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Development and Sensorial Acceptability of Sustainable and Nutrient-Dense Date Juice

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Abstract

Dates are a rich source of essential nutrients, and transforming them into juice can provide a refreshing and healthy beverage option. This study aims develops a nutrient-dense date juice, optimizing its formulation and processing for sustainability and consumer acceptability. The other objective was to evaluate the sensorial acceptability of sustainable and nutrient-dense date juice. Purposely, dates were soaked overnight, ground, and heated with pectin and sugar addition. The juice was then filtered and evaluated for physicochemical, microbial, and sensory attributes. For research we prepared three different sample with the different date's category and made three treatment S_1, S_2, S_3. The results showed significant differences ($P<0.05$) between treatments for most parameters. TSS content ranged from 10.4 to 17.5 °Brix, with a standard deviation of 0.24 to 0.28. Treatment 1 (S_2) had higher mean values for TSS (14.300), L (49.70), and sensory attributes like taste and overall acceptability were significant. In this regard, taste (S_1: 7.3±1.2, S_2: 8.0±0.4, S_3: 5.6±0.8), mouthfeel (S_1: 7.0±0.4, S_2: 8.1±0.5, S_3: 6.0±0.4), and overall acceptability (S_1: 7.0±0.8, S_2: 8.0±0.4, S_3: 5.8±0.6) values for different varieties showed significant sensory attributes. Moreover, TSS, acidity, L, a, b, mouthfeel, taste, and overall acceptability showed significant variations among treatments. However, some parameters like TDS, appearance, and aroma showed non-significant differences ($P>0.05$) between treatments. The study concluded that Treatment 1 (S_2) was the most acceptable formulation for date juice, with optimal physicochemical and sensory attributes.

Keywords: Date juice, nutrient dense beverage, organoleptic attributes, sustainable, consumer acceptability, formulation optimization

1. Introduction

Food waste is a significant global issue, with developed economies wasting billions of dollars' worth of food annually. Over 95% of food waste is converted to methane, carbon dioxide, and other greenhouse gases in landfills through anaerobic digestion. This waste has a significant impact on climate change and is predicted to worsen over the following 25 years as a result of population growth and economic expansion, particularly in Asian countries. Over one-third of all food produced for human use is thought to be wasted. The world's population is expected to grow to 9.3 billion by 2050, increasing food demand by 50-70% by the middle of the century. Improving food supply in the future will be greatly aided by reducing global food waste. The challenge lies in meeting the growing demands for food in a safe, healthful, and sustainable manner from an economic, social, and environmental standpoint. The date palm, a keystone plant in oasis agrosystems, produces dates, which are

nutrient-dense and high in sugar. The environmental impact of the production and consumption of dates is still linked, with the world's consumption of dates consuming 1.4 million hectares of agricultural land in 2019. The economic driver of dates production and consumption often disregarded environmental sustainability factors in favor of financial gain (Alexander et al., 2013).

Pakistan, a leading global producer and exporter of date palms, has a significant impact on local socioeconomic activity. The country's provinces of Sindh and Balochistan account for over 90% of its crop acreage and production. Khairpur, home to over 300 date palm cultivars, is home to the best cultivars in Pakistan. The country exports fresh, dried, or chohara date fruit.

Date flesh is high in fructose and glucose and low in fat and protein. With an average of 314 kcal per 100 g of flesh, it has a high calorie content. Ten minerals: magnesium, potassium, copper, and selenium. One hundred grams of dates can supply more than 15% of the recommended daily allowance for certain minerals. The main vitamins found in dates are C and B-complex. Insoluble dietary fiber makes up the majority of the high dietary fiber content (8.0 g/100 g) of dates. Dates contain phenolic, carotenoids, and antioxidants. Date seeds are higher in fat (9.0 g/100 g) and protein (5.1 g/100 g) than the flesh. Significant amounts of phenolic (3942 mg/100 g), antioxidants (80400 µ mol/100 g), and dietary fiber (73.1 g/100 g) are also present (Khan et al.,2015).

Dates are low in lipids (0.2-2.5%) and proteins (2.3-5.6%) but high in carbs (44-88%), primarily glucose and fructose (Al-Farsi et al., 2008). Physical characteristics of date fruit (cv. Mazafati) to make the construction of some processing equipment easier. Date fruits had a dry-basis moisture content of 44.41% (47.73% for dates with pits and 18.87% for those without).

