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Design and Building a Date Syrup Extractor and Evaluating It under Different Operating Condition

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ABSTRACT

Dates are one of the most important agricultural products in the world, especially in Iran, and currently, their share in Iran's agricultural production is more than one million tons per year. Due to the lack of attention to by-products and the traditional method of date waste is high in our country due to the lack of attention to by-products and the traditional method of its processing. Therefore, conducting research in the field of preparation and use of products (syrup and liquid sugar) is necessary. In this research, a device for extracting date syrup was designed, built and then evaluated. Temperature, pressure and duration of syrup extraction were the main factors of the experiment. The results showed that all three factors have a significant effect on the output date syrup amount. The most produced date syrup was obtained by using the temperature of 70°C, the pressure of 9 kPa and the operation of the device for 5 h. The amount of date syrup produced by the device was about 23% based on the weight. The amount of produced date syrup increased by 3.8 times compared to the traditional method. The date syrup obtained in this research was compared with traditional syrup in terms of some qualitative and sensory characteristics, such as the percentage of total soluble solids (TSS), acidity, pH, reducing sugars, and overall acceptability of taste. The results of the variance analysis of the data showed that the effect of temperature and pressure factors on some characteristics of the produced syrup was significant.

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INTRODUCTION

Currently, date trees are cultivated in 15 provinces of the country. The cultivated area of palm groves in the country, including scattered trees, is about 270 thousand hectares, of which 54,758 hectares belong to Kerman province (Statistics of the Iran Ministry of Jihad Agriculture 2013).More than 90% of the cultivated area of dates in Kerman province is dedicated to Mazafati variety, which is mainly harvested in wet form and has a special position in terms of domestic consumption (Damankeshan et al., 2022). Dates are one of the most important garden products that have been a natural and valuable food for humans. Dates are called "sweet gold" and the fruit of the tree of hope and life, because they played an important role in feeding people during regional famines (Tang et al., 2013).

Dates are one of the major agricultural products of Iran and about 60% of its dry weight is sugar. The poor quality of about 30% of the dates produced in the country has caused them not to be consumed directly in the market and it is necessary to turn them into valuable products in processing industries. There is a lot of date waste in Iran due to the lack of attention to by-products and the way it is processed (Oladzad et al., 2021). One of the date products is date syrup, which is prepared from the fleshy part of the date and can be used in the production of various sweets and candies. Date syrup is the most common product derived from dates, which is produced by three traditional, semi-industrial and industrial methods: 1- As an accidental side product during the storage of wet bags (especially in the Persian Gulf region).2- At the level of houses and villages extract and boiling the extract. 3- On a semi-industrial and industrial scale. In the first method, whose history dates back to the 17th century, maximum of 6% of date weight, syrup is obtained. The quality of the syrup itself is quite good because it is direct and natural, but its contamination with foreign substances is very high because the product is collected in primitive ways (Siddiq & Greiby, 2013).

To produce date syrup in the traditional way, there are three methods: 1. Boiling (hot method): In this method, the syrup is produced by heating and concentrating the mixture of water and dates in open pots. 2. Using cement ponds (cold method): It is a method that is done by pouring dates in ponds that are 1.5 to 1.5 meters higher than the ground level, and the syrup is extracted due to the force of its weight. This type of syrup is natural and it is called natural date syrup (Ashraf & Hamidi-Esfahani, 2011).These ponds are called Madbase in the local language (Hashempoor, 1999). 3. Production of date syrup by mat method: In some areas in the south of the country, such as Minab, instead of cement ponds, dates are poured into wicker baskets made from date leaves. Due to the pressure of the dates on each other, its syrup comes out from the pores of the mat (Ashraf & Hamidi-Esfahani, 2011).

In the industrial method, grade 2 and 3 dates are used to produce syrup. After being delivered to the factory, the dates are separated and washed with cold water to reduce the microbial load, then the dates are pitted. Then dates are boiled with three times water in a double-walled pot and its pH is adjusted to about 3.5 using citric acid. After that, the desired amount of dates is added to the water and stirred so that the date sugar spreads more and faster inside the water. When the temperature of the mixture reaches about 75 °C and the first boiling bubbles appear, the caps and the remaining foreign materials are separated by the pulper. The resulting mixture is filtered and the obtained extract is concentrated (Al-Shahib & Marshall, 2003).

In date-growing rural areas of the country, primitive and traditional methods are used to prepare natural date syrup. The date syrup produced by these methods is not only not hygienic, but its quantity is also very low. The purpose of this research was to evaluate a syrup extraction machine from Mazafati dates and the effect of temperature, mechanical pressure and date syrup extraction time on the quality of the resulting syrup was investigated and compared.

