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ACRYLAMIDE LEVELS IN HEAT-TREATED EGYPTIAN FOODS

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ABSTRACT

This study was conducted to determine the acrylamide levels in selected heat-treated food items, commercially determine foods from the Egyptian market As with some home-prepared foods as part of the traditional ways of food preparation to study the impact of the temperature and time on formation of acrylamide which classified as a Group 2A carcinogen by the International Agency for Research on Cancer that affect the human nervous system. Acrylamide levels were determined in around 70 food samples using liquid chromatography coupled to U.V spectrometric detection LC-UV and the results were expressed in µg kg^{-1}. The food items were also subjected to the relevant high-temperature>120°C or contain high carbohydrates and asparagines as well as those exposed during the processing to high temperatures. The investigated samples included cereal productssnack, rice, pasta noodles, tuberssweet potato, nuts almonds, pine nuts and chestnut & legume, vegetables potatoes, onion,dried fruitsraisins, dates& prunes,,sauces and beverages coffee, cocoa . Roasting and frying experiments under different process conditions were done on potatoes, sweet potato, pasta, rice, corn and noodles which represents a different preparation ways showed that acrylamide increases with the length of exposure to heat; surface color browning as an indicator of acrylamide levels in some foods; and that time has a much stronger effect on acrylamide formation than temperature. The obtained results showed that the acrylamide content ranged from < 11-1845 µg/kg. Highest acrylamide concentrations were found in roasted nuts, while only moderate acrylamide contents were found in dried fruits and roasted bakery product. While the lowest value were in fried sweet and bean flafel.

Keywords: Acrylamide, Egyptian food, Snacks, Coffee, Dried fruits, Nuts, Sweet potato, Roasting, Baking, HPLC.

INTRODUCTION

Acrylamide or acrylic amide is a potentially dangerous chemical compound with the chemical formula C_3H_5NO. Its IUPAC name is 2-propenamide. Acrylamide, an α,β-unsaturated reactive molecule (*Allan, 2002).*

Acrylamide was accidentally discovered in foods in April 2002 by scientists in Sweden when they found the chemical in starchy foods, such as potato chips, French fries , bread and later in coffee that had been heated (*Swedish National Food Agency, 2002)*. Based on current stage of knowledge, acrylamide is a natural byproduct that forms when certain carbohydrate-rich foods are fried, baked, or roasted at high temperatures above 120 °C. (*Svensson et al., 2003).*It was not found in food that had been boiled *(Tornqvist, 2005*) nor in foods that were not heated (*Ahn et al., 2002).*
Acrylamide is found in many common food products; in total, these foods represent approximately 40% of calorie intake (*Petersen, 2003).* Acrylamide

is present mostly in plant-based foods, in particular potato and wheat products that are cooked at high temperatures. Exposure assessments have identified those foods that contribute most significantly to intake. In general, fried potato, breakfast cereals are the most significant sources of dietary acrylamide in the U.S. diet, but bread and coffee also are important sources. For infants and children, cookies biscuits may be a significant source of acrylamide. Not surprisingly, the top acrylamide sources vary somewhat by country, depending on local food choices (*Dybing et al. 2005).* Food items with relatively low acrylamide concentration, consumed in great quantities—such as bread—may be important sources of acrylamide exposure because exposure considers both acrylamide concentration and food consumption. Several studies also have made the important point that the food groups contributing most to exposure are different for the low-percentile, average and high-percentile consumer (*Matthys et al., 2005).* Cooking temperature is directly related to acrylamide concentration. In general, the higher the cooking temperature, the higher the concentration of acrylamide.

FDA does not recommend reducing intake of healthful grain products e.g., whole grain cereals that are a good source of whole grains and fiber. Reduced baking temperature and prolonged heat treatment is favorable. As a result, a reduction of the processing time led to lower concentrations of acrylamide in the product.