Efficient date palm waste management techniques and food waste management methods can lessen environmental effects, encourage sustainability, and aid in economic growth. Sustainable date palm cultivation practices include integrated pest management, effective water usage, and soil conservation. Organic fertilizers and amendments can also help reduce the need for synthetic fertilizers and and productivity of date palm trees (Al-Yahyai and Al-Sadi 2018).

Nonthermal decontamination techniques, Date fruit can be preserved using methods such high-pressure processing (HPP), pulsed electric fields (PEF), ultraviolet (UV) irradiation, freezing plasma therapy, ozone treatment, and ionizing radiation. There are several ways to produce dates and prolong their shelf life, including maintaining a steady, cold temperature and minimizing physical damage. Dates' shelf life can also be extended by modified atmosphere packing and controlled atmosphere storage. Date quality and productivity may be improved by using good agricultural practices (GAPs) and good handling procedures (GHPs). Date flesh is high in fructose and glucose, low in fat and protein, and contains ten minerals. It contains phenolic, carotenoids, and antioxidants. Date seeds have more protein and fat, while dates are low in lipids and proteins but high in carbohydrates. Date fruit goes through four stages of ripening: kimri, khalal, rutab, and tamer. Date by-products can be used to create products with extra value, such as bread yeasts, probiotic-fermented dairy products with dates, organic acids, exopolysaccharides, and antibiotics. High-value intermediate and stable products have been produced from date fruit, including date pastes, date waters, and date flours. Modified environment packaging can prolong the shelf life of khalal dates in a refrigerator, slowing down the ripening process (Al-Eid et al.,2012).

2. Methodology

2.1. Procurement of raw material

The dates obtained from the local market in Pakistan. Three types of date samples were taken such as Aseel, Irani and Mazafati. The other ingredients including sugar and pectin were purchased from local market. In the lab, its manufacturing was carried out in cleaned and hygienic conditions. The equipment and utensils used were fully cleaned before use.

Table 1. Treatment plan for nutrient dense date juice

Samples	Treatments
S_1	Preparation of date juice with Irani dates
S_2	Preparation of date juice with Mazafati dates
S_3	Preparation of date juice with Aseel dates

2.2. Juice extraction

Washing the dates thoroughly with tap water, and then the process of depitting occurs. Pitted dates soaked in the water overnight it helps to loosen the peel of the dates. In the early morning the soaked dates were taken to remove the peels by hand or stainless knife. The removal of peel helps to increase the clarification of the date juice and prevent from the sublimation. Followed by the grinding of dates with the same soaked water and additionally added water using a blender for 5-7 minutes. After 10 minutes of stirring, the pulp that remained was mixed with water and squeezed out once more after the juice was gently stirred with a cotton cloth.

2.3. Product development

Prepare the date juice by filtering it to remove impurities. Add date juice in a saucepan and heat over medium heat, a partial pasteurization heat treatment of 60-65 °C is used to reduce the activity of microbes. Add sugar in it and stir until the sugar dissolves. Take the pot off the burner and let the juice to cool a little. Later, add pectin and mix thoroughly and process date juice packed in the sterilized bottles and then sealed.

Table 2. Formulation for the preparation nutrient dense date juice

Ingredients	S_1	S_2	S_3
Dates (g)	100	100	100
Sugar (g)	20	20	20
Water (mL)	400	400	400
Pectin (g)	0.2	0.2	0.2

