

## **Determination of the Standards of Pomegranate Sour obtained from Hejaz Pomegranate and Katırbaşı Pomegranate Varieties Grown in Hatay Province**

### **Hatay İlinde Yetiştirilen Hicaz Nar ve Katırbaşı Nar Çeşitlerinden Elde Edilen Nar Ekşilerinin Standartlarının Belirlenmesi**

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#### **Özet**

Bu çalışmada, Hatay ilinde geleneksel yöntemlerle açık atmosfer koşullarında üretilen nar ekşilerinin bazı kalite parametreleri değerlendirilmiştir. Üretimde Hicaz ve Katırbaşı nar çeşitlerine ait taze meyveler kullanılmış, elde edilen ürünler cam kavanozlarda ışık almayan bir ortamda muhafaza edilmiştir. Nar ekşilerinin standartlarını belirlemek amacıyla pH, suda çözünür kuru madde, toplam kuru madde, titre edilebilir asit, glukoz/fruktoz/sakkaroz tayini, hidroksimetilfurfural (HMF) düzeyi ve duyuşal özellikler analiz edilmiştir. Elde edilen bulgular, HMF içeriğinin Türk Standartları Enstitüsü TS 4953 standardında belirtilen maksimum limit değeri olan 50 mg/kg'ın üzerinde olduğunu ortaya koymuştur. Bu nedenle, açık atmosferde geleneksel yöntemle üretilen nar ekşilerinin tüketime sunulmadan önce üretim koşullarının iyileştirilmesi gerektiği vurgulanmaktadır.

**Anahtar kelimeler:** Nar ekşisi, HMF, Geleneksel üretim

#### **Abstract**

In this study, certain quality parameters of pomegranate molasses traditionally produced under open-atmosphere conditions in Hatay province were evaluated. Fresh fruits of Hejaz pomegranate and Katırbaşı pomegranate varieties were used in production, and the resulting products were stored in glass jars in a dark environment. To determine the standards of the pomegranate molasses, analyses were conducted for pH, water-soluble dry matter, total dry matter, titratable acidity, glucose/fructose/sucrose content, hydroxymethylfurfural (HMF) levels, and sensory characteristics. The findings revealed that the HMF content exceeded the maximum limit of 50 mg/kg as defined by the Turkish Standards Institute TS 4953. Therefore, it is emphasized that production conditions must be improved before traditionally produced pomegranate molasses is offered for consumption.

**Keywords:** Pomegranate molasses, HMF, Traditional production

#### **1. Introduction**

Throughout history, the pomegranate (*Punica granatum* L.), a significant fruit species that can thrive in both tropical and

subtropical climates, has been used for both culinary and cultural purposes. This fruit's natural distribution areas include the

Mediterranean basin, which includes Turkey [1]. Pomegranate fruit is regarded as a component of a healthy diet and has beneficial effects on the immune system because of its high antioxidant capacity and rich phenolic content [2]. Fresh and processed varieties of superfoods, like pomegranates, have proliferated in the global market in recent years due to the growing demand for healthful products [3]. With the increasing interest in healthy products, both fresh and processed forms of superfoods such as pomegranate have become widespread in the international market in recent years [3].

Hejaz and Katırbaşı are important pomegranate varieties that are grown extensively in Turkey for both export and domestic consumption. Hejaz pomegranates are widely grown, particularly in the Mediterranean and Aegean regions, and are known for their red skin and grain color, high yield, and high market value [4]. In contrast, the Katırbaşı pomegranate is a popular variety in the region that has larger grains and a rich, sweet-sour balance.

These two species directly affect the quality of the final product after processing and are frequently utilized in the creation of traditional pomegranate products [5].

Turkey's Mediterranean and Southeastern Anatolian cuisines make extensive use of pomegranate syrup, a traditional product. Pomegranate syrup, which is obtained by boiling fresh pomegranate juice in an open atmosphere without additives, is preferred as a flavor enhancer in dishes thanks to its unique aroma, high dry matter, and acid content [6]. Traditional production methods generally refer to household production methods and industrial standards such as temperature control cannot be applied in these methods. This is effective in increasing the chemical composition of the product and especially the level of components formed by heat treatments such as HMF [7].

According to 2023 data from the Turkish Statistical Institute (TurkStat), pomegranate production in Turkey reached 647.676 tons in 2021. A significant portion of this production is provided by the Mediterranean region, and Hatay province is at the forefront with an average production of 24.411 tons [8]. In the same years, pomegranate consumption per capita reached 5 kg. When the production data by region are analyzed, it is seen that the climatic and geographical advantages of the Hatay region offer favorable conditions for pomegranate cultivation. This directly affects the quality characteristics of pomegranate species in the region.

