RESEARCH PAPER

INVESTIGATING THE FUNCTIONAL AND ANTI-NUTRITIONAL PROFILE OF FRESH AND HEAT-TREATED *SELENICEREUS COSTARICENSIS* (DRAGON FRUIT) PEEL

Rosalin Nikitha R[1*], Priya Ananda Subramanian[2],

[1]*Research Scholar, Department of Foods and Nutrition, RVS College of Arts and Science, Coimbatore, Tamil Nadu, India,*

[*]Corresponding Author: *E-mail: nikitharose.tk750@gmail.com, Phone: +91 9994089026*

[2]*Associate professor, Department of Food Science and Nutrition, Dr. N.G.P. Arts and Science College, Coimbatore, Tamil Nadu, India*

Abstract

This study had been carried out to compare the physiochemical properties like antinutritional factors and functional groups of the fresh and the processed dragon fruit peel. The fresh dragon fruit was obtained and the fresh mass (454g) longitudinal diameter (8.4cm) and transversal diameter (8.03cm) were measured. After cleaning, the peel was removed and dried at 60°C for 12 hours in a hot air oven. The dehydration ratio (11.62), rehydration ratio (340.85), and angle of repose (26.57°) of the dried peel and powder were assessed. The anti-nutritional factors in the heat-treated material decreases as the process goes through. Oxalate, phytate, and tannin decrease from 197.0mg/100g, 213.0mg/100g, and 724.0mg/100g respectively to 99.0mg/100g, 62.0mg/100g, and 469.0mg/100g, respectively and the significant difference is proved by t-test. The fresh peel has a pH of 2.99, while the dried peel is 6.07. The moisture level drops down from 19.83% (fresh) to 1.72% (dried). The functional groups are determined using FTIR spectrometry and the betalains presence is observed in the UV-Vis spectroscopy absorption spectra.

Key words: Dragon fruit peel, Heat treatment, Physical parameters, Anti-nutrients, Functional groups

How to cite this article: Rosalin Nikitha R, Subramanian PA. Investigating the Functional and Anti-Nutritional Profile of Fresh and Heat-Treated Selenicereus Costaricensis (Dragon Fruit) Peel. Int J Drug Deliv Technol. 2026;16(57s): 1558-1567. DOI: 10.25258/ijddt.16.57s.157

Source of support: Nil.

Conflict of interest: None.

1. Introduction

Dragon fruits are tropical exotic fruits belonging to the family of *Cactaceae,* generally natives from Southern Mexico and Central America. It usually has a red-green or yellow-green outer layer with scales along with a juicy red-purple or whitish inner layer with edible black seeds embedded in it. It generally grows in warm regions with tropical and subtropical climates. It has high tolerance and adaptability to drought conditions and high temperatures. It is also mentioned with various other names like pitaya, strawberry pear (*Hylocereus spp*. and *Selenicereus spp.*), red pitaya, belle of the night, kamalam, night blooming cereus and conderella plant. (Chandni V Mori et al., 2023). The red dragon fruit (*Selenicereus undatus*) is rich in various macro and micronutrients such as fiber, antioxidants (phytochemicals, ascorbic acid, phyto-albumins and betalains), vitamins such as B_1, B_2, B_3 and C and minerals like magnesium, calcium, phosphorus and potassium. Due to their rich nutritional value, they possess certain therapeutic properties like anti-obesity, hypolipidemic, anti-diabetic, lowering blood pressure, neutralizing toxins (heavy metals), aiding in digestion, treating asthma and preventing certain cancers (colon) (Shekade DP et al., 2018 and Kumar SB et al., 2018).

Though these fruits are consumed worldwide for their nutritional benefits, a large amount of the peel go into waste without proper use. The peels shows the rich

presence of bioactive components such as carotenoids, flavonoids, polyphenols, and betalains which protects against the damages interlinked with oxidative stress. In recent days, various studies have been conducted and concluded that the peels are also rich in nutrients and can be utilized as a functional food and a natural colorant (Mahayothee et al., 2019). It has various culinary applications such as in the preparation of candies, jellies, jams and smoothies and also infused in teas. Various studies have showed its use as a natural colorant in the food as well as fabric. The dragon fruit peel is rich in dietary fiber which can be processed into a fiber powder that can be utilized into making various bakery products such as cakes, muffins, breads and cookies.

