Minia J. of Agric. Res. & Develop.
Vol. (٣٢) No. ٦ pp ٩٣٩-٩٦٣, ٢٠١٢

FACULTY OF AGRICULTURE

EFFECT OF SOME PHYTOCHEMICALS ON REDUCTION OF ACRYLAMIDE IN FRIED POTATO CHIPS AND THEIR BIOLOGICAL EFFECTS ON BLOOD LIPID PROFILE

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Received ٧ Dec. ٢٠١٢ Accepted ٢٧ Dec. ٢٠١٢

ABSTRACT

Acrylamide is a chemical compound which is formed in starchy foods such as crisps, chips, bread and crisp breads when cooked at high temperatures. It was first discovered by Scientists in Sweden in ٢٠٠٢. The main purpose of this investigation was to study the effect of some phytochemicals and their rich sources such as curcumin and turmeric or gallic acid and green tea on the reduction of acrylamide formation during frying process of potato chips by using some technological treatments for oil and also, the reduction its harmful effects on health. The biological effects of these phytochemicals on lipid profile were also investigated .The results showed that treatment with curcumin (٠.١ and ٠.٣٪) and turmeric at different concentrations (٠.٥ and ١٪) had reduced the formation of acrylamide in potato chips. The rate of reduction increased with prolonged frying time from ٢٠ min to ٨ hr using curcumin at ٠.١٪ and turmeric at ١٪, respectively. However, fried potato chips treated with gallic acid and green tea increased the final acrylamide value. Biological results indicated that acrylamide alone induced a significant

decrease in the activities of serum total cholesterol (TC), triglycerides (TG), very low density lipoprotein cholesterol (VLDL) and low density lipoprotein cholesterol (LDL)Also, it increased the activities of serum high density lipoprotein cholesterol (HDL) comparing to the control group and other treated groups. In addition, serum total cholesterol, triglycerides, VLDL and LDL level activity decreased with the increase in the concentration of turmeric, curcumin, green tea and gallic acid. While, serum HDL level increased with the increase in the concentration of pervious treatments. Finally treatments with acrylamide together with curcumin or, gallic acid at ٠.٣٪ showed the best biological treatments.

INTRODUCTION

Acrylamide (ACR), a water-soluble vinyl monomer, had many applications in chemical industries and laboratories. ACR can be produced during food processing under high temperature via the Maillard reaction (Tareke et al., ٢٠٠٢), especially during the processing of food containing asparagine and glucose A wide range of cooked foods contain acrylamide at levels ranging from a few parts per billion (ppb) to the excess of ١٠٠٠ ppb (Friedman and Levin, ٢٠٠٨). Acrylamide formation is affected by many factors, such as precursors (i.e., reducing sugar and asparagine) concentration, pH, water content and activity, physical state of the food, and process parameters, mainly represented by the heating time and temperature (Hedegaard et al., ٢٠٠٧). Acrylamide has several harmful health effects including neurotoxicity, reproductive toxicity, carcinogenicity, genotoxicity, and mutagenicity (Erkekoglu and Baydar ٢٠١٠).

Phytochemicals are naturally occurring, non nutritive chemicals. They can be categorized into various groups, i.e., polyphenols, organosulfur compounds, carotenoids, alkaloids, and nitrogen-containing compounds. Most phytochemicals have antioxidant activity and protect cells against oxidative damage and reduce the risk of developing certain types of cancer. They help to reduce menopausal symptoms and osteoporosis (Tyagi et al., ٢٠١٠), exert well-evidenced cardioprotective, neuroprotective, chemopreventive and anti-inflammatory properties, (Chirumbolo, ٢٠١٢).

Effect of some phytochemicals on reduction of acrylamide in fried potato

Gallic acid (GA; ٣,٤,٥-triphydroxyl-benzoic acid) as a polyhydroxylphenolic compound is widely distributed in various plants, fruits and foods, where it is present either in free form or, more commonly, as an ingredient of tannins, namely gallotannin (Ferk *et al* ., ٢٠١١). Green tea is an important source of GA and contains up to ٤.٥ g/kg of fresh weight (Joubert *et al.,* ٢٠٠٨). Gallic acid used to prevent rancidity and spoilage in fats and oils; it has been used as an additive in cosmetics and foods such as shortening, baked goods, candy, and chewing gum (Lee, ٢٠٠٧). Also, some gallic acid esters are widely used as food additives to prevent food oxidation. In addition, gallic acid has biological activities such as anti-allergic, anti-mutagenic anti-bacterial ,antifungal, anti-viral ,anti-inflammatory , antioxidant and antitumor effects.(Jang *et al.,*٢٠٠٩ and You and Park, ٢٠١٠)

Green tea (*Camellia sinensis*) is being used for several medical purposes and its activities have been observed in various experimental models as well as catechins and gallic acid (GA) (Wu et al., ٢٠١١). The increasing evidence indicates that green tea has multiple health benefits, such as antitoxoplasmal, anticataract ,antihypocholesterolemic, anti-trypanosomal, antinematodial and anti-helminthic. anticoccidial (Bin Dajem *et al* ., ٢٠١١). Moreover, the anti-stress, anticancer and antioxidants affects, antifungal, antibacterial anti-inflammation, anticoccidial neuroprotection and anti-obesity, antiviral has been reported (Hsu et al., ٢٠١١). It was also found that it had antidiabetic (Shokrzadeh et al., ٢٠٠٦) and reduced the risk of antigenotoxic (Gupta et al., ٢٠٠٩). In particular, green tea may lower blood pressure and thus reduce the risk of stroke and coronary heart disease. (Finkel et al., ٢٠٠٩) hepatoprotective (Salminen et al ., ٢٠١٢).

