BAHÇE 49(2): *83-98 (2020)*
ISSN 1300-8943

THE EFFECT OF DIFFERENT PROCESSING TECHNIQUES IN PRODUCTION OF FIG AND DATE MOLASSES (PEKMEZ)

Mehmet BEYKAYA[1], Nevzat ARTIK[2]*

[1]Dr. Öğr. Ü., Igdır Univ. Faculty of Tourism Dept. of Gastronomy and Culinary Arts; ORCID: 0000-0003-2594-5011
[2]Prof. Dr., Ankara Univ. Faculty of Engineering Dept. of Food Engineering, Ankara; ORCID: 0000-0001-5583-6719
Geliş Tarihi / Received: 13.08.2020 *Kabul Tarihi / Accepted: 03.11.2020*

ABSTRACT

In this study, molasses (pekmez) was produced from fig and date by use of processing techniques of battery, press, decanter-separator and horizontal press at the pilot plant level. Water-soluble dry matter (Brix) and turbidity values were determined in the pomace of fig and date extracts obtained in the trials performed with each of the fruits. It is possible to produce molasses by various techniques; however, the quality parameters set forth in Turkish Food Codex should be followed and a cost analysis based on raw material input rate, product output rate, process time, the energy consumed should be carried out for determination of the best method and optimum conditions. Brix measurement, turbidity measurement, HMF analysis, ash determination and microbiological analyzes were repeated for fig and molasses in each method. It was concluded that it may be sufficient to use the battery, press, decanter-separator and horizontal press processing techniques in the production of fig and date molasses, however, it is better to use the filtration techniques in combination after production of must and molasses. The best method for production of fig and date molasses is the decanter separator processing technique.

Keywords: Molasses (pekmez), fig, date, process, technique

İNCİR VE HURMA PEKMEZİ ÜRETİMİNDE FARKLI İŞLEME TEKNİKLERİNİN VERİMLİLİĞE ETKİSİ

ÖZ

Bu araştırmada, incir ve hurma meyvelerinden pilot tesis ölçeğinde batarya, pres, dekantör-seperator ve yatay pres işleme teknikleri kullanılarak pekmez üretimi yapılmıştır. Her meyve ile yapılan denemede elde edilen incir ve hurma ekstraktının posasında, suda çözünür kuru madde (Briks) ve bulanıklık değeri saptanmıştır. Farklı tekniklerle pekmez üretiminin mümkün olduğu fakat en doğru yöntem ve optimum koşullar belirlerken muhakkak Türk Gıda Kodeksinde yer alan kalite parametreleri seçilmeli ve hammadde girdi hızı, ürün çıktı hızı, proses süresi, harcanan enerjiyi esas alan maliyet analizinin yapılması gerekmektedir. Her bir yöntemde Brix ölçümü, bulanıklık ölçümü, HMF analizi, kül tayini ve mikrobiyolojik analizler incir pekmezi ve hurma pekmezi için tekrarlanmıştır. İncir ve hurma pekmezi üretiminde batarya, pres, dekantör-seperator ve yatay pres işleme tekniklerinin pekmez üretiminde kullanılmasının yeterli olabileceği, ancak şıra ve pekmez üretim sonrası filtrasyon tekniklerinin kombinasyon olarak kullanılmasının uygun olmadığı sonucuna varılmıştır. İncir ve hurma pekmezi üretimi için en uygun yöntemin dekantör-seperator işleme tekniği olduğu belirlenmiştir.

Anahtar Kelimeler: Pekmez, incir, hurma, işleme, teknik

INTRODUCTION

The shelf life of fresh fruits is usually short and serious losses occur during storage mainly due to decay. Therefore, molasses production is a useful food processing method to preserve the nutritional values of these fruits for a longer time [15].

Ficus carica L., a non-evergreen tree belonging to the *Moraceae* family, is one of the first cultivated fruit trees in the world. Today, fig is a worldwide important product for dry and fresh consumption. Fig does not contain oil

*Sorumlu yazar / *Corresponding author*: artik@ankara.edu.tr

and cholesterol or sodium. Fig contains at least 17 kinds of amino acid compositions including aspartic acid and glutamine that are the highest [24].

Our country plays an important role in the world due to its leadership in the fig exportation. Aegean Region is the leader in fig production throughout our country, while Marmara Region is the second region with the highest production [14].

Fig is a product that is mostly consumed as dried fruit; however, it is also produced as fig molasses. Molasses is a kind of fruit juice concentrate, which is a well-known and widely consumed Turkish food product. It is produced from various fruits such as grapes, dried grapes, mulberries, apples, sugar beets and melons [17].

Table 1. Composition of fig molasses [25, 26]
Çizelge 1. İncir pekmezi bileşimi [25, 26]

Compound *Bileşik*	Minimum *Minimum*	Maximum *Maksimum*	Average *Ortalama*
Total Sugar *Toplam Şeker* (%)	51.96	56.58	54.45
Total Ash *Toplam Kül* (%)	2.98	3.32	3.12
Phosphorus *Fosfor* (P)	42	52	46
Iron *Demir* (Fe)	1.60	1.86	1.72
Copper *Bakır* (Cu)	0.32	0.42	0.38
Zinc *Çinko* (Zn)	0.47	0.63	0.52
Potassium *Potasyum* (K)	535	596	569
Sodium *Sodyum* (Na)	72	88	79
Mangan *Mangan* (Mn)	0.92	1.20	1.05
Calcium *Kalsiyum* (Ca)	496	562	528

Date is a plant belonging to *Arecaceae* family, which is *Phoenix dactylifera* in Latin. Even though date is consumed as fresh or dry product, it is used in a wide variety of fields in the food industry such as date juice concentrate, date syrup, date molasses, vinegar, marmalade and additive in pastry. With a sugar content of 44-88%, date is a good source of potassium and is rich in calcium, magnesium, iron and vitamins [2].

The molasses is defined as "Grape, mulberry, carob and fig molasses is a food product with thick viscosity obtained by decreasing the acidity with calcium carbonate or sodium carbonate without reducing the acidity of fresh or dried grape, mulberry, carob and fig extract and then clarifying with tannins, gelatin and suitable enzymes, thickening under vacuum or in open top tank in accordance with the current technique and finally mixing with addition of honey, chalk plant, milk, milk powder and egg white" in the food regulations in our country [7, 8, 9, 10].

Although the molasses production technique has not greatly changed, there are some differences in the production of molasses with different characteristics. The production stages of different kind of molasseses can be summarized as follows considering the abovementioned differences. Depending on whether the grape must be subjected to deacidification or not, there are two types of liquid molasses, which are sweet and sour liquid molasses [18].

The molasses content varies depending on the species, type, production conditions and processing techniques of the fruit it is produced (Figure 1). Although it varies depending on the fruit composition, the composition of molasses varieties mainly consists of carbohydrates [19, 25, 3, 21, 27].

The effect of heat treatment on the physicochemical and sensory characteristics of different molasses varieties was examined in a study and the apricot molasses was found to have the highest viscosity, which was followed by mulberry and date molasses. The smell, taste and consistency scores of apricot and date molasses were found to be higher than others [16].

The basic carbohydrates contained in molasses, which is a good carbohydrate and energy source due the natural presence of sugar in its composition, are generally glucose and fructose, which constitute the main energy source. In addition, molasses has a high mineral substance content and meets most of the calcium, iron, potassium and magnesium needs in particular [25, 22, 21, 27].

The molasses production flow chart is shown in Table 1. First, the fruits are sorted and then foreign substances are removed. Following the washing process, they are cut into pieces to reduce the size in order to increase the extraction efficiency. Pneumatic or mechanical pressing is used to extract the juice of the juice and the fig and date juice obtained by extraction is then boiled in a calcareous substance called marl that has a high content of $CaCO_3$. The marl ensures decrease in acidity by precipitating the malic acid and tartaric acid, which are naturally contained in the marl, in the form of calcium malate and calcium tartrate and then the sediment is separated by sedimentation. The clear juice with lower acidity is then concentrated to the desired level (approximately 60-80%) under atmospheric conditions or vacuum [12]. Following the clarification and filtration processes, the molasses, water activity of which is reduced by evaporation, is packaged and the molasses with a Brix value of 60-80 molasses is produced.