2. MATERIAL AND METHODS

The study had been conducted at the laboratories of RVS College of Arts and Science, Coimbatore, during 2022 – 2024 period covering summer, rainy and winter (zaid, kharif and rabi) seasons, the framework and literature study have been conducted from December 2022 – November 2023, the procurement of the dragon fruit was done around its harvest period, July 2024 which is the kharif (summer) season and then the analytical research was carried on.

2.1. Sample selection and procurement

The fresh, clean dragon fruits were selected based on the appearance like colour and texture which should be rich, vibrant, firm and avoid the fruits which are dull, spotted, wrinkled, soft or mushy which might indicate its spoilage or over-ripeness. The smell of the fruit is also checked which should be fruity and aromatic. Such fruits are procured from the local market as it is convenient for the researcher.

2.2. Authentication of the dragon fruits

The procured dragon fruits were tested and obtained authentication certificate from the Botanical Survey of India (BSI), TNAU, Coimbatore, Tamil Nadu. It is identified as *Selenicereus costaricensis* (F.A.C. Weber) *S. Arias* and *N. Korotkova ex Hammel*. of Cactaceae family.

2.3. Physical Parameters of the Fresh Dragon Fruit

The physical parameter of the fruit is measured to ensure the quality and suitability for consumption of the fruit for the consumers. These are the attributes measured with the help of physics principles. Some of the attributes includes weight, length and width. The appearance of the dragon fruit selected for the study is a bright red colour with the flesh being ranging from red to magenta colour. It also has a beautiful subtle floral aroma making it more appealing.

2.3.1. Fresh Mass

The weight of the fruit is also known as wet weight which is the weight of the fruit when it is in the fresh state. It is weight before drying or processing. The fresh mass can be influenced by various factors such as ripeness, variety and environmental conditions. It majorly consists of water, fiber, protein and carbohydrates. Usually highly weighing fruits are found to be juicy and are mostly preferred for consumption. The fresh mass can be precisely measured using a weighing balance which ensures that the fruit is harvested at the right stage. It also ensures that fruit is fit for consumption as it assures its freshness (Daphynni et al., 2021).

2.3.2. Longitudinal Diameter

The longitudinal diameter measures the length of a fruit along its longest axis. It is measured from one end to another end. It helps in recognizing the maturity, size and overall quality of the fruit. This also helps in grading and sorting of fruits as the size is primarily considered by the consumers while selecting the fruits. It is measured using a vernier caliper, which helps in checking shape and size (Daphynni et al., 2021).

2.3.3. Transversal Diameter

The transverse diameter measures the width across its shortest axis from side to

side measuring the width. It is measured perpendicular to the longitudinal diameter. It is another main factor to know the size, shape, firmness and fullness of the fruit which in-turn helps in sorting and grading of fruits fit for consumption. It also helps in knowing the weight and volume at the right proportion. The transversal diameter is measured using vernier caliper (Daphynni et al., 2021).

2.4. Processing the Dragon fruit peel

The epicarp, the outer peel of the dragon fruit, is firstly washed over thoroughly to eliminate all surface impurities as well as to ensure the sample is clean. Afterwards, the peel is sliced up into fine pieces, especially the dry, scaly patches found on the surface-most parts. The pieces are then chopped into small pieces for easier drying. The chopped peel is then spread in a hot air oven tray set at 60°C for 12 hours to dry. This method of controlled drying removes all moisture from the peel but without burning or degrading its beneficial compounds. After 12 hours of drying in the hot air oven, the dried peel looks crisp and brittle meaning it is ready to be grinded. Grind the dried peel into a fine powder using a mixer or grinder and pass the grind powder through a sieve to get an even, smooth textured powder. The fine powdery form of the subjected dragon fruit peel after heat treatment can be preserved for additional experimentation and to act as ingredients in several recipes.

