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The Effects of Aromatic Plants on the Quality Characteristics of Grape Pickles

Tuba BÜYÜKSIRIT BEDİR[1*], Merve GÜRGİL[1]

[1]Hitit University, Faculty of Engineering and Natural Sciences, Department of Food Engineering, Çorum, Türkiye

* tubabuyuksirit@hitit.edu.tr (Sorumlu Yazar)

Abstract

Pickle is a traditional preservation method used for centuries to extend the shelf life of agricultural products and enable off-season consumption. It stands out as an alternative processing method, particularly for the utilization of products with a short fresh consumption period, such as grapes. In this study, grapes were processed into pickles, and their chemical, physical, microbiological, and sensory properties were evaluated during ripening and storage. Within the scope of the study, 9 different herbs were used for aromatization, and the most preferred formulation was determined through sensory analysis. Total titration acidity (0.35-1.69 g 100 mL^{-1}), pH (3.02-4.08), salt content (2.46-5.77 %) and L* (34.38-56.61), a* (-1.24-4.31), b* (3.49-24.93) values were determined. The antimicrobial effects of herb-flavored samples against spoilage microorganisms were compared with a control without added herbs. Total mesophilic aerobic bacteria counts ranged from 3.94–7.61 log cfu mL^{-1}, lactic acid bacteria from 3.95–7.76 log cfu mL^{-1}, and yeast–mold counts from 3.53–7.38 log cfu mL^{-1}. Sensory evaluation indicated that dill-flavored grape pickles were the most preferred among the tested herbs.
Keywords: Grape, Pickle, Aromatic plants

Aromatik Bitkilerin Üzüm Turşusunun Kalite Özellikleri Üzerine Etkileri

Özet

Turşu, tarımsal ürünlerin raf ömrünü uzatmak ve mevsim dışı tüketimini sağlamak amacıyla yüzyıllardır kullanılan geleneksel bir muhafaza yöntemidir. Özellikle üzüm gibi taze tüketim süresi kısa olan ürünlerin değerlendirilmesinde alternatif bir işleme yöntemi olarak öne çıkmaktadır. Bu çalışmada üzümler turşu haline getirilmiş ve olgunlaşma ile depolama süreci boyunca kimyasal, fiziksel, mikrobiyolojik ve duyusal özellikleri değerlendirilmiştir. Çalışma kapsamında aromatizasyon amacıyla 9 farklı bitki kullanılmış ve duyusal analiz sonucunda en çok tercih edilen formülasyon belirlenmiştir. Toplam titrasyon asitliği (0.35–1.69 g 100 mL^{-1}), pH (3.02–4.08), tuz içeriği (%2.46–5.77) ile L* (34.38–56.61), a* (-1.24–4.31), b* (3.49–24.93) renk değerleri belirlenmiştir. Farklı bitkilerle aromalandırılan turşuların, bozulmaya neden olan mikroorganizmalara karşı antimikrobiyal etkileri bitki ilavesiz kontrol örneği ile karşılaştırılmıştır. Toplam mezofilik aerobik bakteri sayısı 3.94–7.61 log kob mL^{-1}, laktik asit bakterileri 3.95–7.76 log kob mL^{-1} ve maya–küf sayıları 3.53–7.38 log kob mL^{-1} aralığında bulunmuştur. Duyusal değerlendirme sonucunda test edilen bitkiler arasında dereotlu üzüm turşusunun en çok tercih edilen örnek olduğu belirlenmiştir.
Anahtar Kelimeler: Üzüm, Turşu, Aromatik bitkiler

Introduction

The grape (*Vitis vinifera* L.), which is one of the members of the *Vitaceae* family, is thought to have a history of 150 million years (Türkben, 2010). It is estimated that in 6000 BC, it was cultivated in Anatolia to consume its fruits as fresh or dried and to be used in winemaking (Deliorman et al., 2011). Grapes can generally be classified as table, wine and dried grapes. In addition to this common classification method, local traditional products have also been developed (Gülcü, 2010). In addition to being consumed as fresh grapes in Turkey, it is also processed into products such as raisins, wine, grape juice, grape molasses, pulp, sausage, raki and kome (Cangi and Yağcı, 2012).

The main components of grapes are water, sugar and acids. Grapes contain about 81-87% water, 12-18% carbohydrates, 0.5-0.6% protein and 0.3-0.4% fat. In addition, grapes contain significant amounts of potassium (0.1-0.2%), vitamin C (0.01-0.02%), and vitamin A (0.001-0.0015). There are also small amounts of calcium (0.01-0.02%) and phosphorus (0.008-0.02%) (Çetin and Sağdıç, 2009). The main reason for the extensive research on grapes and products obtained from grapes in recent years is that they have anti-carcinogenic properties due to the substances they contain. As a result of the studies, there are very high amounts of phenolic compounds in grapes and products obtained from grapes (Davalos et al., 2005).

One of the methods used in preserving foods for a long time is to preserve them by making pickles. It is the fermentation of vegetables and fruits with lactic acid bacteria in brines or juices with certain salt concentrations. With the protective effect of salt and lactic acid formed as a result of this, it provides long-

term durability to foods. Although it is possible to produce pickles from many vegetables, fruits and even animal products, vegetables are more suitable for pickle production due to their chemical structures. Pickles can be stored both in brine and in dry form (Aktan et al., 1998).

In this study, grape fruit, which has a rich nutritional content, was processed into the pickled product. The chemical and physical properties of the produced product were followed by periodic analyzes during the ripening and storage periods. It is aimed to determine the most suitable grape pickle by aromatizing and sensory evaluation using 9 different plants. Microbiological analyzes were carried out to determine the antimicrobial effects of pickles flavored with various herbs against harmful or undesirable microorganisms.

Material and Method

In the production of grape pickle, genus of Müşküle white grapes were used as material, and the grapes were obtained from the local market in the Çorum region in 2021. Celery leaves, mint, dill, parsley and garlic were purchased from the market in Çorum, and rosemary, bay leaves, black mustard and coriander were purchased from herbalists. After the plants were washed and cleaned of foreign materials, they were dried.

