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"Effects of Conventional Extraction Methods on Physico-chemical and Nutritional Properties of Date Fruit Liquid Sugar of *'Irani Mazhafati', 'Zahidi', 'Black Buman' Varieties*."

Swapnali S. Bhole[Q*], Gurunath V. Mote[Q], Vikramsinh M. Ingale[Q], Janardan S. Dhekale Prathapan K. Pillai[Q], Jayendra A. Khot[Q],

[Q]Department of Food Technology,
D. Y. Patil Agriculture & Technical University, Talsande, Kolhapur - 416112 , India.
Email: ***SwapnaliBhole@dyp-atu.org****

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ABSTRACT

The added sugars in processed foods significantly influence adverse effects on health, is a contributing factor to many chronic non-communicable diseases, including obesity, metabolic syndrome, type 2 diabetes, overweight, and cardiovascular disorders. Nowadays, natural sweeteners are promoted as a significant replacement for sugars and sweetener that are more palatable to consumers and current possibility to replace added sugars and highlights the benefits of using dates as a new natural, nutritious, and healthy alternative to synthetic and non-nutritive sweeteners. This work is a contribution to give value addition to date fruit cultivars by the production of date fruit liquid sugar. This study elucidates the physiochemical analysis and extraction of liquid sugar ratios (D/W) were 1:1, 1:2, 1:3 across in three Indian date fruit varieties (*'Irani Mazhafati', 'Zahidi', 'Black Buman'*). Analysis encompassed moisture content, ash content, total soluble solids, titrable acidity, pH, reducing sugar, total sugar, and extraction yield of date fruits liquid sugar. Results indicated higher total sugar in '*Irani'* date fruit at 1:1 ratio of extraction (71.5%), progressively declining with increasing extraction ratios. Concurrently, ash content, total soluble solids, reducing sugar, and pH exhibited a downward trend, while higher moisture levels correlated with heightened total soluble content. Moreover, moisture content values were augmented, alongside increased extraction yield of date fruits liquid sugar across all varieties. Understanding these physicochemical changes is imperative for refining post-harvest practices and elevating *Phoenix dactylifera* fruit quality. Intriguingly, the selected three date fruit varieties act as a good source of sugar and can be utilized to develop food products such as jam, jellies, cookies, and beverages.

Key Words: added sugar, date fruit, extraction, natural sweeteners, water

1. INTRODUCTION

Nowadays, sugar plays a major role in the rise of diabetes and obesity. This can be caused by an increasing amount of added sugar in beverages, dairy products, desserts, cookies, candies, jams, and other foods. (Estrella Sayas-Barberá, 2023) Long-term excessive sucrose consumption has an enormous adverse effect on human health since it causes the development of several chronic illnesses,

including diabetes, obesity, kidney impairment, chronic cardiovascular diseases including diabetes, obesity, kidney impairment, chronic cardiovascular diseases. (Singh *et al*., n.d.) Refined sugar is a refined commodity of 99% sucrose produced from sugarcane (70%) or sugar beet (30%). In our daily lives, we regularly consume refined sugar, and in recent decades, this usage has increased greatly. It is frequently used in tea, milk, juices, smoothies, sweets, and bakery goods in every home on this earth. But it poses a serious risk to people's health. The discoloration and other extraction and preparation processes include the use of numerous chemical additions, some of which may be hazardous. Research indicates that sugar contributes to health issues, such as diabetes, obesity, metabolic syndrome, dental cavities, high blood pressure, raised cholesterol, and possibly cancer (Arshad *et al.,* 2022)Consuming refined carbohydrates is also associated with lowered cognitive performance. Sugar consumption is known to lower the resistance to insulin and glucose tolerance, which may be linked to cognitive impairment, even though there is a dearth of human studies on the long-term effects of sugar intake on cognitive functioning (Makarem *et al.,* 2018)

The date palm (*Phoenix dactylifera L., CV. Arecaceae*) fruit has immense contribution to people's nourishment and healthy lives in MENA regions, influencing significantly to the food security and economic growth.(Bouhlali *et al.,* 2020) The palm date, also referred to as the date tree (*Phoenix dactylifera L.*, *CV.* Arecaceae), has been a valuable source of food for humans for the past 5000 years all over the Middle East and North Africa (MENA). Date fruits are an excellent source of phenolic antioxidants (1-2%) and have 6.5–11.5% total dietary fiber (of which 84–94% insoluble and 6–16% soluble dietary fiber), as well as roughly 1% fat, 2% proteins, and 2% ash. More than 400 varieties, among 3000 named varieties worldwide, are found in Iran, thus assembling a main worldwide date palm gene source. About 51% of the world's dates are produced in Iran, given the fact that it ranks among the top four countries globally in terms of date production (Pakkish & Mohammadrezakhani, 2020). Iran was one of the world's biggest producers of dates in 2006, having produced one million tons and exported over 143 thousand tons of the fruit. Iran has over 400 different varieties of dates, but the most popular and delicious is the '*Mazhafati*' variety, typically considered a soft or wet variety. (Orojloo & Orjloo, 2019)

