Study of the Chemical Composition of Hylocereus Undatus and Its Utility after Dehydration

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ABSTRACT

This research deals with the characterization of dragon fruit for the purpose of consumption in different forms. Dragon fruit is supposed to be very nutritious and is rich source of several Phyto-chemicals. However, till now its utility in country like India is highly underrated. Dragon fruit has been found to be rich in antioxidants as well thus providing a wider scope for the research [1]. The fruit also contains high amount of minerals and balanced content of nutrients. High amount of dietary fiber and carotenoids make it beneficial for chronic heart disorders, cancer, and diabetes [1]. The paper highlights the nutritive attribute of fruit pulp and to increase its use as a dehydrated powder keeping the nutritive value intact. The dehydrated form increases the shelf life and is easy to use and also eases the distribution and transportation of fruit.

Keywords: Dehydration, Dragon fruit, Nutritional, Phyto-chemicals.

I. INTRODUCTION

Hylocereus Undatus or dragon fruit is a trending fruit in India among the upper middle class and upper class. Other than consuming it as a fresh fruit the dragon fruit can be made into juices, wines, flavorings etc.

Hylocereus undatus, Pitaya Blanca, Strawberry pear, Dragon fruit, Night blooming cereus, Tuna, Nopal, Pitahaya, Mountain pear or Rock pear is a fruit of Hylocereus genus and Cactaceae family [2]. This fruit has much future potential in several biological field. Its origin is from South, Central and North America [2], [3]. Dragon fruit features a mouth-watering light sweet taste, an intense shape and colour, not forgetting its outstanding flowers [4]. It is getting popularity among growers because of its attractive fruit colour and mouth-watering pulp with edible black seed embedded inside the pulp. It has great nutritional value, excellent export potential and highly remunerative in nature.

A. Nutritional Value

Dragon fruit has many functional nutrients, and the compilation of its nutritive value is given in Table no.1. In the same table the nutritive value is also compared to that of some tropical fruits. On comparing it to various fruits it comes out that the dragon fruit has higher amount of minerals, and its white-fleshed variety has lower amount of fats as well. White skinned pitaya, on the other hand has a lower energy content than other fruits. The predominant sugars present in pitaya are glucose and fructose and it has very less or negligible (in some cases) amount of sucrose. The composition is given in Table no.1. In the same table the nutritive value is also compared to that of some tropical fruits.
be around 83-89 g/100 g of the fresh weight [6]. Dragon fruit is also packed with B vitamin group (B1, B2 and B3) which possess and important role in health benefits [3].

### TABLE I: NUTRITIVE VALUE OF VARIOUS FRUITS (PER 100G OF EDIBLE PORTION) [7-9]

| Composition | White-fleshed pitaya | Red-fleshed pitaya | Mango | Pineapple |
|-------------|----------------------|--------------------|-------|-----------|
| Energy (KJ) | 130                  | 283                | 276   | 243       |
| Carbohydrates (g) | 9.5                  | 11.2               | 16.8  | 13.7      |
| Proteins (g) | 0.5                  | 0.2-1.1            | 0.7   | 0.3       |
| Fat (g)     | 0.1                  | 0.6-0.9            | 0.4   | 0.2       |
| Glucose (g) | 5.5                  | 4.7-5.7            | 0.8   | -         |
| Fructose (g) | 1.9                  | 1.8-3.2            | 6.4   | -         |
| Crude Fiber (g) | 0.3                  | 0.7-1.3            | 0.9   | 0.4       |
| Calcium (mg) | 23-102               | 10                 | 17    |           |
| Magnesium (mg) | 26.6                 | 31.3-38.9          | 8.8   | 13        |
| Sodium (mg) | 3.3                  | 7.3-8.9            | 7     | 1         |
| Potassium (mg) | 399.5                | 272-328.4          | 189   | 146       |
| Phosphorous (mg) | 0.4                  | 0.6-3.4            | 0.4   | 0.5       |

Besides the nutritional property found in flesh and peel, the seeds of dragon fruit also contain significantly higher amount of health beneficial properties. The seeds contain a high yield of the oil which is beneficial to humans and can be used as a dietary oil because of the high tocopherol and beneficial lipid content [10]. The fruit peel is also considered to be rich in pectin [11].