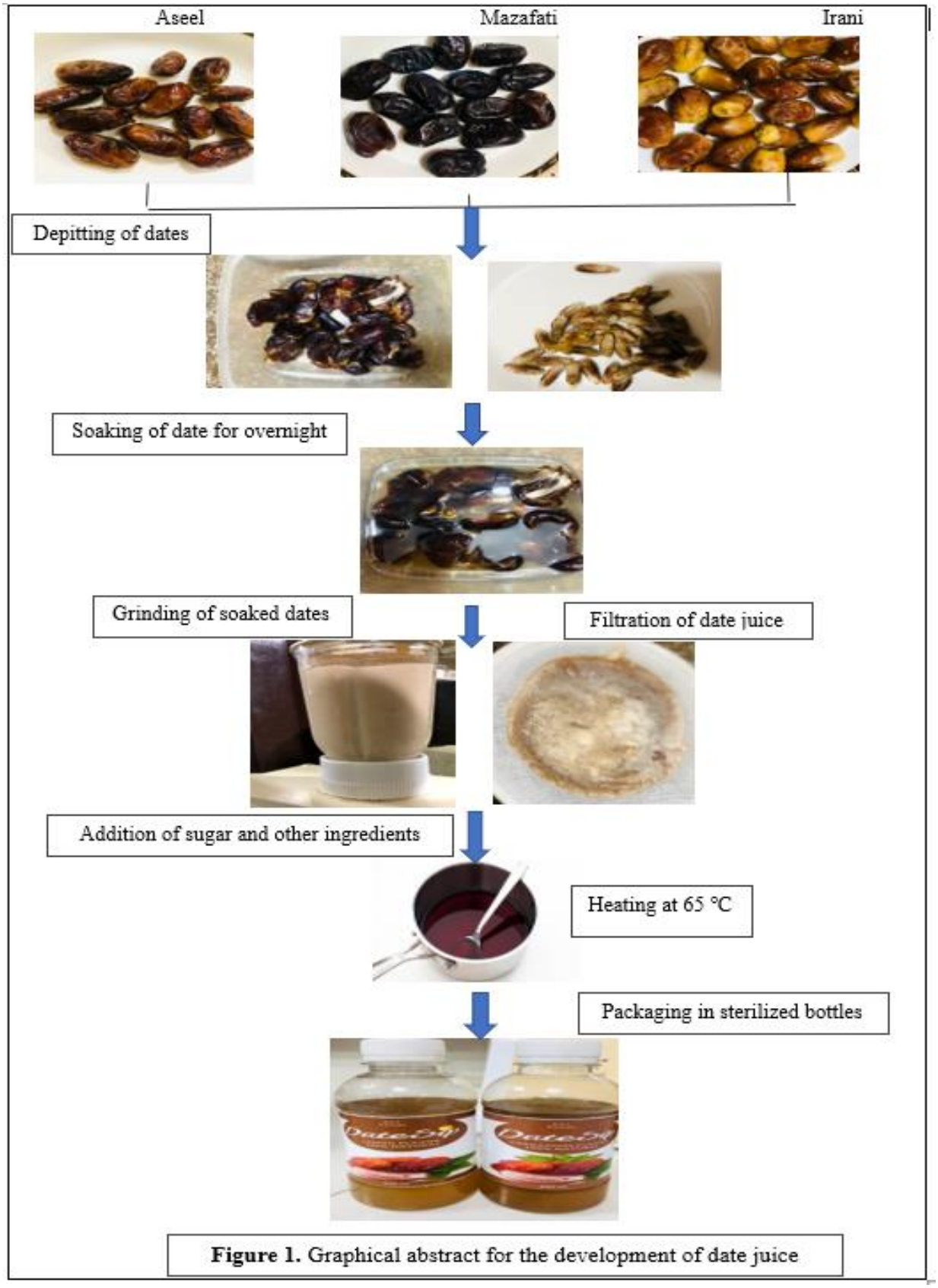


Figure 1. Graphical abstract for the development of date juice

2.4. Physicochemical Analysis of Developed Date Juice

2.4.1. pH

A modified pH meter was used to measure the pH value. Take around 20 mL of sample at 25 °C for this. The data are shown as the means and the associated standard deviation. The measurements were made three times (Cebin et al.,, 2024).

2.4.2. Acidity

The amount of hydrogen ions in a solution, both free and bound in organic acid molecules, is measured by titration acidity. A sample, either liquid or slurry, is put into a beaker and its volume is recorded as part of the titration process. The amount of standard NaOH solution needed to achieve the end point is measured after it is added from a burette that has been calibrated in milliliters. By measuring the quantity of base required to reach a particular endpoint, the total amount of acid present is ascertained. A defined quantity of juice is weighed and then the indicator solution (phenolphthalein) is added. The burette is then filled with the standardized NaOH solution, and the process is repeated until the endpoint is reached. The initial burette reading is subtracted from the final reading to determine the titratable acidity. Typically, the outcome is given as a percentage of a certain acid, like malic or citric acid. An Erlenmeyer flask and a precise quantity of distilled water are needed for the procedure (Cebin et al., 2024).

$$\text{Titratable acidity} = \frac{\text{Vol. of NaOH used} \times 0.1\ \text{NaOH} \times \text{Equivalent weight of the acid)}}{\text{Volume of sample}}$$

2.4.3. Total soluble solids (TSS)

Total soluble solids (TSS) in the juice extracted from immature dates and date juice concentrate (DJC) were measured using a digital refractometer (Model RX 5000) (Kulkarni et al., 2010)

2.4.4. Total dissolved solids (TDS)

A TDS meter is used to measure the conductivity of dissolved materials, such as the sugars and acids in solids. A known weight (10 g) was dissolved in 90 mL of distilled water to produce a 1:10 dilution. The mixture was heated gently while being continuously agitated to ensure complete dissolution; boiling was avoided to prevent thermal degradation. After cooling to room temperature, the solution was filtered through filter paper to remove any leftover particles. If the sample is in liquid state use direct or to filter it. The clean filtrate was transferred to a sterile beaker, and the total dissolved solids (TDS) were measured using a calibrated digital TDS meter. After the probe of the TDS meter stabilized after being immersed in the solution, the reading was recorded. The final TDS value of the first jelly sample was multiplied by the resultant measurement. The final TDS value of the original sample was obtained by multiplying the resultant measurement by the dilution factor 10 if it was diluted. (Adjovu et al., 2023).

