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Osmo-sonication drying and their effect on bioactive compounds, antioxidant and colour properties of apple rings

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Abstract

The effect of osmo-sonication (OS) drying on retention of bioactive compounds i.e. total phenolic content (TPC), total flavonoids content (TFC) and antioxidant power capacity (DPPH) of apple rings under convective dryer was investigated. Thickness of 4mm apple rings, sucrose concentration of 50^0B and osmo-sonication time for 30 min optimized through Response Surface Methodology (RSM) were convectively dried until the weight of samples did not change. Thereafter, the effect of osmo-sonication on quality characteristics were evaluated and compared with osmotically dried rings. Results concluded that osmo-sonication improved the preservation of total phenolic content (TPC) (30.53 mg /100g), total flavonoids content (TFC) (12.00 %) and antioxidant power capacity (DPPH) (30.92 %) as compared to osmotically dried rings. Besides this, osmo-sonication retained the color quality of dried apple rings than the osmotically dried rings. Moreover, osmo-sonication results in lower total color change (ΔE) (4.21) in dried apple rings samples compared to osmotically dried rings (10.59).

Keywords: Osmosonication, apple rings, total phenols, total flavonoids content, antioxidants.

Introduction

Apples are one of the most favorite fruit consumed by majority of population. In India, commercial apple production amounted to 24 million tone/year, of which most (70%) were used for direct consumption, and others (30%) were processed to value added products. Apple posses an important part of the human diet, as they are a source of monosaccharides, minerals, dietary fibre and various biologically active compounds, such as vitamin C and certain phenolic compounds which are known to be act as natural antioxidants. Some researchers also reported that polyphenols as antimutagenic and anticarcinogenic compounds (Miller and Rice-Evans, 1997) [19]. Along with sugars and organic acids, phenolics determine the chemical quality of apples (Dolenc and Stampar, 1997) [9]. They have important roles in providing taste characteristics, such as flavour, bitterness and astringency, and also colour (Miller and Rice-Evans, 1997) [19]. Hence, it becomes important to retain such valuable components in their unchanged form as much as possible during the preserving and processing of food. However, the conventional methods of drying food commodities have led to a substantial decrease in nutritional, functional and sensory values of dried products. In this context, osmotic drying has a protective effect on the structure of the dried material, making it more acceptable for consumption. This reduces the loss of fresh fruit flavor, increases the sugar content and removes some acids, making osmotically concentrated products more acceptable (Ispir and Togrul, 2008; Sharma *et al.*, 2020) [14, 23]. With this, it also has some disadvantages too such as low mass trasnsfer rate, long osmotic drying time and un-desirable reduction in acidity level that reduces the overall acceptability of some products (Yadav and Singh, 2014) [26]. This can be overcome with the use of emerging technologies like high hydrostatic pressure, pulsed electric field and vacuum technology (Witrowa-Rajchert *et al.*, 2014) [25]. Sonication is one of the emerging technologies in the food industry because of vast advantages over the conventional methods of food processing. Sonication means sound waves of 20 kHz and above (Mason, 1996) [17]. The use of sonication increases the product yield, reduces the process time

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and also decreases the use of processing materials (Ercan and Soysal, 2013) [10]. This is due to the fact that sound waves or ultrasound has a sponge-like effect when applied on a solid medium which induces an on and off compressive force on the solid sample (McClements, 1995) [18]. This leads to creation of microscopic channels within the solid sample which enhances the removal of water from the solid sample. As it operated at ambient conditions, it poses little or no threat on quality of foods, thereby texture, colour, flavour, bioactive compounds and functional compounds may be effectively retained. Therefore, the aim of present study is to investigate the effect of osmo-sonication on bioactive compounds, antioxidant and colour properties of apple rings.

