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Determination of the variation in volatile components during the ripening of *Sorbus domestica* L. fruit

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Abstract: *Sorbus domestica* L. is a deciduous shrub-like tree in the *Rosaceae* family that reaches different heights (3–25 m). The service tree commonly grows in the Marmara region, Central and Western Black Sea regions, and Central Anatolia in Türkiye. The fruit of the service tree called *Sorbus domestica*, has an essential place in regards to human health in terms of its antioxidant values. The aroma components and phenolic compounds it contains display a variety of physiological traits. This study was carried out to determine the changes in the pomological characteristics and volatile compounds of *Sorbus domestica* L. fruits in the Tokat region at harvest and the consuming maturities in 2019 and 2020. The aroma extraction from the *Sorbus* fruits identified esters, alcohols, ketones, aldehydes, terpenes, and other volatile aroma compounds. As a result of the study, differences in aldehydes, esters, and terpene compounds were notable within the scope of the volatile aroma compounds. According to the obtained information, our results identified total aldehydes of 70.64%, esters of 7.49%, and terpenes of 21.35% in *Sorbus domestica* during the harvest maturity. When *Sorbus* fruits were left at room temperature until consuming for consumption was reached, the volatile compound rates varied which were 60.59% for the aldehydes, 22.49% for the esters, and 13.20% for the terpenes.

Keywords: aroma; maturity; service tree; rowan

During the growth and maturation of *Sorbus domestica* fruit, aroma compounds continuously synthesise and develop (Amira 2011). *Sorbus domestica*, a member of the *Rosaceae* family with wild fruit, called *Sorbus domestica*, is a deciduous species cultivated in different regions in Türkiye (Öz Atasever 2014). In Türkiye, it commonly grows in the Marmara region, the Central and Western Black Sea region and Central Anatolia. The Inner Aegean Lake region and Hatay are important locations for cultivation (Gültekin, Alan 2007). The *Sorbus* L. genus has more than 80 species in a variety of regions around the world, while 12 species naturally grow in Türkiye (Gültekin 2006). The most important species are the *Sorbus domestica* wild service tree (*Sorbus torminalis*), the rowan (*Sorbus aucuparia*) and the fan-leafed service tree (*Sorbus umbellata*) (Gültekin, Alan 2007). The fruit of the service tree, the *Sorbus domestica*, is a climacteric fruit type, generally softening in the fall period and

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transforming to a dark-brown colour that is consumed with the seeds (Termentzi et al. 2008; Vegvari 2010). *Sorbus domestica* generally has a yellowish and red colour. Just as fruits are liked and consumed, they have ameliorating properties for many diseases in terms of human health (Yılmaz 2010).

The phenolic compounds or pharmacologically bioactive material found in plants are essential for human nutrition (Işık 2017). In recent times, the antioxidant properties and natural bioactive compounds found in plants have attracted great interest in human health (Balasundram et al. 2006; Giorgi et al. 2009). The volatile aroma compounds in fruit are one of the most critical parameters for fruit consumption (Şeker et al. 2021). Volatile aroma compounds are important factors directly affecting the quality of fruit production and fruit maturity (Ekinci et al. 2021).

The compositions of volatile compounds of pome fruits have been determined by different researchers. It has been stated that aldehyde compounds are determined at the harvest period and ester compounds are identified more in the later stages of ripeness, especially in fruits such as apples and pears. In many studies, it has been reported that hexenal, *E*-2-hexenal, and butyl acetate compounds form the typical pome fruit aroma (Şeker et al. 2021). It was reported that hexyl acetate, butyl acetate, and 2-methyl butyl acetate compounds form the characteristic aroma in ripe apple fruits (Ekinci et al. 2016).

The fruits of *Sorbus domestica* L. are astringent until they reach maturity, at which point they become more pleasant tasting (Martínez Gamir 2022). de Rueda Salgueiro et al. (2006) reported that, in the past, fruit ripening was achieved in a slow and staggered manner by placing them in harvested straw or cereal. During this period, a fermentation process takes place, which makes the flesh softer and more palatable. The fruits can also be consumed through different processing processes, such as jams or jellies (Lim 2012).

Studies on the flavour components and changes of rowan fruit are extremely rare. In studies carried out on the production of alcohol by fermentation of the *Sorbus* fruit, a certain aromatic profile was determined and more than 100 compounds were detected (Martínez Gamir 2022).