Fig. 1 – Fresh and Heat-Treated Dragon Fruit Peel

2.5. Physical parameters of the dried dragon fruit peel (powder)

Estimating the physical properties ensures the quality, stability and shelf-life of the heat-treated dragon fruit peel and powder. The colour of the peel and powder after processing appears to be a pinkish red colour varying slightly from the fresh peel and also retains the aromatic floral smell from the fresh fruit. The heat-treated peel and the obtained powder are analysed for its moisture loosing, water reabsorbing, flowability and clumping properties.

2.5.1. Dehydration ratio

The dehydration ratio actually measures the extent of the reduction of water or moisture during the drying of the peel. This is done mostly by calculating the dry weight of the tissue at the end of this period from the fresh weight of this tissue at the beginning of the period. Like the skin of any other fruit contains water it too has water in it. In other words, the dehydration ratio is a means by comparing the fresh weight and the dry weight in order to find out the level of dehydration done to the product. For the present work, the dehydration ratio is calculated from the fresh weight of the sample taken initially before dehydration to the dry weight of the sample, finally obtained after dehydration and multiplying the final value by hundred to get the percentage.

$$\text{Dehydration ratio} = W_2/W_1 \times 100$$

Where,

W2 =Weight of sample after drying

W1 =Weight of sample before drying

(Naimish Gupta and Shukla RN., 2017)

2.5.2. Rehydration ratio

Rehydration ratio of the dragon fruit peel is the extent to which the dried peel is capable of swelling with water or getting

back to its original fresh condition. It is often expressed as the percentage difference between the dried dragon fruit peel and the fresh form of the dragon fruit peel after several rehydration processes. A higher value of rehydration ratio confirms that the heat treatment given has helped retain the ability of the dragon fruit peel to reabsorb water (or the water to re-enter the cells). It is particularly assessed to determine how dried slices turn back into its original form. They obtained by using the following formula The percentage gain in weight is determined by dividing the weight of the rehydrated sample by the weight of the dehydrated sample and then the obtained result value is multiplied by hundred.

$$\text{Rehydration ratio} = W_2/W_1 \times 100$$

Where,

W2 =Weight of the rehydrated sample, g

W1 =Weight of the dehydrated sample, g

(Naimish Gupta and Shukla RN., 2017)

2.5.3 Angle of repose

It is determined in heat-treated dragon fruit peel powder containing an essential aspect to measure the stability and flowability of the powder, which in-turn, acts as a control for flow property and clumping property. It also indicates how the particles of the powder interact within. This is done by placing the powder in such a way that it has a pile, then determine the angle made by the pile's surface peak to the base. Angle of Repose shows the flow characteristics, the lower the angle of repose the better the flow characteristic which is an advantage in handling the dried dragon fruit peel powder. It also provides additional information concerning the moisture content and the particle size.

$$\theta = \tan^{-1}(r/h)$$

Where,

θ = Angle of repose, degrees,

h = Height of cone formed, mm,

r = Radius of the base of the pile, mm.

(Bilal, Muhammad., 2022).

2.6. Physiochemical properties – A comparison

The physiochemical attributes are the factors that combine the physical and the chemical properties that plays a crucial role in influencing the quality, suitability and flavour. Some of the physiochemical attributes like anti-nutrients, pH, moisture content, functional groups and betalain pigments were compared in the fresh dragon fruit peel and the heat-treated dragon fruit peel.

2.6.1. Analyzing the Anti-Nutritional factors

These are the compounds that occurs in the food naturally which hinders the absorption, utilization or digestion of nutrients in the body. These are commonly found in plant-based foods like cereals, legumes, and certain fruits and vegetables which when consumed by humans causes digestive discomfort or reduces bioavailability of certain nutrients. Analyzing these nutrients in the food helps in improving the nutritional value and absorption of the food. The anti-nutrients such as oxalate, phytate and tannin are analyzed in the fresh and heat-treated peel using standard procedures.