Materials and Methods

The fruits of apples harvested at optimum maturity were procured from the local market of Solan, Himachal Pradesh. Sugar was purchased from the local market. Apple was cut in the form of rings (varying thickness 3, 4 and 5 mm). The measured average moisture content of the prepared fresh rings was 85.90 per cent on a wet basis. The drying process was carried out using an osmo-sonicated setup. Apple rings were weighed and dip in sucrose solution of concentration (30, 50 and 70^0B) in glass beaker under sonicator for different sonicated treatment times (0, 30 and 60 min). For each experiment, the ratio of solution/sample was kept 4:1 (w/w) and temperature of 50 ^{0}C was maintained using water bath. Air-drying was done in a specially designed food dehydrator at 60 ^{0}C. After osmo-sonicated drying pretreatment, the samples were taken out from the sonicator, drained and blotted with absorbent paper to remove the excess solution. These pretreated test samples were then subjected to air-drying until reaching a moisture content of 18 per cent (wb). In order to determine the endpoint, the weight of test samples during drying was continuously monitored by attaching the drying tray to an electronic balance. After drying, products were cooled, packed and stored at ambient conditions. Test samples without ultrasound treatment also were similarly dried to get osmotically dried control samples. Then, the effect of osmo-sonication on bioactive comounds (Total phenolic compouds and total flavonoids), antioxidants and colour properties was studied.

Analysis of Bioactive compounds

The amounts of total phenols in the sample were determined with the Folin-Ciocalteu Reagent (Bray and Thorpe, 1954) [6] using catechol as a standard. The flavonoid content in the samples was extracted repeatedly with 100 ml of 80 per cent aqueous methanol at room temperature (Boham and Kocipai-Abyazam, 1974) [4]. The flavonoid content was calculated as given below and expressed in per cent (%).

$$\text{Flavonoids (\%)} = \frac{\text{Final weight obtained (g)}}{\text{Initial dried sample weight (g)}} \times 100$$

DPPH (2, 2-diphenyl-1-picrylhydrazyl) was used as a source of free radical for determining the antioxidant activity (Brand-Williams *et al.*, 199). A quantity of 3.90 ml of $6\text{x}10^{-5}$ mol/L DPPH in methanol was put into a cuvette with 0.10 ml of sample extract (S) and their absorbance was read at 515 nm after 30 min. Methanol was taken as blank (B) and antioxidant activity was calculated using following equation:

$$\text{Antioxidant activity (\%)} = \frac{\text{Ab(B)} - \text{Ab(S)}}{\text{Ab (B)}} \times 100$$

Where, Ab (B) = Absorbance of blank, Ab (S) = Absorbance of sample

Colour of samples was measured in a Lovibond Colour Tintometer Model PFX-I series spectrocolourimeter (Wiktor *et al.*, 2016) [24] in which RYBN colour units were obtained along with CIE readings i.e. L^*, a^* and b^* values. The L* value gives a measure of the lightness of the product colour from 100 to 0, 100 for perfect white while 0 for black. The a* value represents the green to red colour range and b* values represents yellow to blue colour range.All the analytical parameters were recorded in triplicates and the mean value of each parameter was calculated as the method described by Cochran and Cox, 1967 [8]; Abano *et al.*, 2012 [1].

Results and Discussion

Effect of osmo-sonication on bioactive compounds and antioxidant properties

The effect of osmo-sonication on bioactive compounds and antioxidant properties are shown in Fig 1, 2 and 3. Results clearly shown that osmo-sonication had significant effect on retention of bioactive compounds during drying as compared to osmo-drying. The total phenolic content (TPC) of osmo-sonicated and osmo-dried apple rings was 30.53 and 26.50 mg/100g respectively.

