ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering

Tome XII [2014] – Fascicule 4 [November]
ISSN: 1584-2673 [CD-Rom, online]

a free-access multidisciplinary publication of the Faculty of Engineering Hunedoara

[1.] Sándor FERENCZI, [2.] Bálint CZUKOR, [3.] Zsuzsanna CSERHALMI

ANTIOXIDANT CAPACITY OF MICROWAVE VACUUM DRYING ON DIFFERENT CULTIVARS OF APPLES

[1-3.] Food Science Research Institute, Department of Technology and Food Chain Analysis, National Agricultural Research and Innovation Centre, H-1022 Herman Ottó út 15., Budapest, HUNGARY

Abstract: Apple is known to be a considerable source of antioxidant compounds. These naturally occurring antioxidantsecondary plant metabolites help preventing cardiovascular diseases and cancer. The peels of apples, in particular, are high in phenolics.Recent studies show that total antioxidant capacity in dried apple products is a function of drying technology and dryingparameters. Microwave vacuum drying is a novel and mild drying technique, which creates fruit products with not only preferred consumer properties, but because of the low temperature treatment, higher antioxidant capacity, than the conventional hot-air dried products. In this study, the microwave vacuum drying, hot-air drying and the combination of these two technologies (using hot-air drying as pre-drying) were qualified and compared according to the retention of total antioxidant, and within that, the phenolic compounds in different cultivars of apples.
Keywords: apple, microwave vacuum drying, antioxidant activity, phenolic compounds

1. INTRODUCTION

In Hungary, the largest amount harvested (650,595 tons/year) (KSH, 2013a) and the most frequently consumed (9.6 kg/capita/year) fruit is apple (KSH, 2013b). The consumption of this fruit has a great impact on health, because apple is known to be a considerable source of antioxidant compounds(Wang et al. 1996; Floegel et al. 2011). These naturally occurring antioxidant secondary plant metabolites help preventing cardiovascular diseases and cancer(Leopoldini et al. 2011). Phenolics is a group of compounds which also have antioxidant activity (Meyer et al. 1997). The peels of apples, in particular, are high in phenolics and antioxidant components(Manzoor et al. 2012; Łata et al. 2009).Different cultivars have also different amount of antioxidant compounds, and within that, different amount of phenolics (Panzella et al. 2013; Łata et al. 2009). Apples are consumed not only as raw fruit, but processed in high amounts, mostly for juices, and dried products. The expectation for these products is to be as rich in antioxidants as the raw material.

Microwave vacuum drying (MVD) is one of the newest varieties of mild food manufacturing technologies. It is a rapid and efficient dehydration method, which yields unique characteristics, improved product appearance and quality, compared to conventionally dried products (Therdthai & Zhou 2009; Ferenczi et al. 2012). In this study, our aim was to show the mild heating and drying effect of combined MVD by measuring the retention of antioxidant compounds, and within that, the amount of phenolics in different apple cultivars. For that, different drying methods were compared, namely conventional hot-air drying, microwave vacuum drying and microwave vacuum drying combined with hot-air pre-drying. The quality parameters also were measured in raw materials, and in an intermediate status, the pre-dried samples.

2. MATERIALS AND METHODS

2.1. Materials

Three different cultivars of apple (Jonathan, Idared, Jonagold) wereused. Jonathan apple is known to be the most aromatic apple cultivar, Idared is a cross between Jonathan and Wagener, which can

be stored for the longest time without quality loss, and Jonagold is a cross between Jonathan and the popular Golden Delicious. These three cultivars of apple are grown widespread in Hungary. The apples were grown in Zsámbék (Hungary) and were purchased from the local market (Budapest, Hungary). Initial moisture content was between 83.0-84.5% wet basis (w.b.).

$$w.b. = \frac{m_m}{m_m + m_d} \cdot 100,$$

where m_m is moisture mass and m_d is dry mass.

2.2. Methods

The apples were washed; the ovary was removed, and then radially cut into 16 equal size pieces. The different drying methods were applied right after the cutting.

Hot-air drying

The apple slices were dried in a laboratory-scale hot-air dryer at 50°C until constant weight. This process took 16-20 hours, depending on the moisture content of the raw material.The energy consumption of the hot-air drier is 600W and the raw material had 14% dry mass content. Presuming the total drying time lasts for 18 hours, the total energy needed for drying the samples is $\frac{600\frac{J}{s} \cdot 18 \cdot 60 \cdot 60s}{10{,}000 \cdot 0.14g} = 27.77\frac{kJ}{g}$, referred to dry mass.The final moisture content is between 5-7% (w.b.).