Acrylamide levels appear to rise as food is heated for longer periods of time. Though researchers are still unsure of the precise mechanisms by which acrylamide forms in foods, many believe it is a byproduct of the Maillard reaction. In fried or baked goods, acrylamide may be produced by the reaction between asparagine and reducing sugars fructose, glucose, etc. or reactive carbonyls at temperatures above 120 °C 248 °F (*Stadler et al., 2004).* It has been shown that acrylamide is formed during the cooking of foods principally by the Maillard reaction between the amino acid asparagine and reducing sugars such as glucose (*Mottram et al., 2002).*

The recent discovery that acrylamide is formed in significant quantities during high-temperature cooking of animal feed (*Tareke et al., 2000)* and that it is measurable at significant concentrations in many common human foods that are prepared by cooking at high temperatures *(Svensson et al., 2003)*, especially frying, baking or drying, introduced a new and unexpected dimension to carcinogenic risk assessment for acrylamide, one that is still evolving. Acrylamide is a rodent carcinogen and a human neurotoxin and is classified as a probable human carcinogenbe generated by pyrolysis of nitrogen-containing compounds leading to the formation of acrylamide. The second hypothesis is that acrylamide could be formed alone, by rearrangement, from nitrogen-containing compounds already present in foods (*EFSA, 2004).*

Since acrylamide has been classified as a Group 2A carcinogen by the International Agency for Research on Cancer (*IARC, 1994).*

The harmful effects of acrylamide have been proposed to be caused by its neurotoxicity (*LoPachin,2006)* genotoxicity (*Allen et al.,2005*) ,carcinogenicity (*Pelucchi et al., 2005*) reproductive and developmental toxicities (*Fennell et al., 2004*)and cancer risk (*Mucci et al., 2004) .*

Using limited data, an FAO/WHO Expert Consultation estimated daily acrylamide intake at 0.3–0.8 µg g/kg body weight bw/day (*UNFAO/WHO 2002).*

Percentile of consumption, the daily intake values range from 0.6 to 4 µg g/kg-bw/day. Children and/or adolescents typically have higher dietary acrylamide intakes than adults on a bw basis, both because of the higher consumption of certain acrylamide-containing foods such as potato chips and french fries and because children have a lower mean bw than adults (*Dybing et al., 2005).*

Finally; Arabian traditional carbohydrate-rich foods are an all-time favorite in Arab countries. These including a special wide range of traditional products, may represent high-risk levels of acrylamide under heating processes. Hence, the determination of acrylamide level in such foods is highly important in order to improve and control manufacturing process and evaluate the risk of consumption. To our best knowledge, there is a little information reported on the level of acrylamide in Arabian area (*Tawfik and El-Ziney, 2008)*. Accordingly this study was carried out to determine the levels of acrylamide in selected traditional Egyptian foodstuffs. Also, the effects of different thermal-processing treatments on the acrylamide levels were studied.

MATERIALS AND METHODS

Chemicals:

All chemicals HPLC grade were obtain from Merck,Germaney, acrylamide 99% was obtained from Sigma ,USA .

Materials:

More than seventy food samples namely bread, pasta, rice, cakes, potatoes, coffee, fried nuts, fried onion, dried fruits and canned olive these samples were obtained from local market,Cairo,Egypt. The samples were divided into seven groups.

Preparation of the samples:

1st group

Contains 18 samples

- Three ,barbeque Corn stalks for 8 min on direct burn hot charcoal until the out layer become dark brown **;**
- Three fried Buffy extruded snack samples purchased from local market in sunflower oil frying temp. 200°C for 2, 4, 6 min.
- One sample roasted peanut from local market
- Also two roasted hazelnut sample at 180 °C for 10, 15 min.
- One fried hazelnut at 180C/5min.
- Two samples fried almond at 180°C for 3,5 min.
- Two fried pin nuts samples treated at 180°C for 3,5 min.;
- Two chestnut samples baked on oven at 300°C for 20,30 min,-and at last two pop corn samples prepared by roasted special corn in corn oil at 220°Cfor 3 min. until the puffing of pop corn then one sample of it investigated .

- Other sample was a roasted rest not buffed corn seed.

2st group beverage group includes 5 Samples.

Arabic coffee, dark Arabic Coffee Turkish, instant coffee , light cacao , dark cacao acrylymide level determined in dry powder for all previous samples.

3rd group contains five samples

- Two bread Arabian roasted white bread, flat, thickness 5 mm, and 10mm thickness , produced from white wheat flour ,leavened by yeast fermentation, relatively roasting time 8 min. at 300-350°C
- Roasted boksomate type of ground dry bakery products obtained from local market
- Cake composed of white flour milk, sugar, butter, egg and leavened by sodium bicarbonate, long baking time 20 min. at 280-300°C.
- Kataief fried fermented dough stuffed with nuts and rolled type sweet, substantial browning crust, deep-fried at 160-180°C for 6-8 min. in sunflower oil, composed of flour, milk and leavened by yeast.

