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INFLUENCE OF DRYING TECHNOLOGY ON THE QUALITY OF DRIED CANDIED *CHAENOMELES JAPONICA* DURING STORAGE
KALTĒŠANAS TEHNOLOĢIJU IETEKME UZ *CHAENOMELES JAPONICA* SUKĀŽU KVALITĀTI UZGLABĀŠANAS LAIKĀ

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Abstract
In the Baltic region, the development of Japanese quince as a fruit crop started in Latvia in 1951. The fruits of *Chaenomeles japonica* are very firm, acidic, with too low sugar content to be consumed fresh, but they are useful for processing and valuable because of the high content of organic acids, vitamin C, phenolic compounds and fresh aroma. The interest for growing Japanese quince in Latvia reached a peak in 1993, but the processing was not solved. Only juice and puree were produced. Therefore a new Japanese quince processing technology was worked out and patented (RL patent Nr. LV 12779 B) at Dobele Horticultural Plant Breeding Experimental Station (presently Latvia State Institute of Fruit-Growing) and Latvia University of Agriculture in 2002.
In order to enlarge the product spectrum made from Japanese quince, investigations were conducted at the Latvia State Institute of Fruit-Growing during the 2007. The aim of the present work was to characterize the influence of the drying technology on the quality of dried candied Japanese quince during storage for six months. Two different drying technologies were used: with forced air circulation and vacuum-microwave. The sweet dried Japanese quince products were tested for content of vitamin C, phenolic compounds and changes of colour by using the CIE L*a*b* colour system.
The obtained data showed that the content of vitamin C decreased on average by 40 %, but the content of phenolic compounds by 17 % in the product. The over colour of the product changed after two months of storage.

Kopsavilkums
Baltijas reģionā krūmcidoniju selekcija uzsākta Latvijā kopš 1951. gada. *Chaenomeles japonica* augļi ir cieti, skābi, ar pārāk mazu cukura daudzumu, lai tos varētu patērēt svaigā veidā, bet, pateicoties augstajam organisko skābju, C vitamīna, fenolu savienojumu saturam un patīkamā aromāta dēļ, tie ir noderīgi pārstrādei. Interese par Japānas krūmcidoniju audzēšanu Latvijā virsotni sasniedza 1993. gadā, bet netika atrisināta augļu pārstrāde. Galvenokārt tika ražota sula un biezenis. Tādēļ Dobeles Dārzkopības selekcijas un izmēģinājumu stacijā (šobrīd Latvijas Valsts augļkopības institūtā) un Latvijas Lauksaimniecības universitātē 2002. gadā tika izstrādāta un

patentēta (LR patents Nr. LV 12779 B) jauna krūmcidoniju pārstrādes tehnoloģija. Pētījums tika veikts Latvijas Valsts augļkopības institūtā 2007. gadā, lai paplašinātu krūmcidoniju pārstrādes produktu piedāvājumu. Pētījuma mērķis bija novērtēt kaltēšanas tehnoloģiju ietekmi uz krūmcidoniju sukāžu kvalitāti sešu mēnešu uzglabāšanas laikā. Pārbaudītas divas atšķirīgas kaltēšanas tehnoloģijas: piespiedu gaisa cirkulācija un kaltēšana vakuma mikroviļņu iekārtā. Krūmcidoniju sukādēm tika noteikts C vitamīna un polifenolu daudzums, kā arī krāsas izmaiņas CIE L*a*b* krāsu sistēmā. Iegūtie rezultāti rāda, ka pēc 6 mēnešu uzglabāšanas C vitamīna saturs produktā samazinājās vidēji par 40 %, bet polifenolu saturs – par 17 %. Uzglabāšanas laikā produkta krāsa sāk būtiski izmainīties pēc diviem uzglabāšanas mēnešiem.

Key words*: Chaenomeles japonica*, products, technology.

Introduction

The fruits of *Chaenomeles japonica* are used in the food industry for processing because of their high content of biologically active compounds: organic acids, vitamin C, phenolic compounds, pectin and aroma components (Lesinska *et al.*, 2006; Ruisa, 1996). Vitamin C content in fruits differs from 41.2 to 105.8 mg 100 g^{-1}, phenolic compounds range from 523.9 to 1271.7 mg 100 g^{-1} (Krasnova *et al.*, 2007). The juice of Japanese quince can be a useful ingredient for the food industry due to its flavour and high acidity. Another property of great interest is its presumed high antioxidant capacity due to the content of vitamin C and phenolic compounds. The content of vitamin C is 45 to 109 mg 100 ml^{-1} and phenolic compounds in juice of the *Chaenomeles japonica* was 210 – 592 mg 100 ml^{-1} (Hellin *et al.*, 2003). However, juice and puree from the fruits are not demanded in the market.

