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[1]Federal Research Centre for Nutrition and Food, Institute of Chemistry and Biology, Karlsruhe
[2]University of Applied Sciences Fulda, Department of Household Management, Nutrition and Food Quality

Influence of hot water treatment on different quality parameters of apples during storage*

A. Auinger[1], B. Trierweiler[1], F.-K. Lücke[2], B. Tauscher[1]

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Summary

Organically farmed apples of the cultivar 'Topaz' were hot water treated (53 °C, 2 minutes) immediately after harvest and then placed in cold storage (1 °C, air) for 15 weeks. The influence of hot water treatment on peel firmness, titratable acidity, antioxidative capacity and total phenol content, as well as on sensory properties during storage was investigated. Heat-treated apples softened less rapidly and the amount of titratable acidity declined quicker. The thermal treatment did not influence the antioxidative capacity and its total phenol content. There was no significant sensory difference between treated and untreated apples prior to the beginning of maturity for consumption.

Introduction

Storing organically produced apples is a challenge because employing effective synthetic fungicides to delay or prevent fungal rots during storage is not permitted. The most damaging post-harvest disease is the *Gloeosporium* rot which can lead to over 50 % loss during storage. Our institute The Institute of Chemistry and Biology has been working since 1999 on this topic and has been doing research on the effect of hot water treatment on *Gloeosporium* rot of organically produced apples (cultivar 'Topaz'). Investigations have revealed that a temperature of 53 °C over a period of 2 minutes is the most effective method to reduce the fungus *Gloeosporium* on apples (cultivar 'Topaz'). Below 5 % of the apples were infested after a storage time of 4 months, irrespective of storage conditions (cold storage or controlled atmosphere storage). In contrast, more than 56 % of the untreated apples stored at 1 °C in air showed the disease, and even 24 % of these stored under controlled atmosphere showed the typical *Gloeosporium* rot (TRIERWEILER et al., 2003). The reason for this satisfying reduction is probably the temperature sensitivity of the fungus *Gloeosporium*.

Post-harvest heat treatment is a long known method used for disinfestation and disinfection of a variety of plants, e.g. corn, flowers, fruit and vegetables. Hence, there are some studies concerning the influence of thermal treatment on the physiology and the biochemistry of plants. LURIE et al. (1990) reported that heat treated 'Golden Delicious' apples (38 °C, 4 days) softened more slowly than non-treated fruits. There was also a faster decline in titratable acidity by heat treated apples and an increased respiration.

The aim of the present study was to investigate the influence of the thermal treatment on different quality parameters like peel firmness, titratable acidity, antioxidative capacity, total phenolics, and sensory quality of apples (cultivar 'Topaz').

Material and methods

For the investigations apples of the cultivar 'Topaz' were received directly from an organic farmer and dipped into hot water (53 °C, 2 minutes) by using equipment which holds 20 kg fruit boxes. After the thermal treatment in October 2004 the fruits were stored at 1 °C in air (relative humidity 95 %). The dipped and the control (untreated) apples were examined every three weeks over a period of 15 weeks. For each type of sample and analysis, triplicate analyses were done. Each sample consisted of 3 apples.

Firmness

Fruit and peel firmness were evaluated with a TA.XT2i Texture Analyser (Stable Micro Systems). Apples were penetrated by a 3.14 mm² diameter-rod, the downward distance was set at 12.5 mm. Firmness was expressed as kg/cm².

Titratable Acidity

The sum of titratable acidity was measured by the use of potentiometric titration to pH 8.1 with 0.1 n NaOH. The consumption of NaOH per 10 g fruit was mulitplied with factor 0.67 for malic acid.

Antioxidative Capacity

The ABTS⁺ method described by MILLER et al. (1993) was used for the determination of the antioxidative capacity. 10 g of fruit were blended with 10 ml bidistilled water and 10 ml hexane in a Waring Blender and afterwards centrifuged at 8603 g for 15 minutes. The water and fat-soluble supernatant was saved. A solution of 5 mM ABTS⁺ (2,2'-Azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) was diluted for the hydrophilic antioxidative capacity in 5 mM saline phosphate buffer pH 7.4 until absorbance readings reached a value of 1.5 at 735 nm. For the lipophilic antioxidative capacity 5 mM ABTS⁺ solution was diluted in ethanol and adjusted to an absorbance of 0.7 at 735 nm. The system was standardized by means of 100 µl of 0.4 mM Trolox (6-Hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid). The Trolox Equivalent Antioxidant Capacity was calculated as the concentration of Trolox in phosphate buffer showing an antioxidative potential equivalent to the same volume of sample after a reaction time of 15 minutes in the ABTS⁺ solution. The amount of hydrophilic and lipophilic antioxidative capacity was added together for the whole antioxidative capacity.

