Optimal Drying Conditions for Valorization of Industrial Apple Pomace: Potential Source of Food Bioactive Compounds

Optimal Drying of Apple Pomace

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Abstract

Apple pomace contains a large amount of useful bioactive compounds that have wide application in the food industry. In this study the effect of drying temperature and pressure (high temperature 80°C and low temperature 60°C using a conventional oven and a combination of conventional plus vacuum drying oven) on the antioxidant capacity and phenolic compounds of apple pomace extract was investigated. For a combination of conventional and vacuum drying ovens, samples were first dried by a conventional oven to a moisture content of approximately 10 % then vacuum dried to reach a final moisture content of 3 – 4%. After the drying processes, ethanolic extraction was performed and the amount of total polyphenol and the antioxidant capacity (FRAP) were evaluated to determine a best drying method. The drying curves were also determined. The drying temperature affects the duration of the drying, the rate of water loss, and the remaining amount of antioxidant compounds.

Keywords: Apple pomace, Antioxidant activity, Total phenolic content, Water activity, Moisture content

Introduction

Waste from processing of agricultural products can be important source of cheap and reliable raw materials for obtaining bioactive compounds that can be used as natural food additives (Arshad & Batool, 2017). Every year, tons of agricultural industrial wastes are produced from food processing industries. In most cases, these wastes are thrown away to the environment, some are being burnt

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and recently, a small portion are being used to produce various products such as animal feed, biofuel, pharmaceuticals and food additives (Sadh et al., 2018). One of the important agro industrial wastes that can have application in the development of natural food additives are apple pomace. Apple pomace are the solid waste products from processing of apples into juice, wine and cedar. They include skin, seeds, stem and flesh tissues left after obtaining the juice from squeezing the apples. About 25% of an apple's composition and weight is the pomace. Thus, for every amount of the apples that are processed, an estimate of 25% is waste, and most of these are thrown away to the environment, however there are attempts to utilize them as animal feed ingredients. Recently, it has been proved that these substances contain huge amount of bioactive compounds especially pectin and polyphenols (Schieber et al. 2003; Cao et al., 2009; Cetkovic et al., 2008; Kolodziejczyk et al., 2009; Virot et al., 2010). Being rich in bioactive compounds particularly pectin and polyphenols, extracts of the apple pomace have a potential to be used as green food additives. Pectin from apple pomace have been used as thickening and gelling agents in formulation of various food products (Lyu et al, 2020). Similarly, polyphenols from the pomace have also been used to enhance antioxidant activity in production of functional foods that can help to fight inflammation and cancer diseases. In addition to that, extracts from apple pomace have a potential to be used as natural food preservatives due to its antimicrobial activity. In order to properly obtain these bioactive compounds, proper handling of the pomace immediately after being produced is very important. One of the key step in early handling of the pomace is drying.

Drying of the pomace is essential process in order to remove excess water that can cause spoilage prior to its utilization. Usually, fresh apple pomace contain high moisture content and water activity, about 70% and 0.84 respectively. These conditions are ideal for the growth of microorganisms especially fungi that can lead in spoilage and production of toxins. Moreover, drying facilitate proper storage since less space and storage materials are required to store dried pomace as compared to fresh pomace. In addition to that, drying of the pomace is an important technical step that is required during extraction process where most of the bioactive compounds are extracted better on dried pomace rather than fresh (Jung et al., 2015). In order to protect important bioactive compounds from degradation, attention to proper drying methods should be under consideration.

Several drying methods such as traditional sun drying, solar driers, conventional ovens and microwave driers can be employed singular or in combination for the drying of apple pomace.

Considering the effect of the drying method to the quality of the resulting bioactive compounds, energy and cost as well as time, there is a need to properly investigate and optimize different drying conditions that can lead to extracts with high functional properties.

Materials and Methods

Apple pomace from industrial juice production were obtained from Agrana Juice Ltd (Hungary). Drying using the conventional oven (LP 232/1, Esztergom, Hungary), 200g of the pomace were spread in a drying tray with a depth of 0.5 cm. Trays were then taken to the oven and dried at 60°C and 80°C and the moisture content was being monitored every hour. For a vacuum oven drying, samples were first dried by a conventional oven to a moisture content of about 10 percent at 80°C and 60°C. Thereafter, samples were dried in the vacuum dryer at a temperature of 60°C and a pressure of 65 mb, moisture content was monitored every hour until reached 3 – 4 %. Dried samples were ground into fine powder using a "PRINCESS" multi chopper and grinder were vacuum packaged till the day of extraction.