Scientific research on pomegranate and pomegranate syrup provides important findings on the content, quality criteria and health effects of these products. For example, İncedayı et al. [9] analyzed the reducing sugar, protein, total sugar, and total polyphenol contents of pomegranate syrups of different brands in the market and stated that there were significant differences between the products. Vatansever (2018) [10] reported that the amount of HMF in industrially produced pomegranate products ranged between 9.20 and 479.63 mg/kg and some samples were well above the legal limits. In another study conducted by Oğuz (2021) [11], pomegranate sour produced by traditional and modern methods were compared and it was found that the production method played a decisive role on the antioxidant capacity and chemical content. Additionally, Eyigün (2012) [7] demonstrated that the storage process reduced antioxidant activity and increased HMF formation.

According to these studies, the quality of pomegranate sour is greatly influenced by factors like temperature, time, and the kind of pomegranate used in the production process.

The purpose of this study is to assess the physical, chemical, and sensory characteristics of Hejaz and Katırbaşı pomegranate sour made in Hatay province using traditional methods and to determine whether they meet the requirements set forth by the Turkish Standards Institute (TS 4953).

The thorough comparative analysis of pomegranate syrups made from these two pomegranate varieties using conventional techniques is not well documented in the literature. In this respect, the study both contributes to the standardization of Hatay local products and provides a data basis for the improvement of production techniques by drawing attention to the presence of compounds such as HMF that may pose a risk to consumer health [12].

## 2. Method

In this study, Hecaznar and Katırbaşı pomegranate varieties obtained from Hatay province were used as material. Images of the pomegranate varieties used in the study are given in Figure 1 and Figure 2. Pomegranate syrup was produced by processing pomegranate fruits with traditional production techniques. In the production process; the fruits were washed, their seeds were separated, crushed and their water was extracted and the pomegranate syrup was produced by thickening in the open air at 103°C under atmospheric pressure in a 50 cm diameter steel pot. A simple heater mechanism working with bottled gas was used as the heat source. The pomegranate syrup production scheme is given in Figure 3. The obtained pomegranate syrups were filled into glass jars, packaged and stored in Hatay at room temperature (25°C) and in an environment away from light.

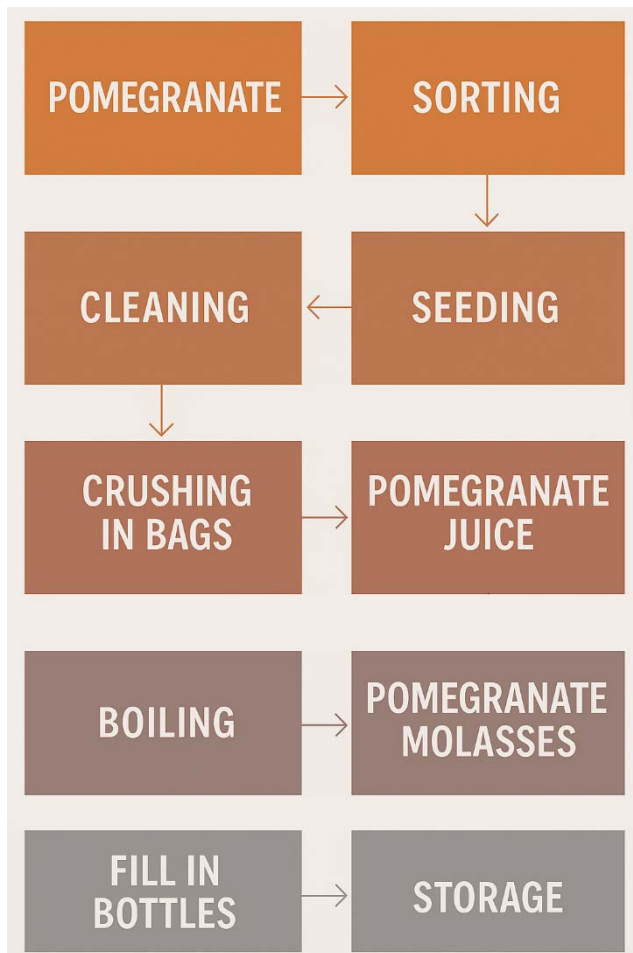


**Figure 1.** Hejaz pomegranate variety



**Figure 2.** Katırbaşı pomegranate variety

Total dry matter, color (by reflectance method), pH, sugar profile (glucose, fructose, sucrose), titratable acidity, HMF and sensory analysis were performed on two different pomegranate sour samples. All analyses were performed in triplicate.



