Journal of Food Science and Technology (Iran)

Homepage:www.fsct.modares.ir

Scientific Research

Effect of microwave roasting pretreatment on extraction efficiency and quality characteristics of pistachio oil

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ARTICLE INFO

Article History:

Received:2024/1/17

Accepted:2024/7/11

Keywords:

Thermal stability,
Oxidation,
Anisidine,
Pistachio oil.

DOI: **10.22034/FSCT.22.162.58.**

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ABSTRACT

Pistachio oil is an oxidation-resistant oil known for its healing properties. The application of a microwave pretreatment process under optimal conditions can enhance both the efficiency and quality of the extracted oil. This process was conducted using microwave powers of 300, 600, and 900 watts, along with three levels of moisture content (0.5%, 2%, and 3.5%). The oil extraction efficiency, as well as qualitative parameters such as polyphenol content, chlorophyll levels, carotenoid concentrations, DPPH inhibition capacity, peroxide value, anisidine value, total polar compound content, and thermal stability, were measured. The data were analyzed using split-plot testing within a completely randomized block design, employing SAS software version 9.4. Mean values were compared using Duncan's method at a 5% significance level. The results indicated that oil extraction efficiency increases with both microwave power and moisture content, as well as with the levels of polyphenols, chlorophyll, carotenoids, and the total amount of polar compounds. Additionally, DPPH radical inhibition activity significantly increased with higher power and lower humidity. Furthermore, the findings revealed that while increasing power and decreasing humidity led to a rise in the peroxide value in the examined treatments, the levels of anisidine and thermal stability exhibited a significant decrease and increase, respectively. These results suggest enhanced oxidative stability of pistachio oil extracted at higher microwave powers. The highest thermal stability index was observed in samples treated with 900 watts of power and 0.5% moisture content.

1-Introduction

Pistachios belong to the *Anacardiaceae* family and the *Pistacia* genus, originating from Central and Southwest Asia. Native cultivars from the Kerman province contain approximately 50% fat. Pistachio nut oil is rich in oleic, linoleic, and linolenic acids, which possess important properties, including the reduction of triglycerides, low-density lipoprotein, cholesterol, total cholesterol, and glycemic index [1]. Due to its high oleic acid content and low levels of polyunsaturated fatty acids, pistachio oil is regarded as an oxidation-resistant oil, making it suitable for cooking and frying. Additionally, it contains fat-soluble vitamins such as A and E, as well as significant amounts of phenolic compounds, including anthocyanins, flavonoids, and proanthocyanidins [2]. It also contains tocopherols and sterols [3].

Since the amount of pistachio oil and its health effects due to its compounds are very high, pistachio oil extraction can be very efficient and useful.

One of the preliminary processes before the extraction of oil is roasting. This roasting process is crucial as it develops a distinctive flavor that significantly influences consumer acceptance [4]. Roasting also aids in oil extraction, inactivates enzymes, and breaks down allergens [5]. The roasting process of nuts is conducted using various methods, including hot air, microwave, infrared radiation, and combined techniques that utilize both hot air and microwave or infrared methods [6]. one of the most recent advancements in food processing is microwaving. Microwaves are electromagnetic radiation that is converted into heat due to the dielectric and magnetic properties of various materials. Microwave heating occurs when a material absorbs microwave energy while exposed to an electromagnetic field [7]. Among the advantages of microwave technology are the reduction of processing costs, improved product quality, the development of new products, enhanced human health, and decreased environmental impact compared to conventional methods [8, 9].

Hu et al., (2018) introduced microwave pretreatment as an effective method for enhancing the speed of oil extraction and improving the quality of peanut oil, resulting in a longer shelf life and superior taste [10]. Additionally, the use of microwaves has been shown to enhance extraction efficiency, nutritional value, and the physicochemical and sensory properties of various oils, including rapeseed, palm, soybean, rice bran, cottonseed, Moringa oleifera, black seed, chia seed, and Chilean hazelnut oil. Also Shahi-Chehragh et al., (2022) stated that microwaves can be utilized as a pretreatment to enhance the efficiency of oil extraction from oilseeds. Their research results indicated that microwaves have minimal adverse effects on oil extraction and have improved the quality of flour.

Given that there has been no research on the effects of microwave radiation on the quality of pistachio oil, this study aims to investigate the impact of microwave pretreatment at various power levels and moisture content on the quality characteristics of pistachio oil.

2- Materials and methods

2-1- Preparation of pistachio and oil extraction

Pistachio seeds, identified as Ahmad Aghaei with ounce 25, harvested in 1401, were acquired from the Pistachio Research Institute at Rafsanjan University of Medical Sciences. After the initial peeling, the pistachio seed was exposed to sunlight until its moisture content reached 4%, and it was then stored at 4 °C until the experiment. In the next step, the pistachios are initially placed at laboratory temperature for 24 hours. Subsequently, the samples are immersed in a 17% salt solution for 8 minutes. Pistachios with a moisture content of 12% were placed in the microwave oven for roasting. The roasting process was carried out in the microwave at power levels of 300, 600, and 900 watts until the moisture content reached 0.5%. Oil extraction from pistachio samples, following peeling and crushing, was conducted using a homemade oil extraction machine (GOL SIRU model) [11].

