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Production of dragon fruit jelly candy enriched with jaggery powder and its quality assessment

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Abstract
The aim of this study was to standardize process parameters to produce fruit jelly candy infused with jaggery powder. Extensive analyses revealed that both red and white dragon fruit varieties exhibit a high moisture content of approximately 88.8% and low fat content at 0.32% and 0.25% respectively, which underscores their potential for health-conscious dietary applications. The study provided a detailed proximate analysis, showing that the red dragon fruit variety contains 2.03 grams of total dietary fiber per 100 grams, slightly higher than its white counterpart, making it an excellent choice for fiber-rich diets. In the product development phase, experimental formulations of jelly candies were methodically varied by adjusting the ratios of sugar and jaggery. Jelly candy was created using a blend of dragon fruit pulp and jaggery powder in varying ratios and the impact of these formulations on proximate composition, mineral content, and dietary fiber content was assessed. Different combinations of dragon fruit pulp and jaggery powder namely 100:0 (JC_0), 100:10(JC_1), 100:20 (JC_2), 100:30 (JC_3) and 100:40 (JC_4) was utilized in the preparation process. As more jaggery powder was added to the Dragon fruit jelly candy recipes there was a clear rise the mineral content of all jelly candy samples due to the addition of jaggery powder which is naturally rich in minerals. The elevated mineral content in the developed jelly candy can be attributed to the high mineral content present in jaggery powder. Furthermore, the dietary fiber content in the prepared jelly candy exhibited a consistent increase with the rise in jaggery powder concentration. The sensory evaluation process highlighted a particular formulation (JC_3), which consisted of 25 grams of sugar and 30 grams of jaggery powder. This formulation achieved the highest scores across all sensory attributes assessed, including a texture score of 8.6 and an overall acceptability of 8.6 on a nine-point hedonic scale, indicating a strong consumer preference for this balance of sweetness and texture.

Keywords: Dragon fruit jelly candy, jaggery powder, proximate composition, minerals, dietary fiber

Introduction
Dragon fruit is also known as Strawberry Pear, Dragon fruit, Pithaya, Night blooming Cereus, Belle of the night, Conderella plant and Jesus in the Cradle. Fruit is named as pitaya because of the bracts or scales on the fruit skin and hence the name of pitaya meaning ‘‘the scaly fruit’’ Several types of dragon fruits based on its colour of the peel and pulp are found throughout the world but mainly cultivated is red peel with white pulp. Dragon fruit was introduced in India late 90s. But the area under dragon fruit is still very limited. In India, it is cultivated on very limited scale. A very few farmers of Karnataka, Kerala, Tamil Nadu, Maharashtra, Gujarat and Andhra Pradesh have taken up dragon fruit cultivation. The total area under dragon fruit cultivation is less than 100 acres. Formerly uncultivated, marginal lands are used to establish dragon fruit orchards. The stem is green in colour, weak and requires support for growth (Tripathi *et al*., 2014) [21] Plants are grown on concrete or wooden posts, trees and fences, for support. The branches are encouraged to hang down to promote flowering and fruit set. Water and fertilizer requirements may be lower when compared to other tropical fruit species grown in these areas.

Dragon fruit has very attractive colour and mellow mouth melting pulp with black colour edible seed embedded in the pulp along with tremendous nutritive property which attract the growers from different part of India to cultivate this fruit crop which is originated in Mexico and Central and South America. (Britton and Rose, 1963) [5].

Dragon fruit can be considered as a potential source of micronutrients and antioxidants, which are found in the peel, flesh and seeds. The dragon fruit flesh may also be a possible

source of oligosaccharide for prebiotic production (Liaotrakoon *et al*., 2011) [16]. Dragon fruit is rich in nutritive value. The dragon fruit pulp contains 82.5-83% moisture, 0.16-0.23% protein, 0.210.61% fat, 0.7-0.9% fiber, 6.3-8.8 mg calcium, 30.2-36.1 mg phosphorous, 0.5-061 mg iron, 8-9 mg vitamin C.

