washed and the peeled by hand with the Albedo attached to it
- The peels are cut into thin strips or juliennes
- The peels are then blanched in hot water for 3 minutes
- Then the peels are removed before being subjected to its specific brine
- The peels are brined for 6-8 hours
- Sun drying for approximately 24 hours
- Grinding the dried peel as per it's required texture. Salty and Sweet and Salty Seasonings were grinded finely whereas Sweet and Karampodi Seasonings were coarsly grinded
- Sieving of required seasoning samples

Images during preparation

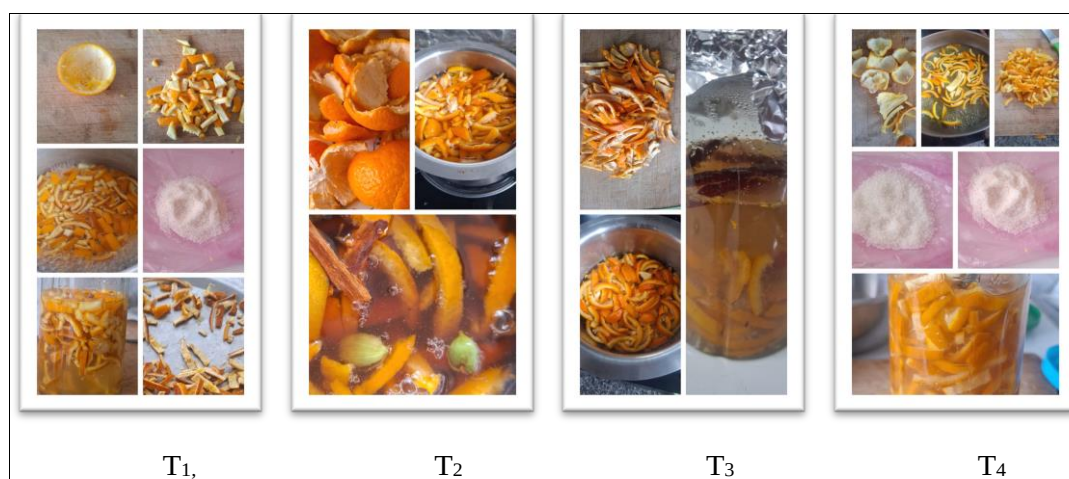


Fig 1: Preparation method of T₁, T₂, T₃, T₄

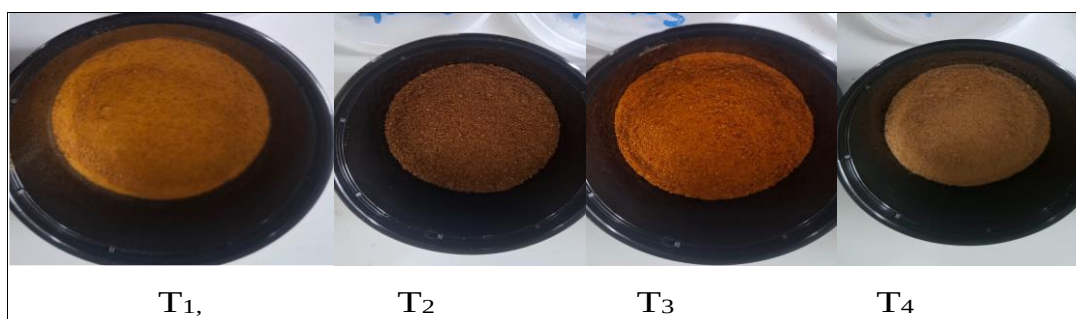


Fig 2: Final Seasoning formulations

Table 1: Formulation of Seasoning samples

Ingredient	T ₁	T ₂	T ₃	T ₄
Mini Orange peel	100g	100g	100g	100g
Salt	30g	-	30g	30g
Vinegar	25ml	-	25ml	-
Water	375ml	375ml	375ml	375ml
Jaggery	-	60g	-	-
Sugar	-	-	-	60g
Cinnamon	-	1g	-	-
Cardamom	-	1g	-	-
Garlic paste	-	-	10g	-
Ginger	-	-	10g	-
Dry Red Chilli	-	-	10g	-
Cumin	-	-	5g	-
Coriander	-	-	5g	-
Urad dal	-	-	1tsp	-
Chana dal	-	-	1tsp	-
Yield	22g	22g	24g	20.8g