One excellent source of polyphenols is date fruit. They are abundant in procyanidins and other flavonoids, as well as simple phenolic acids. The principal phenolic acids found in date fruit were determined to be gallic acid, protocatechuic, p-hydroxybenzoic, syringic, vanillic, caffeic, p-coumaric, and ferulic acids. Foods which include carbohydrates have varying glycemic potential and insulinemic responses depending on whether they are ingested in isoglucidic or isoenergetic proportions. Thus, the glycemic index (GI), a commonly used indicator of how carbohydrate diets affect human health, is used to categorize carbohydrates and carbohydrate foods according to their glycemic responses (Vayalil, 2012). Dates are commonly known for their high carbohydrate content (80%) and low protein content (1-3%). According to dry weight basis, date fruits (Tamr) had moisture content ranging from 10 to 22%, total sugar content 62 to 75%, protein 2.2 to 2.7%, fiber 5 to 8%, fat 0.4 to 0.7%, ash 3.5 to 4.2%, total acidity 0.06 to 0.20%, and ascorbic acid 30.0 to 50.0 mg (Gamal A El Sharnouby, 2014) Natural sugars (unrefined sugar) contain a higher concentration of beneficial substances (bioactive compounds, minerals, fibers, antioxidants, and phytochemicals) than refined sugar, they are considered to have a higher nutritional value and counteract its negative effects. As a result, eliminating refined sugar or at least lowering consumption must be encouraged as a healthy food choice (Sayas-Barberá *et al*., 2024). Natural sweeteners, such as agave nectar, date sugar, molasses, honey, xylitol, erythritol, maltose, maltodextrin, stevia, and coconut sugar, are promoted as a significant substitute for sugars that are more palatable to consumers and present a business potential

(Valle *et al.,* 2020).

Extraction is considered a key step in food processing which consists of separating the desired compounds from the raw material and transferring these compounds into a solvent. it includes several methods, such as solvent extraction, ultrasound-assisted extraction, microwave-assisted extraction, soxhlet extraction, supercritical fluid extraction, and subcritical water extraction (Plaza & Marina, 2023). In the main, natural product extraction goes through the following phases: (1) the solvent penetrates the solid matrix; (2) the solute dissolves in the solvents; (3) the solute is diffused out of the solid matrix; (4) the extracted solutes are collected. The efficiency of the extraction is conditioned by various parameters, including particle size, the extraction solvent, the solvent-to-solid ratio, the extraction temperature, and duration. The most common conventional techniques used for the extraction of valuable compounds from food and other natural sources are solid-liquid extraction (SLE) and liquid-liquid extraction (LLE). These techniques are characterized by simplicity and the use of not expensive instrumentation, but one of their main drawbacks is the consumption of considerable amounts of organic solvents (Plaza & Marina, 2023). The solvent extraction method uses the active ingredient in a variety of solvents with variable solubility levels. A particular solvent is typically chosen to dissolve the most useful components. Hot and cold water, acids, alkali, and organic solutions are among the frequently used solvents. Solvent extraction technology uses low-threshold equipment that requires simple operation processes, with a low overall cost, and allows easy industrial production. The solvent extraction method is affected by various factors like physicochemical, functional, and sensory properties of date fruit liquid sugar (Jones & Kinghorn, 2012). Regarding the available research statements, this research aims to extract liquid sugar from date fruit varieties and its effects on physicochemical, sensory, and functional properties of date fruit liquid sugar.

2. MATERIALS AND METHODS

2.1 Materials

Date fruit of the most abundant cultivars i.e. *Irani Mazhafati, Zahidi, Black Buman* were purchased from Kolhapur super market. Dates were selected at the "Tamr stage," when they were fully grown. Each variety's ten kilograms were immediately separated into 500 g bags and kept at 20 °C until needed. Date fruits were washed, pitted, crushed, and gently defrosted in a meat grinder (Moulinex, type NE 401, France) to create date paste before the date fruit liquid sugar was processed.