### B. Chemical Composition

For the present study the dragon fruit was separated into peel, pulp, and seeds. The chemical composition of peel and pulp was obtained through several tests. A set of qualitative analysis was performed for nutrients (protein, carbohydrate, fats, and several metabolites). The outcome of the analysis will improve our understanding regarding the characteristics of pitaya which may provide benefits to the health sector.

### C. Dehydration of Dragon Fruit

Seeing the potential of the dragon fruit it is necessary that the distribution and availability of the fruit should be made easy. Dragon fruit is available in the market however one may find it difficult to find near their homes.

Dehydration of dragon fruit into powder/paste form helps in the distribution and supply of the fruit provided that the composition remains the same. Dehydration of the fruit also helps in removing enough moisture from the fruit so as to prevent any spoilage or decay [4]. Once dehydrated one may use it with drink like water, milk etc. So, their consumption will also become easier especially for those who find it's taste unpalatable.

However, the major issue faced during the study was to maintain its composition. The carbohydrate content of the food remained more and less similar to that of pre-dehydration form, but the little amount of protein content present is depleted to some extent. The paste was more soluble in milk as compared to the water.

### II. MATERIALS AND METHODS

#### A. Materials Required

1) Lab Equipment

- Test tubes, boiling test tubes, Bunsen burner, water bath, test tube holder, test tube stand, beaker, conical flask, measuring cylinder, gloves, etc.

2) Chemicals

- Distilled water, 95% Ethanol, Fehling’s solution A (CuSO₄·5H₂O), Fehling’s solution B (Sodium Potassium Tartrate), Barfoed’s reagent (Copper acetate, 1% acetic acid), Selivanoff’s reagent (0.5% resorcinol, 3N HCl), Bial’s reagent (orcinol, HCl & 10% FeCl₃), Iodine’s reagent (2% KI & 1% Iodine), HNO₃, 40% NaOH, Ninhydrin reagent (0.2% Ninhydrin, acetone), CaCl₂, 5% Potassium Dichromate solution, Sudan’s reagent, chloroform, H₂SO₄, 1% NH₃, glacial acetic acid, DNS reagent (Dinitro salicylic acid), Folin’s reagent.

3) Apparatus

- Thermometer, Incubator, Spectrophotometer, Spray dryer (Co-current flow dryer).

4) Sample Preparation

The fresh dragon fruit were brought from the market. The fruit was then washed under tap water and was hand peeled. The seeds were then separated from the pulp manually. Two extracts of both peel and pulp were prepared in the ratio of 1:5 (1 g of peel/pulp for 5 mL solution) One extract was the hot water extract and the other was the alcoholic extract. Different qualitative and quantitative tests were performed for the analysis of nutritional content of the fruit. All qualitative and quantitative tests were performed in triplicates.

### B. Qualitative Estimation

1) Tests performed for the presence of Carbohydrates

**Fehling’s Test:** It is performed for the detection of reducing sugars. The test consists of Fehling’s solution A contains CuSO₄·5H₂O while Fehling’s Solution B contains Sodium Potassium Tartrate. In this test Cu⁺² is reduced in Cu⁺ indicating the reducing action of sugars. For the test 2 mL of each extract was taken in test tubes to which 1 mL of Fehling’s A & 1 mL of Fehling’s B were added to each sample and the tubes were put into a water bath till boiling.

**Barfoed’s Test:** It is used for distinguishing reducing monosaccharides and disaccharides. Reducing monosaccharides usually react within 1-2 minutes while disaccharide takes about 7-12 minutes. Barfoed’s reagent is prepared by dissolving copper acetate in 1% acetic acid. For the test, 1 mL of each extract was taken in test tubes to which
2 mL of Barfoed’s reagent was added and all extracts were kept in the water bath. Time was noted till the reaction is complete. 

**Seliwanoff’s Test:** It is used to distinguish aldoses from ketoses. Seliwanoff’s reagent is prepared by adding 0.5% resorcinol in 3N HCl. For the test, 1 mL of each extract was taken in test tubes to which 3 mL of Seliwanoff’s reagent was added and all extracts were kept in water bath for 1-2 minutes and color change was observed.