The osmo-dried apple rings had lower retention of total phenolic content as compared to osmo-sonicated apple rings. The considerable loss in total phenolic content may be ascribed to degradation of the cell walls of the apple rings which resulted in the higher transfer of vacuolar sap to the osmotic solution (Kucner *et al.*, 2013) [16]. Secondly, it may also be as a result of a deficiency of oxygen during the osmotic dehydration pretreatment process. These findings are similar to Kaur and Sogi (2017) [15] for osmo-dried carrot. In agreement with this findings, Horuz *et al.* (2017) [13] reported that ultrasound pretreatment retained greater amount of total phenolic content in dried tomato slices. A similar observation has been reported for onion (Ren *et al.*, 2018) [22]. The maximum retention of total phenolic content by osmo-sonication may be attributed by improved extractability of the bioactive compounds and also by induced ultrasonic cavitation as well as osmotic pressure gradient which led to higher mass transfer and higher solid gain (Rawson *et al.*, 2011) [21]. The data regarding the effect of osmo-sonication on total flavonoid content (TFC) are presented in Fig2. There was significant effect of osmo-sonication on retention of total flavonoid content. Total flavonoid content (TFC) was observed as 12.00 and 9.90 per cent in osmo-sonicated and osmo-dried apple rings respectively. The lower retention of total flavonoid content in osmo-dried apple rings may be due to the loss of some soluble nutrient into the osmotic solution during the pretreatment process (Osae *et al.*, 2019) [20]. The results were in close line with An *et al.* 2016) that, reported higher mass transfer and lower drying temperature makes it more beneficial in preserving TFC in dried ginger. However, the antioxidant activity was also reported higher as 30.92 per cent in osmo-sonicated apple rings as compared to 22.59 per cent in osmo-dried apple rings. The reason may be shorter drying time of the osmo-sonicated apple rings compared to the osmo-dried one. These results are reliable with findings of Osae *et al.* (2019) [20] that revealed as shorter drying time and lower drying temperature (60 °C) are significant in preserving the antioxidant properties of ginger during drying.

Effect of osmo-sonication on colour properties

The colour parameters viz. L^*, a^*, b^*, C values and hue angle (h^0) of osmo-dried and hybrid dried apple rings are shown in Table1. Where, L^* is the lightness or darkness (black ($L^*=0$) and white ($L^*=100$)), $+a^*$ is redness, $-a^*$ is greenness, $+b^*$ is yellowness, $-b^*$ is blueness and C is chroma or saturation of colour (low chroma=dullness and high chroma= brightness) whereas hue angle h^0 was selected as an indicator of browning in pome fruits.

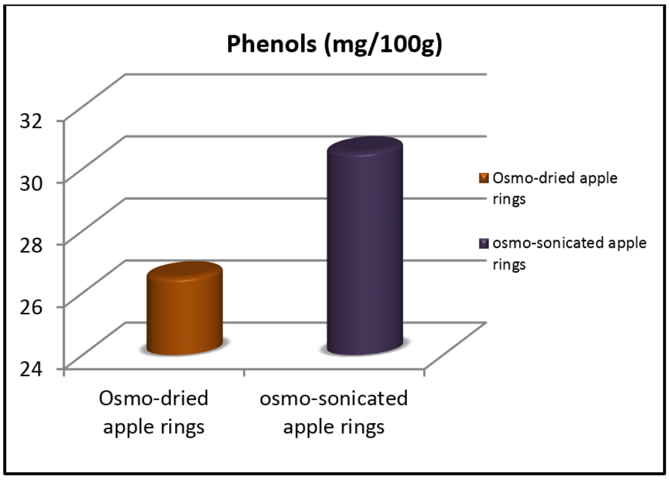

Fig 1: Effect of treatments on Total phenolic content (TPC)