Preparation of pickles

Firstly, the grapes were cleaned from foreign materials and separated from their clusters. Grapes were divided into two groups to be used in making pickles and grape juice. The grapes were blasted without damaging their seeds and passed through cheesecloth to separate them from the seeds. For the sterilization of grape juice, heat treatment was applied at 80˚C for 20 minutes. Brine juice was also obtained by mixing grape juice and pure water at a ratio of 1:2. In addition, 6% of the brine was calculated, at this rate rock salt was added and mixed to dissolve.

The jars have been sterilized and it was filled with 200 g grapes and 250 ml brine. A control group and nine different herbs groups were used, supplemented with celery (10% w/v), mint (10% w/v), parsley (10% w/v), dill (10% w/v), garlic (5% w/v), rosemary (1% w/v), bay leaf (1% w/v), black mustard (2% w/v), and coriander (2% w/v) were added. The same amount of grape and must was used for the herb-free grape pickle prepared as the control group. After the grape pickles were prepared, *Lactobacillus plantarum* bacterial culture was added to each jar in an initial amount of 8.42 log cfu mL^{-1}. Prepared grape pickles were kept at 25˚C for 28 days. After ripening, the grape pickles were stored at 4˚C for 4 months.

Physicochemical analysis

Physical and chemical changes in pickles were monitored during ripening and storage through periodic analyses. pH (Adwa AD1000 pH/mV and Temperature Meter), titratable acidity (potentiometric method, in terms of tartaric acid) (Cemeroğlu, 2013) and salt content (Mohr method) were determined in the brine of the pickle samples. Color values were measured in grape pickles with a colorimeter (Minolta CM-3600d) and results were expressed according to CIE parameters.

Microbiological analysis

Microbial changes in the pickles were monitored on days 0, 7, 14, 21, and 28 during the ripening period, and on days 60, 90, and 120 throughout the storage period. For this purpose, successive dilutions were prepared from pickle brine under aseptic conditions and plated. Plate Count Agar (PCA) for Total Mesophilic Aerobic Bacteria (TMAB), Potato Dextrose Agar (PDA) for yeast and molds (YM), de Man Rogosa and Sharpe agar (MRS) for Lactic Acid Bacteria (LAB) were used. The plates were incubated for 48 hours at 30°C for TMAB counting, 5 days at 25°C for yeast and mold, and 48 hours at 30°C for LAB.

Sensory analysis

Sensory analyzes were performed according to Ova (2002). Pickle samples were evaluated in terms of color, texture, flavor and overall acceptability by 6 panelists from Food Engineering Department of Hitit University. Each parameter was scored using a five-point hedonic scale (1 = very bad, 2 = bad, 3 = fair, 4 = good, 5 = very good).

Statistical analysis

The analysis results were statistically evaluated using the Minitab Statistical Software package program. The statistical data were shown as average ± standard deviation (SD). One-way analysis of variance (ANOVA) was performed to determine significant differences among the groups, and Duncan's multiple range test was subsequently applied for multiple comparisons (Minitab, 1991).

Results and Discussion

The chemical properties of the raw material were determined before the fruits were processed into pickles. The pH value of the grapefruit was 3.98, titratable acidity was 0.0126 g mL^{-1}, salt content was 0.03%.

Physicochemical analysis

The chemical features determined during the ripening and storage period of the grape pickle are given in Table 1. The pH values of the pickles were between 3.45-3.93 on the 7th day, while they tended to decrease throughout the ripening, and the pH

values were between 3.02-3.27 on the 28th day. The decrease in pH value during fermentation is due to changes in the amount of lactic acid. Lactic acid bacteria are also used in the production of pickles and the pH decreases due to lactic acid production.

Table 1. Chemical analysis of grape pickles during ripening and storage
Çizelge 1. Üzüm turşularının olgunlaşma ve depolama boyunca kimyasal analizleri