2-2-Total phenolic content

The total phenolic content was estimated using the Folin-Ciocalteu method. A mixture was prepared by combining 20 μL of pistachio oil, 1.160 mL of distilled water, and 100 μL of Folin-Ciocalteu reagent in a test tube. The solution was allowed to stand for 8 minutes. Subsequently, 300 μL of a 20% sodium carbonate solution was added and thoroughly mixed with the contents of the test tube. The test tubes were then placed in a water bath maintained at 40˚C for 30 minutes. The absorbance was recorded at 760 nm using a spectrophotometer (CARY 100 Scan). Gallic acid solutions with concentrations ranging from 0.04 to 0.4 mg were prepared to establish a calibration curve. The absorbance of the samples was measured at 760 nm. The total phenolic content in pistachio oil was expressed as milligrams of gallic acid equivalent per milliliter of oil [12, 13].

2-3-Chlorophyll and carotenoid content

The pigments (chlorophylls and carotenoids) of pistachio oil were measured by dissolving in cyclohexane. The absorbance was recorded for chlorophyll and carotenoid at wavelengths of 670, and 472 nm, respectively. It was calculated in terms of milligrams per kilogram of oil using the following equations:

$$\mathrm{CCh\_tot} = \frac{\mathrm{A472} \times 10^6}{613 \times 100 \times \mathrm{d}} \qquad (1)$$

$$\mathrm{CCa\_tot} = \frac{\mathrm{A670} \times 10^6}{2000 \times 100 \times \mathrm{d}} \qquad (2)$$

In this equation, CCa_tot and CCh_tot are the total amounts of carotenoid and chlorophyll (ppm/kg oil), respectively, and A472 and A670, respectively, are the amount of absorption in the absorption values at 472 and 670 nm [14].

2-4-Radical scavenging activity

A volume of 0.2 mL of pistachio oil was mixed with 4 mL of a methanolic solution of DPPH free radicals at a concentration of 510 x 10^-6 M. The resulting samples were incubated for 60 minutes at ambient temperature, after which they were measured in a dark environment against a control sample at a wavelength of 517 nm utilizing a CARY 100 Scan spectrophotometer. The inhibitory effect was determined as described in Equation 3.

$$\%\mathrm{RSA} = \frac{(A_{Control} - A_{Sample})}{A_{Control}} \times 100 \qquad (3)$$

where A_{Sample} and $A_{Control}$ are the absorption rate of the sample and control, and RSA is the percentage of free radical inhibition [15].

2-5-Total polar compounds content

A volume of 10 milliliters of oil samples were heated to a temperature of 70 degrees Celsius. Then, the sensor of the TESTO 270 device was inserted into the prepared samples to assess and record the overall concentrations of polar compounds present [15].

2-6-Peroxide value

The peroxide value was assessed utilizing the spectrophotometric method established by Shanta et al (1994). In this procedure, an oil sample weighing between 0.03 and 0.01 g was vortexed with 9.8 ml of a methanol and chloroform mixture (in a 3:7 volume ratio) for 2-4 seconds. Following this, ammonium thiocyanate was introduced, followed by the addition of 50 ml of iron(II) chloride, with vortexing performed for 2 to 4 seconds after each addition. The absorbance of the samples was recorded after a 5-minute incubation period at ambient temperature. The results are expressed in milliequivalents of oxygen per kilogram of oil, calculated according to the specified equation:

$$\mathrm{PV} = \frac{(A_s - \mathrm{A}_b) \times 40.39}{55.84 \times \mathrm{W} \times 2} \qquad (4)$$

A_b, A_S, W, and m show the absorbance of the sample and control, sample weight, and slope of the standard curve, respectively [16].

2-7-Para-Anisidine value

Initially, a sample mass ranging from 0.2 to 1.6 grams was accurately measured using a 10 mL volumetric flask, with a precision of 0.001 g. The solution was subsequently adjusted to a predetermined volume. Following the calibration of the spectrophotometer with an isooctane solution, the absorbance readings were obtained, reflecting the absorption characteristics of the diluted isooctane solvent. The oil sample was analyzed at a wavelength of 350 nm. Subsequently, 5 mL of the sample was diluted with isooctane and transferred to a 10 mL glass flask, to which 1 mL of a p-anisidine reagent (2.5 g/L) in glacial acetic acid was added for calibration purposes. The spectrophotometer was then set up with another glass flask containing 1 mL of the isooctane solution and 1 mL of the p-anisidine reagent. After allowing the mixture to darken for approximately 10 minutes, the absorbance of the sample was measured and recorded:

$$P - A.V = \frac{10 \times 1.2\, A_s - A_b}{m} \qquad (5)$$

A_b, A_S, and m are the absorbance of the sample and control, sample weight, and slope of the standard curve, respectively [17].