Dragon fruit is a popular commercial fruit, which can be eaten fresh and used for culinary and confectionery purposes. It can also be fermented as wine and for the extraction of functional enzymes. The fruit is mostly consumed fresh; however, the frozen pulp may be used to make yogurt, candies, ice cream, marmalade, jelly, juice and pastries. They are widely used in various food products such as sweets, yogurts, ice creams, pastries, jams, jellies, and wines. Dragon fruit is classified as a non-climacteric fruit (Enciso *et al*., 2011) [8] (Zee *et al*., 2004) [22]. The mild laxative activity of dragon fruit is due to its seeds, which contain oil (Cheah and (Zulkarnain, 2008) [6] Crane and Balerdi, (2005) [7] Its products have several useful properties, including as coloring agents, thickening properties, high antioxidant capacity and dietary fibre (Bellec *et al*., 2006) [4].

Utilization of dragon fruit in jelly product will also provide health important in addition to nutritional benefits. The benefits of dragon fruit have a significant contributor to human health as it has heap and good source of protective nutrients and seasonality in production calls for their processing and preservation so that these can be supplied throughout the year for human consumption. Different concentrations of added pectin bring variability in organoleptic and physico-chemical properties of jelly.

Jelly candy is one of the preferred types of confectionaries because it has a distinctive characteristic. The distinction lies in the taste, shape, elasticity and product elasticity. Jelly candy made from fruits or vegetables has the advantage of nutritional value compared with those on the market that only come from the addition essence of chemical material. Jelly candy also called gummy candy, gummies, jelly fruit candy.

It is estimated that the amount of candy consumption is 57 approximately 7 kg per person in high-income countries and whilst it is much lower in the 58 low-income countries, this market is growing daily (Palacıoglu, 2003) [19]. Different kinds of 59 confectionery products such as soft and jelly candy, croquant, and nougat are produced, and 60 the gummy jelly candy group account for about 50% of confectionery market (Garcia, 2000) [9].

Materials and Methods

The current study was conducted at the College of Food Technology, VNMKV, Parbhani, during year 2022-2024.

Materials

The good quality of raw materials during this study such as quinoa and wheat were purchased from local market.

Chemicals and glassware's

The analytical grade chemicals and glassware utilized in this study were sourced from the College of Food Technology, VNMKV, Parbhani.

Equipment's and Machinery

The College of Food Technology, VNMKV, Parbhani provided access to various equipment including an analytical weighing balance, hot air oven, grinder, muffle furnace, Soxhlet apparatus, and microkjeldhal digestion and distillation unit.

Methodology and Formulation for preparation of Dragon fruit jelly candy

Dragon fruit jelly candy was made labeled from JC_0 to JC_4. Various formulations were created by adjusting the proportions of ingredients as outlined in Table 1. Each formulation uses a constant base of 100 ml of dragon fruit juice. The gelatin and pectin quantities remain consistent across all versions at 1 gram and 1 gram respectively, ensuring that any textural differences observed in the candies are due primarily to the variations in sweetener rather than differences in the gelling agents. In the formulations, sugar and jaggery are adjusted to explore their impact on the jelly candy's final taste and texture. Starting with JC_0, which contains 55 grams of sugar and no jaggery, each subsequent formulation decreases the amount of sugar by 10 grams and increases the amount of jaggery by 10 grams, culminating in 4, which contains only 15 grams of sugar and 40 grams of jaggery. This progressive substitution of sugar with jaggery is likely designed to assess how well jaggery can replace sugar in terms of sweetness, texture, and overall acceptability of the jelly candy. Additionally, citric acid is consistently used at 0.5 grams in each formulation to maintain a steady level of acidity, which can influence both the setting of the jelly candy and its flavour profile. This controlled approach allows for a focused examination of how varying levels of natural and refined sweeteners affect the sensory characteristics of the jelly candies. By maintaining fixed amounts of dragon fruit juice, pectin, gelatin, and citric acid, the study aims to isolate the effects of sugar and jaggery variations on the final product, providing clear insights into the potential for sugar replacement in confectionery items.

