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PHYSICOCHEMICAL, MICROBIOLOGICAL AND SENSORY PROPERTIES OF RED BEET VINEGAR

KIRMIZI PANCAR SİRKESİNİN FİZİKOKİMYASAL, MİKROBİYOLOJİK VE DUYUSAL ÖZELLİKLERİ

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Abstract

This study determined that physicochemical, microbiological and sensory properties of red beet vinegar. The color values of red beet vinegar were L: 2.55, a*: 1.54 and b*: -0.98. The mean pH, dry matter%, °Brix, ash%, density and conductivity values of vinegar samples were 2.94±0.32, 3.30±0.12, 3.71±0.17, 0.24 ± 0.21, 1.003±0.002 g/cm³ and 2.13 ± 0.042 µS/cm, respectively. The mean antioxidant value of vinegar samples produced from the red beet was 96.14±3.43 µg TE/mL and the total phenolic content was 1170.78±20.95 mg GAE/L. Of the mineral contents, Na was determined to be the highest with 370.94±2.73 ppm, followed by K with 69.13±1.13 ppm, P with 14.5±0.01 ppm and Ca with 10.07±0.42 ppm. Following the fermentation process, the mean acetic bacterial count in vinegar samples was 3.06±0.14 log cfu/mL while the mean lactic acid bacterial count was 2.84±0.09 log cfu/mL and the mean yeast/mold count was 1.09±0.08 log cfu/mL. According to the sensory analysis results, the highest score was determined to be 7.67 ± 0.57 in color score whereas the lowest score was 5.05 ± 0.21 in aroma score. The general appreciation score of the red beet vinegar was 6.75 ± 0.35.*

Keywords: Red beet, Vinegar, Antioxidant, Phenolic compound

Öz

Bu çalışmada; kırmızı pancar sirkesinin fizikokimyasal, mikrobiyolojik ve duyusal özellikleri belirlenmiştir. Kırmızı pancar sirkesinin renk değerleri, L: 2.55, a*: 1.54 ve b*: -0.98 olarak tespit edilmiştir. Sirke örneğinin ortalama pH, % Kuru Madde, °Brix, % kül miktarları, yoğunluk ve iletkenlik değerleri sırasıyla; 2.94±0.32, 3.30±0.12, 3.71±0.17, 0.24±0.21, 1.003±0.002 g/cm3 ve 2.13±0.042 (µS/cm) olarak saptanmıştır. Kırmızı pancardan üretilen sirke örneğinin ortalama antioksidan değerleri 96.14±3.43 µg TE/mL ve toplam fenolik madde miktarları ise 1170.78±20.95 mg GAE/L olarak saptanmıştır. Tespit edilen mineral maddeler arasından en fazla 370.94±2.73 ppm ile Na olduğu, bunu 69.13±1.13 ppm ile K, 14.5±0.01 ppm ile P ve 10.07±0.42 ile de Ca' un izlediği görülmüştür. Fermantasyon sonrasında sirke örneğinde ortalama asetik bakteri sayısı; 3.06±0.14, laktik asit bakteri sayısı; 2.84±0.09 ve maya/küf sayısı; 1.09±0.08log kob/mL olarak belirlenmiştir. Panelistler tarafından yapılan duyusal analiz sonuçlarına göre; en yüksek puanı 7.67±0.57 ile sirkenin rengi alırken en düşük puanı ise, 5.05±0.21'lik değer ile sirkenin aroması almıştır. Kırmızı pancar sirkesinin genel beğeni puanı ise 6.75±0.35 olarak tespit edilmiştir.*

Anahtar Kelimeler: Kırmızı pancar, Sirke, Antioksidan, Fenolik madde

1 Introduction

Vinegar is a natural product, produced by fermenting different agricultural raw materials, containing edible carbohydrate sources to ethyl alcohol by yeasts and then the fermentation of the ethyl alcohol to acetic acid by acetic acid bacteria such as *Acetobacter, Gluconobacter,* and *Gluconacetobacter* [1]-[4].