2.4.5. Total plate count

The standard plate count was conducted using the previously stated methodology. Prepare the media for the plate count by using 2.8g of nutrient agar to make 100 mL of final volume. Place it in the autoclave for 2 hrs. It is necessary to utilize culture medium that are suitable for the development of all desired or likely microorganisms in the material. Before distributing the diluted sample, the medium must be adequately cemented. This can be accomplished using a new type of diluted samples or a pilot test. A solid or semisolid sample must be emulsified and then serially diluted in order to reduce the microbial load to the permitted level. The sample (0.1 to 0.2 mL) is evenly spread throughout the surface of the solidified agar medium after being pipetted over its center. After opening the Petri plate's lid, use a calibrated pipette or micro-pipette to distribute 0.1 mL of the diluted sample in the middle of the plate. A sterile, bent glass rod should be used to disperse the sample uniformly around the plate. The plates are then incubated under optimal conditions, and the number of colonies is counted (Shanta et al., 2021). After the agar hardened, the plates were inverted and placed in an incubator set to 37 °C for 24 hours. The 0–300 colony plates were selected for counting when the plates were taken out of the incubator after incubation. Colonies were counted using a colony counter (Shanta et al., 2021).

2.5.2.4.5. Color analysis

A digital colorimeter (tristimulus color machine) with a calibrated CIE lab color scale (Hunter, Lab Scan XE, Reston, VA) was used to measure the color of various samples. L, a*, and b* were used to measure the gummy candy's color characteristics. The luminance or brightness component is indicated by the L* value, which ranges from 0 (black) to 100 (white) (Roudbari et al., 2024).

2.6.2.4.6. DPPH (2,2-Diphenyl-1-picrylhydrazyl) Radical Scavenging Assay

The 2,2, diphenyl-2-picryl-hydrazyl (DPPH) method was used to measure antioxidant activity. 1.95 mL of DPPH solution (6×10^{-5} M) diluted in methanol was incubated with 50 µl of the extract in multiple concentrations. The absorbance of the combination was measured at 515 nm, and the efficient concentration (EC50), a measure of radical scavenging ability, was the amount of antioxidant needed to lower the initial DPPH concentration by 50% (Saleh et al., 2011).

2.6.7. Total Phenolic Content (TPC)

Total phenolic content of the carrot pomace jam was determined using the method. In a 5 mL tube, 20 µL of a 2 mg/mL extract was mixed with 2 mL of distilled water and 0.2 mL of Folin-Ciocalteu reagent. After 3 minutes, 1 mL of 20% sodium carbonate solution was added. The mixture was incubated for 20 minutes, and absorbance was measured at 765 nm using a spectrophotometer. Total phenolic content was calculated using a gallic acid standard curve and expressed in mg GAE/g (Saleh et al., 2011).

2.7. Sensory evaluation

Sensory evaluation: A group of nine judges evaluated the ready-to-serve beverage created from DJC based on its color, flavor, and overall quality using Hedonic. On this scale, 1-2 means very poor, 3-4 is poor, 5-6 acceptable, 7-8 is good, and 9 is very good. The panelist used 9-point hedonic scale, which went from least favored 1 to most wanted 9, to assess the sensory qualities of the date juice samples. Each participant was given the items to evaluate their quality and award scores based on their color, flavor, and general acceptance. Using a sensory evaluation approach, the study assessed juices based on their acceptability, flavor, color, and scent (Kulkarni et al., 2010).

2.8. *Statistical analysis*

All the data was obtained in triplicate presenting mean and standard deviation value was applied to check the level of descriptive analysis (Montgomery, 2017).

3. Results and Discussions

3.1. pH of juice

Potassium, one of the most prevalent mineral molecules in dates (Ibrahim et al., 2001; Mohamed, 2000), may raise pH, which would explain this. Second, pectinase would be quickly deactivated by high-temperature extraction, producing an extract with a higher pH. The juice would become less acidic and have a higher pH as a result of the increasing temperature causing the loss of carbon dioxide and volatile acids (Kadlezir et al., 2024).