Total phenolics

Total phenolics were determined using the Folin-Ciocalteu reagent (SINGLETON et al., 1965). 10 g homogenised fruit (Büchi-Mixer 400) were dispersed (Ultra-Turrax) in about 25 ml methanol and sucked off in a feeding bottle over a Büchner funnel. The filter residue was again dispersed with about 25 ml methanol and sucked off. This procedure was repeated once. The filtrate was collected in a 100 ml graduated flask and adjusted with methanol to 100 ml. All chemicals were pre-heated to 45 °C. 125 µl of the extract were mixed with 625 µl of Folin-Ciocalteu reagent (previously diluted 10-fold with

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bidestilled water) and kept 3 minutes at room temperature. 500 µl of sodium carbonate (105.99 g/mol) were added to the mixture. After 15 minutes at 45 °C, absorbance was measured at 750 nm. Gallic acid was used as standard.

Sensory evaluation

A noticeable sensory difference between the heat treated and untreated apples was measured with the "two-out-of-five test" (MEILGAARD et al., 1991, p. 67) by a trained sensory panel. Each panellist was given 5 coded samples of halved apples. Two of the samples belonged to one type (e.g. heat treated) and three to the other (e. g. untreated). Panellists were asked to taste each product and select the two samples that were different from the other three. Presentation design was randomised. The test form was designed with the sensory programme "Fizz Aquisition 2.00 M". The data interpretation was done with "Fizz Calculation 2.10 D".

Statistics

Per cultivation 60 apples were placed in storage. Measurements were done all 3 weeks over a period of 15 weeks. The results reported in this work are the average of three measurements. For each measurement a randomized sample of three apples was taken. Data are presented as mean and standard deviation, and statistical analysis was carried out using the paired Student t-Test. Differences were considered to be significant if $p<0.05$.
Sensory differences among treatments were calculated using the binomial test with the α-risk. The probability that 2 samples are equal or similar was tested by the β-risk, too.

Results and discussion

The changes of peel firmness of heat-treated and untreated apples (cultivar 'Topaz') during 15 weeks of storage are shown in Fig. 1. At the beginning and after 3 weeks of storage there was no difference between the dipped apples and the control samples. After 6 weeks of cold storage, however, the peel of untreated apples softened faster. According to the measurements carried out after 9 ($p<0,05$), 12 ($p<0,05$) and 15 weeks, the rate of softening was slower in hot water treated apples than in untreated ones. Changes in the wax layer of heated apples may be responsible for that observation. LURIE et al. (1996) reported that unheated apples showed in many areas a network of surface cracks in contrast to hot-air treated fruits where this structure was much less apparent.
Infra-red photographs showed that directly after hot water treatment apples heated themselves to a downward distance of 5 mm to about 30 °C (SCHIRMER et al., 2003). It is conceivable that in this small region the flesh is firmer because of the heat treatment. Indeed, an increase of flesh firmness was not found but possibly the resistance of the peel was higher because of a firmer flesh in the outer layer of the treated apple.
The titratable acids, metabolites of the respiratory metabolism, were also investigated in that study (Fig. 2). By the sixth week of storage the decrease in organic acids in both samples was nearly at the same level. From the ninth week on a quicker decline of titratable acidity in the hot water treated apples could be observed. After three months of storage the difference was significant ($p<0,05$). Our Results agreed with other publications in which heated fruits were lower in titratable acidity (ALIQUE et al., 2005; LURIE et al., 1990). A possible reason is the beginning of the climacteric which is associated with an increase in respiratory activity, and hence, with a decline in the involved metabolites.