	Sample	Maturation (25°C)				Storage (4°C)		
		7th day	14th day	21th day	28th day	60th day	90th day	120th day
PH	1	3.48±0.00^{Bg}	3.05±0.01^{Eh}	3.13±0.01^{Di}	3.04±0.02^{Ed}	3.36±0.01^{Ce}	3.37±0.01^{Cg}	3.78±0.01^{Ad}
	2	3.92±0.00^{Aa}	3.11±0.00^{Eg}	3.16±0.01^{Dh}	3.09±0.02^{Ec}	3.43±0.00^{Cd}	3.44±0.01^{Cf}	3.88±0.01^{Bc}
	3	3.93±0.01^{Ba}	3.19±0.00^{Fe}	3.29±0.01^{Df}	3.27±0.02^{Ea}	3.63±0.01^{Ca}	3.65±0.00^{Ca}	4.08±0.00^{Aa}
	4	3.90±0.01^{Ab}	3.16±0.00^{Df}	3.15±0.01^{Dhi}	3.02±0.015^{Ed}	3.30±0.01^{Cf}	3.32±0.01^{Ch}	3.77±0.02^{Bd}
	5	3.70±0.00^{Bd}	3.66±0.00^{Ca}	3.69±0.00^{Ba}	3.18±0.01^{Eb}	3.49±0.00^{Dbc}	3.49±0.01^{Db}	3.91±0.01^{Abc}
	6	3.67±0.00^{Be}	3.64±0.01^{Ca}	3.53±0.00^{Dc}	3.16±0.01^{Fb}	3.49±0.00^{Ebc}	3.48±0.01^{Ec}	3.91±0.01^{Abc}
	7	3.45±0.01^{Dh}	3.54±0.02^{Bc}	3.57±0.01^{Bb}	3.18±0.00^{Eb}	3.50±0.00^{Cb}	3.49±0.00^{Cb}	3.93±0.02^{Ab}
	8	3.73±0.00^{Bc}	3.39±0.01^{Dd}	3.24±0.01^{Eg}	3.17±0.00^{Fb}	3.49±0.01^{Cb}	3.47±0.00^{Cd}	3.90±0.02^{Abc}
	9	3.68±0.00^{Be}	3.64±0.01^{Ca}	3.38±0.00^{Ee}	3.17±0.00^{Fb}	3.50±0.00^{Db}	3.48±0.01^{Dc}	3.91±0.01^{Abc}
	10	3.55±0.00^{Cf}	3.60±0.01^{Bb}	3.43±0.01^{Ed}	3.14±0.01^{Fb}	3.47±0.01^{Dc}	3.45±0.01^{DEe}	3.88±0.02^{Ac}
Acidity (g 100 mL^{-1})	1	1.43±0.04^{Ab}	0.84±0.01^{Ba}	0.83±0.01^{Bb}	0.81±0.03^{Bbcd}	0.83±0.02^{Bb}	0.77±0.01^{Ba}	0.85±0.00^{Bc}
	2	1.43±0.04^{Ab}	0.85±0.01^{Ba}	0.86±0.01^{Bb}	0.84±0.01^{Bbc}	0.71±0.02^{Cc}	0.68±0.00^{Cb}	0.88±0.00^{Bb}
	3	1.05±0.00^{Acd}	0.82±0.00^{Ba}	0.83±0.01^{Bb}	0.81±0.02^{Bbcd}	0.65±0.00^{Dd}	0.62±0.00^{Ec}	0.71±0.00^{Cd}
	4	1.69±0.02^{Aa}	0.78±0.00^{Db}	0.89±0.00^{Ca}	1.04±0.01^{Ba}	0.91±0.00^{Ca}	0.80±0.04^{Da}	0.94±0.00^{Ca}
	5	1.20±0.04^{Ac}	0.44±0.01^{Ec}	0.59±0.00^{Dd}	0.86±0.04^{Bbc}	0.73±0.00^{Cc}	0.68±0.00^{Cb}	0.72±0.00^{Cd}
	6	1.05±0.04^{Acd}	0.35±0.01^{Ff}	0.55±0.01^{Eef}	0.74±0.00^{Bbcd}	0.60±0.01^{Def}	0.59±0.00^{Dc}	0.64±0.00^{Cef}
	7	1.69±0.02^{Aa}	0.39±0.01^{Gef}	0.53±0.01^{Ef}	0.66±0.01^{Bd}	0.56±0.01^{Df}	0.57±0.00^{Dc}	0.60±0.00^{Cg}
	8	0.86±0.02^{Bd}	0.44±0.00^{Dcd}	0.68±0.01^{Cc}	0.91±0.08^{Aab}	0.61±0.00^{Cde}	0.61±0.00^{Cc}	0.63±0.01^{Cf}
	9	1.24±0.07^{Abc}	0.43±0.01^{Ecd}	0.55±0.00^{Ddef}	0.79±0.03^{Bbcd}	0.64±0.00^{Cde}	0.61±0.01^{CDc}	0.66±0.00^{Ce}
	10	1.20±0.04^{Ac}	0.40±0.00^{Ede}	0.56±0.00^{Dde}	0.71±0.04^{Bcd}	0.65±0.00^{BCde}	0.60±0.00^{CDc}	0.63±0.01^{BCDf}
Salt (%)	1	5.03±0.01^{ABab}	4.91±0.01^{Babc}	5.30±0.01^{ABab}	5.15±0.03^{Ababc}	5.54±0.02^{Aba}	5.62±0.01^{Aa}	5.27±0.01^{Ababcd}
	2	5.27±0.03^{Aa}	5.27±0.03^{Aab}	4.80±0.01^{Ab}	5.11±0.02^{Aabc}	5.46±0.03^{Aa}	5.69±0.01^{Aa}	5.62±0.01^{Aab}
	3	4.45±0.05^{Babc}	5.38±0.01^{ABa}	5.62±0.01^{Aba}	5.58±0.02^{Aba}	5.77±0.02^{Aa}	5.69±0.02^{Aba}	5.77±0.02^{Aa}
	4	5.50±0.02^{Aa}	5.27±0.02^{Aab}	3.98±0.01^{Bc}	5.03±0.02^{Aabc}	5.23±0.01^{Aab}	5.03±0.01^{Aa}	4.68±0.03^{Abcde}
	5	4.80±0.01^{Aabc}	5.38±0.03^{Aa}	5.15±0.01^{Aab}	4.56±0.01^{Aabc}	5.15±0.03^{Aab}	5.15±0.03^{Aa}	4.84±0.02^{Abcde}
	6	3.51±0.01^{Bc}	4.80±0.03^{Aabc}	4.80±0.01^{Ab}	4.37±0.04^{ABc}	4.10±0.01^{ABbc}	4.13±0.01^{ABbc}	4.68±0.01^{Acde}
	7	4.80±0.02^{Aabc}	4.10±0.01^{ABc}	3.74±0.01^{Bcd}	4.52±0.02^{ABabc}	3.51±0.04^{Bc}	3.74±0.02^{Bc}	4.10±0.01^{ABe}
	8	3.86±0.03^{Bbc}	4.21±0.03^{ABbc}	3.74±0.01^{Bcd}	5.46±0.02^{Aab}	4.84±0.04^{ABab}	4.99±0.03^{ABab}	5.38±0.01^{Aabc}
	9	5.27±0.02^{Aba}	5.03±0.01^{BCabc}	3.16±0.02^{Dd}	5.58±0.01^{Aba}	5.73±0.07^{Aa}	5.73±0.01^{Aa}	4.52±0.01^{Cde}
	10	3.63±0.01^{Cc}	4.33±0.02^{Babc}	2.46±0.01^{De}	4.45±0.01^{Bbc}	5.15±0.01^{Aab}	5.62±0.01^{Aa}	4.45±0.01^{Be}

* Total titration acidity was calculated in terms of tartaric acid. **There is a significant difference between samples with different uppercase letters in the same row or different lowercase letters in the same column ($p<0.05$).
* Toplam titrasyon asitliği tartarik asit cinsinden hesaplanmıştır. **Aynı satırda farklı büyük harflerle veya aynı sütunda farklı küçük harflerle gösterilen örnekler arasında anlamlı bir fark vardır ($p<0.05$).

