*J. Food and Dairy Sci., Mansoura Univ., Vol. 9(3): 103 - 109, 2018*

# Effect of Roasting Temperature on Safflower Seeds and Oil

**Eman Taha[1] and Bertrand Matthäus[2]**

**[1]Food Science and Technology Dept., Faculty of Agriculture, South Valley University, Qena, Egypt**

**[2]Max Rubner-Institut, Department for Safety and Quality of Cereals, Working group for Lipid Research, Detmold, Germany**



## ABSTRACT

This study was aimed to explain the effect of temperature during roasting on safflower seeds and oil composition regarding the changes in oil content, phenolic compounds, oxidative stability, fatty acids,composition and oil color.In general, no change in the of phenolic compounds content of safflower seeds for all varieties by the roasting process was found, whereas there was a significant increase in antioxidant activity of safflower seeds in both DPPH radical scavenging activity and ß-carotene method. Oil content increased by increasing roasting temperature and the optimal temperature (from 120° to 180 °C) varied depending on the variety. The roasting process at 180°C for 15 min. increase the total phenolic compounds of oil by 2.8-fold in the oil compared with that of unroasted samples. The activity of safflower oil increased gradually by roasting and the maximum activity recorded at180 °C.The fatty acids composition of samples changed slightly by the roasting process compared with the control. The major fatty acids was linoleic acid (75.0- 76.4%). The color intensity as a result of Maillard reaction products (MRP) accumulation in the oil revealed the oil from roasted seeds were more dark than that oil from raw seeds. There was a little change in the induction time (from 1.4 to 1.9 h ) of the roasted seeds oil by the Rancimat test at 120°C.

**Keywords:** Antioxidant activity, oil, roasting, safflower seeds

## INTRODUCTION

Vegetable oils are the essential food compounds that are important for human health. The demand for vegetable oils for food application is consider the main goal for production of oil seeds (Camas *et al*.,2007).Safflower is an oilseed estimated as a good source of high quality vegetable oils(Golkar *et al*., 2011$_a$). Safflower (*Carthamus tinctorius* L.)is an oilseed crop that ranks eighth after soybean, groundnut, rapeseed, sunflower, sesame, linseed, and castor as an oilseeds (Damodaram and Hegde, 2002).Edible safflower oil used for cooking, margarine production and for salad (Emongor,2010).

Safflower oil contain valuable content of essential fatty acids (EFAs), such as linoleicacid (C18: 2). In addition to the saturated fatty acid stearich(C18:0), other longer chain fatty acids such asarachidic (C20:0), eicosenoic (C20:1, cis-11), behenic (C22:0) and lignoceric (C24:0) acids also present (Carvalho*etal*., 2006). Lipid oxidation strongly affects shelf life and sensory characteristics of seed oils and depends on many factors such as the concentrations of unsaturated fatty acids, enzymatic activity, mineral composition and the presence of natural antioxidants (Ozdemir and Devres, 2000).

Functional and nutritional properties of oils mainly affected by the changes in the chemical composition in addition to the level of the minor constituents.

Roasting, cleaning and pressing are the conventional techniques used for seasoned oils preparation as perilla ,sesame and rep pepper oils (Kim *et al*., 2002). Roasting is a heat treatment that used for typical color, flavor and taste development. Roasting is an essential treatment for oilseeds before extraction the oil that caused the chemical composition change, modifies the nutritional quality and the shelf life of the resulting oil (Ozdemir and Devres, 2000).In some countries the roasted safflower seeds or the powder prepared was reported as medicinal plants which used to repair the bon break or for bone formation. (Kim *et al*.,1998). Roasting process could alter the overall antioxidant of oils by increase or decrease the movement of the active compounds from seeds to oils (Durmaz and Gökmen,2011).The roasting process effect on antioxidant activity relies on poise of the thermal decomposition of natural antioxidant component and the accumulation of the incoming Maillard reaction products compounds with good antioxidant properties. (Acar *et al*., 2009).A better extractability of phenolic compounds (Wijesundera *et al*., 2008) and tocopherols (Kim *et al*., 2002)has been described when oil was resulted from roasted seeds.

The objective of this study was to examine roasting process effect on some safflower seeds feature such as oil content, phenolic compounds, fatty acids composition, oil color as well as the antioxidant activity of both roasted seeds and oil extracted from seeds.

## MATERIALS AND METHODS

### Materials

Safflower (*Carthamus tinctorius* L.) (Giza1, Kharga1and Kharga2) varieties were kindly provided by the National Centre for Agriculture Research, Cairo, Egypt.

### Methods

**Roasting of safflower seeds.**

Safflower seeds (around 200g) were singly arranged in aluminium pans (30 ×25 cm) and then placed in an electric forced air oven (Germany, Detmold, MRI).The seeds were roasted for 15 min at different temperatures (120,140,160 and 180ºC) the roasting was repeated and each sample obtained was analyzed once. The roasted safflower seeds were cooled at room temperature, milled then stored in refrigerator until using for analysis.(Lee *et al*., 2004).

Oil content.

The oil content was determined in accordance with method A.O.A.C.(1999).

**Fatty acids composition.**

The Fatty acids methyl esters (FAME) of samples were determined by using gas chromatographic assay according to standard methods(Germany, Detmold, MRI) DGF-C-VI 10 in combination with DGF-C-VI 11d(DGF, 2013). Fatty acids of samples were compared with the known rapeseed oil fatty acids on basis of the retention time. The peak areas were calculated by Chemstation , FAME percents were calculated by direct internal normalization. ( Matthäus and Otgonbayar, 2016).

