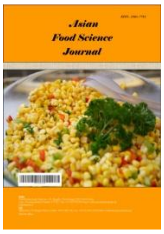

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Organoleptic and Morphological Analysis of Citrus Peel Powder

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Aim: Processing of citrus fruits results in the production of a >40 million tons of by-products worldwide and a major part of this by product is its peels. These peels have the potential of acting as a good nutraceutical resource owing to its high dietary fibre content and phenolic content. However, these peels are under-utilised despite their claimed health benefits. This study evaluates the morphological structure and sensory attributes of sweet lime peel and orange peel powder.
Study Design: The present study was conducted in 3 phases-

1. Collection of Raw Material
2. Pretreatment & dehydration
3. Processing into powder form.

Place and Duration of the Study: The present study was conducted in the Department of Food &Nutrition of Babasa.heb Bhimrao Ambedkar University Lucknow. The duration of the study is 6 months i.e. from Jan, 2022- July, 2022.
Methodology: Peels of sweet lime and orange were transformed into powder through solar drying followed by grinding. In the present study, we have compared the morphology and organoleptic constituents of orange peel powder (OPP) and sweet lime peel powder (SLPP). The morphology of the two samples was studied by Scanning Electron Microscopy (SEM) and element composition was studied and analysed by Energy Dispersive X-Ray Analysis **(**EDX). Organoleptic and sensory attributes were analyzed by a 9 pointer hedonic scale rating. Peel powders were also compared for two functional properties i.e. their Solubility Index and Swelling Power.

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Keywords: Citrus; SEM; EDX; solubility index; swelling power.

1. INTRODUCTION

Citrus fruits belong to the family Rutaceae, and it includes fruits like orange, sweet lime, lemon and so on. They are the largest sector of world fruit production with 100 million tons per season. India holds the fifth position in its production after Brazil, China, the US, and Mexico in the world [1]. Citrus fruits are consumed as fresh fruits as well as in processed forms like juices, squashes, jams, jellies, marmalades etc. [2]. It is incredibly esteemed all through the world for its outstanding wholesome and therapeutic properties [3].

The by-product obtained after the consumption of these fruits in any form accounts for half of the weight of the total fruit weight and it is thrown into the garbage. Peels hold the largest share of the residue of the citrus juice industry and other citrus processing industries [3]. This by-product can be utilized in many ways as peels of citrus fruits are a rich source of dietary fiber (cellulose, hemicelluloses), vitamin C, pectin, and phytochemicals [3].

Peels of citrus fruit is considered to have more polyphenols than the fruit itself. These polyphenols are believed to have anticancer, antifungal, and antioxidant properties [1]. Since citrus fruit peels are rich in dietary fiber and pectin they have many health benefits like cholesterol and blood sugar-lowering effects. In fact the amount of soluble and insoluble dietary fiber in citrus peels is much higher than in cereals [1]. Despite of having enormous health-promoting functions the use of citrus peels is limited and this is because of the extremely bitter taste of the peels. However, they can be subjected to the de-bittering process although the antioxidant properties are compromised in the process [1]. But there is a lot of research required on developing such de-bittering processes such that it has no or minimal effect on the antioxidant properties of the peels.

Citrus peels can be incorporated into foods to develop various functional foods/ fortified food which adds to the fiber content the polyphenolic profile of the food product and can be tested by sensory evaluation to check its acceptance by general public [4,5]. Sensory evaluation is a scientific method of evaluation of a particular food product by a trained or semi trained panel member by using five senses i.e eyes, ear, nose, touch and tongue. The food product is evaluated on the following criteria – appearance, touch, odour, texture, taste, etc [6].

Surface analysis of a food product plays an important role in handling, manufacturing, and processing. Therefore, the processed peel powders were analyzed by SEM for their roughness, morphology, geometric shape [7] and both powders were also evaluated for two functional properties i.e. Swelling Power and Solubility Index. Thus, this study evaluates and compares the sensory attributes and the morphology of two types of citrus fruit peels which are orange *(Citrus sinensis)* and sweet lime peels *(Citrus limetta).*

2. MATERIALS AND METHODS

2.1 Materials

Orange and Sweet Limes were purchased from the local market. Sodium Chloride was taken from the departmental laboratory.