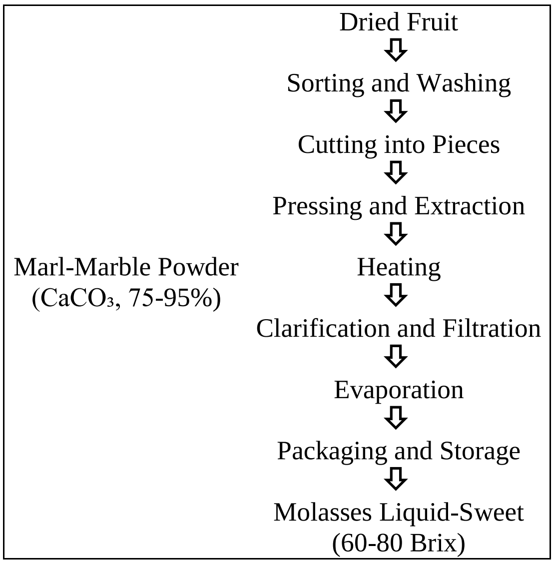

Figure 2. Molasses production flow chart [25, 26]

Şekil 2. Pekmez üretim akım şeması [25, 26]

In a study carried out in this respect by Şimsek and Artık [25], Şimsek et al., [26] to determine the compositions of grape, mulberry, fig and carob molasses produced widely in our country, the total dry matter (79%), water soluble dry matter (brix) (75%) fructose (34.42%), glucose (34.99%), total ash (3.83%), K, (978 mg 100 g^{-1}), P (87 mg 100 g^{-1}), Hunter L (19.33) and Hunter b (0.64) in grape molasses; total sugar (68.79%), formol number (11), sucrose (44.38%), alkali number (14.12) and Hunter a (0.68) in carob molasses, titration acidity (1.008%), HMF (33.6 mg kg^{-1}), ash alkalinity (27.32), Ca (562 mg 100 g^{-1}), Mg (94 mg 100 g^{-1}), Na (88 mg 100 g^{-1}), Fe (1.86 mg 100 g^{-1}), Mn (1.20 mg 100 g^{-1}), Zn (0.63 mg 100 g^{-1}) in fig molasses and Cu (0.49 mg 100 g^{-1}) and pH (5.56) in mulberry molasses were reported to be the highest values [26].

In a study carried out by Akıncı et al. [1] on Syrian juniper (*J. drupacea*) molasses, molasses was found to be rich in some nutritional components such as sugar (34.97 g 100 g^{-1}), ash (3.79 g 100 g^{-1}), Ca, (1499 mg kg^{-1}), P (1445 mg kg^{-1}) and Zn (12.79 mg kg^{-1}). In a study carried out by Al-Hooti et al. (1997), total sugar, protein, oil, ash, pectin, tannin and cellulose contents were found to range between 32.99-79.39%, 2-6.4%, 0.1-0.7%, 1.6-3.9%, 1.3-14.3%, 0.4-2.5% and 2.5-12.3% in the ripening period of 5 different commercial dates. They also reported that date is also a fruit with the highest K (402.8-1668.6 mg 100 g^{-1}) and lowest Na (1.5-9.4 mg 100 g^{-1}) contents.

Molasses production from various raw materials is carried out under vacuum in modern plants. Today, heat treatment at 67-70°C and even lower temperatures under vacuum is possible in many modern plants. Since the heat treatment does not exceed 67-70°C in molasses processed by modern method, the HMF (Hydroxymethylfurfural) content is minimized. Since burning and deterioration do not occur in sugar contained in the molasses composition, the molasses produced in this way has much more beneficial effects on health. In addition, there is no burnt taste and odor and products with higher quality in terms of color are obtained [20, 11, 27].

MATERIAL AND METHOD

Material

Fig and date, which were used raw materials in the study, were brought to Pilot Fruit Juice Processing Plant of Food Engineering Department of Ankara University and SEMAS Gida Sanai and then and sorted in order to remove or minimize dust, soil, foreign matter, microorganism and pesticide residues on the fruits.

Method

Battery, press, decanter-separator and horizontal extraction processing techniques were used in the trial. Brix measurement, turbidity measurement, HMF analysis, ash determination and microbiological analyzes were performed for fig and molasses in each method for 20, 25 and 30 minutes. The raw material input rate, product output rate, process time, level of energy consumed and cost values were calculated.

Fig and date

Washed and sorted figs and dates were then processed into molasses using 4 different (battery, press, decanter-separator and horizontal extraction) processing techniques at the pilot plant level of SEMAS Gida Sanayi and Ankara University. The conditions of the techniques used are as follows.

Battery processing technique: The battery transition time for this process was determined as 20, 25 and 30 minutes, while the water temperature used in extraction was determined as 50°C, 55°C and 60°C. Extraction of both fruits was used in such a way that it could weigh up to 170 kg and maximum 110-160 kg mashed and non-mashed fruits was used for each battery.

Press Processing Technique: The pressing time for the trials on fig and date was 60, 120 and 180 minutes and water temperature was 45°C and 50°C. The amount of mash enzyme used in the water-fruit mixtures prepared was 50 and 75 g ton^{-1} and mash holding time was 60 and 120 minutes. Fruit-water mixture ratios of 1:9, 2:8 and 3:7 were tested.

Decanter Separator Processing Technique: In the trials of Decanter Separator Processing carried out for fig and date at the pilot plant level, the water temperature was 45°C and 50°C and the amount of mash enzyme ranged between 50 and 75 g ton^{-1}. Fruit-water mixture ratios of 1:9, 2:8 and 3:7, mash enzyme holding time of 60 and 120 minutes and decanter feeding rate of 2 and 3-ton hour^{-1} were used in the trial. In addition, the decantation time varied depending on the feed rate.

Horizontal Extraction Processing Technique: In the trials of horizontal extraction processing used in the production of fig and date molasses, the water temperature was 50°C, 55°C and 60°C and amount of fruits was 1250 and 2000 kg, while extraction time was 20, 25 and 30 minutes. The effect of particle size on extraction was determined by trials of mashed and non-mashed fruits.

Physical and chemical analyses

Water soluble dry matter (Brix) analysis: Water soluble dry matter (Brix) values of fruit pomace and samples of fig and date molasses produced were determined by digital refractometer (Hanna HI 96800) [13].

Ash determination: After the samples were weighed into crucibles, the crucibles were kept in the oven at 110°C overnight and then they were burnt in an oven at 520°C for 5-6 hours until white ash was obtained and cooled in the desiccator. Then, the amount of ash was calculated by weight loss [13].

Turbidimeter measurement: The pomace and turbidity value of the must obtained in the trial performed with fig and date was measured by WTW desktop Turb 550 IR (molasses, molasses was found to be rich in some nutritional components such as sugar (34.97 g 100 g^{-1}), ash (3.79 g 100 g^{-1}), Ca, (1499 mg kg^{-1}), P (1445 mg kg^{-1}) and Zn (12.79 mg kg^{-1}) ± 0.01 NTU or ± 2% of the measured value).

Amount of sediment: The sedimentation was determined by taking the mixture, which was prepared by diluting the molasses at a ratio of 1/1, into laboratory tubes of 10 ml and centrifuging it for 15 minutes at 7000 rpm.

Analysis of browning level: Approximately 1.5 g of fig and date and samples of molasses produced therefrom was weighed into centrifuge tubes and brought to volume with 10 mL distilled water. After addition of 20 mL ethyl alcohol, the samples were homogenized by vortex and then centrifuged (Sigma 2-6, Germany) at 2500 rpm for 5 minutes. After centrifugation, 5 ml of supernatant was taken and mixed with 5 ml distilled water and 1 ml $K_2S_2O_5$ and then it was re-centrifuged for 5 minutes at 4000 rpm. It was let to rest for 20 minutes and then the absorbance was measured by UV-VIS (Shimadzu UV mini-1240, Japan) spectrophotometer at 420 nm. The Abs value read was multiplied by the dilution factor and calculations were made [13].

Hydroxymethylfurfural (HMF) analysis: The hydroxymethylfurfural reacted with p-toluidine and barbituric acid and the absorbance of the red color formed by this reaction was measured by spectrophotometer at a wavelength of 550 nm. 1-gram fig and date molasses sample was diluted with distilled water at appropriate ratios and then it was brought up to volume by addition of 2 ml Carrez I and Carrez II solutions and mixed by vortex and filtered by Whatman 42 filter paper. 1 ml of filtrate was taken and 2.5 ml p-toluidine solution and 0.5 ml barbituric acid solution was added into it. The absorbance of homogenized samples was read by UV-VIS (Shimadzu UV mini-1240, Japan) spectrophotometer at 550 in 1-2 minutes and compared to witness sample. The same procedures were applied for the witness sample. However, instead of barbituric acid, the same amount of distilled water was used in the mixture [6].

