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INFLUENCE OF ETHYLENE-BLOCKING ACTION, HARVEST MATURITY AND STORAGE DURATION ON AROMA PROFILE OF APPLES (ILDRØD PIGEON) DURING STORAGE

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Abstract

Effects of the blocker of ethylene action 1-methylcyclopropene (1-MCP), maturity stage, and storage duration on apple aroma profile were investigated. 1-MCP acts as an effective ethylene receptor blocker and is newly registered in Denmark. Experiments were conducted using the popular Danish cultivar Ildrød Pigeon (IP). IP is a small-fruited, red coloured cultivar with a very characteristic aroma. It is harvested in mid-late September and sold as a traditional specialty at Christmas time. Aroma potential of IP has not been investigated yet. Therefore there is a great need to explore it also in connection to 1-MCP treatment. Results revealed a slight tendency of 1-MCP treatment to change the aroma profile at different storage duration. However, delay of 1-MCP application after harvest may have reduced the impact on volatile production.

Introduction

Aroma profile is one apple quality parameter which influences consumer purchase decision. Aroma of apples is a complex mixture of volatile compounds, with a typical profile for each different variety. It is known that many aroma compounds increase in concentration during apple ripening. The ripening process is initiated by the plant hormone ethylene, which plays an important regulatory role in aroma production during ripening (1). Therefore, chemicals which block ethylene action or production are also expected to influence apple aroma profile (1-3). One ethylene blocker is 1-MCP (SmartFresh, AgroFresh, Inc.), which binds to ethylene receptors and thus decreases quality changes caused by the ripening process (4). The Danish cultivar Ildrød Pigeon (IP) was chosen for this study. IP is very popular because of its taste and special aroma (5), and it is eaten especially during Christmas time.

In the current study apples were treated with 1-MCP with a one-week delay after harvest. In practice IP apples should be exposed to sun light after harvest to obtain fully red colour development. Consequently there is a question if 1-MCP should be used straight after or before light exposure, not to intervene into anthocyanin development as part of ripening processes. In this experiment delay of 1-MCP was decided to evaluate aroma profile, so far without exposure to sun light.

The main objective of the study was to determine the effects of apple maturity stage at harvest, 1-MCP treatment, and different storage durations on the aroma profile of IP apples.

Experimental

Apples were grown in the University of Copenhagen's experimental orchard 'Pometet'. Fruits were harvested twice in September 2007; at normal commercial harvest and two weeks later. In total, 10 samples were measured during the experiments. Each sample contained 12 apples.

After each harvest, 5 samples were transferred to cold storage (1.5°C) for one week. After a week in cold storage one sample was used for aroma analyses, two untreated samples were kept in cool storage (1°C) and two samples were treated with 1-MCP (after treatment kept in cool storage as untreated samples).

Treatment with 1-MCP was carried out by releasing 1-MCP gas into a box covered tightly by a plastic bag. A probe with 0.075 g 1-MCP was prepared for each box (one box of volume of 0,0072 m³). According to the producer AgroFresh Inc., in 1m³ the concentration of 1-MCP (0,14%) should be 1000ppb 1-MCP v/v in the air. The probe with 1-MCP was placed in the box together with a small ventilator to ensure adequate distribution of 1-MCP. The 1-MCP treatment lasted for 20 hours at 22°C. After treatment samples were transferred to small cold storage chambers as was done with the untreated samples.

Two samples from each harvest (one treated and one untreated) were stored until mid October – short storage and two samples until mid December (one treated and one untreated) – long storage. On the fifth remaining sample, aroma analysis were made a week after harvest (after a week in a cool storage) to assess starting aroma profile.

After removal from cool storage samples were kept for 5 days at room temperature (23°C) before aroma analysis. Volatile analyses were carried out on juice pressed from 12 apples from each sample and performed in triplicate. The aroma compounds were measured using dynamic headspace sampling and analysed on a Hewlett-Packard G1800A GC/MS. The aroma compounds were measured according to method of Petersen and al. (6). Peak areas were determined from single ion peak areas and used as relative measures of concentration of compounds. A total of 41 aroma compounds were chosen.

Aroma data were analysed by Principal Component Analysis using LatentiX (Version 1.0, Latent5, Denmark). The same PCA model was used to illustrate sample distribution based on aroma compounds and dependency on measured factors. Analyses of variance were carried out using InfoStat (*InfoStat versión 2008*. Grupo InfoStat, FCA, Universidad Nacional de Córdoba, Argentina). The Fisher Least Significant Difference at the $p \leq 0.05$ level was used.

Results

The 41 chosen aroma compounds belonged to 6 groups: acids (1 compound), aldehydes (9 compounds), alcohols (13 compounds), esters (14 compounds), terpene (1 compound), ketones (2 compounds) and phenylpropanoid (1 compound).

Earlier studies have shown that production of volatiles is reduced in apples treated with 1-MCP (1,2). This tendency was also detected in this investigation. ANOVA showed that compared with 1-MCP treated apples, untreated apples produced higher amounts of butanoic acid, propanal, butanal, 1-heptanol, propyl acetate, methyl 2-methylbutanoate, ethyl butanoate and estragole. This indicates that the untreated apples were riper. Accordingly, the PCA plot of PC1 vs. PC5 showed separation of apples treated and not treated with 1-MCP (Figure1) according to

aroma profiles. An incomplete separation can be partly explained by the timing of 1-MCP treatment, which was carried out one week after each harvest time. It is likely that the ethylene-mediated aroma-induction process had already started and 1-MCP was applied too late to inhibit it.

