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Drying characteristics and quality evaluation in microwave-assisted hot air drying of cherry tomato

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Abstract

The aim of this work was to investigate the drying behavior of osmotic cherry tomatoes under different microwave powers and drying temperatures using a microwave assisted hot air dryer. The effective moisture diffusivity, physicochemical properties and bioactive compounds were studied under microwave powers of 300-600 watts (W) combined with drying temperatures of 60-80°C. It was clearly found that microwave power played an important role in moisture removal under microwave application conditions. In contrast, under conventional drying, drying air temperature was a key factor in moisture removal. Drying characteristics were consistent with moisture diffusivity and surface evaporation as a constant rate period was observed. Moisture diffusivity was significantly increased by increasing microwave power in combination with drying air temperature ($p \leq 0.05$). The color and textural properties of dried cherry tomatoes were higher than a conventional drying method ($p \leq 0.05$). However, the degree of shrinkage increased with the increase in drying conditions ($p \leq 0.05$) and contradicted with the decrease in drying time. Moreover, ascorbic acid, total phenolic compounds including flavonoids and lycopene were found superior in microwave assisted air drying compared to conventional air drying and commercial product ($p \leq 0.05$). The use of a microwave power of 450 W in combination with a drying air temperature of 60 °C was suggested for cherry tomatoes pretreated with non-nutritive sweetener, as nutrients were better stabilized than the other conditions.

Keywords: Bioactive compounds, Cherry tomato, Microwave drying, Non-nutritive sweetener

1. Introduction

Cherry tomato (*Lycopersicon esculentum* var. Cerasiforme) is one of the most interesting vegetables because of its health benefits. It contains a complex mixture of nutrients and bioactive compounds such as lycopene, phenolic compounds and flavonoids, vitamins and minerals [1]. However, the shelf life of cherry tomatoes is limited due to its high moisture content and water activity. To extend the shelf life and delay the degradation of nutrients, various dehydration methods have been used, such as osmotic dehydration, conventional drying, and microwave drying. Therefore, processing method can play an important role to increase the quality of cherry tomatoes and reduce the drying time along with high product quality. Recently, drying of tomatoes using osmotic dehydration has been investigated [2-4]. In general, osmotic dehydration is a pretreatment process based on the phenomenon of moisture diffusion from raw materials by immersing with a solution of high osmotic pressure. Different types of osmotic agents include glucose, corn syrup, sodium chloride, starch slurry, fructose and sucrose [5]. However, recently there has been an awareness of healthy and natural foods. Therefore, attention is given to a non-nutritive sweetener as an alternative ingredient for consumer's choice by reducing caloric intake [6]. As a substitute sweetener, sucralose is widely used in foods and beverages because it does not have a bitter taste compared to other substitute sweeteners [7]. In addition, sucralose has been reported to be very stable at mild temperatures in food processing, thus maintaining the sweetness level of foods after processing [8]. As mentioned earlier, osmotic dehydration is a pretreatment method that cannot remove more than 30% of moisture content. Therefore, subsequent drying methods such as air drying, freeze drying and microwave drying must play a role to obtain a shelf stable dried food with better quality [9].

Microwave drying has been shown to be an efficient process that allows high drying rates and improves the quality of food products [10]. Generally, during drying, the high rotational speed of water molecules under the high frequency of microwave generates high internal energy, the temperature of which is usually higher than the surface temperature, so that the internal water is evaporated to the outside [11]. On the other hand, hot air drying is considered to be more superior because it constantly removes free water on the food surface [12], but a case hardening effect may prevent further evaporation of water on the food surface [13]. Therefore, a combination of these two methods would accelerate the drying rate because microwave drying produces a high core temperature, which leads to a large temperature difference between the core and the surface, thus improving heat transfer and water diffusion. However, a large temperature difference can affect the nutrients in the food due to a large pore, resulting in low food quality. Thus, the combination with