**Figure 3.** Stages of pomegranate syrup production using traditional methods

### 2.1. Determination of Water-Soluble Dry Matter

The water-soluble dry matter values of pomegranate syrup samples were determined using a handheld refractometer modeled after the method of Kara and Toplu (2022) [13].

### 2.2. Total dry matter determination

The total dry matter content in pomegranate syrup samples was determined using the method described by AOAC (1990) [14]. The samples were dried in a vacuum oven at 70°C temperature and under 100 mmHg pressure and the total dry matter values were expressed as percent dry matter

### 2.3. Reflectance color determination

While determining the color properties of pomegranate syrup samples, the study conducted by Kovuk et al. (2024) [15] was taken as reference. Color determination device CR-400, Konica Minolta, Inc., Osaka, Japan was used for color determination. In addition, C and hue values of the samples were measured.

### 2.4. Titratable Acidity (TEA) Amount

The titratable acid content of pomegranate sour samples was calculated in terms of citric acid [16].

### 2.5. pH value

The pH values of the samples were measured using a digital pH meter (WTW Series pH 720, Weilheim, Germany).

### 2.6. Glucose/Fructose/Sucrose determination

Glucose, fructose and sucrose determination was based on the method of Mazi et al. (2012) [17]. In HPLC; 80% acetonitrile was prepared as mobile phase. Flow rate was 1.3 mL/min, injection volume was 15 µL and column temperature was 30 ± 1 °C. Sugar amounts were expressed as g/100 g.

### 2.7. Determination of Hydroxymethylfurfural

HMF determination was performed according to Hardt-Stremayr et al. (2012) [18] 90% methanol was used as mobile phase. HPLC conditions were 1.0 mL/min flow rate, 285 nm wavelength.

### 2.8. Sensory analysis

Pomegranate sour samples were evaluated by a panelist group of 10 people using the 'hedonic scale' according to the Sensory Evaluation Form given in Annex-1 [19].

### 2.9. Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics 27.0.1 statistical package program. Tukey multiple comparison test was used to compare the means of the samples. Statistical analysis of sensory evaluation was performed using Kruskal-Wallis test.

## 3. Results and Discussion

In this study, the physicochemical and chemical properties of pomegranate sour obtained by traditional method from Hejaz and Katırbaşı species grown in

Hatay province were analyzed and the results of the analysis are given in Table 1, color analysis results are given in Table 2 and sensory evaluation results are given in Table 3. The data obtained were compared with the existing literature.

**Table 1.** Analysis results and significance levels of Hejaz and Katırbaşı pomegranate syrups

|                                   | Hejaz<br>Pomegranate<br>Sour   | Katırbaşı<br>Pomegranate<br>Sour | Significance<br>Level<br>( $p < 0.05$ ) |
|-----------------------------------|--------------------------------|----------------------------------|-----------------------------------------|
| Water-Soluble<br>Dried Matter (%) | 71.64 $\pm$ 0.03 <sup>b</sup>  | 75.70 $\pm$ 0.02 <sup>a</sup>    | *                                       |
| Total Soot (%)                    | 75.26 $\pm$ 0.02 <sup>b</sup>  | 79.68 $\pm$ 0.02 <sup>a</sup>    | *                                       |
| TEA (%)                           | 11.99 $\pm$ 0.02 <sup>a</sup>  | 6.66 $\pm$ 0.03 <sup>b</sup>     | *                                       |
| pH                                | 3.01 $\pm$ 0.02 <sup>b</sup>   | 3.41 $\pm$ 0.02 <sup>a</sup>     | *                                       |
| Glucose (g/100g)                  | 3.65 $\pm$ 0.01 <sup>b</sup>   | 4.54 $\pm$ 0.01 <sup>a</sup>     | *                                       |
| Fructose (g/100g)                 | 4.63 $\pm$ 0.01 <sup>b</sup>   | 5.56 $\pm$ 0.01 <sup>a</sup>     | *                                       |
| Sucrose (g/100g)                  | Not found                      | Not found                        | -                                       |
| HMF (mg/kg)                       | 182.73 $\pm$ 0.05 <sup>a</sup> | 84.28 $\pm$ 0.03 <sup>b</sup>    | *                                       |