**Total extractable and extractable phenolic compounds content.**

Total extractable and extractable phenolic compounds content were determined according to the

method of (Taga *et al*,1984). Absorbance was measured at 750 nm on a spectrophotometer against the blank. Results were expressed as gallic acid equivalent in dry matter (Gutfinger, 1981).

Safflower oil from unroasted and roasted seeds used for phenolic content determination after phenolics extraction from oil, 60% methanolic solution used for the resulted oil extraction (1:2 w/v) for 10 min with shaking then for 1 min with vortex (twice) The solvent was evaporated and the extract was redissolved in the extraction solvent(Ashrafiand Razmio, 2010).The total phenolic content was assayed using modified Folin–Ciocalteau method as described above.

**Oxidative stability.**

Rancimat measurement was carried out to measure the oxidative stability of oils. The induction time measured using 743 Rancimat (Metrohm, Filderstadt, Germany, Detmold; MRI). The stabilization factor (F) was calculated according to (Moure *et al.*, 2000) F = IPA/IP0, where IP0 is the induction time of control and IPA is the induction time of samples..

**Determination of radical scavenging activity( DPPH).**

Determination of antioxidant activity (DPPH %) was estimated by 2,2 diphenyl-picrylhydrazyl (DPPH) assay ,according to the method of (Brand-William et al., 1995) at MRI, Detmold, Germany. The concentration of an antioxidant which was required to quench 50% of the initial DPPH radicals was expressed as IC50 and was calculated from a calibration curve.

**Determination of antioxidant activity with the ß-carotene bleaching method.**

The decrease of ß-carotene absorbance caused by the co-oxidation by linoleic acid at 55°C was assayed spectrophotometry (UV double beam spectrophotometer, Germany) (Lu and Foo, 2000).Then the antioxidant activity coefficient (AAC) was calculated using by the formula:

**AAC = 1000 x [( AA60-AB60)/(AB0 –AB60)],**

**Where, AB0, AA60, and AB60 are the absorbances at 470 nm of the blank and test samples at 0 and 60 min, respectively (Chevolleau *et al*., 1992)**

**Determination of safflower oil color development.**

The absorbance of 5.0% (w/v) of oil solution in chloroform was measured using spectrophotometer(UV double beam spectrophotometer, Germany) at 420 nm according to(Yoshida *et al*., 1999) for color development measurement.

Statistical analysis.

The obtained data as mean values were analyzed by analysis of variance "ANOVA" at $P \leq 0.05$ followed by Least Significant Difference Test "LSD" using PROC GLM procedure of Statistical Analysis System (SAS®) version 9.2 for Windows, SAS Institute Inc., Cary, NC, USA (SAS®, 2009).

## RESULTS AND DISCUSSION

Total extractable and phenolics content of safflower seeds as affected by roasting temperature.

A significant increase ($p<0.005$) of total extractable compounds content was observed with increasing the roasting temperature at 160°C and 180°C for 15 min compared to the unroasted samples of all safflower seed samples (Table 1). On the other side, at lower roasting temperature the total extractable compounds decreased initially with increasing roasting temperature until 140°C. After roasting at 180°C the highest increase of total extractable compounds was 25% for Giza1 seeds, while for Kharga1 and Kharga 2 it was 5% and 4%, respectively.

According to (Xu and Chang, (2008) treating the plant origin foods by heating or roasting treatment causes the intracellular water evaporation ,in terns change the lignocellulosic structure and denatured the protein which might cause phenolic content in the matrix increase. A different trend was observed for the phenolics content (Table 1). The roasting temperature effect on the phenolics content of safflower seeds had no significantly influence ($p<0.005$) for all varieties. In general, the content of phenolic compounds decreased slightly with increasing roasting temperature even if this tendency was not clear for all varieties and temperatures.

**Table 1.Total extractable and total phenolic compounds of roasted safflower seeds.**

| Total extractable compounds (mg/g sample) | | | | | |
|---|---|---|---|---|---|
| Samples | **Raw seeds** | **Roasted seeds** | | | |
| | | **120°C** | **140°C** | **160°C** | **180°C** |
| Kharga1 | 75.9$^{a}$ | 62.9$^{b}$ | 53.9$^{c}$ | 62.1$^{b}$ | 79.8$^{a}$ |
| Kharga 2 | 71.1$^{ab}$ | 65.8$^{bc}$ | 60.8$^{c}$ | 80.4$^{a}$ | 74.5$^{a}$ |
| Giza1 | 66.5$^{b}$ | 63.5$^{bc}$ | 59.0$^{c}$ | 80.6$^{a}$ | 83.0$^{a}$ |
| Phenolics compounds content (mg gallic acid eq./g dry sample material) | | | | | |
| Samples | Raw seeds | Roasted seeds | | | |
| | | 120°C | 140°C | 160°C | 180°C |
| Kharga1 | 3.56$^{b}$ | 4.17$^{a}$ | 3.15$^{b}$ | 3.92$^{a}$ | 4.58$^{a}$ |
| Kharga 2 | 4.81$^{a}$ | 4.58$^{a}$ | 3.00$^{c}$ | 4.87$^{a}$ | 3.70$^{b}$ |
| Giza1 | 4.89$^{a}$ | 4.75$^{a}$ | 3.80$^{b}$ | 4.82$^{a}$ | 4.51$^{a}$ |

**Mean values of total extractable and phenolics content within a row that have different letters are significantly differentat P<0.05 .**

The results suggest that the phenolic compounds present in safflower seeds are thermo-labile. Chan *et al*.(2009) revealed that thermal treatments such as microwave-, sun- and oven-drying resulted decrease the total phenolic compounds of tea leaves and ginger. Also Xu*et al*. (2007)illustrated that the heat treatment of huyou peel caused a reduction in the total phenolic acids which indicate that the heat treatment causes phenolic acids destroying or converted from soluble phenolics to insoluble phenolic compounds. On the other hand, the increase of polyphenols amount in sweet corn was previously explained by Dewanto *et al*. (2002) they suggested that the thermal processing releases bound phenolic acids within cell walls

**Antioxidant activity of safflower seeds as affected by the roasting temperature.**

The antioxidant activity of methanolic extracts obtained from roasted safflower seeds was assayed using DPPH radical scavenging activity and to prevent the bleaching of ß-carotene by oxidized linoleic acid. Total antioxidant activity shows the occurrence of neo-formed and natural antioxidant constitutes in both raw and roasted safflower seeds. The DPPH radical activity of methanolic extracts of unroasted and roasted safflower seeds was given by EC 50, which is the amount of sample necessary to decrease the initial DPPH concentration of a given solution by 50%.