2.2 Methods

2.2.1 Extraction of date liquid sugar from solvent assisted extraction

The three date fruit cultivars were pitted and sliced into pieces with approximate dimensions of 1 cm x 1 cm x 0.3 cm. Then the prepared date fruit was used for the solvent extraction method. Date fruit (100 gm) in a typical put in a beaker and water was added in different extraction ratios. The date pulp/water ratios (D/W) were 1:1, 1:2, and 1:3 and the sample were blended using a hand blender. The pH was adjusted to 6.0±0.2. Each sample in triplicate was placed in a water bath at 70 °C for 2 Hr. After heating the slurry was filtered through a muslin cloth with a hand press to remove large impurities and insoluble matter, then centrifuged at 8000 RPM for 10 min. (Gamal A El Sharnouby, 2014) the syrup samples were prepared on the same day and stored at 4 °C. After syrup preparation, three samples from each variety were used to perform the physicochemical analysis.

2.3 Physicochemical Analysis of date fruit and date fruit liquid sugar

All analytical determinations were performed at least in triplicate. Values of different parameters were expressed as the mean ± standard deviation

2.3.1 Determination of pH and titrable acidity

A digital pH meter (Denver Instrument, Denver, CO, USA) with a glass electrode was used to test the pH value at 25 °C based on AOAC method 943.02. Three sets of measurements were made. Titrable acidity was determined using the method of I.S.I. Handbook of Food Analysis (Part II) 1984 page 37 with slight modification. 10 gm of the date fruit liquid sample in a suitable titration flask and dissolve in 75 ml of carbon dioxide free water. Mix thoroughly. Titrate against 0.05N NaOH solution using 4-6 drops of phenolphthalein indicator till pink color persists for 10 seconds.

2.3.2 Determination of total soluble solid

Total soluble solids may be determined by Hand Refractometer or Abbe's Refractometer. Place few drops of the sample in between the prisms of hand refractometer and note the reading at the demarcation line and allow the temperature to equilibrate and note the Brix reading, which gives per cent of sucrose sugar or TSS.

2.3.3 Chemical Composition

Nutritional composition of date fruit and date liquid sugar was analyzed according to the AOAC official methods. Moisture content was determined using the gravimetric method (AOAC 945.62). Protein content was analyzed by the Kjeldahl method (AOAC 945.23), in which the nitrogen content was multiplied by the conversion factor of 6.25. Total fat was analyzed by acid hydrolysis of the sample followed by extracting the dried sample with petroleum ether in the Soxhlet apparatus (AOAC 2000.18). Ash was determined by combustion of the sample in a muffle furnace at 550 _C for 8 h (AOAC, 1995). The residue was dissolved in HNO3 (14.44 mol/l) and the mineral constituents (Ca, K, Mg, Na and Zn) were analysed separately, using an atomic absorption spectrophotometer Total carbohydrate was calculated by subtracting the percentage of moisture, crude protein, crude fat, and ash from 100. Crude fiber was analyzed by enzymatically gravimetric method, including soluble and insoluble dietary fibers (AOAC 991.42) (Effects of Extraction and Evaporation Methods on, 2023)

2.3.4 Sensory analysis

The date fruit liquid sugar was assessed by an untrained panel consisting of thirty-six panellists (13 males and 23 females) from the students and the staff members D. Y. Patil Agriculture and Technical University, Talsande, Kolhapur. Their ages ranged from 22 to 45 years. The date fruit liquid sugar was evaluated based on a Nine -point hedonic scale, where one represented “disliked extremely” and seven represented “liked extremely.” Each consumer was given 6 samples labeled with random 3-digit codes simultaneously and asked to evaluate the product for appearance, taste, odor, and texture. The mean value of these sensory properties was evaluated as overall acceptability.

2.4 Statistical Analysis

The physicochemical, and sensory data from all samples underwent ANOVA using IBM Corp.'s SPSS version 20.0 (Armonk, NY, USA). Post hoc tests (LSD test), and one-way ANOVA assessed variations in dates fruits sample quality, with a 95% confidence interval and significance level set at $p < 0.05$. Results are presented as mean ± standard deviation.