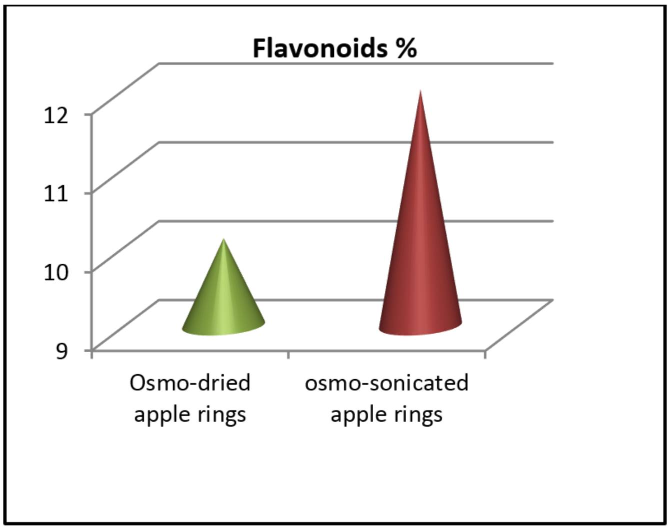

Fig 2: Effect of treatments on Total flavonoids content (TFC)

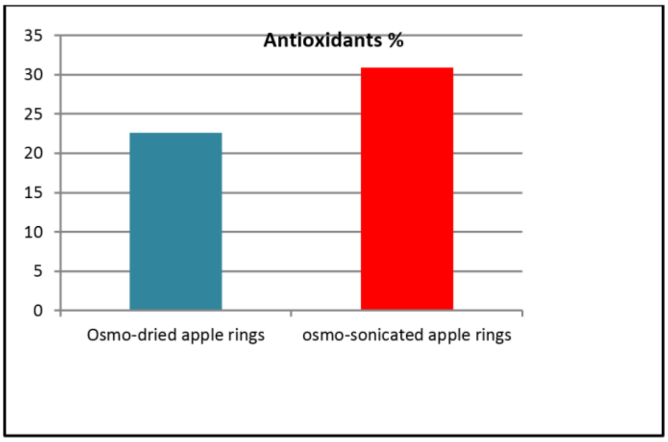

Fig 3: Effect of treatments on antioxidant power capacity

Higher value of hue angle indicates less browning (Goncalves *et al.*, 2007). Hybrid drying modified the color of plant tissue. The value of lightness L^* is higher (52.00 and 45.22) in hybrid dried fruits as compared to osmo-dried fruits. However, results reported by Bantle and Eikevik (2011) [3] for green peas showed that ultrasound applied during drying did not influence the color of plant tissue in comparison with dried control samples. Moreover, the increase in a^* and b^* value related to the enzymatic browning reactions during drying process had been observed. This tendency was observed more in osmo-dried fruits (Table1). Lower value for chromaticity (Chroma) C^* and higher value for hue angle h^0 was reported in hybrid dried fruits.

Table 1: Colour properties of dried apple and pear

Treatments	L^*	a^*	b^*	C	h^0	ΔE
Osmo-dried apple	48.25	6.50	45.00	45.46	5.75	10.59
Hybrid dried apple	52.00	4.20	41.37	41.21	8.23	4.21

Based on the $L^*a^*b^*$ color parameters, the total color differences ΔE in relation to the raw fruits were calculated. According to Choi *et al.* (2002) [7], ΔE higher than 2.00 corresponds to noticeable difference in color. Obtained results are higher than 2.00, so the color changes were noticeable and more reported in osmo-dried as compared to hybrid dried fruits (Table1). Similar trend of colour change are shown by Fijalkowska *et al.* (2017) [11] in ultrasound assisted drying of 'Idared' variety of apple.

Conclusion

The research concluded that the both the treatments (osmo-dried and osmo-sonicated dried) had significant influence on bioactive compounds (TPC and TFC), antioxidant activity and color of apple rings. Osmo-sonication treatment increased the retention of bioactive compounds and antioxidant activity as compared to osmo-dried apple rings. Furthermore, ultrasound (US) pretreatment retained higher color quality in osmo-sonicated apple rings than the osmo-dried samples. Taking all into consideration osmo-sonication will be proven as more promising preservation method for drying of apple fruits as it enhances the conventional osmotic and convective drying methods. The present findings will provide a better understanding of non-thermal pretreatment method.

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