Results and Discussion

1. Physicochemical Analysis

Determination of Moisture Content: Performed using a Moisture Analyzer. The initial sample weight was around 2g for all seasoning samples

Determination of Total Ash Content: Using a Muffle furnace. Around 2g of each sample was incinerated. T₂

(Jaggery) was not analysed for ash because of caramelisation of jaggery sticking to the walls of crucible
Determination of Total Soluble Solids by Abbe Refractometer: The Brix content of seasonings T₂ and T₄ were determined using a Abbe Refractometer. T₁ and T₃ lack a soluble sugar component hence TSS was not performed for those seasonings.

Table 2: Physicochemical Analysis

Physicochemical Test	T1	T2	T3	T4
Moisture Analysis	7.7%	7.5%	10.1%	9.8%
Ash Content	51.87%	Not Analyzed	43.88%	43.19%
Total Soluble Solids (°Brix)	Not Analyzed	7.8°Brix	Not Analyzed	4.0°Brix

Interpretation

The Moisture content ranged between 7.5 to 10.1% with T₃ having the highest moisture percentage. The Ash content ranged from 43.19% to 51.87%. The high readings may be due to salt and other minerals. The values for Total Soluble Solids ranged from 4.0 to 7.8 °Brix due to differences in the sweetening agents and their processing.

2. Sensory Evaluation

Sensory evaluation was conducted through a 9-point hedonic scale, 32 semi trained panelists rated the samples according to their degree of liking. The evaluation considers attributes like Appearance, Odour, Texture, Taste, Overall acceptability and Aftertaste. In the hedonic scale 1= dislike extremely and 9 = liked extremely. The samples were coded to prevent bias and produce the most accurate results. The results were collected using an online form.

Table 3: Mean ± Standard Deviation of Sensory Scores of Mini Orange Peel Seasonings

Sensory attribute	T ₁ Salt-Vinegar	T ₂ Jaggery	T ₃ Karampodi	T ₄ Sweet & Salty
Appearance	7.63 ± 1.04	8.28 ± 0.92	8.34 ± 0.70	8.25 ± 0.80
Colour	7.97 ± 0.93	8.09 ± 0.86	8.25 ± 0.76	8.13 ± 0.83
Aroma	7.47 ± 1.22	8.19 ± 0.82	8.25 ± 0.72	8.09 ± 0.89
Taste	7.38 ± 0.94	8.25 ± 0.72	8.31 ± 0.69	8.25 ± 0.80
Texture	8.22 ± 0.94	8.28 ± 0.96	8.56 ± 0.72	8.41 ± 0.84
Aftertaste	7.44 ± 1.01	8.03 ± 0.90	8.22 ± 0.71	8.09 ± 0.82
Overall Acceptability	7.56 ± 0.91	8.31 ± 0.64	8.38 ± 0.66	8.25 ± 0.88

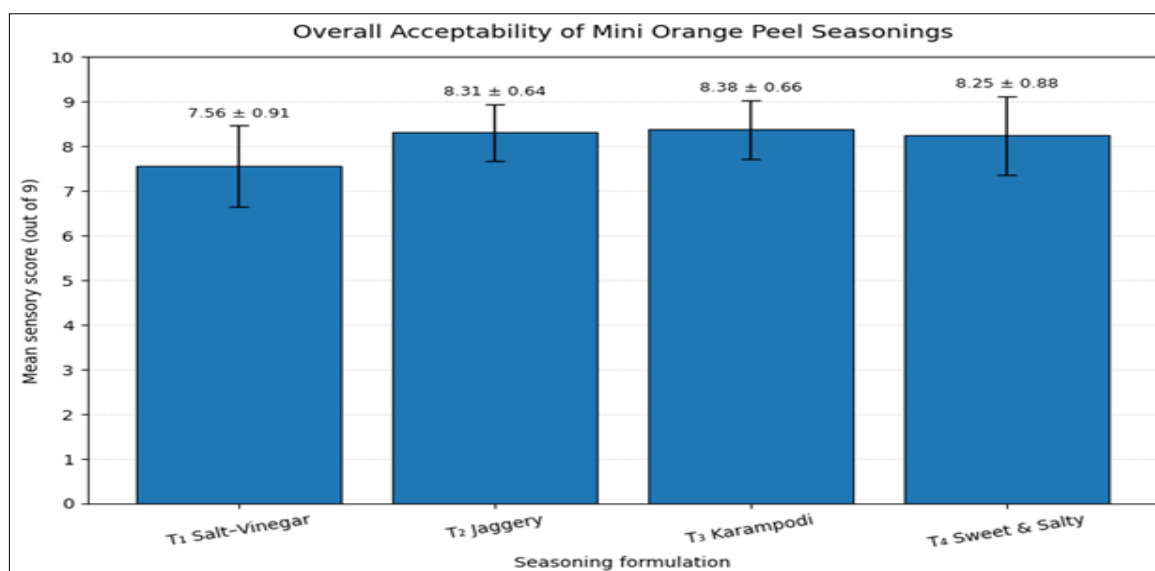


Fig 3: Bar graph of Overall acceptability of Seasoning samples

Table 4: Repeated measures ANOVA

Attribute	F-value	p-value	Result
Appearance	10.923	<0.001	Significant
Colour	1.459	0.231	Not significant
Aroma	12.025	<0.001	Significant
Taste	19.885	<0.001	Significant
Texture	2.402	0.073	Not significant
Aftertaste	10.214	<0.001	Significant
Overall Acceptability	13.640	<0.001	Significant

Sensory evaluation revealed notable variations in appearance, aroma, flavor, aftertaste, and overall liking, whereas color and texture displayed no significant differences across the four formulations.

T₁ (Salt-Vinegar) was notably different from T₂ (Jaggery), T₃ (Karampodi), and T₄ (Sweet and Salty) regarding the significant attributes, while T₂, T₃, and T₄ showed statistical similarity.

3. Statistical Analysis

Sensory evaluation data were expressed as mean $\pm$ standard deviation (SD). Differences in sensory attributes among the four mini orange peel seasoning formulations were analysed using repeated-measures analysis of variance (ANOVA), followed by pairwise comparisons to identify differences between formulations. Statistical significance was considered at $p < 0.05$.

Table 5: Post HOC paired comparison of sensory scores

Sensory attribute	T ₁ vs T ₂	T ₁ vs T ₃	T ₁ vs T ₄	T ₂ vs T ₃	T ₂ vs T ₄	T ₃ vs T ₄
Appearance	Sig.	Sig.	Sig.	NS	NS	NS
Colour	NS	NS	NS	NS	NS	NS
Aroma	Sig.	Sig.	Sig.	NS	NS	NS
Taste	Sig.	Sig.	Sig.	NS	NS	NS
Texture	NS	NS	NS	NS	NS	NS
Aftertaste	Sig.	Sig.	Sig.	NS	NS	NS
Overall Acceptability	Sig.	Sig.	Sig.	NS	NS	NS

Sensory evaluation results were presented as mean $\pm$ standard deviation (SD). Variations among the four mini orange peel seasoning formulations were examined using repeated-measures analysis of variance (ANOVA), subsequently accompanied by post-hoc pairwise comparisons. Statistical significance was defined as $p < 0.05$.

Conclusion

The study successfully produced four formulations of Mini Orange Peel seasonings. Sensory Evaluation of the seasonings was conducted with Semi trained panelists using a 9 point hedonic scale that ranked T₃ (Karampodi) formulation the highest overall acceptability rating (8.38) followed by T₂ (8.31), T₄ (8.25) and T₁ (7.56) which. The reason for T₃ (Karampodi) formulation's rating could be due to the savory and spicy notes of karampodi ingredients complementing the citrus notes of the peel. T₂ (8.31) and T₄ (8.25) could be preferred due to sweet ingredients compatibility with the Mini Orange peels. T₁ recieved the lowest score maybe due to the undesirable aftertaste. Through ANOVA it was determined the four seasoning formulations differed significantly in terms of appearance, odor, taste, aftertaste, and overall acceptability ($p < 0.05$). However, color and texture did not show any significant changes ($p > 0.05$). The attribute with the highest F-value (19.885) among the treatments was taste. Thus, this study proves the potential of citrus peels like the Mini Orange Peel into acceptable seasons that contribute to the waste valorization of Citrus peels and helps prevent food waste.

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