Determination of dry material content was performed by the samples were dried until constant weight at 121 °C using a MAC-50 moisture analyzer (Radwag Waagen GMBH, Hilden, Germany). To determine the water activity, Novasina, LabMaster-aw equipment was used.

Ultrasound assisted extraction was performed as the following: briefly, 15g of the pomace were mixed with 450 ml of 80% ethanol (1:30 w/v) in a flask. There after the flasks were placed in the sonication bath, 35 kHz for 1 hour (Bandelin, RK 52). Obtained solution was filtered using Whatman filter paper No.1, using vacuum pump. Solvent from the obtained filtrate was removed using rotary evaporator (IKA, Model: RW 10C S99) and further removed on circulating air oven (60°C) in a petri dishes. Weight of the obtained extracts was determined and diluted accordingly with distilled water to obtain a final extract solution with a concentration of 200mg mL^{-1}.

Total phenolic content (TPC) of the extracts from apple pomace extract were determined using a Hitachi U-2900 spectrophotometer (Hitachi High-Technologies Europe GmbH, Krefeld, Germany) by the method Folin–Ciocalteu (Singleton and Rossi 1965). Briefly, 1250µL of Folin solution (1:10 v/v Folin; distilled water) was added in the test tube followed by addition of 150µL of methanol (4:1 v/v methanol; distilled water). Then, 100µL of the sample was added and the solution was allowed to stand for 1 minute, followed by the addition of 1000µL of sodium carbonate solution.

Antioxidant capacity was determined using Ferric Reducing Ability of Plasma (FRAP) assay according to the method of Benzie and Strain (1996). FRAP reagent was produced by mixing acetate buffer (pH 3.6), 2,4,6-tripyridyl-s-triazine (TPTZ) solution, and $FeCl_3 \times 6\ H_2O$ solution. Five min after the addition of the apple pomace extract to the FRAP reagent absorbance at 593 nm was read against the reagent. Results were expressed in ascorbic acid equivalent (mg ascorbic acid/mL extract) based on the ascorbic acid standard calibration curve. Colour was determined according to C.I.E.LAB system using a tristimulus colorimeter (Konica Minolta CR 410, Minolta Canada Inc., Mississauga, ON).

Statistical analysis was performed using one factor complete randomized ANOVA.

Results and discussion

Drying curves are shown in Fig. 1. Drying methods (atmospheric or vacuum) and temperature affected the speed of dehydration. Initial wet content was 69.37%, and time needed to reach final wet content (2.94-4.280%) was 3 and 6 h (Table 1.). In case of atmospheric drying at 80°C the moisture content of apple pomace decreased rapidly during the first 2 h (to 11.67-17.17%), then , the moisture content decreased slightly.

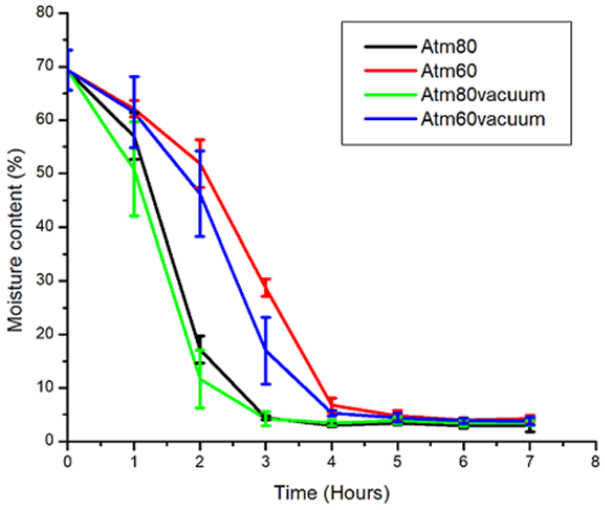

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Figure 1. Decrease of moisture content during drying of the apple pomace.

Atm80 and Atm60 stand for drying the pomace at 80 and 60 using conventional atmospheric oven respectively. Atm80vacuum and Atm60vacuum represent drying the pomace at 80°C conventional oven plus vacuum drying and 60°C conventional oven plus vacuum drying respectively.

Table 1. Shows time, final weight and recovery after drying the pomace using a conventional oven and a combination of a conventional oven with vacuum drying to reach a moisture content of approximately 4%. The final weight was the highest in case of using 60°C atmospheric drying, and the smallest weight was obtained in case of 80°C atm+ Vacuum drying method. The recovery shows similar tendency. The highest recovery % was achieved using 60°C atmospheric drying, and the smallest recovery was in case of 80°C atm+ Vacuum drying method.

