STUDYING THE CHEMICAL AND PHYSICAL PROPERTIES FOR THE JUJUBE PLANT(ZIZIPHUS SPINA-CHRISTI) FRUIT MOLASSES.

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Abstract

This study evaluated the quality of jujube (Nabq) fruit molasses produced via three distinct thermal evaporation and concentration techniques: Sample 1 (oven - concentrated at 50°C), Sample 2 (vacuum - concentrated at 70°C), and Sample 3 (direct heat - concentrated at 100°C). The findings demonstrate that the low temperature oven concentration method at 50 °C (Sample 1) was the most efficient and superior manufacturing model for producing jujube molasses. This technique achieved an optimal equilibrium by reducing the moisture content to 32% while increasing total soluble solids and total sugars to 68% and 48%, respectively. Furthermore, it recorded the highest viscosity (560 cP) and total protein content (6.56%), owing to the preservation of colloidal compounds and their protection against thermal denaturation and Maillard browning reactions, compared to vacuum concentration at 70°C (Sample 2) and direct heating at 100°C (Sample 3). The low - temperature treatments (Sample 1 and 2) also maintained the stability of the dry matter and mineral content of the fruits, which proved to be rich in essential elements, with potassium emerging as the element with the highest concentration (5,112 ppm in Sample 1), followed by calcium and iron, which decreased in the third Sample. Conversely, sodium (Na) exhibited an opposite trend, reaching its highest level in Sample 3 (298.1 ppm). Regarding vitamin content, the results revealed severe degradation and complete depletion of certain vitamins in Sample 3, such as vitamins A, K, and B9, because of heat-induced lipid oxidation. Vitamin C content dropped drastically from (209.607 to 31.004) ppm in Sample 1 and 3,respectively as a result of its high thermal sensitivity, whereas vitamin B3 exhibited remarkable stability. In terms of sensory evaluation, all Samples showed high consumer preference and acceptance without obvious processing defects. Sample 1 was best characterized by its texture, Sample 2 by its flavor, and Sample 3 by its light color, with Sample 1 receiving the highest rating in general acceptability (24 points). Ultimately, these results confirm that jujube fruit molasses processed under low-temperature conditions represents an excellent dietary source with high bio-nutritional value.

Keywords: ziziphus spina- Christi, jujube fruit molasses, physicochemical properties.

Introduction

The jujube tree (*Ziziphus spina- Christi)*, commonly known as Christ thorn jujube, is a hardy evergreen or deciduous tree belonging to the Rhamnaceae family This family comprises approximately 55 genera and over 950 species ,with the genus *Ziziphus* being one of its most prominent taxa, encompassing around 100 to 170 species distributed across tropical, subtropical, and warm temperate regions worldwide [11,13,15,29], its native habitat extends from southern Europe, the Himalayas, and northern China to the Mediterranean basin, North Africa such as Sudan, to the Middle East, with notable prevalence in Iraq, the United Arab Emirates, and the Arabian Peninsula, in Iraq, Studies

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indicate the widespread distribution of four distinct species : *Z. spina Christi* -, *Z. Mauritiana ,Z. nummularia and Z. jujube* (4, 8). The fruits are known locally as Nabq ,are drupes featuring fleshy exocarp that encloses a single central woody core. A very rare variety exists which is devoid of this woody core and contains two-minute nuclei instead. The fruit shape varies from spherical to oval, with diameters ranging 1.5 cm (resembling a cherry) up to 5 cm depending on the variety. The fruit color initiates as green during the early developmental stage, transition to yellow upon full growth, and finally turns red to reddish-brown at complete maturity.

Concurrently, the pulp flavor shifts from a juicy, astringent taste before ripening to a delicious aromatic profile ranging from sour to sweet, these fruits are traditionally consumed fresh and are characterized by a high carbohydrates content, dominated by glucose and sucrose with lower percentages of fructose and xylose, Additionally, they are rich in vitamins (A, B, and C) and essential minerals such as calcium, potassium, phosphorus, and iron. Notably, jujube fruits possess a higher protein content compared to other ripe pomes, providing approximately 20.9 calories per 100 g. which qualifies them for use in the confectionery industry [2, 12 ,16] .The aim of this study was to utilize ripe jujube fruits widely distributed in Iraq to manufacture a high-value food product by converting them into Jujube Fruits molasses, Three distinct thermal concentration methods were employed and compared to evaluate their impacts on the chemical, physical and sensory properties of the final product .