This study aimed to determine the pomological differences and volatile compounds of *Sorbus domestica* fruits that naturally grow in Türkiye and are believed to have the potential to contribute to the global trade in the harvest maturity and consumption maturity periods in normal room conditions after harvest.

MATERIAL AND METHODS

This research was completed on samples with superior fruit features obtained from productive *Sorbus domestica* orchards in Tokat in the 2019 and 2020 production seasons. Five trees were selected for each replication for two years (2019 and 2020) from the fruits of rowan trees grown in a professional producer orchard in the central district of Tokat.

The harvesting of the fruits was repeated three times in total, with at least ten fruits from all directions of the same trees. With this aim, the fruit samples obtained from the orchards were brought directly to the laboratory environment on the same day. The orchard, where the fruit was obtained, regularly applied cultural processes like irrigation, and fertiliser and pesticide applications.

Within the scope of the study, the *Sorbus domestica* fruits were left in normal room conditions at 22–24 °C for 15 days based on the fruit maturing and fully changing colour. The soluble solid content (SSC) was determined as %Brix with a digital hand refractometer (model HI96801, Hanna Instruments®, Germany).

The titratable acid (TA) in the fruit (g/100 mL malic acid) was calculated with the malic acid coefficient for the consumed base amount obtained with the titration of the homogenised fruit juice in water (Kartal, Gür 2020).

The volatile compounds in harvested *Sorbus domestica* fruits were determined using the liquid-liquid extraction method reported by Gündoğdu et al. (2021).

The detection of aroma compounds used a gas chromatography/mass spectrometry (GC/MS) (Shimadzu® QP-2010) device with a capillary column attached (DB-WAX 30 m × 0.25 mm ID × 0.25 μm) and polyethylene glycol as the fixed phase. Extracts of 1 μg were injected into the gas chromatograph with an injection temperature of 280 °C and a 1 : 50 split injection mode. The differentiation in the aroma compound peaks occurred from 40 °C to 250 °C, and the oven temperature programme was left for 10 min at this

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temperature and was completed in 59 minutes. The identification of the aroma compounds with the mass spectrometry at 250 °C ion temperature, 70 eV ionisation energy, 666 amu^{-1} scanning speed and 40–350 amu scanning interval used the NIST and WILEY mass spectral libraries.

Statistical analysis. The data obtained from the study underwent a variance analysis with the aid of the SAS version 9.0 statistical software. The differences between the means were identified with Tukey's test ($P < 0.01$).

RESULTS AND DISCUSSION

Within the scope of the research, *Sorbus domestica* fruit from the rare wild fruit tree *Sorbus domestica*, belonging to the *Rosaceae* family, had pomological checks carried out in the immature and mature period after harvest without any post-harvest application. Care was taken to ensure that the fruits used in the analyses were undamaged and had qualities that represented the features of the species. The values of the TA, SSC, and SSC/TA measurements of the fruits of the *Sorbus domestica* species in 2019 and 2020, as well as an average of both years, are given in Table 1.

Regarding the titratable acidity values of rowan fruits, when both 2019 and 2020 and the average of both years are examined, there is no difference between the years.

However, the difference is statistically significant at the maturity stages. In the average of both years, the TA values were determined as 0.888 g/100 mL at harvest ripeness and 0.649 g/100 mL at the consuming maturity stage.

According to the two-year measurement results of the fruits, the SSC/TA ratio varies between unripened 20.27% – ripened 37.17% (Table 1). In a study in which the agro-morphological characteristics of ten different *Sorbus domestica* genotypes growing naturally in Bolu were determined, the SSC/TA values of the 14MR01 and 14MR03 genotypes were measured as 21.00% and 21.33%, respectively. Among the genotypes, the highest SSC was obtained in the 14MR03 genotype, with 20.58%, followed by the 14MR01 genotype, with 20.25%. The results of the literature search on the SSC, TA and SSC/TA content of *Sorbus domestica* fruit juices are similar to the results obtained in this study (Tas et al. 2023).

In terms of the consumption quality, the conversion products of carbohydrates between the starch and sugar in fruit affect the taste and aroma. However, the conversion products of polymeric carbohydrates, especially the pectic material and hemicelluloses, affect the structural change. These polymers found in excess amounts in fruit are degraded by the ripening of the fruit. At this stage, a variety of reactions may take place, leading to the formation of substances ranging from methyl alcohol to galacturonic acid. The formation of galacturonic acid especially causes the fruit to brown and soften more rapidly (Zhao et al. 2023).