Microbiological Analysis: Total mesophilic aerobic microorganisms were cultivated on Plate Count Agar (PCA-Merck 1.05463) by pouring method and after incubation at 35-37°C for 24 hours, colonies formed in this medium were counted (cfu g^{-1}). For yeast and mold counts, the colonies (cfu g^{-1}) formed after cultivation on Dichloran Rose Bengal Chloramphenicol Agar (DRB-Merck 1.00466) and incubation for 5 days at 22±20°C were counted [23].

Process Analyses: The raw material input rate, product output rate, process time and the level of energy consumed were determined.

Cost Analysis: In calculation of unit cost, the power cost was assumed as TL 0.05 for 1 kg molasses for each molasses in general. In addition, the coal spent for 1 kg molasses was calculated as 0.57 kg and 1 kg coal was calculated over TL 0.47. The average personnel cost was taken as the average monthly cost of shift officers and maintenance/repair officers involved as part of the project. The unit costs were calculated by use of the cost of 1 kg molasses and the amount of molasses produced in the trial.

RESULTS AND DISCUSSION

Fig and date were converted into fig and date molasses by different processing techniques under pilot plant conditions. Within the scope of this study, optimum values were chosen in each production and firstly, the compliance of the molasses of that fruit with the Turkish Food Codex (TGK) and then the efficiency and cost lowness were taken into consideration. In addition, the value of brix in the fruit pomace is requested to be low in extractions. The turbidity of the must was measured by spectrophotometer at 420 nm transmittance; however, no applicable or repeatable results were obtained. Instead, it was decided to carry out turbidity analysis by turbidimeter. Turbidity values were obtained by sensory methods. The highest value preferred for the sediment and turbidity of must was 2+, while the panelists did not like the higher sediment values.

For microbiological values, the upper limit of mesophilic aerobic microorganism count is 10.000 cfu g^{-1} and 100 cfu g^{-1} for yeast-mold. Values higher than abovementioned microbiological values cause the fig and date molasses to ferment, that is to say to degrade, while the values higher than 8.000 cfu g^{-1} and 80 cfu g^{-1} also pose a risk. For the processing techniques used in production, the raw material input rate and product output rate are requested to be high, while the process time, the energy consumed and the cost are requested to be low.

Battery Processing Technique

Changes in the quality parameters of battery processing technique for fig and date molasses are given in Table 1 and Table 2. The product output rates are shown in Table 2, while the unit costs are shown in Table 3.

Since the Brix value of the pomace was found to be higher than the expected in the trials performed with non-mashed fig, the remaining trials were carried out only with mashed fruit. The microbiological values were above the upper limits at 50°C. HMF values were above the limit specified in TFC, when the battery transition time was 30 minutes at 60°C. The optimum condition in battery technique for fig, which ensured the highest product output rate and lowest cost and provided the molasses with desired characteristics, was achieved at a water temperature of 55°C with 160 kg of mashed fruit loaded in each battery and a battery transition time of 30 minutes (Table 1).

Table 1. Results of battery trials on fig and date
Çizelge 1. İncir ve hurma batarya deneme sonuçları

	Temperature *Sıcaklık* (°C)	Pomace *Posa* (brix)	Must turbidity *Şıra bulanıklığı*	HMF (g kg^{-1})	Ash (%) *Kül*	Sediment *Tortu*	Microbiology *Mikrobiyoloji* (Cfu g^{-1})	
							Mesophile *Mezofil*	Mold *Küf*
20 minute / *dakika*								
110 kg	50	5.8	2+	28	1.80	2+	6870	105
Fig, Non-mashed	55	4.7	2+	32	1.82	2+	3250	54
İncir, Ezilmemiş	60	4.7	2+	43	1.78	2+	1980	18
160 kg	50	2.4	3+	29	1.98	2+	7010	118
Fig, Non-mashed	55	2.2	2+	31	2.02	2+	4050	68
İncir Ezilmemiş	60	2.2	2+	47	2.02	2+	2180	29
110 kg	50	2.6	3+	31	1.99	2+	7020	121
Fig, Mashed	55	2.3	2+	30	2.01	2+	4120	73
İncir, Ezilmiş	60	2.3	2+	45	2.02	2+	2500	34
110 kg	50	10.5	4+	50	1.90	4+	7100	98
Date, Non-mashed	55	9.8	3+	54	2.30	3+	4560	76
Hurma, Ezilmemiş	60	9.6	3+	68	2.32	3+	3140	53
160 kg	50	10.6	4+	51	1.93	4+	7280	95
Date, Non-mashed	55	9.7	3 +	57	2.26	3+	4460	79
Hurma, Ezilmemiş	60	9.5	3+	69	2.36	3+	3250	56
110 kg	50	4.0	6+	53	2.10	6+	7150	102
Date, Mashed	55	3.2	4+	58	2.18	4+	4680	62
Hurma, Ezilmiş	60	2.9	4+	72	2.18	4+	3200	58
160 kg	50	4.1	6+	54	2.11	6+	7100	103
Date, Mashed	55	3.2	4+	59	2.16	4+	4600	67
Hurma, Ezilmiş	60	2.8	4+	70	2.18	4+	3310	61
25 minute / *dakika*								
110 kg	50	5.6	2+	30	1.82	2+	6570	130
Fig, Non-mashed	55	4.6	2+	34	1.84	2+	3380	32
İncir, Ezilmemiş	60	4.3	2+	44	1.84	2+	2020	24
160 kg	50	2.1	3+	30	2.00	2+	6980	116
Fig, Non-mashed	55	2.1	2+	44	2.12	2+	4000	70
İncir, Ezilmemiş	60	1.9	2+	58	2.08	2+	2210	32
110 kg	50	2.0	3+	31	2.06	2+	7130	129
Fig, Mashed	55	1.9	2+	34	2.18	2+	4190	75
İncir, Ezilmiş	60	1.9	2+	62	2.17	2+	2480	37
110 kg	50	9.7	4+	50	1.90	4+	7050	82
Date, Non-mashed	55	9.4	3+	56	2.40	3+	4620	74
Hurma, Ezilmemiş	60	9.3	3+	72	2.31	3+	3040	50
160 kg	50	9.7	4+	52	1.96	4+	7200	93
Date, Non-mashed	55	9.5	3+	56	2.31	3+	4610	74
Hurma, Ezilmemiş	60	9.3	3+	73	2.35	3+	3100	55
110 kg	50	2.0	6+	55	2.12	6+	7300	105
Date, Mashed	55	1.8	4+	58	2.20	4+	4690	60
Hurma, Ezilmiş	60	1.8	4+	74	2.28	4+	3340	57
160 kg	50	2.2	6+	56	2.12	6+	7210	105
Date, Mashed	55	1.9	4+	61	2.19	4+	4590	65
Hurma, Ezilmiş	60	1.8	4+	70	2.22	4+	3200	60
30 minute / *dakika*								
110 kg	50	5.6	2+	30	1.88	2+	6680	108
Fig, Non-mashed	55	4.4	2+	35	1.92	2+	3490	62
İncir, Ezilmemiş	60	4.3	2+	43	1.94	2+	2120	27
160 kg	50	1.9	3+	38	2.14	2+	7120	110
Fig, Non-mashed	55	1.5	2+	52	2.16	2+	4210	67
İncir, Ezilmemiş	60	1.5	2+	74	2.22	2+	2180	33
110 kg	50	1.7	3+	42	2.15	2+	7050	108
Fig, Mashed	55	1.5	2+	50	2.20	2+	4220	71
İncir, Ezilmiş	60	1.5	2+	86	2.22	2+	2180	34