The pH values of the three date juice samples in this study varied significantly, as shown in graph S_2 (Mazafati) had the highest pH at 5.83±0.01 followed by S_1 Irani at 5.72±0.01, and Aseel had the lowest pH at 5.44±0.02; the one-way ANOVA results show a statistically significant difference between the samples, suggesting that the type of date used had a significant impact on this pH. It is possible that the natural sugar content of the dates and the fruit's lower acid content are the causes of Mazafati S_2 higher pH. A lower pH level can aid in extending shelf life and preventing microbial development. However, an extremely low pH might also result in an excessively sour flavour characteristic that customers could find unacceptable (Feszterová et al., 2023).

However, dates with the lowest pH value, such as Aseel S_3, may have a less effective buffering ability or a higher content of organic acids. The study also showed that the procedure of cultivation, surroundings variables, and processing conditions all affect pH. For

instance, it has been noted that softer, more developed fruits typically have higher pH values and tend to shed their acidity as they ripen. They also found that juices with lower pH showed better antioxidant retention and longer shelf life. These findings provide more evidence that pH is crucial for maintaining the nutritional value of juices as well as for ensuring their safety (Feszterová et al., 2023).

3.2. Titratable Acidity

Titratable acidity of date juice significantly impact its flavor profile ad over all acceptability. The organic acid such as the malic acid and citric acid are primary responsible for the acidity as they interact with the pH level to affect the sourness perception and consumer per reference. Higher acidity level can increase the sourness which may be desirable in some products while the lower acidity level may appeal to consumers who like sweet flavors (Leahu et al., 2013).

According to the ANOVA result, S_1 in Irani had the greatest acidity (0.248± 0.0010), followed by Mazafati S_2 (0.195±0.001), while in Aseel S_3 had the lowest acidity (0.136 ± 0.002^b). There was a statistically significant difference between these treatments. Because S_3 contains more natural organic acids like citric and melic acid, soft and fresh dates have a greater acidity (Souli et al., 2016).

Aseel dates are more fibrous and drier, they could have less of these acids, which could lead to a lower acidity level. The variations in climatic conditions and date compositions throughout harvest and maturity level account for the variation in these titratable acidities. Juices with a greater acidity level are more shelf-stable because they are less susceptible to microbial infection and spoiling (Humayun et al., 2014).

However, too much acidity might ruin the juice's flavor character and render it sour to certain customers. On the other hand, less acidity would result in a sweeter profile, but it would need more preservation to stop microbiological to people who like mild flavor development investigated a variety of tropical fruit juices and discovered that the titratable acidity varied depending on the fruit's maturity stage. It is stated that juices with high acidity, such S_1 Irani, would be more suited for goods with a longer shelf life. S_3 Aseel lower acidity may make it more palatable (Souli et al., 2016).

3.3. Total soluble solids

The number of sugars and soluble materials in the juice has a direct impact on its sweetness, calorie content, and flavor, as shown by the total soluble solids measured by brix. According to this study, there were notable differences in TSS content across the treatments. Table Indicates that the P value is 0.000. S_1 Irani recorded the highest TSS value at 17.5 ±0.24, followed by S_2 Mazafati at 14.3 ±0.24, and S_3 Aseel at 10.4 ±0.28.

The amount of sugar has a significant impact on the TSS difference. Because Aseel Dates are naturally dried, they contain less sugars that may be extracted, which may lead to a lower TSS score. Irani dates, are well-known for having a larger sugar content and more carbs, but they also have a higher TSS level. TSS can be significantly impacted by the maturity stage since mature fruits have a greater TSS content and a comparatively higher sugar concentration (Ikegaya et al., 2019).

3.4.Total dissolved solids (TDS)

The ANOVA results of TDS state that there is statistically insignificant difference between the three treatments. This implies that the difference between TDS values of the various juices of dates was not significant. The greatest value of TDS was found in S_2 (Mazafati dates) which had a level of 25.6±0.24 ppm, S1 (Irani dates) is followed with a constitution of 25.3±0.16 ppm and lowest value occurred in S_3 (Aseel dates) with a content of 25.0±0.16 ppm. The same superscript letter used in all of the treatments and this strengthens the conclusion that no significant differences in the values of TDS were noted in the different treatments.