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the hot air drying mechanism could promote a relatively high surface temperature to accelerate the water evaporation on the food surface, thereby increasing the drying rate. Several studies using osmotic pretreatments followed by microwave assisted hot air drying for fruits and vegetables showed a reduction in drying time with high product quality, both in terms of food appearance and delay in nutrient degradation [14, 15]. However, contradictory results were found that the nutrient-rich lycopene, which is mainly found in tomatoes, was not stabilized under the conditions of microwave-assisted hot air drying due to trans-cis isomerization as well as thermal oxidation of the cis form of lycopene [16]. This finding was also consistent when apples and carrots were subjected to microwave and pulsed electric field drying [17] and cranberry fruits to vacuum microwave drying [18]. Osmotic pretreatment of cherry tomatoes using sucrose solution in combination with sodium chloride was observed to cause compaction of the plasma membrane and cell wall, as well as plasmolysis, leading to the release of more lycopene when the fruits were subjected to severe drying conditions [19]. It is suggested that the use of a highly concentrated sugar solution might play a role in cell disruption due to the high osmotic pressure gradient as well as the high pretreatment temperature. Therefore, a low osmotic pressure solution, i.e., a low calorie sugar, could be an alternative source to maintain cellular integrity. So far, the drying phenomenon of cherry tomatoes using low caloric sugar as an osmotic solution under microwave assisted air drying has not been found. Therefore, this study aimed to apply these drying techniques to cherry tomatoes using sucralose, a low calorie sweetener, as an osmotic medium during osmotic pretreatment followed by microwave assisted hot air drying process, as well as to observe the nutrient stability.

2. Materials and methods

2.1 Raw material preparation

Fresh cherry tomatoes (*Solanum lycopersicum* L. var. cerasiform) were obtained from Nakhon Pathom Province, Thailand. They were sorted according to color (a*=30-33), total soluble solids (TSS = 4.92±0.31) and homogeneous diameter (1.34±0.23 cm) and stored in a PE plastic bag at 7-10 °C before the experiment. A whole tomato was cleaned with tap water and perforated with a needle (1 mm diameter) [20] before blanching in hot water at 90 °C for 3 min to inactivate enzyme activity [21]. The initial moisture content was determined using a hot air oven at a temperature of 103-105°C [22].

2.2 Osmotic pretreatment method

As brief, a sucralose solution was prepared by comparing with 45% (w/w) sucrose solution and mixed with 1% (w/w) NaCl and 1% (w/w) citric acid. The osmotic medium was heated at 80 °C until completely dissolved before cooling at room temperature. The blanched cherry tomatoes were soaked in the sucralose solution at a mass ratio of tomatoes to sucralose solution of 1:10 in a mixing chamber at a controlled paddle speed of 96 rpm at a constant temperature of 25±0.5 °C for 6 h.

2.3 Microwave- assisted drying treatments and apparatus

The drying experiments were performed using a well-own designed microwave hot air dryer equipped with continuous output microwaves (Figure 1). The microwave (model ME711K, Samsung) monitored the power from 0 - 800 W. The microwave chamber was connected to an insulated steel hot air duct for hot air inlet. The inlet hot air was heated by an 8 kW heater. The temperature of the hot air was controlled by a temperature controller with a magnetic switch and a voltage regulator set at 0-260 volts. On the back wall of the microwave chamber was an insulated steel hot air duct for the exhaust air. The staining tray was installed in the drying chamber and supported by four rods connected to a digital balance (PB3002-S/ FACT, Mettler Toledo, Columbus, OHX with an accuracy of 0.01 g). The weight of the sample during drying was recorded and stored in real time using an interface system (LabX Light Balance Version 1.2). Briefly, microwave power was set at 0, 300, 450 and 600 W combined with hot air temperature of 60, 70 and 80 °C at an air velocity of 1.2 ± 0.5 m/s. The drying process was carried out until the final moisture content reached 25% (wet basis) corresponding to the commercial dried cherry tomato.

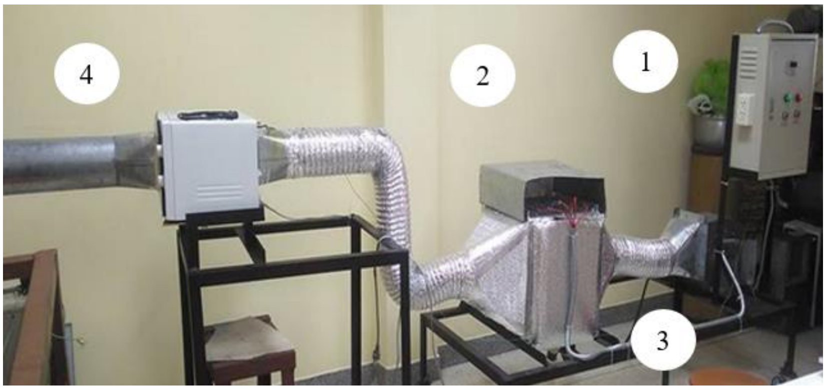

Figure 1 Microwave-assisted hot air dryer apparatus consisted of 1) controller 2) heater 3) blower 4) drying chamber

2.4 Effective moisture diffusivity

Effective moisture diffusivity was determined using Fick's diffusion equation according to Eq. (1) as follows:

$$\ln MR = ln\frac{4}{\beta^2} - \left[\frac{\beta^2 D_{eff}.t}{r^2}\right] \quad (1)$$

Where D*eff* is the effective moisture diffusivity (m^2/s), r is the radius of the cherry tomato measured with a caliper (m), β is the first root of the first kind zero-order Bessel function (β = 2.4048), and t is the drying time (min). As shown in Equation 1, this is the form of a linear equation, where ln MR represents the y-axis and t represents the x-axis. Thus, the effective moisture diffusivity was obtained from the slope by plotting ln MR against t.