To get healthy products from *Chaenomeles japonica* fruits with better market demand, a new processing technology was developed at Dobele in cooperation with the Faculty of Food Technology of Latvia Agricultural University. As a result two products were obtained – sweet dried candies and syrup. The technology was patented in 2002 (RL patent Nr. LV 12779 B). The way of obtaining dried candies is based on cell destruction (mechanically or using low temperatures).

Various methods can be used for drying: convective drying (COD), vacuum-microwave drying (VMD) and others. Drying in vacuum-microwave influences the quality of product slightly, however, it facilitates production on the industry scale.

Small fruit and vegetable companies prefer convective drying, yet increased temperatures are used very often to get faster results, which in turn reduce the nutritive value of the product (Diaz-Moroto *et al.*, 2002). Vacuum-microwave drying of food is becomming more and more popular due to its advantages and simple usage. By this method microwaves penetrate the interior of the material causing water to boil at a relatively low temperature. This creates a high vapour pressure in the centre of the material, allowing rapid transport of moisture out of the product (Sham *et al.*, 2001). For example, the quality of herbs: parsley and oregano (colour, content of volatile oil, aroma) was higher after drying in VM if compared to CO drying (Boehm *et al.*, 2002). In addition the quality of Mexican oregano (*Lippia berlandieri Schauer*) was similar to the results obtained by process of sublimation, which can be characterized as one of the more cautious drying method (Jaloszinsky *et al.*, 2008; Yousif *et al.*, 2000). Similar results were obtained by testing samples of strawberries and carrots – in the process of VM drying the content of vitamin C and phenolic compounds keeps better and antiradical activity is higher compared to drying in free air admission (Wojdylo *et al.*, 2009; Böhm *et al.*, 2006**).**

The aim of the present work was to characterize the influence of the drying technology on the quality of dried candied Japanese quince during storage for six months.

Material and methods

The experiment was carried out at the Experimental Processing Laboratory of Latvia State Institute of Fruit-Growing 2007. The object_of the study – sweet dried quince candies were made corresponding to the patented technology (RL patent Nr. LV 12779 B). Sugar was used as a sweetener, preservatives and colours were not used in the production. The vegetable chopper

„Metos RG-350” (http://www.metos.fi/); was used for cutting up Japanese quince fruits; size of pieces – 13x13x4.5 mm. Two drying methods were used:

- Convective drying (COD) – using equipment „ORAKAS” (www.lkv.com/marlemi) on sieves with forced air circulation at +60 ºC; duration of drying on average 8 hours, until the moisture of the product reaches 32±3%.
- Vacuum-microwave drying (VMD) - using the equipment „Musson-1” (www.ingredient.spb.ru) by an individual program; moisture of the product: 32±3%; duration of drying depends on the initial moisture content. Duration of drying on average for 12 kg was 155 minutes.

Ready sweet dried candies were packed in sealed polypropylene (PP) bags (thickness 25 μm), inserted in paper bags. The mass of the product in each bag was 100 ± 5.0 g. Packed candies were stored at a room temperature of 20±2 °C; relative air humidity ~60±2%.

The duration of the study was 6 months. Three separate replications of product preparation were made. The analyses of the product were carried out before packaging (0 days) and two times per month. At each time of testing, three identical packages were analyzed.

The following properties of dried sweetened quince candies were determined:

- Vitamin C – the content of ascorbic acid (vitamin C) (mg 100 g^{-1}) was determined by the HPLC method LVS EN 14130:2003.
- Phenolic compounds - the total content of phenols (mg 100 g^{-1}) was determined by the method of spectrometry, by spectrometer UV-1650-PC at a wave length 765 nm (Singleton *et al.*, 1999).
- Colour changes - measured during the storage in CIE L*a*b* colour system using Colour Tec PCM/PSM device. The product was placed in a glass container (diameter 30 mm); the changes in colour were determined for three packages; the measurements were repeated for 15 series.

The data were statistically evaluated using SPSS (version 11.5) for Windows and MS Excel variance analysis, significance level at $P < 0.05$.

Results and Discussion

The colour of the product is one of the important organoleptic parameters for consumers. Sharp changes in the colour of dried candied quince were observed during storage. These changes occur as a result of the destruction of carotenoids, vitamins and other substances and the action of enzymes. The changes influence the colour forming component L*, a* and b* values of CIE L* a* b colour system (MacDougall, 2002).

