Evaluation of Total Antioxidant Activity and Total Phenolic Content of Different Tahini (Sesame Paste) Brands in Iran’s Market

ABSTRACT

Background and Objectives: Tahini (sesame paste) is a condiment made from sesame seeds. Given the possible high antioxidant activity and polyphenol content of sesame seeds, we aimed to measure the total antioxidant activity and total phenolic content of different tahini brands in Iran’s market.

Methods: In this study, 111 tahini samples from 37 commercial brands (three samples from each brand) were purchased from the Iran’s market. The ferric reducing ability of plasma (FRAP) method was used to measure the total antioxidant activity in each sample. Total phenolic content was measured by the Folin–Ciocalteu method.

Results: The results showed that Mino-dates (119.93 ± 0.159 µmol/mL), Trang-Chocolate (56.30 ± 0.056 µmol/mL), Barsam-coffee (45.13 ± 0.094 µmol/mL) and Chocolate-barsam (45.13 ± 0.094 µmol/mL) had significantly higher antioxidant activity compared to other brands (p<0.001). Moreover, Mino-dates (2057.33 ± 0.094 µmol/mL), Barsam-coffee (805.51 ± 0.041 µmol/mL), Chocolate-barsam (807.42 ± 0.095 µmol/mL) and Trang-Chocolate (685.75 ± 0.086 µmol/mL) contained higher level of phenolic compounds compared to other brands (p<0.001).

Conclusion: This study is among the first to assess total antioxidant activity and total phenolic content of different tahini brands in Iran. Our results indicate that tahini brands with a higher phenolic content also have higher antioxidant activity. It can be concluded that tahini may be used as rich source of antioxidant compounds in people’s routine diet.

Keywords: Antioxidant Activity, Phenolic Content, Sesame Paste, Tahini.
INTRODUCTION

Free radicals can damage the biological system of the body (1,2). Free radicals are one of the most important causes of diseases, including cancer (3,4), neurological disorders (5) and cardiovascular disease (6). Today, the beneficial health effects of using some herbal have been proven. These effects originate from the antioxidant activity of plant’s phytochemical compounds, especially phenolic compounds, which could contribute to prevention of many diseases such as cancer or cardiovascular disease (7). Sesame seed has a high nutritional value and is a rich source of proteins. It is also a good source of calcium, iron, zinc and folic acid as well as linoleic acid and oleic acid (8). Tahini (sesame paste) is condiment made from toasted ground hulled sesame seeds (9). According to the reports by the USDA National Nutrient Database, two tablespoons of tahini contain 178 calories, 16 g of fats, 6 g of carbohydrates and 5 g of proteins. The major mineral and vitamin components of tahini are thiamine (30%), magnesium (24%), phosphorus (22%), iron (14%) and calcium (12%) (10). According to previous studies, sesame seeds can exert beneficial health effects by preventing symptomatic knee osteoarthritis (11), help preventing/treating cancer (12), decreasing the risk of atherosclerosis and cardiovascular disease (13, 14) and lowering low-density lipoprotein levels while maintaining high-density lipoprotein levels (15). These effects are probably due to the high antioxidant capacity of tahini owing to its high sterols, polyphenols and flavonoids content (16). Moreover, sesame oil shows great stability against oxidation compared to other vegetable oils (17).

In recent years, various methods have been developed for measuring total antioxidant activity (18). Among these methods, ferric reducing ability of plasma (FRAP) has many advantages including no need for prior preparation, simplicity and rapidness. It is also the only method that directly measures the amount of antioxidant compounds. However, the FRAP reagent does not react with thiol compounds, including glutathione (19). Nevertheless, thiol compounds have little contribution to the antioxidant activity of plants. Given the beneficial health effects of tahini and the contribution of reactive oxygen species to development of several disease, for the first time, we aimed to measure the total antioxidant activity and total phenolic content of different tahini brands in Iran’s market.