2.5 Physicochemical properties

2.5.1 Moisture content and water activity (aw)

The moisture content was determined using the AOAC method [22]. The water activity of the sample was measured using a thermoconstanter (Novasina, model PS200 S/N 9809020, Switzerland) calibrated with a salt standard solution (range 0.11-0.99). Experimental data were obtained with 3 replicates.

2.5.2 Surface color measurement

Surface color of dried cherry tomatoes was measured using a colorimeter (IKA, Model Genius 3, Germany). Color was expressed in the CIE system, L* (darkness to lightness), a*(redness and greenness), and b* (yellowness and blueness). In addition, the color intensity (C*) and hue angle (h) were calculated using the following equations 2 and 3, respectively.

$$\text{Chroma } (C*) = \sqrt{a*^2 + b^{*2}} \quad (2)$$

$$\text{Hue angle (h)} = \arctan(b^*)/(a^*) \quad (3)$$

2.5.3 Shrinkage measurement

The shrinkage of the cherry tomato was determined by a dimensional method. It is assumed that the spherical shape can be applied to the cherry tomato considering the heat and mass transfer in the radius dimension during drying. Moreover, the shrinkage along the radius axis was observed during the experiment. The diameter of the major axis of the sample was measured using a Vernier caliper. The average value was obtained with 3 replicates. The percentage shrinkage was determined as follows [23].

$$\%shrinkage = \frac{d_i - d_f}{d_i} \times 100 \quad (4)$$

Where d_i is the diameter of the cherry tomato before drying and d_f is the diameter of the cherry tomato after drying

2.5.4 Textural measurement

Five dried cherry tomatoes were sampled for texture measurement using a texture analyzer (LLOYD, LR model, USA). Samples were compressed with a 0.5 N load cell using a ½ inch diameter spherical probe. The test speed was set at 30 mm/min with a target mode distance of 0.5 cm and a trigger value of 5 g. The compressive force was recorded as hardness (N) at a maximum force.

2.6 Bioactive compounds of cherry tomato

2.6.1 Ascorbic acid

L-ascorbic acid was analyzed by the titrimetric 2, 6-dichlorophenol-indohenol method [22]. One gram of the samples was mixed with 5% dichloroacetic acid. In addition, 0.02 mg/ml ascorbic acid solution was used as a standard. The ascorbic acid content of the samples was obtained from a standard curve using L-ascorbic acid standard (UNILAB, Ajax Finechem, Australia) and expressed as mg/100 g dry weight.

2.6.2 Total phenolic compounds

The total phenolic compound was determined by the Folin-Ciocalteau method [24]. The extraction solution was extracted with 80% methanol using a shaker (GFL, model 1083) and then mixed with the reagent Folin-Ciocalteau. The mixture was allowed to stand at room temperature for 2 hours before absorbance was measured at 765 nm using gallic acid as standard. Results were expressed as mg gallic acid equivalents (GAE) /100 g dried sample.

2.6.3 Lycopene

The total lycopene content was analyzed according to Toor and Savage [25] with some modifications. Briefly, the extraction process was carried out using a mixture of hexane-acetone-ethanol (2:1:1, v/v/v) as solvent with 2 times extraction. The absorbance of the extraction solution was measured at 472 nm with a UV-Vis recording spectrophotometer (UV-2100, PG instruments T60, Japan) using hexane as blank. Lycopene content was determined from a standard curve and expressed as mg/100 g dry matter.

2.6.4 Total flavonoids

Flavonoid content was measured using a colorimetric assay developed by Zhishen et al [26]. The extraction was carried out using 100% methanol as solvent. The extracted solution or standard solutions of rutin (Sigma-Aldrich, St.Louis, Missouri, USA) were mixed with 5% sodium nitrite (w/v) and 10% AlCl3 (w/v). The absorbance was read at 510 nm against the blank (water) and the flavonoid content was expressed as mg rutin equivalents/100 g dry weight.