MATERIALS AND METHODS

A small-scale date juicing machine was built for the use of farmers in date-growing areas of the country. This device included a chassis, cylinder, piston, power source, date and syrup storage tank, strainer, heat source (electric heater) and thermocouple for temperature control (Figure 1).

Figure 1. A picture of date juice extracting machine

In order to extract syrup with this device, Mazafati dates entered the cylindrical chamber from above and heat was transferred to the dates inside the cylindrical chamber through the elements embedded in the device. The heat caused the sap to come out of the date and it passed through the end filter of the cylindrical chamber and was collected in the end tank installed on the base. Simultaneously with the application of heat, pressure was applied to the dates inside the cylindrical chamber by the piston. This pressure was provided by placing different weights on the upper surface of the piston. Variables affecting the juicing of dates that were studied in the experiments, included the temperature inside the cylinder (50, 60 and 70 °C), piston pressure (3, 6 and 9 kPa) and the duration of juicing (3, 4 and 5 h). In each experiment, the mass of extracted sap was measured.

The quality of date syrup obtained from different treatments was evaluated by measuring acidity, pH, percentage of soluble solids and percentage of reducing sugars. The tests were conducted by mixing 25 g of date syrup sample with 100 ml of distilled water, and then filtering the mixture in an Erlenmeyer flask with filter paper. A manual refractometer was used to measure the percentage of soluble solids. In this way, a few drops of the solution were placed on the prism of the device and the corresponding number was read. The amount of acidity was also determined through titration with a normal interest of 0.1 and was calculated as a percentage of citric acid. To determine the pH of date syrup, some of the solution was poured into a small beaker and its pH was measured using a Metrohm 691 digital pH meter. The reducing sugars were also measured by Fehling's method (Golshan Tafti & Fooladi, 2005). Sensory evaluation of date syrup samples was done by 16 evaluators using the hedonic scoring method. The desired sensory attributes included taste (absence of sourness, ripeness, fermentation and moldiness), color (no dark color) and overall acceptability. The evaluation form included 5 points, and the evaluator assigned one of the points for each attribute of the sample. A score of 5 in the relevant form was considered as the highest score (very good), a score of 4 for good quality, a score of 3 for average quality, a score of 2 for poor quality and a score of 1 for bad quality (Basiri, 2022).

The experiments were conducted in the form of a factorial experiment with a randomized complete block design in three replications. Means were compared with Duncan's multiple range test. SAS software version 3.9 was used for data analysis.

RESULTS AND DISCUSSION

The results of the analysis of variance showed that all three factors of temperature, pressure, and duration of juicing and also their mutual effect on the amount of syrup produced are significant at the probability level of 5% (Table 1).

Table 1. The results of the analysis of variance for the amount of juicing of Mazafati dates

Sources Change	Degrees of freedom	ss	Mss	F
Temperature (A)	2	16579.654*	8289.827	201.8263
Pressure (B)	2	46.98944*	49497.235	1205.0724
Time (C)	2	469.40258*	20129.235	490.0715
(AB)	4	3317.901*	829.475	20.1946
(AC)	4	457.449*	112.364	2.7356
(BC)	4	2068.864*	517.216	12.5923
(ABC)	8	099.454*	56.7002	1.3820
Error	54	2218	41.074	
Total error	80	164340.914		
coefficient of variation (CV)		5.89%		

*Significant at the 5% probability level

The comparison of the average data showed that the minimum amount of syrup produced with an average of 42 g/kg of dates corresponds to the lowest temperature (50 ℃), the lowest pressure (3 kPa) and the shortest time (3 h). The maximum amount of extracted syrup with an average of 230 g was related to the highest temperature (70 ℃), and the highest pressure (9 kPa) in the longest period of time (5 h) (Figure 2). However, the increase in temperature increased the effect of other factors in extracting syrup from Mozafati dates. The results of the experiments showed that if a temperature of 40 ℃ is used, the amount of syrup produced is reduced by half. Therefore, production at a temperature below 50 ℃ is not economical. A temperature above 70℃ is not suitable due to the decomposition of sugar, reduction of efficiency, formation of undesirable compounds and production of extra color in date syrup. also reported that increasing the temperature, time and mixing ratio increased the extraction efficiency of Klotte dates (Jahed et al., 2011).

