



ISSN: 2395-7476

IJHS 2023; 9(3): 271-275

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www.home-sciencejournal.com

Received: 02-10-2023

Accepted: 21-11-2023

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Nutritional value of red-fleshed and skinned pitaya (*Hylocereus polyrhizus*) species

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Abstract

The primary objective of this research was to delve into the nutritional value of the red skin with red flesh dragon fruit, which is scientifically known as *Hylocereus polyrhizus*. The study aimed to provide a comprehensive understanding of the nutrient content of this exotic fruit and its potential impact on human health. The fruit's nutritive value is based on its physical and chemical properties, such as its energy content, protein, fat, carbohydrates, crude fiber, calcium, magnesium, vitamin A, vitamin C, antioxidants, flavonoids, phenolic acid, and quercetin. These essential nutrients play a vital role in promoting overall health and well-being by boosting the immune system, reducing inflammation, and preventing chronic diseases. The dragon fruit powder sample has an energy level of 378 Kcals per 100 grams. The nutrient analysis shows that it contains 0.73 g +/-0.03 of protein, 0.15 g +/-0.01 of fat, 93.29 g +/-0.97 of carbohydrates, 0.22 g +/-0.15 of fiber, 0.01 mg +/- 0.001 of calcium, 70.40 mg +/-0.10 of magnesium, 84.33 IU +/-1.53 of Vitamin A, 20.67 mg +/-0.15 of Vitamin C, 464.00 mg/Kg +/-1.00 of antioxidants, 114.00 mg/Kg +/-1.00 of flavonoids, 976.33 mg/Kg +/-1.53 of phenolic acid, and 116.00 mg/Kg +/- 1.00 of quercetin. This red fruit is a valuable ingredient that can be a beneficial addition to culinary and nutritional pursuits due to its high antioxidant content.

Keywords: Dragon fruit, nutrient analysis, antioxidants

1. Introduction

Dragon fruit, a fascinating tropical fruit, is a member of the cacti family. Despite its enigmatic origin, it has gained immense popularity in various regions across the globe, - including Vietnam, Mexico, India, Central America, and Southeast Asia. These resilient crops grow well in dry areas and are mesmerizing to look at, with their scaly skin displaying bright colors of red, purple, or yellow and contrasting with the white flesh that is speckled with edible seeds ^[1, 2]. Apart from being a visual treat, dragon fruit also possesses incredible health benefits. It can enhance eyesight and gut health, regulate hypertension, improve diabetes, and even protect against cancer, liver damage, and neurodegenerative diseases. Recent scientific studies have delved into a comprehensive analysis of the fruit's health benefits, revealing that it is a rich source of antioxidants, vitamins, phenolic compounds, and betalains. The anthocyanins present in the fruit also have potent anti-inflammatory properties ^[1, 3, 4].

Dragon fruit also has medicinal properties as it can help prevent coughing and asthma, and counteract hazardous toxins. Its alluring appearance, combined with its numerous health benefits, make it a must-try fruit for anyone looking to explore tropical flavors and wholesome nutrition ^[5]. Dragon fruit, a fascinating tropical fruit, is a member of the cacti family. Despite its enigmatic origin, it has gained immense popularity in various regions across the globe, including Vietnam, Mexico, India, Central America, and Southeast Asia. Nutritionally speaking, dragon fruit is an excellent source of fiber with 5.6 grams per 1-cup serving, containing also no fat, and being naturally low in calories at 103 kcal per 1-cup serving. Accompanied also with a rich nutrient content in components such as potassium, protein, and calcium, dragon fruit proves its potential in terms of benefiting health with a versatility of applications in real-world food products and scenarios ^[2, 5]. Currently, dragon fruits are commonly eaten in their raw form and are oftentimes incorporated into juices, sorbets, smoothies, and pastries, with the list going on and on ^[1]. These popular super fruits are also useful as natural food colorants due to their highly pigmented red flesh but now also show promise in processed products as well ^[4, 6].

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Many studies highlight the vast potential that dragon fruits hold especially for health-conscious consumers, food additive industries, and for improving storage and stability of food products [6].