Thanks to this decrease in pH value, the development of unwanted microorganisms is prevented (Pistarino et al., 2013). In a study conducted by Trongpanich et al. (2008), five types of dried and semi-dried fruit and vegetable pickles were collected from the local market in Thailand: salted grated green mango, salted grated green papaya, sweetened grated radish, salted whole radish and whole peach. It was reported that the pH of all samples was not more than 4.60 except for pickled radish (pH 4.67). In addition, the pH values ranged between 2.27 and 2.92 in mango pickles and between 2.82 and 3.31 in peach pickles. In another study conducted with pickled plums, it was stated that the pH in brine was 3.68 at the highest and 3.63 at the lowest (Adrian and Cornelia, 2015). These findings are consistent with the results obtained in the present study, where similarly low pH values were observed in grape pickles, indicating that acidic conditions comparable to those reported for fruit-based pickles are achieved during the pickling process.

The total acidity values of the pickle samples during ripening and storage showed noticeable differences depending on both the plant species used in the formulation and the storage time. At the early stage of fermentation (day 7), total acidity values ranged between 0.86% and 1.69%, while a decreasing trend

was observed in some samples during days 14–21. This decrease may be associated with the diffusion of organic acids between the product tissue and the brine, as well as the utilization of these acids by certain microorganisms. Similarly, in peach pickle fermentation, total titratable acidity was reported to range between 2.32% and 6.52%, and a rapid decrease in acidity was observed during the fermentation period (Oh et al., 2017). During the storage period (days 60–120), total acidity values remained relatively stable or showed slight increases, indicating that the fermentation process had largely reached equilibrium and microbial activity had slowed down. In addition, the differences observed among pickle samples may be related to variations in raw material composition, the presence of aromatic herbs, and microbial community dynamics affecting acid production and fermentation kinetics (Di Cagno et al., 2013).

Salt concentrations showed slight variations during the ripening period in several samples. These changes can be attributed to the diffusion of salt between the brine and the plant tissue as well as osmotic interactions occurring during fermentation. The migration of salt into plant tissues and the release of intracellular components into the brine may lead to fluctuations in salt distribution within the fermentation system. During the storage period, salt levels remained relatively stable within a narrow range, indicating that osmotic equilibrium between the brine and the product tissue had largely been established (Di Cagno et al., 2013; Tamang et al., 2016). Similar salt ranges have been reported in previous studies on fruit pickles. For example, salt contents of mango pickles ranged from 4.61% to 9.78%, while peach pickles contained 0.20%–7.97% salt (Trongpanich et al., 2008). In addition, the salt content of plum pickle brine was reported to vary between 2.63% and 2.69% (Adrian and Cornelia, 2015). Slight increases in salt concentration after equilibrium have also been observed in fermented products due to ongoing diffusion processes during storage (Etchells et al., 1975).

Color measurements are made as an index in the quality control of foods (Başoğlu, 2004). According to the data given in Table 2, L* values generally showed an increasing trend during the ripening and storage process. The increase in L* values, especially in the later days of fermentation and at the beginning of the storage process, indicates an increase in the brightness and clarity of the product. In this study, L* values ranged from 34.38 to 56.61, with the highest value observed in sample 3 and the lowest in sample 1. Similarly, a study conducted by Gargin and Altindisli (2016) reported that L* values ranged from 32.7 to 37.4 during 120 days of cold storage of the Red Globe grape variety. In the pickle samples, a* values were determined to range from -1.24 to 4.31. Negative or near-zero a* values indicate a departure from green tones in the product color, which is consistent with the characteristic color properties of grape pickles. Indeed, in the study conducted by Gargin and Altindisli (2016), it was reported that a* values in grapes stored in cold storage for 120 days ranged from 1.51 to 1.88, and that limited changes occurred in a* values during storage. When b* values were examined, a wider range of variation was observed among the samples. In the study, b* values ranged from 3.49 to 24.93, with the highest b* value in sample 1 and the lowest value in sample 5. The increase in b* value is related to the increase in yellow tones and can be explained by the changes occurring in pigments during fermentation.

Microbiological analysis

The microbial changes observed during ripening and storage of grape pickles are summarized in Table 3. A control and 9 groups were monitored at 25°C on days 0, 7, 14, 21, and 28 during the ripening period and at 4°C on days 60, 90, and 120 during storage. The initial TMAB count was 3.94 log cfu mL^{-1} and increased during the early ripening stages (days 7, 14, and 21), continuing until day 28 in most samples except samples 2, 3, and 7. During storage, TMAB counts generally decreased until day 90, followed by a slight increase thereafter, except in samples 9 and 10. Differences between the control (10) and other groups are significant ($p<0.05$). The YM counts were initially 3.53 log cfu mL^{-1} and increased to 4.84–6.66 log cfu mL^{-1} by day 7, likely influenced by the microbial load of the added herbs. YM numbers continued to rise until day 14, after which some samples (2, 3, 4, 8 and 9) showed a decline on day 21, coinciding with increased acidity, while others continued to increase. By day 28, decreases were observed in most samples except the control. During storage, YM counts generally decreased until day 90, followed by a slight increase thereafter, except in samples 5 and 9. and significant differences were observed among the groups ($p<0.05$). Fruits naturally contain high levels of sugars and other nutrients, and their low pH makes them susceptible to mold and yeast spoilage. Previous studies have reported YM growth in 35% of red, green, and black grape varieties stored at room temperature for 14 days (Tournas and Katsoudas, 2005). In grape pickles, YM counts increased from 2.09 log cfu g^{-1} at the beginning to 4.69 log cfu g^{-1} after 28 days of ripening (Göral, 2019), while in Hardaliye beverages, counts ranged between 2–3 log cfu mL^{-1} after maturation (Arici and Coskun, 2001). The higher YM counts observed in the present study may be attributed to the microbial load of the raw grapes and the addition of aromatic plants, which could provide additional substrates for YM growth. These results are

consistent with the general understanding that post-harvest handling and formulation influence microbial dynamics during ripening and storage.