[DOI: 10.22034/FSCT.22.162.58]

2-8-Thermal stability

The Rancimat (Metrohm Company, model 743) was employed to assess the oxidation stability of pistachio oil. In this procedure, 2.5 grams of oil samples were meticulously measured and introduced into the test containers of the Rancimat device. The samples underwent oxidation at a controlled temperature of 110 degrees Celsius, with an airflow rate maintained at 15 liters per hour. The outcomes were analyzed in relation to the induction period (measured in hours), which reflects the duration necessary for the decomposition of peroxides generated during the oxidation of the oil [15].

2-9-Statistical analysis

The experimental design was a split plot arranged in a completely randomized block design with three replications. the first factor was the power level (300, 600, or 900 W) and the second was moisture content (0.5, 2, 3.5, and 5 %). The data was subjected to analysis of variance (ANOVA) using the SAS software version 9.4. Means of treatment were separated using Duncan's new multiple range test ($p < 0.05$).

3- Results and Discussions

3-1- Oil extraction

As illustrated in Figure 1, the efficiency of oil extraction in the treatments examined exhibited a significant increase with the elevation of microwave power, as detailed in Table 1. This phenomenon can be attributed to the effects of microwave radiation, which induces protein denaturation. Such denaturation modifies the structure of the cell wall, which is rich in fat, thereby enhancing the permeability of the cell membrane to oil. This alteration ultimately contributes to an improvement in oil extraction efficiency [9]. Moreover, an increase in microwave power resulted in greater heat generation within the sample. This rise in temperature subsequently enhanced the mass transfer coefficient, thereby further improving oil extraction efficiency [18], as corroborated by the findings of Shahi-Chehragh et al., (2022) .

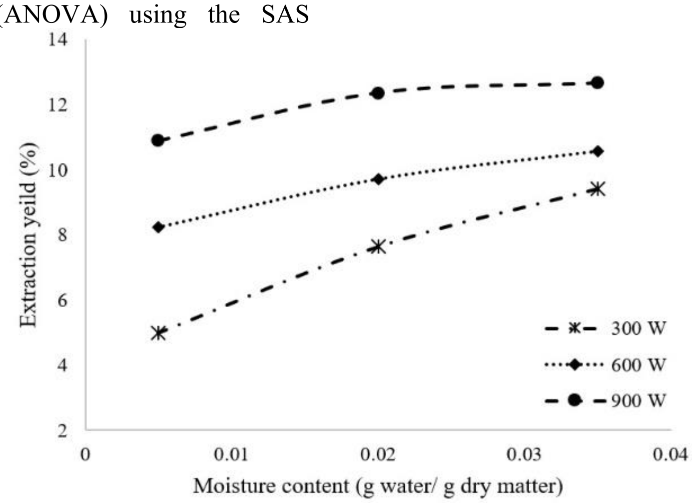


Figure 1- Oil extraction efficiency of microwave roasted pistachio samples at different moisture content

The results also showed thatthe moisture content of pistachio can have a significant effect on the oil extraction efficiency (Table 1). Specifically, as the process time elapsed and the moisture content decreased, the oil extraction efficiency declined. This could be attributed to the reduced flexibility of the materials and the decreased possibility of oil flow [12].

3-2-Total phenolic content

Phenolic compounds constitute a prominent category of secondary metabolites in plants, and their antioxidant properties are primarily due to the presence of hydroxyl groups within their molecular structure. These compounds are known to inhibit the oxidative degradation of lipids, thereby improving the quality and nutritional value of food products [19]. The results from the total polyphenol assay (Figure 2) demonstrated that both the moisture content and the intensity of microwave power utilized during the roasting of pistachios significantly influence the

[DOI: 10.22034/FSCT.22.162.58]

concentration of these beneficial bioactive compounds (Table 1). Specifically, an increase in microwave power was associated with higher levels of polyphenols in the samples analyzed. Notably, the highest concentration of phenolic compounds was recorded in pistachio samples roasted at 900 W. These results are consistent with the findings of Hojjati et al., (2015), and Hayat et al., (2019) on pistachio, and fennel seeds, respectively [20, 21].

The enhancement of polyphenolic compounds, as influenced by microwave irradiation, is primarily due to the cleavage of bonds between these compounds and cellular constituents, which facilitates their release into the extracted oil [9]. Furthermore, polar molecules, including phenolic compounds, possess a notable ability to absorb microwave energy owing to their dipole moment. This absorption leads to an increase in temperature, thereby enhancing the penetration of these compounds into the oil [19]. The results also indicated that among the three applied microwave power levels, the lowest concentration of total polyphenols, measured at 3.5% moisture content, was observed. In essence, an increase in extraction time coupled with a decrease in moisture content resulted in a higher yield of polyphenols. Given that moisture content serves as the primary absorber of microwaves in food, a reduction in moisture content leads to decreased microwave absorption and heat generation, which consequently minimizes the degradation of polyphenols [9].