2.2 Methodology

2.2.1 Citrus Peel powder preparation

Flow chart of Peel Powder preparation

Fresh Sweet lime/ Orange peels
↓
Blanching (To remove Microbial Load)
↓
De-bittering of peels
↓
Solar drying
↓
Dehydration

↓
Grinding
↓
Coarse powder
↓
Sieving
↓
Fine powder

2.2.1.1 De-bittering of peels

Naringenin and neohesperidin are phytochemicals present in citrus peels which are responsible for the bitterness of peels. Hence the peels were de-bittered to make the powder palatable. Citrus peels were blanched to reduce the microbial load. After blanching they were de bittered using 4% NaCl solution. Peels were soaked overnight in 4% NaCl solution [1].

2.2.1.2 Drying of peels

The de-bittered peels were sun dried for 3-4 days followed by tray drying for 1 hour [1].

2.2.1.3 Peel powder formation

Dried peels were then grinded in a mixer. Coarse powder were obtained which was sieved and then grinded again to obtain fine powder [8].

2.2.2 Micro structure analysis of sweet lime peels and orange peels

Scanning Electron Microscopy of Samples:

Scanning electron microscopy (SEM) JSM 6490) is a very useful instrument to visualize morphological structure of the food. Sweet lime peel and orange peel were analysed by using high resolution SEM. Both samples were first made into a powder. After drying, protect the sample from relative humidity. And keep the sample Eppendorf microcentrifuge tubes, then 2-4 mg of dried sample were taken and coated by using the sputter coater of JOEL, both of the samples were examined at 10KV. Image were taken in representative parts of the tested sample and observed at a high magnification [9].

2.2.3 Solubility index and swelling power

One gram (1g) of sample was poured into a test tube and its weight was taken as W_1. 50 ml distilled water was added and mixed to make a slurry. It was heated in a water bath (85°C/30 min) and then cooled (28°C). It was centrifuged at 2200rpm for 15 min to separate supernatant. In a pre-weighed Petri dish (W_3) the supernatant was poured and dried in oven at 100°C for 4 hours and weighed again (W_4). The weight of swollen sediment was also taken as W_2.The following formula was used to calculate solubility index and swelling power [1].

$$\text{Solublity index (\%)} = \frac{W_4 - W_3}{\text{Weight of Sample}} \times 100$$

$$\text{Swelling Power (\%)} = \frac{W_2 - W_1}{\text{Weight of Sample}} \times 100$$

2.2.4 Sensory evaluation and organoleptic properties

The two peel powders were analysed on following sensory quality attributes: Appearance, Flavour, Aroma, Texture, Acceptability etc on 9 point Hedonic Sclae. For this purpose both powders were served to 5 Expert Pannel members for rating on a 9 pointer hedonic scale ranging from 9 (Like extremely), 8 (Like very much), 7(Like Moderately), 6(Like slightly), 5(Neither like nor Dislike), 4(Dislike slightly), 3(Dislike moderately), 2(Dislike very much), 1(Dislike extremely) [10].

3. RESULTS AND DISCUSSION

3.1 SEM-EDX Analysis

Along with SEM, EDX is used which is a micro-analytical technique used to determine local elements in a sample. SEM-EDX analysis was used to determine mineral distribution in peel powders. The aim of EDX in present study was to identify minerals in the prepared samples and to compare the mineral composition of OPP and SLPP. The result showed that both samples contain six elements i.e O, Na, Cl, Ca, Pt. [11] The percentage observed is as follows;

Fig. 1 indicates that in OPP the element present in highest percentage is Carbon i.e 53.48% and Calcium is present in least amount i.e. 0.14%.

And Fig. 2 indicates that in SLPP the element present in highest percentage is Oxygen i.e. 61.29% and the element present in least amount is Calcium i.e. 0.78%. Tables 1 & 2 depicts the percentage of all the elements present in both samples and it is clear that Ca was present in least amount in both samples.