	Temperature *Sıcaklık* (°C)	Pomace *Posa* (brix)	Must turbidity *Şıra bulanıklığı*	HMF (g kg⁻¹)	Ash (%) *Kül*	Sediment *Tortu*	Microbiology *Mikrobiyoloji* (Cfu g⁻¹)	
							Mesophile *Mezofil*	Mold *Küf*
110 kg Date, Non-mashed *Hurma, Ezilmemiş*	50	8.6	4+	52	2.01	4+	7280	80
	55	8.4	3+	56	2.54	3+	4750	72
	60	8.3	3+	74	2.56	3+	2990	47
160 kg Date, Non-mashed *Hurma, Ezilmemiş*	50	9.0	4+	53	1.99	4+	7220	90
	55	8.9	3+	55	2.30	3+	4570	77
	60	8.8	3+	72	2.33	3+	2940	51
110 kg Date, Mashed *Hurma, Ezilmiş*	50	1.9	7+	58	2.30	6+	7280	103
	55	1.5	5+	60	2.38	4+	4720	61
	60	1.4	5+	78	2.42	4+	3390	56
160 kg Date, Mashed *Hurma, Ezilmiş*	50	1.9	6+	55	2.30	6+	7300	102
	55	1.7	4+	61	2.55	4+	4480	61
	60	1.7	4+	72	2.60	4+	3170	58

The pomace Brix value was higher than the expected in the trials performed with non-mashed date. The microbiological values were above the upper limit at 50°C, while HMF values were higher than the upper limit at 60°C. The optimum condition in battery technique for date, which ensured the highest product output rate and lowest cost and provided the molasses with desired characteristics, was achieved at a water temperature of 55°C with 160 kg of mashed date loaded in each battery and a battery transition time of 30 minutes (Table 1).

Table 1 shows the results of battery trials. The process time was calculated by taking the hold time in the battery and the load time between the batteries as 20 minutes. The ratio of the amount of fruit loaded in each battery to the process time and the raw material input rate were found. In the battery trial, since 4 personnel worked throughout the trial, the energy consumed was calculated by the ratio of this figure to the process time.

Table 2 shows the product output rates of fig and date in battery trial. These are the amounts of molasses at the end of the process. The ratio of product output rate to raw material input rate shows the yield of the fruit in the trial performed. In addition, the increase in temperature and time resulted in significant increases in product output rates in mashed fig and date when compared to non-mashed fig and date.

Table 3 shows the unit costs. The power cost was assumed as TL 0.05 for 1 kg molasses in calculation of unit cost. In addition, the coal spent for 1 kg molasses was calculated as 0.57 kg and 1 kg coal was calculated over TL 0.47.

Table 2. The product output rates of battery trials on fig and date
Çizelge 2. İncir ve hurma batarya deneme ürün çıktı hızları

Product Output Rate (kg hour⁻¹) *Ürün Çıktı Hızı (kg saat⁻¹)*	Temperature *Sıcaklık* (°C)	20 minute / *dakika*		25 minute / *dakika*		30 minute / *dakika*	
		Fig *İncir*	Date *Hurma*	Fig *İncir*	Date *Hurma*	Fig *İncir*	Date *Hurma*
110 kg Fruits, Non-mashed *Meyve, Ezilmemiş*	50	26	20	24	20	21	20
	55	32	22	29	20	27	20
	60	32	22	31	20	28	21
160 kg Fruits, Non-mashed *Meyve, Ezilmemiş*	50	*	29	*	28	*	28
	55	*	32	*	29	*	28
	60	*	33	-	30	-	28
110 kg Fruits, Mashed *Meyve, Ezilmiş*	50	62	53	63	95	63	90
	55	68	67	63	105	79	114
	60	68	74	69	105	79	122
160 kg Fruits, Mashed *Meyve, Ezilmiş*	50	83	76	96	131	102	131
	55	94	97	101	145	115	146
	60	94	111	101	153	115	146

*No data was obtained / *Hiçbir veri elde edilmemiştir.*

Table 3. Unit costs in battery trials on fig and date
Çizelge 3. İncir ve hurma batarya deneme birim maliyetleri

Unit Costs *Birim Maliyetler* (TL kg⁻¹)	Temperature *Sıcaklık* (°C)	20 minute / *dakika*		25 minute / *dakika*		30 minute / *dakika*	
		Fig *İncir*	Date *Hurma*	Fig *İncir*	Date *Hurma*	Fig *İncir*	Date *Hurma*
110 kg Fruits, Non-mashed *Meyve, Ezilmemiş*	50	0.606	0.694	0.597	0.658	0.608	0.631
	55	0.551	0.657	0.540	0.658	0.534	0.631
	60	0.551	0.657	0.527	0.658	0.520	0.630
160 kg Fruits, Non-mashed *Meyve, Ezilmemiş*	50	*	0.576	*	0.548	*	0.544
	55	*	0.551	*	0.540	*	0.538
	60	*	0.546	*	0.533	*	0.531
110 kg Fruits, Mashed *Meyve, Ezilmiş*	50	0.439	0.460	0.402	0.361	0.374	0.360
	55	0.428	0.431	0.402	0.354	0.350	0.353
	60	0.428	0.418	0.391	0.354	0.350	0.349
160 kg Fruits, Mashed *Meyve, Ezilmiş*	50	0.409	0.417	0.361	0.340	0.328	0.338
	55	0.397	0.395	0.356	0.334	0.320	0.333
	60	0.397	0.385	0.356	0.334	0.320	0.332

*No data was obtained / *Hiçbir veri elde edilmemiştir.*

The average personnel cost was taken as the average monthly cost of shift officers and maintenance/repair officers involved as part of the project. The unit costs were calculated by use of the cost of 1 kg molasses and the amount of molasses produced in the trial. The unit cost values decreased from TL 0.606 TL kg^{-1} to TL 3.320 kg^{-1} in fig and from TL 0.606 kg^{-1} to TL 0.332 kg^{-1} in date.

Press processing technique

Changes in the quality parameters of press processing technique for fig and date molasses are given in Table 4 and the unit costs are shown in Table 5. The optimum conditions of battery technique for fig and date were determined. The optimum processing conditions of press technique for the fruits will be determined.

Table 4 shows the analysis results of press trials of fig and date. When the quality parameters of fig are reviewed, it is seen that the brix in pomace decreases and must turbidity, HMF, ash and sediment amount increases when the water temperature, enzyme dose, fruit ratio and holding time increases. Another important result is that when the water temperature increases from 45°C to 50°C, total mesophile and mold amount decreases. HMF values increased slightly above the limit specified in TFC at the final temperature values. The optimum condition in press technique for fig, which ensured the highest product output rate and lowest cost and provided the molasses with desired characteristics, was achieved at a water temperature of 55°C with 160 kg of mashed fruit loaded in each battery and a battery transition time of 30 minutes.

All trials on fig gave a pomace brix value of approximately 20, which was much higher than the expected. In addition, it was seen that some particles did not explode at the end of pressing. These trials were ignored and the rest of the trials were carried out fit with cut figs. The microbiology values were higher than the upper limit in the trials performed at a water temperature of 45°C. The must turbidity and sediment value were higher than the upper limit when pressing time of 120 and 180 minutes were tested in the trials performed at a water temperature of 50°C. The must turbidity and sediment values were again higher in the trial performed by use of 75 g ton^{-1} enzyme with a pressing time of 60 minutes. Taking into consideration the high raw material input and low cost, the optimum processing conditions for fig in press technique were achieved at a water temperature of 50°C with an enzyme amount of 50 g ton^{-1}, fruit: water mixture ratio of 3:7 and pressing time of 60 minutes.

When the pressing time increases, the must turbidity and sediment also increase. The must turbidity and sediment values were also higher when the water at a temperature of 50°C was used. Taking into consideration the high raw material input and low cost, the optimum processing conditions for date in press technique were achieved at a water temperature of 45°C with an enzyme amount of 50 g ton^{-1}, fruit: water mixture ratio of 3:7 and pressing time of 60 minutes.

