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VOLATILE AND SOME FRUIT QUALITY CHARACTERISTICS OF NEW PROMISING PEACH GENOTYPES

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Abstract. Peach breeding studies were initiated in 1998 to improve early cultivars for subtropical conditions and late cultivars for highland areas. 4 genotypes (RU-24, J-92, J-28 and S-6) were selected and are currently in the process of being patented. The purpose of this paper was to evaluate these promising genotypes in terms of their volatile compounds using Headspace-Solid Phase Micro Extraction Mass Spectrometry (HS-SPME/GC/MS) techniques. Volatile compounds, especially esters, are the main contributors to fruity and floral notes and pleasant fruit flavours. Esters comprised the majority of volatile compounds in all four peach genotypes, however the composition of volatile compounds differed among genotypes. J-92 contained the most esters, while Ru-24 contained the least. Ru-24, however, contained the highest levels of lactones, aldehydes, and total acids of the four genotypes tested. The S-6 genotype contained the most total alcohols. Thus, the volatile composition and contents depended largely upon the peach genetic background. In addition to the volatile compounds, the highest fruit weight were detected in genotype Ru-24 and total soluble solids (TSS) was greatest in genotype S-6.

Key words: peach, aroma, GC/MS, Headspce, SPME

INTRODUCTION

Peaches are believed to have originated in China where they were cultivated for at least 4.000 years and the greatest genetic diversity still exists [Rieger 2006]. The spread of peaches to the west followed along ancient trade routes from China to Persia (hence the name for peach, *Prunus persica*) and from Persia into the Mediterranean region

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including Greece, Italy and Spain [Goffreda 1999]. Since Turkish peach cultivars were derived from a relatively small subsample of the genetic diversity available in China, the genetic base of cultivars in Turkey is limited.

Turkish cultivars, however, have important agricultural characteristics such as resistance to cold, drought, and diseases, earliness, lateness, etc. That can be used in a breeding programme [Yildiz 1995].

The peach is one of the most genetically diverse deciduous fruit species in the world and about 100 new peach and nectarine cultivars have been introduced per year over the last 10 years [Fideghelli et al.1998, Byrne 2002, Badenes et al. 2006, Sansavini et al. 2006].

'Ustun' is a local peach cultivar found at 1400 m highlands of Central Anatolia. It was obtained from J.H. Hale from open pollination and ripens around 15–20 October at 1400 m 25–30 days after 'Hale' and 'Monroe' cultivars [Küden et al.1997]. Fruit flesh is firm, yellow, fruit rind color is red blushed on yellow color. It is suitable for shipping also [Küden et al. 1997].

Flavour, texture, and appearance are the three most important quality characteristics of fruits and play a very important role in the quality assessment of fruits and vegetables. As such, these parameters affect the economic importance of a cultivar by influencing the purchasing behavior of consumers [Kühn and Thybo 2001, Peneau et al. 2006].

Flavour is defined as the interaction of individual taste and aroma components with the human sensory system [Vermeir et al. 2009]. The relative contributions of specific aroma volatile compounds to the flavor of peaches have been previously reported and more than 100 compounds have been identified [Engel et al. 1988a, Takeoka et al. 1988, Chapman et al. 1991, Kaiuchi and Ohmiya 1991, Derail et al. 1999, Lavilla et al. 2002, Aubert et al. 2003, Jia et al. 2005, Aubert and Milhet 2007]. Conventional sampling methods for fruit aromas in previous studies were mainly liquid-liquid extraction (LLE) and steam distillation extraction (SDE) [Baldry et al. 1972 and Aubert et al. 2007] These conventional methods always require long extraction times, large amounts of solvents, and multiple steps. Furthermore, many unstable aroma volatiles may be thermally decomposed and degraded during thermal extraction or distillation. However, they were still extensively applied for fragrance-and-aroma characterization, either alone or combined with other sample-preparation procedures [Moser et al. 1980]. There are many variables in headspace solid-phase micro-extraction analysis that affect the final analysis (e.g. agitation conditions, sampling time, temperature, sample volume, headspace volume, vial shape, condition and geometry of the fibre coating, sample matrix and injector set-up) [Pawliszyn 1999]. Thus, it is important to monitor the formation of volatiles not only in order to fulfill the consumers' expectations and select for genotypes that contain high levels of volatile compounds. The methods used for the isolation, concentration and identification of fruit flavour compounds often have a profound influence on the results obtained in the volatile composition determination [Kafkas et al. 2005]. Solid-phase microextracton (SPME) is a simple, solvent-free method for concentration of volatiles present in the headspace. This technique had been used to analyze the volatile compounds of different fruits [Zhang et al. 2007]. Extraction of peach volatiles using SPME techniques, however, has been poorly studied.