3. RESULT AND DISCUSSION

3.1 Physiochemical analysis of date fruit cultivars ‘*Irani Mazhafati’, ‘Zahidi’, ‘Black Buman’*

Chemical composition date fruit cultivars, *'Irani Mazhafati,' 'Zahidi,' 'Black Buman'* is given in Figure 1. The figure illustrates that moisture content of '*Irani Mazhafati,' 'Zahidi,' 'Black Buman'* date cultivars were 17.9± 0.12 %, 18.6±0.24% and 19.2±0.11% respectively. The value of both *'Zahidi,' 'Black Buman'* date fruit cultivars were higher than '*Irani Mazhafati.'* The ash content of '*Irani Mazhafati,' 'Zahidi,' 'Black Buman'* date cultivars were 2.68±0.02, 2.01± 0.04, 2.53± 0.02. The value of '*Irani Mazhafati'* date fruit cultivars were higher than both *'Zahidi,' 'Black Buman.'* The protein content of '*Irani Mazhafati,' 'Zahidi,' 'Black Buman'* date cultivars were 2.86±0.02%, 1.98 ±0.01%, 2.21±0.06%. The value of '*Irani Mazhafati'* date fruit cultivars were higher than both *'Zahidi,' 'Black Buman'*. The fat content of '*Irani Mazhafati,' 'Zahidi,' 'Black Buman'* date cultivars were 0.40 ± 0.12%, 0.32 ±0.06%, 0.39±0.10. The value of *'Zahidi'* Date fruit cultivars was lower than both '*Irani Mazhafati,' 'Black Buman.'* The crude fiber of '*Irani Mazhafati,' 'Zahidi,' 'Black Buman'* date cultivars were 2.96 ± 0.08%, 1.82 ± 0.05%, 1.21±0.03%. The value of '*Irani Mazhafati'* date fruit cultivars were higher than *'Zahidi,' 'Black Buman.'* The carbohydrate of '*Irani Mazhafati,' 'Zahidi,' 'Black Buman'* date cultivars were 71.80 ±0.21%, 65.80±0.25% and 62.55±0.10%. The macro elements (potassium, calcium, phosphorus, magnesium) of '*Irani Mazhafati'* date cultivars were in 4963±0.24, 512 ± 0.05, 247± 0.17, 4± 0.31 as well as *'Zahidi'* 3821± 0.12, 456± 0.25, 198± 0.42, 2.3± 0.05 and *'Black Buman'* 2254±0.31, 312±0.02, 141±0.42, 1.2± 0.04. The nutritional value of '*Irani Mazhafati'* date fruit cultivars were higher than *'Zahidi,' 'Black Buman.'*

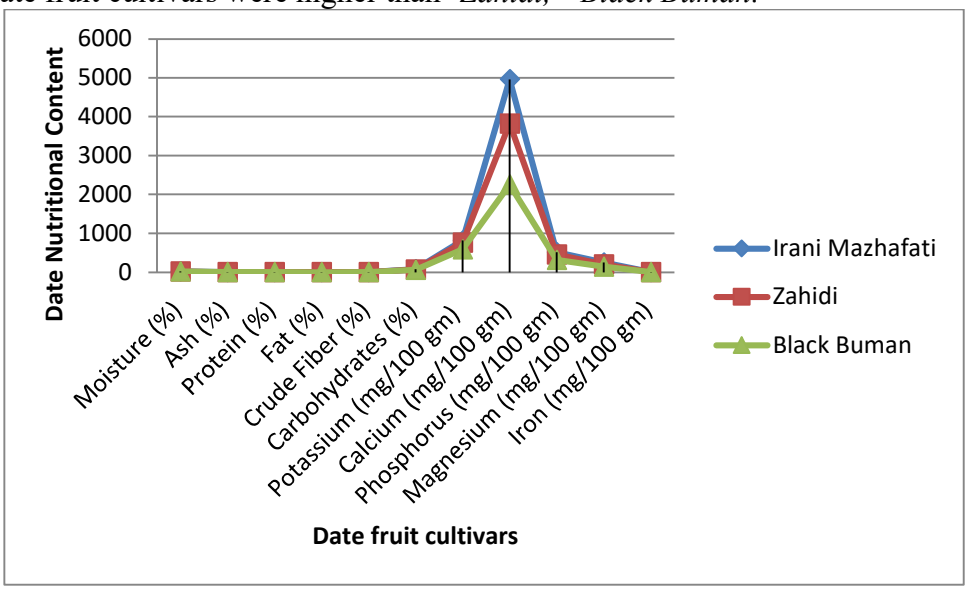


Fig 1. Chemical composition of date fruit cultivars

3.2 Physiochemical analysis of date fruit liquid sugar (DFLS)

3.2.1 Moisture content

The Figure 2 and Table 1 illustrated the moisture content of different DFLS. The effects of extraction ratio on moisture content of extracted sugar in date fruit cultivars it is observed that *'Irani* DFLS moisture content is lower as compared to *'Zahidi,'* and *'Black Buman.'* The Figure 2 observed that the increased extraction ratio significantly increased moisture content in each date fruit variety. Therefore, more water helps the soluble solids from the dates dissolve, producing a liquid phase with higher moisture levels. Notably, a significant difference ($P \leq 0.05$) was observed between the 1:1 and 1:3 ratio samples in date fruit cultivars.