**Bial’s Test:** It is used to distinguish pentose sugars. Bial’s reagent consists of 0.4 g oxolin in 200 mL HCl and 0.5 mL of 10% FeCl₃. For the test, 2 mL of Bial’s reagent was taken into each test tube and 4-5 drops of each extract were added to it. All extracts were kept in water bath for 30 seconds and the color change was observed.

**Iodine Test:** It is used to identify polysaccharides like starch. Iodine’s reagent consists of 2% KI & 1% Iodine. 2 mL of each extract was taken in test tubes. For the test, 2 mL of each extract was taken in test tubes to which 5 drops of iodine solution was added to each tube and color change was observed [12].

2) Tests performed for the presence of Proteins

**Xanthoproteic Test:** It is used to identify amino acids containing aromatic group. For the test, 2 mL of each extract was taken in boiling test tube to which equal volume of conc. HNO₃ was added. Each test tube was heated over flame for 2 minutes and then cooled thoroughly and 40% NaOH was added to each of them. It is used to detect the presence of amino groups-containing amino acids. It also differentiates tyrosine and tryptophan from other amino acids.

**Ninhydrin Test:** It is used to detect primary and secondary amines containing free NH₂. Ninhydrin Reagent is prepared by adding 0.2% ninhydrin to acetone. For the test, 1 mL of each extract was taken in test tubes and 5 drops of ninhydrin reagent was added to each. They were boiled over a water bath for 2 minutes and then allowed to cool after which color change was observed. It is used to distinguish carbohydrates from amino acids [13].

3) Tests performed for the presence of fats

**Ca Soap Formation Test:** Fats with CaCl₂ form soaps. For the test, 1mL of each extract was taken to which CaCl₂ was added to each extract. Any physical Change was observed.

**Dichromate Test:** It is used to detect the presence of Glycerol. For the test, 2 mL of each extract was taken in test tubes to which few drops of 5% Potassium Dichromate Solution were added and then 5 mL of conc. HCl was added to each extract.

**Sudan Test:** It is a test for the detection of Lipids. For the test, 1 mL of each extract was taken in test tubes and 2 drops of Sudan Reagent was added to each test tube. Colour change was observed.

**Salkowski's Test:** It is a test for detection of steroids. For the test, 1 mL of each extract was taken in test tubes and 2 mL of chloroform was added to it. Equal volume of conc. H₂SO₄ was added to each extract and shaken gently [14].

4) Test for Plant Metabolites

**Test for Tannins:** Tannins are naturally occurring complex organic compounds possessing nitrogen free polyphenols of higher molecular weight. 0.5 mL of each extract was taken in test tubes and 2 mL of 5% FeCl₃ was added to each test tube. Color change was observed.

**Test for Saponins:** Saponins are bitter-tasting usually toxic plant derived organic chemicals that have a foamy quality when agitated in water.0.5 mL of each extract was taken in test tubes and shaken vigorously on addition of distilled water. Change was observed.

**Test for Flavonoids:** Flavonoids are important for human health because of their anti-oxidant, antiviral, antibacterial, and anti-inflammatory activities. 5 mL of each extract was taken in test tubes and few drops of 1% NH₃ was added to each test tube. Color change was observed.

**Test for Terpenoids:** Terpene is a natural compound with various medical properties and found in both plants and animals. It is used to enhance skin penetration, prevent inflammatory diseases. 5 mL of each extract was taken in test tubes and 2 mL of Chloroform was added to each extract. 3 mL of H₂SO₄ was then added to it. Color change was observed.

**Test for Cardiac Glycosides:** These can be activated by enzyme hydrolysis, which causes the sugar part to be broken off, making the chemical available for use. Many of these glycosides are employed as pharmaceuticals. 5 mL of each extract was taken in test tubes and 2 mL of glacial acetic acid containing few drops of FeCl₃ was added to each test tube. All the contents were transferred to another test tube containing 1 mL conc. H₂SO₄ [15].

The nutritional content of the dragon fruit (pulp+ seed) was estimated before and after dehydration by different estimation processes.

**C. Quantitative Estimation**

1) **DNS method of carbohydrate estimation (Dinitro salicylic acid)**

This test is performed for determining carbohydrate concentration in the sample using colorimetric techniques.