4nd group includes 17 fried samples 5 Samples rice fried at 220°C for 2,4,6,8,10 min., and 6 samples for each kind of pasta Shearia, and noodle for soup Lesan el Asfour, All samples fried in butter at 220°C for 1,2,3,4,5,6 min.

5th group contains Medium white potatoes were peeled, sliced into pieces approximately 3 mm , 30 mm and 40 mm, and fried in batches of 100 g in 200 mL of preheated sunflower oil in an frying pan at 175°C for 5,10,12 or 15 min. Frying temperature in the French fries fried at 170–190°C for up to 15 min., Sweet potato sample was baked in oven at 280° for 30 min .the last sample in this group was the outer layer of previous Sweet Potato sample.

6th group includes 9 samples;

- One fried onion rings sliced 3mm thickness and fried in sunflower oil for 180°C/10 min.
- Second sample was a , *flafel is made from* soaked and blended beans with onion, parsley, cilantro, garlic, baking powder, salt, cumin and crushed red pepper, flour,the falafel balls was fried at sunflower oil, two inches deep 350°C for 5min until they become crispy and turn a golden brown color.
- Outer layer of fried chicken slices which dipped in egg, salt and powder boksomat fried in oil at 200°C for15 min.
- Outer layer of fried fish which dipped in whole flour and fried in sunflower oil at 200°C/10 min.
- The last five samples includes white sauce Bashamiel composed from butter ,flour, milk, salt on different time of heat treatment at 170°C for 3, 5,8,10,12 min.

7th group includes six samples

- Three samples for canned black olive, dried date and prunes were purchased from local market.
- Three raw raisins
- Two, fried raisin samples in oil and butter at 180°Cfor 2 min.

Methods:

A simple and convenient analytical method for the determination of acrylamide in processed foods was used (*Terada, 2003).* In general, the given sample In the case of dry ,two grams of the fine-grained sample were weighed in on a filter paper ,pre-dried, crushed/minced, degreased The sample preparation entails extraction of acrylamide with methanol, purification with Carrez solutions, evaporation and solvent change to water, and clean-up with an Oasis HLB solid-phase extraction SPE cartridge. and acrylamide was water extracted at 60°C in a ultrasonic bath. The aqueous solution was clean-up using a Carrez-Precipitation followed by centrifugation. The clean-up extract was then analyzed by HPLC. In the case of complex matrices, clean-up extract was directly re-extracted with ethylacetate and acrylamide in organic phase was analyzed by HPLC. Acrylamide was extracted with methanol in an ultrasonic bath. The HPLC system dionex ultimate 3000. At first, the sample solution was chromatographed on an ODS column with a mobile phase of water, then the flow of the mobile phase was 0.6 ml/min., and the eluate was syring-filtered waters 0.45 µm, in an autosampler-vial monitored with a UV detector 205 nm. A three replicates had been done for each sample.

RESULTS AND DISCUSSION

The acrylamide content was found to vary considerably between different food groups in this study, food samples from seven food groups subdivided into ٧٠ sub - groups were analyzed for their AA contents. From the current study conducted, the level of acrylamide in different samples which represented a significant part of Egyptian diet ; acrylamide content ranged from 11-1845 µg kg^{-1}.

Acrylamid content in roasted and fried nuts:

Acrylamide concentrations in roasted and fried nuts were in the range of 79–1845 µg/kg whereas only low amounts 79 µg/kg were found in roasted peanut. However, the median acrylamide contents were in a roasted almond 120 µg/kg and in chestnut sample was 221 µg/kg. The influence of the roasting time on the acrylamide content in roasted chestnuts was evaluated to give value 904 µg/kg after 15 min.and 1285 µg/kg in roasted hazelnut. the roasting time has a significant influence on the acrylamide formation., and it is noticed that comparing frying and roasting, frying causes the highest acrylamide formation. Roasting causes less acrylamide formation; if the time factor was taken in consideration. Acrylamide ratio increased ten folds from 144 to 1845 µg/kg in pine nut by increasing the frying time from 3 to 5 min. During roasting reducing sugars are consumed faster and to a larger extent than free asparagine, suggesting that the content of reducing sugars may be a critical factor for acrylamide formation in roasted almonds, In spite of the differences ,in the 6th group which include the snacks food products ; the mean AA level in a kind of fried Buffy locally snacks was 550 µg kg^{-1}.while the home made pop corn show a low level of AA23 µg kg^{-1} and the rest dark close pop corn seed give high AA value 750 µg kg^{-1},the last sample in this group was the grilled corn stalk on charcoal which give values ranged from 269, 356 and 1690 µg kg^{-1} for the dark brown stalk this fifth AA concentration was observed in dark grilled corn stalk is represented a significant part of Egyptian snacks especially for children . Similarly, more acrylamide was formed in “dark” roasted pine nut 1845 µg/kg wet weight, than “light” 144 µg/kg .also the highest levels in the most processed highest frying times/temperatures and the most highly browned fries. During roasting reducing sugars are consumed faster and to a larger extent than free asparagine, suggesting that the content of reducing sugars may be a critical factor for acrylamide formation in roasted almonds. Acrylamide was found to decrease in roasted almonds during storage at room temperature. Acrylamide concentrations in roasted chestnuts were in the range of <8–1278 µg/kg whereas only low amounts <4–159 µg/kg were found in chestnut products. However, the median acrylamide content of the roasted chestnut samples was 90 µg/kg. The influence of the roasting time on the acrylamide content in roasted nuts was evaluated too. As with roasted and other fried products, the roasting time has a significant influence on the acrylamide formation. Therefore, the consumers might be exposed to significant amounts of acrylamide by eating roasted nuts. Comparing frying and roasting, frying causes the highest acrylamide formation. Therefore, the consumers might be exposed to significant amounts of acrylamide by eating dark roasted nuts.

Table (1): influence of thermal-processing on acrylamide level in nuts and snacks samples.

Nuts and snacks samples	Thermal processing (frying &Roasting) C°/min.	Acrylamide content (µg kg^{-1})
Fried Pin nut	180°C for 3 min	144
Fried Pin nut	180°C for 5 min	1845
Roasted chest nut	300°C for 20min,	221
Roasted chest nut	300°C for 30 min,	904
Roasted peanut		79
Roasted hazelnut	180 °C for 10min.	585
Roasted hazelnut	180 °C for 15 min	1285
Fried hazelnut	180°C/5min	881
Fried almond/	180°C for 3min.	120
Fried almond	180°C for 5 min	1300
Fried Buffy snack	200°C for 2 min.	354
Fried Buffy snack	200°C for ,4 min	518
Fried Buffy snack	200°C for,6 min	542
Pop corn	220°Cfor 3 min	23
Pop corn/ fried not Buffy seeds	220°Cfor 3 min	750
Grilled corn (yellow)	Direct barbeque 3/ min.	<10
Grilled corn (golden brown)	Direct barbeque 5/ min.	269
Grilled corn (dark brown)	Direct barbeque 8/ min.	690

Acrylamide levels in beverage products:

In regard to beverage group coffee drink Table (2), highest amount of AA was observed in soluble coffee 710 µg kg^{-1} followed by roasted dark arabic coffee 480 µg kg^{-1} with lower amount in light cocoa 201µg kg^{-1}.

Asparagine is the limiting factor for acrylamide formation in coffee. 3-Aminopropionamide formation was observed with mixtures of asparagine with sugars sucrose, glucose. Thermal decarboxylation and elimination of the α-amino group of asparagine at high temperatures >220 °C led to a measurable formation of acrylamide (*Taeymans et al. ,2004)* As shown by previous data soluble coffee contained significantly larger amounts of acrylamide than Arabica coffee . Acrylamide is not a stable molecule, and in coffee; most acrylamide is formed in the early stages of the roasting process, reaching > 7 mg/ kg and then declining steeply toward the end of the roasting cycle because of higher rates of elimination. 95% of the acrylamide formed is degraded during roasting, and darker roasted coffee beans have been shown to have lower concentrations of acrylamide than lighter roasted coffees (*Taeymans et al. ,2004).* In coffee, acrylamide is not stable and In some products such as roasted coffee, prolonged heating or heating at very high temperatures can decrease acrylamide in the packed finished product, and concentrations have been shown to decrease with storage time, with losses of up to 60% throughout several months recorded for ground coffees stored at room temperature (*Andrzejewski et al., 2004).* Acrylamide forms in coffee when coffee beans are roasted, not when coffee is brewed at home or in a restaurant. So far, scientists have not found good ways to reduce acrylamide formation in coffee. Based on FDA studies.

Table (2): Acrylamide (AA) levels in selected beverage groups.