a) Oxalate – Oxalates are present in the dragon fruit peel in a wide percentage. These oxalates present in the peel interfere with the absorption of calcium by forming insoluble salts. These calcium oxalate can have a deleterious effect on the nutritional value in the body and forms kidney stones. Several methods have been used in the determination of oxalate in foodstuffs, according to the literature. They include enzymatic

assays, titration, spectrophotometry, spectrofluorimetry, capillary electrophoresis, electrochemistry, amperometry, HPLC and GC (Karamad D et al., 2019).

b) Phytate – The phytate and the phytic acid present in the dragon fruit peel is widely under study for its antioxidant properties. Phytates binds with iron, calcium, zinc and magnesium and reduces its absorption in the body. It can be estimated using colorimetric methods, chromatographic techniques, quantitative methods, precipitation methods and also using Nuclear Magnetic Resonance (NMR) spectroscopy (Sivakumaran et al., 2018).

c) Tannin – These are water-soluble phenolic compounds present in the dragon fruit peel. It usually binds with iron irreversibly and interferes with its absorption. It also forms complexes with carbohydrates and protein. Some of the most commonly used methods ranges from the simplest method such as colorimetric and UV spectrophotometric, or more advanced methods including chromatography and enzymic analysis, and finally nuclear magnetic resonance are also used for determination (Ojo M. A., 2022).

2.6.2. pH

It is used to measure the acidity and alkalinity of any solution, which in-turn shows the concentration of hydrogen ions. The scale ranges from 0 to 14, where 7 indicates neutral below which indicates acidic and above which indicates basic. On the basis of food, the pH is an important factor in affecting the overall appearance like texture, taste, colour and also the susceptibility to microbial contamination. This helps in ensuring the food quality and the safety standards of the foods. It is estimated using a pH meter.

2.6.3. Comparing the Moisture content

It is the amount of water (water content) present in the food ingredient or product. It plays a major role in determining the quality and shelf-life of the product. High moisture can lead to microbial growth such as bacterial, fungal yeast and mold, whereas the low moisture can make the product self-stable. Accurate control over moisture is required as it also influences the structural integrity, flavour and nutritional quality. It is measured using a moisture analyser.

2.6.4. Estimating the functional groups

A group of specific molecules forming a chemical structure of a particular component in food. These affect the chemical behaviour and properties of the food compound which in-turn contributes to the nutritional value, flavour, texture and stability. Each functional group performs a specific role. For instance, the food with hydroxyl functional groups has sugars which dissolve more easily and tastes sweeter, whereas carboxylic groups, characteristic of organic acids, enhance food flavors such as sour oranges and the amine group presence in amino acids is important for the synthesis of protein and hence determines the protein structure and its properties. By estimating the functional groups the food processing techniques, the method of cooking, the technique to prevent nutritional value and the right sensory experience is also optimized. The functional group is estimated using Fourier Transform Infrared Spectroscopy (FTIR).

2.6.5. Assessing the Betalains

A water-soluble pigment that helps in knowing the antioxidant capacity, the nutrients present and their relevant health benefits. In certain plants, responsible for vibrant bright coloured pigments like red, purple and yellow colors. It has two types of

pigments betacyanin and betaxanthin. Betacyanin is responsible for red to red-purple colour, whereas the betaxanthin is responsible of yellow to orange-coloured pigments. Their estimation helps in finding the betalains sensitivity towards various environmental factors such as temperature, pH and light and to maintain its stability to be used as a potential antioxidant in the food products. The functional groups are assessed using UV-Visible spectroscopy.

2.6.6. Statistical analysis

All the physical parameter value's measurements were conducted thrice and the mean values of the measurements were calculated along with the standard deviation and the t-test is also calculated and recorded in the table.

3. RESULT AND DISCUSSION

3.1. Physical Parameters of the Fresh Dragon Fruit and the Dried Dragon Fruit Peel Powder

The physical parameters like fresh mass, longitudinal diameter and transversal diameter helps in assessing the quality of the fruit and also the suitability for consumption. The fresh mass is the wet weight of the fruit which is measured when it is fresh. The longitudinal and the transversal diameter is the length and width of the fruit measured from both the axis of top to bottom and side to side.

Whereas, the physical parameters such as dehydration and rehydration ratio helps in finding the moisture loosing and moisture reabsorbing ability of the heat-treated dragon fruit peel. Whereas, the angle of repose helps in finding the flowability, stability and clumping properties of the dried dragon fruit peel powder.