Table 4. Results of press trials on fig and date
Çizelge 4. İncir ve hurma pres deneme sonuçları

	Temperature *Sıcaklık* (°C)	Pomace *Posa* (brix)	Must turbidity *Şıra bulanıklığı*	HMF (g kg⁻¹)	Ash *Kül* (%)	Sediment *Tortu*	Microbiology *Mikrobiyoloji* (Cfu g⁻¹) Mesophile *Mezofil*	Microbiology *Mikrobiyoloji* (Cfu g⁻¹) Mold *Küf*
60 minutes / *dakika*								
50 g ton⁻¹ Enzyme, Fig *Enzim, İncir*	45	1.8	2+	25	1.60	2+	8230	114
	45	2.0	2+	28	1.82	2+	8560	138
	45	2.0	2+	32	1.94	2+	8890	146
75 g ton⁻¹ Enzyme, Fig *Enzim, İncir*	45	1.7	2+	23	1.59	2+	8250	110
	45	1.9	2+	27	1.85	2+	8610	143
	45	1.9	2+	30	1.90	2+	8900	152
50 g ton⁻¹ Enzyme, Fig *Enzim, İncir*	50	0.8	2+	32	1.61	2+	7040	51
	50	1.0	2+	37	1.76	2+	7190	58
	50	1.0	2+	41	1.88	2+	7260	63
75 g ton⁻¹ Enzyme, Fig *Enzim, İncir*	50	0.8	2+	35	1.72	2+	7420	48
	55	1.0	3+	40	1.84	3+	7390	62
	60	1.0	3+	48	2.00	3+	7615	66
50 g ton⁻¹ Enzyme, Date *Enzim, Hurma*	45	1.9	2+	32	1.72	2+	4120	38
	45	2.2	2+	36	1.83	2+	4180	42
	45	2.2	2+	36	1.88	2+	4210	48
75 g ton⁻¹ Enzyme, Date *Enzim, Hurma*	45	1.7	2+	23	1.59	2+	8250	110
	45	1.9	2+	27	1.85	2+	8610	143
	45	1.9	2+	30	1.90	2+	8900	152
50 g ton⁻¹ Enzyme, Date *Enzim, Hurma*	50	0.8	2+	32	1.61	2+	7040	51
	50	1.0	2+	37	1.76	2+	7190	58
	50	1.0	2+	41	1.88	2+	7260	63
75 g ton⁻¹ Enzyme, Date *Enzim, Hurma*	50	0.8	2+	35	1.72	2+	7420	48
	50	1.0	3+	40	1.84	3+	7390	62
	50	1.0	3+	48	2.00	3+	7615	66
120 minutes / *dakika*								
50 g ton⁻¹ Enzyme, Fig *Enzim, İncir*	45	1.6	2+	26	1.62	2+	8310	118
	45	1.8	2+	27	1.85	2+	8620	141
	45	1.9	2+	30	1.98	2+	8900	169
75 g ton⁻¹ Enzyme, Fig *Enzim, İncir*	45	1.3	2+	25	1.63	2+	8310	117
	45	1.5	2+	30	1.88	2+	8690	149
	45	1.5	2+	31	1.95	2+	8960	155
50 g ton⁻¹ Enzyme, Fig *Enzim, İncir*	50	0.7	3+	35	1.66	2+	7090	53
	50	1.0	3+	40	1.79	2+	7210	59
	50	1.0	3+	44	1.92	2+	7280	66
75 g ton⁻¹ Enzyme, Fig *Enzim, İncir*	50	0.6	4+	35	1.74	3+	7300	58
	55	0.8	4+	40	1.82	3+	7410	63
	60	0.8	4+	49	1.98	3+	7720	72
50 g ton⁻¹ Enzyme, Date *Enzim, Hurma*	45	1.7	2+	34	1.78	2+	4280	36
	45	2.0	3+	36	1.84	2+	4305	44
	45	2.1	3+	37	1.91	2+	4325	51
75 g ton⁻¹ Enzyme, Date *Enzim, Hurma*	45	1.3	2+	25	1.63	2+	8310	117
	45	1.5	2+	30	1.88	2+	8690	149
	45	1.5	2+	31	1.95	2+	8960	155
50 g ton⁻¹ Enzyme, Date *Enzim, Hurma*	50	0.7	3+	35	1.66	2+	7090	53
	50	1.0	3+	40	1.79	2+	7210	59
	50	1.0	3+	44	1.92	2+	7280	66
75 g ton⁻¹ Enzyme, Date *Enzim, Hurma*	50	0.6	4+	35	1.74	3+	7300	58
	50	0.8	4+	40	1.82	3+	7410	63
	50	0.8	4+	49	1.98	3+	7720	72
180 minute / *dakika*								
50 g ton⁻¹ Enzyme, Fig *Enzim, İncir*	45	1.5	2+	28	1.64	2+	8380	121
	45	1.6	2+	28	1.88	2+	8690	148
	45	1.6	2+	32	2.01	2+	8950	175

	Temperature *Sıcaklık* (°C)	Pomace *Posa* (brix)	Must turbidity *Şıra bulanıklığı*	HMF (g kg⁻¹)	Ash *Kül* (%)	Sediment *Tortu*	Microbiology *Mikrobiyoloji* (Cfu g⁻¹)	
							Mesophile *Mezofil*	Mold *Küf*
75 g ton⁻¹ Enzyme, Fig *Enzim, İncir*	45	1.0	2+	28	1.66	2+	8390	120
	45	1.2	2+	32	1.90	2+	8740	153
	45	1.2	2+	35	1.98	2+	9040	158
50 g ton⁻¹ Enzyme, Fig *Enzim, İncir*	50	0.6	3+	40	1.70	2+	7180	55
	50	0.9	3+	48	1.83	2+	7320	62
	50	0.9	3+	52	1.98	2+	7450	71
75 g ton⁻¹ Enzyme, Fig *Enzim, İncir*	50	0.6	4+	39	1.83	3+	7290	54
	55	0.7	4+	42	1.88	3+	7580	63
	60	0.7	5+	51	2.03	4+	7690	78
50 g ton⁻¹ Enzyme, Date *Enzim, Hurma*	45	1.5	4+	33	1.76	3+	4460	41
	45	1.9	4+	38	1.89	3+	4510	45
	45	1.9	4+	41	1.93	3+	4650	50
75 g ton⁻¹ Enzyme, Date *Enzim, Hurma*	45	1.0	2+	28	1.66	2+	8390	120
	45	1.2	2+	32	1.90	2+	8740	153
	45	1.2	2+	35	1.98	2+	9040	158
50 g ton⁻¹ Enzyme, Date *Enzim, Hurma*	50	0.6	3+	40	1.70	2+	7180	55
	50	0.9	3+	48	1.83	2+	7320	62
	50	0.9	3+	52	1.98	2+	7450	71
75 g ton⁻¹ Enzyme, Date *Enzim, Hurma*	50	0.6	4+	39	1.83	3+	7290	54
	50	0.7	4+	42	1.88	3+	7580	63
	50	0.7	5+	51	2.03	4+	7690	78

Table 5. Unit costs in press trials on fig and date
Çizelge 5. İncir ve hurma pres deneme birim maliyetleri

Unit Costs *Birim Maliyetler* (TL kg⁻¹)	Temperature *Sıcaklık* (°C)	60 minute / *dakika*		120 minute / *dakika*		180 minute / *dakika*	
		Fig *İncir*	Date *Hurma*	Fig *İncir*	Date *Hurma*	Fig *İncir*	Date *Hurma*
50 g ton⁻¹ Enzyme, Fruit *Enzim, Meyve*	45	0.413	0.387	0.418	0.393	0.427	0.395
	45	0356	0.357	0.357	0.361	0.375	0.366
	45	0.353	0.345	0.357	0.348	0.357	0.350
75 g ton⁻¹ Enzyme, Fruit *Enzim, Meyve*	45	0.407	0.377	0.399	0.379	0.391	0.379
	45	0.367	0.350	0.365	0.353	0.362	0.351
	45	0.351	0.340	0.349	0.343	0.347	0.340
50 g ton⁻¹ Enzyme, Fruit *Enzim, Meyve*	50	0.360	0.372	0.362	0.370	0.362	0.368
	50	0.344	0.347	0.349	0.347	0.351	0.346
	50	0.335	0.337	0.339	0.338	0.340	0.336
75 g ton⁻¹ Enzyme, Fruit *Enzim, Meyve*	50	0.360	0.369	0.355	0.361	0.362	0.369
	50	0.344	0.345	0.343	0.342	0.344	0.346
	50	0.335	0.336	0.334	0.334	0.335	0.336

When the mash enzyme holding time of fig and date tested was 120 minutes, the pressing capability was found to decrease even if the enzyme amount was kept fixed. The turbidity of the resulting juice was so high that clarification was not possible. It was decided not to test mash holding time of 120 minutes since it decreased the yield of fruit juice significantly. All trials were performed with a holding time of 60 minutes.