In order to determine the number of natural lactic acid bacteria in the structure of the produced grape pickle samples, counts were made before adding *Lb. plantarum* culture. The LAB count on day 0 was found to be 3.95 log cfu mL^{-1}. When the results were examined, it was determined that the LAB at the end of the 7th day varied between 5.05 and 7.50 log cfu mL^{-1}. The increase in LAB continued in all pickles until 21st day. On the 28th day, LAB count decreased in all of the pickle samples except the 2nd sample. During storage, LAB counts generally decreased until day 90, with a slight resurgence by day 120, and significant differences were observed among the groups ($p<0.05$). The results highlight the critical role of LAB in successful fermentation, as their growth controls microbial activity and suppresses non-lactic flora, directly influencing product quality and flavor (Etchells et al., 1975; Hutkins, 2006).

Table 2. L*, a*, b* values of grape pickles during ripening and storage
Çizelge 2. Üzüm turşularının olgunlaşma ve depolama boyunca L*, a*, b* değerleri

	Sample	Maturation (25°C)				Storage (4°C)		
		7th day	14th day	21th day	28th day	60th day	90th day	120th day
L* value	1	42.97±1.46^{Ba}	37.78±0.83^{Ccd}	42.99±0.56^{Bef}	42.62±1.16^{Bbc}	56.61±0.13^{Ba}	45.67±0.60^{Aa}	42.66±0.77^{Bab}
	2	41.64±0.91^{Bab}	41.75±1.36^{Babc}	42.12±0.57^{Bef}	42.75±1.23^{Bbc}	51.06±0.70^{Ab}	43.34±1.08^{Bab}	41.99±1.30^{Bab}
	3	34.38±0.75^{Dc}	35.71±0.45^{Dd}	45.19±0.31^{Bcde}	40.06±1.22^{Cc}	50.31±0.83^{Ab}	43.97±0.90^{BCab}	44.86±1.29^{Ba}
	4	38.97±1.30^{Eabc}	44.39±0.56^{CDab}	51.96±0.98^{Aa}	45.94±0.50^{BCab}	48.56±0.85^{ABb}	45.37±0.57^{BCa}	41.16±0.32^{DEab}
	5	34.85±1.49^{Dc}	42.51±2.28^{BCabc}	50.95±0.54^{Aab}	47.99±1.61^{Aba}	49.78±0.74^{Ab}	42.85±1.12^{BCab}	41.66±1.00^{Cab}
	6	40.30±0.55^{DEab}	46.06±1.33^{ABCa}	47.25±1.06^{ABbcd}	43.92±0.36B^{Cabc}	48.69±0.58^{Ab}	43.65±0.45^{CDab}	39.77±0.43^{Eb}
	7	37.57±0.15^{Cbc}	43.92±0.22^{Bab}	49.12±0.83^{Aabc}	43.69±0.65^{Babc}	49.63±0.35^{Ab}	43.77±0.95^{Bab}	41.43±0.43^{Bab}
	8	38.56±1.03^{Cabc}	40.06±1.86^{Cbcd}	40.22±1.43^{Cf}	46.85±0.20^{ABab}	48.95±0.42^{Ab}	43.20±0.75^{BCab}	43.24±1.09^{Bcab}
	9	40.45±0.55^{Bab}	43.15±0.58^{Babc}	43.42±0.85^{Bdef}	44.36±1.19^{Babc}	49.16±1.20^{Ab}	42.55±1.02^{Bab}	43.84±1.40^{Bab}
	10	34.92±1.48^{Dc}	39.40±0.76^{CDbcd}	42.70±0.91^{BCef}	44.08±0.79^{Babc}	50.67±1.53^{Ab}	41.10±0.18^{BCb}	40.98±0.83^{Bcab}
a* value	1	-0.84±0.25^{Cab}	-1.21±0.06^{Cb}	-1.14±0.45^{Ca}	-1.61±0.23^{Cab}	1.74±0.08^{Babc}	0.62±0.94^{BCa}	4.31±0.95^{Aa}
	2	-1.65±0.16^{BCab}	0.11±0.31^{Aba}	-1.77±0.09^{Ca}	-2.71±0.19^{Cc}	1.17±1.62^{Aabc}	-0.94±0.25^{BCa}	1.55±0.56^{Acd}
	3	-0.04±0.83^{Ba}	-1.94±0.06^{Bbc}	-1.67±0.24^{Ba}	-1.99±0.16^{Babc}	3.14±1.32^{Aab}	-2.53±0.09^{Ba}	-0.51±0.20^{Bd}
	4	-1.48±0.44^{Bab}	-2.37±0.22^{Bc}	-0.90±0.29^{Ba}	-1.22±0.15^{Ba}	4.08±0.67^{Aa}	2.58±0.27^{Aa}	3.58±0.19^{Aabc}
	5	-2.04±0.20^{Bb}	-2.08±0.11^{Bbc}	-2.10±0.09^{Ba}	-1,24±0,43^{Ba}	0.50±0.79^{Abc}	1.03±0.13^{Aa}	2.00±0.13^{Abc}
	6	-0.85±0.38^{BCab}	-1.77±0.37^{Cbc}	-1.82±0.36^{Ca}	-2.46±0.23^{Cbc}	0.69±0.48^{ABbc}	0.94±0.52^{Aa}	2.02±0.04^{Abc}
	7	-1.23±0.13^{Cab}	-2.37±0.06^{Ec}	-1.73±0.22^{CDEa}	-2.16±0.10^{DEabc}	-0.26±0.37^{Bc}	-1.52±0.10^{CDa}	2.30±0.11^{Aabc}
	8	-1.48±0.28^{CDab}	-1.60±0.12^{CDbc}	-0.94±0.51^{Ca}	-2.99±0.15^{Dc}	-1.34±0.29^{Cc}	0.77±0.63^{Ba}	3.93±0.32^{Aab}
	9	-0.83±0.09^{Bcab}	-1.49±0.10^{BCbc}	-1.82±0.08^{BCa}	-2.67±0.27^{Cbc}	0.10±0.70^{Bbc}	-0.32±0.27^{Ba}	2.96±0.84^{Aabc}
	10	-1.71±0.27^{Cab}	-1.90±0.14^{Cbc}	-1.67±0.13^{Ca}	-2.43±0.10^{Cbc}	0.42±0.32^{Bbc}	2.76±0.21^{Aa}	3.33±0.23^{Aabc}
b* value	1	3.97±0.50^{Ebc}	5.38±0.53^{Eb}	8.71±0.46^{Db}	9.62±0.49^{CDbc}	24.93±0.22^{Aa}	13.96±0.92^{Bb}	12.45±1.08^{BCa}
	2	4.05±0.51^{Cbc}	11.64±0.83^{Ba}	8.83±1.02^{Bb}	9.50±0.91^{Bbc}	22.78±1.82^{Aab}	11.32±0.11^{Bcde}	7.49±0.85^{Ccd}
	3	5.80±0.61^{Cbc}	5.33±0.55^{Cb}	7.76±0.89^{Cb}	6.64±0.51^{Cc}	19.39±0.58^{Aabc}	11.06±0.20^{Bdef}	11.46±0.33^{Ba}
	4	5.28±0.23^{Ebc}	7.65±0.37^{DEab}	17.43±1.71^{ABa}	10.52±1.42^{CDabc}	18.40±0.68^{Aabcd}	13.63±1.11^{BCbcd}	9.80±0.53^{CDabc}
	5	3.49±0.42^{Bc}	6.61±1.26^{Bab}	17.01±1.43^{Aa}	14.58±1.11^{Aa}	16.45±1.46^{Abcd}	6.79±0.75^{Bg}	6.55±0.45^{Bd}
	6	10.69±0.37^{Aa}	11.67±2.71^{Aa}	12.33±1.55^{Aab}	11.41±0.66^{Aab}	14.94±0.52^{Acd}	9.27±1.05^{Aefg}	10.93±0.31^{Aa}
	7	3.92±0.48^{Ebc}	10,77±0,51^{BCa}	9.96±1.14^{BCDb}	12.45±0.38^{ABab}	14.15±0.52^{Acd}	8.70±0.23^{CDfg}	7.82±0.35^{Dbcd}
	8	6.57±0.78^{CDb}	3.92±0.70^{Db}	7.65±1.11^{BCDb}	11.05±1.19^{ABab}	11.78±1.28^{ABd}	12.31±0.11^{Abcd}	10.61±0.60^{ABCab}
	9	4.27±0.47^{Ebc}	7.00±0.51^{DEab}	10.94±0.60^{CDb}	14.10±0.87^{BCa}	18.19±2.60^{ABabcd}	19.90±0.41^{Aa}	9.99±0.38^{CDabc}
	10	6.57±0.93^{Db}	7.81±0.19^{CDab}	8.82±0.27^{BCDb}	9.00±0.72^{BCDbc}	17.98±2.46^{Aabcd}	13.74±0.64^{ABbc}	11.82±0.72^{BCa}