2.7 Experimental design and data analysis

The drying kinetics and nutritional stability of cherry tomatoes using microwave assisted hot air drying were conducted using a randomized completed design (CRD) with three replications. Both microwave power and drying air temperature were combined at different levels to obtain different treatments (0, 300, 450 and 600 watts and 60, 70 and 80 °C). Analysis of variance (ANOVA) using SPSS V.17 was used to evaluate the variances of the data. Least significant difference test was applied for multiple comparisons at the 95% confidence level.

3. Results and discussion

3.1 Drying characteristics

The drying characteristics of osmotic cherry tomatoes are shown in Figures 2 and 3. As shown, the moisture ratio of the sample at different drying conditions decreased slightly under microwave feed in the first stage of the drying period, followed by a constant decrease, especially when microwave power was used. It is noteworthy that the moisture loss of cherry tomatoes under conventional air drying depends on the drying temperature, as shown in Figure 2. However, under microwave conditions, moisture reduction was obviously dependent on microwave power (as shown in Figure 3). As a result of applying microwave power for drying cherry tomatoes, the drying time was reduced by up to 90% to achieve a final moisture content of 25% (wet basis) compared to conventional drying (Table 1). This result is in agreement with previous studies in which food drying time was shorten when increasing microwave power [27, 28]. This is due to the fact that the food absorbs the microwave power and the water molecules inside the food can migrate to the surface and evaporate faster. Moreover, it was clearly found that this phenomenon of drying cherry tomatoes under microwave assisted air drying occurs in a constant rate period of time, which is consistent with other fruits with waxy skin [29], where moisture diffusion and water evaporation play an important role in moisture removal during drying. Therefore, it is possible to obtain the effective moisture diffusivity using Fick's law [30] (Table 1) to describe the drying characteristics of cherry tomatoes. As shown in Table 1, it was clearly found that the effective moisture diffusivity was not significantly different at different air drying temperatures at the same microwave power ($p>0.05$). On the other hand, with increasing microwave power at the same drying air temperature, moisture diffusivity was significantly increased ($p\leq0.05$). Therefore, it can be confirmed that microwave power plays a role in moisture diffusion, as the effective diffusivity was three times higher than conventional hot air drying. It is suggested that microwave power accelerates the rotational speed of water molecules, so increasing the kinetic energy of water molecules could induce moisture diffusion to the food surface for evaporation. In addition, high temperature of drying air is not favored to moisture diffusion under microwave drying conditions because moisture evaporation can be occurred inside food product under a medium level temperature of drying air [27].

Table 1 Effective moisture diffusivity of cherry tomato under different microwave-assisted air drying conditions

Drying conditions	Drying time (min)	Moisture diffusivity x 10^{-3} (cm^2/min)
HA60-MW0	2,220±14.00	2.04±0.67^{f}
HA60-MW300	54±1.00	3.55±0.78^{d}
HA60-MW450	30±1.00	4.12±0.65^{c}
HA60-MW600	20±2.00	7.32±0.48^{a}
HA70-MW0	1,740±15.00	2.58±0.93^{e}
HA70-MW300	50±2.00	3.74±0.75^{cd}
HA70-MW450	28±2.00	4.63±0.73^{b}
HA70-MW600	18±1.00	7.42±0.30^{a}
HA80-MW0	1,440±18.00	2.69±0.23^{e}
HA80-MW300	50±2.00	3.93±0.22^{cd}
HA80-MW450	28±1.00	4.95±0.71^{b}
HA80-MW600	18±2.00	7.53±0.54^{a}

Note: a, b, c expressed a significantly difference at 95% confidence between microwave power input at the same drying air temperature

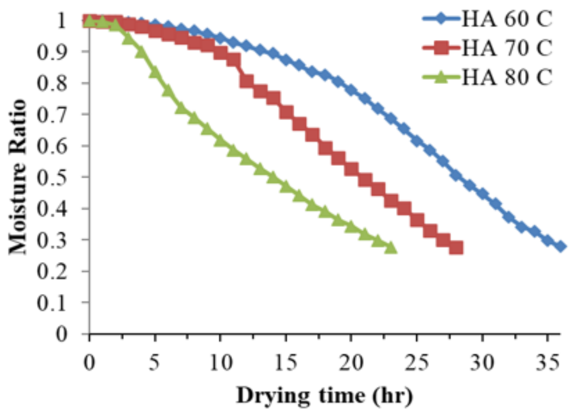

Figure 2 MR Curves of cherry tomato using different hot air temperatures without microwave power.

