

Effects of roasting temperature and time on the physicochemical properties of sesame (*Sesamum indicum* .L) seeds

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ABSTRACT: Sesame seed (*Sesamum indicum* .L) is one of the world's most important and oldest oilseed crops with a high level content of antioxidant known to human health. The antioxidant factors responsible for the stability of roasted sesame seeds is highly affected by the conditions of the roasting process. Survey of the roasting temperature and time effects on antioxidants, phenolic, flavonoids, flavonols, sugar and protein content in sesame seeds was the aim of this investigation. Spectrophotometer methods based on different reagents were used before and after roasting processes. The present study showed that sesame seeds can be considered as a good source of natural antioxidant specially after roasting. The optimum roasting time and temperature to obtain the most antioxidants and total phenolic, flavonoids and other contents was 150°C for 90 min.

KEYWORDS: sesame seeds, antioxidant, phenolic, flavonoids, sugar, protein, roasting.

1 INTRODUCTION

Sesame (*Sesamum indicum* .L) seed has been considered as one of the most important health crops in the world for many years. This crop is renowned as a nutritious food for human health and used as an ingredient in sweets and confectionaries [1]. In particular, sesame seeds are known to exhibit various health beneficial properties, including hypocholesterolaemic, hepatoprotective, and antimutagenic effects [2],[3],[4]. The sesame seeds (*Sesamum indicum*.L) contain approximately 20-25 g/100g protein, 50g/ 100g fat, 14g/100g carbohydrate, and 1-11g/100g fiber [5] it was also revealed that sesame spots, cakes, and seeds exhibited high activities in reducing power and radical scavenging methods as well as protection against oxidative deterioration, sesame seeds provides highly stable oil and nutritious protein and meals, used in swetmeats and confectionery foods, and have varieties of medicinal properties [6]. In the middle East, dehulled sesame seeds are mainly utilized in the production of tehineh (a peanut butter counterpart), which is made from a paste of dehulled roasted sesame seeds and Halaweh, generally, the most commercial products of sesame are made with roasted sesame seeds which increase his antioxidant activity and bioactive molecules.

The antioxidant properties of some bioactive compounds, such as phenolics, flavonoids, have been widely described in animal models or in cell culture, demonstrating animal cell protection against the action of reactive oxygen species and consequently protection against chronic diseases [7]. These bioactive compounds which are distributed throughout all plant parts, are actually the defense system of plants in response to abiotic stress or the action of pathogens to which they are subjected. It has been shown that roasting can increase the total phenolic and antioxidants compounds and activity, and the use of those natural antioxidants in foods as flavonoids, phenolics is recently at special attention because of the world wide

trend to minimize the use of synthetic additives. Phenolic compounds are widely distributed in the plant, they are known as important antioxidants because of their ability to donate hydrogen atom or an electron in order to form stable radical intermediate. They prevent the oxidation of biological molecules [1]. It was reported that the bioactive molecules are extracted well from the oil obtained from a roasted oil seed [8]

Roasting is an important treatment for oily seeds prior to oil extraction. It causes some desirable or undesirable changes in physical, chemical and nutritional properties of the seeds. One of the desired outcomes of the roasting process is the increase in antioxidant activity that occurs due to the formation of Maillard reaction products. The net effect of roasting on the total antioxidant capacity of the seeds depends on the balance between the thermal degradation of naturally occurring antioxidant compounds and the formation of new products having antioxidant activity [9]. In the food industry, roasting is the process much used to improve the food quality, to extend the shelf-life of foods. The process is carried out for promoting more flavor, desired color and texture changes that ultimately increase the overall palatability. The most important conditions of the roasting process are the temperature and time. The effects of roasting conditions on chemical components of different seeds have been reported. It has long been reported that during roasting, the flavonols reduce in concentrations [10]. There are many forms of using roasted sesame; sesame paste (butter) called as tahina, tehneh, tahin are produced by milling of mechanically dehulled roasted sesame. Sesame oil prepared from roasted sesame seeds also has a distinctive flavor and extended shelf-life. Bread, breadsticks, cookies, crackers, chocolate, and ice cream are the other ideal products for roasted sesame seed [11].