Table 1: Formulations for Standardization of different level of jaggery powder and ingredients for dragon fruit jelly candies

Formulations	Ingredients					
	Dragon Fruit Juice (ml)	Sugar (g)	Jaggery Powder (g)	Pectin(g)	Citric Acid(g)	Gelatin(g)
JC_0	100	55	-	1	0.5	1
JC_1	100	45	10	1	0.5	1
JC_2	100	35	20	1	0.5	1
JC_3	100	25	30	1	0.5	1
JC_4	100	15	40	1	0.5	1

Flow chart for preparation of Dragon fruit jelly candy

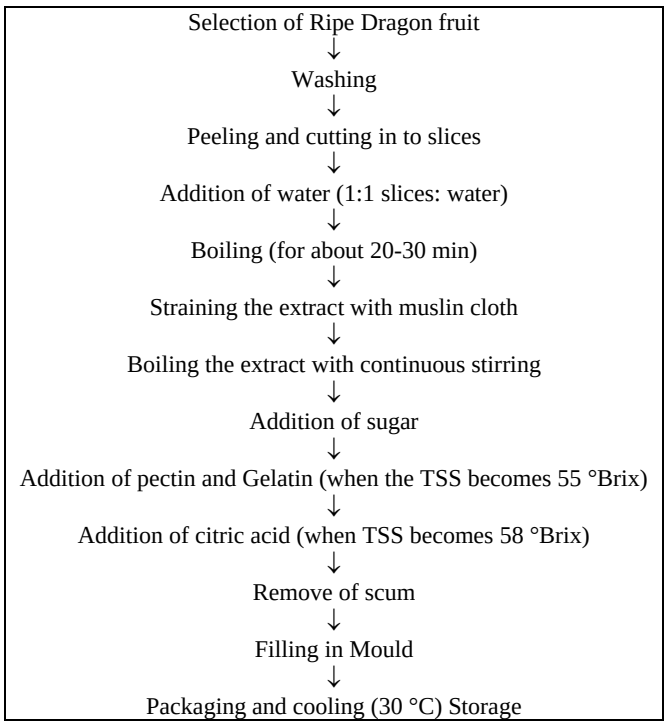

Fig 1: Preparation Dragon Fruit Jelly Candies

Proximate Analysis

Various chemical properties of the samples were examined such as moisture content, ash, fat, protein and total carbohydrate. Each process was performed three times and the results were reported as the average value according to their respective standard methods as described in (A.O.A.C., 2005) [1].

Determination of minerals

Two grams of the defatted sample was weighed and burned at 550 °C. The obtained ash was then treated with concentrated hydrochloric acid (HCl) on a hot plate. After digestion the material was filtered using Whatsman No. 42 filter paper and the volume was makeup to 100 ml with distilled water for mineral analysis by following the procedures given by (A.O.A.C., 2005) [1].

Determination of dietary fiber

The dietary fiber such as total dietary fiber (TDF), soluble dietary fiber (SDF) and insoluble dietary fiber (IDF) was estimated from samples using (AOAC, 2005) [1] method.

Statistical analysis

The data obtained was analysed statistically by Completely Randomized Design (CRD) as per the procedure given by Panse and Sukhatme (1985) [20]. The analysis of variance revealed at significance of p 0.05 level S.E. and C.D. at 5% level is mentioned wherever required.

Results and Discussion

Proximate composition of raw materials used for preparation of Dragon fruit jelly candy

Proximate analysis is typically indicative of a products nutritional value. Dragon fruit pulp serves as the primary ingredient for making jelly candy. The proximate composition of red and white Dragon fruit varieties was analyzed and is detailed in Table 2.

The results indicated that the both the red and white varieties of dragon fruit exhibit very similar moisture levels, slightly above 88%, reflecting their high water content that contributes to their hydrating properties. The low fat content, approximately 0.32% in the red variety and 0.25% in the white, positions dragon fruit as an excellent choice for low-fat diet considerations.

Protein content is also relatively low, with the red variety at about 0.78% and the white variety slightly lower at 0.75%. The fiber content is close between the two types, around 2.63% in the red and 2.62% in the white, useful for gastrointestinal health without being overly high. The ash content, indicative of mineral presence, is nearly identical in both varieties, around 0.61%, suggesting a balanced mineral contribution to the diet. The present finding was in proximity with findings of Kumar *et al*., (2022) [14], Arivalagan *et al*., (2021) [3], Jaffar *et al*. (2009) [11] and Khalil *et al*., (2006) [13].