The aims of this research were to compare new promising peach genotypes based on their volatiles using HS-SPME/GC/MS techniques and pomological characteristics.

MATERIALS AND METHODS

The experimental line Ru-224 was obtained by crossing Rio-Oso-Gem × Üstün varieties while J-28, J-92 and S-6 genotypes were obtained from open pollination of J.H. Hale, Monroe, Rio-Oso-Gem late and Suncrest in 1995. [Küden and Kaşka 1993, Son and Küden 1995, Kaşka and Küden 1998]. Approximately 2000 genotypes were evaluated and four were selected based on superior performance. These genotypes were evaluated for 3 years based on their yield and fruit quality characteristics both at sea level (Adana) and high latitudes (at Pozanti Agricultural Research Station at about 1100 m) to compare their climate responses.

The pomological analyses were done according to standard procedures [Küden et al. 1995, Monet 1995]. Harvested fruits were immediately placed into a portable cooler and transferred to the Fruit Sensory Lab in the Horticulture Department at University of Çukurova.

Fruit volatiles were extracted by Headspace Solid Phase Micro Extraction Technique (HS-SPME) using 250 g of fruits in each replicate. The fruit flesh was homogenised in a food processor and 5 g of the homogenate were diluted with 2 ml of NaCl saturated aqueous solution and immediately headspace sampling was conducted on 100 µm fused silica fibres coated with polydimethylsiloxane/divinylbenzene (CAR/PDMS) (Supelco). Volatile compounds were analyzed on an automatic HS-40 head space autosampler (Perkin Almer GC with split splitless inlet MSD system combine with Combi PAL autosampler system). Needle temperature was set to 120ºC, thermostic time and degree was 30 min and 35ºC during the extraction in the headspace autosampler. HP-5 MS (30 m × 0.25 mm × 0.25 µm) fused-silica capillary column was used. Helium (1 ml/min) was used as a carrier gas. The injector temperature was 250°C, set for splitless injection. The oven conditions were set to 50°C for 1 min and then the temperature was increased to 200°C at a rate of 4°C/min. Thermal desorption was allowed for 1.5 min. The detector temperature was 280°C. The components were identified by comparison of mass spectra and retention time data with those of authentic samples and complemented with a identified by doing a NIST, Wiley, Flavor library search of the acquired mass spectral data.

RESULTS AND DISCUSSION

Phenological dates and fruit characteristics. Dates of important phonological events of the four f promising peach genotypes are given in Table 1. Qualities genetics select for include: 1) late bud break date to avoid early spring frosts and 2) early harvest date to maximize income to bring the fruit to market before the main harvest season. Full bloom date was similar among J-28, J-92, and S-6, while Ru-24 tended to be 4–5 days earlier than the other genotypes (tab. 1). As for the harvesting time, genotype S-6 was found to be the earliest one whereas J-28 was the latest.

Table 1. The flowering and harvesting dates of the promising peach genotypes in Pozantı

Cultivars	Dates of			
	bud break	first bloom	full bloom	harvesting
RU-24	22.03.2008	01.04.2008	07.04.2008	18.09.2008
J-28	20.03.2008	03.04.2008	11.04.2008	21.08.2008
J-92	20.03.2008	05.04.2008	12.04.2008	15.08.2008
S-6	18.03.2008	05.04.2008	12.04.2008	13.08.2008

The results of fruit quality characteristics of the peach genotypes are presented in Table 2. Ru-24 produced the largest t fruits and a high brix value (16.50%). All fruit genotypes produced yellow fruit flesh color, but fruit color ranged from yellow red to pink red, and all had high brix values. Brix values were detected using hand refractometer. Obtained data were scaled based on their values. When the values lower than 10 (%) detected and classified as non desirable, between 10 to 11 (%) mid-desirable, higher than 11 (%) desirable [Kaşka and Küden 1998]. As seen in Table 2, obtained values were detected higher than 11.