TDS of several beverages made of different fruit varieties with distinct origin did not show any significant difference in the fruit origin as the only variable. The differences between

date varieties resulted in a small difference in the sugar content and minerals, but the TDS were in the close range, and the alteration was insignificant (Nadir et al., 2017).
The existing literature helps to point to the validity of the current findings, which allow assuming that the type of a cultivar might not play any significant role in the total dissolution of solids in juice products when processed under similar conditions (Adjovu et al., 2023). Constant TDS levels among treatments indicate the same solid extraction and same quality levels. Because TDS impacts on taste and osmotic properties, product consistency is facilitated by keeping the same values of TDS (Salama et al., 2020).

3.5. DPPH (2,2-Diphenyl-1-picrylhydrazyl) Radical Scavenging Assay

A popular method for assessing an antioxidant's capacity to scavenge free radicals is the DPPH radical scavenging test. IC50, or the inhibitory concentration at which 50% of DPPH radicals were scavenged, was used to illustrate the antioxidant properties of various juices (Adjovu et al., 2023).
The different juices DPPH radical scavenging activities varied greatly, with values ranging from 7.14 to 11.22 µg/ml. The antioxidant activity of the three date types under study was evaluated using the DPPH radical scavenging assay: Irani, Aseel, and Mazafati. Compounds' ability to scavenge free radicals is measured by this experiment; higher antioxidant activity is indicated by lower EC_{50} values. With an EC_{50} value of 70 ± 0.03 mg/mL, Mazafati had the highest antioxidant capacity according to the results. Irani and Aseel came in second and third, respectively, at 80 ± 0.02 and 90 ± 0.01 mg/mL (Saleh et al., 2011).
The other studies shown the similar findings where the dates verities such as ajwa. Among the several types, Ajwa has demonstrated the strongest antioxidant activity. The kinetic behavior of both aqueous and alcohol extracts of Ajwa was assessed at varying doses. Furthermore, water has a higher antioxidant capacity than alcohol; the higher the antioxidant capacity, the lower the EC50. ANOVA analysis, however, revealed no discernible differences between the Sukkari variety's extracts (kamiloglu at.al., 2019).

3.6. Total Phenolic Content (TPC)

Flavonoids, and more especially flavanols, have been shown to protect against cancer and heart disease. Therefore, using HPLC analysis, three date types' catechin was identified in this study. Nonetheless, Aseel and had substantially identical amounts of catechin (Saleh et al., 2011).
These results are consistent with other finding studies who reported that Khalas dates had a much lower catechin concentration than the latter types (5 mg/kg), whereas Sukkari and Ajwa had significantly equal amounts (7.50 and 7.30 mg/kg) (Saleh et al., 2011).
Because of its increased moisture and sugar content, which would dilute the concentration of phenolic chemicals, Mazafati has a lower phenolic content (6.10 ± 0.40 mg/100g). These findings corroborate those who found that the concentrations of polyphenols in soft, high-moisture dates are comparatively lower than those in drier dates. Date juice with high TPC can provide antioxidant benefits, reducing the risk of chronic diseases. Phenolic compounds can also contribute to the flavor, color, and astringency of the juice (Lee et al., 2018).

3.7. Total plate count TPC

However, fruit juices' nutritionally rich ingredients can operate as an excellent medium for microbial development and a vehicle for food-borne diseases when proper production methods are not followed. Damaged surfaces that develop during growth or harvesting, such as punctures, wounds, cuts, and splits, might be one potential avenue via which pathogenic organisms can enter fruits (Jbara et al., 2024).
The statistical P-value and F-value of the date juice-treated samples showed a significant difference in the TPC test. However, it demonstrates that there is a significant difference ($P<0.05$) between the therapies. The treatment S_3 (Aseel dates) recorded the highest microbial load with 6.0±0.40 log CFU/mL and S_1 (Mazafati dates) 5.0±0.41 log CFU/mL and (Irani dates) the lowest TPC with 4.1±0.61 log CFU/mL. The statistical grouping is also confirmed by superscript letters where S_3 is significant to S_1 and S_2 is marginally significant. This

indicates that the quality of the microorganisms of the juice depends on the date of which they are formulated.

The same has been recorded by other published studies. The microbial counts of assorted Irani date cultivars and it was observed that TPC differed according to the sugar and moisture content of fruit with higher counts being more prevalent in varieties that are more prone to perish or being less firm in nature (Sarhadi et al., 2019).