* There is a significant difference between samples with different uppercase letters in the same row or different lowercase letters in the same column ($p<0.05$)
* Aynı satırda farklı büyük harflere veya aynı sütunda farklı küçük harflere sahip örnekler arasında anlamlı bir fark vardır ($p<0.05$).

Consistent with previous studies, factors such as raw material characteristics, harvest conditions, temperature, pH, and oxygen availability strongly affect the microbial dynamics and composition in fermented pickles (Nyanga et al., 2007; Nguen et al., 2013; Liu et al., 2017; Park et al., 2019).

Sensory analysis

As a result of pickling, foods lose their appearance, smell, taste and texture characteristics of the raw material. In this way, a new product with its own sensory properties is obtained (Ova, 2002). Sensory analyzes were carried out at the end of the 28-day ripening period at 25°C (Figure 1). Among the samples, D4 (dill) received the highest scores in terms of color (3.16), taste (3.66), texture (4.16), aroma (4.00), and overall acceptability (4.16). Based on the sensory evaluation results, sample D4 (dill) exhibited the highest overall acceptability, whereas sample D7 (bay leaf) showed the lowest score. Sample D3 (parsley) ranked second in overall acceptability with a mean score of 3.16. The product's presence in the domestic and foreign markets is related to its quality features (Ferrante and Maggiore, 2007). Factors affecting consumer preference are the color and appearance of the pickle. Color is often considered to indicate freshness and taste. It affects the acceptability of the pickle and also gives an idea about sweetness, bitterness, saltiness and flavor intensity. There is a

positive relationship between color and taste (Hung et al., 1995).

Table 3. Microbiological values of grape pickles during ripening and storage (log cfu mL^{-1})
Çizelge 3. Üzüm turşularının olgunlaşma ve depolama boyunca mikrobiyolojik değerleri (log kob mL^{-1})