Material and Methods1

Collection of Jujube Fruits (Nabq)

Fully mature Jujube fruits were harvested after from trees distributed across the Baghdad governorate during the 2026 agricultural season. Following harvest, the fruit were sorted, washed thoroughly with running and distilled water to remove extraneous matter, and subsequently air-dried to prepare them for downstream analyses.

Manufacturing of Jujube Fruits Molasses (Dibs Al-Nabq)

The production of Jujube Fruits molasses was carried out according to the methodology described by [27]. A minimum of 2 kg of pitted jujube fruits was blended with water at a ratio of 1:3 (w/w) in metallic pots. The mixture was heated to extract the juice, which was subsequently concentrated using three comparative thermal techniques to yield three distinct molasses Samples. The first Sample was concentrated inside an oven at 50 °C. The second Sample was concentrated under low-temperature vacuum conditions at 70 °C. The third Sample was concentrated via direct heat at 100 °C accompanied by continuous stirring. The evaporation processes were sustained until the desired concentration level was achieved.

Chemical and Physical Analyses:

Moisture Determination: The percentage of moisture content in the Samples was determined in accordance with the [9] standard method.

Ash Determination: The total ash percentage was evaluated based on the standard procedure approved by the [9]

Crude Fiber Determination: The percentage of crude fiber in the Samples was quantified following the standard method outlined by [19].

Fat Determination: Total fat content was determined according to the procedures described by the [9].

Protein Determination: Total protein content in the Samples was determined using

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the Micro-Kjeldahl apparatus, following the method described by [28].

Total Sugars Determination: Samples were prepared and analyzed for total sugar content based on the methodology proposed by [3].

Total Soluble Solids (TSS): The percentage of total soluble solids was measured using a digital refractometer, following the standard method of the [9].

Viscosity Measurement: The viscosity of the Samples was measured using a viscometer at the Directorate of Environment and Water / Center of Environment, Water, and Renewable Energy Research and Technology.

pH Measurement: The hydrogen ion concentration (pH) of the jujube molasses was determined using a pH meter supplied by HANNA Instruments.

Estimation of Vitamins:

The qualitative and quantitative analysis of vitamins was conducted at the Directorate of Environment and Water using High-Performance Liquid Chromatography (HPLC) on a system manufactured by SYKAM (Germany).

Determination of Water-Soluble Vitamins:

A 10 g portion of the dried Sample was taken, to which 100 mL of chilled distilled water was added—or 100 mL of a 3% meta-phosphoric acid solution if ascorbic acid (Vitamin C) analysis was intended. It is mixed for 5-10 minutes and kept in the dark at a temperature of (4-10°C) for -30-60 minutes with intermittent stirring, after which the extract is filtered or centrifugalized at 4000-5000 rpm for 10 minutes. The supernatant containing the water-soluble vitamins was collected and directly used for analysis. Vitamin C quantification was carried out using HPLC-UV or via titration with 2,6-dichlorophenolindophenol (D CPIP). Vitamin B complex components were quantified via HPLC equipped with either a UV or fluorescence detector, depending on the targeted vitamin type [10].

Determination of Fat-Soluble Vitamins:

According to the method of [26], the Sample was initially dried at a temperature ranging between 40–50 °C. A 5 g aliquot of the dried Sample was extracted by adding 50 mL of 95% ethanol, or an ethanol : hexane mixture (1:1, v/v). The extraction was performed under continuous stirring for 1–2 hours in the absence of light, followed by phase separation via filtration or centrifugation. To ensure maximum extraction efficiency, the process was repeated on the solid residue once or twice. After pooling the filtrates, the solvent was evaporated under reduced pressure using a rotary evaporator at a temperature not exceeding 40 °C. The dry residue was then re-dissolved in a specific volume of methanol or ethanol prior to HPLC analysis .