Table I – Physical parameters measured in the Fresh Dragon fruit and the Dried Dragon fruit Peel Powder

S.No	Parameters (Fresh fruit)	Measurements
1	Fresh Mass	454±41.96g
2	Longitudinal Diameter	9.6±0.16cm
3	Transversal Diameter	9.25±0.41cm
S.No	Parameters (Dried fruit peel)	Measurements
1	Dehydration ratio	11.62
2	Rehydration ratio	340.85
3	Angle of repose (θ)	26.57°

From the Table I, the fresh mass, longitudinal diameter and transversal diameter are found to be 454g, 9.6cm and 9.25cm for the fresh dragon fruit respectively. The dehydration ratio and rehydration ratio are found to be 11.62 and 340.85 (showing good quality as the water can re-enter the cells) respectively for dried dragon fruit peel and the angle of repose for dried dragon fruit peel powder is 26.57 which when compared with the standard chart shows excellent flow properties.

3.2. Physiochemical properties – A comparison

The comparison of the physiochemical properties of the fresh dragon fruit peel and the dried dragon fruit peel helps in understanding the impact of the heat-treatment on the fresh dragon fruit peel.

3.2.1. Analyzing the Anti-Nutritional factors

These are the commonly found components in the plant-based food compounds that can interfere with absorption and digestibility of the available nutrients thus decreasing their bioavailability. The t-test is used to evaluate the impact of heat-treatment on the anti-nutrients of the fresh dragon fruit peel.

Table II – Comparison of Anti-Nutritional factors

S. No	Ingredients	Result (mg/100 g)			t-test
		Oxalate	Phytate	Tannin	
1	Fresh Dragon Fruit Peel	197.0	213.0	724.0	3.6433
2	Dried Dragon Fruit Peel	99.0	62.0	469.0	

From the above Table II, the fresh dragon fruit peel has 197.0mg/100g of oxalate, 213.0mg/100g of phytate and 724.0mg/100g of tannin and the dried dragon fruit peel has 99.0 mg/100g of oxalate, 62.0mg/100g of phytate and 469.0mg/100g of tannin. The t-test is calculated by comparing the anti-nutrients in fresh dragon fruit peel and heat-treated dragon fruit peel. The calculated t value is 3.6433 which is higher than the Critical t value (i.e) 3.6433 > 2.9199. So, it can be concluded that the H_1 can be accepted and the H_0 is rejected, it is because there is significant difference between the anti-nutrients such as oxalate, phytate and tannins present in the fresh dragon fruit peel and the heat-treated dragon fruit peel respectively.

3.2.2. pH

3.2.4. Estimating the functional groups

The pH shows the stability, enzymatic activity and flavour of the of the fruit. The value below 7 shows the acidic nature and above which shows basic nature. The fresh dragon fruit peel has a pH of 2.99±0.06 and the heat-treated dragon fruit peel has a pH of 6.07±0.45.

3.2.3. Comparing the Moisture content

The moisture content is the presence of water in the fruit peel. The moisture content in the fresh dragon fruit peel and the dried dragon fruit peel is compared and tabulated.

Table III – Moisture Content in the ingredients

S. No	Ingredient	Weight (Before)	Weight (After)	Timing (105°C)	Moisture Content
1	Fresh Dragon Fruit Peel	19.580g	15.695g	10 min	19.83%
2	Dried Dragon Fruit Peel	10.021g	9.848g	8.57 min	1.72 %

From the above Table III, the fresh and the heat-treated dragon fruit peel has a moisture content of 19.83% and 1.72% respectively.

The functional groups are the chemical structures forming different molecules, each possessing specific chemical properties and exhibiting vivid chemical behaviours.