Sample		Maturation (25°C)					Storage (4°C)		
		0th day	7th day	14th day	21th day	28th day	60th day	90th day	120th day
1	TMAB	3.94±0.06^{G}	4.89±0.02^{Ff}	6.50±0.07^{Cf}	7.01±0.01^{Acd}	6.73±0.03^{Bd}	6.91±0.02^{ABb}	5.36±0.04^{Ec}	6.19±0.01^{Db}
	LAB	3.95±0.03^{F}	7.44±0.02^{Aab}	7.11±0.09^{Bcd}	6.97±0.04^{BCf}	6.74±0.02Cd	5.42±0.03^{Ec}	5.50±0.14^{Eb}	5.83±0.01^{Db}
	YM	3.53±0.27^{E}	4.84±0.03^{De}	6.33±0.12^{ABe}	6.75±0.09^{Ad}	6.48±0.08^{ABe}	5.95±0.03^{BCbc}	5.41±0.06^{Cc}	5.72±0.02^{Cb}
2	TMAB	3.94±0.06^{F}	5.87±0.02^{Dc}	6.91±0.05^{Bcdef}	7.06±0.13^{Bcd}	8.19±0.01^{Aa}	5.87±0.02^{Dc}	5.12±0.07^{Ec}	6.59±0.01^{Ca}
	LAB	3.95±0.03^{G}	7.50±0.06^{Ca}	7.83±0.02^{Ba}	6.95±0.03^{Df}	8.30±0.02^{Aa}	5.92±0.05^{Eab}	5.38±0.16^{Fb}	6.08±0.03^{Eb}
	YM	3.53±0.27^{D}	5.64±0.02^{Bc}	6.80±0.04^{Ad}	5.92±0.04^{Bc}	6.97±0.04^{Ad}	6.16±0.09^{Babc}	5.01±0.06^{Cd}	5.79±0.04^{Bb}
3	TMAB	3.94±0.06^{D}	5.75±0.05^{Ccd}	7.29±0.08^{Abc}	7.29±0.02^{Aabcd}	7.32±0.04^{Ab}	7.22±0.17^{Aab}	6.51±0.02^{Ba}	6.62±0.05^{Ba}
	LAB	3.95±0.03^{D}	7.17±0.05^{ABbc}	7.27±0.04^{ABc}	7.37±0.04^{Ade}	7.13±0.09^{ABbc}	6.09±0.11^{ABCa}	6.06±0.03^{Ca}	6.48±0.07^{BCa}
	YM	3.53±0.27^{D}	5.58±0.04^{Cc}	7.28±0.02^{Abc}	7.27±0.06^{Aab}	7.60±0.07^{Aa}	6.14±0.09^{Babc}	6.28±0.03^{Ba}	6.36±0.01^{Ba}
4	TMAB	3.94±0.06^{E}	5.49±0.06^{De}	7.21±0.08^{Abc}	7.12±0.07^{Acd}	6.67±0.06^{Bd}	7.04±0.04^{Ab}	5.29±0.10^{Dc}	6.25±0.03^{Cb}
	LAB	3.95±0.03^{E}	6.48±0.08^{Bf}	7.10±0.09^{Acd}	7.29±0.03^{Ae}	7.13±0.06^{Abc}	6.05±0.05^{Ca}	5.08±0.08^{Dbc}	4.80±0.02^{Dc}
	YM	3.53±0.27^{E}	5.48±0.02^{Ccd}	7.26±0.06^{Abc}	6.92±0.16^{ABbc}	7.23±0.19^{Aabcd}	6.51±0.14^{Ba}	4.87±0.02^{CDde}	4.62±0.05^{Dde}
5	TMAB	3.94±0.06^{F}	5.66±0.03^{Dcde}	7.35±0.03^{Bb}	7.79±0.11^{Aa}	7.51±0.05^{Bb}	6.99±0.05^{Cb}	5.30±0.03^{Ec}	5.47±0.01^{DEc}
	LAB	3.95±0.03^{G}	6.79±0.09^{Cde}	7.34±0.13^{Bbc}	7.88±0.06^{Aa}	7.48±0.05^{Bb}	5.91±0.02^{Dab}	5.31±0.02^{Eb}	4.43±0.06^{Fd}
	YM	3.53±0.27^{E}	5.54±0.03^{Ccd}	7.36±0.06^{Ab}	7.44±0.07^{Aa}	7.44±0.07^{Aab}	6.50±0.14^{Ba}	5.02±0.07^{CDd}	4.52±0.04^{Dde}
6	TMAB	3.94±0.06^{D}	5.47±0.09^{BCe}	6.67±0.18^{Aef}	7.13±0.33^{Abcd}	7.03±0.03^{Ac}	5.84±0.04^{Bc}	5.02±0.05^{Cc}	5.49±0.07^{BCc}
	LAB	3.95±0.03^{F}	5.91±0.01^{Dg}	6.66±0.09^{Ce}	7.69±0.03^{Abc}	7.36±0.05^{Bbc}	5.83±0.03^{Dab}	5.08±0.12^{Ebc}	4.93±0.07^{Ec}
	YM	3.53±0.27^{F}	5.39±0.05^{Dd}	6.67±0.03^{BCde}	7.65±0.03^{Aa}	7.05±0.03^{ABbcd}	6.41±0.05^{Cab}	4.65±0.09^{Ee}	4.65±0.18^{Ede}
7	TMAB	3.94±0.06^{D}	6.41±0.05^{Bb}	7.14±0.11^{Abcd}	7.41±0.04^{Aabcd}	7.43±0.07^{Ab}	5.97±0.03^{Cc}	6.08±0.04^{Cb}	6.07±0.06^{Cb}
	LAB	3.95±0.03^{D}	6.86±0.01^{Bcd}	6.91±0.06^{Bde}	7.51±0.05^{Acd}	7.46±0.07^{Abc}	5.93±0.05^{Cab}	6.02±0.03^{Ca}	5.86±0.07^{Cb}
	YM	3.53±0.27^{E}	6.26±0.06^{CDb}	6.97±0.11^{ABcd}	7.40±0.05^{Aab}	7.30±0.04^{Aabcd}	6.53±0.12^{BCa}	5.92±0.05^{Db}	5.88±0.08^{Db}
8	TMAB	3.94±0.06^{F}	5.57±0.03^{Ede}	6.01±0.05^{Aa}	6.96±0.06^{Cd}	6.65±0.03^{Dd}	7.39±0.06^{Ba}	4.17±0.09^{Fd}	5.36±0.10^{Ec}
	LAB	3.95±0.03^{E}	5.05±0.08^{Dh}	5.64±0.02^{Aab}	6.69±0.05^{Bg}	6.62±0.09^{Bd}	5.67±0.11^{Cbc}	4.10±0.10^{Ed}	4.30±0.17^{Ed}
	YM	3.53±0.27^{F}	5.51±0.02^{Dcd}	6.00±0.05^{Aa}	6.92±0.21^{BCbc}	7.01±0.04^{Bcd}	6.26±0.14^{Cab}	4.27±0. 03^{Ef}	4.46±0.09^{Ee}
9	TMAB	3.94±0.06^{E}	6.81±0.02^{Ba}	7.05±0.03^{Bbcde}	7.73±0.03^{Aab}	5.96±0.06^{Ce}	5.98±0.04^{Cd}	5.21±0.13^{Dc}	5.17±0.11^{Dcd}
	LAB	3.95±0.03^{F}	6.49±0.10^{Cef}	6.80±0.01^{BCde}	7.78±0.01^{Aab}	7.12±0.13^{Bc}	5.75±0.05^{Db}	5.14±0.02^{Ebc}	5.09±0.07^{Ec}
	YM	3.53±0.27^{F}	5.51±0.02^{Dcd}	7.01±0.04^{Bbcd}	7.60±0.05^{Aa}	7.17±0.09^{ABbcd}	6.15±0.08^{Cabc}	4.94±0.03^{Ede}	4.85±0.01^{Ecd}
10	TMAB	3.94±0.06^{E}	6.69±0.04^{Ba}	6.75±0.06^{Bdef}	7.61±0.02^{Aabc}	7.47±0.01^{Ab}	6.13±0.09^{Cd}	5.24±0.12^{Dc}	4.98±0.11^{Dd}
	LAB	3.95±0.03^{G}	6.02±0.05^{Dg}	7.03±0.01^{Ccd}	7.76±0.02^{Aab}	7.34±0.03^{Bbc}	5.95±0.03^{Dab}	4.84±0.04^{Fc}	5.05±0.01^{Ec}
	YM	3.53±0.27^{E}	6.66±0.04^{Ca}	6.76±0.10^{BCd}	7.32±0.05^{ABab}	7.38±0.04^{Aabc}	5.65±0.09^{Dc}	5.16±0.09^{Dcd}	5.19±0.07^{Dc}