Determination of Mineral Elements:

For the determination of mineral elements in molasses Samples, an Atomic Absorption Spectrophotometer (SHIMADZU, Japan) was used, belonging to the Center for Environmental, Water, and Renewable Energy Research and Technology at the Commission of Scientific Research.

Preparation of Standard Solutions:

Original standard solution was (1000µg/ml in 2% HNO3) for interested elements. Four standard solutions were prepared by dilution from original standard stock solution using general dilution law (C1 V1 = C2 V2). It must prepare a series of concentrations from the highest one reaching the values required for calibration curve performs. Series of

concentrations which were prepared as follows -:

1000)µg/ml → 100µg/ml → 10µg/ml → prepare the needed concentration of any element.)

Standard Curve Perform

Four or five standard solutions of interested elements were prepared as previously mentioned and described for the calibration curve. The concentrations of these elements in Samples were measured directly and continuously beyond measuring standard solutions depending on the calibration curve.

Sample Preparation: Digestion of plant extract

1.Weigh each Sample (2.0 g, dried at 105°C and ground) into a clean, dry, numbered conical flask.

2.Weigh standard and duplicate Samples and leave empty flasks at random intervals for blank determinations.

3.Add nitric acid (40 ml) to each flask, cover with watch glass and set aside in a fume cupboard overnight.

.4Place covered flasks on a hotplate and warm gently until frothing ceases.

5.Allow the flasks to cool and add Per chloric acid (3 ml).

6.Replace the flasks on the hotplate, remove the covers and heat cautiously just to dryness.

7. Allow the flasks to cool, add hydrochloric Acid (2.0 ml) and deionized water (2-3 ml) to each flask. Heat it gently to dissolve the residue.

8. Transfer the cooled solutions either to graduated flasks or to graduated test tubes.

9. Dilute volume with water and use the solutions for atomic absorption analysis**.**

Determination of Elements:

The concentrations of calcium (Ca), iron (Fe), sodium (Na), potassium (K), and magnesium (Mg) and Zinc (Zn) in the Samples were determined directly and sequentially, following the measurement of their respective standard solutions to establish calibration curves. Four standard solutions were prepared at concentrations of 1, 2, 3, and 4 mg/L for Ca and Fe, and 0.5, 1, 1.5, and 2 mg/L for zinc (Zn), Na, and K. For Mg, five standard solutions were prepared at concentrations of 2, 4, 6, 8, and 10 mg/L.

Sensory Evaluation of Jujube Molasses

The sensory evaluation of the jujube molasses Samples was conducted based on four core quality attributes: texture (consistency), flavor, color, and overall acceptability. The evaluation was carried out by a panel of ten expert judges from the College of Food Sciences at Al-Qasim Green University. A maximum score of 25 points was allocated to each sensory attribute, and the Samples were rated according to the standard evaluation form approved by [24].

RESULTS AND DISCUSSION

The results presented in Table (1) significant variations in physical, chemical and rheological properties among the three Samples of jujube molasses, reflecting the direct impact of the evaporation and concentration methods, The oven concentration method at 50°C (Sample 1), identified as the optimal manufacturing model, excelled by reducing the moisture content to 32% while increasing total soluble solids (TSS) Brix and total sugars to 68% and 48% respectively. This efficiency is attributed to the prolonged exposure to low temperature heating preventing Thermal

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Degradation compared to the vacuum concentrated Sample at 70°C (Sample 2) and the direct heat concentrated Sample at 100°C(Sample 3) both of which exhibited 66% total solids and 34% moisture, these finding align with the observations of [1] which state that molasses produced via modern, controlled methods is characterized by high total solids and low moisture content. in this study, further concentration was restricted to avoid adverse effects on sensory attributes, such as flavor and taste, could arise from enhanced sugar caramelization. Consequently, Sample 1 achieved a superior and optimal equilibrium.