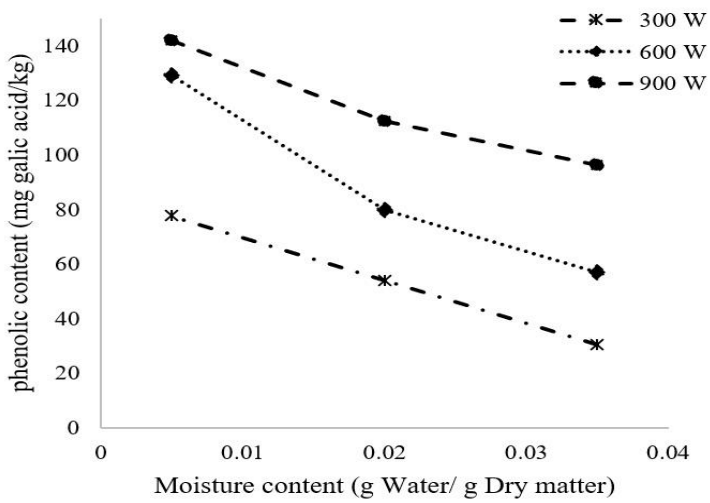
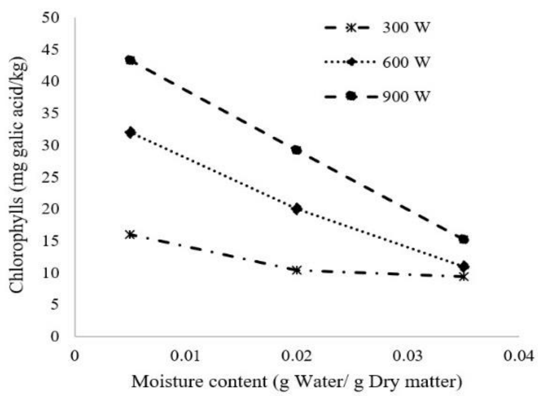


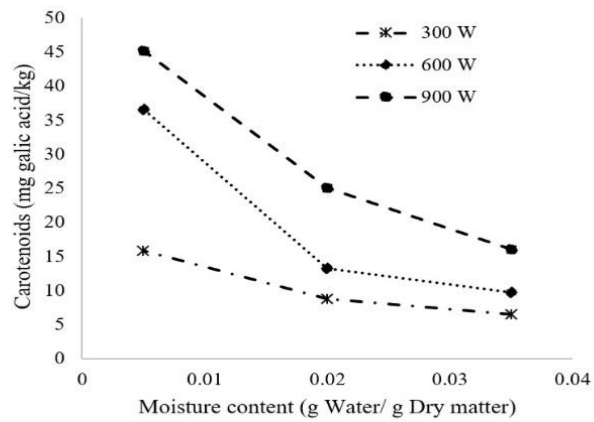
Figure 2- The total phenolic compounds in the oil of microwave roasted pistachio samples at different moisture content

3-3-Chlorophyll and carotenoid

The experimental results pertaining to the quantification of chlorophyll and carotenoids, as illustrated in Figures 3-a and 3-b, demonstrated that, akin to polyphenolic compounds, the concentrations of these antioxidant compounds exhibited a significant increase with elevated microwave power and reduced seed moisture content. The maximum levels of chlorophyll and carotenoid pigments were recorded in the sample subjected to a power setting of 900 watts and a moisture content of 0.5 %, yielding values of 43.28 mg/kg and 45.12 mg/kg, respectively. In contrast, the minimum concentrations were observed at a power level of 300 W and a moisture content of 3.5 %, with values of 9.39 mg/kg and 6.46 mg/kg, respectively. The similar findings were reported on by suri et al., (2020, 2022) on flaxseed and nigella seed [22, 23].



(A)



(B)

Figure 3- The chlorophyll (a) and carotenoid (b) contents in the oil of microwave roasted pistachio samples at different moisture contents

The results indicate that an increase in processing time, coupled with a decrease in the moisture content of pistachio seeds, significantly enhances the levels of carotenoids and chlorophyll in the examined treatments (see Figures 3(A) and 3(B)). Carotenoids possess a conjugated double-bonded structure, which confers a strong antioxidant capacity. During the microwave heating process, their these bonds are easily susceptible to oxidation, isomerization, and decomposition. Therefore, the reduction of moisture contributes to a decrease in oxidation [9].