Roasting of sesame can be done in a number of ways for sesame products production, it was reported that sesame seeds were roasted at 90°C-100°C for sesame paste production [12]. El Adawi and al., studied the effect of roasting methods on the nutritional properties of sesame paste, they advised roasting at 130 °C for 1 hour [13], Ozcan and Akgul reported that sesame should be roasted at 100-150°C for 2h30-3hours [14]. The control of roasting in sesame by-products production is carried out by experienced operators as many food processing operations. On the other hand, sesame products producers considered that determination of optimum roasting conditions should be established in order to make good quality of sesame products. During the roasting, seeds become more crumbly and brittle, which are typical characteristics of the roasted products. Therefore, the main goal of our work was to propose the roasting conditions optimal for obtaining high polyphenol yields and strong antioxidant activity, and also, in order to make good quality, the optimum roasting conditions should be established with the purpose of investigating the effects of roasting temperature and time on the nutritional and organoleptic quality properties.

2 MATERIALS AND METHODS

2.1 CHEMICALS AND REAGENTS

The solvents and the chemicals used were of analytical grade, ethanol and distilled water were used as solvent for extraction of antioxidant compounds. DPPH, Na₂CO₃, Folin-Ciocalteu, gallic acid, aluminium trichloride, quercetin, phenol, sulphuric acid, Bradford were stored at prescribed conditions in the laboratory.

2.2 SESAME SEEDS ROASTING

Sesame seeds were roasted at the temperature of 150°C for 6 hours. During the roasting process samples were taken at different time intervals (30,60,90,120,150,180,210,240,270,300,330,360 min), and they were immediately equilibrated to room temperature to prevent further heating. Therefore 13 roasting conditions were used in this study, roasted seeds were packed in polyethylene plastic bags and stored for analysis.

2.3 ASSESSMENT OF BIOACTIVE ACTIVITY

2.3.1 PREPARATION OF SEED EXTRACTS

The seeds of each cultivar were ground in the mixer separately. 10g of the powder was weighed and suspended in 100ml of 90% ethanol and kept for shaking for 2 hours. After filtration, the samples were subjected to vacuum evaporation. The extract was redissolved in a 2 ml of 90% ethanol and assayed for its antioxidant activity, phenolic content, flavonoids and flavonols [15].

2.3.2 DPPH RADICAL SCAVENGING ACTIVITY

For determination of the antioxidant activity of sesame extracts, the stable, 1 diphenyl-2-picryl hydrazyl (DPPH) radical was used [16]. An aliquot 0.5ml of DPPH solution was diluted in 4.5 ml of methanol, and 30 μ l of ethanolic solution sesame extract was added. A control without extract was also maintained. The mixture was shaken vigorously and allowed to stand for 45 minutes in the dark and the absorbance was measured at 515nm. The antioxidant activity of the extract was calculated using the formula,

$$\% \text{ scavenging activity} = ((\text{Absorbance sample} - \text{Absorbance control}) / \text{Absorbance control}) \times 100.$$

2.3.3 TOTAL PHENOLIC CONTENT

The amount of total phenolic compounds was measured using the method [17]; 15mg of extract was dissolved in 1ml of 90% ethanol. A 10 μ l aliquot of the resulting solution was added to 2ml of 2% Na₂CO₃ and after 2 minutes 100 μ l of Folin-ciocalteu reagent (diluted with water 1:1) was added. After a further 30 minutes, the absorbance was measured at 750nm. The concentration was calculated using gallic acid as standard, and the results were expressed as mg gallic acid equivalents per mg extract.

2.3.4 TOTAL FLAVONOID CONTENT

The flavonoid content was determined using the method [18]; 1ml of the extract was added to 1ml of aluminium trichlorid ALCL₃ (2%).After 15 min of incubation. The absorbance was measured at 430 nm and the results were expressed an mg quercetin equivalents per mg extract.

2.3.5 TOTAL FLAVONOLS

Total flavonol content was determined by the method of [19]. To 2.0ml of extract solution, 2.0ml of 2% AlCl₃ ethanol and 3.0 ml (50g/l) sodium acetate solutions were added. The absorption at 440 nm was recorded after 2,5h at 20°C. Extract samples were evaluated at a final concentration of 0.1mg/ml. total flavonols content expressed as quercetin equivalent (QE).

2.3.6 SOLUBLE SUGARS

Sugars were extracted with ethanol (80%) by centrifuged for 40 min. After the centrifugation, the supernatant was collected and the sugar content was analysed with phenol/ sulphuric reagent [20].