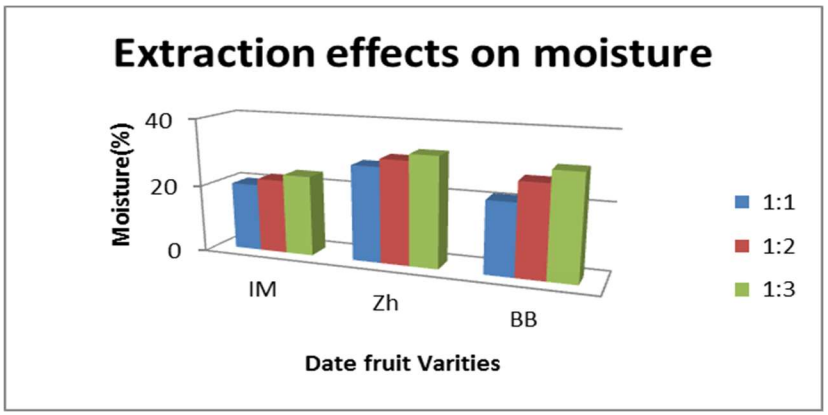


Figure 2. Moisture content of date fruit liquid sugar in *'Irani Mazhafati,' 'Zahidi,' 'Black Buman'* varieties

3.2.2 Ash content

The Figure 3 and Table 1 illustrates the ash content of different DFLS. As regards effects of extraction on ash content in date fruit cultivars *'Irani Mazhafati,' 'Zahidi,' 'Black Buman'* shown in Figure 3. The observed that *'Irani Mazhafati'* DFLS ash content is higher compared to *'Zahidi,'* and *'Black Buman'* date cultivars. Hence, the increased dilution facilitates the extraction of soluble sugars but may also lead to a relative decrease in the concentration of minerals and other non-soluble components. Water tends to dilute the concentration of these minerals in the final product, thereby reducing the overall ash content. Statistical analysis revealed that ash content in extraction ratio 1:1, 1:2 and 1:3 significantly difference ($P \leq 0.05$) in date fruit cultivar. Conversely, when a lower amount of water is involved (such as a D/W ratio of 1:1), the extraction process concentrates not only the sugars but also the ash, which contains essential minerals such as potassium, magnesium, and calcium. This can result in a higher ash content in the extracted liquid sugar.

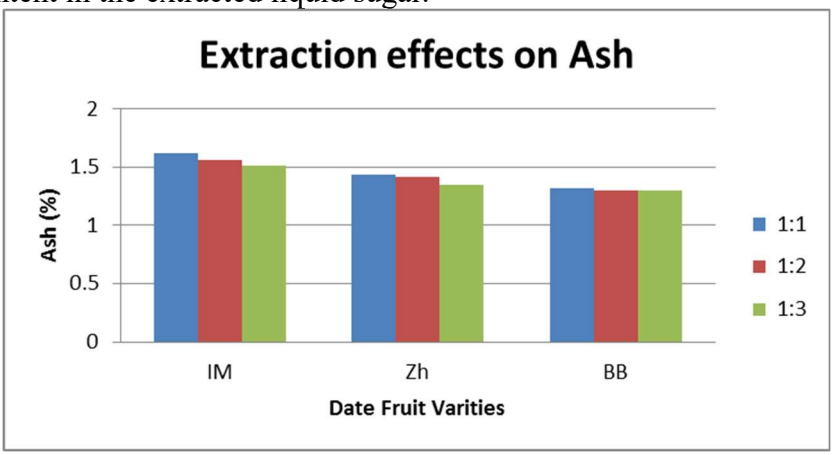


Figure 3. Ash content of date fruit liquid sugar in *'Irani Mazhafati,' 'Zahidi,' 'Black Buman'* varieties

3.2.3 Total soluble solid (TSS)

In the Figure 4 and Table 1 showed the difference in the TSS of *'Irani Mazhafati,' 'Zahidi,' 'Black Buman'* varieties. As regards brix of different varieties have different brix (°) which was significantly different from each other. The maximum brix (64°) was found in *'Irani Mazhafati'* variety which was followed by varieties *'Zahidi,' 'Black Buman'*. The various extraction proportions the maximum 64° Brix was found in the ratio (1:1) which was significantly more than the ratio 1:2 (44° Brix) and

minimum (36° Brix) in the ratio (1:3) shown in Figure 4. TSS is an important determinant in the flavor profile and sweetness level of the extracted liquid sugar. A higher TSS content typically translates to a sweeter product with enhanced sensory properties desirable in food applications. Statistical analysis revealed that *'Zahidi'* date cultivars TSS content in extraction ratio 1:3 was not significant difference but in extraction ratio 1:1 and 1:2 was significantly difference observed in *'Irani Mazhafati,'* and *'Black Buman'* date fruit cultivars.