It has been reported that the total soluble solid contents in the fruits of the Golden Delicious apple variety are affected by many factors, such as the climate, temperature, harvest maturity and cold storage conditions (Şeker et al. 2021).

In the average values of *Sorbus domestica* fruits in both years, the SSC value, measured as 24.08% at harvest ripeness, was determined as 17.95%

Table 1. Changes in the quality criteria of *Sorbus domestica* fruits in 2019–2020

Pomological analyses	2019			2020			Mean of years		
	unripened fruits	ripened fruits	HSD	unripened fruits	ripened fruits	HSD	unripened fruits	ripened fruits	HSD
SSC (%)	17.95 ± 0.45^{b}	24.03 ± 0.60^{a}	2.00	17.93 ± 0.72^{b}	24.13 ± 1.06^{a}	3.41	17.95 ± 0.23^{b}	24.08 ± 0.83^{a}	1.32
TA (g/100 mL)	0.896 ± 0.030	0.654 ± 0.039	0.132	0.880 ± 0.054^{a}	0.643 ± 0.035^{b}	0.17	0.888 ± 0.038^{a}	0.649 ± 0.037	0.072
SSC/TA	20.07 ± 0.68^{b}	36.79 ± 1.56^{a}	4.52	20.46 ± 1.98^{b}	37.55 ± 1.11^{a}	6.04	20.27 ± 1.05^{b}	37.17 ± 1.27^{a}	2.52

Data are the means of 3 replicates; ^{a,b}values followed by different lowercase letters are significantly different at $P < 0.01$
HSD – the honestly significant difference; SSC – soluble solid content; TA – titratable acid

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at consumption ripeness. A reduction occurred in the SSC ratio of *Sorbus domestica* between the harvest maturity and consuming maturity periods. Due to the climacteric features of *Sorbus domestica*, fruit contains high amounts of starch at harvest time. A large portion of the total soluble solid contents of fruit is comprised of sugars. The starch content converts to sugar with the ripening and reduces, and the total soluble sugar (TSS) content increases (Karaçalı 2006). However, the reduction is an expected result due to the increased respiration and the use of sugars in respiration or the degradation to alcohol during the ripening of fruit (Kaynaş, Kuzucu 2002; Kartal, Gur 2020; Kaynaş et al. 2022a; Kaynaş et al. 2022b).

The number of volatile compounds detected in *Sorbus domestica* fruits is given in Table 2. According to the results of the study, *Sorbus* fruits at harvest ripening contained 11 volatile compounds, while the *Sorbus* fruits matured to the consumption level were identified to contain 25 volatile compounds. In terms of aroma diversity, the ripening of fruit is very effective in increasing the volatile compounds. The identification of volatile compounds observed that esters, aldehydes, and terpenoids were the most effective. Although it was determined that rowan fruits had an aroma concentration of 1 103.22 μg/kg during harvest, the aroma concentration reached 3 869.33 μg/kg at the consumption ripeness. At both ripening periods, aldehyde compounds were observed to be the highest rates in *Sorbus domestica* (70.64% unripened, 60.59% ripened). The aldehydes were followed by the ester and terpene groups. In spite of the fruit harvested at the harvest maturity period having higher rates of terpene compounds (21.35% unripened, 13.29% ripened), the fruit had higher rates of ester compounds identified after ripening (7.49% unripened, 22.49% ripened). Additionally, as the fruit ripened, the proportion of alcohol compounds, initially undetected, increased (2.62%).

The volatile composition of *Sorbus domestica* species ecotypes cultivated in the Pera and Manzana ecologies in Spain was determined at different maturity stages. As a result of the research, aroma profiles were formed according to the regions and ripeness. The aroma compounds of the fruits were examined at three different stages according to their ripeness: the unripe, ripe, and over-ripe stages. As a result of the research, a total of 51 volatile aroma compounds, including esters, terpenes, alcohols, aldehydes, ketones, hydrocarbons, carboxylic acids, and other compound groups were determined in all the ripeness conditions in both regions. When the volatile compounds of ripe rowan fruits were analysed, ester compounds at 1.96%, sesquiterpenes at 2.47%, alcohols at 46.75%, aldehydes at 21.92%, carboxylic acid at 2.95% and other compounds at 21.66% were determined in the Pera region. On the other hand, in the ripe rowan fruits in the Manzana region, the alcohols increased by 74.25%, aldehydes by 6.12%, esters by 2.93%, sesquiterpenes by 3.04%, carboxylic acids by 2.94% and other compounds by 7.38% (Martínez Gamir 2022).