Table 1- Comparison of means of the effect of temperature and moisture content on quality parameters of pistachio oil

	Extraction yeild	Oxidation stability	Carotenoid	chlorophyl	Total phenolic content	Anisidine value	Peroxide value	Total polar content	Antioxidant activity
Moisture content									
0.035	10.880^{a}	69564.00^{c}	9.110^{c}	10.582^{c}	61.077^{c}	2.209^{a}	0.033^{b}	7.000^{c}	735.88^{b}
0.02	9.901^{b}	94209.00^{b}	15.710^{b}	19.807^{b}	81.971^{b}	1.703^{b}	0.037^{a}	8.400^{b}	832.68^{b}
0.005	15.036^{c}	108893.00^{a}	32.503^{a}	30.376^{a}	116.13^{a}	0.467^{c}	0.039^{a}	10.333^{a}	1147.82^{a}
Power									
300	7.353^{c}	65509.00^{c}	10.372^{c}	11.897^{c}	53.863^{c}	0.889^{b}	0.030^{b}	7.833^{c}	695.82^{b}
600	9.505^{b}	94665.00^{b}	19.862^{b}	20.923^{b}	88.615^{b}	1.426^{ab}	0.038^{ab}	8.400^{b}	892.46^{b}
900	11.959^{a}	112492.00^{a}	27.089^{a}	27.944^{a}	116.70^{a}	2.064^{b}	0.042^{a}	9.500^{a}	1128.11^{a}

3-4-Radical scavenging activity

In this study, antioxidant molecules facilitate the transfer of electron or hydrogen atoms to 2,2-diphenyl-1-picrylhydrazyl ($DPPH^{\bullet}$) radicals, resulting in the formation of 1,1-diphenyl-2-picrylhydrazine ($DPPH_2$) radicals. Consequently, the capacity to reduce the DPPH radical can be obtained by assessed by measuring in absorbance at 517 nm:

$$(DPPH^{\bullet} + AH \rightarrow DPPH_2 + A^{\bullet}) \qquad (6)$$

The results presented in Figure 4 indicate that the antiradical activity of the treated pistachio oil increased with higher microwave power and lower moisture content. This enhancement in antioxidant activity may be attributed to the concentrations of polyphenolic compounds and carotenoids. As illustrated in Figure 3, a similar trend was observed between these compounds and both power level and moisture content. Martínez et al., (2016) conducted an evaluation of pistachio samples from Argentinian cultivars and found a positive correlation between antioxidant activity and the levels of polyphenols, flavonoids, and tocopherols in the pistachio samples [24].

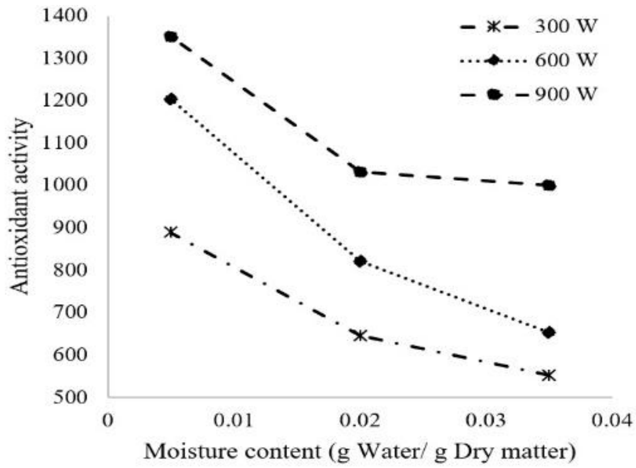


Figure 4- Antioxidant activity in the oil of microwave roasted pistachio samples at different moisture content

3-5-Peroxide value

During the early stages of lipid oxidation within the kinetic regime, hydroperoxides are the primary products generated. Although hydroperoxides exhibit greater stability than radical species, they are still classified as weak oxidizing agents. Their intrinsic instability leads to their decomposition into peroxyl and alkoxyl radicals [8].

Figure 5 illustrates that as microwave power increases, the peroxide value of the treatments exhibits a significant increase, with the highest value recorded at 900 watts. However, no statistically significant difference was observed in the peroxide values of the samples treated at 600, and 900 watts. The findings of this study align with the results reported by Suri et al., (2020), and Hu et al., (2018) on flaxseed, and peanut oil, respectively [10, 22].

The findings regarding polyphenolic compounds and carotenoids, as illustrated in Figures 2 and 3, demonstrate a significant increase in the concentration of antioxidant compounds with the escalation of microwave power, peaking at 900 watts. Consequently, a reduction in peroxide value is anticipated, as an increase in the concentration of polyphenols and carotenoids correlates with an enhancement in antiradical activity (Figure 4).

Hu et al., (2021) proposed that the application of microwave radiation to lipids promotes the generation of free radicals, thereby increasing the susceptibility of lipid compounds to oxidation in comparison to conventional heating methods.