Turmeric (*Curcuma longa*) has been used in Ayurvedic medicine for its anti-inflammatory properties. *Curcuma longa* is a perennial member of the Zingiberaceae family, and cultivated mainly in India, and Southeast Asia (Ammon and Wahl, ١٩٩١). Curcuma is commonly used as a spice, flavoring agent, food preservative, and color agent. The primary active ingredient of turmeric is in a group of three curcuminoid. Curcumin (Difeurloylmethane), the yellow pigment of turmeric considered as anti-oxidant, anti-microbial, anti-fungal, antiviral and anti-inflammatory, anti-carcinogenic agent (Bower et al., ٢٠١٠). Recent studies, and extensive review literature has also proved curcumin role in enhancement of wound healing (Singh et al., ٢٠١٠), reducing blood cholesterol (Xiao et al., ٢٠٠٨).

The aim of this work was to study the effect of some phytochemicals and their rich sources such as curcumin and turmeric or gallic acid as well as green tea on the reduction of acrylamide formation during frying process of potato chips using different concentrations and reduction the harmful effects of acrylamide. Also, the biological effects of these phytochemicals on lipid profile were investigated.

MATERIALS AND METHODS

Materials

Phytochemicals (curcumin ($C_{٢١}H_{٢٠}O_{٦}$) and gallic acid ($C_{٦}H_{٢}(OH)_{٣}COOH$) were obtained from Sigma (Diesenhofen ,Germany). Herbs [turmeric (*Curcuma longa*), green tea (*Camellia sinensis*)] were purchased from local market (Harraz Company) in Cairo city (December, ٢٠١١). Potatoes, local variety (Spunta) were donated from Horticultural Research Institute, Agriculture Research Center, Giza, Egypt. Frying oil Helwa oil (A mixture of olein, soy bean and sunflower oils) were purchased from Affia International Corporation, Egypt).

Acrylamide (٩٩٪ pure) $C_{٣}H_{٥}ON$ was purchased from Sigma (Diesenhofen, Germany). All chemical and solvents used in the analyses were of analytical grade and purchased from Merck, Darmstadt, Germany.

Analytical Methods

Determination of amino acids content of potatoes

Free amino acids content was determined using ion-exchange chromatography following the method described by **Williams (٢٠٠٥)**

Determination of sugars content of potatoes

Glucose and fructose were determined enzymatically. A mixture of ٦٠g of grated potato and ١٨٠ml of deionized water were homogenized .Solutions, ٥ml Carrez 1 (١٥٠g of potassium hexacyanoferrate (ll) trihydrate per liter) and ٥ml Carrez ll (٣٠٠g of zinc sulfate heptahydrate per liter) were added. The mixture was thoroughly shaken, the pH was adjusted to ٧.٠-٧.٥ with a few drops of KOH solution (٤mol/L) then, foam was broken by addition of ٥ µl of Iso-octanol, and the volume adjusted to ٢٥٠ml with deionized water .Filtered samples were subjected to enzymatic analysis as described by the producer Amerin et al., (٢٠٠٤).

Preparation of potato chips and technological treatments of frying oil

Potatoes were peeled, washed with water and thereafter chopped into uniform pieces. In order to perform each frying experiment in a repeatable manner, a large homogeneous batch of raw potato chips with similar size was prepared using home plane at the beginning of each series of experiments. Potato chips were immersed in one liter of water (١٠ min) until frying. To examine the phytochemicals and its rich source as a reduction agent for acryalmide formation during frying process, the additives were added to frying oil before starting frying process as follows; Turmeric or green tea (٠.٥٪ and ١٪ for each) and Gallic acid or curcumin (٠.١٪ and ٠.٣% for each). Each additive was added separately to frying oil. The frying was performed in thermoelectric domestic fryers containing ١٥٠٠ ml frying oil at ١٨٠ºC to equilibrated for ٥min. Potatoes chips were added to the oil and frying process was prolonged to ١٥ min. Potatoes chips cooled directly after frying in a stainless steel basket at room temperature. Fried potatoes chips were divided into two groups: a part of the batch was thoroughly homogenized for acrylamide analysis and the other used for sensory analysis.

Prolonged frying time test

After taking zero time sample (٢٠ min) for determination of acrylamide content and sensory analysis, frying process was continued in different batches for each additive treatment separately for ٨ hours to study the prolonged frying time on acrylamide formation and treatments on oil quality. The final batch of each treatment was collected for determination of acrylamide by HPLC, sensory analysis and quality characteristic of oil.