2.3.7 PROTEINS

Total protein was determined by the method described [21]. Protein was extracted with phosphate buffer. After centrifugation, the supernatant was collected and the protein content was analyzed with the Bradford reagent.

2.3.8 STATISTICAL ANALYSIS

Statistical analyses were conducted using SPSS (Statistical Program for Social sciences) version 17.0 for window. All analyses were performed in triplicate and data reported as means \pm standard deviation (SD).

3 RESULTS AND DISCUSSION

The determination of the total content polyphenols, flavonoids, flavonols and antioxidant activity was performed in ethanol extract due to the high solubility of those compounds in this medium, and since the antioxidant composition of plant food is rather complex, and dietary antioxidants are associated with numerous health benefits, conducting rapid and simple antioxidant capacity assays as the mean of roughly estimating the potential of certain food or plant as the functional food ingredient is attracting lot of interest. In this study, the antioxidant activity of roasted sesame seeds was determined by the ability of the samples to trap DPPH radical. This methodology has been widely used to evaluate the antioxidant activity of extracts and pure substances [22]. The antioxidant activity of sesame seeds extracts was determined before and after roasting at 150°C for 30,60,90,120,150,180,210,240,270,300,330,360 min. the range of this activity values was between 64,25 and 50,1%. Total antioxidant reflects presence of naturally occurring and neo-formed antioxidant constituents in oils

obtained from either roasted or raw sesame seeds. Roasting caused a clear increase in antioxidant activity. This activity gradually increased during roasting reaching to an apparent maximum within 120 min, and there was a decrease in the antioxidant activity of samples after roasting time of 180 min (Fig1).

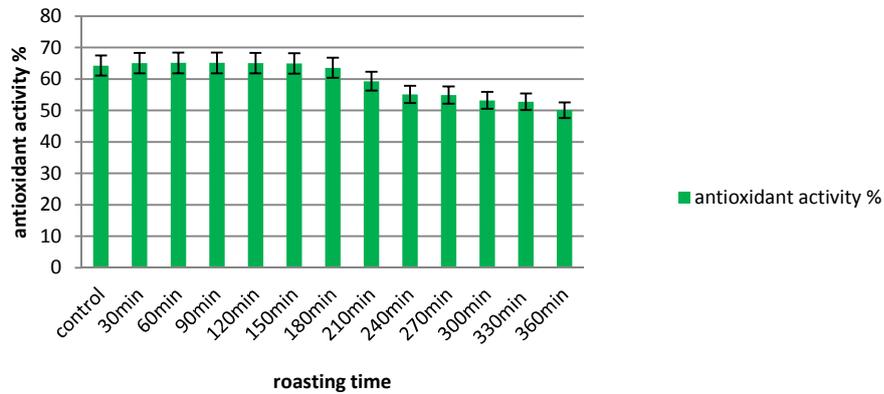


Fig. 1. effects of roasting temperature and time on antioxidant activity

Phenolic compounds, widely distributed in plants foods, have many biological and functional properties that are important in terms of food quality and human health, they are associated with a protector system of fruit and seeds against biotic and abiotic factors(UV, drought and salt stress) which may explain the higher content of bioactive compounds [23].Level of phenolic content and flavonoids were determined.The total phenolic in ethanolic extracts was determined before and after roasting at 150°C for 30,60,90,120,150,180,210,240,270,300,330,360 min. The content of phenolic and flavonoids compounds of sesame seeds increased with increase in roasting time, the highest levels of phenolic compounds and flavonoids were obtained with a roasting temperature of 150°C and a roasting time of 90 min with the values 3,9mg gallic acid/g dry matter and 0,14 mg quercetin/g dry matter, and start to decreased until arrive to 1,22 mg gallic acid/g dry matter and 0,08mg quercetin/g dry matter respectively (Fig 2) and (Fig3). The increased production of phenolic compounds during roasting in this study may be related to the increased generation of Maillard reaction products during roasting [24]. The technique measures the Maillard reaction products that contain phenolic structures in addition to naturally occurring phenolic compounds [25], generally, the thermal treatment applied to foods of plant origin by heating or roasting causes evaporation of intracellular water, triggering chemical reactions that can change the lignocellulosic structure and promotes protein denaturation, which may result in a greater availability of plant phenolic compounds in the matrix. Therefore, a thermal process can affect both the nutritional and bioactive characteristics of foods.