* There is a significant difference between samples with different uppercase letters in the same row or different lowercase letters in the same column (p<0.05). **TMAB Total mesophilic aerobic bacteria LAB Lactic asit bacteria YM Yeast and molds.
* Aynı satırda farklı büyük harflerle veya aynı sütunda farklı küçük harflerle gösterilen örnekler arasında anlamlı bir fark vardır (p<0,05).
**TMAB Toplam mezofilik aerobik bakteri LAB Laktik asit bakterileri YM Maya ve küf.

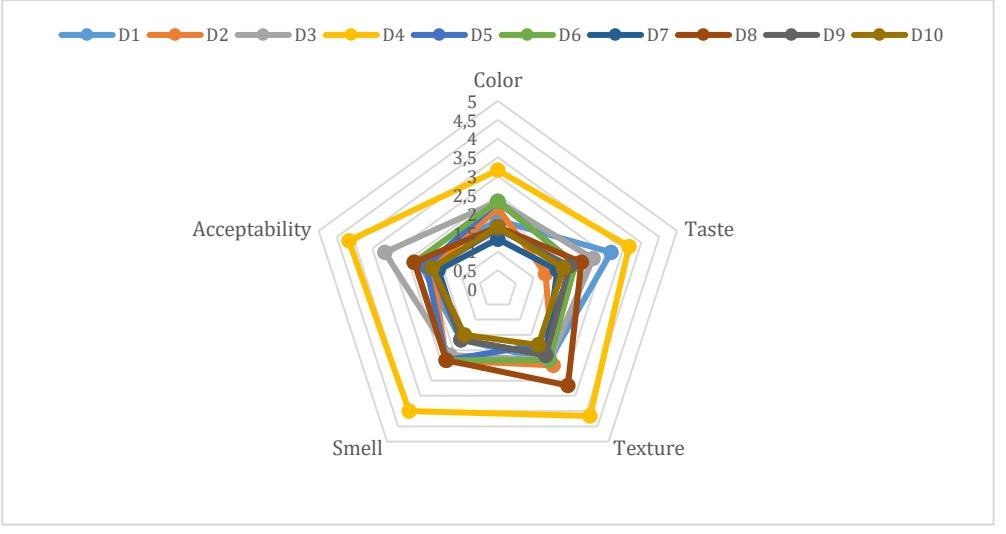

Figure 1. Sensory analysis flavor profile of pickles
Şekil 1. Turşuların duyusal analiz lezzet profili
D1: celery, D2: mint, D3: parsley, D4: dill, D5: garlic, D6: rosemary, D7: bay leaf, D8: black mustard, D9: coriander, D10: control.
D1: kereviz, D2: nane, D3: maydanoz, D4: dereotu, D5: sarımsak, D6: biberiye, D7: defne yaprağı, D8: siyah hardal, D9: kişniş, D10: kontrol.

Conclusion

Grape pickles produced with different aromatic herbs exhibited significant changes in physicochemical, microbiological, and sensory properties during ripening and storage. The pH decreased and total acidity increased during

fermentation, providing an environment unfavorable for spoilage microorganisms and consistent with reported values for fruit-based pickles. TMAB and YM counts increased during early ripening, with subsequent decreases during storage, while LAB showed sustained growth, highlighting their essential role in controlling fermentation and ensuring product quality. Variations in microbial dynamics were influenced by raw material composition, added herbs and storage conditions. Color parameters indicated increased brightness and slight shifts in hue, reflecting changes in pigments during fermentation. Sensory evaluation demonstrated that dill-flavored pickles achieved the highest overall acceptability, confirming that herb selection affects both flavor and consumer preference. Generally, the study demonstrates that controlled fermentation with appropriate raw materials and aromatic additives can produce grape pickles with desirable safety, quality, and sensory attributes, suitable for both domestic and international markets. In addition, by increasing the product diversity with the aromatic plants used and determining the antimicrobial effects of the plants, there is a possibility that they have the potential to extend the shelf life.

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