(Different letters in the same row indicate a statistical difference ( $p < 0.05$ ))

**Table 2.** Color analysis results of Hejaz and Katırbaşı pomegranate sour

|                         | Hejaz<br>Pomegranate<br>Sour  | Katırbaşı<br>Pomegranate<br>Sour | Significance<br>Level<br>( $p < 0.05$ ) |
|-------------------------|-------------------------------|----------------------------------|-----------------------------------------|
| <i>L</i> *              | 22.45 $\pm$ 0.14 <sup>b</sup> | 25.76 $\pm$ 0.08 <sup>a</sup>    | *                                       |
| <i>a</i> *              | 5.37 $\pm$ 0.11 <sup>a</sup>  | 5.08 $\pm$ 0.06 <sup>b</sup>     | *                                       |
| <i>b</i> *              | 1.24 $\pm$ 0.09 <sup>b</sup>  | 2.43 $\pm$ 0.06 <sup>a</sup>     | *                                       |
| <i>C</i>                | 5.51 $\pm$ 0.08 <sup>b</sup>  | 5.64 $\pm$ 0.11 <sup>a</sup>     | *                                       |
| Hue Angle ( $h^\circ$ ) | 13.00 $\pm$ 0.35 <sup>b</sup> | 25.31 $\pm$ 0.48 <sup>a</sup>    | *                                       |

(Different letters in the same row indicate a statistical difference ( $p < 0.05$ ))

**Table 3.** Sensory analysis results of Hejaz and Katırbaşı pomegranate syrups

|                | TS89           | TS14           |
|----------------|----------------|----------------|
| Color          | 8 $\pm$ 0.67   | 7.9 $\pm$ 0.32 |
| Appearance     | 8.9 $\pm$ 0.32 | 8.4 $\pm$ 0.70 |
| Taste          | 7.5 $\pm$ 0.85 | 6.7 $\pm$ 0.82 |
| Odor           | 7.4 $\pm$ 0.52 | 7.2 $\pm$ 0.63 |
| Consistency    | 7.4 $\pm$ 0.84 | 7.5 $\pm$ 0.71 |
| Overall Rating | 7.84           | 7.54           |

(TS89: Hejaz pomegranate syrup; TS14: Katırbaşı pomegranate syrup)

(There is no statistical difference between the samples in the same row ( $p > 0.05$ ))

Water-soluble dry matter (Brix) values were measured as 71.64% in Hejaz pomegranate sour and 75.70% in Katırbaşı pomegranate sour. These values are well above the minimum 40% limit specified in TS 4953 standard [12] and indicate that the products have concentrated properties. When compared with the water-soluble dry matter values in the range of 60-70% reported by Vardin and Abbasoğlu (2004) [5] it is understood that the findings in our study are parallel to the literature.

Total dry matter content was found to be 75.26% in Hejaz pomegranate sour and 79.68% in Katırbaşı pomegranate sour. These results are similar to the 70-80% total dry matter range reported by İncedayı et al. (2010) [9]. It is thought that the higher dry matter content of the Katırbaşı type may be due to the differences in the internal structure of the pomegranate type used and the heat treatment time.

Hejaz pomegranate sour had a pH of 3.01, while Katırbaşı pomegranate sour had a pH of 3.41. These numbers demonstrate that the naturally acidic structure of pomegranate syrup is preserved. The data in our study are consistent with the pH values between 2.85 and 3.53 found in Vatansever's (2018) [10] study on various brands.

TEA value was found as 11.99% for Hicaz pomegranate syrup and 6.66% for Katırbaşı pomegranate syrup. This result shows that Hicaz pomegranate has a more intense acidic profile. These findings coincide with the TEA values in the range of 6-13% reported by Oğuz (2021) [11]. It has been stated that high TEA levels can positively affect product durability by increasing the sense of sourness and microbial stability.

Hejaz and Katırbaşı pomegranate sour had HMF levels of 182.73 and 84.28 mg/kg, respectively. Both samples exceeded the TS 4953 standard's 50 mg/kg limit value. This indicates that high temperatures were exposed to high temperatures for a long time during production and as a result, Maillard reactions triggered the formation of HMF. Eyigün (2012)[10] and Vatansever (2018)[12] stated that HMF levels are often high in pomegranate syrups produced by the traditional method and due to the lack of control over the temperature-time relationship. Therefore, the high HMF levels obtained in this study are consistent with the risky classifications in the literature [7].