Preparation of sample for HPLC analysis

Preparation of samples was carried out according to the method described by Gokmen and Senyuva (٢٠٠٦). One gram of ground sample was weighed in to centrifuge tube with cup .The sample was suspended in ٥ ml methanol and extracted for ٢min in a vortex mixer. The suspension was centrifuged at ٥٠٠٠rpm for ١٠ min. The clear supernatant was transferred into a centrifuge tube and treated with Carrez l and ll solutions (٢٥µ/each) to precipitate the co-extractives. Following centrifugation at ٥٠٠٠ rpm for ٥ min, ١.٠ ml of clear supernatant (٠.٢g sample) was quantitatively transferred into a conical bottom glass test tube placed in a water bath at ٤٠ºC and evaporated to dryness under nitrogen at psi. The remaining residue was immediately re-dissolved in ١ml of water by mixing in a vortex mixer for ١min.

HPLC determination of acrylamide

Twenty microliter of the methanol extract was filtered through a ٠.٢٢ µl syringe filter and then injected in HPLC (Hewlett Packard ١٠٥٠), using column C١٨ (٢٥٠x ٤.٦ nm, ٥µ purity C١٨). The column was eluted with ٨٠٪ methanol / water (v/v) with a flow rate ١ml/١ min. The effluent was monitored by UV absorbance at ٢٥٤ nm, and the acrylamide peak was obtained with retention time of ٥.٧ min according to the method of Gokmen and Senyuva, (٢٠٠٦).

Determination of frying oils quality characteristics

To estimate the effect of using acrylamide lowering agents on the oil quality, in both fresh and oil samples drawn at ٨ hr from each fryers of treated and untreated oil (control) potato chips were analysed for their quality characteristics, changes in viscosity (CP) were monitored using viscometer Brookfield RVDV Spindle SC٤-٢١ connected to a water bath Brookfield TC٥٠٠. Viscosity determination was carried out at ٢٥º± ٠.١ºC according to the method described by Howard (١٩٩١). Refractive index, peroxide value (PV) and acid value were determined according to A.O.A.C (٢٠٠٥).

Determination of fatty acids

Methylation of fatty acids

An aliquot of fatty acids, about ١٠mg, was dissolved in ٢ml hexane and then ٠.٤ml ٢N KOH in anhydrous methanol was added (Cossignani et al., ٢٠٠٥), after ٣ min ٣ml water was added .The organic layer was separated by centrifugation, it was dried over anhydrous sodium sulfate, then concentrated with a N٢ stream to around ٠.٥ml for GC analysis of fatty acids methyl esters (FAME) as described below.

Gas chromatography analysis of FAME

Agilent ٦٨٩٠ series GC apparatus provided with a DB-٢٣ column (٦٠mx٠.٣٢mmx٠.٢٥µm) was used. Fatty acids results after the previous procedures steps were transformed into their methyl esters and directly injected into the gas chromatography instrument. Relative fatty acid percentages were calculating using GC Chemstaion software.

Organoleptic evaluation

An organoleptic test was conducted by ten highly trained panelists. The panelists gave different scores for quality parameters including flavor, color, crispness and over acceptability. The organoleptic analysis was evaluated according to the numerical scoring test (Ranganna, ١٩٧٧).

Experiment biological design

All biological experiments were done at the Research Institute of Ophthalmology, Medical Analysis Department, Giza, Egypt. Rats (n = ٦٠ rats) were housed individually in wire cages in a room maintained at ٢٥ ± ٢° C and kept under normal healthy conditions. Basal diet was prepared according to AIN (١٩٩٣). All rats (٦٠ rats) were fed on basal diet for one – week before starting the experiment for acclimatization. After one week period, the rats were divided into ١٠ groups (٦ rats each), all groups were fed for ٣٥ days on experimental diet as follows: Group (١): This group was fed on the standard diet only as a negative control (healthy rats) (control). Group (٢): This group was fed on the standard diet containing ٦٠ mg acrylamide as a positive control (AA). Group (٣): This group was fed on the standard diet containing ٦٠ mg acrylamide and ١٪ curcumin ($C_١$). Group (٤): This group was fed on the standard diet containing ٦٠mg acrylamide and ٣٪ curcumin ($C_٢$). Group (٥): This group was fed on the standard diet containing ٦٠ mg acrylamide and ٥٪ turmeric powder ($T_١$). Group (٦): This group was fed on standard diet containing ٦٠mg acrylamide and ١٠٪ turmeric powder ($T_٢$). Group (٧): This group was fed on the standard diet containing containing ٦٠mg acrylamide and ١٪ gallic acid ($GA_١$). Group (٨): This group was fed on the standard diet containing ٦٠mg acrylamide and ٣٪ gallic acid ($GA_٢$). Group (٩): This group was fed on the standard diet containing ٦٠mg acrylamide and ٥٪ Chinese green tea ($G_١$). Group (١٠): This group was fed on the standard diet containing ٦٠mg acrylamide and ١٠٪ Chinese green tea ($G_٢$).