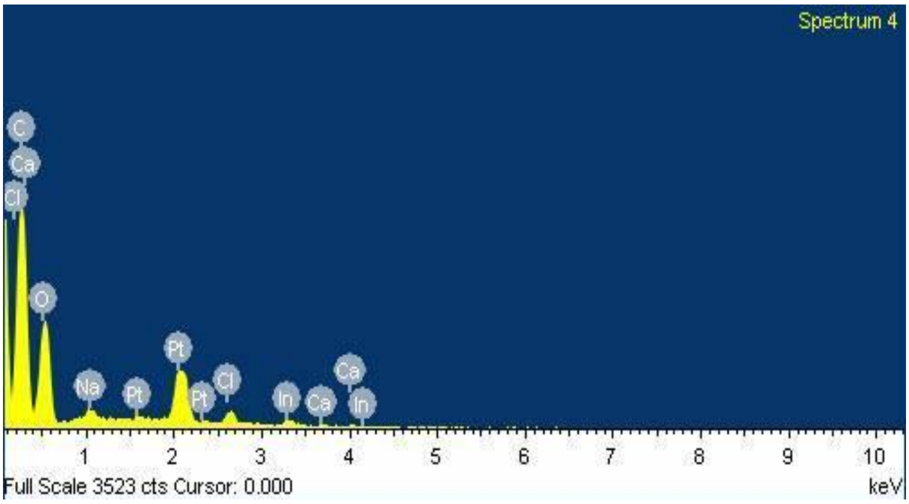


Fig. 1. EDX of Orange Peel Powder (OPP)

Table 1. Element (%) of OPP as per EDX

Element	Weight%	Atomic%
C K	53.48	64.55
O K	37.61	34.07
Na K	0.68	0.43
Cl K	0.77	0.31
Ca K	0.14	0.05
In L	0.78	0.10
Pt M	6.54	0.49
Total	100.0	-