The extraction was taken in different volumes in five separate test tubes (0 ml, 0.2 ml, 0.4 ml, 0.6 ml, 0.8 ml, 1.0 ml) and volume was made up to 1ml by adding distilled water. These solutions were then treated with DNS reagent and transferred to boiling water bath for 15 minutes and cooled to room temperature. 8.5 ml of distilled water was added to each test tube. Then optical density was measured at 540 nm using colorimeter and taking the solution in separate cuvettes. The concentration of carbohydrate was calculated [16].

2) **Folin-Lowry method of protein estimation**

This test is performed to determine the protein concentration in the sample using colorimetric techniques.

The extraction was taken in six separate test tubes in different volumes (0 ml, 0.2 ml, 0.4 ml, 0.6 ml, 0.8 ml, 1.0 ml) and volume was made up to 1ml by adding distilled water. 5ml Alkaline solution was then added to each test tube and mixed. These test tubes were then incubated for 10 minutes at 37 °C in a water bath. 0.5 ml Folin reagent was then added to each test tubes and they were further incubated for 30 minutes at 37 °C. Then optical density was measured at 640 nm using colorimeter and concentration of protein was calculated [17].

**D. Dehydration of Dragon Fruit**

Dragon fruit was separated into three components (seed,
pulp, and peel). After the separation each of its component were dehydrated using spray dehydration process, which is a process of forming dehydrated powder of liquid or semi liquid paste by rapidly drying [18]. The spray drying is well known industrial technology used extensively on large scale for drying and powdering heat-sensitive materials, from liquid foods [19], such as vegetables, fruits, and pharmaceuticals. The spray dryer used in this experiment was laboratory spray dry. We have used Round Nozzle Type Laboratory spray dryer of capacity 1liter,1kg by Spray Tech systems company. The spray drying method is usually carried forward in given steps.

1. Concentration: Increment in solid content and decrease in moisture content that has to be removed.
2. Atomization: Regulation of the conditions for dehydration process.
3. Droplet-Air contact: Evaporation takes place at a constant rate.
4. Droplet drying: Rate of evaporation decreases rapidly.
5. Separation: Cyclones, bag filters and electrostatic precipitators are used for this.

The dehydrated components were taken out and were crushed in the form of powder.

After the formation of powder all the qualitative and quantitative tests were re-performed by preparing its hot water extract in the same dilution as before and their results were matched with the results of fresh Dragon fruit components.

### III. OBSERVATION

On performing these tests, we got to know the composition of peel and pulp. The results show us the presence of various carbohydrates in which reducing carbohydrates are also present. It also gave positive results for protein however fats were not detected. Besides these some plant metabolites were also reported as indicated in Table II and Table III.

As we can see in the table, the ethanolic extract was found to contain carbohydrates in the form of reducing sugars, ketose sugars but pentose sugar and starch were absent. Proteins were present in ethanolic pulp extract in the form of aromatic groups and free amino acids were also present in this extract. All the tests for the fats were negative which inferred the absence of fatty acids, glycerol, lipids, and steroids.

The hot water extract was found to contain carbohydrates in the form of reducing sugars and ketose sugars, but pentose sugar and starch were absent. Proteins were present in hot water pulp extract in the form of aromatic groups and free amino acids. All the tests for fats were negative which inferred the absence of fatty acids, glycerol, lipids, and steroids.

The table shows that the ethanolic extract was found to contain a small amount of flavonoids and a moderate amount of cardiac glycosides but tannins, saponins, and terpenoids were absent.

The hot water extract was found to contain cardiac glycosides but tannins, saponins, terpenoids, and flavonoids were absent.