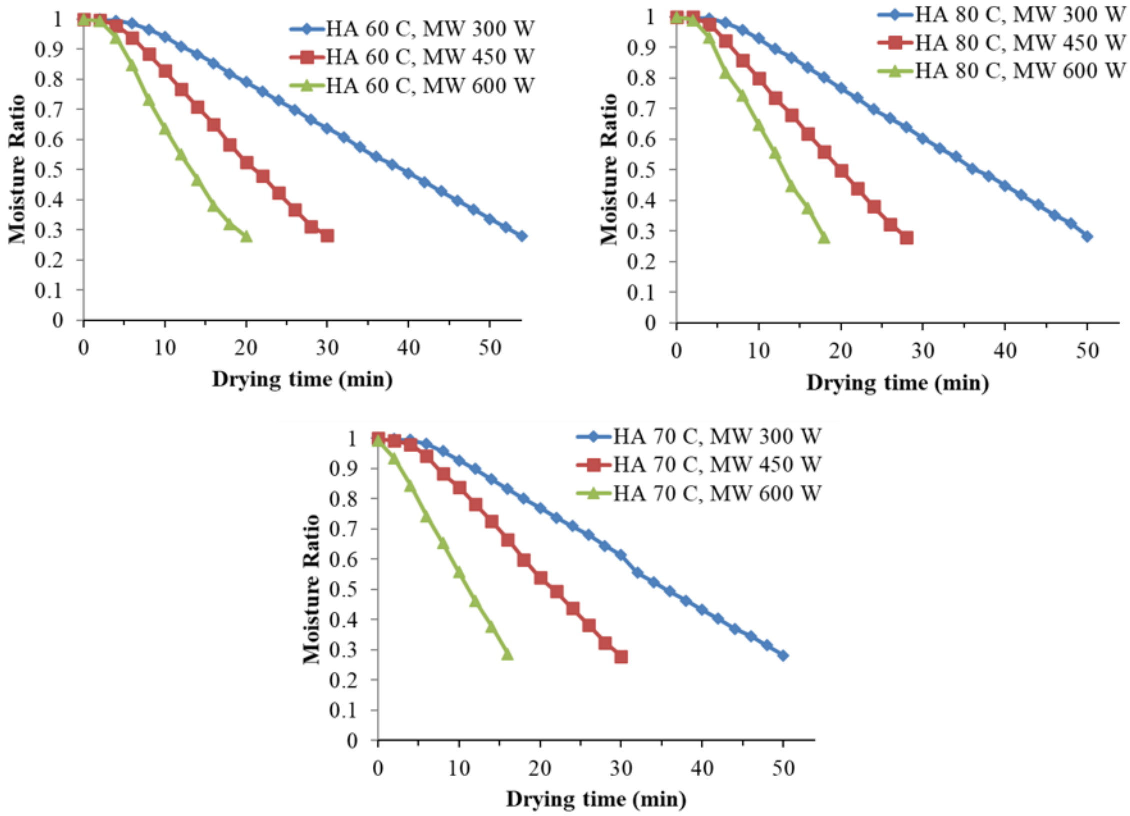

Figure 3 MR Curves of cherry tomato using different microwave powers

3.2 Physicochemical properties

The final moisture content of the dried cherry tomato was found to be 25±1.25% (wet basis) corresponding to the commercial dried cherry tomato. However, the key parameter for shelf stable food is water activity as it is correlated with food deterioration rate known as food stability map [31]. It was found that the water activity (a_w) of dried cherry tomatoes ranged from 0.46-0.49 ($p > 0.05$). These values were lower than those of the commercial products ($p \leq 0.05$) (Table 2). It is suggested that the water activity of the dried osmotic cherry tomato obtained under different conditions of microwave assisted air drying was in the range of 0.2-0.7, which means that the water molecules are weakly bound to the solutes or retained by capillary forces [32]. Since the range of water activity of dried cherry tomatoes was in the second region of the food stability map, weakly bound water molecules are still not available for microbial growth except for some molds where some chemical reactions such as Maillard reaction and enzyme activity could be observed [31]. Therefore, the dried cherry tomato obtained by microwave assisted air drying is a shelf stable product.