MATERIALS AND METHODS

In the present study, 111 samples were collected from 37 commercial tahini brands (three samples for each brand) purchased from Iran’s market. Then, 2 g of each sample were weighed (Sartorius BP 61, sensitivity 0.1mg) and poured into plastic Falcon. Each sample was mixed with 2 mL of methanol 50% for 120 minutes on a rotary shaker (200 rpm) and then centrifuged at 6000 rpm for 10 minutes. Each sample was strained and mixed with 2 mL of methanol 50%, and then the above steps were repeated again. The essence derived from the first and second stages were mixed together and centrifuged at 6000 rpm for 15 minutes. Finally, the antioxidant activity and total phenolic content of each tahini essence was measured.

Spectrophotometric analysis was performed by a GBC UV-visible spectrophotometer (Cintra 40, Australia). The extraction process was performed by an ultrasound-assisted extractor (Tecno-Gaz SpA, Italy) at 40 kHz and 0.138 kW for 15 min. Other instruments used in the study included a digital balance (Sartorius TE-153S-DS-MG, Germany) and a Bain-Marie (37±0.5 °C). In this study, the FRAP method was used to measure the total antioxidant activity in each sample. In this method, 2, 4, 6-tripyridyl-triazine (TPTZ, purchased from Sigma-Aldrich) was used as the complexing reagent. A mixture of 5 mL of TPTZ (10 mmol/L) in 40 mmol/L HCL, 50 mL of acetate buffer and 5 mL of FeCl3x6H2O solution were used as the FRAP reagent. The aqueous solution of FeSO4x7H2O was used for calibration. A quantity of 1.5 mL of the FRAP reagent was added to each of tube. After placing the tubes at 37 °C for 5 minutes, 50 µL of the test sample or the calibration curve standard were added to the tubes. After incubation at 37 °C for 10 minutes, absorbance of the samples and control (distilled water) was read at 593 nm using a spectrophotometer. Calibration curve for the FRAP method was plotted based on the absorbance of seven standard concentrations, and the value of the measured concentrations was calculated from the curve. This method was based on a protocol described by
The Folin–Ciocalteu method was used to measure total phenolic content in tahini samples (21, 22). First, 1.5 mL of the Folin–Ciocalteu reagent (Sigma-Aldrich) diluted 1:10 by double-distilled water, was added to each tube. Then, 200 μL of the sample were added and the tubes were maintained at 22 °C for 5 minutes. Next, 1.5 mL of sodium carbonate was added and the tubes were kept at 22 °C for 90 minutes. Absorbance of the sample was read at 725 nm and compared with that of the control. For plotting the standard curve of gallic acid, a stock solution was prepared at a concentration of 100 µg/mL. Then, different concentrations (25, 50, 75, 100, 125, 150, and 200 µg/mL) was prepared from the solution. The absorbance of samples was read based on the calibration curve plotted for the standard solutions. Finally, total phenolic contents were reported as gallic acid equivalents (GAE)(23). Statistical Package for the Social Sciences (SPSS, version 16) was used for data analysis (24). One-way ANOVA was used for comparing mean total antioxidant activity and total phenolic contents between different brands of tahini. Data were expressed as mean ± standard deviation.

RESULTS

The results for measuring the total antioxidant activity of different brands of tahini are presented in table 1.