Researchers have already attempted to use dragon fruit powder to create a biscuit that is high in fiber. Dragon fruit powder was used in place of 50% of wheat in the finished product, which enhanced both the fiber content and some sensory qualities of the biscuits [4]. Other studies focused in on the vibrant red hues that can be obtained from the dragon fruit peel as a potential betalain-rich red dye [6]. Within the research, dragon fruit proved to have high tolerance for factors such as light and temperature with high stability and pigment retention over time as well [6]. Further researchers focused on dragon fruit peel powder related to quality and acceptability of fish nuggets stored in solar coolers. Researchers here found better sensory attributes for the final food products with observed significant inhibited microbial load during storage times. The dragon fruit peel powder showed great promise as a natural agent with antioxidative and antimicrobial properties aiding also in increasing the shelf-life in the fish and fish products while positively influencing the “physicochemical, microbial and sensory qualities” of the final food products [7].

In all of these studies, new and innovative uses were introduced and investigated related to dragon fruit and its widespread benefits and potential. With the current study, a wider exploration is made possible, broadening the knowledge of dragon fruit and laying the groundwork for more application-based research in the future. This study's primary goals were to measure the proximate analysis parameters, such as energy, protein, fat, carbohydrates, crude fiber, calcium, magnesium, vitamin A, vitamin C, antioxidants, flavonoids, phenolic acid, and quercetin, and to produce the dragon fruit in powder form using the dehydration principle.

2. Methodology

To prepare the sample for the research, a bulk of dragon fruit was purchased from a grocery store in Illinois, USA. The dragon fruit is a tropical fruit that comes in four different types - pink, red flesh, white flesh, and yellow skin with white flesh. All varieties of this fruit consist of small black seeds, which can be eaten just like the seeds in kiwifruit. For this research, dragon fruit with red flesh and skin, also known as Pitaya Roja or *Hylocereus costaricensis*, was used. This variety of dragon fruit is sweet and has a texture similar to that of a kiwi. It can be consumed raw or added to smoothies. Before use, the fruit was meticulously cleaned and drained. The outer leaves were carefully removed, and the skin was left intact. The fruit was then sliced into 1/4" pieces with the skin still on. The slices were dehydrated using a Presto Dehydro electric food dehydrator that was set to operate at a pre-set temperature of approximately 165 Fahrenheit. The slices with the skin on were laid on the tray with adequate space for sufficient air flow for drying. Following the general dehydrating information, the dehydrator was plugged into an electrical outlet, and the drying process was initiated for a duration of 4 hours.

Once the drying process was complete, the dried slices were ground into a powder using a mechanical blender. The resulting powdered samples were then stored in a clean, airtight container at room temperature (30 ± 2 -degree C) until they were needed for use. The powder had a light pink color and a sweet, fruity aroma. The texture was fine and powdery,

with no visible lumps or clumps. The powder was easy to handle and had a long shelf life, making it ideal for use in various applications.

2.1 Nutritional analysis of dragon fruit powder

The nutrient content of dragon fruit powder was thoroughly analyzed for various parameters including energy, protein, fat, carbohydrates, crude fiber, calcium, magnesium, Vitamin A, Vitamin C, antioxidants, flavonoids, phenolic acid, and quercetin. The analysis was conducted in triplicates and followed the methods specified by AOAC [8]. The testing was carried out at a reputable food analysis laboratory to ensure accuracy and reliability. The results of the analysis were averaged to provide precise and dependable information.

2.2 Estimation of Fat

In order to determine the fat content of powdered dried dragon fruit, a direct extraction method was employed using petroleum ether in an intermittent Soxhlet extractor. The sample was subjected to a four-hour extraction process, after which the solvent was removed, leaving behind a residue in the round-bottom flask that indicated the sample's fat content. The residue was subsequently weighed using a reflectometer, and the Reflective Index (RI) was checked. This method provides a reliable and accurate means of determining the fat content of powdered dried dragon fruit and can be used in a variety of academic and business settings.