The aroma compounds identified in *Sorbus domestica* at harvest had limited numbers, with three types of aldehyde, three types of ester, four types of terpene and one other compound. Benzaldehyde, hexanal and *E*-2-hexanal aldehydes; hexyl acetate, butyl acetate and *Z*-3-hexenyl acetate esters; and *E*-β-caryophyllene, *Z*-ocimene, α-pinene, and α-gurjunene terpenes and ethylbenzene were the aroma compounds detected.

As a result of the analyses, *E*-2-hexanal (11.72–7.64%), hexanal (56.53–50.81%) and benzaldehyde (2.39–1.96%) were identified in the aldehyde group aroma compounds from harvest to consuming maturity, respectively. Although the concentrations of aldehyde compounds increased during the ripening rowan fruits, their ratio in the total aroma compounds decreased. The main reason for this situation is that the rates of the other volatile compounds synthesised during ripening increased faster than the aldehydes. Hexanal [unripened 623.49 μg/kg fruit weight (FW) – ripened 1 966.64 μg/kg FW], *E*-2-hexenal (unripened 129.34 μg/kg FW – ripened 295.58 μg/kg FW) and benzaldehyde (unripened 26.37 μg/kg FW –ripened 76.02 μg/kg FW) compounds were of major importance among the volatile compounds identified.

These compounds are aroma components produced in fruit by the lipoxygenase enzyme activity and generally represent a green and freshly-cut grass odour (Gündoğdu et al. 2021). The measurements of the harvested *Sorbus domestica* identified high amounts of aldehyde group compounds in the unripe *Sorbus domestica*. Vyviurska et al. (2015) reported hexanal and benzaldehyde compounds in unripe *Sorbus domestica.*

From the aldehyde group, hexanal and *E*-2-hexenal were especially high in the immature fruit,

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Table 2. Significant volatile aromatic substance ratios and contents of *Sorbus domestica* fruits (%) and (μg/kg fruit weight)*

Volatile compounds	Unripe *Sorbus* fruit (%)	Ripe *Sorbus* fruit (%)	HSD ($P < 0.01$)	Unripe content (μg/kg FW)	Ripe content (μg/kg FW)	HSD ($P < 0.01$)
Aldehydes						
Benzaldehyde	2.39	1.96	ns	26.37^{B}	76.02^{A}	27.03
Hexanal	56.53^{A**}	50.81^{B}	5.46	623.49^{B}	1 966.64^{A}	140.77
Nonanal	0.00^{B}	0.18^{A}	0.17	0.00^{B}	6.96^{A}	6.51
E-2-hexenal	11.72^{A}	7.64^{B}	1.17	129.34^{B}	295.58^{A}	34.98
Total aldehydes	70.64^{A}	60.59^{B}	7.44	779.20^{B}	2 345.08^{A}	208.60
Esters						
Hexyl acetate	1.35^{B}	2.32^{A}	0.76	14.94^{B}	89.69^{A}	23.22
Butyl acetate	1.88^{B}	9.04^{A}	1.05	20.77^{B}	349.61^{A}	38.26
Z-3-hexenyl acetate	4.26	4.40	ns	47.02^{B}	170.10^{A}	39.47
2-methyl butyl acetate	0.00^{B}	2.58^{A}	0.79	0.00^{B}	99.87^{A}	30.88
Ethyl butanoate	0.00^{B}	0.19^{A}	0.16	0.00^{B}	7.26^{A}	6.08
Hexyl propionate	0.00^{B}	1.46^{A}	0.50	0.00^{B}	56.53^{A}	19.56
Pentyl propionate	0.00^{B}	1.52^{A}	0.72	0.00^{B}	58.79^{A}	27.77
Isobutyl acetate	0.00^{B}	0.98^{A}	0.74	0.00^{B}	37.95^{A}	28.82
Total esters	7.49^{B}	22.49^{A}	1.90	82.72^{B}	869.80^{A}	30.16
Terpenoids						
E-β-caryophyllene	7.38^{A}	2.47^{B}	1.41	81.42	95.54	ns
Linalool	0.00^{B}	0.26^{A}	0.11	0.00^{B}	9.93^{A}	4.07
Z-ocimene	4.37^{A}	3.23^{B}	1.00	48.24^{B}	124.95^{A}	15.48
α-pinene	4.16^{A}	2.35^{B}	1.33	45.89^{B}	90.84^{A}	27.83
α -gurjunene	5.44^{A}	4.00^{B}	1.05	60.07^{B}	154.78^{A}	33.61
Limonene	0.00^{B}	0.98^{A}	0.35	0.00^{B}	38.10^{A}	13.44
Total terpenoids	21.35	13.20	3.62	235.61^{B}	514.13^{A}	97.26
Ketones						
6-methyl-5-hepten-2-one	0.00^{B}	0.12^{A}	0.11	0.00^{B}	4.78^{A}	4.24
Total ketones	0.00^{B}	0.12^{A}	0.11	0.00^{B}	4.78^{A}	4.24
Alcohols						
Farnesol	0.00^{B}	0.54^{A}	0.29	0.00^{B}	21.04^{A}	11.39
Isohexanol	0.00^{B}	1.38^{A}	1.04	0.00^{B}	53.44^{A}	40.14
Pentanol	0.00^{B}	0.49^{A}	0.37	0.00^{B}	18.81	14.29
Octanol	0.00^{B}	0.21^{A}	0.11	0.00^{B}	8.08	4.09
Total alcohols	0.00^{B}	2.62^{A}	1.22	0.00^{B}	106.16^{A}	47.32
Other compounds						
Ethylbenzene	0.52	0.67	ns	5.69^{B}	25.74^{A}	10.31
Hexane	0.00^{B}	0.22^{A}	0.05	0.00^{B}	8.43^{A}	2.05
Total others	0.52	0.89	ns	5.69^{B}	34.17^{A}	8.53
Total	100.00	100.00	–	1 103.22^{B}	3 869.33^{A}	339.76