The antioxidant activity of methanolic safflower seeds extracts was determined before and after roasting at 120, 140, 160, and 180 °C for 15 min (Table 2). Roasting significant caused a clear increase in the antioxidant activity in both DPPH radical scavenging activity and ß-carotene bleaching method. Reducing characteristics of antioxidants are mainly associated with reductones occurring (Lingnertand Eriksson, 1981). The highest roasting temperature (180°C) for15 min. caused an increase of the antioxidant activity of methanolic seed extracts of Kharga1, Kharga2 and Giza1by 39.5, 31.4, and 13.7%, respectively compared to unroasted seeds. Irregular increasing in the antioxidant activity by DPPH assay of the roasted seed extracts at 120-180 °C was noted. This is may be due to the chemical alteration of phenolic component at higher temperatures that changed the activity of those compounds during roasting progress. The balance between the formation of new maillard reaction products having antioxidant capacity and the thermal degradation of naturally occurring antioxidant compounds during roasting process of oilseeds is the main factor which influences the total antioxidant capacity of oilseeds Acar *et al* ( 2009).

Concerning the ß-carotene bleaching method the antioxidant activity of the methanolic safflower seed extracts increased significantly as roasting temperature reaching an apparent maximum at 180°C. The antioxidant activity of the methanolic extracts from roasted Kharga1, Kharga2 and Giza1 at 180°C was 3.0, 2.6 and 2.4- fold, respectively higher than that of unroasted safflower seeds. The increase of the antioxidant activity as affected by roasting temperature of safflower seeds may be as a result of formation of new compounds with antioxidant properties during the heating, such as the melanoidins during Millard reactions. Jannat *et al* .(2010)concluded that the antioxidant activity of sesame extracts was significantly affected by roasting temperature and time. Our results indicated that the roasting process was effective in liberating antioxidant compounds from safflower seeds with increasing roasting temperature. Thus roasting process of seeds between 120 - 180 °C is effective procedure in increasing the antioxidant activity.

**Table 2. Effect of roasting on antioxidant activity of safflower seeds.**

| **50% DPPH radical scavenging activity EC 50 mg** | | | | | | |
|---|---|---|---|---|---|---|
| **Samples** | **Raw seeds** | **Oil from roasted seeds** | | | | **increase** |
| | | **120°C** | **140°C** | **160°C** | **180°C** | **[%]** |
| Kharga1 | 0.91[a] | 0.78[ab] | 0.39[d] | 0.68[bc] | 0.55[c] | 39.5 |
| Kharga2 | 0.86[b] | 0.73[c] | 0.73[c] | 0.99[a] | 0.59[d] | 31.4 |
| Giza1 | 0.8[b] | 0.66[b] | 0.71[b] | 1.17[a] | 0.69[b] | 13.7 |
| Antioxidant activity by ß-Carotene bleaching method(AAC) | | | | | | |
| Samples | Raw seeds | Oil from roasted seeds | | | | Increase |
| | | 120°C | 140°C | 160°C | 180°C | |
| Kharga1 | 212.8[c] | 516.9[b] | 545.5[b] | 638.1[a] | 646.6[a] | 3.0 fold |
| Kharga2 | 208.0[c] | 435.8[b] | 492.5[ab] | 496.3[ab] | 536.2[a] | 2.5 fold |
| Giza1 | 273.1[c] | 592.4[b] | 629.3[ab] | 619.4[ab] | 650.3[a] | 2.4 fold |

***Increase calculated for maximum roasting temperature in comparison to the control without roasting.**
**Mean values of ß-carotene bleaching methodwithin a row that have different letters are significantly different at P < 0.05**

**Effect of roasting temperature on oil content of safflower seeds.**

The extractable oil content of unroasted and roasted safflower seeds at different temperatures are presented in Table (3). The oil content of unroasted safflower seeds varied between 30.5 -31.5%, depending on the variety. Yeilaghi *et al* .(2012) showed that significant effects of genotype on oil content of seeds and fatty acids profile of 64 safflower genotypes. Golkar *et al*. (2011b) indicated that the importance role of gentic variance in controlling of safflower oil content, fatty acids and protein contents.

The observed oil contents were close to those reported by Ashrafi and Razmjo (2010).The oil content increased significantly ($p<0.005$) after roasting treatment at 120° to 180 °C compared with the unroasted seeds. But there is not a strong significance between the roasted seeds at different temperatures. It was obviously that the different varieties of safflower seeds showed a different response on the temperatures. The different temperatures of roasting showed that the highest oil content were 140°C for Kharga1,160°C for Giza1 and 180°C for kharga 2. Kharga1seeds had the highest oil content 33.7% after roasting at 140°C, while it was 34.2 and 32.8 % at 180 C and 160 C for Giza1 and Kharga 2, respectively. The increase of the extractable of oil content of the roasted safflower seeds at different temperatures seems to be the result of changes in seeds matrix by protein denaturation, led to the oil passes easily from seeds during the extraction process. The results also indicate that the studied varieties of seeds had different ability in its response to the different roasting temperatures. The results are agree with that showed by Mariod *et al*.(2012) who found that the oil content of safflower seeds increased as a results of the roasting process.

**Table 3. Effect of roasting process on oil content of safflower seeds varieties.**

| Samples | Oil content % | | | | |
|---|---|---|---|---|---|
| | Raw seeds | Oil from roasted seeds | | | |
| | | 120°C | 140°C | 160°C | 180°C |
| Kharga1 | 30.5$^{c}$ | 31.3$^{bc}$ | 33.7$^{a}$ | 31.1$^{bc}$ | 32.8$^{ab}$ |
| Kharga2 | 30.8$^{c}$ | 31.3$^{bc}$ | 32.4$^{ab}$ | 32.8$^{a}$ | 31.9$^{ab}$ |
| Giza1 | 31.5$^{c}$ | 32.7$^{bc}$ | 33.7$^{a}$ | 33.1$^{ab}$ | 34.2$^{a}$ |

**Mean values within a raw that have different letter are significantly different at P < 0.05.**

**Effect of the roasting temperature on phenolics compounds content and antioxidant activity(DPPH) of safflower oil.**

Phenolic compounds are natural antioxidants that can be occur in considerable amounts in natural oils and correlate well with oil stability and flavor Tovar *et al* ( 2011). The contents of these compounds show differences in different oils according to the cultivar Ben Moumen *et al*. (2013).

The results summarized in Table (4) show that roasting at 140-180 °C caused a significant increase in phenolics compounds content of oil. While it was not observed at 120°C.Phenolic compounds pass into the oil phase by roasting process of oilseeds, this is might be due to the phenolic compounds liberation from the bounded form or due to the chemical change of the phenolics compounds during heat treatment (Veldsink *et al*.,1999 and Wijesundera *et al*., 2008). The results show that the increase of total phenolic compounds in oil as affected by the roasting process was higher than those mentioned above for seeds. This increase might be related to the new formed or liberated compounds by the roasting process that could be more lipophilic and passed into oil. Also the darker color of oil which noted in this work at higher roasting temperatures could explain this great formation and passing of the new products with high antioxidant activity into the oil. A similar trend was observed for the antioxidant activity of safflower oil extracted from roasted safflower seeds measured by the DPPH assay. The antioxidant activity of safflower oil increased with increasing roasting temperature reaching an apparent maximum at 180°C.

At this temperature the lowest amount of sample is necessary to reduce the amount of DPPH in a given solution for 50% indicating the highest antioxidant activity.These results are in agreement with that previously reported by Lee *et al*. (2004) they showed that the great oxidative stability of oil from roasted safflower seeds was a result of enzymatic reaction compounds that formed by heating process, browning substances are very polar due to active radicals (Anjum*et al*., 2006).A strong antioxidant activity for maillard reaction products has been previously reported by (Lee,1992;Jung*etal.*,1999).The antioxidant activity increase of oils methanolic extracts from the treated seeds with increasing roasting temperature was reported earlier (Durmaz*et al*., 2010). This increase almost occurs due to the formed polar compounds in oil during roasting Therefore; an increase in browning compounds might be related to the increase in other lipids in oil, such as glyceroglycolipids. On the other hand millared reactions product occurred during the roasting process could have participated to this activity increase. (Durmaz*et al*., 2010).The improvement in oxidative stability of roasted oils could have been caused by antioxidative millard reactions products or inactivation of oil degrading enzymes Nederal *et al*. (2012).

**Table 4. Effect of roasting temperatures on total phenolic compounds and antioxidant activity of safflower oil.**

| Samples | Total phenolic compounds (mg/100g safflower oil) | | | | | Increase at 180°C % |
|---|---|---|---|---|---|---|
| | Raw oil | Oil from roasted seeds | | | | |
| | | 120°C | 140°C | 160°C | 180°C | |
| Kharga1 | 19.9$^{c}$ | 20.2$^{c}$ | 21.2$^{c}$ | 35.2$^{b}$ | 43.1$^{a}$ | 216.6 |
| Kharga 2 | 22.8$^{c}$ | 28.1$^{c}$ | 38.3$^{b}$ | 46.9$^{b}$ | 71.1$^{a}$ | 311.8 |
| Giza1 | 22.0$^{b}$ | 23.1$^{b}$ | 22.8$^{b}$ | 24.1$^{b}$ | 43.3$^{a}$ | 196.8 |
| EC50-value of safflower oil measured by the DPPH assay | | | | | | |
| Sample | Raw oil | Oil from roasted seeds | | | | Increase at 180°C % |
| | | 120°C | 140°C | 160°C | 180°C | |
| Kharga1 | 298.2$^{a}$ | 293.8$^{b}$ | 277.1$^{c}$ | 267.1$^{d}$ | 230.9$^{e}$ | 22.5 |
| Kharga 2 | 414.5$^{a}$ | 402.7$^{b}$ | 378.8$^{c}$ | 364.5$^{d}$ | 322.9$^{e}$ | 22.0 |
| Giza1 | 284.9$^{a}$ | 283.8$^{b}$ | 264.8$^{c}$ | 257.5$^{d}$ | 220.9$^{e}$ | 22.8 |

***Increase calculated for maximum roasting temperature in comparison to the control without roasting.**
**Mean values of total phenolic compounds within a raw that have different letter are significantly different at P < 0.05**

**Effect of roasting temperatures on oxidative stability of safflower oil.**

During processing and storage edible oils are oxidized by autoxidation reactions. The oxidative stability is an indication of stability of oil against oxidation and one method for the evaluation of the oxidative stability is the Rancimat test. The results of the oxidative stability of roasted and unroasted safflower seeds oils are presented in Table 5

The results showed that the oxidative stability of oil from unroasted seeds was between 1.4 and 1.6 h. These results are in a accordance with Mihaela *et al*.(2013)where the rancimat measurement of the high linoleic safflower oil showed low induction time ranged between 2 and 4 h. For oils from roasted safflower seeds a small increase was noted in the induction time from 120° to 160°C compared with that of unroasted seeds. The most pronounced effect for all varieties of seeds was found at 160°C, while the induction

period decreased at 180°C for oil from roasted seeds of Kharga1 and Kharga2. For Giza1 no change was found between oil obtained from seeds roasted at 160 and 180°C, respectively. The small differences between the oxidative stability of roasted and unroasted safflower seeds oils could be related to the effect of the new formed compounds during roasting process.

Oxidative stability of the oils is positively correlated with oleic acid content and negatively correlated with linoleic and linolenic acid contents Nederal *et al*.( 2012).This study reported that safflower oil with high linoleic acid has low oxidative stability and accordingly is not suited for deep frying applications.

**Table 5.Rancimat measurements for safflower oil from unroasted and roasted safflower seeds.**

| Sample | Induction time (h) | | | | |
|---|---|---|---|---|---|
| | Raw Oil | Oil from roasted seeds | | | |
| | | 120°C | 140°C | 160°C | 180°C |
| Kharga1 | 1.4 | 1.4 | 1.8 | 1.9 | 1.3 |
| Kharga2 | 1.5 | 1.4 | 1.9 | 1.9 | 1.7 |
| Giza1 | 1.6 | 1.5 | 1.5 | 1.9 | 1.9 |

**Effect of roasting temperatures on the fatty acids composition (FA).**

The fatty acid profile of the oil reflects the nutritional value of the edible oils. The fatty acids composition of oil can be an indicator of its stability, physical properties, and nutritional value. The principal fatty acids components of the safflower oil varieties (unroasted) consisted of palmitic (C16:0)(6.2-7.5%),stearic(C18:0)(2.2-2.8%), oleic (C18;1)(10.6-13.4%),linoleic (C18:2) (75.1-76.4%),and arachidic(C20:0)(0.4%), Table (6). The fatty acids profile of safflower oils is closed to those reported by Bozan and Temelli, (2007);Yeilaghi *et al*.( 2012).The composition was generally characterized by relatively higher percentages of polyunsaturated linoleic acid and relatively low content of saturated fatty acids as palmitic and stearic acids. The results of the fatty acids content showed no trans fatty acids formation using oven roasting at temperatures up to 180°C. The results are in accordance with Ben Moumen *et al*. (2013) they demonstrated that the proportion of saturated fatty acids (SFA) slightly varies between 9.7 and 10.8% while they found amounts between89.2 and 90.2%for the unsaturated fatty acids (UFA).

Roasting of the seeds in an oven for 15 min at 120, 140, 160 ,and 180°C resulted only in little changes in the fatty acids composition of the oils. The results showed that Kharga2 was more affected by the roasting process than Kharga1 and Giza1.For Kharga 2 oleic and linoleic acids were more affected by roasting than other fatty acids. (Durmaz and Gökmen, 2011) early reported that a slight change in the fatty acid composition of *P. terebinthus* oil after roasting of the seeds has been occurred. Kim *et al*.( 2002)found no change in the fatty acid profile of rice germ and sesame seed oils get from roasted seeds at different temperatures and times.

**Table 6. Effect of roasting temperatures of safflower seeds on the fatty acid composition of oil.**

| Fattyacid | Carbon chain | Kharga1 | | | | | Kharga2 | | | | | Giza1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FAME concentration mg/mg sample | | | | | | | | | | | | | | |
| | | Raw | R.O 120°C | R.O 140°C | R.O 160°C | R.O 180°C | Raw | R.O 120°C | R.O 140°C | R.O 160°C | R.O 180°C | raw | R.O 120°C | R.O 140°C | R.O 160°C | R.O 180°C |
| 'palmitic' | 16:0 | 7.46a | 7.03 c | 7.44ab | 7.20 bc | 7.35 ab | 6.210a | 6.28a | 6.22 a | 6.31a | 6.21a | 6. 72 | 6.45a | 6.56 b | 6.67 ab | 6.52 ab |
| Stearic | 18:0 | 2.16a | 2.69a | 2.48a | 2.33a | 2.38a | 2.52abc | 2.81a | 2.74 ab | 2.45bc | 2.38 c | 2.84 a | 2.83a | 2.91a | 2.72a | 2.86a |
| Oleic | 18:1 D9 | 13.35b | 13.27 b | 13.90a | 12.43c | 12.47c | 10.90bc | 11.29b | 10.61c | 11.07b | 12.53 a | 11.99ab | 11.82b | 11.80b | 12.53a | 11.14 c |
| Vaccenicacid | 18:1 D11 | 0.736b | 0.878 a | 0.871 ab | 0.876a | 0.776ab | 0.623a | 0.725a | 0.588 a | 0.613 a | 0.603 a | 0.648 b | 0.685b | 0.870a | 0.730 ab | 0.775 ab |
| Linoleic | 18:2 | 75.06 a | 73.8c | 74.95 a | 74.95 a | 74.57 b | 75.32a | 72.64c | 73.56 b | 73.76b | 72.49 c | 76.42a | 75.99b | 75.99b | 75.35 c | 76.66 a |
| Arachidic | 20:0 | 0.367d | 0.885 a | 0.586 c | 0.789 ab | 0.731 b | 0.355b | 0.6165 a | 0.621a | 0.386b | 0.411b | 0.382d | 0.805bc | 0.779c | 0.859ab | 0.865a |

**Mean values of fatty acids within a raw that have different letter are significantly different at P < 0.05.**
***R.O = Safflower oil from roasted seeds. FAME: fatty acids methyl ester.**

Anjum *et al*.(2006) reported that after microwave roasting of two different sunflower seeds varieties for15 min oleic acid was increased to 43.8and 46.0%, whereas linoleic acid were decreased to 43.6 and 40.7%. The longer roasting time resulted the higher oleic acid percent and lesser linoleic acid percent. The decrease in linoleic acid content might be due to the deactivation of the omega-6fatty acid desaturase(FAD2-1) enzyme during roasting process. Hassanien *et al* . (2003) also showed that the microwave heating had highly decrease unsaturated fatty acids(UFA) and polyunsaturated fatty acids (PUFA) of oils than conventional heating methods, at the same time no change of saturated fatty acids contents.

**Effect of roasting temperature on oil color development.**

Roasted seeds normally produce dark color oils comparing to raw seeds(Durmaz and Gökmen, 2011). The color development of safflower oil extracted from roasted safflower seeds presented in Table (7). An increase of ultra violet UV absorbance 420 nm by increasing the roasting temperatures revealed browning substances formation. A gradually change of oil color of roasted safflower seeds from light –yellow before roasting (absorbance: 0.0574, 0.0366 and 0.055 for Kharga 1, Kharga 2, and Giza 1,respectively to brown (absorbance from 0.0571 to 0.0788 ) at 120, 140 , and 160°C then to deep-brown (absorbance: 0.1098, 0.1069 and 0.1126 at 180°C for the same seed varieties, respectively).The formation of browning substances in most thermally processed foods as a result of caramelization, Maillard-type nonenzymatic reactions, and phospholipid degradation. Megahad (2001)showed that the color index of stripped and non-stripped linseed oil recorded higher values for non-stripped oil compared to the striped one probably due to interaction of tocopherol components with unsaturated fatty acids to give toco-red compounds similar to

that reported in soybean oil. Also, Kim *et al*.(2002)reported an increase of the color index in oil from roasted seeds and they showed that the dark color of oil was found to be most probably due to the passage of the maillard reaction products (MRPs) formed during roasting. Durmaz and Gökmen (2011)measured hydroxyl methyl furfural (HMF) level and color intensity of *Pistacia terebinthus* oil as an indicator for (MRPs) formation in oil as affected by the roasting process and found an increase with increasing roasting time.

**Table 7. Effect of roasting temperatures on color development of safflower oil.**

| Sample | Absorbance(420nm) | | | | |
|---|---|---|---|---|---|
| | Raw Oil | Oil from roasted seeds | | | |
| | | (120°C) | (140°C) | (160°C) | (180°C) |
| Kharga1 | 0.0574 | 0.066 | 0.0655 | 0.0706 | 0.1098 |
| Kharga2 | 0.0366 | 0.0571 | 0.0678 | 0.0788 | 0.1069 |
| Giza1 | 0.055 | 0.0639 | 0.0686 | 0.0773 | 0.1126 |

## CONCLUSION

Safflower seeds are a good source of oil rich in unsaturated fatty acids mainly linoleic acid in addition to phenolic compounds that have an antioxidant activity. The phenolic compounds content and antioxidant activity of safflower seeds and oil were obviously affected by the roasting process.The exposure to higher temperatures has a great effect on oil color, total phenolic compounds of the oil, and the antioxidant activity of seeds oil. However, roasting had only little effect on the fatty acids content, the induction time and subsequently the stability of the oil. Roasting of safflower seeds was better for the quality of both the oil and the seeds.

## REFERENCES


Acar, O.C., Gokmen, V., Pellegrini, N. and Fogliano, V.(2009). Direct evaluation of the total antioxidant capacity of raw and roasted pulses, nuts and seeds. Eur. Food Res. Technol*229*,961–969.

AOAC International (1999) Official methods of analysis,16th Edn,5th Rev.

Anjum, F,, Anwar, F,, Jamil, A, and Iqbal, M. (2006).Microwave roasting effects on the physico-chemical composition and oxidative stability of sunflower seed oil. J. Amer. Oil Chem. Soc.*83*, 777–784.

Ashrafi, E. and Razmio, K. (2010).Effect of irrigation regimes on oil content and composition of safflower *(Carthamus tinctorius* L.)cultivars. J. Amer. Oil Chem. Soc *87*, 499–506.

Ben Moumen, A.,Mansouria, F., Zraibia, L., Nabloussid, M.A.A., Fauconnierc, M.L., Sindicb, M.,Elamrania, A. and Caida, H.S. (2013).Comparative study of four safflower oils (*Carthamus tinctorius* L) varieties grown in eastern of Morocco. InsideFood Symposium.9-12 April 2013, Leuven, Belgium.

Bozan, B.and Temelli, F. (2007).Chemical composition and oxidative stability of flax, safflower and poppy seed and seed oils.Biores.Technol*99*, 6354–6359.

Brand-Williams,W-Cuvelier,M and Berset,C.(1995).Use of free radical method to evaluate antioxidants activity.Lebensm,Wiss,Tech.,28:25-30.

Çamaş,N., Çırak, C. and Esendal, E. (2007). Seed yield, oil content and fatty acids composition of safflower(*Carthamus tinctorius* L.)grown in northern Turkey conditions.J. Fac. Agric., Omu, *22(1),*98-104.

Chan, E.W.C., Lim, Y.Y., Wong, S.K., Lim, K.K. and Tan, S.P.(2009).Lianto, F.S., Yong, M.Y., Effect of different drying methods on the antioxidant properties of leaves and tea of ginger species. Food Chem.*113*, 166–172.

Chevolleau,S.,Mallet, J.F., Ucciani, E., Gamisans, J. and Gruber, M.(1992). Antioxidant activity in leaves of some Mediterranean plants. J Amer. Oil Chem. Soc. *69*, 1269-1271.

Carvalho, I.S., Miranda, I. and Pereira, H. (2006). Evaluation of oil composition of some crops suitable for human nutrition. Ind. Crops Prod*24*, 75–78.

Damodaram, T. and Hegde, D.M.(2002). Oilseeds Situation: A Statistical Compendium 2002. Directorate of Oilseeds Research, Rajendranagar, Hyderabad 500030, India, p. 471.

Dewanto, V., Wu,X.and Liu, R.H. (2002). Processed sweet corn has higher antioxidant activity. J. Agric. Food Chem.*50*, 4959-4964.

DGF Deutsche Einheitsmethoden zur Untersuchung von Fetten, Fettprodukten, Tensiden und verwandten Stoffen, Wissenschaftliche Verlagsgesellschaft, Stuttgart, 2013.

Durmaz, G. and Gökmen,V. (2011).Changes in oxidative stability, antioxidant capacity and phytochemical composition of Pistacia terebinthus L. oil with roasting. Food Chem. *128*, 410–414.

Durmaz, G., Karabulut, I., Topcu, A., Asilturk, M. and Kutlu, T. (2010).Roasting-related changes in oxidative stability and antioxidant capacity of apricot kernel oil. J. Amer. Oil Chem. Soc.*87*, 401–409.

Emongor, V. (2010). Safflower(*Carthamus tinctorius* L.) the underutilized and neglected crop: A review. Asian Journal of Plant Sciences *9*, 299–306.

Golkar,P.,Arzani,A. and Rezaei,A.M.(2011a). Genetic variation in safflower (*Carthamus tinctorious* L.) for seed quality-related traits and inter-simple sequence repeat (ISSR) markers. Int J Mol Sci. *12* (4), 2664-2677

Golkar,P.,Arzani,A. and Rezaei,A.M. (2011b).Genetic analysis of oil content and fatty acid composition in safflower (*Carthamus tinctorius* L.).J Am Oil Chem Soc. *88*, 975–982.

Gutfinger, T. (1981).Polyphenols in olive oils. J. Amer. Oil Chem. Soc.*58*, 966–968.

Hassanein, M.M., El-Shami, S.M. and Al-Mallah, M.H. (2003). Changes occurring in vegetable oils composition due to microwave heating. Grasas Aceites.*54*, 343–349.

Hatano, T., Kagawa, H., Yasuhara, T. and Okauda, T. (1988). Two new flavonoids and other constituents in licorice root: Their relative astringency and radical scavenging effects. Chem. Pharm. Bull.36, 1090–2097.

Jannat, B., Oveisi, M.R., Sadeghi, N., Hajimahmoodi, M.,Behzad, M. ,ChoopankariE.and Behfar,A.A. (2010).Effect of roasting temperature and time on healthy nutraceuticals of antioxidants and total phenolic content in Iranian sesame seeds (*Sesamum indicum.*L). Iran. J. Environ. Health. Sci. Eng.*7*, 97-102.

Jung, M.Y., Bock, J.Y.,Baik, S.O., Lee, J.H. and Lee, T.K. (1999). Effects of roasting on pyrazine contents and oxidative stability of red pepper seed oil prior to its extraction. J. Agric. Food Chem.*47*, 1700–1704.

Kim, J.H., Jeon, S.M., An, M.Y., Ku, S.K. and Lee, J.H.(1998). Choi, M. S., Moon, K.D., Effects of diet of Korean safflower (*Carthamus tinctorious* L.) seed powder on bone tissue in rats during the recovery of rib fracture. J. Kor. Soc. Food Sci. Nutr*27*, 698–704.

Kim, I.H., Kim, C.J., You, J.M., Lee, K.W., Kim, C.T., Chung, S.H. and Tae, B.S. (2002). Effect of roasting temperature and time on the chemical composition of rice germ oil. J. Amer. Oil Chem. Soc. *79,* 413–418.

Lee, H.S. (1992). Antioxidative activity of browning reaction products isolated from storage-aged orange juice. J. Agric Food Chem.*40*, 550–552.

Lee, Y., Oh, S., Chang, J. and Kim, I. (2004). Chemical composition and oxidative stability of safflower oil prepared from safflower seed roasted with different temperatures. Food Chem. *84*, 1–6.

Lingnert, H, and Eriksson, C.E.(1981). Antioxidative effect of maillard reaction products. Prog. Food Nutr. Sci. *5*, 453–466.

Lu, Y.and Foo, L.Y. (2000). Antioxidant and radical scavenging activities of polyphenols from apple pomace. Food Chem. *68*, 81–85.

Mariod, A.A., Ahmed, S.Y.,Abdelwahab, S.I., Chen, S.F., Eltom, A.M., Yagoub, S.O. and Gouk, S.W.(2012). Effects of roasting and boiling on the chemical composition, amino acids and oil stability of safflower seeds. Int. J. Food Sci. Technol.*47*, 1737–1743

Matthäus, B. and Otgonbayar,C. (2016). Chemotaxonomic screening of seed oils from the family Saxifragaceae and comparison with data on seed oils from grossulariaceae obtained from literature. Chemistry &Biodiversity.*13(11)*, 1511-1520.

Megahad, M.G. (2001).Microwave roasting of peanuts: Effects on oil characteristics and composition,Nahrung *45*, 255–257.

Mihaela, P., Rathbauer, J., Negrea, M. and Zeller, R. (2013). Perspectives of safflower oil as biodiesel source for South Eastern Europe (comparative study: Safflower, soybean and rapeseed). Fuel *111*, 114–119.