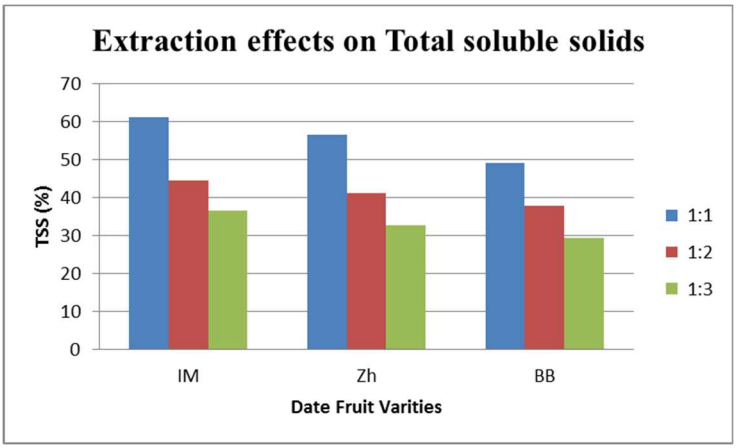


Figure 4. Total soluble solid content of date fruit liquid sugar in *'Irani Mazhafati,' 'Zahidi,' 'Black Buman'* varieties

Table 1. Physiochemical parameters of date fruit liquid sugar (DFLS) in *'Irani Mazhafati,' 'Zahidi,' 'Black Buman'* varieties with extraction ratios of 1:1, 1:2, and 1:3.

Parameter (%)	***'Irani Mazhafati'***			***'Zahidi'***			***'Black Buman'***		
	1:1	**1:2**	**1:3**	**1:1**	**1:2**	**1:3**	**1:1**	**1:2**	**s**
Moisture	20.1	22.3	23.5	28.4	30.4	32.4	21.6	27.2	30.3
Ash	2.58	1.81	1.58	2.48	2.19	2.13	2.08	1.97	1.84
Total Soluble Solid	64	44	36	56.5	41.2	32.8	49	38.5	29.1
Reducing Sugar	45.2	40.5	32.8	44	36	29	38	32.2	27.8
Total Sugar	62.3	45	37	57	42	33	50	39	30
Titrable Acidity	0.02	0.029	0.02	0.02	0.03	0.08	0.66	0.02	0.02
pH Value	4.5	4.1	4.4	5	5.1	5.5	5.0	4.8	4.6
Extraction Yield	55.2	67.9	78.9	48.7	65.4	76.1	47.6	63.9	74.2

3.2.4 Reducing sugar content

The Figure 5 and Table 1 illustrates the reducing sugar of different DFLS. The effects of extraction ratio on reducing sugar in date fruit cultivars showed in Figure 5. The observed that *'Irani Mazhafati'* date fruit liquid sugar reducing sugar were higher in all extraction ratio compared to *'Zahidi,'* and *'Black Buman'* date fruit cultivars. When using a higher extraction ratio, such as a D/W ratio of 1:3, the yield of reducing sugars may decrease. The increased volume of water can dilute the concentration of sugars extracted from the date fruits. Statistical analysis observed that reducing sugar in extraction ratio 1:1 and 1:2 in *'Black Buman'* date fruit cultivar was not significant difference.