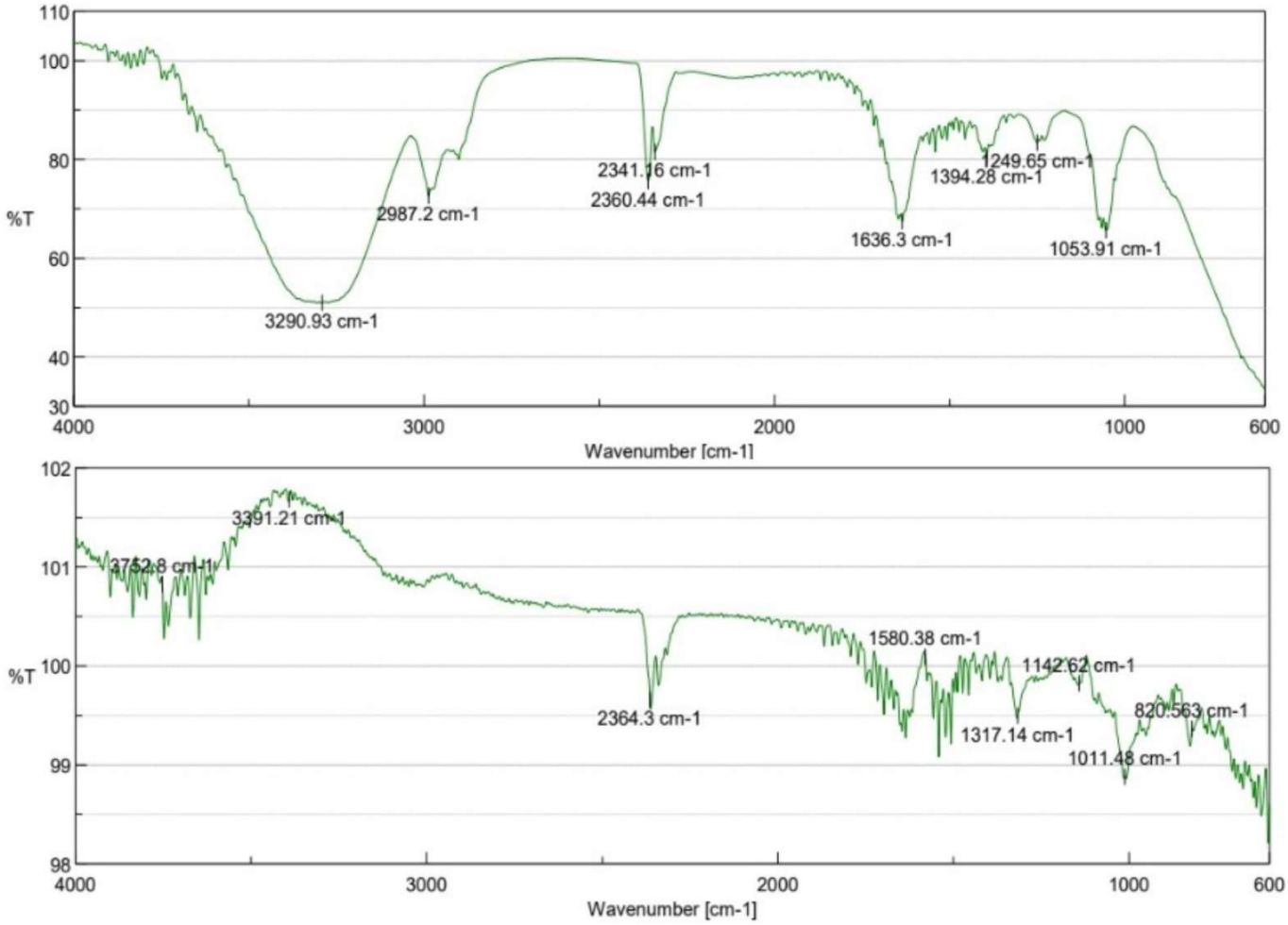

Fig. 2 – Functional groups in Fresh and Dried Dragon Fruit Peel respectively

From the Figure 2, the FTIR spectroscopy peak shows the presence of functional groups such as alcohol, carboxylic acid, amine salt, alkene, conjugated alkene, cyclic alkene and amine in fresh dragon fruit peel and aliphatic primary amine, amine, alkene, cyclic alkene, fluoro compound, sulfone and aromatic amine in dried dragon fruit peel.