Blood sampling

In all experimental groups, blood samples were collected after ١٢ hours fasting at the end of each experiment, using the reto orbital method by means of micro capillary glass heparin zed tubes. Blood samples were collected into dry clean centrifuge tubes and left to clot in water bath (٣٧^{o} C) for half an hour. The blood was centrifuged for ١٠ minutes at ٣٠٠٠ rpm to separate the serum. Serum was carefully aspirated into clean cuvette tube and stored frozen at – ٢٠^{o} C for analysis as described by **Schermer, (١٩٦٧)**.

Determination of serum lipids profile

Kits for total cholesterol, triglycerides, high density lipoprotein (HDL) were obtained from Biodiagnostic Company, Egypt. Total cholesterol was calorimetrically determined according to NIHP, (١٩٨٧). Triglycerides were determined according to the method of Fassati and Prencipe, (١٩٨٢). Determination of HDL was carried out according to the method of Lopes-Virella et al., (١٩٧٧). While, VLDL and LDL were calculated according to the equation given by Lee and Nieman, (١٩٩٦) as follows:

VLDL (mg / dl) = triglycerides / ٥.

LDL (mg / dl) = (Total cholesterol – HDL) – VLDL

Statistical analysis

The data were analyzed using SPSS (Statistical Package for Social Sciences) version, ١٤.٠.The results are presented as Mean ±

S.D. One way analysis of variance (ANOVA) was used to test the difference between groups. Comparisons between means of groups were analyzed by L.S.D test with significance level ٠.٠٥, SPSS (٢٠٠٠).

RESULTS AND DISCUSSION

Free amino acids of potatoes tubers were determined and the results are shown in Table (١). Results revealed that asparagine and glutamine are the major free amino acids and were found to be ٢.٠٥٪ and ٢.٣٩٪, respectively, followed by argnine (٠.٥١٪).

Table ١: Free amino acids content of potatoes

Amino Acids	Content (mg /١٠٠ mg)
Argnine	٠.٥١ %
Asparagine	٢.٠٥ %
Alanine	٠.٢٦ %
Isoleucine	٠.٢٣ %
Proline	٠.٢١ %
Therionine	٠.١٩ %
Glutamine	٢.٣٩ %
Glycine	٠.١٨ %
Serine	٠.١٩ %
Cystein	٠.١ %
Valine	٠.٣٨ %
Phenylalanine	٠.٣٣ %
Lysine	٠.٤٠ %
Leucine	٠.٢٩ %
Methinoine	٠.١٦ %
Histidine	٠.١٤ %
Tyrosine	٠.٢٢ %

Brierley et al., (١٩٩٧) indicated that, in potato tubers, asparagine and glutamine are the predominant amino acids, often accounting for up to ٩٠٪ of the total free amino acid composition.

Five tubers from a lot of Spunta potatoes were analyzed individually. Reducing sugars content (glucose and fructose) varied strongly. The size of the five tubers varied from small and oversize and results were expressed as mg/kg. Data in Table (٢) revealed that the main content of reducing sugar were glucose and fructose, ٦٨.٧ and ٨٥٦.٩ mg/Kg potato sample, respectively. Dietary ACR is largely derived from heat – induced reactions (Maillard reaction) between the predominantly amino group of the free amino acid precursor asparagine and carbonyl groups of glucose and fructose during heat processing (baking, frying, roasting and extrusion) of plant-derived foods such as potato fries and cereals at temperature above ١٢٠ °C (Rayburn and Friedman (٢٠١٠)

Table ٢:Reducing sugars content of potatoes

Reducing Sugars	Content (mg /Kg)
Glucose	٦٨.٧
Fructose	٨٥٦.٩

Results from HPLC determination of acrylamide content were expressed as µg/Kg of original sample weight and the obtained results are shown in Table (٣). Results revealed that frying potato chips, without any additives, (control) for ٢٠ min. were effective. When the frying time was increase to ٨ hour, led to the reduction of acrylamide formation in control fried potatoes chips by - ٢٨.٨٥٪. Conflicting result was accordance (Gokmen and Senyuva ٢٠٠٦) who illuminated that acrylamide was decreased after prolonged frying hours, evidently due to the degradation /elimination of acrylamide.

Curcumin treatments at concentrations of ٠.١ , ٠.٣ % and turmeric at concentrations of ٠.٥٪ and ١٪ had reduced the formation of acrylamide in potato chips. Reducing acrylamide formation efficiency was found with addition of curcumin by rate of ٠.١٪ and turmeric ١٪ which recorded -٢٥.٥٢ and -١١.٨٢٪, respectively. Moreover, the reducing efficiency increased with the prolonged time of frying from ٢٠min to ٨ hour to reach -٢٨.٨٥ and- ٣٤.٩٥٪, respectively. While, fried potato chips with curcumin at a concentration of ٠.٣ % and with turmeric at a concentration of ٠.٥٪ for ٢٠min reduced the final acrylamide content by -١١.٢٦ and -٤٠.٦٨٪, respectively. On the other hand, the prolonged frying of potato from ٢٠min to ٨ hour decreased the reduction of acrylamide to - ٦.١٣ and -٣٠.٨٧٪, respectively.