The influence of microwave radiation on pistachio oil has resulted in accelerated oxidation and an increase in peroxide levels. Additionally, a positive correlation has been identified between the rate of peroxide formation and the power applied. Specifically, elevated temperatures enhance the generation of radicals. Conversely, an investigation into the effects of treatments on the extraction of flaxseed oil revealed that an increase in peroxide levels correlates with a higher yield of oil extracted through this method, which is greater than that obtained via Soxhlet extraction [9]. The findings from stability tests conducted in the current study are illustrated in Figure 8.

The results indicated that the peroxide value of the treated samples can be significantly influenced by moisture content. Reducing the moisture content of pistachio led to a substantial increase in peroxide values. This increase is attributed to the enhanced oxidation and hydrolysis reactions of the oil as moisture content decreases [17, 23].

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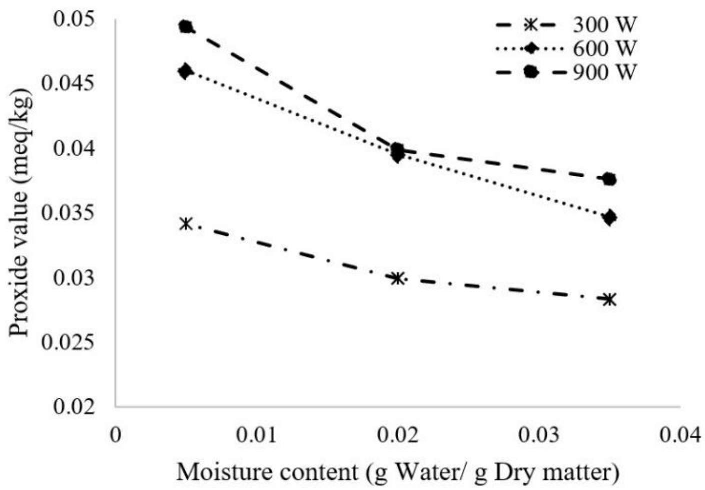

Figure 5- Peroxide value in the oil of microwave roasted pistachio samples at different moisture contents

3-6-Anisidine value

Compared to the peroxide value, the anisidine value is significant it measures the accumulation of secondary oxidation products. Figure 6 illustrates the anisidine value at different moisture content, power levels during roasting. results indicated that the anisidine value decreased with increasing microwave power and decreasing moisture content. Similar results were reported by Ali et al., (2017) on pumpkin seed [25].

The decrease in the anisidine value of treatments at higher power levels, despite the increased peroxide value, may be attributed to the enhanced stability of oil micelles under microwave irradiation. Similar findings were reported by Hu et al., (2018) [10].

Investigating the effect of microwave radiation on rapeseed oil has shown that even though the initial peroxide value of rapeseed oil treated with microwaves was higher than the peroxide value of untreated rapeseed oil. But the treated sample after storage for 32 days had a lower amount of peroxide compared to the untreated sample [10]. Therefore, it can be concluded that the samples treated with microwaves have fewer secondary oxidation products compared to untreated samples due to higher micellar stability. Microwave radiation can increase the oxidative stability of the treated oils. The results of the Rancimat test (Figure 8) also prove this well.

Shahi-Chehragh et al., (2022) investigated the effect of microwaves on safflower oil and concluded that with increasing power, the amount of phosphatides in the oil increased significantly. It has been suggested that phospholipids enhance the antioxidant activity of alpha-tocopherol by forming microemulsion bodies in oil in the presence of low moisture content. These compounds transport tocopherols to the oxidation sites. Furthermore, the decrease in surface tension and interfacial free energy in oils, attributed to the emulsifying properties of phospholipids, inhibits the formation of peroxides and subsequently reduces the rate of oxidation reactions.

Figure 6 indicate that the aniline value of the treatments under investigation is significantly influenced by the moisture content of the seeds. Notably, a decrease in moisture content correlates with a decline in the aniline value, with this reduction becoming particularly evident at moisture levels falling below 2 %.

An increase in the moisture content is one of the factors that affect the instability of peroxides, and lipid oxidation by affecting micellar bodies through the hydrolysis of triacylglycerols and the formation of mono- and diacylglycerols and fatty acids [26]. Moreover, increasing microwave heating in high moisture content may also cause the instability of oil micellar structures.

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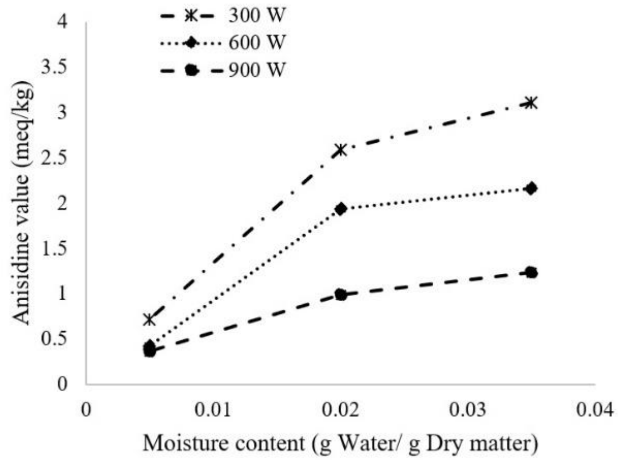