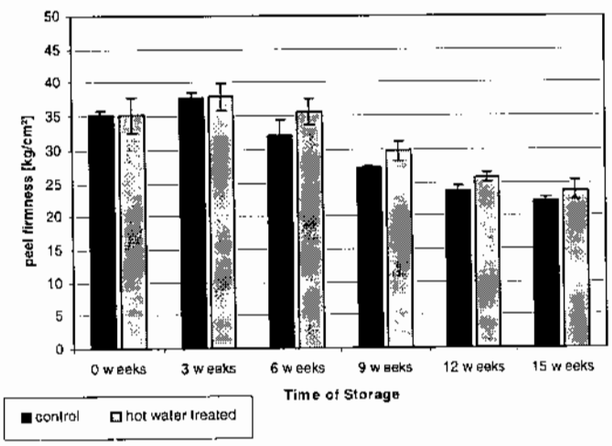

Fig. 1: Changes of peel firmness during storage (cold storage, 1 °C) of hot water treated and untreated (control) apples (cultivar 'Topaz'). Data are the mean and standard deviation of 3 apples (Every apple was measured at 4 different positions in the equatorial layer)

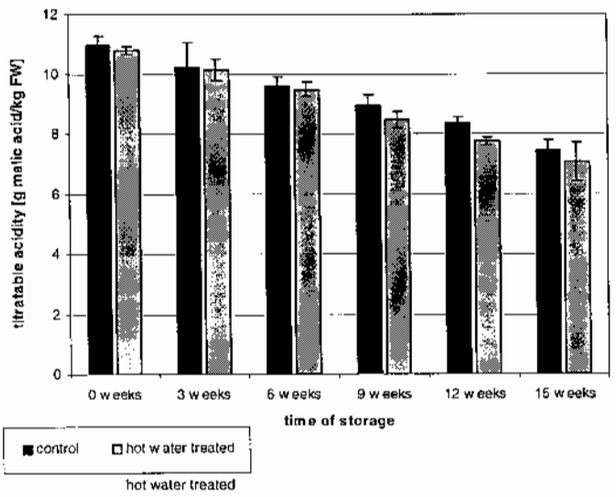

Fig. 2: Changes of titratable acidity during storage (cold storage, 1 °C) of hot water treated and untreated (control) apples (cultivar 'Topaz'). Data are the mean and standard deviation of 3 replicate analyses (3 homogenised apples were used for 1 analyse).

There is a growing interest in antioxidants because of their radical scavenging activities in the human body. Therefore, the antioxidative capacity and the total phenol content was examined. The results are shown in Fig. 3. Over a period of 15 weeks in cold storage, the antioxidative capacity of hot water treated and untreated apples was found to be nearly constant and at the same level. As a result, it can be said that the thermal treatment of apples did not influence the antioxidative capacity. Similar results were found for total phenolics. The content did not differ in the two samples.
For investigation of a sensory difference between hot water treated and untreated apples the "two-out-of-five test" was selected. After 2 weeks of cold storage the first test was carried out. The panellists could significantly distinguish between the two samples ($p<0,05$). The proximate test of similarity shows that 35.6 % of a universe would be able to differ between treated and untreated apples. With the following tests the panellists, however, could not distinguish

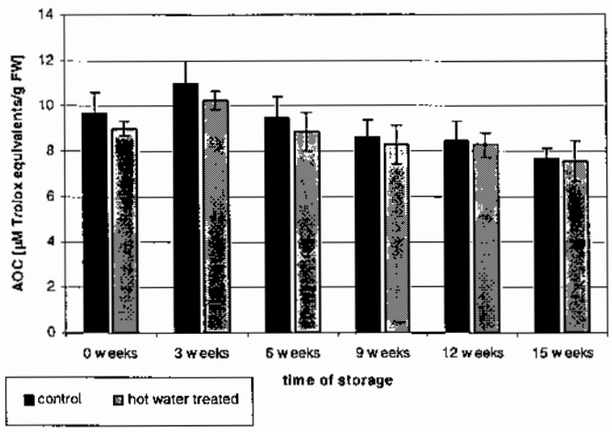

Fig. 3: Changes of antioxidative capacity during storage (cold storage, 1 °C) of hot water treated and untreated (control) apples (cultivar 'Topaz'). Data are the mean and standard deviation of 3 replicate analyses (3 homogenised apples were used for 1 analyse).

between the samples after 10 and 15 weeks of storage. This leads to the conclusion that the hot water treated and untreated apples are equal or similar.

The detected differences at the beginning of the cold storage period are not based on a difference in the sugar/acid ratio, because no differences were observed between the hot water treated and untreated apples. A possible reason for the examined findings may be related to changes in synthesis of aroma compounds which were not determined in this work.

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Address of the authors:
Bundesforschungsanstalt für Ernährung und Lebensmittel, Institut für Chemie und Biologie, Haid-und-Neu-Straße 9, D-76131 Karlsruhe