Vinegar is used not only as a seasoning ingredient but also as a medicine [5],[6]. Depending on the type and composition of the raw material it is produced, vinegar can contain bioactive components in different types, amounts, and proportions. Its effects on health are related to these bioactive components [7]. Today, different kinds of vinegar are produced in the World from different kinds of raw materials including grapes, apples, sugar cane, rice, barley, various fruits and vegetables [8].

Red beet (*Beta vulgaris* var. cruenta) is a flowering root vegetable, belonging to the *Amaranthaceae* family. It is cultivated in regions with mild climates such as the Mediterranean region, Western and Eastern Europe [9]. Color substances, mostly composed of betanin [10] are very rich in terms of betalains [11],[12]. Red beet is widely used as a natural coloring agent in many dairy and meat products (milk, ice cream, yogurt, kefir, sausage, and salami), beverages (fruit juices, carbonated drinks) and confectionery products [13],[14].

Red beet contains high amounts of minerals including K, Mg, Ca. It is also rich in Fe and is a good source of Vitamins B9 (Folate) and C. Red beet contains high levels of citric and malic acid, as well as shikimic acid [15]. Also, it has been reported that it has a very rich folic acid and amino acid content [14].

Betalains have many beneficial biological activities including antioxidant, anti-inflammatory, hepatoprotective and antitumor properties, in addition to red coloration [16],[17]. Red beet antioxidant values are substantially higher compared to those in many similar vegetables [18].

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In this study, it is aimed to determine the physicochemical, microbiological and sensory properties of vinegars made of red beets, which are rich in minerals such as sodium, potassium, phosphorus, and vitamins such as A, B, C, proteins and high antioxidant capacity, as opposed to grape and apple vinegar.

2 Materials and Method

2.1 Materials

The red beets used in the research were obtained from the local markets in Afyonkarahisar. Then, 1000 g samples of red beet were taken and sliced using a knife in 10-cm-sided cubes and placed into glass jars (Şişe Cam, Turkey) (5 L) at 1/3 ratio. For the natural fermentation process, 50 g honey (Özkovan, Turkey) and 1% yeast *Saccharomyces cerevisiae* culture (Dry yeast, Pakmaya, Turkey) were added to the jar. Also, 150 mL additive-free red beet vinegar previously produced with a similar method was added to the jar to form the fermentation conditions. Then, water was added to the jar until the total volume reached 5L. The brim of the jar was closed using a cloth that will allow air intake and the samples were kept in a dark place in the laboratory at 20±2 °C for three months.

At the end of this period, the main vinegar culture gel formed on the surface, sediment and the vinegar was separated from each other by filtration using a coarse filter paper. The filtered vinegar was placed in 500 ml colored-glass bottles and their lids were closed. The bottles were then refrigerated at 4 °C.

2.2 Method

2.2.1 Physicochemical Analyses

The color values of red beet vinegar samples were measured using a Konika Minolta Chromameter (CR-400, Japan) using the CIE LAB system [19]. pH measurements of vinegar samples were carried out using a Hanna HI 2215 pH meter (Germany) [20]. The titrimetric method was adopted to determine the total acidity and the results were given in acetic acid g/L [21]. The °Brix values of the vinegar samples were determined in Brix% by digital refractometer (Atago PAL1, Japan) at room temperature [22]. Dry matter, ash and alcohol content analyses were carried out according to AOAC 930.15, 923.03, 52.03 rescpectively [20]. Density was measured using a pycnometer as described by [23]. Conductivity values were measured in mS/cm using a manual conductivity measuring device (Sension 5 model Hach, CO, USA) [24].

2.2.2 Total Phenolic Content

Total phenolic content was determined by the Folin-Ciocalteu method and the absorbance values were determined using a spectrophotometer (Shimadzu UV-1208, Japan). Results were determined in mg GAE/L [25].