Table 2. Fruit quality characteristics of the promising peach genotypes

Cultivars	Weight (g)	Width (mm)	Length (mm)	Height (mm)	Brix (%)	Seed weight (g)	Fruit flesh color	Fruit color	Seed position
Ru-24	193.36	63.79	66.06	66.17	16.50	7.70	yellow	pink red	freestone
J-28	181.18	53.94	62.87	57.42	15.20	8.38	yellow	yellow red	freestone
J-92	137.15	53.94	62.87	57.42	15.20	8.38	yellow	yellow red	freestone
S-6	181.13	63.22	62.40	64.76	16.80	8.55	yellow	yellow red	freestone

The climatic datas including temperature, rainfall and humidity were given in Table 3 during the vegetation period of experimental location.

Table 3. Some climatic values of Pozantı Agricultural Research Station in 2008

Average monthly	March	April	May	June	July	August	September	October
Temperature (°C)	6.4	11.5	16.2	20.4	23.7	23.1	18.4	12.9
Rainfall (kg/m^2)	39.1	48.5	31.0	12.9	1.3	1.5	5.2	25.7
Humidity (%)	55	72	70	75	80	75	60	50

Volatile Compounds Analyses. Aroma is one of the essential components of fruit quality. Volatile components of peach genotypes were given in Table 4. As seen in Table 4, esters, lactones, aldehydes, alcohols, acids and ketones were detected in peach genotypes with esters comprising the majority of the volatile compounds. Esters are considered to be main contributors to fruity and floral notes and high ester content give a pleasant flavour in most fruits especially peaches [Sumitani et al. 1994]. Higher content of esters were detected in genotypes J-92, J-28, S-6 (88.18, 76.21 and 73.20%, respectively) and the lowest in Ru-24. Eleven esters were detected with ethyl acetate being the most abundant in all genotypes. Wang et al. [2009], reported that esters were the second major compounds after lactones. The composition of volatiles and their contents not only depend on the genotypic background and germplasm origins, but also on extraction and detection procedures. The type of SPME fibre coating of various polarities and extraction time were carried out to select the optimum condition for the analyses of the volatile compounds. The most exploited fibre in volatile analysis is based on a poly-dimethyl-siloxane stationary phase (PDMS) [Jia et al. 2005] or its upgraded phase using divinyl-benzene known as PDMS/DVB fibre [Wang et al. 2009]. The results showed that the last of which was the most efficient fibre to trap the volatile compounds. In this paper, extraction of volatiles was also efficient when application of CAR/PDMS 50/30 μm fibre was used. In the previous peach studies the volatiles hexyl acetate and 2-hexenyl acetate were detected in the largest quantities and were commonly define as the typical peach odour and aroma [Sevenants et al. 1966, Spencer et al. 1978, Engel et al. 1988b, Rizzolo et al. 1993, Sumitani et al. 1994, Auber et al. 2003]. In this paper, ethyl acetate was the major compound, followed by hexyl acetate, 2-hexenyl acetate, cis-2-hexen-1-ol acetate and linalyl butyrate. These differences were likely caused by genetic heritage and breeding location. Addition to this, usage of different fibres are also affect the identifying of the volatiles.

Lactones, particularly gamma decalactones have been reported as “character impact” compounds in peach aroma. They act in association with other volatiles such as C6 alcohols and terpenoids to produce the flavours specific to peach, and lactone contribute the “peachy” background whilst others contribute fruity and floral notes [Horvat et al. 1990a, b]. In this paper, gamma-decalactones was detected in all genotypes, except S-6.

Eight aldehyde compounds were detected and benzaldehyde, ethanal, n-heptanal, n-hexanal were detected in all genotypes while 2-hexene-1-al and n-octanal were detected only in Ru-24 (6.35 and 3.15%, respectively). In addition, Ru-24 fruits produced the highest quantities of total aldehydes of all the genotypes tested.

Eight alcohol compounds were detected while only the hexyl alcohol was detected in all genotypes. Esters such as hexyl acetate and (Z)-3-hexenyl acetate are considered as key odorants influencing the flavor quality of peach fruit. The highest total alcohol was detected in line S-6 while the lowest in line J-28. Propanedioic acid was detected in all genotypes except line J-92 while 6-methyl-5-heptene-2-one was only detected in line Ru-24.