*percentages obtained by GC/MS peak area normalisation, **data are the means of three replicates; ^{A,B}values followed by different capital letters are significantly different at $P < 0.01$

FW – fruit weight; HSD – the honestly significant difference; ns – non-significant

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with reductions occurring as the ripening progressed. With fruit ripening, the aldehyde amount reduced and the ester, ketone and alcohol rates increased. Martínez Gamir (2022) determined nine aldehyde compounds from the volatile compounds of *Sorbus domestica* fruits cultivated in two different regions. Also, Martínez Gamir (2022) identified hexenal, *E*-2-hexanal, benzaldehyde and nonanal compounds similar to our research. Martínez Gamir (2022) explained that the aldehyde compounds of rowan fruits decreased with maturity in both ecologies. However, the aldehyde ratios of the fruits cultivated in the Pera ecology were determined at a higher rate than in Manzana.

Within the scope of the research, when the aroma compounds in the harvested *Sorbus domestica* were investigated, no alcohol compound was encountered in the unripe fruit. With the ripening of the fruit, four alcohol compounds were identified. The compounds were identified at significant rates of 2.62% in the aroma profile after ripening. The identified alcohol compounds increased when the fruits reached consumption maturity. Within the aroma compounds, the highest alcohol amount was 1.38% for isohexanol (53.44 μg/kg). The lowest amount was 0.21% for octanol (8.08 μg/kg). A study by Vyviurska et al. (2015) identified 2-pentanol (0.05%), 3-pentanol (0.01%), 2-octanol (0.14%) and 3-octanol (0.13%) alcohols, with the alcohol amounts below the amount in our study.

A study by Vyviurska et al. (2015) identified 2-pentanol (0.05%), 3-pentanol (0.01%), 2-octanol (0.14%) and 3-octanol (0.13%) alcohols and observed that the alcohol proportions increased with the ripening of the fruit. The limonene compound, one of the terpenes responsible for the aroma characteristics of the fruit, increased with the ripening of fruit, though only slightly (0.98%). Martínez Gamir (2022) determined 11 alcohol compounds from the volatile compounds of *Sorbus domestica* fruits cultivated in two different regions. Also, Martínez Gamir (2022) identified pentanol, hexanol and octanol compounds similar to our study. Martínez Gamir (2022) stated that the alcohol compounds of rowan fruits increased with the ripening in both ecologies. However, the alcohol ratios of the fruits cultivated in the Manzana ecology were determined at a higher rate than in Pera.