Table 5 shows the unit costs. The power cost was assumed as TL 0.005 for 1 kg molasses in calculation of unit cost. In addition, the coal spent for 1 kg molasses was calculated as 0.57 kg and 1 kg coal was calculated over TL 0.47. The average personnel cost was taken as the average monthly cost of shift officers and maintenance/repair officers involved as part of the project. The unit costs were calculated by use of the cost of 1 kg molasses and the amount of molasses produced in the trial. The unit cost values decreased from TL 0.427 TL kg⁻¹ to TL 3.35 kg-1 in fig and from TL 0.395 kg⁻¹ to TL 0.334 kg⁻¹ in date.

Decanter separator processing technique

Changes in the quality parameters of decanter separator processing technique for fig and date molasses are given in Table 6 and Table 7. The product output rates are shown in Table 2, while the unit costs are shown in Table 8.

The must turbidity and sediment values were much higher than the desired for fig in the trials performed at a water temperature of 50°C. The must turbidity was also higher than the desired with the fruit-water mixture ratios of 2:8 and 3:7. The trial with the lowest must turbidity, sediment value and cost was found to have the optimum processing conditions for date in decanter separator technique with a water temperature of 45°C, mash enzyme of 75 g ton^{-1}, feed rate of 3-ton hour^{-1} and fruit-water mixture ratio of 1:9 (Table 6).

When the mash enzyme holding time tested was 120 minutes, the turbidity of the resulting fruit juice was so high that clarification was not possible even if the enzyme amount was kept fixed. It was decided not to test mash holding time of 120 minutes since it decreased the yield of fruit juice significantly. All trials were performed with a holding time of 60 minutes.

Table 6 shows the yield of decanter separator trials. The process time was calculated on the basis of decanter feed rate. The tank used in decanter separator trials was 8.000 kg. The amount of the fruit used was calculated accordingly over the fruit-water ratios and this value was used in calculation of the raw material input rate. In the decanter separator trial, since 4 personnel worked throughout the trial, the energy consumed was calculated by the ratio of this figure to the process time.

Table 7 shows the product output rates of fig and date in decanter separator trial. These are the amounts of molasses at the end of the process. The ratio of product output rate to raw material input rate shows the yield of the fruit in the trial performed.

Table 8 shows the unit costs. The power cost was assumed as TL 0.05 for 1 kg molasses in calculation of unit cost. In addition, the coal spent for 1 kg molasses was calculated as 0.57 kg and 1 kg coal was calculated over TL 0.47. The average personnel cost was taken as the average monthly cost of shift officers and maintenance/repair officers involved as part of the project. The unit costs were calculated by use of the cost of 1 kg molasses and the amount of molasses produced in the trial.

The unit costs of the decanter trial show that the increase in water temperature, enzyme dose, fruit rate and decanter feed rate for the fig and date resulted in decrease in unit costs. The unit cost values decreased from TL 1.105 TL kg^{-1} to TL 0.563 kg^{-1} in fig and from TL 0.929 kg^{-1} to TL 0.458 kg^{-1} in date.

Table 6. Results of decanter separator trials on fig and date
Çizelge 6. İncir ve hurma dekantör-seperator deneme sonuçları

		2 tons/hour^{-1} (*ton/saat*)			3 tons/hour^{-1} (*ton/saat*)		
	Temperature *Sıcaklık* (°C)	Raw material input rate (kg/hour) *Hammadde çıktı hızı (kg/saat)*	Process time (hour) *Proses süresi (saat)*	Energy consumed (capita/hour) *Harcanan enerji (adam/saat)*	Raw material input rate (kg/hour) *Hammadde çıktı hızı (kg/saat)*	Process time (hour) *Proses süresi (saat)*	Energy consumed (capita/hour) *Harcanan enerji (adam/saat)*
50 g ton^{-1}	45	133.3	6	0.67	171.3	4.67	0.86
Enzyme, Fruit	45	267	6	0.67	343	4.67	0.86
Enzim, Meyve	45	400	6	0.67	514	4.67	0.86
75 g ton^{-1}	45	133.3	6	0.67	171.3	4.67	0.86
Enzyme, Fruit	45	267	6	0.67	343	4.67	0.86
Enzim, Meyve	45	400	6	0.67	514	4.67	0.86
50 g ton^{-1}	50	133.3	6	0.67	171.3	4.67	0.86
Enzyme, Fruit	50	267	6	0.67	343	4.67	0.86
Enzim, Meyve	50	400	6	0.67	514	4.67	0.86
75 g ton^{-1}	50	133.3	6	0.67	171.3	4.67	0.86
Enzyme, Fruit	50	267	6	0.67	343	4.67	0.86
Enzim, Meyve	50	400	6	0.67	514	4.67	0.86

Table 7. The product output rates in decanter separator trials on fig and date
Çizelge 7. İncir ve hurma dekantör-seperator deneme ürün çıktı hızları

Product Output Rate (kg hour^{-1}) *Ürün Çıktı Hızı (kg saat^{-1})*	Temperature *Sıcaklık* (°C)	2 tons/hour^{-1} (*ton/saat*)		3 tons/hour^{-1} (*ton/saat*)	
		Fig *İncir*	Date *Hurma*	Fig *İncir*	Date *Hurma*
50 g ton^{-1}	45	38	49	43	61
Enzyme, Fruit	45	60	88	72	108
Enzim, Meyve	45	75	117	93	148
75 g ton^{-1}	45	43	54	44	65
Enzyme, Fruit	45	67	98	77	123
Enzim, Meyve	45	90	133	105	166
50 g ton^{-1}	50	41	59	47	74
Enzyme, Fruit	50	69	108	81	130
Enzim, Meyve	50	95	157	116	190
75 g ton^{-1}	50	41	64	50	79
Enzyme, Fruit	50	73	119	86	143
Enzim, Meyve	50	100	172	122	214

Table 8. Unit costs in decanter separator trials on fig and date
Çizelge 8. İncir ve hurma dekantör-seperator deneme birim maliyetleri

Unit Costs *Birim Maliyetleri* (TL kg^{-1})	Temperature *Sıcaklık* (°C)	2 tons/hour^{-1} (*ton/saat*)		3 tons/hour^{-1} (*ton/saat*)	
		Fig *İncir*	Date *Hurma*	Fig *İncir*	Date *Hurma*
50 g ton^{-1}	45	1.105	0.929	1.016	0.811
Enzyme	45	0.817	0.659	0.735	0.595
Enzim	45	0.718	0.574	0.640	0.521
75 g ton^{-1}	45	1.016	0.873	0.998	0.781
Enzyme	45	0.766	0.624	0.706	0.562
Enzim	45	0.652	0.544	0.604	0.499
50 g ton^{-1}	50	1.049	0.828	0.957	0.723
Enzyme	50	0.754	0.596	0.687	0.549
Enzim	50	0.633	0.508	0.576	0.476
75 g ton^{-1}	50	1.049	0.786	0.916	0.697
Enzyme	50	0.728	0.570	0.667	0.527
Enzim	50	0.617	0.492	0.563	0.458

Horizontal extraction processing technique

Changes in the quality parameters of horizontal extraction processing technique for fig and date molasses are given in Table 9. The results of trials are shown in Table 10. The product output rates are given in Table 11 and the unit costs are shown in Table 12.

The results of the trials performed on fruit particle sizes and mashed and non-mashed fruits showed that horizontal extraction system was not suitable for processing mashed fruits. The mashed fruits block the pores of the system and fruit juice cannot be obtained (Table 10).

The trials were performed for fig and date at pilot plant level. The water temperatures used in these trials were 50°C, 55°C and 60°C. The amount of fruits used in the trials was 1250 and 2000 kg. The extraction times used were 20, 25 and 30 minutes. The effect of particle size on extraction was measured by trials of mashed and non-mashed fruits. Pomace brix and turbidity of the must obtained were measured. HMF, ash, sediment and microbiology analyses were performed on the molasses obtained from this must. The results of the trial are shown in Table 10.

The pomace brix and turbidity of the must obtained were measured. HMF, ash, sediment and microbiology analyses were performed on the molasses obtained from this must. The raw material input rate, product output rate, process time, level of energy consumed and cost values were calculated. Firstly, the compliance of the molasses with the codex and then the cost lowness was taken into consideration when determining the optimum values. In addition, the raw material input rate and product output rate are requested to be high, while the process time, the energy consumed and the cost are requested to be low.