Furthermore, the high viscosity (560 cP) of Sample 1 demonstrates the success of low temperature processing in maintaining the integrity of colloidal binding compounds, such as pectin and proteins, This Sample recorded the highest total protein content (6.56%) due to its protection against thermal denaturing and consumption in non-enzymatic browning reactions (Maillard reaction) associated with elevated temperature, Conversely, the other Samples exhibited a significant reduction in protein content due to the thermal degradation of amino acids, Interestingly, Sample 3 achieved a relatively higher viscosity (480 cP) than the Sample 2 (420 cP) despite having identical moisture levels; this was due to Partial thermal condensation induced by direct cooking heat (100°C), which also reduced its pH directly to 4.14 compared to the oven dried Sample [4.24], generating some free organic acids.

From a nutritional perspective, total sugars constituted the primary component of the product, representing over 70% of the total dissolved solids. This is consistent with previous studies[7,11,22] highlighting the richness of jujube fruits in sugars, acting synergistically with the safe acidic pH, serve as a vital line of defense for the microbiological preservation of molasses by increasing osmotic pressure and reducing water activity available to microbes. Meanwhile, the percentages of ash (ranging between 1.89% and 2.18%), fiber and lipids remained stable and closely comparable across all treatment, constant as they are thermally stable compounds that reflect the inherent mineral and nutritional richness of the raw jujube fruits

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Table 1. chemical and physical composition in the three Samples of jujube fruit molasses

Sample NO.	Moisture%	Ash%	Crude% Fiber	Fat%	Protein %	Total Sugar %	TSS %	pHالـ	Viscosity CP
1	32	1.89	1.81	0.69	6.56	48	68	4.24	560
2	34	2.18	1.88	0.79	4.71	46	66	4.20	420
3	34	1.99	1.85	0.77	4.65	46	66	4.14	480

The results presented in Table (2) outline the mineral composition of the jujube molasses Samples, demonstrating that the jujube fruits are inherently rich in essential minerals, which aligns with the finding of [7], Furthermore, a significant manufacturing induced variation was observed, reflecting the profound impact of evaporation and concentration methods on the final mineral concentrations.

ISSN 2072-3857

Potassium (K) emerged as the most abundant element across all treatments, peaking significantly in Sample 1 (oven concentrated at 50°C) at 5112 ppm, followed by Sample 2 (vacuum concentrated at 70°C) at 4720 ppm, whereas it sharply decreased to 2149 ppm in Sample 3 (direct heat at 100°C). The superiority of the first and second Samples is attributed to the low temperature and vacuum pressure conditions, which preserve the stability of the dry matter [17]. A similar trend was observed for calcium (Ca) and iron (Fe), where Sample 1 recorded the highest concentration at 105.6 ppm and 31.74 ppm, respectively, while Sample 3 declined to 81.80 ppm of calcium and 14.06 ppm of iron. This reduction suggests that cooking via high direct heat (100°C) may induce the binding of these metallic ions with residual fibers or facilitate their incorporation into complex melanoidins generated by the highly active Maillard and Caramelization reactions under intensive thermal conditions, thereby reducing their detectable free ratio. [20, 25].

Conversely, sodium (Na) exhibited an opposite behavior, where the concentration of free sodium increased as indirect consequence of the reduction in bound water. Meanwhile, magnesium (Mg) and zinc (Zn) levels maintained a remarkable relative stability and convergence among the treatments, with magnesium ranging from 23.76 to 26.86 ppm and zinc between 13.59 and 19.68 ppm. Ultimately, these findings confirm that the low-temperature oven concentration method (50°C) is the most efficient approach for maintaining the mineral integrity and high nutritional value of the molasses. Consequently, jujube fruit molasses can be considered an excellent natural source for nutrient fortification.

Table 2. Mineral Elements content in the three Samples of jujube fruit molasses

Sample NO.	Ca ppm	Fe ppm	K ppm	Mg Ppm	Na ppm	Zn Ppm
1	**105.6**	**31.74**	**5112**	**26.86**	**277.7**	**19.33**
2	**104.5**	**23.15**	**4720**	**22.47**	**31.37**	**13.59**
3	**81.80**	**14.06**	**2149**	**23.76**	**298.1**	**19.68**