Food category		**Acrylamide level (μg kg^{-1})**
Beverage Group	Arabic coffee	272
	Arabic dark coffee	480
	Soluble coffee	710
	Light cocoa	206
	Dark cocoa	201

Acrylamide levels in bakery products:

In group three bakery products clearly demonstrates that formulation and baking technology have strong influence on the acrylamide content in the baked products the roasted balady bread contained higher AA 968 μg $kg^{-1)}$than thick balady bread746μg kg^{-1} ,while the AA in ground toast boksomat was 894 μg kg^{-1}; and the baked cake was 229 μg kg^{-1}; (table 3) AA formation is varied depending on flour type, ingredients, temperature/time and layer thickness. In the two treatment of fried kataief samples there wasn't detectable level of acrylamide for 6 min. and 18 μg kg^{-1} which still achieve the lowest level . Food items with relatively low acrylamide concentration, consumed in great quantities— such as bread—may be important sources of acrylamide exposure because exposure considers both acrylamide concentration and food consumption. Several studies also have made the important point that the food groups contributing most to exposure are different for the low-percentile, average, and high-percentile consumer

(*Matthys et al., 2005).* Cooking temperature is directly related to acrylamide concentration. In general, the higher the cooking temperature, the higher the concentration of acrylamide. For example, bread crust, which reaches higher temperatures than the soft part of bread called the crumb, has more acrylamide than the crumb. No acrylamide has been reported in uncooked foods. A significant source of dietary acrylamide is foods cooked and prepared at home, by catering services, or served in restaurants. For example, when bread white or brown is toasted, the acrylamide content increases by nearly tenfold depending on the toasting time and temperature (Ahn *et al. 2002).* Approximately 50% of acrylamide intake may be from such sources, but quantitative data are scarce (*Dybing et al., 2005).*

Table(3): Acrylamide (AA) levels in selected bakery products.

Bakery and sweet products	**Acrylamide content(µg kg^{-1})**
Boksomat(ground toast)	894
Toasted balady bread (8 min. at 300-350°C)	968
Toasted thick balady bread min. at 300-350°C	746
Baked cake 20 min. at 280-300°C	229
Kataief(160-180°C for 6 min.)	<10
Kataief(160-180°C for 8 min.)	18

Acrylamide in starchy foods:

In starchy food the results (Table 4) show a clear example about the correlation between time of thermal processing frying and the content level of AA . in fried Shearea kind of pasta made from wheat flour the AA level increased from 102 to 228 µg kg^{-1} by increasing the time of frying ; for the same AA increased by seventh times in fried noodle lesan el asfour from 90 to 279 µg kg^{-1} ; for the previous reason ,also the fried rice content of AA elevated from 60 to 257 µg kg^{-1} this degree of strong frying represent a manner way of cooking to large sector in Egyptian community. As a result, a reduction of the processing time led to lower concentrations of acrylamide in the product.

It is well established that high oil temperatures during frying strongly increase acrylamide formation in French fries, In most fryers, the oil temperature strongly drops on adding the potato sticks and may not fully recover up to the end of the frying process depending on the amount of potato added in relation to the volume of oil and the heating power of the fryer. An initial temperature of 170–175 °C dropping to 140–145 °C and a virtually isothermal frying at 160 °C resulted in products of similar quality and acrylamide content. In group four; amongst the ,three samples of fried potato our findings revealed that the levels of acrylamide vary considerably by time of frying, ranging from a low level of 10<123 µg/kg to 467 to 883µg/kg ;while in five samples of baked sweet potato the acrylamide levels were found to be in the range of < 10µg/kg , 80 ,756 to 865 µg/kg the result showed that the outer layer of baked sweet potato contain a high level of AA equal 1185 µg kg^{-1}.which mean that this layer must exclude from edible part. In this experiments conducted, It was found that acrylamide levels in cooked food depended greatly on the cooking conditions and the degree of “doneness”, as measured by the level of surface browning. For example, French fries fried at 170–190°C for up to 15 min had acrylamide levels of 123 to 883 µg/kg, with the highest levels in the most processed highest roasting times/temperatures and the most highly browned fries. To aim for a golden yellow instead of a brown colour after frying at temperatures not higher than 175°C, has been recommended as an approach also for home cooking (*EU, 2003).*

Table (4): influence of thermal-processing on acrylamide level in starchy food samples.