Table 9. Results of horizontal extraction trials on fig and date
Çizelge 9. İncir ve hurma yatay ekstraksiyon deneme sonuçları

	Temperature *Sıcaklık* (°C)	Pomace *Tortu* (brix)	Must turbidity *Şıra bulanıklığı*	HMF (g kg^{-1})	Ash *Kül* (%)	Sediment *Tortu*	Microbiology *Mikrobiyoloji* (Cfu g^{-1})	
							Mesophile *Mezofil*	Mold *Küf*
20 minute / *dakika*								
1250 kg Fig, Non-mashed *İncir, Ezilmemiş*	50	6.0	3+	26	1.68	3+	6470	114
	55	5.1	2+	28	1.80	3+	3015	68
	60	4.9	2+	36	1.84	2+	1830	33
2000 kg Fig, Non-mashed *İncir, Ezilmemiş*	50	10.9	3+	31	1.74	3+	6580	102
	55	10.2	3+	36	1.92	2+	3370	70
	60	10.2	2+	42	1.90	2+	2040	38
1250 kg Date, Non-mashed *Hurma, Ezilmemiş*	50	9.5	5+	48	2.00	4+	7360	84
	55	8.7	4+	52	2.10	4+	4230	66
	60	8.6	4+	68	2.24	3+	3075	48
2000 kg Date, Non-mashed *Hurma, Ezilmemiş*	50	11.8	5+	50	2.06	5+	7520	98
	55	10.4	5+	54	2.13	4+	4380	77
	60	10.4	4+	72	2.20	4+	3170	46
25 minute / *dakika*								
1250 kg Fig, Non-mashed *İncir, Ezilmemiş*	50	5.1	3+	28	1.73	2+	6910	122
	55	4.8	2+	30	1.84	2+	3310	73
	60	4.6	2+	36	1.87	2+	1970	38
2000 kg Fig, Non-mashed *İncir, Ezilmemiş*	50	8.7	3+	36	1.88	3+	7150	10
	55	8.5		37	1.94	2+	3820	77
	60	8.3	2+	53	2.00	2+	2110	41
1250 kg Date, Non-mashed *Hurma, Ezilmemiş*	50	9.1	5+	48	2.08	4+	7710	84
	55	8.5	4+	53	2.11	4+	4250	72
	60	8.5	4+	67	2.28	3+	3120	50
2000 kg Date, Non-mashed *Hurma, Ezilmemiş*	50	10.8	5+	52	2.09	5+	7780	105
	55	10.2	5+	56	2.15	4+	4750	82
	60							
30 minute / *dakika*								
1250 kg Fig, Non-mashed *İncir, Ezilmemiş*	50	4.9	3+	30	1.75	2+	7360	128
	55	4.6	2+	34	1.84	2+	3450	75
	60	4.5	2+	40	1.91	2+	2030	36
2000 kg Fig, Non-mashed *İncir, Ezilmemiş*	50	8.1	3+	36	1.88	3+	7240	120
	55	7.8	3+	40	1.97	2+	4010	83
	60	7.5	2+	58	2.10	2+	2220	44
1250 kg Date, Non-mashed *Hurma, Ezilmemiş*	50	8.8	5+	50	2.10	4+	8120	92
	55	8.4	4+	54	2.12	4+	4230	68
	60	8.3	4+	68	2.33	3+	3340	48
2000 kg Date, non-mashed *Hurma, Ezilmemiş*	50	10.2	5+	53	2.13	5+	7690	108
	55	9.8	5+	58	2.18	4+	4760	84
	60	9.6	4+	84	2.30	4+	3280	49

The results of the date showed that the must turbidity and sediment were higher than the desired in the trials performed at a water temperature of 50°C and 55°C, as well as 60°C with 2000 kg fruits. In addition, HMF value was close to or higher than legal upper limit in the trials performed at 60°C. Among the trials with the lowest sediment value, the trial with the highest product output rate and lowest cost was considered to ensure optimum parameters in horizontal extraction for date with a water temperature of 55°C, 1250 kg non-mashed fruit and an extraction time of 20 minutes (Table 9).

For fig, the must turbidity and sediment values were higher than the desired in the trials performed at a water temperature of 50°C and 55°C with 2000 kg fruits. The sediment value was also high in the trial performed at a water temperature of 55°C with 1250 kg fruits and an extraction time of 20 minutes. The trial with the suitable analysis values was the trial with the highest product output rate and lowest cost, which was performed at a water temperature of

55°C with 1250 kg non-mashed fruits and extraction time of 25 minutes and these values were determined as optimum parameters for fig in horizontal extraction technique.

Table 10 shows the yield of horizontal extraction trials. The calculation of process time was based on the extraction time and the time for feeding of the fruit to the system was added. The raw material input rate was calculated according to the amount of fruit used. In the horizontal extraction trial, since 3 personnel worked throughout the trial, the energy consumed was calculated by the ratio of this figure to the process time.

Table 11 shows the product output rates of horizontal extraction trial. These are the amounts of molasses at the end of the process. The ratio of product output rate to raw material input rate shows the yield of the fruit in the trial performed.

Table 10. Results of horizontal extraction trials on fig and date
Çizelge 10. İncir ve hurma yatay ekstraksiyon deneme sonuçları

	Temperature *Sıcaklık* (°C)	20 minute / *dakika*			25 minute / *dakika*			30 minute / *dakika*		
		Raw material input rate (kg/hour) *Hammadde girdi hızı (kg/saat)*	Process time (hour) *Proses süresi (saat)*	Energy consumed (capita/hour) *Enerji tüketimi (adam/saat)*	Raw material input rate (kg/hour) *Hammadde girdi hızı (kg/saat)*	Process time (hour) *Proses süresi (saat)*	Energy consumed (capita/hour) *Enerji tüketimi (adam/saat)*	Raw material input rate (kg/hour) *Hammadde girdi hızı (kg/saat)*	Process time (hour) *Proses süresi (saat)*	Energy consumed (capita/hour) *Enerji tüketimi (adam/saat)*
1250 kg	50	417	3	1	385	3.25	0.92	357	3.5	0.86
Fruits	55	417	3	1	385	3.25	0.92	357	3.5	0.86
Meyve	60	417	3	1	385	3.25	0.92	357	3.5	0.86
2000 kg	50	667	3	1	615	3.25	0.92	571	3.5	0.86
Fruits	55	667	3	1	615	3.25	0.92	571	3.5	0.86
Meyve	60	667	3	1	615	3.25	0.92	571	3.5	0.86

Table 11. The product output rates in horizontal extraction trials on fig and date
Çizelge 11. İncir ve hurma yatay ekstraksiyon deneme ürün çıktı hızları

Product Output Rate (kg hour^{-1}) *Ürün Çıktı Hızı (kg saat^{-1})*	Temperature *Sıcaklık* (°C)	20 minute / *dakika*		25 minute / *dakika*		30 minute / *dakika*	
		Fig *İncir*	Date *Hurma*	Fig *İncir*	Date *Hurma*	Fig *İncir*	Date *Hurma*
1250 kg	50	188	254	204	246	196	232
Non-mashed	55	221	275	215	262	211	246
Ezilmemiş	60	229	279	227	262	214	250
2000 kg	50	167	327	191	332	189	326
Non-mashed	55	173	373	197	351	200	337
Ezilmemiş	60	173	373	203	357	206	343

Table 12. Unit costs in horizontal extraction trials on fig and date
Çizelge 12. İncir ve hurma yatay ekstraksiyon deneme birim maliyetleri

Unit Costs *Birim Maliyetler* (TL/kg)	Temperature *Sıcaklık* (°C)	20 minute / *dakika*		25 minute / *dakika*		30 minute / *dakika*	
		Fig *İncir*	Date *Hurma*	Fig *İncir*	Date *Hurma*	Fig *İncir*	Date *Hurma*
1250 kg	50	0.345	0.337	0.342	0.338	0.343	0.339
Non-mashed	55	0.341	0.336	0.341	0.337	0.342	0.338
Ezilmemiş	60	0.340	0.336	0.340	0.337	0.341	0.338
2000 kg	50	0.348	0.333	0.344	0.333	0.344	0.333
Non-mashed	55	0.347	0.331	0.343	0.332	0.343	0.333
Ezilmemiş	60	0.347	0.331	0.343	0.332	0.342	0.332

The trials were performed for fig and date at pilot plant level. The water temperatures used in these trials were 50°C, 55°C and 60°C. The amount of fruits used in the trials was 1250 and 2000 kg. The extraction times used were 20, 25 and 30 minutes. The effect of particle size on extraction was measured by trials on non-mashed fruits. As a result of the trials performed on fruit particle sizes with mashed fruits, it was seen that horizontal extraction system was not suitable for mashed fruit since the mashed fruit in the horizontal extraction system blocked the pores of the system and fruit juice could not be obtained (Table 11).