2.3 Estimation of Crude fiber

The experiment involved the use of a 250 mL conical flask, which was filled with a 1.25% sulfuric acid solution. Two grams of the sample were added to the flask, and the mixture was heated for approximately thirty minutes. The resulting mixture was then filtered through a vacuum filter and cleaned with pH paper until no acid residue was visible. Subsequently, the acid extract was transferred to another 250 mL conical flask, where it was mixed with a 1.25% NaOH solution. The mixture was heated for an additional thirty minutes and then filtered through a vacuum filter. The filtered sample was washed with water to remove any remaining base. The entire substance was then transferred to a crucible and dried at 120 °C for 12 hours. Finally, the crucible was heated in a muffle oven at 550 °C for 12 hours. This process was carried out with the utmost care and precision to ensure accurate results. The resulting substance was analyzed using established methods to determine its properties.

2.4 Estimation of Protein

The nitrogen content was determined using the micro-Kjeldahl method. Approximately 2 grams of dried material were transferred into a digestion tube, along with 2 catalyst tablets and 20 mL of sulfuric acid. The digestion tube was then placed in a Kjeldahl digester, which operated at a minimum temperature of 400°C for a duration of 30 minutes. After digestion, 50 milliliters of distilled water were added for Kjeldahl distillation. The sample was then titrated with 0.20 N hydrochloric acid to determine the amount of HCL (40%) in the NaOH solution. A catalytic reagent, in the form of a 4% boric acid solution, was employed during the experiment. The nitrogen percentages obtained were multiplied by 6.25 to obtain the protein percentages.

2.5 Vitamin C content

The official method for determining the vitamin C content in fruits and vegetables is the AOAC (2005) method. This

method involves taking 5 grams of each sample and thoroughly mixing it with 3% HPO₃ in a separate flask. The mixture is then brought to a volume of 100 ml and filtered through Whitman paper 40. Subsequently, the extraction is titrated with dye until a faint pink color persists for 15 seconds. This process enables the precise determination of the vitamin C content in each sample, ensuring that the measurements are accurate and reliable.

2.6 Total phenolic content

The Folin-Ciocalteu method was utilized to determine the total phenolic content of the powdered dragon fruit pulp extract. After diluting the extract with 7.9 mL of distilled water, 50 µL of Folin-Ciocalteu reagent was combined with 100 µL of the diluted extract. 1.5 mL of 7.5% sodium carbonate was added to the mixture after 4 minutes. For two hours, the mixture was incubated at room temperature in a dark room. Following the incubation period, 200 µL of the mixture was put into a microtiter plate, and a UV-VIS microplate reader was used to read it at 765 nm. Three duplicates of each sample and measurement were taken.

2.7 Total flavonoid and Quercetin content

With the use of spectrophotometric analysis, the extract's total flavonoid content was ascertained. After mixing 2% aluminum chloride with 100 µL of diluted extract, the mixture was allowed to incubate for 15 minutes at room temperature. Using the UV-Vis Microplate reader, the absorbance was determined spectrophotometrically at 415 nm. To obtain the calibration curve, the same process was carried out with the quercetin standard solution.

2.8 Statistical analysis

The statistical analysis of the nutritional content was conducted using the Statistical Package for the Social Sciences (SPSS).

3. Results and Discussion

The results of the study suggest that dragon fruit powder is an excellent source of essential vitamins, minerals, and other bioactive compounds. These nutrients are essential for maintaining optimal health and well-being, and therefore, the regular consumption of dragon fruit powder could potentially confer numerous health benefits. Dragon fruit powder is rich in vitamin C, which is a powerful antioxidant that helps protect the body against free radicals. It also contains vitamin B1, B2, and B3, which are essential for energy production and maintaining healthy skin, eyes, and nervous system. Additionally, dragon fruit powder is a good source of minerals such as iron, calcium, and phosphorus, which are necessary for strong bones and teeth, and proper muscle and nerve function.

