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Acrylamide formation in some Egyptian foods as affected by food processing conditions and pre-frying treatments

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ABSTRACT

The objective of the present study is to estimate acrylamide levels in some different food samples from Egyptian local market and to determine the levels of acrylamide formation during different processing conditions, and effects of pre-frying treatments on acrylamide reduction in some Egyptian foods. Results showed that in market samples, the highest mean acrylamide level value was in coffee "Bin Shaheen" with cardamom dark color (5181.61 µg/kg) which was a highly significant value compared with all of other samples. The mean of acrylamide concentration of all potato market samples was 25.97 µg/kg. The highest mean levels in prepared meals was in onion "dark color" (309.35 µg/kg), while in homemade samples, the highest mean value of acrylamide content was in fried noodles at 120°C/6 min (310.75 µg/kg). The effect of different temperatures and/or times on acrylamide formation in fried rice and fried potatoes results are recorded. It was observed that the increasing of frying temperatures from 110 to 175°C increase the acrylamide levels in rice and potatoes, the same trend was happened by time increasing from 15 to 20 min. In addition, the highest acrylamide value was 3066.38 µg/kg at 180°C/20 min followed by 1860.28 and 1755.34 µg/kg at 180°C/15 min and 160°C/20 min, respectively. The effects of different pre-frying treatments on reduction of acrylamide formation of fried rice at 180°C for 10 min were studied. Soaking rice in acetic acid (1%) for 20 min caused the highest significant ($p \leq 0.05$) decreases in acrylamide content compared with control. This reduction was 94.65% followed by soaking rice in citric acid (1%) for 20 min, which gave acrylamide reduction of 93.7%. Generally, soaking rice in water or different solutions caused significant reduction in acrylamide formation (89.1 to 94.65%).

Keywords: Acrylamide, potato, rice, soaking, coffee, frying temperature.

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INTRODUCTION

Acrylamide is a monomer which has a molecular formula of C_3H_5NO (CH_2=CH-$CONH_2$) and has a molecular weight of 71.08 g, is colorless, odorless and has crystalline form, (can be solved in water, solvents such as acetone, ethanol, methanol and can be transformed into acrylic acid when hydrolyzed) (IARC, 1994). The acrylamide used in the production of polyacrylamide is also extremely used in the treatment of drinking and waste water, in paper production, in petroleum industry, in the production of mine, mineral, asphalt and in the treatment of land and soil. Moreover, it is also commonly used as an additive in cosmetic industry, in electrophoresis used in molecular biology applications, in the production of photographic film, in the manufacturing of adhesive, varnish and dye and in the preparation of some alloys in dentistry (EURAR, 2002). The risk of acrylamide to health was also shown in 1997 when a large water leakage happened during the building of a tunnel in Sweden and large numbers of dead fish and paralyzed cattle were found near the construction site. The walls of the tunnel contained monomeric acrylamide and N-methylolacrylamide, and a large leak of these

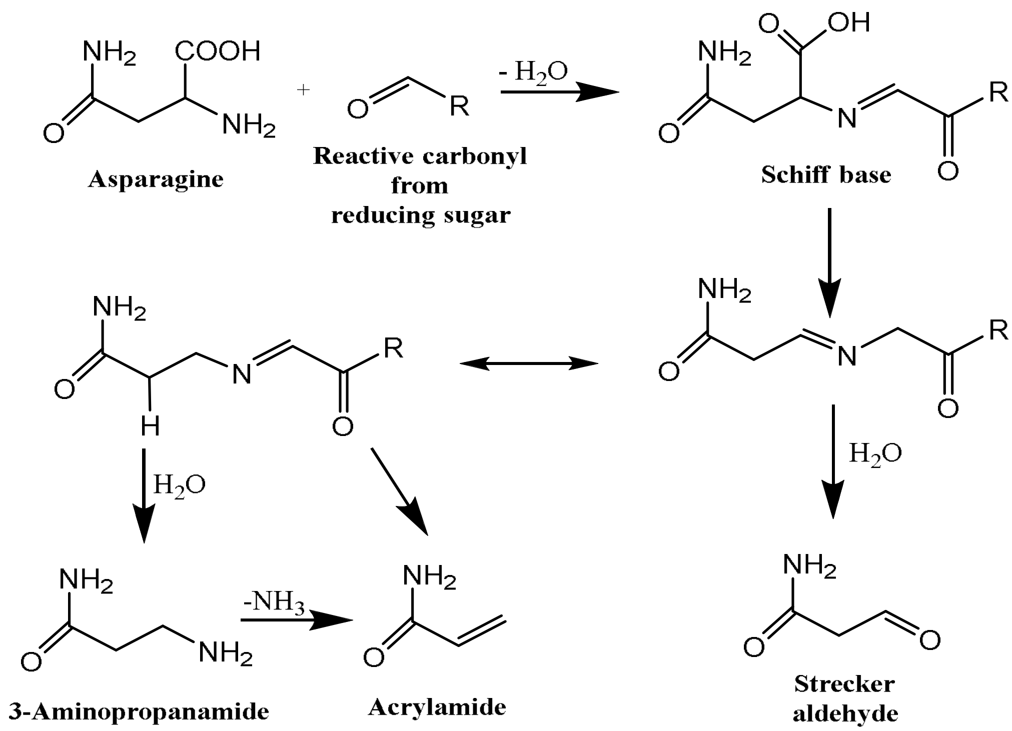

Figure 1. Proposed mechanism for the formation of acrylamide in heat-treated foods (HEATOX Project, 2007).

compounds into the environment appeared to be the cause of the health problem. Through the measurement of reaction products (adducts) with protein haemoglobin in blood, it was shown that several of the tunnel workers had developed peripheral nerve symptoms similar to those reported for acrylamide poisoning (Eriksson, 2005; Hagmar et al., 2005; IARC, 1994) classified acrylamide as "potentially carcinogenic to humans". In 2001, the Scientific Committee on Toxicity, Ecotoxicity and the Environment demonstrated its inherent toxic properties (neurotoxicity, genotoxicity to both somatic and germ cells, carcinogenicity, and reproductive toxicity). The importance of acrylamide in food was mentioned for the first time by Tareke et al. (2002) who showed that feeding rats with fried feed led to a large increase in the level of the haemoglobin adduct, which was concluded to be N-(2-carbamoyl methyl) valine. It is assumed that the mechanism leading to the formation of acrylamide derives from Maillard reaction, that is, the reaction between reducing sugars and proteins/amino acids (mainly asparagine; Figure 1) (HEATOX Project, 2007). Also, in April 2002, a group of Swedish researchers reported that some heat treated starch-rich foods such as potato and cereal products and coffee contained high levels of acrylamide (Surdyk et al., 2004; Tareke et al., 2002; Svensson et al., 2003). In 2005, the Swedish National Food Administration announced that foods processed and cooked at high temperatures contain relatively high levels of acrylamide (Zhang et al., 2005).

Factors affecting acrylamide formation and degradation in foods are acrylamide precursors such as free amino acids (mainly asparagine, reducing sugars and processing conditions, that is, baking time and temperature, moisture content and matrix of product).

The objective of the present study is to estimate acrylamide levels in some different food samples from Egyptian local market and to determine the levels of acrylamide formation during different processing conditions. In addition, investigate the effects of pre-frying treatments on acrylamide reduction in some Egyptian foods.

MATERIALS AND METHODS

Chemicals

Acrylamide (Fisher chemical), 1-Propanol (HPLC grade, Fisher chemical), Hexane 95% (TEDIA), Acetonitrile J.T.Baker (HPLC grade), citric acid (1%), acetic acid (1%) and distilled water.

Equipment

The quantification of acrylamide levels in food was performed on a GC (Agilent Technologies 7890A) interfaced with a mass-selective detector (MSD, Agilent 7000) equipped with Agilent HP-5ms (5%-phenyl methyl poly siloxane) capillary column (30 m × 0.25 mm i.d. and 0.25 μm film thickness).

Samples

Different types of food samples (potato, toast, coffee and peanut) were purchased from the local markets.

Prepared samples were divided into two brands, first brand is used in Egyptian popular prepared meals, that is, “onion in Koushari” and “Falafel”, second brand is used in Egyptian homemade meals, that is, fried noodles, fried rice and cooked rice.

Pre-frying treatments

Rice was pre-treated by different treatments before frying, that is, wash rice with water, washing rice and soaking in water for 20 min, soaking rice in citric acid (1%) for 20 min, soaking rice in acetic acid (1%) for 20 min, soaking rice in water “resulting from the soak of grape leaves” for 20 min, soaking rice in water “resulting from the boiling of grape leaves” for 20 min, soaking rice in water “resulting from the soak of poached grape leaves” for 20 min

Frying conditions

First: potato and rice were deep-fried in hot sunflower oil at each of two temperatures (110 and 175°C) for 15 and 20 min for each temperature; second: rice was deep-fried in hot oil at each of the five temperatures (100, 120, 140, 160 and 180°C) for 5, 10, 15 and 20 min of each temperature; Third: pre-treated rice was deep-fried in hot oil at 180°C for 10 min.

Determination of acrylamide

Samples preparation

Samples were allowed to swell adding water in an amount normally corresponding to 3 times the weight of the sample (more for exceptionally dry samples). Taking into consideration homogeneity and availability of the sample, often 25 g of sample and 75 ml of water were combined in a 150 ml beaker glass. 500 µg/kg of the two internal standards methacrylamide and D3-acrylamide (internal standard 1, IS1), was added, that is, 1 µl per 1 g of sample of a 500 mg/L acetonitrile solution. After mixing (Polytron, Kinematica, Luzern, Switzerland), the homogenate was allowed to swell during 30 min at 70°C in a water bath. The glass beaker was covered by aluminium foil to prevent evaporation of water.

Ten grams of the homogenate was weighed into a 100 ml centrifuge glass with a screw cap and thoroughly mixed with 40 ml of 1-propanol. When the solids form lumps, mixing was supported by a blender (Polytron). 10 ml (8.4 g) of the supernatant (possibly after centrifugation of 12 ml of turbid supernatant) was transferred to a 25 ml mark flask. Fifteen droplets (about 200 mg) of a vegetable oil were added and the water/propanol removed in a rotary evaporator at about 50 Torr and 60 to 70°C in a water bath. Evaporation was stopped as soon as no liquid was left. The residue from the evaporation, consisting of fat/added oil and often much salt, was extracted with acetonitrile and defatted with hexane. 3 ml acetonitrile and 20 ml hexane were added and mixed with the sample with the help of an ultrasonic bath. The acetonitrile (lower) phase was transferred into a 10 ml reagent glass with screw cap by means of a Pasteur pipette, losing acetonitrile rather than carrying along hexane. The acetonitrile phase was extracted by another 5 ml hexane, now transferring 1.5 ml of the acetonitrile phase (assumed to be half) into a 1.5 ml autosampler vial. Butyramide solution (internal standard 2, IS2) was added. For the common 25 g sample swollen with 75 ml water this meant 5 µl of a 25 mg/l solution in acetonitrile (Biedermann et al., 2002).

Acrylamide analysis by GC/MS

The analysis of the acrylamide was carried out using a GC (Agilent Technologies 7890A) interfaced with a mass-selective detector (MSD, Agilent 7000) equipped with Agilent HP-5ms (5%-phenyl methyl poly siloxane) capillary column (30 m × 0.25 mm i.d. and 0.25 µm film thickness). The carrier gas was helium with the linear velocity of 1 ml/min. The oven temperature was set at 100°C for 2 min and then programmed until 285°C at a rate of 50°C/min. The injector and detector temperatures were 250 and 250°C respectively. Injection mode, split; split ratio 1: 20, volume injected 1 µl. The MS operating parameters were as follows: ionization potential 70 eV, interface temperature 280°C. Selected ion monitoring (SIM) mode was applied used m/z at 44, 55 and 71 (Biedermann et al., 2002).

Statistical analysis

Statistical analysis (standard deviation ‘’SD’’ and standard error ‘’SE’’) was carried out according to Fisher (1970). LSD (Least significant difference) test was used to compare the significant differences between means of treatment (Waller and Duncan, 1969). The Costat program was used for all analysis.

RESULTS AND DISSCUSSION

Survey of acrylamide levels in some Egyptian foods

Acrylamide content in all sample types studied (market, prepared and homemade samples) are shown in Table 1. It was noticed that the highest mean acrylamide level values was in coffee "Bin Shaheen" with cardamom dark color (5181.61 µg/kg) which was a highly significant value compared with all of other samples, followed by Coffee "Bin Shaheen" with cardamom average color (699.81 µg/kg); whilst the lowest were for cooked rice at 2.05 µg/kg. The ANOVA analyses indicated that there were significant differences present between samples ($p \leq 0.05$). The mean of acrylamide concentration of all potato samples was 25.97 µg/kg ranged from 17.64 to 49.53 µg/kg which was non-significant with the mean of acrylamide levels in toast "Sun Bates" was 40.53 µg/kg.

On the other hand the highest mean levels in prepared meals was in onion "dark color " (309.35 µg/kg), followed by Onion in Koushari " light color " (78.52 µg/kg). In homemade samples, the highest mean value of acrylamide content was in fried noodles at 120°C/6 min (310.75 µg/kg) which was significant with fried noodles at 100°C/1.40 min (63.04 µg/kg). No significant differences in acrylamide content in fried rice sample under different time and temperature. Our results are in agreement with World Health Organization (2005), which reported that the acrylamide levels in coffee products ranged from <3 to 7300 µg/kg, also the acrylamide values of 95th percentile of coffee and coffee substitutes ranged from 641 to 8044 µg/kg in the year of 2010 according to EFSA (2012). On the other hand, acrylamide concentrations range of our market potato samples were 17.64 to 49.53 µg/kg) which lower than all potato chips tested by the

Table 1. Acrylamide levels (µg/kg) in some Egyptian food.

Food commodity	Number of samples	Acrylamide concentration (µg/kg)	Range
Market samples:			
Potato (Shipsey) with salt	1	28.06 ± 1.80[e]	24.57 - 30.72
Potato (Totch) with salt	1	19.01 ± 0.67[e]	17.97 - 20.25
Potato (Fox) with salt and Vinegar	1	20.68 ± 0.51[e]	19.74 - 21.51
Potato (Slice) with salt	1	20.51 ± 1.69[e]	17.64 - 23.31
Potato (Master Potato) with salt	1	41.58 ± 4.59[e]	33.63 - 49.53
Mean	5	25.97 ± 5.41	17.64 - 49.53
Toast "Sun Bates" with olive and thyme	1	41.33 ± 1.04[e]	39.42 - 43.02
Toast "Sun Bates" with olive	1	39.74 ± 0.50[e]	39.15-40.74
Mean	2	40.53 ± 0.63	39.15 - 43.02
Coffee "Bin Shaheen" with cardamom light color	1	29.64 ± 4.31[e]	23.04 - 37.74
Coffee "Bin Shaheen" with cardamom average color	1	699.81 ± 14.37[b]	673.38 - 722.82
Coffee "Bin Shaheen" with cardamom dark color	1	5181.61 ± 148.48[a]	4926.21 - 5473.02
Mean	3	1970.35 ± 809.92	23.04 - 5473.02
Peanut	1	22.62 ± 0.86[e]	21.33 - 24.27
Popular prepared Meals:			
Koushari " light color onion "	1	78.52 ± 0.75[de]	77.01 - 79.32
Koushari " dark color onion "	1	309.35 ± 8.02[c]	294.51 - 322.05
Mean	2	193.93 ± 51.74	77.01 - 322.05
Falafel " light color "	1	29.18 ± 2.61[e]	24.45 - 33.48
Falafel " dark color "	1	18.39 ± 1.32[e]	16.02 - 20.61
Mean	2	23.78 ± 2.74	16.02 - 33.48
Homemade samples:			
Fried noodles at 100°C for 1.40 min	1	63.04 ± 0.74[de]	61.59 - 64.14
Fried noodles at 120°C for 3 min	1	111.77 ± 1.96[de]	109.32 - 125.37
Fried noodles at 120°C for 6 min	1	310.75 ± 0.76[c]	309.63 - 312.21
Mean (100 - 120°C for 1.4-6 min)	3	192.93 ± 35.88	61.59 - 312.21
Fried rice at 115°C for 3 min	1	103.77 ± 1.44[de]	101.04 - 105.93
Fried rice at 115°C for 6 min	1	117.96 ± 4.67[de]	109.32 - 125.37
Fried rice at 120°C for 6 min	1	205.01 ± 1.96[cd]	202.20 - 208.8
Mean (115-120°C for 3-6 min)	3	142.25 ± 15.9	101.04 - 208.8
Cooked rice	1	2.05[e] ± 0.01	2.01 - 2.11
LSD 0.05		99.69	

Each value represents the mean ± S.E (Standard Error) and mean of three replicates.
Values in the same column with the same letter are not significant at $p \leq 0.05$.

U.S. Food and Drug Administration (2003) who reported that acrylamide concentrations ranged from 117 to 2510 µg/kg from different companies.

In addition, our results are in agreement with FEHD (2013); range indicated for acrylamide levels in fried onion ranged from 62 to 240 µg/kg. Also agree with FEHD (2003) values reported for boiled rice (< 3 µg/kg), while results are disagreement in fried noodles values (3 to 84 µg/kg), and fried rice values (< 3 to 67 µg/kg) (principally >120°C).

Table 2. Acrylamide levels (µg/kg) in fried rice and potato as affected by temperature and time.

Sample	Treatment		Acrylamide concentration (µg/kg)
	Temperature (°C)	Time (min)	
Rice	110	15	756.06 ± 0.96[h]
		20	1791.36 ± 15.3[c]
	175	15	2567.20 ± 24.5[b]
		20	3221.24 ± 18.4[a]
Potato	110	15	1340.40 ± 10.4[g]
		20	1509.63 ± 0.92[f]
	175	15	1618.21 ± 5.3[e]
		20	1711.98 ± 4.77[d]
LSD 0.05			38.74

Each value represents the mean ± S.E (Standard Error) and mean of three replicates.
Values in the same column with the same letter are not significant at p ≤ 0.05.

Effect of frying temperature and time on acrylamide formation

The effect of different temperatures and/or times on acrylamide formation in fried rice and fried potatoes results are recorded in Table 2. It was observed that the increasing frying temperatures from 110 to 175°C increased the acrylamide levels in rice and potatoes at different times; the same trend was noticed by time increasing from 15 to 20 min at the same temperature. The higher values of acrylamide (3221.24 and 2567.20 µg/kg) were found in fried rice at 175°C for 20 and 15 min, respectively. The lowest value of acrylamide concentration (756.06 µg/kg) was recorded in fried rice at 110°C for 15 min. Also, it was noticed a significant increases in all acrylamide values in fried rice compared with potatoes except at 110°C/15 min. Heating and time parameters have a direct influence on acrylamide formation in fried potatoes and fried rice. In food, acrylamide is produced in the course of Maillard reaction and its precursors are reducing saccharides and amino acid asparagine. Acrylamide formation in food depends on food composition and processing conditions. Significant quantities are formed during heat treatment above 120°C, mostly at 150 to 180°C, while at still higher temperatures the extent of formation decreases. The decrease may be explained by the fact that acrylamide as an intermediate product of Maillard reaction (Mikulíková and Sobotováb, 2007). Pedreschi et al. (2005) reported a significant increase in acrylamide level as the frying temperature increased from 150 to 190°C. They found that the acrylamide content of potato slices was about 500 µg/kg after frying for 7 min at 150°C as opposed to about 4500 µg/kg after frying for 3.5 min at 190°C.

Mattha¨us et al. (2004) showed that the amount of acrylamide was relatively low at temperatures between 150 and 175°C, whereas a drastic increase was observed at higher temperatures. The amount of acrylamide formed in French fries was about 800 ng/g after frying for 10 min at 170°C and increased to about 3700 ng/g after frying for 10 min at 190°C. Granda *et al.* (2004) indicated that the effect of frying temperatures (150, 165 and 180°C) on the acrylamide formation in potato chips (Atlantic variety) fried for a maximum of 6 min in a traditional fryer, acrylamide content increased significantly with frying time for all frying temperatures. The rate of acrylamide formation increased with temperature, and it was greatest (about 6.06 ppb/s on average) for the potato chips fried at 180°C. Chen et al. (2012) recorded that acrylamide levels in fried rice crust and fried potato ranged from 100.46 to 491.76 µg/kg and 58.40 to 4126.26 µg/kg, respectively.

From previous results showed significant increases in the concentrations of acrylamide in rice compared with potatoes. Frying rice is one of the methods used by Egyptians, so we went to study the effect of temperatures and time on the rice in more details. The results of the effects of different frying temperature and time on acrylamide formation in rice are recorded in Table 3 and Figure 2.

It is clear that the acrylamide concentration significantly increased by increasing in temperature at all different times, significant quantities are formed during heat treatment above 100°C specifically at a temperature of 120°C. In the same trend, by increasing frying time, the acrylamide concentration significantly increased at all different temperatures.

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Table 3. Acrylamide levels (µg/kg) in rice at different frying temperatures with different times.

Acrylamide concentration (µg/kg)							Acrylamide formation rate (ppb/°C)	
		Temperature (°C)					LSD 0.05	
		100	120	140	160	180		
Time	5	$36.22 \pm 0.79^{c*}$	$130.34 \pm 1.77^{d*}$	$165.19 \pm 1.2^{d*}$	$268.87 \pm 0.96^{d*}$	$1013.47 \pm 10.65^{d*}$	16.96	12.22
	10	$39.11 \pm 1.16^{c*}$	$170.43 \pm 1.44^{c*}$	$218.45 \pm 1.81^{c*}$	$748.94 \pm 1.9^{c*}$	$1302.36 \pm 2.28^{c*}$	5.57	15.79
	15	$42.42 \pm 0.39^{b*}$	$185.13 \pm 2.8^{b*}$	$267.06 \pm 1.71^{b*}$	$1453.10 \pm 1.45^{b*}$	$1860.28 \pm 1.05^{b*}$	5.31	22.72
	20	$128.80 \pm 1.33^{a*}$	$311.92 \pm 6.14^{a*}$	$369.68 \pm 4.57^{a*}$	$1755.34 \pm 3.92^{a*}$	$3066.38 \pm 0.93^{a*}$	12.34	36.72
LSD 0.05		3.24	14.21	8.72	7.66	17.92		
Acrylamide formation rate (ppb/s)		0.10	0.20	0.23	1.65	2.28		

Each value represents the mean ± S.E (Standard Error) and mean of three replicates.
Values in the same column with the same letter are not significant at $p \leq 0.05$.
Values in the same row with (*) are significantly at $p \leq 0.05$.

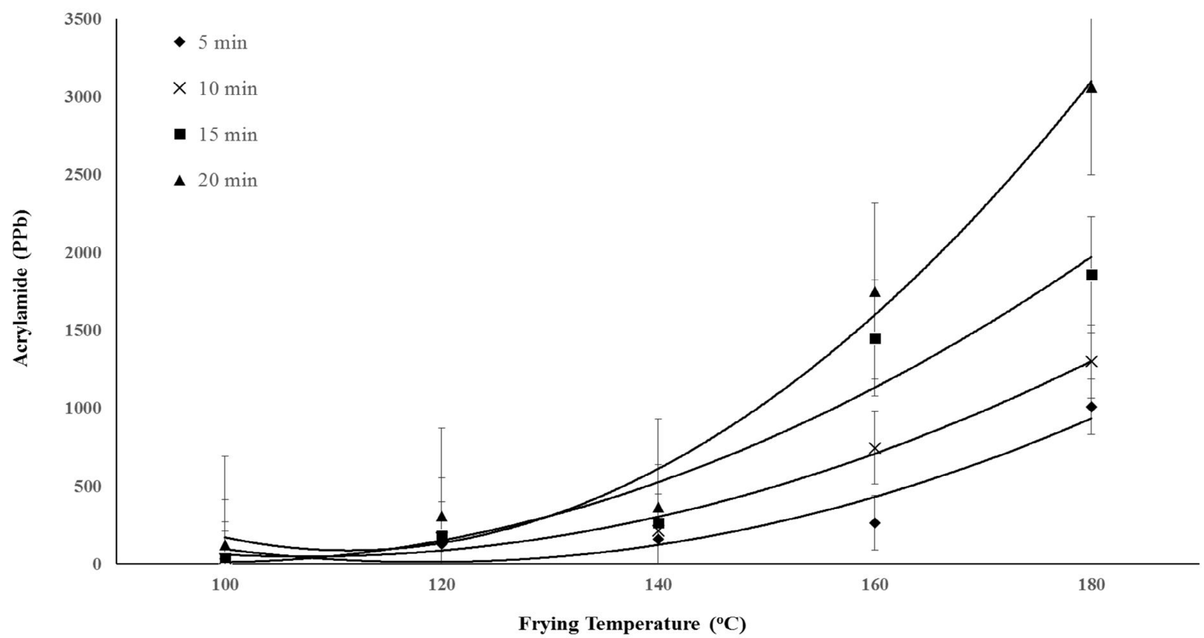

Figure 2. Effect of frying temperature on acrylamide content (ppb) of rice fried under atmospheric frying conditions. The solid lines correspond to a 2nd-order polynomial fit: 5 min = acrylamide (ppb) = 97.482[Temp.(°C)]^2 – 377.75[Temp.(°C)] + 379.8;10 min = acrylamide (ppb) = 94.762[Temp.(°C)]^2 - 258.07[Temp.(°C)] + 227.69; 15 min = acrylamide (ppb) = 116.65[Temp.(°C)]^2 - 209.51[Temp.(°C)] + 107.02; 20 min = acrylamide (ppb) = 255.98[Temp.(°C)]^2 - 804.03[Temp.(°C)] + 722.72.

Table 4. Acrylamide contents (µg/kg) of pre-treated rice with different treatments before frying at 180°C for 10 min.

Pre-treatment of rice	Acrylamide concentration (µg/kg)	% Reduction
Control	1302.36 ± 2.28[a]	-
Water washing	351.94 ± 1.4[b]	72.97
Washing and soaking in water for 20 min	130.43 ± 1.45[d]	89.98
Soaking in citric acid (1%) soaking for 20 min	80.96 ± 0.38[g]	93.70
Soaking in acetic acid (1%) soaking for 20 min	69.70 ± 0.82[h]	94.65
Soaking in water “resulting from grape leaves soaking” for 20 min	99.18 ± 1.63[f]	92.38
Soaking in water “resulting from grape leaves boiling” for 20 min	104.91 ± 0.78[e]	91.91
Soaking in water “resulting from poached grape leaves soaking” for 20 min	143.01 ± 1.18[c]	89.01
LSD 0.05	4.08	

Each value represents the mean ± S.E (Standard Error) and mean of three replicates.
Values in the same column with the same letter are not significant at $p \leq 0.05$.

acrylamide concentration significantly increased at all different temperatures. The highest acrylamide value was 3066.38 µg/kg was recorded at 180°C/20 min followed by 1860.28 and 1755.34 µg/kg at 180°C/15 min and 160°C/20 min, respectively. The lowest acrylamide value was 36.22 µg/kg at 100°C/5 min. The average acrylamide formation in fried rice (between 100 and 180°C) increased by increasing time from 5 to 20 min and from 12.22 to 36.72 ppb/°C. Also this average rate was increased by time in temperature range between 100 and 180°C by about 228 folds (0.10 to 2.28 ppb/s).

These results are disagreement with FEHD (2003), who reported that deep fried rice value is 67 µg/kg (principally >120°C).

The reduction of acrylamide formation in rice by different pre-frying treatments

The main goal of this part of our investigation was to study the effects of different pre-frying treatments on reduction of acrylamide formation of fried rice at 180°C for 10 min.

Hanley et al. (2005) to mitigate acrylamide formation in fried potatoes: (i) prevention of acrylamide formation by acrylamide removal of the essential precursors (asparagine and a source of a carbonyl moiety—generally a reducing sugar); (ii) interruption of the reaction by the addition of chemically reactive compounds that are able to react with intermediates in the Maillard reaction; (iii) removal of acrylamide after it has been formed; and (iv) minimization of acrylamide formation by changing frying conditions (frying temperature, pressure, time, etc).

The principal objective of our pretreatments is either to minimize the concentration of acrylamide precursors in rice or to minimize or to inhibit Maillard reaction during frying. The acrylamide reduction percentages of different pre-frying treatments are recorded in Table 4. These results show that the formation of acrylamide was higher in control than in pre-treated samples. Soak rice in acetic acid (1%) for 20 min caused the highest significant ($p \leq 0.05$) decreases in acrylamide content compared with control. This reduction was 94.65% followed by soak rice in citric acid (1%) for 20 min, which gave acrylamide reduction by 93.7%. Organic acids, such as citric, acetic and lactic acid reduced the final acrylamide content, but merely due to a reduced pH (Mestdagh et al., 2007). Lowering the pH using organic acids of the food system to reduce acrylamide generation may attribute to protonating the α-amino group of asparagine, which subsequently cannot engage in nucleophilic addition reactions with carbonyl sources (Jung et al., 2003). Lowering the pH of the cut potatoes (e.g., with citric acid 0.5 to 1.0% < 20 min) has been shown to lower the levels of acrylamide formed (Jung et al., 2003). Also, our results were in agreement with Ismial et al. (2013) who found that potato slices soaked in 0.01 and 0.05 M of citric acid and 0.3 M of acetic acid had significantly reduced acrylamide levels in fried potato by 97.47, 96.96 and 90.40%, respectively.

Soak rice in water “resulting from the soak of grape leaves” for 20 min and Soak rice in water “resulting from the boiling of grape leaves” for 20 min before frying significantly reduced the acrylamide levels by 92.38 and 91.91%, while soak rice in water “resulting from the soak of poached grape leaves” for 20 min reduced acrylamide level by 89.01%. The lowest percentage of acrylamide reduction was 72.97% by wash rice with water. On the other hand, wash rice and soak in water for 20 min reduced acrylamide levels by 89.98%.

Soaking of rice in water or different solutions caused significant reduction in the formation of acrylamide. Some authors reported that the reduction of the sugar content by soaking could decrease acrylamide concentration by about 60% in potato chips (Haase et al., 2003; Pedreschi et al., 2004). Soaking process leads to a higher leaching of one important acrylamide precursor such as glucose that finally results in lower acrylamide formation (Pedreschi et al., 2004).

Conclusion

In conclusion, the present results clearly refer to the highest mean acrylamide level value was in coffee "Bin Shaheen" with cardamom dark color (5181.61 µg/kg). The highest mean levels in prepared meals was in onion "dark color " (309.35 µg/kg), while in homemade samples, the highest mean value of acrylamide content was in fried noodles at 120°C/6 min (310.75 µg/kg). In addition, the highest acrylamide value was 3066.38 µg/kg at 180°C/20 min followed by 1860.28 and 1755.34 µg/kg at 180°C/15 min and 160°C/20 min, respectively. The effects of different pre-frying treatments on reduction of acrylamide formation of fried rice at 180°C for 10 min were studied. Soak rice in acetic acid (1%) for 20 min caused the highest significant ($p \leq 0.05$) decreases in acrylamide content compared with control. This reduction was 94.65% followed by soak rice in citric acid (1%) for 20 min, which gave acrylamide reduction by 93.7%. Soaking of rice in water or different solutions caused significant reduction in the formation of acrylamide.

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