Table 1- Mean level of total antioxidants in different brands of tahini

| Brand                        | Mean (µmol/mL) | Standard deviation | CV (%) | P-value |
|------------------------------|----------------|--------------------|--------|---------|
| Foladi                       | 20.86          | 0.086              | 16.50  | < 0.001 |
| Oghab                        | 26.64          | 0.102              | 14.98  |         |
| Behjati                      | 28.70          | 0.033              | 4.55   |         |
| Shaboli                      | 20.27          | 0.083              | 16.44  |         |
| Barsam                       | 24.46          | 0.025              | 10.60  |         |
| Ideal                        | 28.61          | 0.027              | 4.07   |         |
| Shayan                       | 26.50          | 0.027              | 4.07   |         |
| Niaaam                       | 21.13          | 0.070              | 11.98  |         |
| Trang                        | 29.33          | 0.017              | 2.33   |         |
| Ghadima                      | 26.29          | 0.069              | 10.60  |         |
| Halvaeyan                    | 16.43          | 0.031              | 7.63   |         |
| Mino-dates                   | 119.93         | 0.159              | 4.87   |         |
| Barsam-coffee                | 45.13          | 0.094              | 7.87   |         |
| Abe hayat                    | 20.81          | 0.069              | 13.24  |         |
| Shir reza                    | 34.71          | 0.042              | 6.24   |         |
| Tohid                        | 16.78          | 0.040              | 2.43   |         |
| Eradat                       | 26.78          | 0.066              | 6.16   |         |
| Barzegar va beheshti         | 24.81          | 0.047              | 7.41   |         |
| Kakh                         | 31.46          | 0.044              | 4.34   |         |
| Mandegar                     | 33.26          | 0.050              | 5.35   |         |
| Mahdi                        | 20.47          | 0.046              | 8.96   |         |
| Trang-chocolate              | 56.30          | 0.056              | 3.75   |         |
| Trang-vanilla                | 16.34          | 0.023              | 8.88   |         |
| Mahpor                       | 17.87          | 0.009              | 2.24   |         |
| Keshavarz                    | 20.16          | 0.005              | 1.14   |         |
| Kila                         | 28.39          | 0.079              | 10.87  |         |
| Shir- Chocolate-barsam       | 24.57          | 0.124              | 19.70  |         |
| Javaher                      | 24.83          | 0.009              | 1.41   |         |
| Mostafa                      | 26.76          | 0.017              | 2.52   |         |
| Chocolate-barsam             | 53.23          | 0.112              | 7.94   |         |
| Shah hamze                   | 24.51          | 0.009              | 1.51   |         |
| Barpaz                       | 19.76          | 0.019              | 3.91   |         |
| Sonati dezfol                | 28.02          | 0.063              | 8.80   |         |
| Sonati shoshtar              | 24.10          | 0.066              | 10.82  |         |
| Sadeghi                      | 34.36          | 0.058              | 6.51   |         |
| Dobhar tafte dezfol          | 26.02          | 0.007              | 1.18   |         |
| Yekbar tafte dezfol          | 27.49          | 0.025              | 3.54   |         |

*P-value shows significant difference between the brands.

The results showed that Mino-dates (119.93 ± 0.159 µmol/mL), Trang-Chocolate (56.30 ± 0.056 µmol/mL), Barsam-coffee (45.13 ± 0.094 µmol/mL) and Chocolate-barsam (53.23 ± 0.112 µmol/mL) had significantly higher total antioxidant activity than other brands (p<0.001). Among these, the antioxidant activity of Mino-dates and Barsam-coffee was significantly higher than that of the other two brands (p<0.001). Also, there was a significant difference between the antioxidant activity of Mino-dates and Barsam-coffee brands (p<0.001). However, the difference between the antioxidant activity...
of Chocolate-barsam and Trang-Chocolate was not significant. The remaining 33 brands were divided into six groups. There was significant differences between these groups in terms of antioxidant activity ($p<0.001$), but there was no significant intra-group difference found within the groups. Table 2 shows the antioxidant activity of these six groups in a descending order from the highest to the lowest.

Table 2- Classification of tahini brands based on the total antioxidant activity

| Antioxidant activity | Brands |
|----------------------|--------|
| 1 (Highest)          | Mino-dates, Trang-chocolate, Barsam-coffee, and Chocolate-barsam |
| 2                    | Shiri reza, Sadeghi, Mandegar |
| 3                    | Kakh, Trang, Behjati, Ideal, Kila, Sonata dezfol, Yekebar tafta dezfol |
| 4                    | Eradat, Mostafa, Oghab, Shayan, Dobar tafta dezfol, Ghadima, Barzegar va beheshht, Shirli-chocolate-barsam, Shah hamze, Barsam, Javaner sonati shoshtar |
| 5                    | Niakaan, Abe hayat, Foladi |
| 6                    | Mahdi, Shaboli, Keshavarz, Barpaz |
| 7 (Lowest)           | Mahpor, Halvaeyan, Tohid, Trang-vanilla |