Moreover, dragon fruit powder is rich in fiber, which helps regulate digestion and prevent constipation. It also contains phytochemicals such as betacyanins, which have been shown to have anti-inflammatory and antioxidant properties. These compounds may help reduce the risk of chronic diseases such as cancer, diabetes, and heart disease. In this study, dragon fruit was processed into a powder to determine its nutritional composition based on a 100-gram sample. The results, presented in Table I below, show that dragon fruit powder is a nutrient-dense food that could potentially provide numerous health benefits. However, further research is necessary to explore its full potential.

Table 1: Nutritional analysis of dragon fruit powder

Nutrients per 100grams of dragon fruit powder	Mean +/- SD
Energy (Kcals)	378.19 +/-0.98
Protein (g)	0.73 +/-0.03
Fat (g)	0.15 +/-0.01
Carbohydrates (g)	93.29 +/-0.97
Crude fiber (g)	0.22 +/-0.15
Calcium(mg)	0.01 +/- 0.001
Magnesium (mg)	70.40 +/-0.10
Vitamin-A(IU)	84.33 +/-1.53
Vitamin- C (mg)	20.67 +/-0.15
Antioxidants (mg per Kg)	464.00 +/-1.00
Flavonoids (mg per Kg)	114.00 +/-1.00
Phenolic acid (mg per Kg)	976.33 +/-1.53
Quercetin (mg per Kg)	116.00 +/- 1.00

As shown in table I which was generated from SPSS statistical analyses based on an average, the 100g sample of dragon fruit powder contained about 378.19 kcal. Further, the sample showed 0.73g of protein, 0.15g of fat and about 93.29g of carbohydrates of which 0.22g was crude fiber. Calcium within the sample was 0.01mg. Overall the results show the high nutrient concentration that can be made from dragon fruit once it is turned into a powder and with this the high vitamin, mineral, and overall nutritional makeup components as well.

As a whole, there are more proximate analysis studies related to dragon fruits as fresh fruits rather than in powdered form ^[1, 2, 9]. As a means of comparison though, for example, in 100 grams of fresh dragon fruit there are between 35.36 and 67.7 kcal, between 0.41 and 2.27 g protein, and between 0.21 to 0.6 g fat while in the powdered sample from the present study their resulted 378 kcal, 0.73 g protein, and 0.15 g fat ^[1]. Within the same study for the fresh fruit, researchers found between 5.42 and 12.97 g carbohydrates, 0.7 to 1.125 g crude fiber, and 1.55 to 10.2 mg calcium (dependent on the type of dragon fruit and its origin) ^[1]. In contrast here, the present study found 93.29 g carbohydrates, 0.22 g crude fiber, and 0.01 mg calcium within the dragon fruit powder. As for the calories and with comparing between the fresh fruit and the powder, it is important to note that the powder proves to be more potent as the fresh fruit is nutritionally noted to be low-calorie (103 kcal per 1-cup serving or between 35 and 67.7 kcal per 100 g) compared to the present studies' finding (378 kcal per 100g of dragon fruit powder) ^[3]. Of important note too is that smaller amounts of the powder may be needed for product development or for daily intake all the while still maintaining the dragon fruit's low-calorie status. For the protein, another distinction can be seen as the whole fresh dragon fruit is known to be protein-rich while the dragon fruit powder shows lower amounts of protein (0.73 g protein per 100 g). With this knowledge, depending on the nutritional goal and uses, amounts of the dragon fruit powder may need to be adjusted ^[3].

For the fat, no matter if the actual fruit is eaten or the powder form is consumed, the fat profile is very low at 0.15 g per 100 g sample (present study) making this an excellent addition to an individual's diet especially to those affected with conditions related to the heart, bones, and even with other conditions such as diabetes, hair loss, etc. ^[4]. For the carbohydrates the 100 g powdered dragon fruit sample resulted in 93.29 g carbohydrates while the fresh fruit itself resulted between 5 and 12 g of carbohydrates. Overall, with the many wide and varied beneficial effects that the fruit and the powder provide, the carbohydrates are yet another aspect that is also not too high or too low and once which aids the

nutritional makeup and the related and subsequent health claims. For the crude fiber the powdered dragon fruit yielded 0.22 g and within the fresh fruit there is about 0.7 g. As detailed time and time again in the literature, fiber is essential for good digestive health and can even be used as measures of reducing certain cancer and cardiovascular conditions and risks^[5]. As for the calcium, the 100 g of dragon fruit powder contained 0.01 mg of calcium compared to the 1.5 to 10.2 mg of calcium in the whole fruit. While both the powder and fresh fruit forms contain smaller amounts of calcium, the body still requires minerals such as these for overall good health and wellbeing with dragon fruit as a great dietary addition.