Table 2: Proximate composition of Dragon fruits

Content	Content (%) Red Variety (*H. polyrhizhius*)	Content% White Variety (*H. undatus*)
Moisture	88.80±1.11	88.85±1.23
Crude fat	0.32±0.01	0.25±0.01
Crude Protein	0.78±0.02	0.75±0.02
Crude fiber	2.63±0.01	2.62±0.01
Ash	0.61±0.03	0.61±0.01
Carbohydrate	9.16±1.21	9.17±1.11
TSS ^{0BX}	11.0 ± 0.2	11.0 ± 0.2
Acidity	0.45 ± 0.02	0.47 ± 0.02
pH	4.20± 0.05	4.15± 0.05

Carbohydrates, vital for energy, show minimal difference between the varieties, with the red containing 9.16% and the white slightly more at 9.17%. This moderate level of carbohydrates supports energy without excessive caloric intake, suitable for energy balance in dietary planning. These nutritional components underline the health benefits of dragon fruit, reinforcing its role in dietary strategies focused on hydration, low fat intake, and balanced minerals and carbohydrates (Arivalagan *et al*., 2021) [3].

Both varieties of dragon fruit show identical TSS values at 11.0 °Brix, indicating a consistent level of dissolved sugars and solids, which is crucial for predicting the sweetness and density of the pulp. The acidity levels are slightly different, with the red variety at 0.45% and the White variety a bit higher at 0.47%. This slight variation can affect the perceived tartness and stability of the pulp. The pH values are close, with the red variety slightly more acidic at 4.20 compared to 4.15 in the White variety, influencing the microbial stability and flavor profile of the fruit. This present finding is similar with findings of Arivalagan *et al*., (2021) [3], Abirami *et al*., (2021) [2] and Islam *et al*., (2012) [10].

Mineral composition of raw materials used for preparation of Dragon fruit jelly candy

Analyzing the mineral composition of dragon fruit pulp is crucial for understanding its nutritional profile and potential health benefits. Minerals play essential roles in various physiological processes, including bone health, nerve function, and enzyme activity. By assessing the mineral content of dragon fruit pulp, we gain insights into its contribution to daily mineral intake and its potential role in

supporting overall well-being. The findings regarding the mineral composition of both red and white pulp of dragon fruit are outlined in Table 3.

The mineral composition of Dragon fruit pulp was assessed and it was discovered that Dragon fruit has the greatest potassium content (50 and 45.5 mg/100 g) in red and white dragon fruit varieties respectively as compared to the other minerals. The Red dragon fruit variety has a calcium content 4.3 mg/100 g, which contrasts with the White variety, which contain 3.5 mg/100 g.

Table 3: Mineral composition of Dragon fruit

Minerals	Mineral Content (mg/100 g)	
	Red Variety (*H. polyrhizhius*)	**White Variety (*H. undatus*)**
Calcium	4.3±0.5	3.5±0.6
Phosphorus	29.2±1.5	19±1.6
Magnesium	33.4±1.1	26.6±1.1
Iron	1.6±0.4	0.4±0.5
Potassium	50±1.8	45.5±1.7
Sodium	45±1.0	44.5±1.1