The volatiles of peaches and nectarines include many six carbon (C6) compounds such as alcohols, aldehydes, esters, terpenoids, ketones and lactones. Among the lactones, c- and d-decalactones, have been reported to be the major contributors to peach aroma with smaller contributions by other volatiles such as C6 aldehydes, alcohols and

Table 4. Volatile compounds of promising peach genotypes by Hs/Spme-Gc/Ms technique. n.d: not detected

		J-92	J-28	S-6	Ru-24
Compounds esters	2-hexenyl acetate	4.24 ±1.09	1.24 ±0.56	1.39 ±0.12	1.97 ±0.04
	hexyl acetate	10.17 ±3.06	5.92 ±1.12	3.23 ±0.45	4.14 ±0.67
	cis-2-hexen-1-ol acetate	3.44 ±1.05	1.04 ±0.25	1.31 ±0.21	1.97 ±0.59
	2-methylbutyl hexanoate	0.09 ±0.02	n.d.	n.d.	n.d.
	butyl acetate	0.45 ±0.05	0.32 ±0.04	0.34 ±0.06	n.d.
	ethyl acetate	63.80 ±5.98	64.48 ±7.89	66.62 ±6.55	42.57 ±6.23
	ethyl octanoate	0.03 ±0.06	n.d.	0.01 ±0.04	n.d.
	isobutyl ethanoate	0.41 ±0.12	0.29 ±0.12	n.d.	n.d.
	linalool acetate	n.d.	n.d.	0.13 ±0.01	n.d.
	linalyl butyrate	3.65 ±0.23	2.68 ±0.65	n.d.	4.13 ±0.90
	vinyl formate	1.90 ±0.06	0.24 ±0.11	0.17 ±0.06	n.d.
	total esters	88.18	76.21	73.20	54.78
	Γ-decalactone	0.12 ±0.02	0.08 ±0.05	n.d.	0.23 ±0.11
	Γ-undecalactone	0.08 ±0.04	0.07 ±0.02	n.d.	n.d.
	total lactons	0.20	0.15	n.d.	0.23
Aldehydes	2-hexen-1-al	n.d.	n.d.	n.d.	6.35 ±2.06
	benzyaldehyde	1.36 ±0.15	1.39 ±0.11	0.59 ±0.008	1.40 ±0.19
	ethanal	0.77 ±0.13	0.86 ±0.45	1.57 ±0.37	4.16 ±1.29
	n-decanal	0.49 ±0.05	n.d.	n.d.	n.d.
	n-heptanal	1.06 ±0.25	0.78 ±0.35	0.23 ±0.12	0.90 ±0.07
	n-hexanal	0.53 ±0.11	0.94 ±0.17	0.58 ±0.22	2.93 ±0.15
	n-nonanal	n.d.	n.d.	0.71	n.d.
	n-octanal	n.d.	n.d.	n.d.	3.15 ±0.75
	total aldehydes	4.46	4.00	3.68	18.89
Alcohols	3-butanol	0.25 ±0.03	0.03 ±0.02	n.d.	n.d.
	cis-2-hexenol	n.d.	n.d.	1.55 ±0.21	0.99 ±0.16
	2-hexenol	n.d.	n.d.	1.09 ±0.23	1.33 ±0.16
	eucalyptol	0.19	n.d.	n.d.	n.d.
	cyclohexyl alcohol	0.76	0.56 ±0.13	n.d.	0.13 ±0.03
	cyclobutanol	0.76 ±0.21	0.43 ±0.01	n.d	1.10 ±0.02
	hexyl alcohol	1.26 ±0.23	1.48 ±0.16	5.76 ±1.23	1.41 ±0.08
	α-terpineol	n.d.	0.09 ±0.02	n.d.	n.d.
	total alcohol	2.97	2.56	8.40	4.96
	acids				
	propanedioic acid	n.d.	0.79	0.38	1.02 ±0.35
Kethones	6-methyl-5-heptene-2-one	n.d.	n.d.	n.d.	6.26 ±1.19

Peach genotypes by hs/spme-gc/ms technique. n.d: not detected.