The results presented in Table (3) demonstrate significant variations and a gradual decline in vitamins content across the treatments, moving from Sample 1 to Sample 3. Sample 1 retained the highest concentrations of all water and fat-soluble vitamins, followed by Sample 2 exhibited a moderate reduction. In contrast, Sample 3 witnessed severe deterioration, leading to the complete depletion of certain vitamins, namely vitamins B9, A, and K. The drastic reduction of vitamin C, which dropped from 209.607 ppm in Sample 1 to 31.004 ppm in Sample 3, is attributed to its extreme susceptibility to oxidation and thermal processing conditions [14]. Conversely, vitamin B3 exhibited relatively higher stability compared to the other B vitamins across all treatments, owing to its inherent thermal resistance. Furthermore, the sharp decline and total disappearance of fat-soluble vitamins (A and K) in Sample 3 are directly associated with exposure to high thermal stress,

which triggered lipid oxidation [21]. This oxidative degradation subsequently led to

the complete consumption and destruction of these vitamins. Ultimately, these findings indicate that Sample 1 (oven-concentrated at 50°C) is the most efficient method for preserving the nutritional value and heat- sensitive bioactive compounds whereas Sample 3 sustained the highest percentage of nutrient loss.

Table 3. The vitamins present in the three Samples of jujube fruit molasses

Sample NO.	Vit.B_1 ppm	Vit.B_2 ppm	Vit.B_3 ppm	Vit.B_5 ppm	Vit.B_6 ppm	Vit.B_9 Ppm	Vit.C ppm	Vit.A Ppm	Vit.E ppm	Vit.K ppm
1	0.249	0.306	7.053	1.571	0.540	0.059	209.607	0.269	2.427	0.025
2	0.161	0.233	4.104	0.803	0.411	0.020	125.522	0.153	1.049	0.011
3	0.080	0.077	0.617	0.206	0.089	-	31.004	-	0.063	-

The sensory evaluation results presented in Table (4) demonstrate a high convergence and consistency in acceptance scores across all studied Samples, indicating the absence of any severe adverse effects of the processing treatment on the sensory properties of the product.

Regarding the texture attribute, Sample 1 excelled by scoring the highest rating (22), whereas Samples 2 and 3 exhibited a very slight decrease to (20).This minor decline could be attributed to subtle structural alterations in viscosity or product cohesion induced by thermal treatments. In terms of flavor, Sample 2 received the highest rating (24), followed closely by Sample 3, (23) and Sample 1 (22.6). suggesting that treatments 2 and 3 contributed positively to enhancing the flavor profile due to the concentration of sugars and soluble solids. For the Color attribute, Sample 3 achieved the highest score (24) owing to its lighter molasses coloration compared to the other Samples. Interestingly, this finding contrasts with [5,6,18] results where reported that exposing the fruit juices (such as the Zuhdi date variety) to high thermal treatment (100-120°C) typically induces un undesirable dark coloration. Sample 3 was followed by Sample 2 (23) and then Sample 1 (22.5), reflecting the panelists' distinct preference for the color of the third Sample. For Overall acceptability, Sample 1 recorded the highest score (24), primarily driven by its superior texture quality, while Samples 2 and 3 are followed closely with equal scores of (23.5) due to successful compensation in their flavor and color attributes. Ultimately, these findings confirm that all Samples successfully maintained excellent sensory appeal and very high consumer acceptance without any discernible manufacturing defects.

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Table 4. Sensory evaluation of the jujube fruit molasses Samples

Sample NO.	Texture	Flavor	Color	Overall acceptability
1	22	22.6	22.5	24
2	20	24	23	23.5
3	20	23	24	23.5

Conclusion

This study demonstrates that low-temperature oven concentration at 50°C(Sample 1) is the optimal method for producing high-quality jujube (Nabq) molasses. This technique efficiently preserved the physical, chemical, and nutritional properties of the fruit, recording the highest protein content, viscosity, and essential minerals (potassium, calcium, and iron), while preventing the thermal degradation of sensitive vitamins (A, K, B9, and C) observed at higher temperatures. Furthermore, Sample 1 achieved the highest consumer rating in overall sensory acceptance. Consequently, processing jujube molasses under low-temperature conditions is highly recommended to maximize its bio-nutritional and industrial value.

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