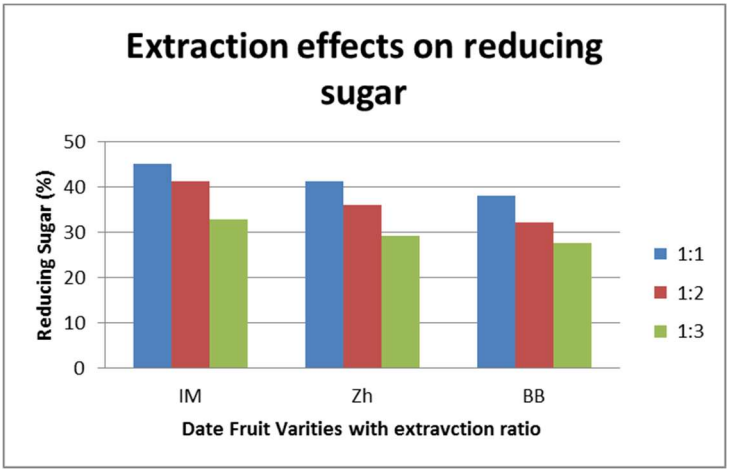


Figure 5. Reducing sugar content of date fruit liquid sugar in *'Irani Mazhafati,' 'Zahidi,' 'Black Buman'* varieties

3.2.5 Total sugar content

The Figure 6 and Table 1 depicted the total sugar content in different varieties of DFLS. The effects of extraction ratio on total sugar in date fruit liquid sugar observed that increase in extraction ratio decrease in total sugar in different varieties. The *'Irani Mazhafati'* date fruit cultivar has higher total sugar in each extraction ratio as compare to *'Zahidi,'* and '*Black Buman'* date fruit cultivars. With less water used, the extraction process produces a more concentrated syrup that retains a greater proportion of the sugars present in the date fruits. Statistical analysis revealed a significant difference ($P \leq 0.05$) was not observed in all date fruit varieties.

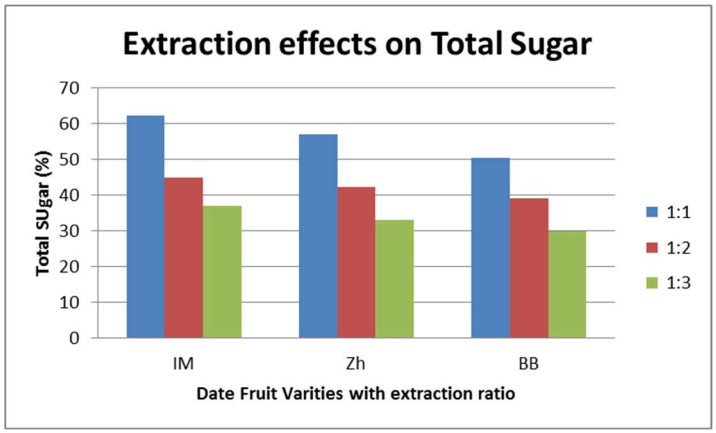


Figure 6. Total sugar content of date fruit liquid sugar in *'Irani Mazhafati,' 'Zahidi,' 'Black Buman'* varieties

3.2.6 Extraction yield

Figure 7 and Table 1 shown the on-extraction yield in different date fruit cultivars. The observed that increase in extraction ratio yield of date fruit liquid sugar has increases in date fruit cultivars *'Irani Mazhafati'* date fruit has higher extraction yield in each extraction ratio as compared to *'Zahidi',* and *'Black Buman'* date fruits.