terpenoids [Do et al. 1969, Engel et al. 1988b, Horvat et al. 1990b, Visai and Vanoli 1997]. Intensive investigations have focused on the evolution of peach and nectarine aromas during ripening [Do et al. 1969, Horvat and Chapman 1990a, Chapman et al. 1991, Kakiuchi and Ohmiya 1991, Visai and Vanoli 1997, Lavilla et al. 2002] and during cold storage [Watada at al. 1979, Robertson et al. 1990]. The composition and content of volatile aromas change during maturation. In immature fruits, C6 compounds are the major contributors, but their levels decrease drastically whilst those of lactones, benzaldehyde and linalool increase significantly during maturation [Do et al. 1969, Engel et al. 1988b]. Several studies have also investigated the effect of culture techniques and management on composition and content of volatiles. Volatiles may be modified by orchard management, such as fertilization [Jia et al. 1999] and bagging [Jia et al. 2005] climate or microclimate conditions as sun light [Génard and Bruchou 1992], and postharvest treatment [Fideghelli et al. 1989, Kakiuchi and Ohmiya 1991, Sumitani et al. 1994]. Volatile composition is also cultivar dependent. Engel et al. [1988b] concluded that nectarines contain significantly higher amounts of d-decalactone than peaches do and Robertson et al. [1990] reported that white-fleshed peaches contain more linalool than yellow-fleshed cultivars. Lactones were detected at very low levels in these genotypes and in Line S-6 no lactones were detected. As a result, 11 esters, 2 lactones, 8 aldehydes, 8 alcohols, 1 acid and 1 kethone compounds were detected in peach genotypes. The highest ester compounds was detected in line J-92 and ethyl acetate was the most abundant one. The highest aldehyde, lactones, alcohol, acid and kethone percentages were detected in line Ru-24. Volatile composition and content depended largely upon genetic background.

CONCLUSIONS

1. Ru-24 produced the largest t fruits and a high brix value (16.50%). All fruit genotypes produced yellow fruit flesh color, but fruit color ranged from yellow red to pink red, and all had high brix values.

2. Full bloom date was similar among J-28, J-92, and S-6, while Ru-24 tended to be 4-5 days earlier than the other genotypes.

3. Lactones were detected at very low levels in these genotypes and in Line S-6 no lactones were detected. As a result, 11 esters, 2 lactones, 8 aldehydes, 8 alcohols, 1 acid and 1 kethone compounds were detected in peach genotypes. The highest ester compounds was detected in line J-92 and ethyl acetate was the most abundant one. The highest aldehyde, lactones, alcohol, acid and kethone percentages were detected in line Ru-24.

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ZWIĄZKI LOTNE ORAZ CECHY JAKOŚCI OWOCÓW NOWYCH OBIECUJĄCYCH GENOTYPÓW BRZOSKWINI

Streszczenie. Badania nad uprawą brzoskwini rozpoczęto w roku 1998 w celu ulepszenia wczesnych odmian w warunkach subtropikalnych oraz późnych odmian w obszarach górskich. Wyselekcjonowano 4 genotypy (RU-24, J-92, J-28 i S-6), które są obecnie w procesie patentowania. Celem niniejszego opracowania jest ocena tych obiecujących genotypów w aspekcie ich składników lotnych przy użyciu technik HS-SPME/GC/MS. Składniki lotne, zwłaszcza estry, są głównymi elementami nut owocowych i kwiatowych oraz przyjemnych zapachów owocowych. Estry tworzą większość składników lotnych we wszystkich czterech genotypach brzoskwini, jednak skład elementów lotnych różnił się między genotypami. J-92 zawierał najwięcej estrów, a Ru-24 najmniej. Spośród wszystkich czterech badanych genotypów Ru-24 zawierał najwyższy poziom laktonów, aldehydów i całkowitej liczby kwasów, a genotyp S-6 zawierał najwięcej alkoholi, zatem skład elementów lotnych zależał głównie od genetycznego pochodzenia brzoskwini. Poza składnikami lotnymi, największą masę owocu stwierdzono w genotypie Ru-24 natomiast najmniej rozpuszczalnych substancji stałych (TSS) wykazano w genotypie S-6.

Słowa kluczowe: brzoskwinia, aromat, GC/MS, Headspce, SPME

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