Md. Shariful Islam *et al* conducted a comprehensive study on the nutritional properties of dragon fruit. The study aimed to provide valuable insights into the nutritional value of this exotic fruit and its potential health benefits^[9]. He analyzed the magnesium content of three different types of dragon fruit and found that the average magnesium content was 68.3mg. This finding is consistent with current research on the subject and highlights the importance of magnesium in our diet. Magnesium is an essential mineral that plays a crucial role in various bodily functions, including muscle and nerve function, blood sugar regulation, and blood pressure control^[10]. The study also compared the vitamin C levels among different types of dragon fruit. The team found that the Red flesh dragon fruit had the highest vitamin C content of 5.6 mg/g, while the white flesh fruit had the lowest value of 3.8mg/g. These findings suggest that the vitamin C content of dragon fruit can vary significantly depending on the type.

The study also found that the vitamin C content of the sample in Table-I was 20.67 mg/100 grams, highlighting the nutritional value of dragon fruit. Vitamin C is a powerful antioxidant that helps protect our cells from damage caused by free radicals. It also plays a vital role in collagen synthesis, wound healing, and immune function^[11]. Furthermore, the team analyzed the flavonoid content of various types of dragon fruit. Flavonoids are a group of plant compounds that have antioxidant and anti-inflammatory properties^[12]. The results showed that the red dragon fruit with white flesh, red dragon fruit with red flesh, and yellow dragon fruit with white flesh contain flavonoid levels ranging from 180mg/100g to 210mg/g. The research also revealed that the antioxidant activity of dragon fruit varies from 72% to 81%, with the current study showing exceptionally high levels of antioxidants, measuring at 464.00+/-1.00. Additionally, the study found that dragon fruit has a significant flavonoid content, with levels measuring at 114.00+/-1.00. These findings underscore the potential health benefits of incorporating dragon fruit into one's diet, including reducing the risk of chronic diseases such as cancer, heart disease, and diabetes.

4. Conclusion

Dragon fruit is a fascinating fruit that is gaining popularity as a crop worldwide. This exotic fruit has a striking appearance, with a vibrant pink or yellow outer skin that is covered in green scales resembling a dragon's skin. The inner flesh is white or red and speckled with tiny edible black seeds, giving it a unique texture and appearance. Its pulp is juicy and refreshing with a mildly sweet taste, making it an excellent choice for fresh consumption or as an ingredient in a variety of dishes. Apart from its delicious taste, dragon fruit is also packed with essential nutrients that contribute to maintaining a healthy body. The fruit is a rich source of magnesium,

vitamin A, vitamin C, and antioxidants, making it an excellent choice for people looking to boost their immune system and maintain their overall health. Additionally, it is a great source of flavonoids, phenolic acid, and quercetin, which are all beneficial to the body. Dragon fruit is known to possess medicinal properties that help prevent colon cancer, diabetes, and other diseases. It also helps in neutralizing toxic substances such as heavy metals and reducing cholesterol and high blood pressure levels^[13].

In conclusion, the nutrient analysis of the red skin dragon fruit shows that it is an ideal fruit to consume regularly as it contains high levels of energy, magnesium, vitamin A, vitamin C, antioxidants, flavonoids, phenolic acid, and quercetin. Its unique appearance, taste, and health benefits make it a must-try fruit for anyone looking to explore new, healthy foods. The findings highlight the importance of including this exotic fruit in the diet to reap its potential health benefits.

Disclosure: The authors hereby state that they have no conflicts of interest to disclose.

Funding: No external funding was received for this research.

Authors' contribution: Both authors have made valuable contributions to the study's conception and the writing of the paper. Their expertise and dedication have been instrumental in ensuring the quality and accuracy of the research.

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