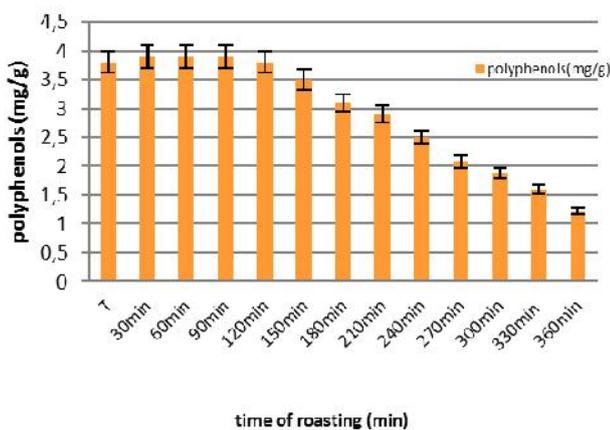


Fig. 2. effects of roasting temperature and time

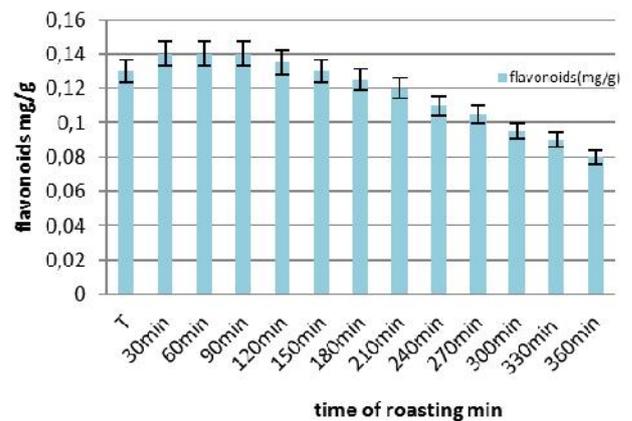


Fig. 3. effects of roasting temperature and time on the on phenolic compounds(mg gallic acid/g dry matter) on flavonoids content(mg quercetin/g dry matter)

Also the flavonols content was determined on the control and on samples roasted at the same temperature for different times. A similar trend was observed for this compounds that increased with the value 0, 43 mg quercetin/g dry matter for the first 90 min at 150 °C compared to unroasted sample with the values 0, 41 mg quercetin/g dry matter (Fig 4). Further roasting caused a fluctuation and decrease. This result was similar in those reported in different study [26], [27], [28]. It was also reported that the flavonols exhibit several biological properties associated with antioxidant activity [29],[30],[31],such as the ability to scavenge superoxide radicals and hydroxyl radicals, reduce lipid peroxyl radicals and inhibit lipid per oxidation.

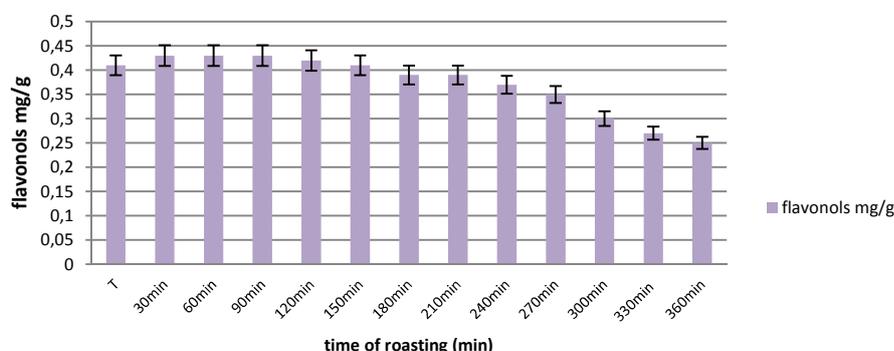


Fig. 4. effects of roasting time and temperature on flavonols content

It has been observed, for all analysed parameters that after prolonged roasting (longer than 90 min at 150°C), the increase of antioxidant activity, phenolic compounds, flavonoids compounds and flavonols is stopped or even decreases.