Table 12 shows the unit costs. The power cost was assumed as TL 0.05 for 1 kg molasses in calculation of unit cost. In addition, the coal spent for 1 kg molasses was calculated as 0.57 kg and 1 kg coal was calculated over TL 0.47. The average personnel cost was taken as the average monthly cost of shift officers and maintenance/repair officers involved as part of the project. The unit costs were calculated by use of the cost of 1 kg molasses and the amount of molasses produced in the trial. The unit cost values decreased from TL 0.348 TL kg^{-1} to TL 0.340 kg^{-1} in fig and from TL 0.339 kg^{-1} to TL 0.331 kg^{-1} in date.

CONCLUSION

It has been shown that extraction conditions such as water temperature, fruit amount, fruit: water ratio, time and enzyme amount beside the feed rate and capacity of the machine used play an important role on the quality in production of molasses from fig and date by use of battery, press, decanter separator and horizontal press processing techniques at pilot plant level.

It is possible to produce molasses by various techniques; however, the quality parameters set forth in Turkish Food Codex should be followed and a cost analysis based on raw material input rate, product output rate, process time, the energy consumed should be carried out for determination of the best method and optimum conditions. Within the scope of this study, it has been determined that it is sufficient to check whether the pomace brix, turbidity and sediment amount as must quality parameters in the production of fig and date molasses and HMF, mineral substance, sediment and microbiological analysis in the production of fig and date molasses comply with the limit values set forth in codex or not.

It was shown that the optimum conditions determined in this study vary depending on the molasses production techniques used. Decanter separator processing technique was found to be the best method for production of fig and date molasses.

However, it was concluded that it is sufficient to use the battery, press, decanter-separator and horizontal press processing techniques in the production of fig and date molasses and that it is better to use the filtration techniques in combination after production of must and molasses.

ACKNOWLEDGEMENTS

This study was supported by the Scientific and Technological Research Council of Turkey (TUBITAK), Technology and Innovation Funding Programs Directorate (TEYDEB) as part of the project "Optimization of Parameters for Molasses Processing from Various Fruits" numbered 3130522. We would like to thank TUBITAK and SEMAS Gida Sanai for their support.

REFERENCES

1. Akıncı, I., F. Özdemir, A. Topuz, O. Kabas and M. Çanakçı, 2004. Some physical and nutritional properties of *Juniperus drupacea* fruits. *Journal of Food Engineering, 65:325-331.*
2. Aktürk, Z., 2012. Besin değeri ve sağlık açısından hurma (*Phoenix dactylifera*). *Konuralp Tip Dergisi, 4(3):62-68.*
3. Alasalvar, C., M. Al-Farsi and F. Shahidi, 2005. Compositional characteristics and antioxidant components of cherry laurel varieties and pekmez. *Journal of Food Science, 70(1):47-52.*
4. Al-Hooti, S., J.S. Sıdhu and H. Qabazard, 1997. Physicochemical characteristics of five date fruit cultivars grown in the United Arab Emirates. *Plant Foods for Human Nutrition, 50:101-113.*
5. Anonymous, 1962. Determination of ash. *IFJU Analyses No:9, 2p.*
6. Anonymous, 1972. Determination of hydroxymethylfulfural (HMF). *IFFJP Analyses No:12, 4p.*
7. Anonymous, 1989. Grape molasses standard TS.3792. *Turkish Standards Institution (TSE), Ankara.*

8. Anonymous, 1996. Mulberry molasses standard TS.12001. *Turkish Standards Institution (TSE), Ankara.*
9. Anonymous, 1997. Fig molasses standard TS.12292. *Turkish Standards Institution (TSE), Ankara.*
10. Anonymous, 2016. Carob molasses standard TS.13717. *Turkish Standards Institution (TSE), Ankara.*
11. Artık, N., E. Poyrazoğlu ve A. Şimsek, 2007. Üzüm pekmezi, zile pekmezi ve pestil üretimi. *Ministry of Agriculture and Rural Affairs, Department of Publication, Publication Serial No: Gıda Serisi-9, Ankara.*
12. Batu, A., 2005. Production of liquid and white solid pekmez in Turkey. *Journal of Food Quality, 28(5-6):417-427.*
13. Cemeroğlu, B., 2010. Gıda analizleri. *Gıda Teknolojisi Derneği Yayın No: 34, Ankara, 657s.*
14. Çakmak, B., H.Z. Can, R.C. Akdeniz, F.N. Alayunt ve U. Aksoy, 2007. Taze incirin taşınması sırasında paketleme özelliklerinin kalite kayıpları üzerine etkisi. *Ege Üniversitesi Ziraat Fakültesi Dergisi, 44(1):123-135.*
15. Evrendilek, G.A., 2017. Journal of Nutrition Food Sciences.
16. Inan, O., D. Arslan, S. Tasdemir and M.M. Ozcan, 2011. Application of fuzzy expert system approach on prediction of some quality characteristics of grape juice concentrate (pekmez) after different heat treatments. *Journal of Food Science and Technology, 48(4):423-431.*
17. Karababa, E. and N. Develi Işıklı, 2005. Pekmez: a traditional concentrated fruit product. *Food Reviews International, 21(4):357-366.*
18. Kaya, C., M. Yıldız, I. Hayoğlu ve O. Kola, 2005. Pekmez üretim teknikleri. *GAP VI. Tarım Kongresi, 1482-1490. 21-23 Eylül 2005, Şanlıurfa.*
19. Kayahan, M., 1982. Üzüm şırasının pekmeze işlenmesinde meydana gelen terkip değişmeleri üzerinde araştırmalar. Ankara Üniversitesi Ziraat Fakültesi Yayın No: 797, 75s.
20. Kayahan, M., 1998. Pekmez teknolojisi. Gıda Denetçisi Eğitim Materyali, T.C. Sağlık Bakanlığı Temel Sağlık Hizmetleri Genel Müdürlüğü, Ankara, s:389-397.
21. Koca, I., A.F. Koca, B. Karadeniz ve H. Yolcu, 2007. Karadeniz bölgesinde üretilen bazı pekmez çeşitlerinin fiziksel ve kimyasal özellikleri. *Gıda Teknolojileri Elektronik Dergisi, 2:1-6.*
22. Kolaylı, S., M. Kücük, C. Duran, F. Candan and B. Dinçer, 2003. Chemical and antioxidant properties of *Laurocerasus officinalis* Roem. fruit grown in the Black Sea Region. *Journal of Agricultural and Food Chemistry, 51:7489-7494.*
23. Özbey, A., N. Öncül, K. Erdoğan, Z. Yıldırım ve M. Yıldırım, 2013. Tokat yöresinde üretilen çalma pekmezin bazı fiziksel, kimyasal ve mikrobiyolojik özellikleri. *Akademik Gıda, 11(1):46-52.*
24. Solomon, A., S. Golubowicz, Z. Yablowicz, S. Grossman, M. Bergman, H.E. Gottlieb and M.A. Flaishman, 2006. Antioxidant activities and anthocyanin content of fresh fruits of common fig (*Ficus carica* L.). *Journal of Agricultural and Food Chemistry, 54(20):7717-7723.*
25. Şimsek, A. ve N. Artık, 2002. Değişik meyvelerden üretilen pekmezlerin bileşim unsurları üzerine araştırma. *Gıda, 27(6):459-467.*
26. Şimşek, A., N. Artık and E. Başpınar, 2004. Detection of raisin concentrate (pekmez) adulteration by regression analyses method. *Journal of Food Composition and Analysis 17:155-163.*
27. Uçar, A., 2008. Geleneksel Türk tadı: pekmez. *38. ICANAS Bildiriler, Maddi Kültür, III. Cilt, Atatürk Kültür, Dil ve Tarih Yüksek Kurumu, Uluslararası Asya ve Kuzey Afrika Çalışmaları Kongresi, Ankara, s:1383-1397.*