Figure 6- Anisidine value value in the oil of microwave roasted pistachio samples at different moisture contents

3-7-Total polar compounds

Figure 7 illustrates the total concentration of polar compounds. It is evident that an increase in microwave power, coupled with a reduction in moisture content, correlates with an elevation in the total quantity of polar compounds. Similar findings were reported by Kheto et al., (2022), and Abbas Ali et al., (2016) on quinoa and corn oil, respectively [27, 28].

increase in polar compounds in pistachio oil can be attributed to the breaking of molecular bonds within the cellular matrix, which enhances the solubility of molecules such as polyphenolic compounds [27, 28]. The results of phenolic compounds (Figure 2), and anisidine (Figure 6) substantiate this rationale. On the other hands, The anisidine value, an indicator of secondary oxidation compounds, significantly decreased with increasing microwave power and decreasing moisture content that results in an increase in the total polar compounds as microwave power rises, which is attributed to the higher concentration of polyphenolic compounds.

Nonetheless, the application of microwave radiation has the potential to initiate a range of chemical reactions, resulting in the synthesis of compounds characterized by elevated molecular weights and polarities [21].In this context, it is essential to examine the structural transformation of the carotenoid astaxanthin from its trans configuration to its cis configuration following the absorption of microwave energy in peanut oil [10]. Moreover, microwave radiation can induce the transformation of lipids into polar secondary oxidation products, such as aldehydes, ketones, acids, and alcohols, following the peroxidation process [28].

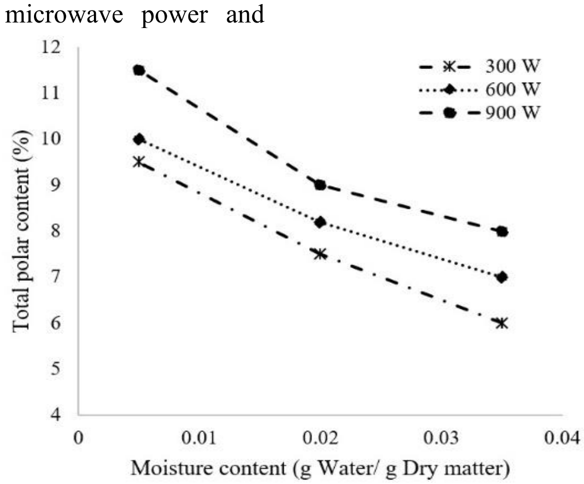

Figure 7- Total polar content in the oil of microwave roasted pistachio samples at different moisture contents

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3-8-Oxidation stability index

The oxidation stability index indicates the oil's susceptibility to oxidation, which is largely influenced by the level of unsaturation and the presence of antioxidant compounds within the oil [3]. As illustrated in Figure 8, the oxidation stability of the treatments under investigation improved with an increase in microwave power and a decrease in the moisture content of the pistachio. The highest oxidation stability was recorded in the treatment roasted at 900 W with a moisture content of 0.5 %, demonstrating a 62 % increase compared to the sample treated at 300 W with the same moisture content. The oxidation stability index rose from 21.54 hours for the sample treated at 300 W to 34.93 hours at 900 W. similar findings were reported by Hu et al., (2018) on peanut. The oxidation stability index of Rafsanjan Kale Ghochi, Fandoghi, Akbari, and Ahmed Aghaei cultivars are 12.68, 12.95, 12.24, and 14.75 hours respectively, and Azerbaijan Kale Ghochi and Akbari cultivars with a maximum amount of 16 and 16.4 hours respectively [3].

The increase in thermal stability of treatments with higher microwave power may be attributed to the rise in antioxidant compounds. The results of total polyphenol (Figure2), and carotenoids (Figure 3(B)) confirm this fact. Moreover, The presence of oxidizing agents with better transport properties (higher thermal resistance) at higher powers compared to lower microwave powers could be another reason for oxidation stability. These compounds delay the production of new alkyl radicals by transferring hydrogen atoms (HAT) to peroxide radicals [29].

The Rancimat test, which assesses oxidation by measuring volatile compounds, suggests that the enhanced thermal stability observed in the treatments may be attributed to the increased stability of micellar structures within the oil at higher power levels (Refer to the Anisidine value section).