For the free sugar content, is generally considered as indirect measure of the concentration of the substrate of non-enzymatic browning reactions or of the nutrients remaining after the browning reactions [32], free sugar content was related to roasting temperature and time, the content of free sugar increase for the first 120 min with the value 0,38 g/100g compared with the unroasted sample with the value 0,38g/100g and then decreased with increasing the time (Fig5). The higher content of free sugar was obtained with a roasting time of 120 min and roasting temperature of 150 °C, These results suggest that higher temperature and longer roasting times should not be used in the roasting of sesame seeds, because many nutrients, including carbonyl and amino compounds, are degraded in the non-enzymatic browning reactions during the roasting process [32].

The same observation was about the protein; this content increase in the first 90 min to 29, 1 g/100g (Fig 6) and then decrease, those proteins can be degraded at amino acid level which causes a decline in nutritional quality after a prolonged roasting, it was reported that roasting affects also the ability of polyphenols to interact with protein, causing a decrease in astringency [33]. It was reported also that with further roasting time, the protein can be decomposed or get cross reactions at the level of essential amino-acid, which causes a decrease in nutritional quality of protein, the vitamins also undergo oxidative degradation, forming reactive compounds which react again with protein in the Maillard reaction.

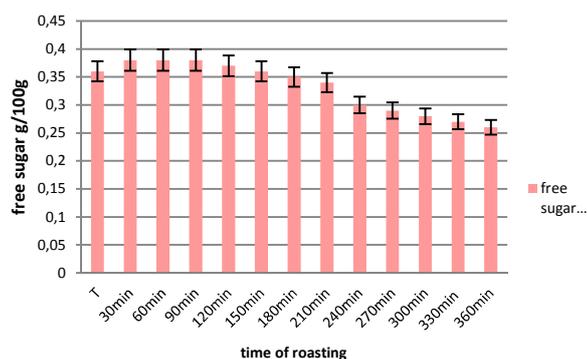


Fig. 5. Effects of roasting temperature and time

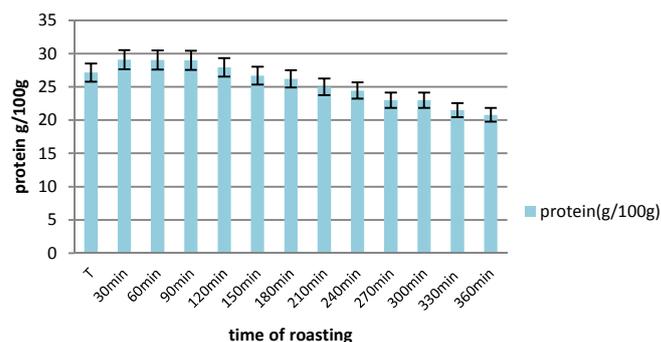


Fig. 6. Effects of roasting temperature and time on the on free sugar compounds on protein content

Many authors have demonstrated a positive correlation between total phenolic, flavonoids and the antioxidant activity of fruits, vegetable and seeds, in this study, the antioxidant activity increase the same time when the phenolic compounds increase which indicate a high correlation between those parameters. The correlation between the phenolic, flavonoids, flavonols and antioxidant activity performed by Pearson's test showed a high and significant positive correlation ($R=0,98$) in all the times and temperature of roasting, suggesting a strong involvement of phenolic compounds in the antioxidant activity measured by the DPPH methodology. In the present study, roasting increased the phenolic compounds for the first 90 min, the reduction of the phenolic content shows after 2 hours. The increase of those parameters specially the antioxidant capacity may also be due to the formation of new compounds with antioxidant properties forming during heating process, such as the melanoidins formed by the Maillard reaction, Turkmen and *al.*, have observed an increase in the antioxidant activity in vegetables [34]. Some studies were undertaken to evaluate the effects of seed roasting conditions on the antioxidant activity in which phenolic content and other bioactive molecule, 3,4 dimethoxy phenol were newly formed in the sesame meal after roasting sesame seeds for 60 min [35].

4 CONCLUSION

The results indicate that antioxidant activity of sesame extracts was significantly affected by roasting temperature and time. To obtain the highest antioxidant activity, total phenolic, flavonoids, flavonols content, sesame seeds should be roasted at 150°C for 90 min, the results also indicate that bioactive molecule are responsible for antioxidant capacity. The roasting affected also the chemical composition; sesame has been considered to be a valuable oil-seed, not only because of its high oil content, but also because of its medical effects, some valuable components in sesame contribute to a nutritional and functional food for humans. Considering all above, our results can be proposed as the procedure choice for obtaining sesame roasted with high antioxidant activity and low content of undesirable newly formed products.

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