2.2.3 Determination of Antioxidant Activity

For the determination of antioxidant activity, the method used by Molyneux [26] was adopted. Samples diluted with methanol were treated with the DPPH solution, then it was left to stand for thirty minutes at room temperature in the dark. The absorbance values of the samples and the control sample were then read on a spectrophotometer at 517 nm (Shimadzu UV-1208, Japan). The results were expressed in Trolox-equivalent antioxidant capacity (TEAC).

2.2.4 Determination of Mineral Content

ICP-OES (Plasma Quant PQ 9000, Germany) was used for the determination of mineral substances. The samples were burned using acid and heat before their analysis using ICP. Then, 5 mL of vinegar, 5 mL of nitric acid and 2.5 mL of hydrogen peroxide were used to break down the samples taken into Teflon microwave tubes with acid. The combustion was carried out in a microwave combustion unit (Cem Mars 6, USA) [27].

2.2.5 Microbiological Analysis

To determine the acetic acid bacterial counts of the vinegar samples, Yeast Extract Calcium Carbonate Glucose Agar (Himedia, M1182, India) was used. The Petri dishes were incubated in an incubator (Incucell, MMM, Germany) for 5-10 days at 30 °C under aerobic conditions [28]. Lactic acid bacterial counts were determined using de Man Rogosa and Sharpe Agar (MRS) (Merck, 1.10660, Germany) media. The Petri dishes were then taken into the jars (Merck 1.16387), an Anaerocult C (Merck, 116375, Germany) prepared appropriately was added and the jar was incubated in an incubator (Incucell, MMM, Germany) under anaerobic conditions at 30 °C for 24-48 hours [29]. Rose Bengal Chloramphenicol Agar (Merck 1.00467) (RBC) was used to determine the yeast/mold counts and the Petri dishes were incubated for 5-7 days at 22 °C under aerobic conditions [30]. Inoculations were carried out according to the spread plate method.

2.2.6 Sensory Analyses

For the sensory analyses of vinegar samples, a panelist group consisting of 20 faculty members of Afyon Kocatepe University Faculty of Engineering Food Engineering Department and graduate and post-graduate students participated in the sensory evaluations. The 9-point hedonic scale was used in the analyses. The scale was established as; <4 unacceptable, 4-5 bad, 5-6 medium, 6-7 good, 7-8 very good, > 8 perfect [31],[32].

2.2.7 Statistical Analysis

This study was conducted in triplicate, and two parallels were used for each repetition.

3 Results and Discussion

The mean color values of red beet vinegar samples are given in Table 1. The mean L* value of the samples was 2.55, the mean a* value of the samples was 1.54 and the mean b* value of the sampleswas -0.98. Er [33], for the color values of red beet samples subjected to different pre-treatment and drying temperatures, have reported the L* value between 25.86 and 32.26, the a* value between 8.96 and 22.64 and the b* value between 1.91 and 14.27. The values indicated by the researcher were in line with the results of the present study, except for the a* value. The differences in the a* value were related to the differences in the production processes.

Table 1: Color (L*, a* and b*) values of red beet vinegar

Analysis	Value
L* Value	26.55±0,46
a* Value	1.54±0.03
b* Value	-0.98±0,29

Following a three-month-fermentation period, the mean pH value of red beet vinegar samples was found to be 2.94 ± 0.32 (Table 2). Similarly, Unal [21], in vinegar samples obtained

from Dimrit grapes by different methods, found the pH value in the range of 2.68-2.85. Also, Budak et al. [34], in apple cider vinegar samples produced by different methods have reported the pH values in the range of 2.83-3.21. Chemical analysis results of red beet vinegar samples are shown in Table 2.