Microwave Vacuum drying

The microwave vacuum drying equipment has a cylindrical stainless steel vacuum chamber, with a conical dome for better vapor removal. The samples are hold in a rotary teflon tray. Microwaves are generated by two, 850W nominal efficiency magnetrons. The effective output is 450W. The vacuum is kept constant at 50 mbar by a vacuum pump, which is connected to a heat exchanger for vapor condensation. The cooling water for the heat exchanger is cooled by a compressor and kept circulating by a pump. 400 grams of apple is dried for 72 minutes, within that 48 minutes active and 24 minutes passive time. The total treatment energy is $\frac{450\frac{J}{s} \cdot 48 \cdot 60s}{400 \cdot 0.14g} = 23.14\frac{kJ}{g}$, referred to dry mass.The temperature of samples during MVD did not exceed 50°C. The final moisture content is between 10-13% (w.b.).

Combined microwave vacuum drying with hot-air pre-drying

After the preparation, the sampleswere hot-air dried in the laboratory-scale drying equipment at 50°C, for 9.5 hours for 30% moisture content (w.b.), and then microwave vacuum-dried for 2%moisture content (w.b.).At microwave vacuum drying, 400grams of pre-dried apple was treated for 42 minutes, within that 28 minutes active and 14 minutes passive time. The raw material had 14%, and the pre-dried material had 70% dry mass content, so the total energy needed for drying the samples was $\frac{600\frac{J}{s} \cdot 9.5 \cdot 60 \cdot 60s}{10{,}000 \cdot 0.14g} + \frac{450\frac{J}{s} \cdot 28 \cdot 60s}{400 \cdot 0.7g} = 17.36\frac{kJ}{g}$, referred to dry mass. The final moisture content was between 4-6% (w.b.).

The antioxidant activity was measured with 1,1-diphenyl-2-picrylhydrazyl(DPPH)radical scavenging assay (Yamaguchi et al. 1998). The raw material, the hot-air dried, the pre-dried, the microwave vacuum dried and the combined samples were measured at all three cultivars. Because of the moisture content of the samples varies in wide range, from 86% to 4% (w.b.), a modified preparation method must be applied, which equivalently extracts the total antioxidant compounds from all samples.

The raw material and the 70% moisture-content pre-dried samples were minced by a meat masticator, and the low moisture content samples were milled by a coffee grinder. The samples were soaked in 80% methanol for a night, then strained. The sample solutions were mixed with DPPH stock solution, shaked, and then left to stand for 20 minutes at ambient room temperature in

the dark. The absorbance was measured by an UV-VIS spectrophotometer. Calibration was made with trolox solution. The antioxidant activity values are expressed in mmol trolox equivalent (TE)/100g dry mass.

The total phenolic content was measured with Folin-Ciocalteu method.(Singleton & Rossi 1965)The preparation procedure was the same as at antioxidant activity method, until straining. One milliliter of Folin-Ciocalteu'sphenol reagent was added to the mixture and shaken. After 5 min, 10 ml of 7 % Na_2CO_3 solution was addedto the mixture. The solution was diluted to volume (25 ml) with distilled H_2O and mixed. After incubation for 90min at ambient room temperature, the absorbance against pre-pared reagent blank was determined at 750 nm. Calibration was made with gallic acid. Total phenolic content is expressed as mg gallic acid equivalent (GAE)/100 g dry mass.

3. RESULTS AND DISCUSSION

The antioxidant activity results are shown in Fig.1.

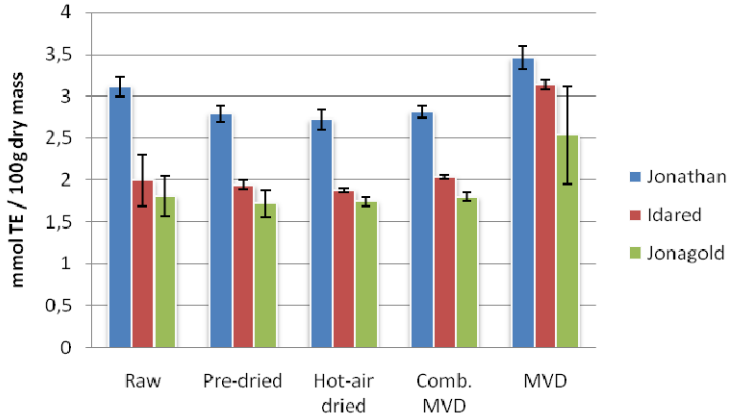

Figure 1. Antioxidant activity of dried apple samples

Jonathan apple has the highest TE value, followed by Idared, and Jonagold, respectively. Between the drying technologies, no significant differences can be observed, probably because of the relatively low temperature at all drying technologies, which do not damage temperature-sensitiveantioxidant components. A significant and slight increace can be detected at MVD, especially at Idared and Jonagold cultivars.

The total phenolic values are shown in Fig.2.