In addition, the color stability of dried cherry tomatoes was improved by using microwave assisted air drying compared to hot air drying at the same drying temperature. The brightness (L*) of the dried cherry tomato was increased to 24.5 (Table 2), which is comparable to the fresh cherry tomato (L*= 25.28±0.34). The chroma values of dried cherry tomatoes from microwave assisted air drying were higher than those of dried cherry tomatoes from hot air oven and commercial product ($p \leq 0.05$). Moreover, it was observed that high microwave power level combined with high drying air gave higher value of brightness and chroma value. It could be concluded that shorter drying time was obtained by using higher microwave power level with high drying air temperature. This reduced the non-enzymatic browning reaction and oxidation of pigment compounds, resulting in less dark color and high chroma value, respectively. However, it was found that the hue of dried cherry tomatoes expressed as hue angle increased from 35° to 41.65-45.56° by using microwave assisted air drying as compared to hot air drying. The increase in hue angle showed that the color of dried cherry tomatoes tended more towards orange in microwave assisted air drying. On the other hand, the color of the dried cherry tomatoes obtained with hot air drying was more in the red color range as the hue angle was between 35-37°. It is suggested that the trans-cis isomerization of the color pigment compound of cherry tomato, i.e. carotenoids, was induced by microwave drying.

Another physicochemical property related to overall consumer perception preference is appearance, which can be described as shrinkage degree and texture properties. As shown in Table 2, low shrinkage of dried cherry tomatoes was observed during hot air drying at different temperatures, and the degree of shrinkage increased slightly with increasing drying air temperature ($p > 0.05$). However, a high degree of shrinkage was found under microwave energy input combined with high drying air temperature ($p \leq 0.05$). It can be described that high internal heat is generated during drying under microwave energy, which causes high rotation speed of water molecules, resulting in phase change from liquid water to vapor phase. Thus, the difference of vapor pressure between the inside of the food and the outer layer could improve the vapor diffusion. In addition, the combination of microwave energy with high temperature of drying air could accelerate water diffusion (as described in 3.1), because the high microwave energy activated the kinetic energy of water molecules, which caused rapid evaporation at the food surface and increased the porosity of food. Therefore, a soft textural property was found as low hardness values were obtained for dried cherry tomatoes under microwave assisted air drying. This mechanism affected the structural, textural and optical properties as maximum stress, maximum strain and viscous behavior were observed in microwave dried foods [33]. Moreover, since a non-nutritive sweetener was used in cherry tomatoes during the pretreatment process, it affected the high degree of shrinkage. It is believed that solid uptake during pretreatment using sucralose solution containing three chlorine atoms which induced rotational speed of water molecule during microwave power input. Therefore, the high internal heat generation under the microwave power input leads to a high diffusion and evaporation rate. However, the shrinkage of the dried cherry tomatoes would affect the nutritional stability of the cherry tomatoes, which will be discussed in the next topic.

Table 2 Physicochemical properties of dried cherry tomato using microwave assisted air drying comparing with hot air drying and the commercial product

Treatments	Water activity (a_w)	Color characteristics			Hardness (N)	Shrinkage (%)
		L*	Chroma	Hue angle (°)		
HA60-MW0	0.48±0.05^{bc}	18.34±0.86^{f}	13.98±0.98^{d}	35.03±1.49^{e}	0.91±0.15^{a}	21.45±1.14^{e}
HA60-MW300	0.48±0.05^{bc}	18.37±0.78^{f}	15.25±2.49^{d}	41.65±0.44^{c}	0.76±0.23^{c}	50.35±1.22^{d}
HA60-MW450	0.49±0.03^{b}	19.75±0.63^{e}	20.68±2.42^{bc}	43.67±0.78^{b}	0.47±0.06^{f}	53.32±2.24^{d}
HA60-MW600	0.47±0.06^{bc}	21.43±0.50^{c}	21.29±3.01^{bc}	44.66±0.43^{ab}	0.46±0.15^{f}	60.29±2.06^{ab}
HA70-MW0	0.46±0.06^{c}	18.31±0.57^{f}	14.21±3.22^{d}	35.95±1.42^{e}	0.89±0.45^{a}	23.53±2.12^{ef}
HA70-MW300	0.46±0.04^{c}	20.62±0.36^{de}	19.41±1.56^{c}	42.01±1.01^{bc}	0.69±0.14^{d}	56.37±1.14^{c}
HA70-MW450	0.47±0.02^{bc}	20.99±0.76^{d}	21.79±2.53^{bc}	44.49±1.30^{ab}	0.38±0.12^{g}	57.73±1.12^{c}
HA70-MW600	0.46±0.02^{bc}	23.29±0.88^{b}	26.32±2.93^{a}	45.49±1.22^{a}	0.36±0.22^{g}	61.72±1.24^{a}
HA80-MW0	0.48±0.02^{bc}	18.34±0.32^{f}	14.91±2.14^{d}	37.42±1.83^{d}	0.80±0.26^{b}	24.76±2.06^{f}
HA80-MW300	0.47±0.05^{bc}	23.96±0.87^{ab}	22.65±2.34^{b}	42.87±1.87^{bc}	0.59±0.11^{e}	57.78±2.23^{c}
HA80-MW450	0.46±0.05^{c}	24.01±0.64^{a}	22.68±0.99^{b}	44.53±1.32^{ab}	0.28±0.34^{h}	58.63±2.25^{bc}
HA80-MW600	0.47±0.06^{bc}	24.57±0.46^{a}	26.57±2.76^{a}	45.56±1.37^{a}	0.27±0.15^{h}	61.82±2.15^{a}
Commercial cherry tomato	0.56±0.02^{a}	18.51±0.91^{fe}	15.54±0.73^{d}	35.89±1.91^{e}	0.86±0.14^{a}	N.A.