Greater colour intensity L* (0=black, 100=white) at the beginning of the study was observed for the product dried in the microwave vacuum equipment (value 72.4). However, the product dried in forced air circulation was darker (L* value 66.9). The colour of the product changed during storage – colour intensity value L* and b* (+ yellow, - blue) reduced during first 2 months, but a* (+ red, - green) value increased for both product types. Statistically significant differences depending on the drying method were ascertained between the colour intensity values L* and b* of the product ($p=0.004$; $p=0.009$ respectively), but a* value did not differ significantly ($p=0.86$).

The total changes of the colour component of the product during storage characterize the sum of differences – total difference ΔE^*, formed by L*, a* and b* values. The colour changes of the product were observed on average after 2 months of storage – products became darker independent of the drying method. Calculating the total colour difference ΔE^* after 48 days of storage one can conclude that differences do exist but are hard to evaluate organoleptically (Figure 1). However, the total colour differences of the product were significant at the end of the study - the value for COD product was 4.75, but for VMD 10.25.

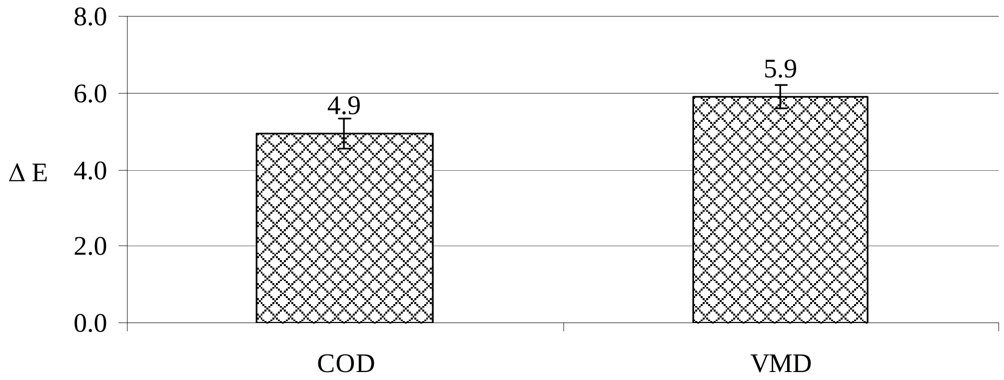

Figure 1. The colour difference ΔE of dried candied quince product, after 48 days of storage (COD - convective drying, VMD - vacuum-microwave drying)

Since the drying temperature for both drying methods did not exceed the 60 °C necessary for the Maillard reaction (between amino acids and reducing sugars), there is a reason to assume that the action of enzymes could cause the browning of Japanese quince candies during their storage.

Plant enzymes like oxireductases (polyphenoloxidases, lipoxidases and peroxidases) enables the oxidation and reduction processes of biologically important substances. Enzymatic browning of plant material is caused mainly by polyphenoloxidases. They are released from membranes because of damage occurring to fresh fruits and come into contact with plant phenolic compounds. Polyphenoloxidases dehydrogenate phenolic compounds form into unstable chinons, therefore causing the formation of melanin (black, brown or red polymer colour). Peroxidases found in plant products in turn transfer hydrogen peroxide, oxidizing hydrogen donors. Peroxidases become inactive after heating. However, it has been found frequently that inactivated peroxidase after some time can become active (Baltess, 1998).

Phenolic compounds are a large group of organic substances determining fruit taste and aroma. However, the aroma in the skin, flesh and juice of Japanese quince fruits constitutes an essence which is a solution of aromatic components in water and not an essential oil. These substances are susceptible to changes of temperature, so after freezing fruits loose their aroma. Taste of the obtained product – sweet dried candies is good after adding sugar and drying at high temperature.

The total content of the phenolic compounds of both dried products at the beginning of the investigation was similar: for the product dried in forced air circulation (COD) it was 467.2 mg 100 g^{-1}, but 481.5 mg 100 g^{-1} after drying by vacuum-microwave (VMD) equipment (Figure 2). The content of phenolic compounds was reduced on average by 9 % in products obtained in COD and by 4.7 % if obtained in VMD, after 2 months of storage. But at the end of the study the total content of phenolic compounds reduced on average by 17 % apart from the drying method.

Significant differences (p=0.037) between the quince products obtained by the two drying methods were ascertained during storage, the higher total content of phenolic compounds remained in VMD product method.

Several investigations on the biochemical composition of fruits, berries and herbs present evidence that the VMD method is the better way to preserve the phenolic compounds compared to the COD method.