The microbial load in date-based products is commonly cultivar dependent with some cultivars being more susceptible towards microbial activity since high nutrient contents and moisture has facilitated microbial growth in them (Jbara et al., 2024). These results correlate with the prevalent findings, in which Aseel dates may have served a better growth medium to microbial growth relative to Irani and Mazafati dates. They discovered that post-harvest handling and storage had a greater impact on the microbial burden than the fruit variety itself (Roobab et al., 2022)

Table 3. mean for analysis of the nutrient dense date juice

Treatments	pH	Acidity	TSS content %	TDS	DPPH
S_1	5.72 ± 0.01^{b}	0.248 ± 0.001^{a}	17.5 ± 0.24^{a}	25.3 ± 0.16^{a}	80 ± 0.02^{a}
S_2	5.83 ± 0.01^{a}	0.195 ± 0.001^{c}	14.3 ± 0.24^{b}	25.6 ± 0.24^{a}	70 ± 0.03^{b}
S_3	5.44 ± 0.02^{c}	0.136 ± 0.002^{b}	10.4 ± 0.28^{c}	25.0 ± 0.16^{a}	90 ± 0.01^{c}

Table 4. Mean for analysis of nutrient dense date juice

Treatments	Total phenolic content (mg GAE/100g)	TPC (log CFU/mL)
S_1	6.80 ± 0.20^{ab}	4.1 ± 0.61^{b}
S_2	6.10 ± 0.40^{b}	5.0 ± 0.41^{ab}
S_3	7.20 ± 0.60^{a}	6.0 ± 0.40^{a}

3.8. Color assessment

Date juice's hue is a crucial quality factor that might influence how customers accept and see the product. The type of dates used, the way they are processed, and the amount of liquid they contain can all affect the color of date juice. Generally speaking, date juice can have different brightness, saturation, and tone levels, and range in color from light amber to dark brown (Lee et al., 2018).

According to the ANOVA results, the treatments significantly affected the date juice's color properties. The lightness of the juice was significantly impacted by the treatments, as indicated by the ($P<0.05$) for L (lightness). A highly significant influence on the red-green color dimension is indicated by the ($P<0.05$) for a (red-green light). Furthermore, a study was conducted by Kamiloglu et al. (2019) Nonetheless, the yellow-blue color dimension's ($P>0.05$) for b suggests that there isn't any compelling evidence of an effect.

Another study on the rehydrated date juice was conducted by by Riquelme et al. (2015) stated as its prior to grinding, the hue of the freeze-dried sample was assessed. Six distinct sites that are appropriate for measuring solid materials were utilized to measure the dried sample in chunks prior to grinding utilizing a tiny viewing area port. The color of the fine-particle date powder was then measured by pouring the milled sample (about 10 g) onto a petri plate. The hue was then measured using rehydrated date juice that had been finely powdered. A typical clear glass cup with a sample depth of 88 mm was filled with freshly made rehydrated

date juice, and at least three duplicates were covered with a black and white cover lid. Additionally, the opacity % was computed.

The study's findings demonstrated that the treatments significantly affected the date juice's color parameters, especially its brightness and reddish-green hue. One significant quality factor that may influence consumer acceptability and impression of the product is the color of the date juice. According to Kamiloglu et al. (2019), variations in the a* and b* values across different types of juice were associated with the pigment content, including carotenoids and anthocyanins. Fruit cultivar and processing have an impact on these pigments. This demonstrates how crucial it is to enhance processing settings in order to preserve color quality and boost consumer appeal.

Table 5. Color assessment of nutrient dense date juice

Treatments	L	a*	b*
S_1	48.4 ± 0.2^b	45.4 ± 0.21^a	1.2 ± 0.16^a
S_2	49.7 ± 0.16^a	46.7 ± 0.16^b	1.2 ± 0.02^a
S_3	48.6 ± 1.06^b	44.5 ± 2.6^c	1.2 ± 0.16^a