Table 2: Chemical analysis results of red beet vinegar

Analysis	Value
pH	2.94±0.32
Total acidity (g/L)	27.87±0.38
Brix (°Brix)	3.71±0.17
Total dry matter (%)	3.30±0.12
Ash (%)	0.24±0.21

The mean total dry matter value of the vinegar samples was 3.30±0.12% while the mean Brix (°Brix) value was 3.71 ± 0.17 (Table 2). According to the TS 1880 EN 13188 vinegar standard, there is no limit specified regarding the dry matter content of the vinegar [35]. Aykın [36] has reported that the mean dry matter content of apple cider vinegar samples between 2.14% and 2.42%. Kadaş [37] has reported that the mean °Brix values in hawthorn vinegar samples as 5.33 °Brix. In their study, Marangoz [38] found the °Brix values in black mulberry vinegar after alcohol fermentation and acidification as 2.65 and 1.8 °Brix, respectively. Examining the studies, it was seen that the findings of the present research were similar to those reported by Marangoz[38] but lower than those obtained by Kadas[37]. The mean ash content of red beet vinegar was determined to be 0.24±0.21% (Table 2). According to the TS 1880 EN 13188 vinegar standard, ash value should be 0.05 g/L minimum [35]. Accordingly, it was found that the red beet vinegar samples complied with the values specified in the standard in terms of ash content. In similar studies, Budak [32], has reported that the total dry matter content of apple and grape vinegar samples varied between 1.94% and 4.98%. Aykın [36], has stated that the ash content of apple and pomegranate vinegar samples was 0.22% and 0.39%, respectively, similar to those obtained in our research results.

The mean density value of vinegar samples was found to be 1.003 ± 0.002 g/cm^3 (Table 3). In similar studies, the density values of vinegar samples have been reported as 0.9987-1.0517 g/cm^3 by Budak [32] and 1.013-1.024 g/cm^3 by Plessi[39]. The findings obtained in the studies were in line with the results obtained in the present study. The mean conductivity value of the vinegar sample in the present study was found to be 2.13±0.042 (µS/cm) (Table 3). Siddeeg et al. [40] have reported the mean conductivity value as 3.10±0.15 mS/cm, while Kadas et al. [41] have reported the mean conductivity value as 3.86±0.45 mS/cm. As a result of a three-month-fermentation period, alcohol was not detected in the red beet vinegar samples.

Table 3: Density, conductivity, alcohol, total antioxidants and total phenolic content amounts of red beet vinegar

Analysis	Value
Density (g/cm^3)	1.003±0.002
Conductivity (µS/cm)	2.13±0.042
Alcohol (%)	-
Total antioxidants (µg TE/mL)	96.14±3.43
Total phenolic content (mg GAE/L)	1170.78±20.95

The mean antioxidant value of red beet vinegar was 96.14±3.43 µg TE/mL while the mean total phenolic content was 1170.78±20.95 mg GAE/L (Table 3). Unal [21] has reported the total phenolic compound value of the vinegar samples in terms of gallic acid in the range of 423.90-499.90 mg/L. Ozturk et al. [42] have reported that the total phenolic content of the red beet was 944±22 GAE mg/g.

Er [33] has reported that the antioxidant capacity (DPPH) value of the red beet that was subjected to different pre-treatment and drying temperatures in methanol extract varied between 1771 µmol Trolox equivalent/100 g and 5133 µmol Trolox equivalent/100 g and the phenolic compound value in methanol extract between 671.1 mg GAE/100 g and 1399.8 mg GAE/100 g. Kayın [9] has determined the antioxidant value of red beet concentrate to be 151.4 µM Trolox/100 mL. Antioxidant values obtained in our study were substantially higher than the studies mentioned above. Therefore, the functional properties of red beet, which is rich in phenolic and antioxidant compounds, were found to increase with vinegar production.