Table ٣: Impact of different treatments on acrylamide formation

Treatments	Acrylamide content (µg/Kg)	Reduction%
Control (٢٠min) **(٨hr)**	٢٦٧٢ ١٩٠٤	_ -٢٨.٧٤
Curcumin ٠.١٪(٢٠min) **(٨hr)**	١٩٩٠ ١٩٠١	-٢٥.٥٢ -٢٨.٨٥
Curcumin ٠.٣٪ (٢٠min) **(٨hr)**	٢٣٧١ ٢٥٠٨	-١١.٢٦ -٦.١٣
(Turmeric ٠.٥٪ (٢٠min) **(٨hr)**	١٥٨٥ ١٨٤٧	-٤٠.٦٨ -٣٠.٨٧
Turmeric ١٪ (٢٠min) **(٨hr)**	٢٣٥٦ ١٧٣٨	-١١.٨٢ -٣٤.٩٥
Gallic acid ٠.١٪ (٢٠min) **(٨hr)**	٤١٧٧ ٢٩٥٧	+٥٦.٣٢ -٢٦.٧٥
Gallic acid ٠.٣٪ (٢٠min) **(٨hr)**	٤٣٣٦ ٣٥١٤	+٦٢.٢٧ +٣١.٥١
Green tea ٠.٥٪ (٢٠min) **(٨h)**	٣٢٠١ ٢٧٠٥	+١٩.٧٩ +١.٢٣
Green tea ١٪ (٢٠min) **(٨h)**	٥٦١٠ ٢٧٧٧	+١٠٩.٩٥ +٣.٩٢

Compared to potato chips without treatment (control)
(٢٠min): fried treated potato chips for ٢٠min
(٨hr): fried treated potato chips for ٨ hr

The present results indicated that the superior reduction rate of acrylamide had occurred for turmeric at ٠.٥ % for ٢٠ min and after prolonged frying time to ٨ hr, followed by curcumin at ٠.١ %. Nor et al., (٢٠٠٩) reported that *Curcuma longa* leaf extract, which had a polyphenol content of ١١٦.٣ ± ٠.٢ mg/g, possessed heat-stable antioxidant properties and may be a good natural alternative to existing synthetic antioxidants in the food industry. Antioxidants such as phenolic compounds, flavonoids, vitamins, and phenolic extracts from various spices have been reported as inhibiting acrylamide formation (Ou et al., ٢٠١٠ and Kotsiou et al., ٢٠١١).

Furthermore, fried potato chips with gallic acid at ٠.١ and ٠.٣٪ or green tea at ٠.٥ and ١٪ for ٢٠min increased the final acrylamide content by +٥٦.٣٢, + ٦٢.٢٧, +١٩.٧٩ and +١٠٩.٩٥٪, respectively. While, the prolonged frying of potato from ٢٠min to ٨ hour decreased the acrylamide content in fried potato chips to - ٢٦.٧٥, +٣١.٥١, + ١.٢٣ and ٣.٩٢٪). Yoshida et al., (٢٠٠٥) reported that the acrylamide level in green tea is not as high as in roasted products such as Houjicha and roasted cereal grains used as tea substitutes or in herb teas. Based on the analytical data, it appears that steeping in boiling or hot water resulted in extraction of most of the acrylamide in the infusions. They investigated also the effect of roasting conditions on acrylamide accumulation in the tea products. It was found that epigallocatechin in the tea samples inhibited the formation of the brominated derivative.

The effect of the previous treatments on frying oil quality characteristics was studied and results are present in Table (٤). Data demonstrated the quality changes of fresh oil and samples drawn at ٨ hr from different fryers. The relative changes in viscosity, refractive index, acid value and peroxide value, all provided good indices of lipid deterioration rate of frying oils. Viscosity of frying oil is strongly affected by its degradation products, increasing as a result of formation of dimmers, trimers, polymers, epoxides, alcohols and hydrocarbons (Stevenson et al., ١٩٨٤).

Table ٤: Quality changes in frying oils during repeated frying of the treated potato chips after ٨ hour

Characteristics / Treatments	Viscosity cP	Refractive Index	Acid Value	Peroxide Value (PV)	C١٨:٢/C١٦:٠
Fresh oil	٦٦	١.٤٧٣٧	٠.١	١.٣٧	٤.٦٦٤٣
Control (٨ hr)	٧٨	١.٤٧٢٣	٠.٩٥	٢٦.٣	٤.٠٥١٧
Curcumin ٠.١٪	٨١.١	١.٤٧٢٧	٠.٤	٣.٧٥	٤.٥٤٤٢
Curcumin ٠.٣٪	٨٧	١.٤٧٣٠	٠.٢	٢.٧	٤.٤٨٠١
Turmeric ٠.٥٪	٨٨.٩	١.٤٧٢٨	٠.٣٨	٣.١	٤.٤٨٣٤
Turmeric ١٪	٩٠	١.٤٧٢٧	٠.٢٩	٢.٩	٤.٥٣١٣
Gallic acid ٠.١٪	٩٤	١.٤٧٢٦	٠.٥	٨.٧	٤.٣٤٩٢
Gallic acid ٠.٣٪	٩٧	١.٤٧٢٥	٠.٧٥	١٢.٠٨	٤.٣٦٨٨
Green tea ٠.٥٪	٩٢	١.٤٧٢٧	٠.٨	١٤.٢٨	٤.٥٠٥٤
Green tea ١٪	٩٨	١.٤٧٢٩	٠.٩٢	١٩.٧	٤.٥٢٦٤

Table (٤) shows that the initial viscosity of fresh frying oil was ٦٦ cP at ٢٥°C . The high viscosity values of frying oil samples were observed in the potato chips treated with Green tea ١٪ (٩٨ cP) , Gallic acid ٠.٣٪ and ٠.١٪ (٩٧ and ٩٤ cP) , Green tea ٠.٥٪(٩٤ cP), Turmeric١٪ and ٠.٥٪ (٩٠ cP and ٨٨.٩ cP) compared with frying oil for untreated Potato chips (control) (٧٨ cP). These results are in accordance with Sánchez-Gimeno et al ., (٢٠٠٨) who suggested that the increase of oil viscosity was due to dimer formation which was attributed to polymerization and highly correlated to polar compounds formation. They reported that the viscosity measurements are a good index of oil degradation. Acid Value indicator is usually used to access oil quality. Results in Table (٤) revealed that, acid value and peroxide value increased during prolonged frying for ٨ hr compared with fresh oil. However, the increasing rate was too small in all treatments compared with the control sample. Curcumin at ٠.١٪ or ٠.٣٪ and turmeric at ٠.٥٪ or ١٪ treatments showed antioxidant properties, since they were kept the quality of the oil after ٨ hr.

Monitoring of changes in fatty acids composition of oils during frying is an effective method to assess thermal oxidative changes in the oil, Linoleic (C١٨:٢), Oleic (C١٨:١), palmitic (C١٦:٠), and Stearic (C١٨:٠) are the major fatty acids presented in the frying oil used, with relative proportions of ٥١.٤٤, ٢٥.٥٩ , ١١.٠٢ and ٣.٧٩٪, respectively . During frying, the relative proportions of palmitic and stearic for all the evaluated samples were slightly increased in the oil, while the relative composition of linoleic and Oleic were slightly decreased during frying period. This tendency is in accordance with the results reported by Irwandi et al .,(٢٠٠٠), who reported that the marked increase in C١٦:٠ proportion following frying correlated with the breakdown of double bonds of fatty acids with higher carbon numbers. The change in C١٨:٢/C١٦:٠ ratios was an effective parameter for assessing oxidation and quality of frying oil. The use of this ratio as a quality parameter in fat and oil analysis was first reported by Augustine et al., (١٩٨٧). Results presented in Table (٤) showed slight decrease in C١٨:٢/C١٦:٠ ratio as a function of process time and treatment of potato fried in different oils, and as a result of changes in C١٨:٢ and C١٦:٠ content as mentioned before. However, commercial oil for untreated potato chips (control) had lower scores as compared to other treatments. The obtained results revealed that all quality parameters of frying oil did not highly increased after ٨hr and did not reach the normal recommended guidelines for frying parameters except for PV in some treatments. *Curcuma longa* leaf extract exhibited good antioxidant activity. The topping up of the oil and natural antioxidant, may explain why *Curcuma longa* extract showed better antioxidant protection in the frying experiments comparing to the accelerated oxidation study at similar concentrations of ٠.٢٪. Interaction between the polyphenol compounds and existing tocopherols or tocotrienols in RBD palm olein may have resulted in synergistic antioxidant effects. This results demonstrated the antioxidant properties of *Curcuma longa* leaves and it may be another potential source of natural antioxidants to be exploited in the food and nutraceutical industries (Nor et al., ٢٠٠٩).

Sensory evaluation

Fried potato chips treated with different treatments after ٢٠ min and prolonged frying time for ٨ hr, were sensorial evaluated among the ١٠ taster. The results in Table ٥ revealed that they all had a higher score for over all acceptability, but score for flavor, colour, crispness and overall acceptability in chips treated with curcumin at a concentration of ٠.١ and ٠.٣ % or turmeric at a concentration of ٠.٥ and ١٪ had higher significant different (p<٠.٠٥) scores as compared to other treatments.

Table ٥: Sensory evaluation of fried potato chips treated with different treatments after ٢٠ min and ٨ hr

Treatments	Flavor		color		crispness		Overall acceptability	
Control	٢٠ min	٨ hr	٢٠ min	٨ hr	٢٠ min	٨ hr	٢٠ min	٨ hr
	٨.٢٠ ^{c} ± ٠.٤٢	٨ ^{c}± ٠.٤٢	٨.٢ ^{c} ±٠.٢٥	٨.٢ c ±٠.٢٥	٨.٦٥ ^{c} ± ٠.٢٤	٧.٦٥ ^{b} ± ٠.٢٤	٩ ^{b} ± ٠.٣٣٣٣	٨.١ ^{c}± ٠.٣١
Curcumin ٠.١٪ (C١)	٩.٤٥ ^{a} ± ٠.٣٦	٩.١ ^{a}± ٠.٣٩	٩.٨٥ ^{a} ٠.٢٥	٩.٨٥ ^{a} ± ٠.٢٤	٩.٣٥ ^{a} ± ٠.٤٧	٩.٤٥ ^{a} ± ٠ .٣٦	٩.٤ ^{a}± ٠.٣١	٩.٨ ^{a}±٠.٢ ٥
Curcumin ٠.٣٪ (C٢)	٩.٣٥ ^{a}± ٠.٤١	٨.٩ ^{a}± ٠.٣٤	٩.١ ^{b} ±٠.٣٩	٩.١٥ ^{b} ±٠.٤١	٩.٦ ^{a}± ٠.٤٥	٩.٧ ^{a}± ٠.٤٨	٩.٣٥ ^{ab} ± ٠.٣٣	٩.٣٥ ^{b}±٠.٣٣
Turmeric ٠.٥٪ (T١)	٨.٩ ^{b} ± ٠.٥٦	٨.٣ ^{b}±٠.٦٧	٩.٣ ^{b}±٠.٦٩	٩.١ ^{b} ±٠.٧٣	٨.٩٥ ^{b} ± ٠.٥٩	٩.٢ ^{b}± ٠.٦٣	٩.٤٥ ^{a} ± ٠.٣٦	٩.٦ ^{a}± ٠.٤٥
Turmeric ١٪ (T٢)	٩.١٥ ^{b}±٠.٦٧	٩.٢٥ ^{a} ± ٠.٦٧	٩.١٥ ^{b} ±٠.٦٢	٩.١٥ ^{b} ±٠.٦٢	٩.٠٥ ^{b}± ٠.٤٩	٩.٠٥ ^{b}± ٠.٤٩	٨.٩٥ ^{b} ±٠.٤٣	٨.٩٥ ^{b}± ٠.٤٣
Gallic acid ٠.١٪(GA١)	٧.٣٥ ^{d} ± ٠.٤٧	٧.٣٥ ^{d}±٠ .٤٧	٨.٠٥ ^{c}± ٠.٥٩	٨.٠٨ ^{c}± ٠.٦٣	٧.٥ ^{d} ± ٠.٥٢	٧.٤ ^{c}± ٠ .٣٩	٨.١ ^{c} ± ٠.٦١	٨.١ ^{c}±٠ .٦١٤٦
Gallic acid ٠.٣٪(GA٢)	٧ ^{d}± ٠.٦٦	٥.١ ^{f}± ٠.٥٦	٨.١ ^{c} ± ٠.٤٥	٧.٨ ^{cd}± ٠.٤٨	٧.٢٥ ^{d} ± ٠.٦٧	٦.٧٥ ^{d}±.٤ ٢٤٩	٧.٣ ^{d} ± ٠.٥٣	٧.٩٥ ^{c}± ٠ .٥٥
Green tea ٠.٥٪(G١)	٦.٣٥ ^{f}± ٠.٦٦	٦.٥ ^{e}± ٠.٤٠	٨.٨ ^{b}± ٠.٨٥	٨. ٥ ^{c} ± ٠.٧٠	٦.٦٥ ^{e} ± ٠.٤٧	٥.٨ ^{e}± ٠.٥٧٧٤	٧.٠٥ ^{d} ± ٠.٦٤	٦.٩٥ ^{d} ± ٠.٣٦
Green tea ١٪(G٢)	٦.٨٥ ^{e} ± ٠.٦٢	٤.٨ ^{f}± ٠.٥٣	٨.٢٥ ^{c}± ٠.٣٥	٧.٠٥ ^{e} ± ٠.٤٩	٦.٠٥ ^{f}± ٠.٥٥	٤.٩٥ ^{f}± ٠.٥٩	٦.١٥ ^{f}± ٠.٧٠	٥.٠٥ ^{e}± ٠.٤٣
LSD	٠.٣٩٢٤	٠.٣٦٣٠	٠.٣٧٩٩	٠.٣٨٠٧	٠.٣٦٢٤	٠.٣٤١٨	٠.٣٥٢٥	٠. ٣٠٦٦

Similar small letter for each property mean there is no significant differences at P ≤ ٠.٠٥.

The effect of acrylamide alone or combined with curcumin, turmeric, gallic acid or green tea on serum lipids are shown in Table ٦.