A significant difference in aroma production was detected between maturity stages. Apples from first and second harvest developed significantly different aroma profiles during storage. In the PCA plot in (Figure 2), the maturity stages are clearly separated.

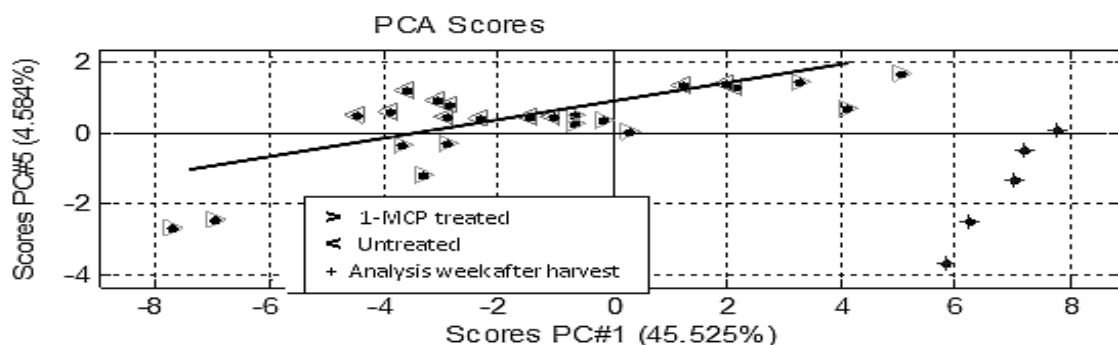


Figure 1. Scores plot PC1 vs PC5 represents PCA model for aroma production of apples treated and untreated with 1-MCP.

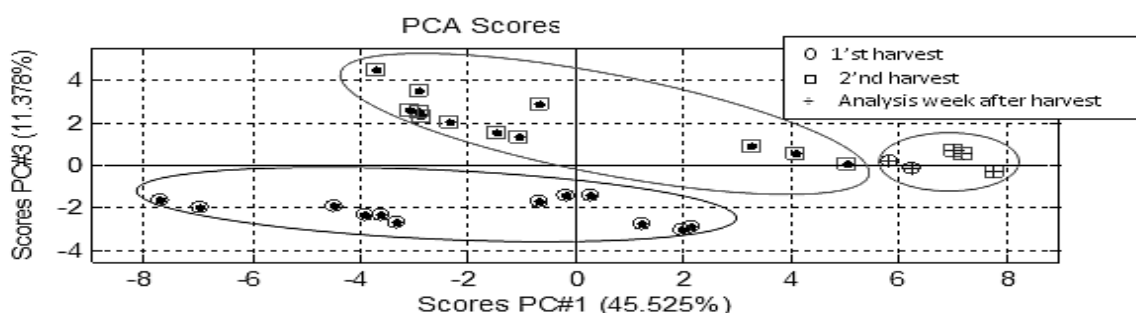


Figure 2. Scores plot PC1 vs PC3 presents PCA model for aroma production of apples from 1st and 2nd harvest (model includes treated and untreated samples).

Apples from first harvest (commercial maturity) had a relatively high concentration of the aldehydes hexanal, E-2-hexenal and (E,E)-2,4-hexadienal. By contrast, production of alcohols and esters was generally greater in apples harvested two weeks later. However, 2-methyl-1-propanol, 3-octanol, methyl acetate, ethyl acetate and hexyl formate were more abundant in the aroma profile of apples harvested at commercial maturity. The same was observed with estragole and (E,E)- α -farnesene. The distinct separation in PCA indicates that harvest time had an impact on apple aroma development during storage.

The duration of storage influenced the aroma profile of the apples notably. The 3 groups of different storage duration were clearly separated. Samples analysed one week after harvests had low amounts of aroma compounds. Only (E,E)-2,4-hexadienal, 2-hexen-1-ol and hexyl acetate were present in high amounts. However, the aroma profile changed substantially during further cold storage. In some studies it has been observed that concentrations of aldehydes and alcohols decrease with the time of storage, whereas ester production increases (2). Increases in acids, esters

and ketones were noted in the current study with IP apples. The measured ketones (2 compounds), the acid (butanoic acid) and the esters (14 compounds), except hexyl acetate, increased during the storage period. Hexyl acetate was at the highest concentration when measured one week after harvest.

The production of some of the alcohols and aldehydes increased during the short storage, after which production was quite stable. In contrast to this, (E)-2-hexenal, (E,E)-2,4-hexadienal and 2-hexen-1-ol declined in production. Those compounds had the highest concentration at the beginning of the experiments.

In conclusion, the results showed that harvest time (maturity stage) and storage period influenced production of volatiles in Ildrød Pigeon apples more than 1-MCP application. Apples treated with the ethylene blocker had decreased production of some aroma compounds. Apples picked at two different maturity stages two weeks apart developed different volatile profiles. Apples from the first harvest had a higher concentration of most aldehydes, the terpene (E,E)- α -farnesene and the phenylpropanoid estragole, but were low in some alcohols and esters. The aroma profile of IP apples one week after harvest was low in total volatiles, but production increased significantly during additional storage time, especially for esters and ketones.

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