Table 4: Amounts of mineral substances detected in red beet vinegar (ppm)

Minerals	Value
Na	370.94±2.73
Mg	3.25±0.07
K	69.13±1.13
Ca	10.07±0.42
P	14.5±0.01
Fe	0.22±0.01
B	0.17±0.00
Mn	0.03±0.00
Al	0.09±0.00
Sn*	7.34±0.11

*ppb

The mineral substances detected in red beet vinegar and their mean values are shown in Table 4. It was determined that the most abundant mineral was Na with 370.94±2.73 ppm, followed by K with 69.13±1.13 ppm, P with 14.5±0.01 ppm and Ca with 10.07±0.42 ppm. It was also determined Sn 7.34±0.11 ppm, Mg 3.25±0.07 ppm, Fe 0.22±0.01 ppm, B 0.17±0.00 ppm, Al 0.09±0.00 ppm and Mn 0.03±0.00 ppm. In similar studies conducted on the subject, Ozturk et al. [42] have reported the Na and Ca values in the range of 27.70-4070.20 mg/L and 627.10-1599.70 mg/L, respectively, while Kapukaya [43] has reported the Mg and Fe values as 0.64 ppm and 1.37 ppm, respectively, and Aykın [36] has reported the K value as 25814.17 mg/L. Kadas et al [41], in their research on hawthorn vinegar, determined the mineral values as 6638.7±452.7 ppm for K, 521.4 ± 39.5 for Ca, 241.9±43.7 ppm for Mg, 240.0±28.3 ppm for Fe, 123.1±21.3 ppm for Na, 40.1±9.8 ppm for Zn and 0.273±0.5 ppm for Cu.

Table 5: Microbiological analysis results for vinegar sample

Microorganism count (Log CFU/mL)	Value
Acetic acid bacteria	3.06±0.14
Lactic acid bacteria	2.84±0.09
Yeast / Mold	1.09±0.08

After the fermentation, the mean acetic bacterial count of vinegar sample was 3.06±0.14 while the lactic acid bacteria count was 2.84±0.09 and yeast/mold count was 1.09±0.08 log cfu/mL (Table 5). Sengun and Kılıc [44], in homemade mulberry vinegar samples, have reported the acetic acid bacteria, lactic acid bacteria and yeast/mold count as 2.84, 3.17 and 1.32 log cfu/mL, respectively. In the same study, the researchers determined these values as 1.65, 1.03 and 1.47 log

cfu/mL in commercial mulberry vinegar samples. The microbiological results obtained in the study were similar to those of homemade vinegar samples but higher than those of commercial vinegar samples, except for yeast/mold counts. It was thought that the differences obtained in the study were related to the raw materials and processes adopted in production.

Table 6: Sensory evaluation scores of vinegar sample

Sensory evaluation	Score
Color	7.67±0.57
Aroma	5.05±0.21
Odor	5.53±0.71
Consistency	7.52±0.70
General appreciation	6.75±0.35

> 8 perfect 7-8: Very good, 6-7: Good, 5-6: Medium, 4-5: Bat, <4: Unacceptable.

According to the sensory analysis results of the panelists (Table 6), the highest score was determined to be 7.67 ± 0.57 in color scores whereas the lowest score was 5.05 ± 0.21 in aroma scores. The mean general evaluation score of the red beet vinegar was 6.75 ± 0.35. According to the results of the analysis, the vinegar obtained from red beet was found to have acceptable properties.

4 Conclusion

Vinegar is a fermented product that is becoming more popular due to its positive effects on health and its usage in the food industry is increasing. In general, apple and grapes are preferred as raw materials in the food sector, but vinegar can be produced from all raw materials such as fruits, vegetables and even cereals containing sugar. In the present study, physicochemical, microbiological and sensory properties of red beet vinegar were investigated. The results showed that antioxidant capacity and total phenolic content of red beet vinegar were very high. Also, red beet vinegar was found to be rich in minerals such as Na, K, P, Ca and Mg. The consumption of red beet, which is known to be rich in bioactive components, is very low. The benefits of this product, which is consumed only locally, are unknown to many.

As a result of this research, it is thought that the marketing range of red beet vinegar should be enlarged from local to nation-wide in Turkey and red beet vinegar should be used not only as a seasoning in salads and sauces but as an alternative functional product in various areas. Thus, both the recognition and economic value of red beet will increase and an alternative product will be created to apple and grape vinegar commonly used in Turkey.

5 Referance

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