3.3.5. Assessing the Betalains

Betalains are the water-soluble pigments showing the presence of bright vibrant red to magenta colour in-turn confirming the presence of betacyanins.

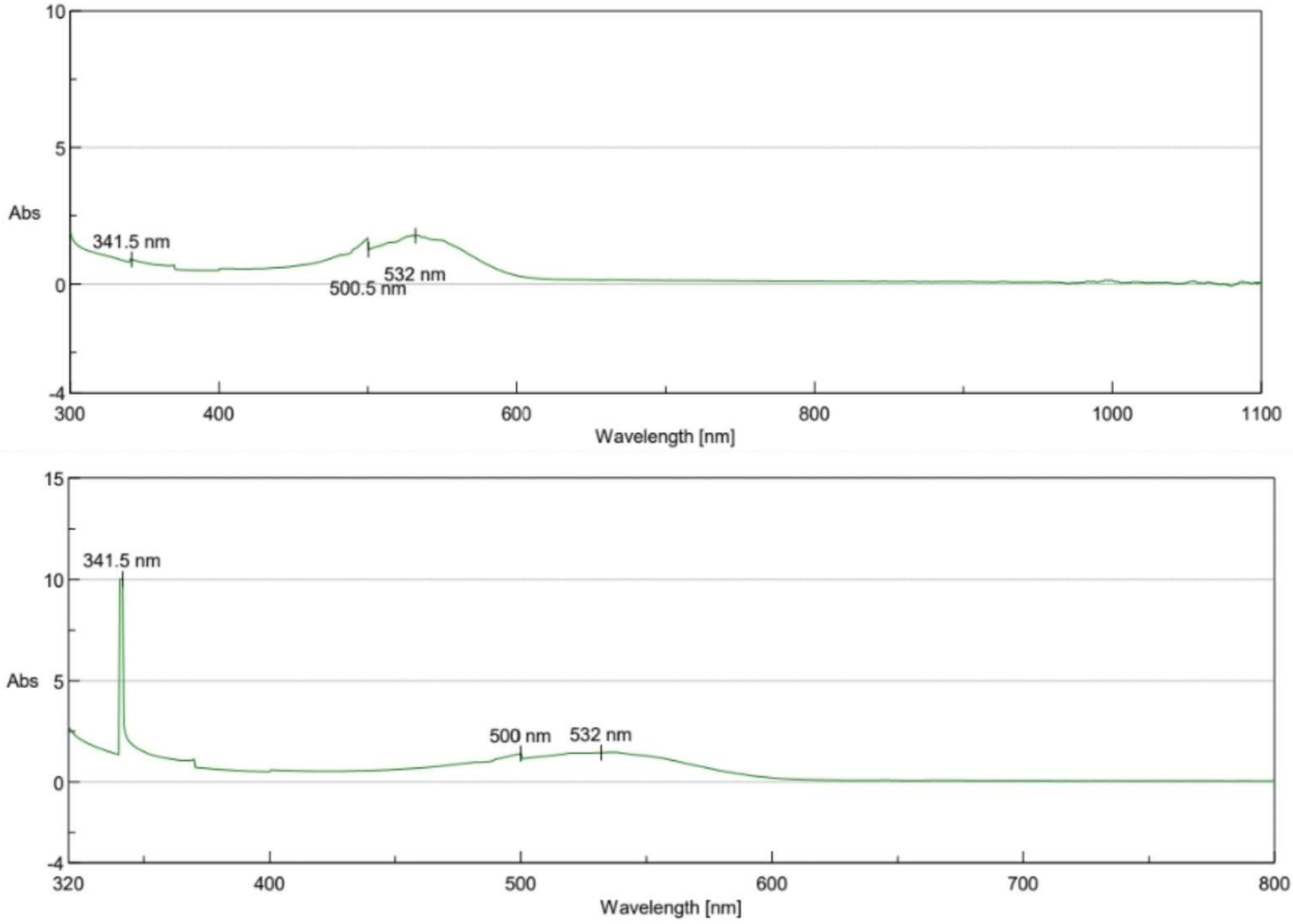

Fig. 3 – UV-Vis absorption spectra of Fresh and Dried Dragon Fruit Peel respectively

From the above Figure 3, the spectra show the absorption at 341.5nm, 500nm and 532nm in both the fresh and the heat-treated dragon fruit peel.