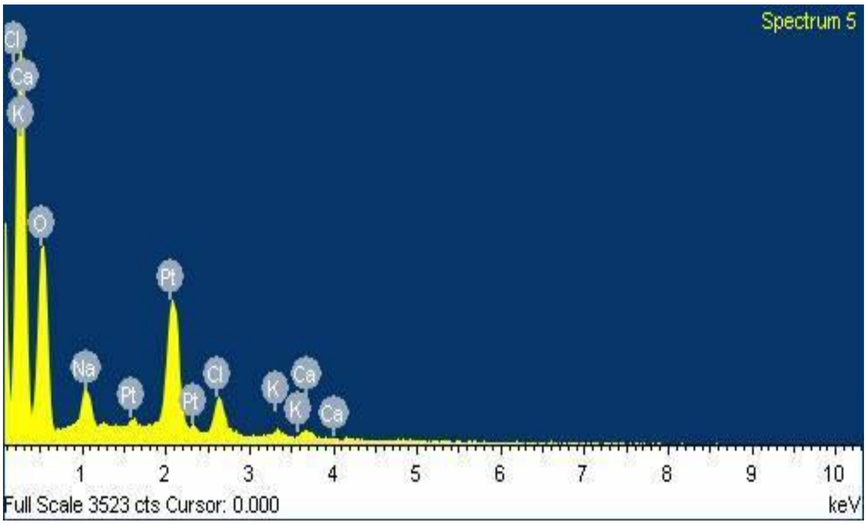
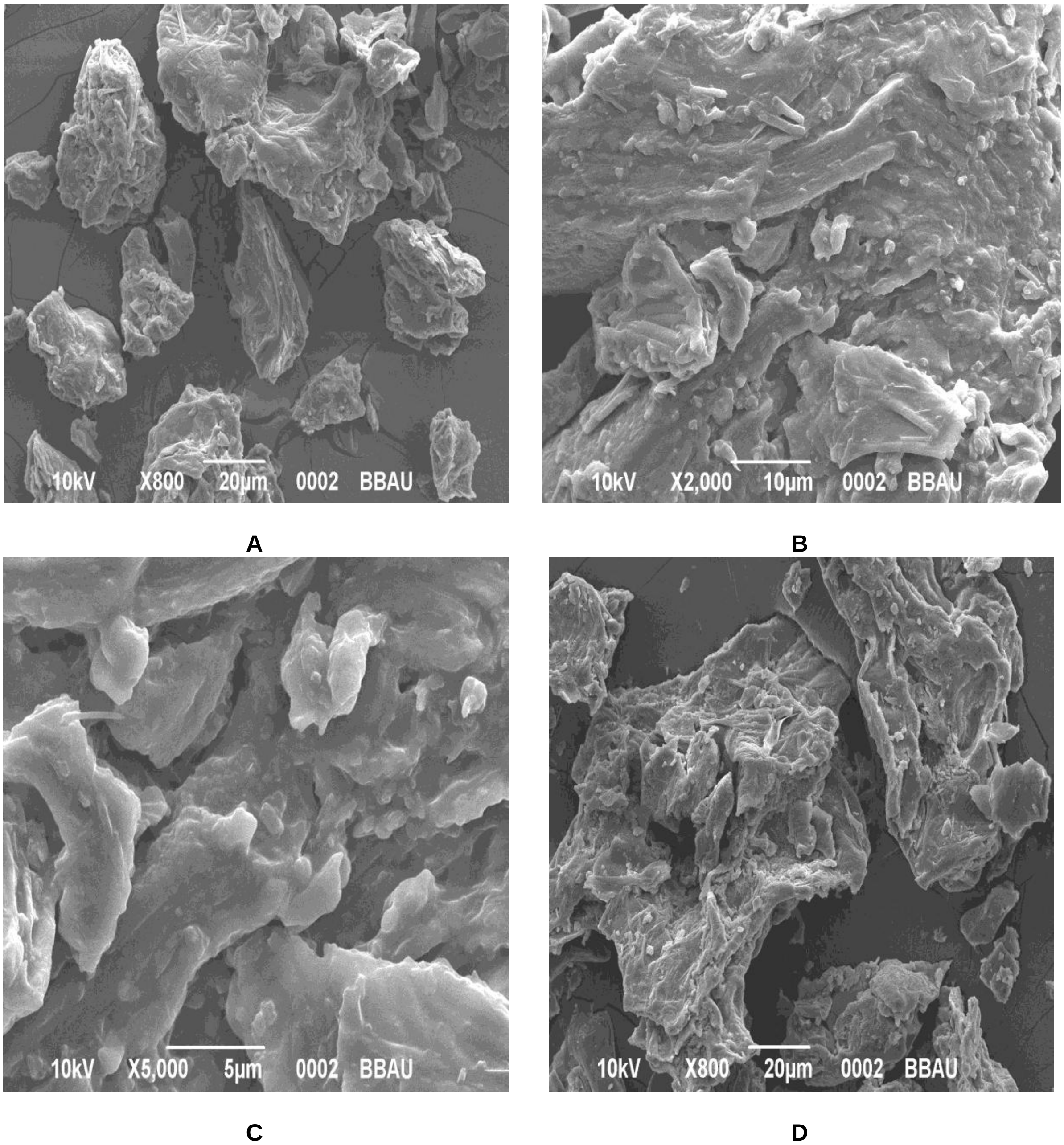
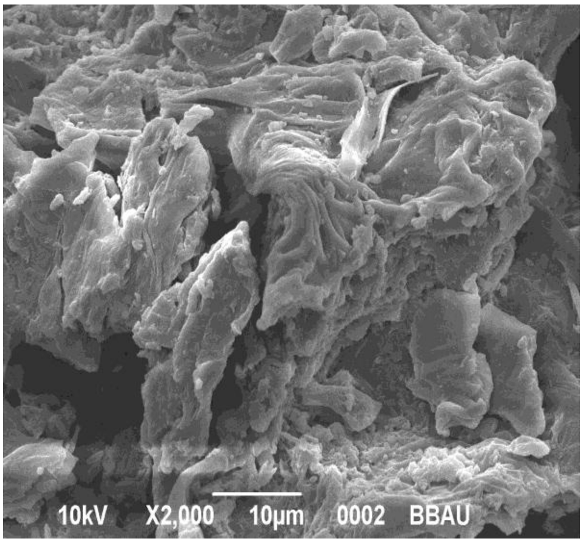


Fig. 2. EDX of Sweet Lime Peel Powder (SLPP)

Table 2. Element (%) of SLPP as per E

Element	Weight%	Atomic%
O K	61.29	87.74
Na K	5.44	5.42
Cl K	4.17	2.69
K K	0.81	0.47
Ca K	0.78	0.44
Pt M	27.52	3.23
Total	100.0	-





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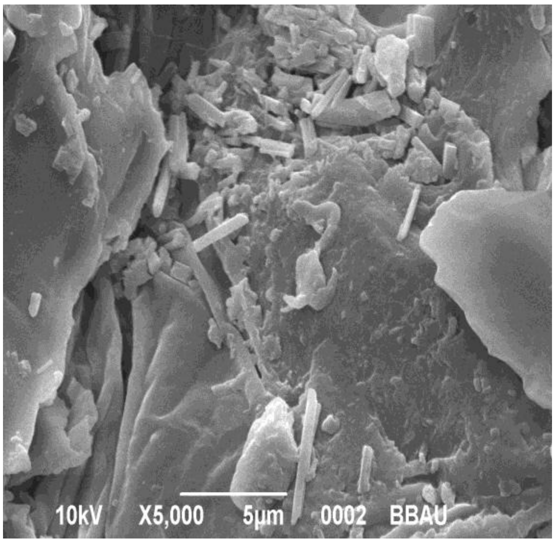