### TABLE II: OBSERVATION TABLE FOR QUALITATIVE TEST OF CARBOHYDRATES, PROTEINS & FATS

| Test               | Observation | Preference          | A   | B   |
|--------------------|-------------|---------------------|-----|-----|
| Fehling’s Test     | Red brown   | Reducing Sugar is   | Positive | Positive |
| Barfoed’s Test     | Brick red   | Reducing Sugar is   | Positive | Positive |
| Salkowski’s Test   | Red colour  | Ketose Sugars are   | Positive | Positive |
| Bial’s Test        | Greenish    | No Pentose Sugars   | Negative | Negative |
| Iodine Test        | No Violet Colour | Absence of Starch | Negative | Negative |

### TABLE III: OBSERVATION TABLE FOR QUALITATIVE TEST OF PLANT METABOLITES

| Test               | Observation | Inference          | A   | B   |
|--------------------|-------------|---------------------|-----|-----|
| Tannin             | No change observed | Tannin absent | Negative | Negative |
| Saponins           | No change observed | Saponins absent | Negative | Negative |
| Flavonoids         | Yellow colour is observed | Flavonoid present | Slight | Positive |
| Terpenoids         | No change observed | Terpenoids absent | Negative | Negative |
| Cardiac Glycosides | Brown ring fermentation | Glycoside formation | Positive | Positive |

**A = Ethanolic extract.**

**B = Hot water extract.**

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Fig. 2. Salkowski Test.

Fig. 3. Ca soap formation Test.
These tests show us that there is very small depletion of nutrients after dehydration process and the dragon fruit powder is healthy to consume even after the moisture is lost.

The observations of the analysis before dehydration are given in Table IV (Estimation of nutrients before dehydration) and the observations of analysis after dehydration is given in Table V (Estimation of nutrients after dehydration).

Before dehydration the carbohydrate content in 100 g water extract was found to be 11.0 g and that in 100 g methanol extract was found to be 11.6 g. Protein content in 100 g of water extract was found to be 1.1 g and that in 100 g methanol extract was found to be 1.2 g.

After dehydration the carbohydrate content in 100 g water extract was found to be 10.4 g and that in 100 g methanol extract was found to be 10.6 g.

Protein content in 100g water extract was found to be 0.98 g and that in 100 g methanol extract was found to be 1.0 g.

Thus, from Table IV and Table V we can see that there is very little depletion of carbohydrates and proteins after dehydration.

Dehydration of dragon fruit: The fruit was then again analyzed and compared with its nutritional quality before dehydration and the following differences were observed.

From the table we can see that it had showed positive tests for protein however the intensity of the obtained colors (results) is too weak indicating that some of its protein content has definitely denatured.

Test for fats were negative which inferred the absence of fatty acids, glycerol, lipids, and steroids before and after dehydration.

### TABLE IV: ESTIMATION OF NUTRIENTS BEFORE DEHYDRATION

| Nutrients | Amount per 100g (Water Extract) | Amount per 5g (Water Extract) | Amount per 100g (Methanol Extract) | Amount per 5g (Methanol Extract) |
|-----------|---------------------------------|-------------------------------|-----------------------------------|----------------------------------|
| Carbohydrates | 11.0 g | 0.55 g | 11.6 g | 0.58 g |
| Proteins | 1.1 g | 0.055 g | 1.2 g | 0.060 g |

### TABLE V: ESTIMATION OF NUTRIENTS AFTER DEHYDRATION

| Nutrients | Amount per 100g (Water Extract) | Amount per 5g (Water Extract) | Amount per 100g (Methanol Extract) | Amount per 5g (Methanol Extract) |
|-----------|---------------------------------|-------------------------------|-----------------------------------|----------------------------------|
| Carbohydrate | 10.4 g | 0.52 g | 10.6 g | 0.53 g |
| Protein | 0.98 g | 0.049 g | 1.0 g | 0.050 g |

### TABLE VI: TESTS PERFORMED BEFORE AND AFTER DEHYDRATION IN HOT WATER EXTRACTS

| Test | Observation | Preference | A | B | C | D |
|------|-------------|------------|---|---|---|---|
| Fehling’s Test | Red brown ppt | Reducing Sugar is present | Positive | Positive | Positive | Positive |
| Barfoed’s Test | Brick red ppt | Reducing Sugar is present | Positive | Positive | Positive | Positive |
| Selvinoff’s Test | Red colour | Ketose Sugars are present | Positive | Negative | Positive | Negative |
| Bial’s Test | Greenish colour | No Pentose Sugars are present | Negative | Negative | Negative | Negative |
| Iodine Test | No Violet Colour | Absence of Starch | Negative | Negative | Negative | Negative |
| TEST | OBSERVATION | PREFERENCE | A | B | C | D |
| Xanthoprotein | Colour changes from yellow to orange | Aromatic group present | Positive | Positive | Positive | Positive |
| Ninhydrin | Blue purple colour was obtained | Free amino acids present | Positive | Positive | Positive | Positive |
| TEST | OBSERVATION | INFERENCE | A | B | C | D |
| Ca soap formation Test | No foam formed | Absence of fatty acids | Negative | Negative | Negative | Negative |
| Dichromate Test | Brown colour was observed | No glycerol is present | Negative | Negative | Negative | Negative |
| Salkowski’s Test | No change observed | No steroids present | Negative | Negative | Negative | Negative |