The results for measuring phenolic compounds of different brands of tahini are presented in table 3. Based on the results, the level of phenolic compounds was significantly higher in Mino-dates (2057.33 ± 0.094 µmol/mL), Barsam-coffee (805.51 ± 0.041 µmol/mL), Chocolate-barsam (807.42 ± 0.095 µmol/mL) and Trang-Chocolate (685.75 ± 0.086 µmol/mL) than in other brands ($P<0.001$). Among these four brands, the phenolic content of Mino-dates and Trang-Chocolate differed significantly with that of the other two brands ($p<0.001$). Also, there was a significant difference between Mino-dates and Trang-Chocolate in total phenolic content ($p<0.001$), but there was no significant difference between the other two brands (Barsam-coffee and Chocolate-barsam). The other 33 brands were divided into six groups. The phenolic content differed significantly between these groups ($p<0.001$). However, there was no significant intra-group difference in the total phenolic content of these six groups (Table 4).

**DISCUSSION**

As mentioned before, there is a strong association between antioxidant activity and total phenolic content of foods. Since tahini may be a good source of phenols, we evaluated the total phenolic content and antioxidant activity of different tahini brands in Iran’s market. Then, the amount of total phenolic compounds is measured by calorimetry. In line with the present study, several studies have shown that sesame seeds are a natural source of antioxidants and phenolic compounds (25-27). Tahini can be introduced as a beneficial ingredient with a high content of polyphenol and antioxidant compounds in the human diet. In order to prepare tahini, sesame seeds are soaked in water to facilitate peeling the brown skin, the obtained white seeds are ground, and the 50% remaining constituents are water and oil (28). Several studies showed that intake of sesame seeds and its by-products have favorable health effects including decreased risk of developing cardiovascular disease (29, 30), hypertension, hyperlipidemia (31) and knee osteoarthritis (11).

Our study demonstrated that some brands of tahini such as Mino-dates, Trang-Chocolate, Barsam-coffee and Chocolate-barsam have more antioxidants and phenolic compounds than other brands. This may be due to the diversity of sesame seeds types that are used in the production of tahini. It has been reported that white sesame seeds have more antioxidants and phenolic compounds compared to black sesame seeds (32, 33). In addition, certain processing procedures such as roasting time and temperature can affect the amount of antioxidants and phenolic compounds in the final product (34, 35).
ACKNOWLEDGEMENTS

This article has been derived from results of a thesis supported by a grant (No: 95-02-33-29746) from the Tehran University of Medical Science, Tehran, Iran.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

CONCLUSION

According to the results of this study, tahini brands with higher polyphenolic contents had higher antioxidant activity. It can be concluded that tahini may be used as a rich source of antioxidant compounds in people's routine diet.