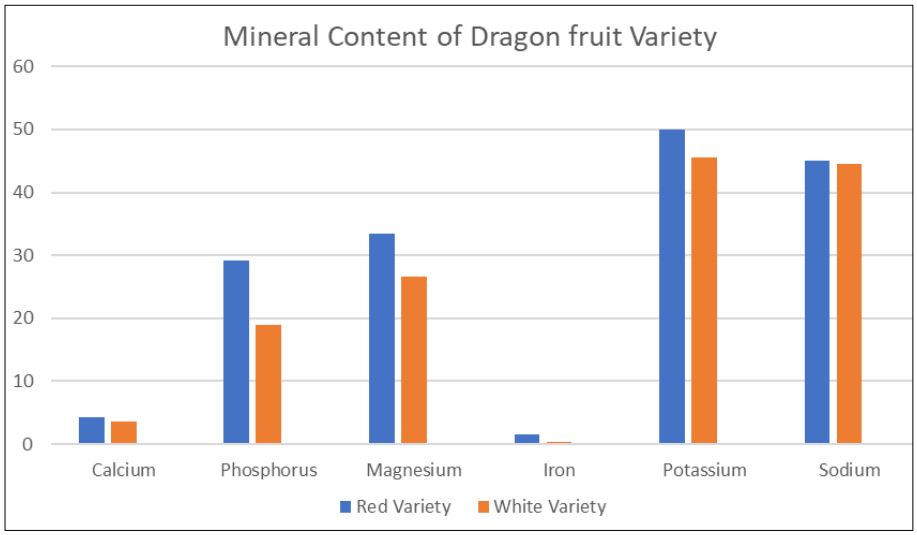

Fig 2: Mineral content of Dragon fruit variety

Phosphorus content is significantly higher in the red variety, which contain 29.2 mg/100 g, compared to 19 mg/100 g in the White variety. Magnesium levels are also higher in the red variety, with 33.4 mg/100 g, versus 26.6 mg/100 g in the White variety. Iron content shows considerable variation between the two types, with the red variety containing 1.6 mg/100 g and the White variety only 0.4 mg/100 g. Potassium levels are significantly higher in the White dragon fruit at 385.5 mg/100 g compared to 250 mg/100 g in the red variety. Sodium content is higher in the red variety, ranging from 7.8 mg/100 g, compared to only 3.3 mg/100 g in the White variety. This present finding is similar with findings of Arivalagan *et al*., (2021) [3], Luu *et al*., (2021) [17] and Khalil *et al*., (2006) [13].

Proximate composition of Dragon fruit jelly candy incorporated with jaggery powder instead of sugar

Table 4. provides detailed information of the physicochemical composition of Dragon fruit Jelly Candy across different formulations (JC_0 to JC_4) is provided, detailing the content of Moisture, Tss, pH, Acidity, Carbohydrate, Crude fiber. The variations observed in the physicochemical content can be explained by the changing ratios of sugar to jaggery in each formulation, as these ingredients can influence the overall profile of the products.

The proximate composition of a food product holds significant importance in both its processing and consumption. A nutritionally complete food should contain adequate amounts of both macronutrients (such as carbohydrates, proteins, fats, fiber) and micronutrients (including vitamins and minerals). For instance, the levels of moisture, fat, protein, carbohydrates, crude fiber, Tss and Ph in Dragon fruit jelly candy enriched with jaggery powder instead of sugar were measured and are detailed in Table 4.

Table 4: Physicochemical Composition of Dragon fruit Jelly Candy at different formulation

Formulations	Moisture%	TSS^{0}Bx	pH	Acidity %	Carbohydrate%	Protein %	Fat%	Crude fire %
JC_0	22.0	67.23	4.50	0.59	64.2	0.8	0.9	1.50
JC_1	22.5	67.50	4.70	0.58	64.5	0.8	0.9	1.54
JC_2	23.0	67.80	4.75	0.56	64.7	0.8	0.9	1.60
JC_3	23.2	68.00	4.80	0.55	65.0	0.8	0.9	1.73
JC_4	23.5	68.15	4.85	0.52	65.3	0.8	0.9	1.75
SE±	0.433	0.064	0.038	0.010	0.118	0.008	0.010	0.010
CD@5%	1.300	0.196	0.117	0.031	0.360	0.026	0.03	0.031

*Each value is average of three determinations

The study examined the proximate composition of Dragon fruit jelly candy enriched with jaggery powder instead of sugar. The data depicted in the table above indicates that as the proportion of jaggery powder increased in the jelly candy there was a notable rise in moisture, Tss, pH, crude fiber, and Carbohydrate content along with a decrease in acidity content.