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Fig. 3. (A-F): SEM images of peel powders (A) orange peel power at 800 magnification (B) OPP at 2000 magnification (C) OPP at 5000 magnification (D) Sweet Lime peel powder at 800 magnification (E) SLPP at 2000 magnification (F) SLPP at 5000 magnification

3.2 Morphological Analysis

Fig. 3 A, B, C, D, E, F shows morphological behaviour of Orange peel and Sweet Lime peel at different magnifications.

The aim of SEM analysis was to obtain the exact morphology of both citrus peel samples and to compare them. Fig. 3 A shows the results of Orange peel powder at X800 magnification; it depicts the uneven geometry of particles which might be due to the amorphous nature of the sample. When observed on a X5000 magnification (C) it clearly shows a very smooth surface. On the other hand Sweet Lime Peel powder when analysed under SEM at X 800 magnification shows a larger particle size than OPP however there is no clear geometrical shape of the particles. When observed at X5000 magnification it shows a less smooth surface than the OPP.

3.3 Solubility Index and Swelling Power

Swelling Power of any substance is considered to be an important hydration capacity of any substance and this is in direct relation with the cellulosic content of that substance [1]. From the results as shown in Table 3, it is clear that Sweet Lime peel powder has a high swelling power than Orange peel powder. Solubility index is the measure of the amount of soluble compounds emitted during heating. Results show that Orange peel powder has a comparatively higher solubility index than Sweet lime peel powder.

3.4 Sensory Analysis

Both peel powders were evaluated and compared on 9 pointer hedonic scale on following parameters:

- Appearance
- Flavour
- Aroma
- Texture
- Overall Acceptability

3.4.1 Appearance

The average score of appearance of Citrus peel powder i.e. Orange and sweet lime peel powder was 8.8 and 7.6 respectively. The higher score of Orange peels powder must be due to the bright orange colour while the Sweet lime peel powder was of cream colour.

Table 3. Solubility Index and Swelling Power

Parameter	Orange Peel Powder	Sweet lime peel powder
Solubility Index (%)	1.2	0.95
Swelling Power (%)	8.08	9.75

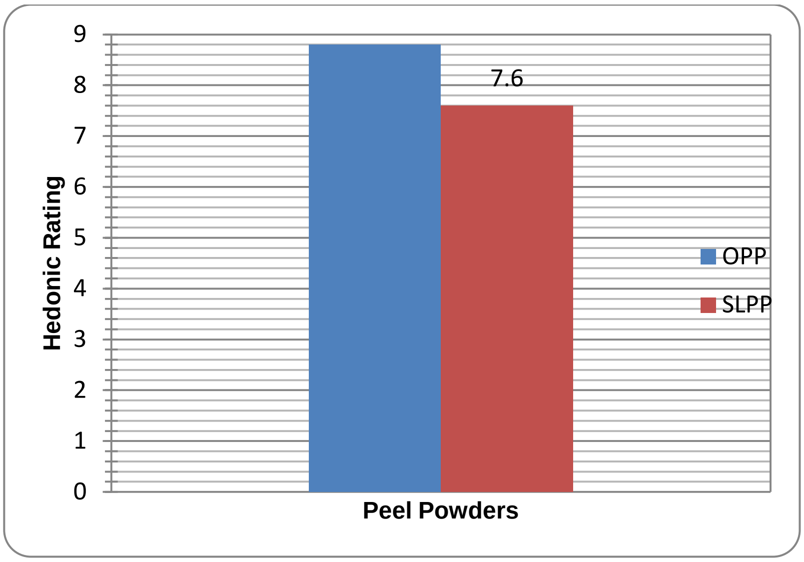

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Fig. 4. Appearance of OP and SLPP

Table 4. Appearance scores

Panel Members	Score	
	OPP	**SLPP**
Panel Member 1	9	8
Panel Member 2	9	8
Panel Member 3	8	7
Panel Member 4	9	8
Panel Member 5	9	7
Mean Score	8.8	7.6