Note: HA Refers hot air drying, MW Refers microwave power input

3.3 A stability of bioactive compounds

Different bioactive compounds of dried cherry tomatoes were monitored, ascorbic acid expressed as vitamin C, lycopene, flavonoids and total phenolic compounds (TPC) under different drying conditions. As expected, the loss of ascorbic acid or vitamin C was more than 50% compared to fresh cherry tomato (Table 3). In addition, the total phenolic content and total flavonoid content were decreased by about 18.87% and 34%, respectively, compared to the fresh product. This could be due to thermal oxidation of ascorbic acid, as it is known that ascorbic acid is a heat-sensitive compound that can be degraded at high temperatures [34, 35]. Degradation of ascorbic acid by oxidation produces a browning pigment known as furfural compounds, resulting in a dark color, as mentioned previously [36]. Meanwhile, the degradation of total phenolic compounds and flavonoids could be due to oxidative condensation or decomposition of phenolic compounds by breaking the cell structure at high drying air temperature [37, 38]. On the other hand, the lycopene content was increased compared to fresh tomato. It can be described that this nutritive color pigment was released from the disruptive cell structure induced by the heat treatment process, so it can be found higher compared to the non-destructive cell [39].

Table 3 Bioactive compounds of fresh cherry tomato and the commercial dried product

Bioactive compounds (mg/ 100 g db)	Fresh cherry tomato	Commercial dried cherry tomato
Ascorbic acid	401.24±2.61	228.91±2.61
Lycopene	36.94±0.14	13.83±0.01
Total phenolic compounds	341.02±19.36	223.60±5.81
Total Flavonoids	200.33±0.23	107.20±0.06

The effect of microwave assisted air drying on bioactive compounds was shown in Figure 4 in comparison to hot air drying. A slight deterioration rate of ascorbic acid, total phenolic compounds and total flavonoid of dried cherry tomato was found under microwave assisted air drying compared to conventional drying at different drying air temperatures, but inconsistent with lycopene degradation rate. When the microwave power was increased from 300 W to 450 W, the stability of ascorbic acid, total phenolic compounds and total flavonoid was observed. This could be explained by the fact that the acceleration of the internal heat of the food by the high microwave power induced a high rotational speed of the water molecules, which increased the water diffusivity (as shown in Table 1) with rapid evaporation at the outer surface. Therefore, a short drying time was obtained (Table 1), resulting in less direct heat exposure, which could delay the thermal degradation. However, the degradation of ascorbic acid, lycopene, total phenolic compounds and flavonoids was obviously detected by microwave power application at 600 W. Under this drying condition, the degradation of bioactive compounds was well related to the high degree of shrinkage (Table 2) and moisture diffusivity (Table 1). As described previously, a microwave power of 600 W provides a high rotational speed of water molecules combined with a high temperature of the drying air, resulting in high porosity due to the water vapor pressure difference. Therefore, the cell structure can be disrupted, which can release bioactive compounds and directly contact with the high air temperature under severe conditions. Therefore, the thermal degradation of all bioactive compounds under 600 W microwave power was higher than under 450 W. However, the bioactive compounds obtained in this study were obtained to a higher extent than a commercial product (Table 3). It could be a different pretreatment medium as sucralose solution was used for the pretreatment method. This can be explained by the fact that sucralose is an artificial sweetener with three chlorine atoms replacing the hydroxyl group in sucrose. This creates a strong bond between the carbon atom and chlorine, resulting in a low degree of water binding with the sugar, allowing the water molecule to be unbound water and freely removed during drying. Therefore, moisture diffusivity and water evaporation may be increased, resulting in a short period for direct heat contact. Another possible explanation could be different drying methods, fruit varieties, packaging and storage conditions between this study and the commercial product.