Table 3- Mean phenolic content in different brands of tahini

| Brand            | Mean level (µmol/mL) | Standard deviation | CV (%) | P-value |
|------------------|----------------------|--------------------|--------|---------|
| Foladi           | 340.68               | 0.018              | 4.95   | < 0.001 |
| Oghab            | 372.05               | 0.082              | 19.68  |         |
| Behjati          | 493.75               | 0.049              | 8.70   |         |
| Shaboli          | 385.009              | 0.113              | 26.08  |         |
| Barsam           | 365.59               | 0.077              | 18.78  |         |
| Ideal            | 380.43               | 0.049              | 11.56  |         |
| Shayan           | 389.37               | 0.013              | 2.98   |         |
| Niakaan          | 317.32               | 0.060              | 17.06  |         |
| Trang            | 431.47               | 0.022              | 4.51   |         |
| Ghadima          | 447.41               | 0.037              | 7.29   |         |
| Halvayyan        | 251.49               | 0.025              | 9.22   |         |
| Mino-dates       | 2057.33              | 0.094              | 3.87   |         |
| Barsam-coffee    | 805.51               | 0.041              | 4.39   |         |
| Abe hayat        | 375.78               | 0.029              | 7.04   |         |
| Shiri reza       | 397.53               | 0.027              | 6.06   |         |
| Tohid            | 331.88               | 0.006              | 1.88   |         |
| Eradat           | 367.32               | 0.015              | 3.81   |         |
| Barzegar va beheshti | 415.33           | 0.018              | 3.99   |         |
| Kakh             | 399.89               | 0.016              | 3.75   |         |
| Mandegar         | 394.42               | 0.020              | 4.56   |         |
| Mahdi            | 357.55               | 0.009              | 2.45   |         |
| Trang-chocolate  | 685.75               | 0.086              | 10.95  |         |
| Trang-vanilla    | 286.64               | 0.033              | 10.49  |         |
| Mahpor           | 351.82               | 0.027              | 6.86   |         |
| Keshavarz        | 318.65               | 0.027              | 8.08   |         |
| Kila             | 427.009              | 0.013              | 2.79   |         |
| Shiri- Chocolate-barsam | 510.24        | 0.020              | 3.54   |         |
| Javaher          | 362.97               | 0.014              | 3.54   |         |
| Mostafa          | 423.52               | 0.042              | 8.87   |         |
| Chocolate-barsam | 807.42               | 0.095              | 10.12  |         |
| Shah hamze       | 362.21               | 0.035              | 8.70   |         |
| Barpaz           | 318.45               | 0.034              | 9.65   |         |
| Sonati dezfol    | 350.79               | 0.021              | 5.40   |         |
| Sonati shoshtar  | 375.08               | 0.055              | 13.19  |         |
| Sadeghi          | 442.04               | 0.023              | 4.72   |         |
| Dobar tafte dezfol | 363.99           | 0.002              | 0.77   |         |
| Yekbar tafte dezfol | 366.57           | 0.006              | 1.65   |         |

*P-value shows significant difference between the brands.

Table 4- Subgroups of tahini brands based on the total phenolic content

| Phenolic content | Brands                                                                 |
|------------------|------------------------------------------------------------------------|
| 1 (Highest)      | Mino-dates, Barsam-coffee, Chocolate-barsam, and Trang-chocolate       |
| 2                | Shiri-chocolate-Barsa, Behjati                                          |
| 3                | Ghadima, Sadeghi, Trang, Kila, Mostafa, Barzegar va beheshti           |
| 4                | Kakh, Shiri Reza, Mandegar, Shayan, Shaboli, Ideal, Abe hayat, Sonati shoshtar, Oghab, Eradat, Yekbar tafte dezfol |
| 5                | Barsam, Shah hamze, Javaher, Mahdi, Mahpor, Sonati dezfol, Dobar tafte Dezfol, Foladi, Tohid |
| 6                | Keshavarz, Barpaz, Niakaan, Trang-vanilla                              |
| 7 (Lowest)       | Halvayyan                                                              |