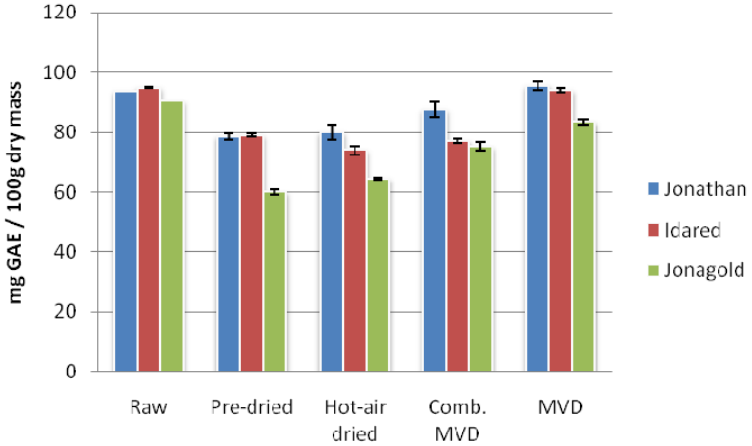

Figure 2. Total phenolics of dried apple samples

In the state of raw fruits, the three cultivars have similar amount of phenolics. At dried forms, a slight difference is observed, where Jonathan has the most phenolics, followed by Idared and Jonagold, respectively.The amount of phenolics in the pre-dried and hot-air dried samples is similar, but it shows 22% reduction compared to raw fruits.The combined MVD and MVD samples are more mild, because of noticeably higher phenolics, which shows only2.3% reduction in average compared to raw fruits.

The results show that Jonathan apple has the most antioxidant activity and the highest phenolic content, followed by Idared.Jonagold has the least amount of these biological active compounds. The hot-air drying and pre-dryinghave no significant impact on antioxidant activity, butthe amount of phenolics decreased significantly. At the MVD dried samples, greater retention of scavenging activity and total phenolic content is observed. The higher amount of biological active compounds in MDV samplesis caused by the short drying time, low temperature and the lack of oxygen.

REFERENCES

[1.] Ferenczi, S., Czukor, B., Cserhalmi, Z. (2012). Légárammal kombinált mikrohullámú vákuumszárítás III. Különböző szárítási módszerekkel készült alma szárítmányok összehasonlító vizsgálata. Élelmiszer Tudomány Technológia, LXVI.(1), 25–29.

[2.] Floegel, A., Kim, D., Chung, S., Koo, S., Chun, O. (2011). Comparison of ABTS/DPPH assays to measure antioxidant capacity in popular antioxidant-rich US foods. Journal of Food Composition and Analysis, 24(7), 1043–1048.

[3.] KSH (2013a). Mezőgazdasági Statisztikai Évkönyv 2012. (Statistical Yearbook of Agriculture 2012). Pp. 84. Budapest, Hungary, Központi Statisztikai Hivatal.

[4.] KSH (2013b). Magyar Statisztikai Évkönyv 2012. (Statistical Yearbook of Hungary 2012). Pp. 84. Budapest, Hungary, Központi Statisztikai Hivatal.

[5.] Łata, B., Trampczynska, A., Paczesna, J., 2009. Cultivar variation in apple peel and whole fruit phenolic composition. Scientia Horticulturae, 121, pp.176–181.

[6.] Leopoldini, M., Russo, N., Toscano, M. (2011). The molecular basis of working mechanism of natural polyphenolic antioxidants. Food Chemistry, 125(2), 288–306.

[7.] Manzoor, M., Anwar, F., Saari, N., Ashraf, M.(2012). Variations of Antioxidant Characteristics and Mineral Contents in Pulp and Peel of Different Apple (Malus domestica Borkh.) Cultivars from Pakistan. Molecules, 17, 390–407.

[8.] Meyer, A.S., Yi, O., Pearson, D.A., Waterhouse, A.L., Frankel, E.N. (1997). Inhibition of Human Low-Density Lipoprotein Oxidation in Relation to Composition of Phenolic Antioxidants in Grapes (Vitis vinifera). Journal of Agricultural and Food Chemistry, 45(5), 1638–1643.

[9.] Panzella, L., Petriccione, M., Rega, P., Scortichini, M., Napolitano, A.(2013). A reappraisal of traditional apple cultivars from Southern Italy as a rich source of phenols with superior antioxidant activity. Food chemistry, 140(4), 672–9.

[10.] Singleton, V.L., Rossi, J.A. (1965). Colorimetry of Total Phenolics with Phosphomolybdic-Phosphotungstic Acid Reagents. American Journal of Enology and Viticulture, 16(3), 144–158.

[11.] Therdthai, N., Zhou, W. (2009). Characterization of microwave vacuum drying and hot air drying of mint leaves (Mentha cordifolia Opiz ex Fresen). Journal of Food Engineering, 91(3), 482–489.

[12.] Wang, H., Cao, G., Prior, R.L. (1996). Total Antioxidant Capacity of Fruits. Journal of Agricultural and Food Chemistry, 44(3),701–705.

[13.] Yamaguchi, T., Takamura, H., Matoba, T., Terao, J. (1998). HPLC method for evaluation of the free radical-scavenging activity of foods by using 1,1-diphenyl-2-picrylhydrazyl. Bioscience, biotechnology, and biochemistry, 62(6), 1201–1204.

ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering