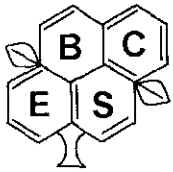

EFFECT OF ROASTING CONDITIONS ON THE ACRYLAMIDE FORMATION AND POLYPHENOLS CONTENT IN ARABICA COFFEE BEANS

Journal

J. Biol. Chem. Environ. Sci., 2010, Vol. 5(3): 331-345
www.acepsag.org

EL-Saied[2], M. H.; Abul-Fadl,[1] M. M. and EL-Badry, N.[1]

[1]Department of Food Science and Technology, Faculty of Agriculture, AL-Azhar University, Cairo, Egypt.
[2] College of Food & Agricultural Sciences, King Saud University, P.O. Box 2460, Riyadh 11451, Kingdom of Saudi Arabia

ABSTRACT

The aim of this investigation was to study the effect of different roasting time on acrylamide (AA) formation and polyphenols content in green coffee beans when roasted for 15, 30, 45, 60, 90 and 120 min at 200 °C. Also, AA content in different roasted coffee (light and dark roasted coffee) collected from different regions in Cairo and Giza governorates was determined. The obtained results by GC-MS indicated that the amount of AA rapidly increased at the onset of roasting, reaching a maximum level (283µg/kg) for 15 min of the roasting time. While, as the roasting time increased from 30 to 120 min. the AA content was a drastically decreased. The colour of coffee samples was increased from very light to very dark by increasing the roasting time which was inversely linked to AA concentration in the roasted coffee, ranging from 283 µg/kg in very light roast down to 39 µg/kg in very dark roast. The AA content in collected samples (local market) from light roasted ground coffee was ranged between 116 to 169 µg/kg. While, the collected samples of dark roasted ground coffee was ranged between 59 to 98 µg/kg of AA content. Light roasted coffee samples had higher content of AA (mean 137.66 µg/kg) than those found in dark roasted coffee samples (mean 73.66 µg/kg). Concerning the HPLC- polyphenols content, Chlorogenic acid was the major phenolic compound detected in green coffee (raw), followed by caffeic acid and coumaric acid. Chlorogenic acid was sharply decreased as the roasting time increased up to 120 min. Coumaric acid, resolcenol, pyrogallic acid, quercetin, cinnamic acid, ρ-hydroxy

benzoic acid and chrysin were decreased as the roasting time increased. While, no appreciable change was found in caffeic acid content as a result of roasting time increasing.

INTRODUCTION

Acrylamide is a compound, with a potential to cause a spectrum of toxic effects IARC, (1994); European Union Risk Assessment Report (2002); Manson et al. (2005), including neurotoxic effects as has been observed in humans. Acrylamide has also been classified as a probable human carcinogen under the Group 2A by the International Agency for Research on Cancer IARC (1994). Similar classifications have been done by other authorities within the European Union and USA US EPA (1993).Until the recent decade only occupational exposure to acrylamide was thought to represent a significant health risk. The mutagenic and carcinogenic properties of acrylamide are assumed to depend on the epoxy metabolite, glycidamide, as reviewed by Rice (2005).

Coffee plays a major social and economical role. It is one of the most widely consumed beverages throughout the world due to its pleasant taste and aroma and stimulant effect Martins and Gloria (2010).

Since, roasted coffee is widely consumed among worldwide population, so they potentially expose to AA. The chemistry of coffee roasting is complex and still not completely understood (Senyuva and Gökmen 2005). Aromatics, acids, and other flavor components are either created, balanced, or altered in a way that should augment the flavor, acidity, after taste of the coffee during roasting. The roasting conditions (temperature & time) determine the specific types of chemical reactions that occur in coffee. In addition, to produce desired characteristics, undesirable changes such as the formation of acrylamide should also be considered in this process. Coffee, as a source of acrylamide, needs to be investigated in depth to determine the effects of roasting conditions on acrylamide levels (Senyuva and Gökmen 2005).

Coffee has factors affecting acrylamide (AA) formation during the roasting procedure. Roasting time, temperature and variety give a variation in content. Extended temperature and time lowered the acrylamide content, since temperature above 240 °C and time longer

than 5 minutes, gave a decrease in acrylamide formation Bagdonaite and Murkovic (2004) and Anese, et al. (2010).

Despite the controversial effects of coffee on human health, coffee is nowadays accepted as a rich source of compounds possessing antioxidants and radical scavenging activities; Green coffee beans contain effective plant antioxidants, such as chlorogenic acids, phenolic acids, polyphenols and alkaloids; their content varies mainly with the species of coffee tree (e.g. *Coffea arabica*, Arabica, *Coffea canephora*, Robusta) and with their origin, and also their content depend on the roasting conditions. Depending on the roasting conditions, natural coffee antioxidants are partly decomposed or bound to polymer structures. However, roasting results in the generation of Maillard reaction products (melanoidins), exhibiting significant antioxidant activities previously, it was confirmed that the antioxidant capacity of roasted coffee exceeded than of green coffee beans, and an optimum of antioxidant action was found for medium-roasted samples. On the contrary, the level of acrylamide was suppressed upon increasing the roasting degree, but this process resulted in a loss of antioxidant capacity Brezov et al. (2009) and Summa et al. (2007).

A high relevance is being given to coffee, as an important dietary source of acrylamide, mainly in the Nordic European countries where it may contribute up to one third of total dietary intake Among other possible reaction pathways, the Maillard reaction represents the main route for acrylamide formation in coffee, being initiated by the condensation of asparagine and reducing carbohydrates or reactive carbonyls, when the beans are subjected to the high roasting temperature. Therefore, the degree of roasting will be a key factor in acrylamide content, with light roasted coffee attaining significantly higher amounts when compared with dark roasted counterparts Moreover, when comparing the two coffee species of higher economical importance, namely *Coffea arabica* and *Coffea canephora* (also known as arabica and robusta coffees, respectively) increased levels of acrylamide are described for the latter As a result, the reported levels for roasted coffee beans vary widely, usually within the range of 35–540 μg/kg of coffee (Alves et al., 2010).

The aim of the present study can be summarized as follow:

1- To study the effect of the roasting conditions (at different roasting times) on the formation of acrylamide (AA) in coffee beans.

2- Determination of AA content in different roasted coffee (light and dark roasted coffee) collected from different regions in Cairo and Giza governorates.
3- Study the effect of the roasting conditions on polyphenols content in coffee beans.

MATERIALS AND METHODS

Samples:

Three Kg arabica green coffee beans, Brazilian coffee specie, (*Coffea arabica*) were purchased from the local coffee market at Mataryia region, Cairo, Egypt. Green coffee beans samples were divided to 7 portions, each portion (300g) was roasted individually at different time started from 15 to 120 min., one of them was tested as control samples (without roasting).

Surveying samples: Six different samples of commercial medium and dark roasted and ground coffee were collected from 6 different areas in Cairo and Giza governorate. All collected samples were gathered at two times during the year of 2009(within the shelf life of consumption as written on their labels information).

Preparation of Coffee Samples

Green coffee beans (300 g) with a moisture content of around 7.18 % were roasted in a convective oven at 200±5°C. Six degrees of roasting times were achieved, very light roast (15 min), light roast (30 min), medium roast (45 min), medium dark roast (60 min), dark roast (90 min) and very dark roast (120 min) as described by Franca et al. (2005) and Vasconcelos et al. (2007). Roasted coffee bean samples from each roasting operation were degassed for 12 h at -20°C prior to grinding Gonzalez-Rios et al. (2007). Roasted coffee samples were naturally brought to ambient temperature (25 ± 2°C), packed in plastic pouches and stored in dry conditions. Prior to analysis coffee samples were ground in a coffee mill (Braun AG Frankfurt Type: KM 32, Germany) to obtain fine particle size Sacchetti et al. (2009).

Preparation of Standard Solution:

Standard grade of acrylamide (99.8%) was obtained from Sigma-Aldrich (USA), and the Standard solution was prepared according to the method as described by Henares and Morales, (2006).

Determination of Acrylamide in Coffee Samples:

1-Extraction of Acrylamide by Solid Phase Extraction (SPE):

Sample Preparation: 5g of ground Coffee samples was transfer into a 125-mL Erlenmeyer flask with 40 ml of deionized distilled water, and placed into water bath at 65°C for 30 min. Ethylene dichloride (10 ml) was added, and the flask contents were homogenized for 30scond, and extracted 3 times with 10, 5, and 5 ml of ethyl acetate, respectively. The extract was dried with addition of anhydrous sodium sulfate, and the solution was concentrated by rotary evaporator to a final volume of approximately 4 ml. The sample was then ready for final extraction by Solid Phase Extraction (SPE) sing

Discovery MCAX 300mg C18 3mL tube. The C18 tube were Conditioned with 1.0 ml of methanol followed by 1.0 ml water, dried with vacuum, then 1.0 ml of aqueous extract was loaded onto conditioned tube, and wash with 1.0 ml of water. Sample extracted were Elute to remove the acrylamide from C18 tube with 2.0 ml methanol and concentrate samples using a nitrogen manifold at 30°C, and reconstitute to 0.5 mL with water to be ready for LC/MS analysis Henares and Morales (2006) and Senyuva and Gökmen (2006).

2-Analysis of Acrylamide by GC-MS was carried out

According to the method described by Soares et al. (2006) GC-MS analysis were performed in a gas chromatograph, model HP GC-6890, split-splitless injector, coupled to a mass selective detector model Agilent MSD-5973N (Agilent, Palo Alto, CA, USA). The analytical separation was performed in a capillary column DB 1301 (30m x 0.25 µm, 0.25mm i.d.) from J&W Scientific (Folsom, CA, USA). The centrifugations were made in an ultra-centrifuge from ppendorf, model 5810R (Hamburg, Germany) at 15 000g and in a Heraeus Sepatek, model Labofuge Ae (Osterode, Germany) at 3000g. The SPE clean-up was made in a Visiprep Solid Phase Extraction Manifold from Supelco (Taufkirchen, Germany) with capacity for 12 columns. Evaporation of the solvents was performed in a Bu" chi Rotavapor model RE 111 and 461 water bath (Flawil, Switzerland). Evaporation under a stream of nitrogen was carried out on a Pierce; model Reacti-therm 18790 (Rockford, IL, USA) with capacity for nine vials. GC-MS operating conditions Gas-chromatography. Carrier gas: helium (constant flow at 1ml min^{-1}). Sample injection volume: 1 µl (splitless, pulsed pressure 32 psi, 60 s). Injector temperature: 280°C.

oven temperature: 85°C (1 min), 15°C min^{-1} to 280°C, hold for 10 min (24 min), transfer line, 240°C. Mass-spectrometry. Electron energy, 70 eV (EI mode). Mode of acquisition: selected ion monitoring (SIM), m/z 106, 108, 150 and 152. The identity of the peak was confirmed by retention time and by comparing the relative abundance ratios of the confirmatory ions with AA standard solution.

Extraction and Identification of Phenolic Compounds by HPLC

Phenolic compounds of coffee samples (Twelve of polyphenol compounds were identified in raw (green coffee) and roasted coffee beans including chlorogenic acid, caffeic acid, coumaric acid, resolcenol, pyrogallic acid, vanillin, ferulic acid, quercetin, cinnamic acid, gallic acid, ρ-hydroxy benzoic acid and chrysin) were extracted according to the method outlines by Ben-Hammouda et al. (1995). One g. of coffee ground sample was soaked in 10ml of ethanol (80%) and filtered through a 0.2μ filter sterilized membrane prior to HPLC analysis.

Identification of individual phenolic compounds of the ground coffee samples was performed on a JASCO HPLC, using a hypersil C_{18} reversed-phase column (250 x 4.6 mm) with 5 μm particle size. Injection by means of a Rheodyne injection valve (Model 7125) with 50 pj fixed loop was used. A constant flow rate of 1ml/min was used with two mobile phases: (A) 0.5% acetic acid in distilled water at pH 2.62; and solvent (B) 0.5% acetic acid in 99.5% acetonitrile. The elution gradient was linear starting with (A) and ending with (B) over 50 min, using an UV detector set at wavelength 254 nm. Phenolic compounds of each sample were identified by comparing their relative retention times with those of the standard mixtures chromatogram. The concentration of an individual compound was calculated on the basis of peak area measurements, then convert to μg phenolic g^{-1} dry weight.

All chemicals and solvents used were HPLC spectral grade. They were obtained from Sigma (St. Louis, USA) and Merck-sheuehrdt (Munich, Germany).

Statistical Analysis:

Data were subjected to the statistical analysis according to Analysis of Variance (ANOVA) of Completely Randomized Design as described by Gomez and Gomez (1984) Treatment means were compared using the Least Significant Differences (LSD) at 0.05 levels

of probability and Standard Error. Computations and statistical analysis of data were done using facilities of computer and statistical analysis system package SAS (1985).

RESULTS AND DISCUSSION

Effect of Roasting Degree for Different Times at 200 °C on Acrylamide Formation in Coffee samples

Data presented in Table 1 show the effect of roasting degree at 200 °C on the formation of AA during the roasting process for six different times (15, 30, 45, 60, 90 and 120 min). It could be observed that the amount of AA rapidly increased (283 µg/kg) at the onset of roasting, reaching for 15 min of the roasting time. Meanwhile, as the roasting time increased from 30 to 120 min the AA content was a progressive drastically decreased, it was decreased from 251 µg/kg after 30 min to 39 µg/kg after 120 min of the roasting time.

Table (1) Effect of Roasting Degree for Different Times at 200 °C on Acrylamide Formation (µg/kg) in Coffee Beans.

Roasting Time (min)	Acrylamide Content (µg/kg) (Mean ±SE)	Coffee Color
0	10 ± 0.58^{G}	Raw (Green)
15	283 ± 6.93^{A}	Very light
30	251 ± 5.77^{B}	Light
45	162 ± 4.04^{C}	Medium
60	116 ± 2.89^{D}	Medium Dark
90	79 ± 1.73^{E}	Dark
120	39 ± 1.15^{F}	Very Dark
LSD*	7.39	

*Least Significant Difference at 0.05

The presented results are confirmed with the data reported by Alves et al. (2010); Bagdonaite et al. (2008) and Taeymans et al. (2004) they reported that the Acrylamide formation starts rapidly at the beginning of the roasting process and it decreases shortly after reaching a maximum level, probably due to physical and chemical losses. In addition, Confédération des Industries Agro-Alimentaires (CIAA, 2004) reported that the acrylamide formation in coffee is very different from any other food product. During the initial phase of

roasting, acrylamide starts to form rapidly, and reached to a maximum level of formation, the acrylamide content is reduced during the final stage of the roasting process. At the end of the roasting process, only 25-30% of the maximum level can be determined, indicating a loss of acrylamide of about 70%. This behavior is unique and different from any acrylamide study so far conducted on food products. Also, Guenther et al. (2007) reported that the acrylamide levels in roast coffee are determined by concomitant formation and reduction reactions during the roasting process; the profile of acrylamide formation reflects this effect very clearly. Acrylamide formation reactions are dominant at the beginning of the roasting cycle, leading to increased levels at this stage, 47 $mgkg^{-1}$, and then declining steeply toward the end of the roasting cycle due to higher rates of elimination (physical and chemical loss).

From the same Table, it could be also noticed that colour degree of coffee samples was increased from very light to very dark by increasing the roasting time at 200°C from 15 min to 120 min. Meanwhile, the degree of roast is inversely linked to AA concentration in the roasted coffee, ranging from 283 µg/kg in very light roast down to 39 µg/kg in very dark roast.

It could be concluded from the present results that there was a relationship between the color of roasted coffee and it content of AA as observed darker coloured coffee may contain much lower amounts of acrylamide than light coloured coffee. This indication that the degree of roasting will be a key factor in acrylamide content, with light roasted coffee attaining considerably higher amounts. Our result is concomitant with the results of Bagdonaite et al. (2008); Lantz et al. (2006) and Senyuva and Gökmen (2005).

Acrylamide Contents in Different collected Samples of Light and Dark Roasted Coffee.

Table (2) shows the AA content in commercial light and dark roasted coffee collected from the local markets of different six regions at Cairo and Giza governorates.

Table (2) Acrylamide Contents (µg/kg) in Different collected Samples of Light and Dark Roasted Coffee.

Samples	Acrylamide Content (µg/kg) (Mean ± SE)**	
	Light Roasted Coffee	Dark Roasted Coffee
1	133±1.73^{CD}	68±1.73^{CD}
2	142±2.31^{B}	77±1.73^{B}
3	129±1.73^{D}	61±1.73^{DE}
4	116±1.15^{E}	59±1.73^{AE}
5	137±1.15^{C}	98±2.31^{A}
6	169±4.62^{A}	79±2.31^{BC}
Average	137.66	73.66
LSD*	4.41	8.11

*Least Significant Difference at 0.05 ** average of two samples collected from each region

The tabulated data revealed that the AA content in collected samples from light roasted ground coffee was ranged between 116 to 169 µg/kg, by mean 137.66 µg/kg of AA content. While, the collected samples of dark roasted ground coffee was ranged from 59 to 98 µg/kg of AA content, by mean 73.66 µg/kg.

It could be observed that these results are confirmed the forenamed that obtained from table (1), which means that light roasted coffee samples had higher content of AA (mean 137.66 µg/kg) than those found in dark roasted coffee samples (mean 73.66 µg/kg). This may be due to that AA is formed at the beginning of the roasting step, and then it declining steeply towards the end of the roasting cycle due to higher rates of elimination (through physical and chemical losses) versus formation.

These results are also in agreement with previous studies Alves et al. (2010) and Seal et al. (2008).

Effect of Roasting Degree for Different Times at 200 °C on Polyphenol Compounds (g/100g) in Coffee Beans.

Coffee beans are one of the richest dietary sources of hydroxycinnamic acid derivatives (especially chlorogenic acid) and other phenolics. Depending on species, green coffee beans contain some 6 - 10% chlorogenic acids on a dry matter basis. Besides the chlorogenic acid isomers (major component being 5-caffeoyl-quinic

acid) and their di-esters, other hydroxycinnamic acid conjugates like feruloyl-quinic acids and caffeoyl-tyrosine were identified and their content in roasted coffee estimated (Rawel and Kulling, 2007).

Twelve of polyphenol compounds were identified in raw (green coffee) and roasted coffee beans (at 200° for different times) including chlorogenic acid, caffeic acid, coumaric acid, resolcenol, pyrogallic acid, vanillin, ferulic acid, quercetin, cinnamic acid, gallic acid, ρ-hydroxy benzoic acid and chrysin, and the results are given in Table (3).

As illustrated in Table (3), chlorogenic acid was the major of phenolic compounds detected in raw green coffee (4.9 g/100g), followed by caffeic acid (0.528 g/100g) and coumaric acid (0.259 g/100g). These results are in accordance with the trend of polyphenol compound contents in coffee obtained by other researchers. Brezov et al. (2009) and Somoza et al. (2003) reported that antioxidants are natural constituents in coffee and include phenolic compounds, chlorogenic acid, caffeic acid and caffeine. While many of the antioxidants naturally present in coffee are degraded (phenolic compounds, caffeic acid, ferulic acid, coumaric acid), others are formed by roasting in the Maillard reaction (melanoidins).

Concerning the effect of the roasting degree at 200°C for different times on polyphenols content in coffee beans, it could be noticed from Table (3) that chlorogenic acid was sharply and gradually decreased as the roasting time increased up to 120 min, which was represented about 3.1 g/100g after 30 min, 1.3 g/100g after 60 min and 0.198 g/100g after the end of the roasting time (120 min). This is due to the fact that the chlorogenic acid is a thermolabile compound, which more sensitive degradation to form the other (low molecular weight) polyphenol compounds by the roasting process Vignoli et al. (2010). These results are in agreement with the data obtained by Rawel and Kulling (2007) who reported that during roasting there is a progressive destruction and transformation of chlorogenic acid and a parallel release of a series reactive products.

Also the same behavior was observed for some phenolic compounds; namely coumaric acid, resolcenol, pyrogallic acid, quercetin, cinnamic acid, ρ-hydroxy benzoic acid and chrysin which were decreased as the roasting time increased, as also found by Naidu et al. (2008) they reported that during the roasting process, the naturally occurring polyphenolic constituents are transformed to a

Table (3) Effect of Roasting Degree for Different Times at 200 °C on Polyphenol Compounds (g/100g) in Coffee Beans (Mean ± SE).

Polyphenol Compounds	Roasting Degree at 200 °C for Different Times						
	Raw (0)	15 min	30 min	45 min	60 min	90 min	120 min
Pyrogallic acid	0.3225±0.0018	0.321±0.0011	0.3054±0.0028	0.2854±0.0007	0.2282±0.0010	0.1932±0.0009	0.1672±0.0014
Gallic acid	0.0296±0.0006	0.0301±0.0005	0.0423±0.0006	0.04820.0006	0.0686±0.0012	0.0835±0.0008	0.0104±0.0005
Resolcenol	0.3265±0.0014	0.489±0.0104	0.8878±0.0017	0.3984±0.0017	0.2588±0.0012	0.356±0.0098	0.2203±0.0008
ρ- hydroxy benzoic acid	0.0117±0.0010	0.0125±0.0009	0.0134±0.0006	0.0118±0.0010	0.0102±0.0006	0.0098±0.0010	0.0046±0.0003
Chlorogenic acid	4.9253±0.0012	4.6535±0.0020	3.155±0.0173	2.5321±0.0011	1.3879±0.0013	0.9752±0.0006	0.1982±0.0008
Caffeic acid	0.5287±0.0010	0.5298±0.0031	0.5427±0.0006	0.5463±0.0008	0.5554±0.0013	0.5543±0.0012	0.5532±0.0017
Vanillin	0.0156±0.0003	0.0158±0.0010	0.0158±0.0012	0.0145±0.0005	0.0141±0.0011	0.0154±0.0017	0.0164±0.0007
Ferulic acid	0.0079±0.0008	0.0112±0.0006	0.0156±0.0014	0.0173±0.0012	0.0185±0.0017	0.0211±0.0006	0.023±0.0007
Coumaric acid	0.2594±0.0008	0.1852±0.0021	0.0778±0.0008	0.0542±0.0006	0.0283±0.0010	0.0266±0.0008	0.0253±0.0006
Cinnamic acid	0.0033±0.0002	0.0033±0.0003	0.0034±0.0005	0.0028±0.0002	0.0011±0.0001	0.0011±0.0001	0.001±0.0001
Quercetin	0.0062±0.0006	0.0061±0.0003	0.0052±0.0002	0.0049±0.0008	0.0045±0.0003	0.0038±0.0005	0.0033±0.0003
Chrysin	0.0009±0.0001	0.0008±0.0001	0.0007±0.0001	0.0005±0.0001	0.0002±0.0001	0.0002±0.0001	0.0002±0.0001
Total	6.4376^{A}	6.2583^{B}	5.0651^{C}	3.9164^{D}	2.5758^{E}	2.2402^{F}	1.2231^{G}
LSD*	0.018						

*Least Significant Difference at 0.05

complex mixture of maillard reaction products. In addition, Summa et al. (2007) reported that the antioxidant activity decrease in coffee beans upon darker roasting. Because the caffeic acid is more stable compound at roasting temperature and time (Vignoli et al., 2010), so it was no appreciable change after roasting at 120min. The same behavior was also noticed for vanillin compound.

REFERENCES

Alves, R. C.; Soares, C.; Casal, S.; Fernandes, J.O. and Oliveira, M. B.P.P. (2010). Acrylamide in espresso coffee: Influence of species, roast degree and brew length. Food Chemistry 119 (2010) 929–934.

Anese, M.; Suman, M. and Nicoli, C. (2010). Acrylamide removal from heated foods. Food Chemistry 119: 791–794.

Bagdonaite, K. and Murkovic, M. (2004). Factors affecting the formation of acrylamide in coffee. Czech Journal of Food Science, 22(Special issue), 22-24.

Bagdonaite, K.; Derler, K.and Murkovic, M. (2008). Determination of acrylamide during roasting of coffee. J. Agric. Food Chem., 56 (15): 6081 – 6086.

Ben-Hammouda,M. ; Kremer,R.J.; Minor, H.C. and Sarwar, M. (1995). A chemical basis for differential alleopathic potential of sorghum hybrids on wheat. J. Chem. Ecol., 21: 775 – 786.

Brezov, V.; Šlebodov, A. and Staško, A. (2009). Coffee as a source of antioxidants: An EPR study Food Chemistry 114: 859–868

CIAA (Confédération des Industries Agro-Alimentaires), (2004). Acrylamide Status Report, December 2004: A summary of the Efforts and Progress Achieved to date by the European Food and Drink Industry (CIAA) in lowering levels of acrylamide in food. Pp. 40-41. Available: http://www.CIAA.be.

European Union Risk Assessment Report, (2002). Acrylamide, Volume 24, EUR 19835 EN. (pp 1-207). Luxembourg: Office for Official Publications of the European Communities.

Franca, A.S.; Mendonca, J.C.F. and Oliveira, S. D. (2005). Composition of green and roasted coffees of different cup qualities. LWT 38 (2005) 709–715.

Gomez, K.A. and A.A. Gomez, (1984). Statistical procedures for agricultural research 2nd Edn John Wiley, New York, USA.

Gonzalez-Rios,O.; Suarez-Quiroz, M.L.; Boulanger,R.; Barelb,M.; Guyot,B.; Guiraudc,J-P. and Schorr-Galindoc,S. (2007). Impact of

ecological post-harvest processing on coffee aroma: II. Roasted coffee. J. Food Composition and Analysis 20: 297–307.

Guenther,H.; Anklam, E.; Wenzl, T. and Stadler, R. H. (2007). Acrylamide in coffee: Review of progress in analysis, formation and level reduction. Food Additives and Contaminants, 24(S1): 60–70.

Henares, R.J.A. and F.J. Morales, (2006) Determination of acrylamide in potato chips by a reversed-phase LC-MS method on a stable isotope dilution assay. Food Chem., 97: 555-562.

IARC, (1994). Acrylamide. In *IARC monographs on the evaluation of carcinogenic risks to humans. Some industrial chemicals, Volume 60.* (pp 389-433). Geneva, Switzerland: WHO.

Lantz, I.; Ternite, R.; Wilkens, J.; Hoenicke, K.; Guenther, H. and van der Stegen, G.H. (2006): Studies on acrylamide levels in roasting, storage and brewing of coffee. Mol Nutr Food Res 50, 1039–1046.

Manson, J., Brabec, M.J., Buelke-Sam, J., Carlson, G.P., Chapin, R.E., Favor, J.B., Fischer, L.J., Hattis, D., Lees, P.S.J., Perreault-Darney, S., Rutledge, J., Smith, T.J., Tice, R.R. & Working, P. (2005). NTP-CERHR expert panel report on the reproductive and developmental toxicity of acrylamide. *Birth Defects Research (Part B)*, 74, 17-113.

Martins, A.C.C.L. Gloria, M.B.A. (2010): Changes on the levels of serotonin precursors - tryptophan and 5-hydroxytryptophan – during roasting of Arabica and Robusta coffee. Food Chemistry 118: 529–533.

Naidu, M. M.; Sulochanamma, G.; Sampathu, S.R. and Srinivas, P. (2008). Studies on extraction and antioxidant potential of green coffee. Food Chemistry 107: 377–384.

Rawel, H. M. and Kulling, S. E. (2007). Nutritional contribution of coffee, cacao and tea phenolics to human health. J. Verbr. Lebensm. 2: 399 – 406.

Rice, J.M. (2005). The carcinogenicity of acrylamide. *Mutation Research*, 580, 3-20.

Sacchetti, G.; Di Mattia,C.; Pittia,P. and Mastrocola,D. (2009). Effect of roasting degree, equivalent thermal effect and coffee type on theradical scavenging activity of coffee brews and their phenolic fraction. J. Food Engineering 90: 74–80.

SAS, (1985). Statistical Analysis System (SAS) user' sguide: Statistics, 5th Edn. Cary, N.C.: SAS Institute, Inc.

Seal,C. J.; de Mul, A.; Eisenbrand,G.; Haverkort,A. J.; Franke, K.; Lalljie,S. P. D.; Mykkänen, H.; Reimerdes, E.;Scholz, G.; Somoza, V.; Tuijtelaars,; van Boekel,S. M.; van Klaveren, J.; Wilcockson, S. J.

and Wilms, L. (2008). Risk-Benefit Considerations of Mitigation Measures on Acrylamide Content of Foods – A Case Study on Potatoes, Cereals and Coffee. British Journal of Nutrition, Apr.99, suppl.2: s1-s46.

Senyuva, H.Z. and Gökmen, V. (2005). Study of acrylamide in coffee using an improved liquid chromatography mass spectrometry method: Investigation of colour changes and acrylamide formation in coffee during roasting. Food Additives and Contaminants, 22 (3): 214–220g.

Senyuva, H.Z. and V. Gökmen, (2006). Interference free determination of acrylamide in potato and cereal- based-foods by laboratory validated liquid chromatography-mass spectrometry methods. Food Chem., 97: 539-545.

Soares, C.; Cunha, S. and Fernandes, J. (2006). Determination of acrylamide in coffee and coffee products by GC-MS using an improved SPE clean-up.Food Additives and Contaminants, December 2006, 23(12): 1276–1282.

Somoza, V.; Lindenmeier, M.; Wenzel, E.; Frank, O.; Erbersdobler, H.F. and Hofmann, T. (2003). Activity-guided identification of a chemopreventive compound in coffee beverage using in vitro and in vivo techniques. J Agric Food Chem 51, 6861–6869.

Summa,C. A.; de la Calle, B.; Brohee,M.; Stadler, R. H. and Anklam, E. (2007). Impact of the roasting degree of coffee on the in vitro radical scavenging capacity and content of acrylamide. LWT 40: 1849–1854.

Tacymans, D.; Ashby, P. and Blank, I. (2004). Review of Acrylamide: An Industry Perspective on Research, Analysis, Formation, and Control. Crit. Rev. Food Sci. & Nutr., 44: 323-347.

US-EPA, (1993). Acrylamide. Environmental Protection Agency, USA;Integrated Risk Information System (IRIS). Available: www.epa.-gov/iris.

Vasconcelos, A.L.S.; Franca, A.S.; Glória, M.B. A. and Mendonca, J.C.F. (2007). A comparative study of chemical attributes and levels of amines in defective green and roasted coffee beans. Food Chemistry 101 (2007) 26–32.

Vignoli, J. A.; Bassoli, D. G. and Benassi, M. T. (2010). Antioxidant Activity, Polyphenols, Caffeine and Melanoidins in Soluble Coffee: The Influence of Processing Conditions and Raw Material. Food Chemistry. Article in press. www.sciencedirect.com

تأثيرظروف التحميص على تكوين الأكريلاميد ومحتوى الفينولات فى حبوب القهوة العربى

[2] محمد حمزه السعيد - [1]مصطفى أبوالفضل محمد - [1] ناصر البدرى عبداللاه
[1]قسم علوم وتكنولوجيا الأغذية- كلية الزراعة جامعة الأزهر- القاهرة
[2] كلية علوم الأغذية والزراعة- جامعة الملك سعود- الرياض- المملكة العربية السعودية

يهدف هذا البحث إلى دراسة تأثير درجات التحميص لحبوب القهوه (على درجة حرارة 200°م ولمدة 15 ،30 ،45 ،60 ،90و120دقيقة) على تكوين الأكريلاميد ومحتوى الفينولات فى القهوة. وكذلك تقدير محتوى الأكريلاميد فى عينات القهوة المحمصة على درجات مختلفة (القهوة الفاتحة والغامقة المحمصة) والتى جمعت من مناطق مختلفة لمحافظتى القاهرة والجيزة. وقد دلت النتائج المتحصل عليها على أن محتوى الأكريلاميد يزداد بسرعة فى المرحلة الأولى من التحميص حيث وصل إلى أعلى معدل 283 ميكروجرام/ كيلوجرام بعد 15 ق من مدة التحميص ، وبعد ذلك حدث نقص شديد وتدريجى فى محتوى الأكريلاميد مع زيادة مدة التحميص من 30 ق إلى 120 ق. أما فيما يتعلق بلون عينات القهوة فكان يزداد اللون من الفاتح جداً إلى الغامق بدرجة كبيرة مع زيادة مدة التحميص من 15 ق إلى 120 ق وكان ذلك على عكس محتوى الأكريلاميد حيث سجل 283 ميكروجرام/ كيلوجرام مع عينات القهوة الفاتحة بدرجة كبيرة بينما سجل 39 ميكروجرام/ كيلوجرام مع عينات القهوة الغامقة بدرجة كبيرة. أما بالنسبة لعينات القهوة التى تم تجمعها من السوق المحلى فكان محتوى الأكريلاميد لعينات القهوة الفاتحة يتراوح من 116 إلى 169 ميكروجرام/ كيلوجرام. بينما كان محتوى الأكريلاميد لعينات القهوة الغامقة يتراوح من 59 إلى 98 ميكروجرام/ كيلوجرام. أما فيما يتعلق بمحتوى الفينولات ، فكان حامض الكلوروجينيك هو المكون الرئيسى من المركبات الفينولية حيث سجل 4.9 جرام/100 جرام يليه كلا من حامض الكافييك والكيوميريك حيث سجلا 0.528 و 0.259 جرام/100 جرام على التوالى.أما تأثير عملية التحميص على المواد الفينولية فكان حامض الكلوروجينيك هو الأكثر تأثرا حيث حدث له نقص شديد وتدريجى كلما زادت مدة التحميص. كما حدث نقص ايضا فى الكيوميريك والريسولسينول و البيروجالييك و كويرسيتين و السناميك و البارا هيدروكسى بنزويك و الكيريسين كلما زادت مدة التحميص. بينما لم يلاحظ أى تغير تقريبا فى محتوى حامض الكافييك بزيادة مدة التحميص حتى 120 ق.