In sugar analysis, glucose 3.65 g/100g and fructose 4.63 g/100g were detected in Hejaz pomegranate syrup; sucrose was not detected. In Katırbaşı pomegranate syrup, glucose was 4.54g/100g, fructose was 5.56g/100g and sucrose was not detected. The fact that the fructose content of both products is higher than that of glucose reflects the natural structure of pomegranate. These values are similar to the fructose-dominated sugar profile reported by İncedayı et al. (2021) [20].

When the sensory analysis results were examined; both pomegranate syrups received high scores in terms of taste, color, consistency and general taste. According to the panelists, Hejaz pomegranate sour had a thicker consistency, but Katırbaşı pomegranate sour had a more balanced flavor. This is comparable to earlier research (Oğuz, 2021) [11] and results from variations in sugar and acid content. In summary, the information gathered indicates that pomegranate sour made using the conventional method has good results in a number of physical and sensory parameters, but it may also be risky, particularly when it comes to the HMF level. Therefore, it is advised that more regulated heat treatment and quality control procedures be used to support traditional production.

#### 4. Conclusion

This study compared the physicochemical and sensory characteristics of pomegranate sour made from Hejaz and Katırbaşı pomegranate varieties grown in Hatay province using traditional methods. The information gathered showed that the pomegranate variety had a substantial impact on quality parameters. In comparison to Hejaz pomegranate syrup, Katırbaşı pomegranate syrup had a higher total dry matter and water-soluble dry matter content ( $p<0.05$ ), suggesting a denser product structure. Hejaz pomegranate syrup was characterized by a higher titratable acidity value ( $p<0.05$ ). Color analysis showed that Katırbaşı samples had a lighter and more saturated color profile ( $p<0.05$ ).

HMF levels in both pomegranate sour samples were well above the maximum limit value of 50 mg/kg specified by the Turkish Standards Institute (TS 4953). This situation reveals the negative effect of prolonged and high temperature heat treatments applied in traditional production. Sensory evaluations also showed that Katırbaşı pomegranate syrup was more highly appreciated in terms of taste, color and aroma, while Hejaz pomegranate syrup stood out in terms of consistency.

In conclusion, although the products obtained from both pomegranate varieties comply with Turkish Standards in terms of many quality parameters, the high HMF content poses a significant risk to public health. Therefore, it is recommended to control the traditional production processes, especially to optimize the heat treatment time and temperature. In addition, it is important to encourage healthy and standardized production through informative activities for producers and consumers.

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#### Conflict of Interest

This study has no conflict of interest. All data in the study were collected with a scientific and objective approach and the results obtained were evaluated in accordance with academic honesty and ethical rules.

#### Similarity rate:

%4

#### Artificial Intelligence Usage rate:

Artificial intelligence was not used in the preparation of the article.

#### Contribution Rate of Researchers

Researchers contributed equally to the study.

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## Annexes

### Annex-1: Sensory analysis evaluation form

#### NAR EKŞİSİ DUYUSAL ANALİZ FORMU

Tarih .../.../...

Panelistin Adı ve Soyadı:

Tarafınıza sunulan 2 farklı nar ekşisi örneklerini aşağıda belirtilen özellikler çerçevesinde 1-9 (1- çok kötü, 9- mükemmel) arasında puanlama yaparak değerlendiriniz.

#### ÖZELLİKLER

|                |                                                                                                   |
|----------------|---------------------------------------------------------------------------------------------------|
| <b>Renk</b>    | Nar ekşisi kendine özgü açık kahverengiden koyu kahverengiye kadar değişebilen renkte olmalıdır.  |
| <b>Görünüş</b> | Nar ekşisi tortusuz olmalı, meyve parçacıkları içermemeli ve tekniğe uygun durultulmuş olmalıdır. |
| <b>Tat</b>     | Nar ekşisinin tadı kendine özgü olmalı, yanık ve yabancı tat bulunmamalıdır.                      |
| <b>Koku</b>    | Nar ekşisine özgü kokuda olmalı, yabancı koku bulunmamalıdır.                                     |
| <b>Kıvam</b>   | Nar ekşisi akışkan kıvamlı olup, sulu bir yapıya sahip olmamalıdır.                               |

| Örnek kodu | Renk | Görünüş | Tat | Koku | Kıvam | Ortalama Puan |
|------------|------|---------|-----|------|-------|---------------|
| TS89       |      |         |     |      |       |               |
| TS14       |      |         |     |      |       |               |

İmza