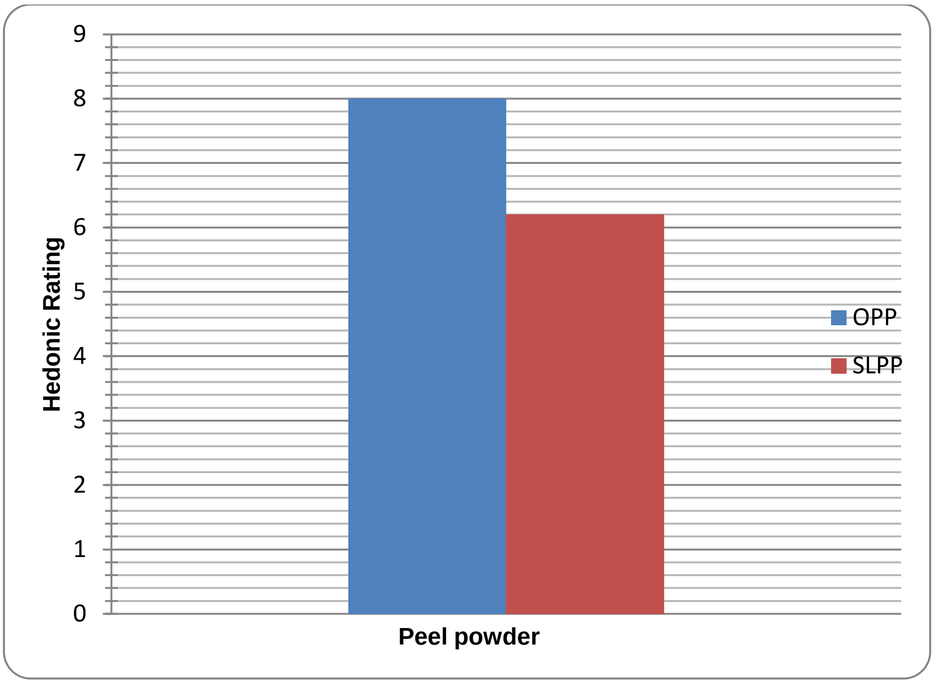

Fig. 5. Flavour of OP and SLPP

Table 5. Flavour scores

Panel Members	Score	
	OPP	**SLPP**
Panel Member 1	9	7
Panel Member 2	7	6
Panel Member 3	8	5
Panel Member 4	9	6
Panel Member 5	7	7
Mean Score	8	6.2

3.4.2 Flavour

The average score of flavour/ taste is 8 for OP and 6.2 for SLP. Sweet lime peel powder was a little bitter despite the debittering process but the orange peel powder was not bitter hence it received a higher score by the panel members.

3.4.3 Aroma

Average score of OPP was 9 because of its very strong and pleasant citrus smell, however SLP received an average score of 7.6 as its aroma was weak but pleasant.

3.4.4 Texture

Both powders received almost equal rating average rating for their texture i.e. OPP 8.6 and SLP 8.4. The slightly low rating of SLP must be due to its coarse texture while OPP has a texture of very fine powder.

3.4.5 Overall acceptability

The average acceptability of OPP and SLP are 8.8 and 7 respectively. This is due to the strong aroma and bright colour of OPP. Despite de-bittering SLP was found to taste bitter hence this makes it less acceptable to the panel members. However the OPP was not bitter.