Above table indicates that the Dragon fruit Jelly candy has a moisture content varies from (JC_0 to JC_4) 22.0 to 23.5%. Treatment JC_0 Contained 22.0, JC_1 contained 22.5, JC_2 contained 23.0, JC_3 contained 23.2, JC_4 contained 23.5 percent moisture content. Treatment JC_4 had higher moisture content. There were the significant differences in moisture content of jelly prepared by using different treatments. The TSS content of Dragon fruit Jelly candy was ranged from 67.23 to 69 ºBrix. Treatment JC_0 Contained 67.23^0Bx, JC_1 contained 67.50^0Bx, JC_2 contained 67.80^0Bx, JC_3 contained 68.00^0Bx, JC_4 contained 68.15^0Bx of Total soluble solid. There were no significant differences between the TSS content of jelly. The acidity of Dragon Fruit Jelly candy was maintained to 0.5 in all treatments during preparation of fresh Dragon Fruit Jelly candy who influencing tartness and stability, while the pH value varies from 4.50 to 4.85, suggests a slightly acidic nature, which is beneficial for both flavor enhancement and preservation. Carbohydrates dominate the composition from 64.2 to 65.3 percent. The fat and protein content were relatively low 0.8% and 0.9 respectively typical for fruit-based confections. (JC_0 to JC_4). The crude fiber content varies from (JC_0 TO JC_4) 1.5 to 1.75%, contributing modestly to digestive health. The results obtained were less or more similar to Islam *et al*, (2012) [10], and Kumar and Deen, (2017) [15].

Mineral composition of Dragon fruit Jelly Candy incorporated with jaggery powder instead of sugar

Table 5 provides detailed information of the mineral composition of Dragon fruit Jelly Candy across different formulations (JC_0 to JC_4) is provided, detailing the content of calcium, phosphorus, magnesium, iron, and zinc. The variations observed in the mineral content can be explained by the changing ratios of sugar to jaggery in each formulation, as these ingredients can influence the overall mineral profile of the products.

Table 5: Mineral composition of Dragon fruit Jelly Candy

Formulations	Content (mg/100 g)				
	Calcium	Phosphorus	Magnesium	Iron	Potassium
JC_0	10.3	15	5.2	2.0	16.2
JC_1	11.9	16	5.5	2.2	16.3
JC_2	12.4	18	6.2	2.5	16.4
JC_3	13.4	20	7.6	3.4	16.6
JC_4	13.5	21	7.8	3.6	16.7
SE±	0.068	0.106	0.084	0.068	0.063
0CD@5%	0.206	0.322	0.255	0.206	0.193

*Each value is average of three determinations

The mineral composition of the developed Dragon fruit jelly candy samples was analysed and compared to the control sample. The results presented in Table 5 demonstrate the impact of adding Jaggery powder on the mineral content of the jelly candy. It was observed that incorporating jaggery powder had only a slight effect on the mineral content of the jelly candy. The details regarding the mineral content of jelly candy enriched with jaggery powder are outlined in Table 5.

It could be demonstrates from Table 5 that the inclusion of jaggery powder in jelly candy led to notable enhancements in mineral content. The control batch exhibited 10.3 mg/100 g of calcium, 15 mg/100 g of phosphorus, 5.2 mg/100 g of magnesium, 16.2 mg of potassium, and 2.0 mg/100 g of iron. Conversely sample JC_3 showed increased levels with 13.4 mg of calcium, 20 mg of phosphorus, 7.6 mg of magnesium, 16.6 mg of potassium, and 3.4 mg of iron.

The calcium content in samples JC_1, JC_2 and JC_4 measured at 11.9,12.4 and 13.5 mg/100 g respectively while phosphorus content stood at 16, 18 and 21 mg/100 g, magnesium at 5.5, 6.2 and 7.8 mg/100 g, potassium at 16.3, 16.4 and 16.7 mg/100 g, and iron at 2.2, 2.5 and 3.6 mg/100 g correspondingly. The increase in mineral content across all samples could be attributed to the incorporation of jaggery powder. This increase aligns with the substitution of sugar with jaggery, suggesting that jaggery contributes more significantly to the mineral density of the candy. Jaggery is known to contain higher amounts of certain minerals compared to refined sugar due to its less processed nature (Joshi *et al*., 2019) [12]. Jaggery's natural composition includes higher iron content, which likely explains the increased levels observed in formulations with more jaggery (Onyekwelu, 2018) [18].

Conclusion

The use of jaggery powder instead of sugar improved the nutritional status of Dragon fruit jelly candy in different formulations. The proximate composition and mineral content of all Dragon fruit jelly candy samples were seen increasing which may be attributed to the addition of jaggery powder. Traditional confectionary product like Dragon fruit jelly candy could be prepared by incorporating with 100% Dragon fruit juice and 30 gm jaggery powder was found to be highly acceptable in terms of nutritional qualities.

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