Medical Laboratory Journal, Mar-Apr, 2020; Vol 14: No 2
REFERENCES
1. Firuzi O, Miri R, Tavakkoli M, Saso L. Antioxidant therapy: current status and future prospects. Current medicinal chemistry. 2011; 18(25): 3871-88.
2. Chen Q, Wang Q, Zhu J, Xiao Q, Zhang L. Reactive oxygen species: key regulators in vascular health and diseases. British journal of pharmacology. 2018; 175(8): 1279-92.
3. Sharma GN, Gupta G, Sharma P. A comprehensive review of free radicals, antioxidants, and their relationship with human ailments. Crit Rev Eukaryot Gene Expr. 2018; 28(2): 139-154. doi: 10.1615/CritRevEukaryotGeneExpr.2018022258.
4. Gorrini C, Harris IS, Mak TW. Modulation of oxidative stress as an anticancer strategy. Nat Rev Drug Discov. 2013; 12(12): 931-47. doi: 10.1038/nrd4002.
5. Poprac P, Jomova K, Simunkova M, Kollar V, Rhodes CJ, Valko M. Targeting free radicals in oxidative stress-related human diseases. Trends Pharmacol Sci. 2017; 38(7): 592-607. doi: 10.1016/j.tips.2017.04.005.
6. Godo S, Shimokawa H. Divergent roles of endothelial nitric oxide synthase system in maintaining cardiovascular homeostasis. Free Radic Biol Med. 2017; 109-4-10. doi: 10.1016/j.freeradbiomed.2016.12.019.
7. Dillard CJ, German JB. Phytochemicals: nutraceuticals and human health. Journal of the science of food and agriculture. 2000; 80(12): 1744-56.
8. Caminiti L, Vita D, Passalaquca G, Arrigo T, Barberi S, Lombardo F. et al. Tahini, a little known sesame-containing food, as an unexpected cause of severe allergic reaction. J Investig Allergol Clin Immunol. 2006; 16(5): 308-10.
9. Kotezekidou P. Microbial stability and fate of Salmonella Enteritidis in halva, a low-moisture confection. Journal of food protection. 1998; 61(2): 181-5.
10. Food Composition Databases Show Foods Sead, sesame butter, tahini, type of kernels unspecified, United States Department of Agriculture Agricultural Research Service. Retrieved 22 June2019.
11. Haghhighian MK, Alipoor B, Mahdavi AM, Sadat BE, Jafarabadi MA, Moghaddam A. Effects of sesame seed supplementation on inflammatory factors and oxidative stress biomarkers in patients with knee osteoarthritis. Acta Medica Iranica. 2015; 53(4): 207-13.
12. Majdalawieh AF, Massri M, Nasrallah GK. A comprehensive review on the anticancer properties and mechanisms of action of sesamin, a lignan in sesame seeds (Sesamum indicum). Eur J Pharmocol. 2017; 815: 512-521. doi: 10.1016/j.ejphar.2017.10.020.
13. Hsu E, Parthasarathy S. Anti-inflammatory and Antioxidant Effects of Sesame Oil on Atherosclerosis: A Descriptive Literature Review. Cureus. 2017; 9(7): e1438. doi: 10.7759/cureus.1438.
14. Khosravi-Boroujeni H, Nikbakht E, Natanelov E, Khalesi S. Can sesame consumption improve blood pressure? A systematic review and meta-analysis of controlled trials. J Sci Food Agric. 2017; 97(10): 3087-3094. doi: 10.1002/jsfa.8361.
15. Hsu E, Parthasarathy S. Anti-inflammatory and Antioxidant Effects of Sesame Oil on Atherosclerosis: A Descriptive Literature Review. Cureus. 2017; 9(7): e1438. doi: 10.7759/cureus.1438.
16. Visavidya NP, Narasimhacharya AV. Sesame as a hypocholesteremic and antioxidant dietary component. Food and chemical toxicology, an international journal published for the British Industrial Biological Research Association. 2008; 46(6): 1889-95. DOI: 10.1016/j.fct.2008.01.012.
17. Hussain SA, Hameed A, Ajmal I, Nosheen S, Suleria HAR, Song Y. Effects of sesame seed extract as a natural antioxidant on the oxidative stability of sunflower oil. J Food Sci Technol. 2018; 55(10): 4099-4110. doi: 10.1007/s13197-018-3336-2.
18. Ciulo M, Cádiz-Gurrea M, Segura-Carretero A. Extraction and analysis of phenolic compounds in rice: a review. Molecules. 2018; 23(11). pii: E2890. doi: 10.3390/molecules23112890.
19. Benzie IF, Devaki M. The ferric reducing/antioxidant power (FRAP) assay for non-enzymatic antioxidant capacity: concepts, procedures, limitations and applications. Measurement of antioxidant activity & capacity: recent trends and applications Wiley, New York. 2018: 77-106. DOI: 10.1002/97811191193538.ch5.
20. Esmacielzadeh Kenari R, Mohsenzadeh F, Amiri ZR. Antioxidant activity and total phenolic compounds of Dezful sesame cake extracts obtained by classical and ultrasound-assisted extraction methods. Food Sci Nutr. 2014; 2(4): 426-35. doi: 10.1002/fsn3.118.
21. Jennings AC. The determination of dihydroxylphenolic compounds in extracts of plant tissues. Analytical biochemistry. 1981; 118(2): 396-8.
22. Slinkard K, Singleton VL. Total phenol analysis: automation and comparison with manual methods. American journal of enology and viticulture. 1977; 28(1): 49-55.
23. Antolovich M, Prenzler PD, Patsalides E, McDonald S, Robards K. Methods for testing antioxidant activity. Analyst. 2002; 127(1): 183-98. DOI: 10.1039/B009171P.
24. Nie NH, Bent DH, Hull CH. SPSS: Statistical package for the social sciences. McGraw-Hill New York; 1970.
25. Bouhlali EdT, Alem C, Ennassir J, Mbirn AN, Zegzouti YF. Phytochemical compositions and antioxidant capacity of three date (Phoenix dactylifera L.) seeds varieties grown in the South East Morocco. Journal of the Saudi Society of Agricultural Sciences. 2017; 16(4): 350-7.
26. Elleuch M, Bedijian D, Zitoun A. Sesame (Sesamum indicum L.) Seeds in Food, Nutrition, and Health. Nuts and Seeds in Health and Disease Prevention. San Diego: Academic Press. Chapter 122. 2011; 1029-36.
27. Chang L-W, Yen W-J, Huang SC, Duh P-D. Antioxidant activity of sesame coat. Food chemistry. 2002; 78(3): 347-54.
28. Tokusoglu O, Koçak S, Aycan S. The contents of sesamol and related lignans in sesame, tahina and halva as determined by a newly developed polarographic and stripping voltammetric analysis. Grasas y Aceites. 2009; 60(2): 119-24.
29. Wu JH, Hodgson JM, Puddey IB, Belski R, Burke V, Croft KD. Sesame supplementation does not improve cardiovascular disease risk markers in overweight men and women. Nutr Metab Cardiovasc Dis. 2009; 19(11): 774-80. doi: 10.1016/j.numecd.2009.01.003.
30. Pathak N, Bhaduri A, Rai AK. Sesame: Bioactive Compounds and Health Benefits. Bioactive Molecules in Food. 2019; 181-200.