Moure, A., Franco, D., Sineiro, J. and Dominguez, H.(2000). Evaluation of extracts from Gevuina hulls as antioxidants. J. Agric. Food Chem. *48*, 3890–3897.

Nederal, S., Skevin, D.,Kraljic, K., Obranovic, M. and Papesa, S. (2012).Chemical composition and oxidative stability of roasted and cold pressed pumpkin seed oils. J. Amer. Oil Chem. Soc.*89*, 1763–1770.

Ozdemir, M. and Devres, O. (2000). Analysis of colour development during roasting of hazelnuts using response surface methodology. J. Food Eng. *45*, 17–24.

SAS®I I.2009.SAS Online Doc. Version 9.2 Copyright (2009).SAS Institute Inc, Cary, NC, USA.

Taga, M.S., Miller, D.E. and Pratt, D.E. (1984). Chia seeds as a source of natural lipid antioxidants. J. Amer. Oil Chem. Soc., *61*, 928-931.

Tovar, M.J., Romero, M.P. and Motilva, M.J.2001.Changes in the phenolic composition of olive oil from young trees(*OleaeuropaeaL*.cv,Arbequina)grown under linear irrigation strategies.J.Agric. Food Chem *49*,5502-5508

Veldsink, J.W., Muuse, B.G., Meijer, M.M.T., Cuperus,F.P., van de Sande,R.L.K.M.and van Putte, K.P.A.M. (1999). Heat pretreatment of oil seeds: Effect on oil quality. Fett/Lipid*101*, 244–248.

Wijesundera, C., Ceccato, C., Fagan, P.and Shen, Z. (2008). Seed roasting improves the oxidative stability of canola (*B. napus*) and mustard (*B. juncea*) seed oils. Eur. J. Lipid Sci. Technol*110*, 360–367.

Xu, B. and Chang, S.K.C.(2008).Total phenolic acids, isoflavones and antioxidant properties of yellow and black soybean as affected by thermal processing. J. Agric. Food Chem.*56*, 7165-717.

Xu, G., Ye, X., Chen,J.and Liu, D. (2007). Effect of heat treatment on the phenolic compound and antioxidant capacity of citrus peel extract. J. Agric. Food Chem. *55*, 330-335.

Yeilaghi, H.,Arzani, A., Ghaderian, M.,Fotovat, R.,Feizi, M. and Pourdad, S.S. (2012). Effect of salinity on seed oil content and fatty acid composition of safflower (*Carthamus tinctorius* L.)genotypes. Food Chem. *130*, 618-625.

Yoshida, H., Takagi, S. and Mitsuhashi, S.(1999) . Tocopherol distribution and oxidative stability of oils prepared from the hypocotyl of soybeans roasted in microwave oven. J. Amer. Oil Chem. Soc. *76*, 915–920.

## تأثير درجات حرارة التحميص على بذور و زيت القرطم

**ايمان محمد ممدوح عبدالظاهر طه[١]و برتراند ماثيوس[٢]**

**[١]قسم الصناعات الغذائية والالبان– كلية الزراعة (قنا) – جامعة جنوب الوادى.**

**[٢]قسم جودة وسلامة الحبوب معهد ماكس روبنر .ديتمولد المانيا**

اجرى هذا البحث بهدف دراسة تأثير درجات حرارة التحميص على جودة كل من بذور وزيت القرطم المستخرج من البذور بعد التحميص ، أُجري هذا البحث على ثلاثة أصناف من بذور القرطم وهى جيزة ١ ، خارجة ١، خارجة ٢حيث تم تعريض البذور لدرجات حرارة (١٢٠ ، ١٤٠ ، ١٦٠ ،١٨٠ م ) لمدة ١٥ دقيقة ودراسة التغيرات التي تحدث في كل من البذور والزيت المستخلص من هذه البذور بعد التحميص عن طريق تقديرالمحتوى من الزيت ، المركبات المستخلصة الكلية لكل من البذور والزيت، المركبات الفينولية الكلية لكل من البذور والزيت، النشاط المضاد للأكسدة لكل من البذور والزيت ، تركيب الأحماض الدهنية ، التغير في اللون، الثبات ضد الأكسدة للزيت . أكدت النتائج أنه لم يحدث تغيير في محتوى المركبات الفينولية لبذور القرطم في كل الأصناف نتيجة للتحميص ، بينما أحدثت عملية التحميص زيادة النشاط المضاد للأكسدة للبذور، وكذلك زاد محتوى البذور من الزيت نتيجة لعملية التحميص، وتوقفت درجة الحرارة المثلى على الصنف. كذلك زاد كل من المحتوى من المركبات الفينولية النشاط المضاد للأكسدة لزيت القرطم زيادة تدريجية بزيادة حرارة التحميص حتى وصل أعلى قيمة عند ١٨٠°م. ولكن بالنسبة للتغير الحادث في محتوى الأحماض الدهنية كان صغيرا للغاية، وكذلك تغير وقت ثبات الزيت ضد الأكسدة تغير طفيف نتيجة التحميص، بينما زادت دكانة لون الزيت الناتج بزيادة حرارة التحميص نتيجة لتفاعل ميلارد وقد خلصت الدراسة الى ان عملية التحميص لها تأثيرات إيجابية على محتوى الزيت وتطور اللون كما أن التحميص يزيد من ثبات الزيت وقيمته الغذائية بالاضافة لتأثيره الإيجابي على زيادة النشاط المضاد للاكسدة للبذور والزيت الناتج بعد التحميص. مسحوق القرطم الناتج بعد استخلاص الزيت يمكن أن يستخدم كمصدر لمضادات الأكسدة وبالتالي يمكن ان يستخدم على نطاق واسع في تطبيقات غذائية وعلاجية.