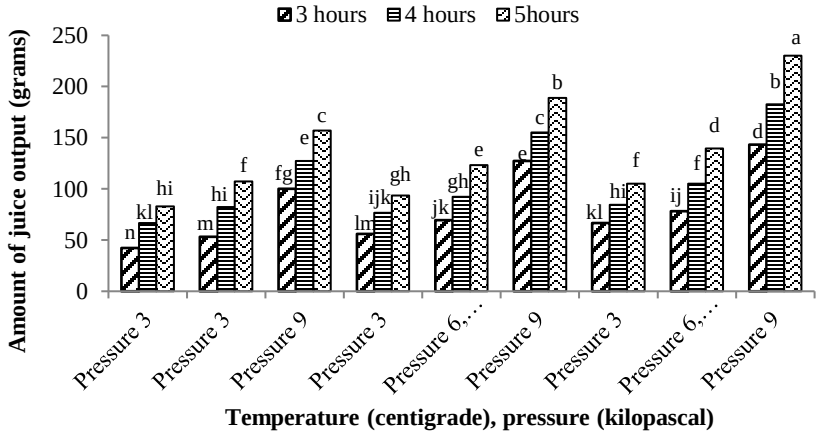

Figure 2. The mutual effect of heat treatment, pressure and time on date sap production

According to Figure 2, it can be seen that by reducing the temperature and increasing the time of applying pressure, the syrup can be produced as well as at high temperatures and time of applying low pressure. For example, the amount of date syrup produced at a temperature of 70 ℃ and a pressure of 9 kPa for a period of 4 h was not significantly different from the amount of syrup of dates produced at a temperature of 60 ℃, a pressure of 9 kPa and a duration of 5 h.

Natural date syrup obtained with different treatments was examined and compared with the control (natural syrup sample) in terms of characteristics such as pH, acidity, percentage of

total soluble solids, percentage of revitalizing sugars and sensory attributes.

Table 2. Variance analysis of date syrup characteristics

Sources Change	Degrees of freedom	BRICS	pH	Pcidity	Regenerating sugars	Sensory attributes
Temperature (A)	3	159.181*	0.469*	0/.08*	616.729*	1.273^{ns}
Pressure (B)	2	162.945*	0.531*	0.017^{ns}	23.424^{ns}	0.335^{ns}
(A*B)	6	169.362*	0.833*	0.024^{ns}	*223.201	*0.799
Error	24	38.283	0.069	0.046	94.979	0.297
Total error	35	-	-	-	-	-
CV%		10.1	4.1	20	6.7	14.5

$^{n.s}$ and * are respectively non-significant and significant at the 5% probability level

The results of the analysis of variance showed that the temperature had a significant effect on the studied traits except for sensory traits at a probability level of 5% compared to the control (Table 2). Also, the effect of pressure on the percentage of total soluble solids and the amount of pH and acidity was significant compared to the control and was not significant on other characteristics of the test. The interaction effect of temperature and pressure, except for acidity, on other characteristics of the produced syrup was significant at the 5% probability level. The average comparison of the interaction effect of temperature and pressure on the studied traits of date syrup is given in Table 2.

The effect of different temperature and pressure treatments

The pressure treatment of 9 kPa with a temperature of 70 ℃ had the highest percentage of total soluble solids with an average of 85. The effect of temperature of 50 ℃ with pressures of 3 and 6 kPa was not significant with the control (Figure 3).

The highest pH value was obtained from the treatment of 70°C temperature and 3kPa pressure, as well as 60°C temperature treatment with 3kPa pressure, with an average of 6.867. The lowest pH was obtained from the treatment of 70°C with a pressure of 9 kPa, 60°C with a pressure of 6 kPa, and 50°C with a pressure of 6 kPa with an average of 6.333. The effect of 70°C temperature with 6kPa pressure and 50°C temperature with 3kPa pressure had no difference in pH level. The pH of the date syrup samples obtained from different treatments was in the neutral range (Figure 4).

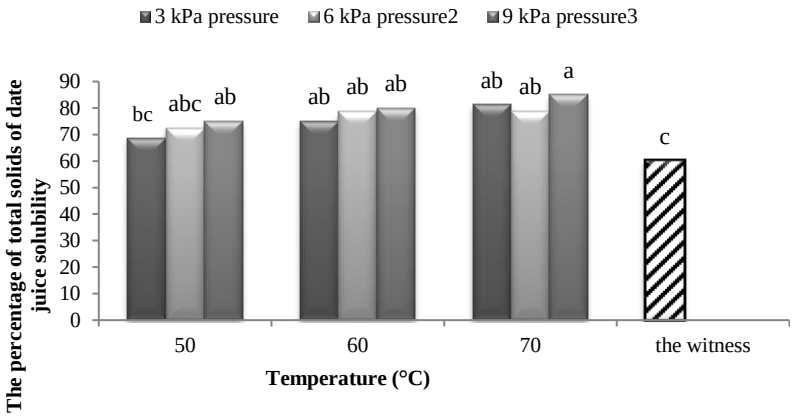

Figure 3. The interaction effect of temperature and pressure treatment on the percentage of total soluble solids of date syrup