31. Cardoso CA, Oliveira GMMd, Gouveia LdAV, Moreira ASB, Rosa G. The effect of dietary intake of sesame (Sesamum indicum L.) derivatives related to the lipid profile and blood pressure: A systematic review. Crit Rev Food Sci Nutr. 2018; 58(1): 116-125. doi: 10.1080/10408398.2015.1137858.

32. Rangkadilok N, Pholphana N, Mahidol C, Wongyai W, Saengsooksree K, Nookabkaew S, et al. Variation of sesamin, sesamolin and tocopherols in sesame (Sesamum indicum L.) seeds and oil products in Thailand. Food Chemistry. 2010; 122(3): 724-30.

33. Vishwanath H, Anilakumar K, Harsha S, Khanum F, Bawa A. In vitro antioxidant activity of Sesamum indicum seeds. Asian Journal of Pharmaceutical and Clinical Research. 2012; 5(1): 56-60.

34. Jeong SM, Kim SY, Kim DR, Nam K, Ahn D, Lee SC. Effect of seed roasting conditions on the antioxidant activity of defatted sesame meal extracts. Journal of Food Science. 2004; 69(5): 377-381.

35. Jannat B, Oveisi M, Sadeghi N, Hajimahmoodi M, Behzad M, Choopankari E, et al. Effects of roasting temperature and time on healthy nutraceuticals of antioxidants and total phenolic content in Iranian sesame seeds (Sesamum indicum L.). Iranian Journal of Environmental Health Science & Engineering. 2010; 7(1): 97-102.