The results of the research identified several ester compounds. Esters are among the essential aroma compounds in *Sorbus domestica* fruit. Ester compounds in fruit mean that the taste and odour of the fruit are intense and are the reason the fruit is chosen by consumers. In this study, eight ester compounds were detected in the consumption maturity period. The values presented in Table 2 show that the ratios of the ester compounds had a tendency to increase in parallel with the ripening of *Sorbus* fruits. Significantly, the increase in the concentration content of ester compounds (82.72 μg/kg and 869.80 μg/kg, respectively) is noteworthy.

Martínez Gamir (2022) identified six ester compounds in the fruits of *Sorbus domestica* species. In rowan fruits cultivated in two different regions, the butyl acetate and hexyl acetate compounds were found to be similar to this study. As a result of the research, it was determined that the ester components of rowan fruits cultivated in both ecologies increased as the maturity progressed. Martínez Gamir (2022) explained that the ester ratios of the fruits grown in the Manzana ecology were higher than in the Pera ecology.

Considering the variation in the terpene group compounds in the study, *E*-β-caryophyllene is notable, with a value of 7.38% in the initial analyses after the harvest of the fruit. *E*-β-caryophyllene displayed an inverse reduction with the increase in the duration of fruit ripening. *E*-β-caryophyllene reached the highest concentrations as the fruits were hard when harvested (Table 2). The limonene and *E*-β-caryophyllene compounds are responsible for the unique aroma characteristics of the fruit (Guillot et al. 2006). As a result of the study, six terpenoid compounds were identified in the harvested *Sorbus domestica* fruits, with the most important being *E*-β-caryophyllene, α-gurjunene, *Z*-ocimene and α-pinene, while the other terpenes were limonene and linalool. Although the contents of the terpene compounds (235.61 μg/kg and 514.13 μg/kg, respectively) increased with the ripening of the fruits (from harvest to consumption ripeness), their ratio in the total aroma compounds (21.35% and 13.20%, respectively) decreased. With the identification of these compounds at high rates, especially *E*-β-caryophyllene at 7.38% in the unripe fruit, linalool (0.26%) was identified at lower rates in the ripened *Sorbus* fruits.

Martínez Gamir (2022) identified six terpene compounds, including β-caryophyllene and linalool, in the fruits of the *Sorbus domestica* species cultivated in two different regions. Additionally,

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Martínez Gamir (2002) observed that terpenoid levels decrease as the fruit matures and reported that fruits cultivated in the Pera ecology have a higher concentration of terpenes.

As a result of the research, initially, ketone compounds were not encountered in the harvested fruits of *Sorbus domestica*, while one ketone compound was identified with the increased ripening. The total ketone compound rates were 0.12% for 6-methyl-5-hepten-2-one in the general aroma profile of the ripened *Sorbus* fruits. Vyviurska et al. (2015) found similar ketone rates from 0.55–0.22% in their study.

The volatile compounds in the category of other compounds were identified at low levels in the unripe and matured *Sorbus domestica* fruits (Table 2). These were ethylbenzene (0.52–0.67% and 5.69–25.74 μg/kg) and hexane (0–0.22% and 0–8.43 μg/kg). These compounds are known not to be notable compounds in the aroma structure.

CONCLUSION

Unlike other studies, the lack of any study related to the determination of volatile compounds in *Sorbus* fruits, which are grown in most regions of Türkiye, but not commercially cultivated, increases the importance of this research.

As a result of the research, the volatile compounds were identified using chromatography methods on unripe and matured fruits of *Sorbus domestica*.

It was determined that the ester and aldehyde compounds comprised the major aroma structure in *Sorbus* fruits. While the ester ratio was 7.49% in the immature *Sorbus* fruits, the rate increased to 22.49% with the ripening. This increase in the ester ratio indicates that the fruit aroma increases to the desired level.

It was determined that the aldehyde compounds were the major aroma compound group in the *Sorbus domestica* fruits. Aldehydes (70.64%) had the highest ratios in the unripe fruits and decreased to 60.59% in the ripe fruits.

Many studies have reported that rowan fruits have vital properties for human health (Orsavová et al. 2023; Tas et al. 2023). Consumers do not like rowan fruits because they are usually consumed at harvest ripeness. However, it has been determined that when the fruits ripen, the desired volatile compounds are synthesised, and the quality characteristics of the fruits reach the edible and desired levels. Based on the information obtained in this research, significant contributions can be made to the cultivation of *Sorbus domestica*.

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