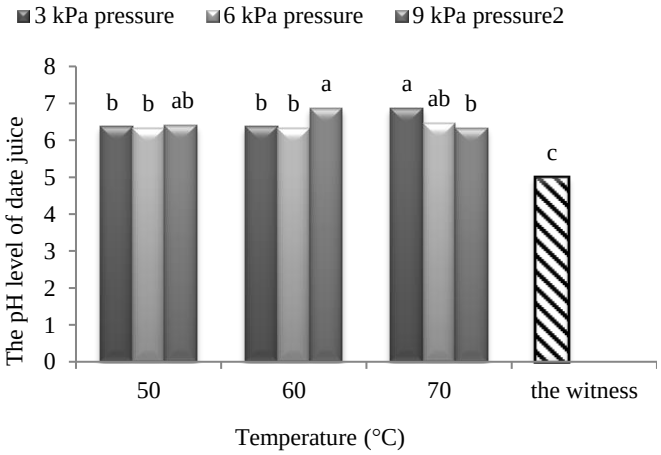

Figure 4. Interaction effect of temperature and pressure treatment on date sap pH

As can be seen from Table 2, there is no significant difference between them in terms of the amount of reducing sugars in each temperature treatment at different pressures. The highest amount of reducing sugars was obtained at a temperature of 70 ℃ and a pressure of 9 kPa with an average of 79.08, and the simultaneous application of this temperature and pressure had the highest amount of date syrup production (Figure 5).

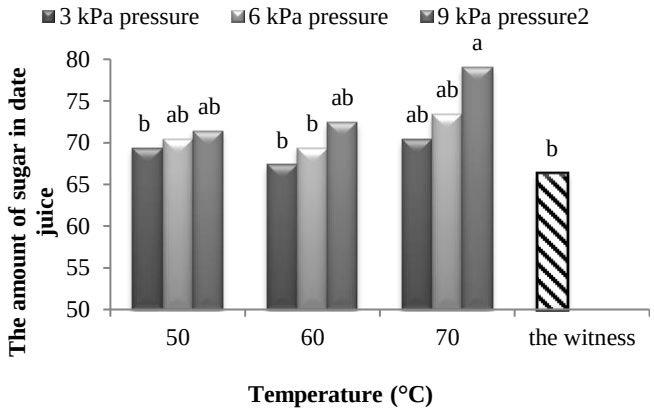

Figure 5. Interaction effect of stress and treatment on sugar content of date sap

The results of the interaction of temperature and pressure on the sensory quality of date syrup

The comparison of average data showed that there is no significant difference in the effect of pressure on the total acceptability of the produced date syrup compared to the control at the probability level of 5%. The results showed that there is no difference in taste between the date syrup produced with different pressures. Therefore, lower pressure can be used when the output syrup production rate is not considered.

Based on the results of the variance analysis of the data, the interaction effect of temperature and pressure on the taste of date syrup is significant at the 5% probability level compared to the control. The results of the double effect of temperature and pressure on the taste of the obtained date syrup showed that the use of a temperature of 50 ℃ and pressure of 6 kPa with an average score of 4.533 had the highest level of acceptability, and temperature of 70 ℃ and pressure of 6 kPa with an average score of 2.967 had the lowest acceptability (Figure 6).Considering that the amount of date syrup produced at a temperature of 70 ℃ and a pressure of 6 kPa was relatively high, but it was not very acceptable in terms of taste. Therefore, it can be said that temperature has no effect on the taste of date syrup. These results are consistent with the results of Jalali et al. (2012).

CONCLUSION

According to the obtained results, the maximum amount of syrup extracted with the syrup in the treatment with a temperature of 70 ℃, a pressure of 9 kPa and a duration of 5 h was 230 g/kg. This amount was about 23% based on the weight of dates used, which has increased 3.8 times compared to the traditional method. Increasing all three factors of temperature, pressure and time improved the extraction process and increased the amount of produced syrup.

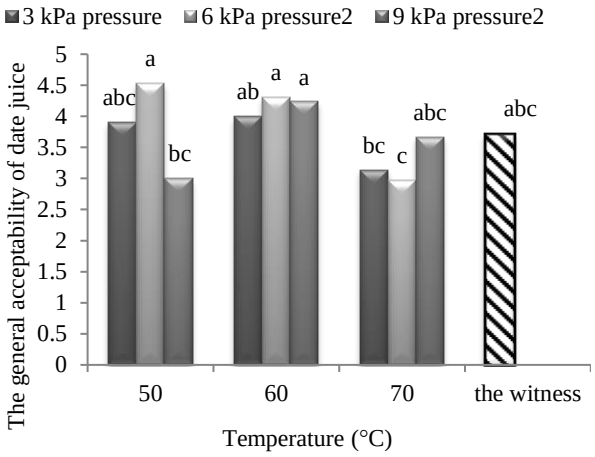

Figure 6. The mutual effect of temperature and pressure treatment on the sensory quality of date syrup

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