Research by Mejia-Meza (2008) at Washington State University on dried bilberries (*Vaccinium corymbosum L.*) indicates that the total content of phenolic compounds is maintained the best by drying at low temperatures (sublimation) followed by the VMD method and after that the COD method. Similar results were obtained at Jena and Dresden Universities investigating different VM drying regimes and vacuum-microwave drying combined with convective pre- and post-drying to improve the quality of dried strawberries (Böhm, 2006). Convective drying and VM drying decreased the content of ascorbic acid to approximately 40 % of the initial value, phenolic compounds to approximately 35 % in dried strawberries. Jaloszynski *et al.* (2008) found that the content of phenolic compounds were reduced sharply by using CO drying for herbs at 60 – 70 °C.

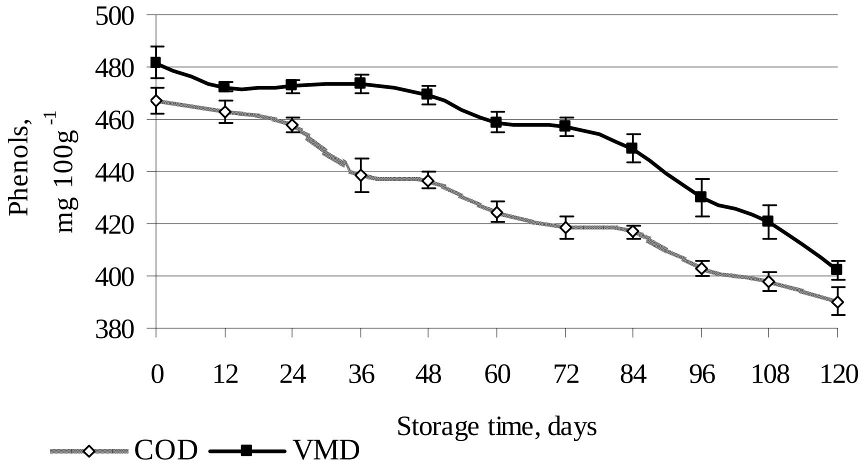

Figure 2. Changes of total content of phenolic compounds during storage
(COD - convective drying, VMD - vacuum-microwave drying)

The content of vitamin C in the products was on average 51 mg 100 g^{-1} at the beginning of the investigation – immediately after drying (Figure 3). A sharp reduction of vitamin C was observed after 24 days of storage. After 2 months of storage the content of vitamin C was reduced by 29.5 % using the COD method and by 33 % using the VMD, but by 37.9 % and 40.2 % respectively at the end of the investigation. Drying methods used in this study did not influence the content of vitamin C ($p=0.71$).

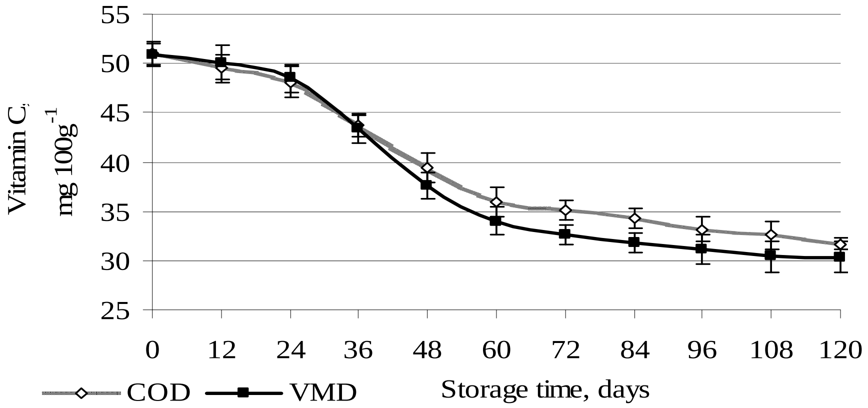

Figure 3. Changes of the content of vitamin C during storage
(COD - convective drying, VMD - vacuum-microwave drying)

Due to the high content of total phenolic compounds in fruits vitamin C was retained during the processing. Several researchers emphasized that drying by the vacuum-microwave method the vitamin C in the product was preserved better than by the CO or spraying methods. Tein *et al.* (1998) compared the effect of different drying methods on the quality of dried carrot slices and established fact that a higher content of vitamin C and carotene was found in the product dried by the VMD method compared to the COD method. The content of vitamin C was influenced not only by the drying method, but also by the microwave power intensity. Nurul Asyikin *et al.* (2007) studied the content of vitamin C in the dried fruits of papaya depending on the drying temperature and concluded that lower microwave intensity helped to keep a higher content of vitamin C in the product.

Conclusions

The drying methods used in this study influenced the quality of the dried candied Japanese quince. A higher content of total phenolic compounds remained in the product dried by the vacuum-

microwave method. The drying method did not influence the content of vitamin C in the product (p=0.71). The colour of the product started to change after two months of storage.
For the industrial production of sweet dried candies it is recommended to use the vacuum-microwave drying method, and the optimal storage time of the product without significant losses of quality is two months.

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