A = Ethanolic extract before dehydration
B = Ethanolic extract after dehydration.
C = Hot water extract before dehydration
D = Hot water extract after dehydration.
From the table we can observe that it had showed positive results for flavonoids but the yellow coloration was too weak to indicate the present of flavonoids in the dehydrated fruit.

**IV. RESULT AND DISCUSSION**

The obtained results from quantitative test of carbohydrates and proteins show that there is very small change in the nutrient content after dehydration of the fruit which shows the nutrient depletion is almost negligible.

The qualitative test of nutrients show that the fruit contains some carbohydrates, proteins, and some plant metabolites but the amount of fat was almost negligible.

The obtained results are of great significance as it provides us a scope to work on different field. Dragon fruit is rich source of indigestible fibers and hence good fruit for diabetics. It contains good fats which were not traced in our results may be because of the very less amount of fat present.

However, Dragon fruit shows positive results for flavonoids and the peel gives the strongest indication of the presence of flavonoids. Flavonoid is a very good antioxidant and we have utilized this study and refocused it in a particular direction in our other related study [1].

The obtained dehydrated product of dragon fruit was observed to possess almost similar contents as that of the fresh dragon fruit. There was very little depletion of nutrients after dehydration of the fruit, and it was healthy and easy to consume. There were many advantages in preparing dehydrated dragon fruit. Firstly, it will boost the availability of the dragon fruit in Indian markets. Secondly the consumption of the dragon fruit will also become significantly easier and effortless. Thirdly it can provide nutrient supplements by the ways of its solubility in milk and lastly the lack of moisture in the dehydrated product inhibits the growth of fungi on the fruit thus the product’s shelf life could be increased. However various test will be required for the exact estimation of the increase in shelf life and thus it provides us a future scope in establishing a relation between the depletion of nutrition and increase in shelf life. Another future aspect for the project can be the addition of certain minerals like CaCl₂ and perform various methods for pre-treatment prior to dehydration out of which the most efficient method could be the osmotic pre-treatment as done in the case of mango [20].

The research allows us to treat the dragon fruit in a similar manner and pretend for the escalation of nutrients and minerals in the dehydrated food product.

**V. CONCLUSION**

The dehydration of dragon fruit into a powder form by the use of spray drier could make the availability of the content smooth. It can also increase the shelf life of the product as the lack of moisture will prevent the growth of bacteria and fungi. It also increases the solubility of the fruit and could be prepared in the form of sachet and can be easily utilized with water or milk as beverages. The product would be rich and healthy sources of nutrient for the population by enlarge.

**REFERENCES**

[1] P. Rathore, S. Seth, L. Kaba, “Study of antioxidant properties of Hylocereus undatus (Dragon Fruit),” National Conference on Global Perspective towards Green Pharmacy and Modern Era of Phyto-Pharmaceuticals. Published in International journal of Pharmaceutical Sciences and research Special Edition vol. 30, pp. 88-90, 2020.

[2] “Hylocereus undatus (dragon fruit)”. CABF. 3 January 2018. Retrieved 19 April 2018.

[3] T. Perween, KK Mandal, MA Hasan, “Dragon fruit: An exotic super future fruit of India,” J Pharmacogn Phytochem vol. 7(2), pp. 1022-1026, 2018.

[4] M. Islam, M. Khan, M. Hoque and M. Rahman, “Studies on the Processing and Preservation of Dragon Fruit (Hylocereus undatus) Jelly,” The Agriculturists, vol. 10(2), pp. 29-35, 2012. https://doi.org/10.3329/agric.v10i2.13139.