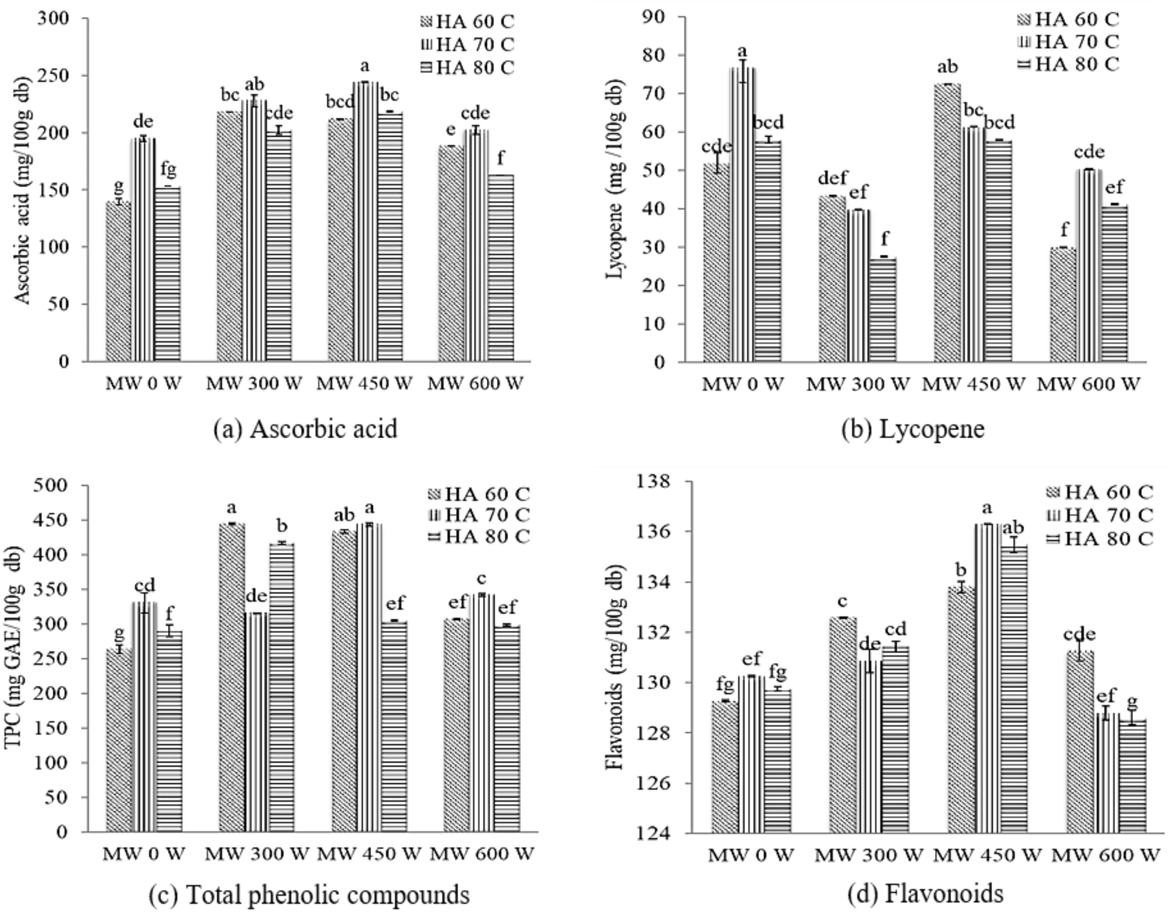

Figure 4 Bioactive compounds of dried cherry tomato under different microwave assisted air drying conditions

4. Conclusions

Microwave assisted air drying was found to be superior for cherry tomatoes, which microwave power plays an important role in moisture removal. Increasing the microwave power induced high moisture diffusivity compared to conventional air drying. The use of drying air temperature of 60°C in combination with microwave power of 450 W can be proposed for stabilization of dried cherry tomatoes with high nutritional value. Under these proposed drying conditions, the dried cherry tomato can be shelf-stable food (a_w <0.65) with color stability and softer texture than a commercial dried cherry tomato. However, a high shrinkage effect was observed when the non-nutritive sweetener was used for the pretreatment method. Despite the high moisture diffusivity, the drying time can be reduced by up to 98% compared to conventional hot air drying, but the bioactive compounds were not stabilized under the high microwave power of 600 W. However, bioactive compounds, ascorbic acid, lycopene, total phenolic compounds and flavonoids were degraded less than commercial dried cherry tomato and conventional drying method.

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