Cooked Starch-Enriched Food	Thermal Processing(frying) Temp.°C/ time (min.)	Acrylamide level(µg kg^{-1})
Shearea (same color)	220°C / 1 min.	<10
Shearea (yellow)	220°C / 2 min.	<10
Shearea (golden yellow)	220°C / 3 min.	102
Shearea (golden brown)	220°C / 4 min.	122
Shearea (brown)	220°C / 5 min.	191
Shearea (dark brown)	220°C / 6 min.	228
Noodle for soup (lesan elasfour) (same color)	220°C / 1 min.	<10
Noodle for soup (lesan elasfour) (yellow)	220°C / 2 min.	<10
Noodle for soup (lesan elasfour) (golden yellow)	220°C / 3 min.	90
Noodle for soup (lesan elasfour) (golden brown)	220°C / 4 min.	135
Noodle for soup (lesan elasfour) (brown)	220°C / 5 min.	232
Noodle for soup (lesan elasfour) (dark brown)	220°C / 6 min.	279
Fried rice (same color)	220°C / 2 min.	<10
Fried rice (yellow)	220°C / 4 min.	<10
Fried rice (dark yellow)	220°C / 6 min.	60
Fried rice (brown)	220°C / 8 min.	173
Fried rice (dark brown)	220°C / 10 min.	257

Table (5) :The effect of thermal treatment on acrylamide level in frying potato &sweet potato samples.

Frying treatment (temp. °C/time min.)	fried potato &sweet potato	Acrylamide level(µg kg^{-1})
175°C for 5 min.	Fried potato	<10
175°C for 10min.	Fried potato	123
175°C for 12min.	Fried potato	467
175°C for 15min.	Fried potato	883
30 min./280°min.	Baked Sweet potato	<10
	Baked Sweet potato	80
	Baked Sweet potato	756
	Baked Sweet potato	865
	Outer layer of baked sweet potato	1185

In fifth group which related with some traditional food staffs the content of AA level gave a lower content in fried bean and vegetable known as tammia 11 µg kg^{-1}, followed by fried onion which use as one ingredient of koshary , bosara ,fata and keshk dishes 36 µg kg^{-1} . AA concentration was observed as half in fried fish out layer 20 µg kg^{-1} in compared to fried chicken out layer 38 µg kg^{-1} . In this experiments conducted, It was found that acrylamide levels in cooked food depended greatly on the cooking conditions and the degree of “doneness”, as measured by the level of surface browning. For example, more acrylamide was formed in “dark” cooked white sauce 282 µg/kg wet weight, than “light” 39 µg/kg or “medium” 203–205 µg/kg cooked. This indicates that the degree of surface browning could be used as an indicator of acrylamide formation during cooking also, Addition of other free amino acids or a protein-rich food component strongly reduced the acrylamide content, probably by promoting competing reactions and/or covalently binding acrylamide formed. As a result of last group which include dried fruits showed that the dried date give a lower value of AA <10 µg/kg and a moderate level of AA in raw raisin 131 µg/kg ,there was a slight increment in AA level due to frying treatment of raisin but there wasn’t a significant difference between frying in oil and butter. Also prunes gave AA value 462 µg/kg while the highest content was in canned black olive given550 µg/kg which achieve the highest value in all investigated samples in these group.

Although; Acrylamide formation occurs primarily at elevated cooking temperatures used when frying or baking above 120°C and in low moisture conditions. There are also several a food in which acrylamide appears to form in high-moisture conditions at lower temperatures, such as prune and canned ripe black olives. FDA detected acrylamide in these foods during sampling of foods that are part of FDA’s Total Diet Study program.*USFDA* in analysed samples of group eight unexpectedly discovered acrylamide in Canned black olives samples contain relatively high amounts of acrylamide .Acrylamide in olives, prunes, and dried pears develops through another process. Genetics professor *(Joe Cummins,2002*)suggests a link between acrylamide and herbicides such as glyphosate Roundup, citing studies which show that heat and light can decompose polyacrylamide, the thickening agent used in commercial herbicides, into acrylamide *(*Joe Cummins, 2002)acrylamide could be produced from oils and nitrogen-containing compounds present in foods. The most plausible scheme would include the formation of acrolein from the thermal degradation of glycerol *,* oxidation of acrolein to acrylic acid, and finally reaction of acrylic acid with ammoniaswhich potentially couldmption FSA,2008 prompted us to investigate the levels and sources of acrylamide in the Egyptian food supply.

Table (6): Acrylamide (AA) levels in selected Egyptian traditional foodstuff.

Fried sauce and vegetable products	Thermal treatment (Temp. °C/Time min.)	Acrylamide level(µg kg^{-1})
Fried onion	180°C/10 min and	36
Fried tammia	350 degrees for 5min	<10
Outer layer of fried chicken	200°C/15 min.	38
Outer layer of fried fish	at 200°C/10 min.)	20
White sauce (bashamiel)	170°C for 3 min.	39
White sauce (bashamiel)	170°C for 5 min.,	203
White sauce (bashamiel)	170°C for 8 min.	205
White sauce (bashamiel)	170°C for 10min.	266
White sauce (bashamiel)	170°C for 12min.	282

The more recent finding of acrylamide in black olives and prune juice (Roach *et al.*, 2003) and in laboratory animal feed sterilised by autoclaving (*Twaddle et al., 2004*)may implicate the involvement of another route of formation during curing or at lower temperatures. The exact chemical mechanism(s) for acrylamide formation in heated foods is unknown. Several plausible mechanistic routes may be suggested, involving reactions of carbohydrates, proteins/amino acids, lipids and probably also other food components as precursors. With the data and knowledge available today it is not possible to point out any specific routes, or to exclude any possibilities. It is likely that a multitude of reaction mechanisms is involved. Acrolein is one strong precursor candidate, the origin of which could be lipids, carbohydrates or proteins/amino acids. Thus different mechanisms of formation should be considered in specialty food as yet unknown to be a classical source of acrylamide formation. Even if the overall acrylamide exposure of the average consumer will probably not be influenced by acrylamide from products such as prune juice or olives, special food types may well be relevant for specific subgroups of consumers, as e.g. certain age groups, consumers with a special diet due to diseases, or cultural subgroups.

Table (7): Acrylamide (AA) levels in certain dried fruits and canned black olive products.

Dried fruits and canned black olive	Thermal treatment (Temp. °C/Time min.)	Acrylamide level(μg kg^{-1})
Dried prunes		462
Dried date		<10
Black pickled olive		550
Raisin raw		131
Fried raisin in oil	180°C/2min	135
Fried raisin in butter	180°C/2min	145

A study by the U.S. Food and Drug Administration FDA proposed a mechanism that involves asparagine, which, when heated in the presence of glucose, forms acrylamide. Browning during baking, frying or deep-frying will produce acrylamide, and over-cooking foods may produce large amounts of acrylamide. Acrylamides can also be created during microwaving. In daily life, acrylamide can be formed during the cooking and processing of foods via the decarboxylation of the Schiff base derived from carbonyl reactants, resulting in human consumption of relatively high doses of acrylamide (*Rydberg et al., 2005)*.

Maillard pathway leading from asparagine to acrylamide is complex and may involve very different intermediates. (*Mottram et al., 2002)* proposed that "Strecker degradation" is involved. (*Yaylayan et al., 2003) and(*Zyzak *et al.*, 2003)provided evidence for an alternative route involving the early decarboxylation of the asparagine *N*-glycoside.Alternative Mechanisms of Acrylamide Formation Model studies have shown that acrylamide can be formed by several indirect routes. For example, both *acrolein* and its oxidized product *acrylic acid* may react with ammonia to produce acrylamide (*Becalski et al., 2003).* In model experiments, reacting equal moles of glucose with *aspartic acid* at temperatures >120°C led to a yield of acrylic acid comparable to that of acrylamide from an analogous reaction with asparagine plus glucose, indicating a common route to vinyl compounds from the corresponding free amino acids and sugars (*Stadler et al., 2003)*. In certain conditions, acrolein together with asparagine may lead to the formation of acrylamide (Yasuhara *et al.*, 2003). In this instance, acrolein rather than reducing sugars provides the carbonyl group for the Maillard reaction. Additionally, aspartic acid also can be converted to acrylic acid without the involvement of sugars or a carbonyl source following a concerted *decarboxylation/ deamination pathway* (*Yaylayan and Stadler 2005).* Preliminary studies have shown that other amino acids such as L-alanine and L-arginine also are capable of releasing acrylic acid at temperatures above 180°C, with yields within the same order of magnitude as aspartic acid.Carnosine in meat products can generate -alanine through hydrolysis to form acrylic acid and eventually acrylamide or its derivatives (*Yaylayan and Stadler* 2005)*. (Yaylayan et al., 2004)*found that creatine, a component of meat, may form N-methylacrylamide in cooked meat, but the importance of this formation is not known. Only low concentrations of acrylamide have been reported for cooked meat products. Another route to the formation of acrylamide, which may occur in potatoes, is through the enzymatic decarboxylation of asparagine to produce 3-aminopropionamide (*Granvogl et al. 2004).* Cooking potatoes converts 3- aminopropionamide to acrylamide by a deamination reaction.The yields of this reaction are excellent ~ 60 mol%, but only traces low mg/kg of the precursor 3-aminopropionamide actually have been detected in potatoes, limiting the pathway's importance when compared with the final yields of the thermal Maillard pathway (*Granvogl et al. 2004*). Significantly more acrylamide forms at all temperatures from 3-aminopropionamide than from asparagines/glucose. This fact underlines the enormous precursor potential of 3-aminopropionamide in the formation of acrylamide. The kinetics of the formation is comparable with those of acrylamide formation from asparagines/glucose. The fact that the 3-aminopropionamide content increases in the course of storage, in dependence on the storage conditions, gives weight to this hypothesis.

Additional studies are needed to develop practical methods for reducing acrylamide formation in home-prepared foods without changing the acceptability of these foods.

Also, Future research should be carried out on the mechanism of acrylamide formation in dried fruits and vegetables.

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مستوي الاكريلاميد فى الاغذية المصرية المعاملة حرارياً .

منال عبد المطلع عطوة, محمد فهمي عمارة ,عقيلة صالح حمزة, خالد مصطفي المليجي و محمد عبد المطلع عطوة.
المركز الاقليمي للاغذية والاعلاف – مركز البحوث الزراعية .

تم اجراء هذه الدراسة على بعض الاغذ ية المتداولة في السوق المصرية كذلك التى يتم تصنيعها و اعدادها في المنزل كجزء من طرق اعداد الطعام التقليدية وذلك لدراسة تأثير طريقة الاعداد وما يميزها من درجة حرارة وزمن على تكون مادة الاكريلاميد المسرطنة و التي تؤثر على الجهاز العصبي للانسان و التي صنفتها الوكالة الدولية لابحاث السرطان علي انها مسرطنة من الدرجة الثانية. وعليه فقد تم اختيار اكثر من ٧٠عينة من الاغذية المعنية بتكون ما دة الاكريلاميد نظراً لاحتوائها على مواد نشوية والاسبارجين وكذلك التي تتعرض اثناء اعدادها او تصنيعها لدرجات حرارة اعلى من ١٢٠° م وتم تحديد مستويات الأكريلاميد باستخدام جهاز الكروماتوغرافيا السوائل بالإضافة إلى الكا شف الطيفي للأشعة فوق البنفسجية و تم وضع النتائج بنسب ميكروجرام /كجم وهذه العينات قد اشتملت على البطاطس المحمرة والبطاطا والذرة المشوية وصوص البشاميل والمكرونة الشعرية ولسان العصفوروالفيشار والقهوة والكاكو والارز والمكسرات (اللوز والصنوبر والبندق وابو فروة) والخبزالمحمص والبصل المحمر والبقسماط والطعمية و القطايف والكيك وكذلك بعض عينات الفواكه المجففة مثل (القراصية والزبيب والتمر) والزيتون الاسود المعلب والتي ثبت احتوائها على مادة الاكريلاميد. وكذلك تم عمل تجارب على المعاملات الحرارية وتأثر طول مدة التحمير او التحميص و الخبز و الشوي على بعض الاغذية التي يتم اعدادها منزلياً والتي تمثل جزء معنى من الطعام المصرى واكدت النتائج المتحصل عليها العلاقه الطردية الوثيقة بين نسبة الاكريلاميد المتكون وطول مدة التعرض للحرارة وكذلك ارتفاع درجات حرارة الاعداد وكذلك مدى دكانة لون المادة الغذائيةالمتحصل عليها، وان الوقت له أثر أقوى بكثير على تشكيل الأكريلاميد من درجة الحرارة. واشارت نتائج البحث ان نسب الاكريلاميد في العينات تراوحت بين (١١ -١٨٤٥ ميكرو جرام / كجم) و ان اعلى قيم الاكريلاميد المتحصل عليها كانت (١٨٤٥ميكرو جرام / كجم) فى عينات المكسرات المحمرة بينما اعطت نسب متوسطة من الاكريلاميد فى عينات الفواكه المجففة و منتجات المخابز المحمصة فى حين اعطت اقل القيم فى عينات الطعمية والقطايف. ومما هو جدير بالملاحظة محتوي الاكريلاميد المرتفع نسبيا في الفواكه المجففة .

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