[5] B. Jamilah, C.E. Shu, M. Kharidah, M.A. Dzulkiifly, and A. Noranizan, “Physico-chemical characteristics of red pitaya (Hylocereus polyrhizus) peel,” International Food Research Journal, vol. 18, pp. 279-286, 2011.

[6] K. Mahattanataweew, J.A. Manthey, G. Luzio, S.T. Talcott, K. Goodner, and E.A. Baldwin, “Total antioxidant activity and fiber content of select florida-grown tropical fruits,” Journal of Agricultural and Food Chemistry, vol. 54, pp. 7355-7363, 2006. https://doi.org/10.1021/jf060566s.

[7] H.P. Gunasena, D.K.N.G. Pushpakumara, and M. Kariyawasam, “Undertulitized fruit trees in Sri Lanka: Dragon fruit Hylocereus undatus (Haw.),” Britton and Rose, pp. 110-141. World agroforestry centre ICRAF, New Delhi, India, 2007.

[8] G. Kansci, B.B. Koubala, and I.L. Mbome, “Biochemical and physicochemical properties of four mango varieties and some quality characteristics of their jams,” Journal of Food Processing and Preservation, vol. 32, pp. 644-655, 2008. https://doi.org/10.1111/j.1745-4549.2008.00204.x.

[9] F.C. Stintzing, A. Schieber, and R. Carle, “Evaluation of colour properties and chemical quality parameters of cactus juices,” European Food Research Technology, vol. 216, pp. 303-311, 2003. https://doi.org/10.1007/s00217-002-0657-0.

[10] T.C. Chernah, A. Aminah, A. Noriham, and W.M.W. Aida, “Determination of pitaya seeds as a natural antioxidant and source of essential fatty acids,” International Food Research Journal, vol. 17, pp. 1003-1010, 2010.

[11] M. Sonawane, “Nutritive and medicinal value of dragon fruit. The Asian Journal of Horticulture,” vol. 12, pp. 267-271, 2017. https://doi.org/10.15740/HAS/TAJH/12.2/267-271.
[12] D. Roberts, “Qualitative and quantitative determination of the wheat leaf carbohydrates,” Canadian Journal of Research, vol. 28C, pp. 754-779, 2011. https://doi.org/10.1139/cjrp50c-049.

[13] N. Soltani, “Quantitative and qualitative analysis of proteins in gonads of Donax trunculus from the Annaba Bay: effects of site, season and sex,” Advances in Environmental Biology, vol. 8, pp. 740-749, 2014.

[14] N. Abdulkadir & M. Tsuchiya, “One-step method for quantitative and qualitative analysis of fatty acids in marine animal samples,” Journal of Experimental Marine Biology and Ecology – J EXP MAR BIOL ECOL, vol. 354, pp. 1-8, 2008. https://doi.org/10.1016/j.jembe.2007.08.024.

[15] Dr. Patil & Kd, Gurav & A.S. Kadam & Thite, Sachin & Rh. Thoke & Kore, Dr. B., “Qualitative analysis of secondary metabolites from some filicale members,” IJRPC, vol. 3, pp. 300-302, 2013.

[16] Z. Marsden & P. Gray & G. Nippard & M. Quinlan, “Evaluation of the DNS method for analysing lignocellulosic hydrolysates. Journal of Chemical Technology and Biotechnology,” vol. 32, pp. 1016–1022, 2007. https://doi.org/10.1016/j.jctb.2007.03.036.

[17] J. Waterborg & H. Matthews, “The Lowry Method for Protein Quantitation,” 1996. https://doi.org/10.1007/978-1-60327-259-9_2.

[18] N. Phisut “Spray drying technique of fruit juice powder: some factors influencing the properties of product,” International food research journal, vol. 19 (2012), pp. 1297-1306.

[19] V.R. Sagar, S. Kumar, P., “Recent advances in drying and dehydration of fruits and vegetables: a review,” J Food Sci Technol, vol. 47, pp. 15–26, 2010. https://doi.org/10.1007/s13197-010-0010-8.

[20] S. Argandoña, Eliana & Y. Luciane & C. Tais & Giunco, Aline, “Mango dehydration: influence of osmotic pre-treatment and addition of calcium chloride,” Revista Brasileira de Fruticultura, vol. 40, 2018. https://doi.org/10.1590/0100-29452018419.