4. CONCLUSION

From the study, it can be concluded that the physical parameters of the fruit shows that it is fresh and suitable for consumption, whereas the physical parameters of the heat-treated fruit peel such as dehydration ratio shows that the peel had dried to a good quality, rehydration ratio shows the capability to reabsorb water in turn showing its capacity to combine with other ingredients and the angle of repose shows an excellent flowing property when compared with the flowing properties standard chart. When the physiochemical parameters of the fresh dragon fruit peel and the heat-treated dragon fruit peel is compared, it shows the anti-nutritional factors like oxalate, phytate and tannin in fresh dragon fruit peel are reduced by heat treatment, the statistical analysing using t-test shows there is significant difference between anti-nutrients present in the fresh dragon fruit peel and the heat-treated dragon fruit peel, whereas the pH is increased in the dried peel than the fresh peel. The moisture content is found to be reduced to a considerable extent. The functional groups like alkene and amine were commonly found in both the fresh and the dried dragon fruit peel and the betalains

spectrum was also determined showing the presence of betacyanin in the dragon fruit peel which codes for red and red-purple colour.

AUTHORSHIP CONTRIBUTION STATEMENT

- Rosalin Nikitha R, contributed in procuring and drying the ingredients, performing the analytical experiments, computing statistical analyses, interpreting data and obtaining the results. Responsible for preparing the initial manuscript draft.
- Priya A, contributed in providing crucial revisions, ideational, foundational and visionary guidance and feedback throughout the entire research framework process. Ensured the overall quality and integrity of the research work and the manuscript.

CONFLICT OF INTEREST

There is no conflict of interest.

REFERENCES

- Bilal, Muhammad. 2022., Lab Report for Angle of Repose.
- Chandni V Mori, AR Patel, VK Parmar and GS Patel. 2023. Dragon fruit (Kamalam): An excellent exotic fruit crop of India., *The Pharma Innovation Journal*; **12**(1): 115-123.
- Daphynni Carolinne Moreira Morais, Vânia Maria Alves, Eduardo Ramirez Asquieri, Adriana Régia Marques de Souza and Clarissa Damiani. 2021. Physical, chemical, nutritional and antinutritional characterization of fresh peels of yellow pitaya (Selenicereus megalanthus) and red pitaya (Hylocereus costaricensis) and their flours., *Revista Ciência Agronômica*, v. **52**, n. 3, e20207289.
- Gupta N, Shukla RN. 2017. Preparation and Quality Evaluation of Dehydrated Carrot and Onion Slices. *J Food Process Technol.* **8**: 692.
- Karamad D., Khosravi-Darani K., Hosseini H., Tavasoli S. 2019., Analytical Procedures and Methods Validation for Oxalate Content Estimation. Biointerface Res. *Appl. Chem*.; **9**: 4305–4310.
- Kumar SB, Issac R, Prabha ML. 2018., Functional and health-promoting bioactivities of dragon fruit. *Drug Invent Today*.;10.
- Mahayothee, B., Komonsing, N., Khuwijitjaru, P., Nagle, M., and Müller, J. 2019., Influence of drying conditions on colour, betacyanin content and antioxidant capacities in dried red-fleshed dragon fruit (Hylocereus polyrhizus). *International Journal of Food Science & Technology*. **54**(2): 460-470.
- Ojo M. A., 2022., Tannins in Foods: Nutritional Implications and Processing Effects of Hydrothermal Techniques on Underutilized Hard-to-Cook Legume Seeds-A Review. *Preventive nutrition and food science*, **27**(1), 14–19.
- Shekade DP, Patil PD, Mote G V., Sahoo AK., 2018., Potential use of dragon fruit and Taro leaves as functional food: a review. *Eur J Eng Sci Technol*.; **1**(1):10-20.
- Sivakumaran, Keerthana & Kothalawala, Sukitha. 2018., An overview of the analytical methods for food phytates. 6.