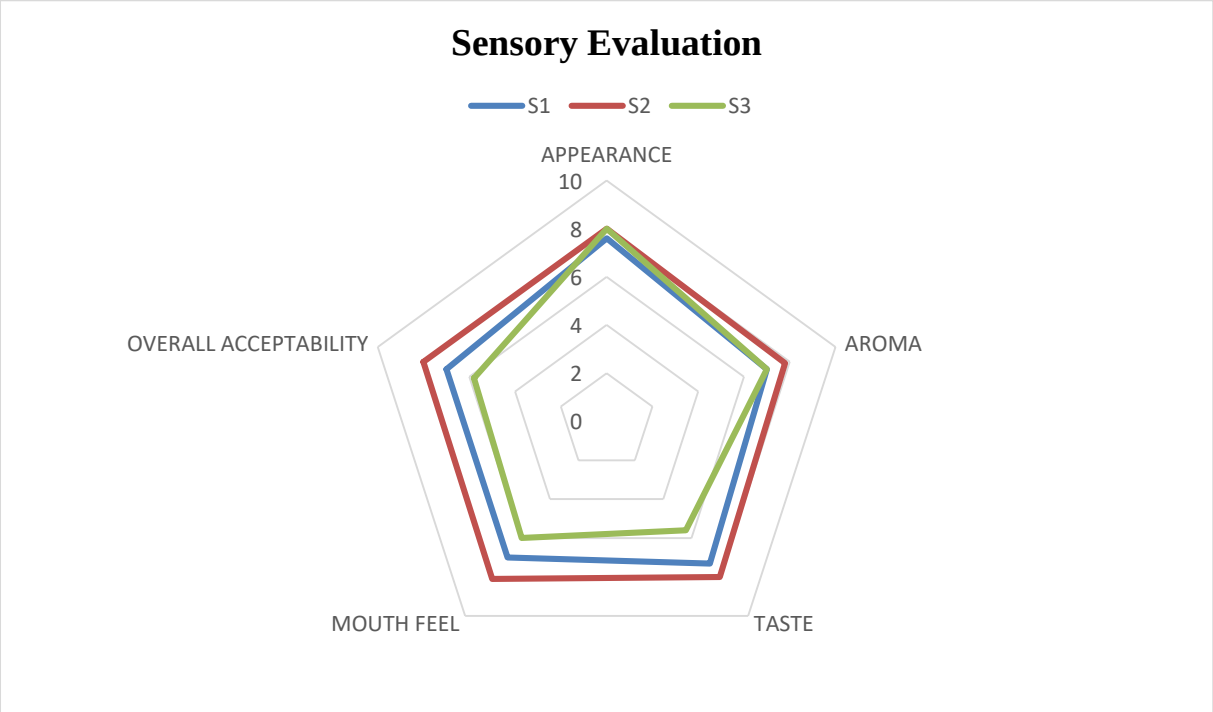
3.9. Sensory Evaluation

According to Offia-Olua and Ekwunife (2015), acidity enhances food's palatability and nutritional value, which affects the goods' flavor, color, stability, and shelf life. The goods' sweetness, consistency, and quality were enhanced by the greater TSS and higher acidity in S_1 and S_2, which may have affected their general appeal.

Table 3 showed that samples S_1 S_2 outperformed control and other samples in terms of color by a substantial ($P<0.05$) margin. However, samples S_1, S_2, and S_2 did not differ significantly ($P<0.05$) in their analysis. Samples S_1 of concentrated date palm juice received higher scores for sweetness acceptance than the other samples. After sample S_1, samples S_2 and S_3 had the lowest acceptance scores for sweetness. The sample S_2 scored considerably ($P<0.05$) higher than the other concentrated date palm juice in terms of overall acceptability.

Studies have demonstrated the importance of sensory evaluation in assessing the acceptability and quality of juice products. According to a study by Shanta et al. (2021), for instance, sensory evaluation can be used to choose the date juice variety that is most acceptable based on its sensory qualities. To evaluate and quantify the preference differences, the data was statistically analyzed for variance. The tests used for sensory evaluation were conducted in accordance with recognized ethical guidelines. Prior to the trial, each participant provided their agreement while following all guidelines (Shanta et al., 2021).

The study's findings demonstrated that the treatments significantly affected date juice's taste, texture, and general acceptance, among other sensory qualities. Additionally, the results demonstrated that (S_2) was the most chosen therapy among the panelists, as evidenced by its highest overall acceptability score. The results of this study provide useful information regarding the acceptance and preferences of different date juice products and may be utilized to develop new products that meet customer preferences.



4. Conclusion

The study concluded that sample S_2 the most acceptable formulation for date juice, with optimal physicochemical and sensory attributes. The statistical analysis of data for sensory evaluation of concentrated juice revealed that the juice sample containing was the best, securing a higher score for color, flavor, and overall acceptability. The physical and chemical properties of this sample were also better than the others. The study provides valuable insights into the development of sustainable and nutrient-dense date juice products. This study was a little attempt to identify some other commercial uses for date palm sap, focused on the production of beverages, in order to encourage farmers to increase date palm commercial agriculture, which is declining daily. Other juice-based products can be developed with more research. In conclusion, this study demonstrated the importance of treatment on the quality of date juice, and the results can be used to develop high-quality date juice products that meet consumer preferences.

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