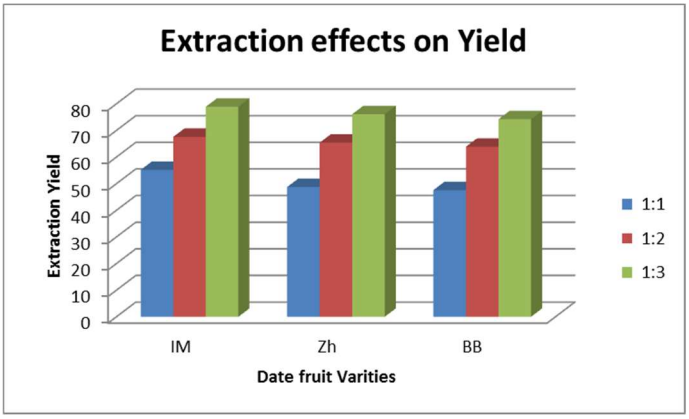


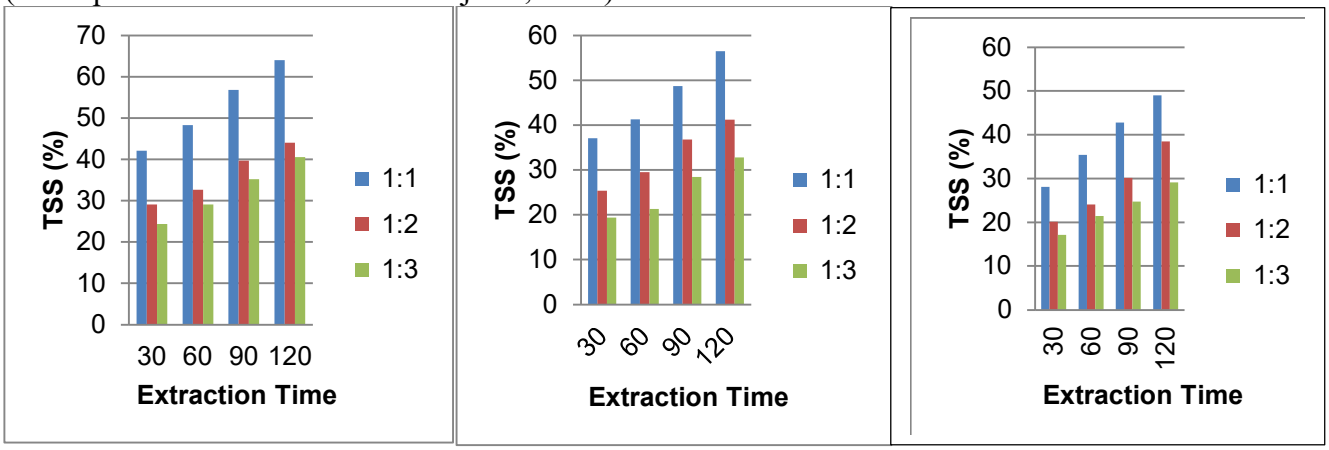
Figure 7. Total extraction yield of date fruit liquid sugar in *'Irani Mazhafati,' 'Zahidi,' 'Black Buman'* varieties

The increased water content facilitates the dissolution of soluble components such as sugars, acids, and other valuable compounds present in the date fruit. This dilution effect allows for a more complete extraction of the soluble materials, resulting in a potentially higher overall yield. Statistical analysis revealed a significant difference ($P \leq 0.05$) was not observed in date fruit varieties

3.3 Effects of conventional extraction on nutrient content of date fruit liquid sugar

3.3.1 Effect of extraction time on total soluble solids

The Figure 8 illustrated the extraction time of date fruit liquid sugar effect on the total soluble solid. The extraction time it is observed that time increases TSS (%) also increase significantly. It was observed that the maximum TSS in *'Irani Mazhafati'* (64 °Brix) was found at time 120 Minute which was at par (non-significantly different) from 90 Minute which was at par (non-significantly different) from 90 minute, but both were significantly more than 30- & 60-minute times which can see Figure 8 A, B, and C. The effectiveness of extraction depends considerably on the solubility of the desired compounds in water. Heating water can enhance the solubility of both polar and nonpolar compounds, leading to improved extraction ratios. Higher temperatures increase kinetic energy, promoting molecular movement and the diffusion of solutes into the solvent, thus expanding the extraction ratio (I E Septiani A C Kumoro and M Djaeni, 2020).



The Figure 8 illustrated the extraction time of date fruit liquid sugar effect on the total soluble solid in A) *'Irani Mazhafati' B) Zahidi'* and *C) 'Black Buman' varieties*

CONCLUSION

The processed foods added sugars have a major negative impact on health and are a contributing factor in a number of chronic non-communicable diseases, such as obesity, metabolic syndrome, type 2 diabetes, overweight, and cardiovascular disorders. Nowadays, natural sweeteners are promoted as an important substitute for sugars and sweeteners that are more palatable to consumers. Furthermore, they highlight the positive effects of using dates as a new natural, healthy, and nutritious substitute for artificial and non-nutritive sweeteners. This study investigated the extraction of liquid sugar from three different date fruit cultivars and its effects on chemical analysis of extracted sugar. This study has shown how extraction techniques substantially impact on the physico-chemical attributes, sensory characteristics, and functional qualities of liquid sugar derived from different date cultivars. This study elucidates the physiochemical dynamics and extraction of liquid sugar ratios (D/W) were 1:1, 1:2, 1:3 across in three Indian date fruit varieties *'Irani Mazhafati', 'Zahidi', 'Black Buman'*. Results indicated higher total sugar in 'Irani' date fruit at 1:1 ratio of extraction (71.5%), progressively declining with increasing extraction ratios. Concurrently, ash content, total soluble solids, reducing sugar, and pH exhibited a downward trend, while higher moisture levels correlated with heightened total soluble content. Moreover, moisture content values were augmented, alongside increased extraction yield of date fruits liquid sugar across all varieties. The three date fruit varieties that were chosen are significant because they are an excellent source of sugar and may be used to make beverages, preserves, jellies, and cookies. The present work is a contribution to give value addition to date fruit cultivars by the production of date fruit liquid sugar.

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