Table 1. Time, final weight and recovery of the pomace using different drying method

Drying method	**80°C atm.**	**60°C atm.**	**80°C atm. + Vacuum**	**60°C atm. + Vacuum**
Time (hours)	3	6	3	6
Final Moisture content	2.94	4.28	3.42	3.82
Final weight (g)	41.92 ± 2.42	45.25 ± 1.26	39.97 ± 2.84	40.98 ± 2.34
Recovery (%)	20.96	22.63	19.99	20.49

After extraction method, the water soluble dry material content of the extracts were between 13.77-15.81%. According to the ANOVA results, the drying method had significant effect on the water soluble dry material content (p=0.000).

Table 2 shows the colour values in case of extracts. L* values, representing the lightness of the pomace extracts, in case of using Atm 80°C+vac. drying method, the L* value is smaller than in the two other case. In the case of a* values (red-green), values were in range of -0.99-+0.6. Negative values indicate green while positive values indicate red.

The b* values (blue-yellow) were between 22.47-24.36. There is similar increasing tendency as in the case of L*values. The effect of drying method and the colour values of the extracts was evaluated by one-way analysis of variance (ANOVA). The drying method had no significant effect on colour values of the extracts (p=0.177).

Table 2. Color values of the extracts

	Atm_80	Atm_60	Atm_80_vac	Atm_60_vac
L*±SD	44.68±2.70	42.37±2.18	40.02±3.48	44.32±3.86
a*± SD	-0.70±0.82	-0.77±0.23	0.6±0.56	-0.99±0.86
b*± SD	26.72±1.98	24.01±1.33	22.47±2.47	24.36±2.39

Table 3 contains the TPC content of the apple pomace extracts. The TPC of the final apple pomace extract was the highest (1075 μg mL^{-1}) in case of atmospheric drying at 80 °C+vacuum drying, and was lower when atmospheric 60°C and vacuum drying methods were used (at 60°C atm + vacuum 874 μg mL^{-1}.

Table 3. TPC content of the extract (μg mL^{-1} extract)

	Atm_80	Atm_60	Atm_80_vac	Atm_60_vac
TPC±SD	1000±184	944±106	1075 ±79	874±47

Similar results were obtained by Madrau and co-workers (2007) when vacuum drying apricot at 55 and 75 °C, and by Somsong and co-workers (2010) when vacuum drying blueberries at 70 and 90°C: higher polyphenol content was measured at higher temperature. They explained it by inhibition of polyphenol oxidases and the antioxidant effect of Maillard reaction products. Diverse changes of polyphenols may be influenced by many factors during processing technologies such as temperature, duration of treatments, presence of other components (i.e. vitamins, organic acids), activity of different types of oxidative enzymes, etc. These effects may cause degradation, transformations or interactions with other components of the matrix. Enzymatic browning may also occur where polyphenol oxidase plays key role. The actual polyphenol content is the result of these contradictory effects (Manzocco et al., 2001). During atmospheric drying the presence of oxygen facilitated functioning polyphenol oxidases and temperature was not high enough to inhibit these enzymes. During vacuum drying lack of oxygen decreased the activity of polyphenol oxidases. At higher temperatures polyphenol content was higher, probably due to the increased Maillard reaction products. The effect of drying method and the TPC content of the extracts was evaluated by one-way analysis of variance (ANOVA). The drying method had significant effect on TPC content of the extracts (p value at 95% confidence: 0.043).

Table 4 shows the antioxidant capacity of the apple pomace extract expressed in ascorbic acid equivalent (µg ascorbic acid/mL extract). The highest antioxidant capacity were measured the sample was dried 60°C atmospheric, and the lowest value was determined in case of the sample was dried 80ºC atmospheric. Between atmospheric 80°+vacuum and atmospheric 60°C +vacuum there was no difference. According to the statistical analysis, drying method has significant effect on the antioxidant capacity (p values at 95% confidence: 0.000).

Table 4. FRAP values of the extract (µg AS mL^{-1} extract)

	Atm_80	**Atm_60**	**Atm_80_vac**	**Atm_60_vac**
FRAP value ±SD	471±21	744±52	576±20	588±106

Conclusion

Our results showed that, in addition to the grape seeds, the apple pomace, an inedible waste product of juice manufacture, might be another potent source of antioxidants. Apple pomace should be regarded as a valuable product and has potential as a value-added ingredient for functional foods. Future investigations will be directed at further purification of the phenolic fraction and will include studies on their stability and their application as natural antioxidants and functional food ingredients.

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