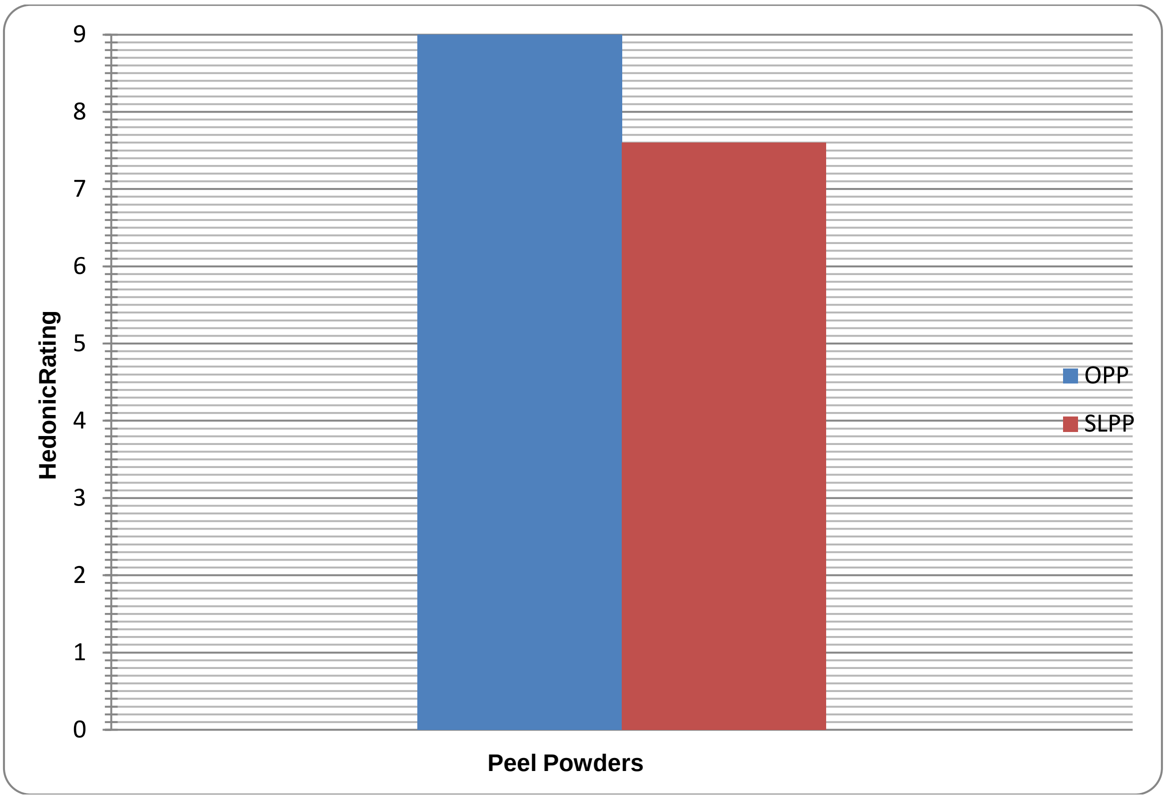

Fig. 6. Aroma of OP and SLPP

Table 6. Aroma scores

Panel Members	Score	
	OPP	SLPP
Panel Member 1	9	7
Panel Member 2	9	8
Panel Member 3	9	8
Panel Member 4	9	8
Panel Menber 5	9	7
Mean Score	9	7.6

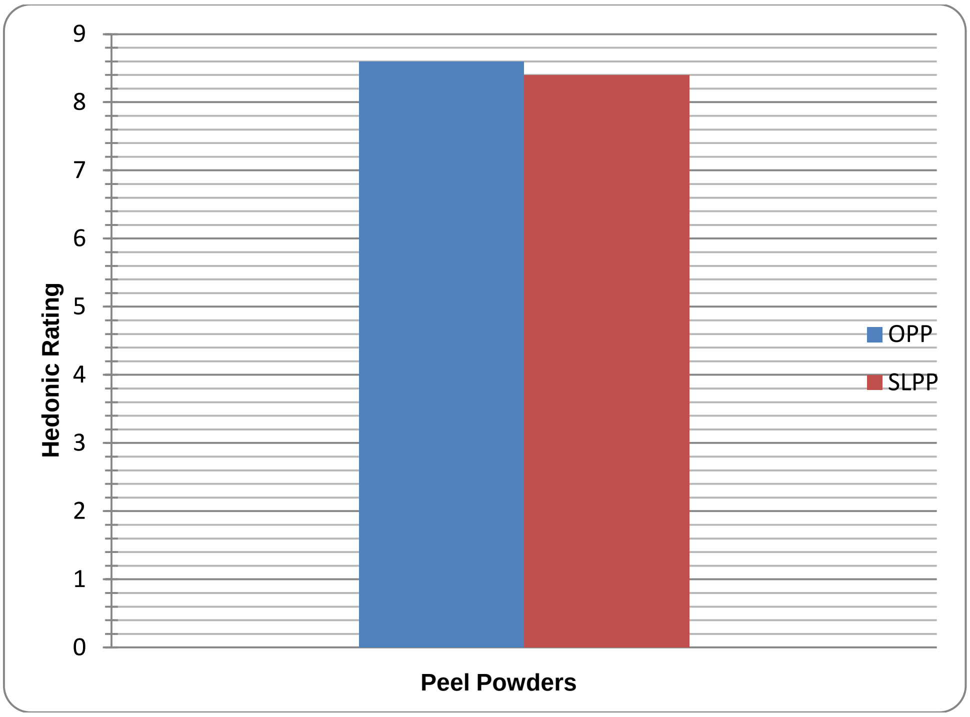

Fig. 7. Texture of OP &SLPP

Table 7. Texture scores

Panel Members	Score	
	OPP	SLPP
Panel Member 1	9	8
Panel Member 2	9	9
Panel Member 3	8	8
Panel Member 4	8	8
Panel Menber 5	9	9
Mean Score	8.6	8.4

Table 8. Overall acceptability scores

Panel Members	Score	
	OPP	SLPP
Panel Member 1	9	7
Panel Member 2	9	8
Panel Member 3	8	7
Panel Member 4	9	6
Panel Member 5	9	7
Mean Score	8.8	7

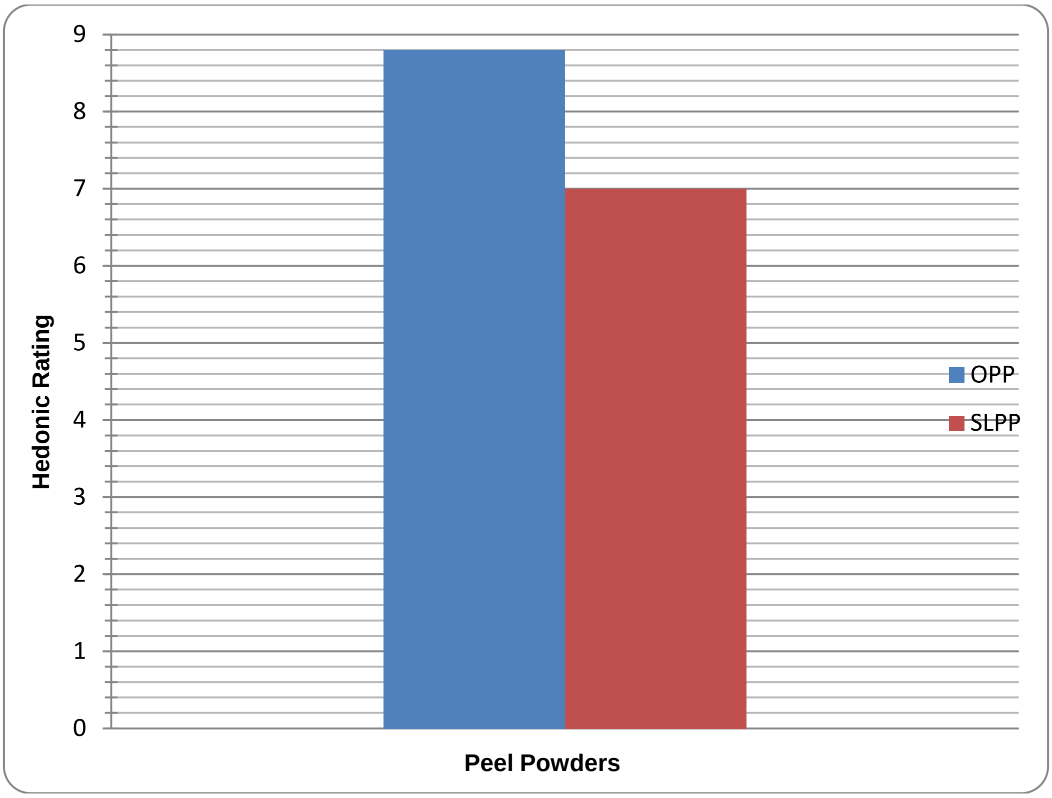

Fig. 8. Overall acceptability of OP and SLPP

4. CONCLUSION

Citrus peel is one of the major by-products of the juice industry. Many researchers have proven that it has health benefiting effects due its high content of dietary fibre, phyto-chemicals, and antioxidants. The bitterness of these peels has a limiting effect on its incorporation in value added food products. However, the process of de-bittering can be done to lower that bitterness to some extent [12,13]. From the results obtained after conducting this study we conclude that OPP has better sensory attributes than SLPP. The solubility index of both powders was poor but OPP was more soluble in water than SLPP. The SI of OPP and SLPP is 1.2% and 0.98% respectively. The swelling power is related to the amount of soluble dietary fibre (especially pectin), particle size and surface area [14]. From the results obtained the SP of OPP and SLPP was 8.08% and 9.75%. respectively. Since the SP of SLPP is more than OPP we can conclude that SLPP has a higher amount of soluble dietary fibre than OPP. Morphology of both the powders were smooth however it is evident from the results of SEM that SLPP has a comparatively rough surface than OPP.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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