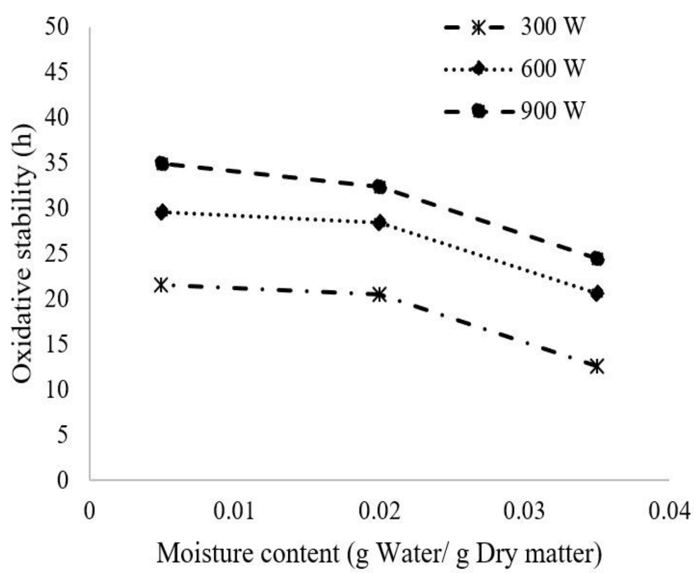

Figure 8- Oxidative stability in the oil of microwave roasted pistachio samples at different moisture contents

4- Conclusions

This study assessed the extraction efficiency and quality of pistachio oil obtained through microwave roasting, examining the effects of varying microwave powers (300, 600, and 900 W) and moisture levels (0.5 %, 2 %, and 3.5 %). The findings indicated a significant enhancement in the extraction efficiency of pistachio seed oil as microwave power increased, with the highest efficiency achieved at a power level of 900 W. The concentrations of polyphenols, chlorophyll, and carotenoids were found to increase when measured at higher power levels and under conditions of reduced moisture content. Therefore, using microwave radiation on pistachio roasting will be richer in bioactive antioxidant compounds. However, the peroxide value of the treated samples increased with the increase of microwave power. However, the anisidine value and thermal stability showed that the oxidation stability increased with increasing microwave power. The lowest value of anisidine, and the highest thermal stability belonged to the 900 W treatment.

5-Acknowledgements

This research supported by a grant from the University of Zabol (IR-UOZ-GR-0946).

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[DOI: 10.22034/FSCT.22.162.58]

مجله علوم و صنایع غذایی ایران

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مقاله علمی_پژوهشی

تأثیر پیش تیمار برشته کردن به روش مایکروویو بر راندمان استخراج و ویژگی‌های کیفی روغن پسته

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اطلاعات مقاله

تاریخ های مقاله :

تاریخ دریافت:۱٤۰۲/۱۰/۲۷

تاریخ پذیرش: ۱٤۰۳/٤/۲۱

کلمات کلیدی:

پایداری حرارتی،

اکسایش،

آنیزیدین،

روغن پسته.

DOI:10.22034/FSCT.22.162.58.

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چکیده

روغن مغز پسته، روغنی مقاوم به اکسایش و دارای خواص‌درمانی است. با توجه به اینکه فرایند پیش تیمار مایکروویو در شرایط بهینه می‌تواند سبب افزایش راندمان و کیفیت روغن استحصالی شود. لذا در این پژوهش تأثیر فرایند پیش تیمار برشته کردن پسته با استفاده از مایکروویو در توان‌های ۳۰۰، ۶۰۰ و ۹۰۰ وات در سه سطح رطوبت ۰/۵، ۲ و ۳/۵ درصد انجام شد. راندمان استخراج روغن و هم‌چنین پارامترهای کیفی از جمله میزان پلی فنل‌ها، کلروفیل و کاروتنوئیدها، آزمون مهارکنندگی DPPH، عدد پراکسید، عدد آنیزیدین، میزان کل ترکیبات قطبی و پایداری حرارتی اندازه‌گیری شد. داده‌ها با استفاده از آزمایش کرت خرد شده در قالب طرح بلوک کاملاً تصادفی با نرم افزار SAS نسخه ۹/٤ و مقایسه میانگین صفات با استفاده از روش دانکن در سطح معنی‌داری ۵ درصد آنالیز شد. نتایج نشان داد که با افزایش توان مایکروویو و مقدار رطوبت راندمان استحصال روغن افزایش می‌یابد، میزان پلی‌فنل‌ها، کلروفیل، کاروتنوئیدها، میزان کل ترکیبات‌قطبی و هم‌چنین فعالیت مهار کنندگی رادیکال DPPH با افزایش توان و کاهش رطوبت به‌طور معنی‌داری افزایش یافت. نتایج هم‌چنین آشکار کرد اگرچه افزایش توان و کاهش رطوبت باعث افزایش عدد پراکسید تیمارهای مورد بررسی شد، اما عدد آنیزیدین و پایداری حرارتی به‌طور معنی‌داری به ترتیب کاهش و افزایش یافت. این نتایج حکایت از پایداری اکسیداتیو بیش‌تر روغن پسته استحصالی در توان‌های بالاتر مایکروویو داشت. بالاترین میزان شاخص پایداری حرارتی به نمونه‌های تیمار شده با توان ۹۰۰ وات و محتوی رطوبت ۰/۵ درصد تعلق داشت.