Table ٦: Biological effects of phytochemicals on lipid profile

Groups / Parameters	Group (١) Control	Group (٢) A A	Group (٣) $C_{١}$+ A A	Group (٤) $C_{٢}$+ A A	Group (٥) $T_{١}$+ A A	Group (٦) $T_{٢}$+ A A	Group (٧) $GA_{١}$+A A	Group (٨) $GA_{٢}$+ A A	Group (٩) $G_{١}$+ A A	Group (١٠) $G_{٢}$+ A A	L.S.D.
	Mean±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	
Total cholesterol (T.C mg/dl)	٨٥.٦٧^{h} ±٣.٠٥٥	١١٥^{a} ±٣.٦٠٦	١٠٦.٨^{c} ±١.٥٨٨	٩٩.٦٧^{g} ±٢.٠٨٢	١٠٨.٦٧^{b} ±١.٥٢٨	١٠٤.٦^{d} ±٤.٨١٣	١٠٩.٤٧ ^{b}±٣.٥٠	١٠٢.٣٣ ^{e}±٣.٠٥٥	١٠٢.٢٦٧^{e} ±٢.٢٣٧	٩٧.٥^{f} ±١.٨٠	٢.٠٥٥٦
Triglycerides (T.G mg/dl)	٩١.٥٣^{h} ±٢.٧٣٠	١٣٨.١^{a} ±١.٣٠٨	١١١.٣٣^{d} ±١.٥٢٨	١٠١.٦٦ ^{f}±٣.٥١٢	١١٥.٢٧^{b} ±١.٤١٩	١٠٧.٣٣^{e} ±٣.٥١٢	١١٦.٦٦ ^{b}±٣.٢١٥	١١٣.٤ ^{c}±٢.٠٣٠	١١٠^{d} ±١.٠٠	٩٩^{g} ±٣.٦٠٦	١.٨٢٥٢
HDL (mg/dl)	٤٥^{a} ±٢.٠٠	٢٥^{g} ±٣.٠٠	٣١.٦٧^{e} ±٠.٧٠٢	٣٩.٦٦^{c} ±٢.٠٨١	٣٠^{f} ±١.٠٠	٣٥.٦٦^{d} ±٢.٠٨٢	٢٩.٦٧ ^{f}±١.٥٢٨	٣٥^{d} ±٣.٠٠	٣٦.٦٦^{d} ±٢.٠٨٢	٤١^{b} ±١.٠٠	١.٤٤٣٤
VLDL (mg/dl)	١٨.٣٠٧^{h} ±٠.٥٤٦	٢٧.٦٢^{a} ±٠.٢٦٣	٢٢.٢٦٧^{d} ±٠.٣٠٦	٢٠.٣٣^{f} ±٠.٧٠٢٤	٢٣.٠٤٣^{bc} ±٠.٢٨٤	٢١.٤٦٧^{e} ±٠.٧٠٢	٢٣.٣٣ ^{b}±٠.٦٤٣	٢٢.٦٨^{c} ±٠.٤٠٦	٢٢.٠٠^{d} ±٠.٢٠٠	١٩.٨٠٠^{g} ±٠.٧٢١	٠..٣٦٥
LDL (mg/dl)	٢٢.٣٦^{h} ±١.٨١٢	٦٢.٣٨^{a} ±٣.٧٦١	٥٢.٨٧^{c} ±٢.٦٤١	٣٩.٦٦^{fg} ±٠.٧٠٢	٥٥.٦١٣^{b} ±٢.٥٧٨	٤٧.٤٧^{d} ±٥.٢٥٥	٥٥.٤٦٧ ^{b}±٣.٧٨١	٤١.٣٢٠^{f} ±٤.٠١١	٤٣.٩٣^{e} ±٠.٨٥١	٣٧.٧٢^{g} ±٠.٨٨٤	٢.٥٥٧٣

AA: Standard diet containing ٦٠mg acrylamde. $C_{١}$: Curcumin ١٪. $C_{٢}$: Curcumin ٣٪. $T_{١}$: Turmeric ٥٪.
$T_{٢}$: Turmeric ١٠٪. $GA_{١}$: Gallic acid ١٪. $GA_{٢}$: Gallic acid ٣٪. $G_{١}$: Green tea ٥٪. $G_{٢}$: Green tea ١٠٪.

Acrylamide alone induced a significant decrease in the activities of serum total cholesterol, triglycerides, VLDL and LDL level, and induced a significant increase in the activities of serum HDL compared with the control group and other treated groups (p < ٠.٠٥). It was also found that serum total cholesterol, triglycerides, VLDL and LDL level activity decreased with the increase in the concentration of turmeric, curcumin, green tea and gallic acid. While, serum HDL level increased with the increase in the concentration of pervious treatments.

Treatments with acrylamide, and curcumin together or, gallic acid at concentrations ٠.٣٪ showed the best treatments. On the other hand data revealed that, no significant differences were observed in all parameters between $T_{١}$ and $GA_{١}$ treated groups and between $T_{١}$ and $GA_{٢}$ with respect to VLDL.

Also there were no significant differences between $C_{١}$ and $G_{١}$ treated groups were found with respect to TG and VLDL and between

$GA_{٢}$ and $G_{١}$ treated groups with respect to TC. In addition, non significant change in HDL between $T_{٢}$, $GA_{٢}$ and $G_{١}$.

The data obtained from this study regarding the influence of acrylamide on serum TC, LDL and TG levels come partially in contradiction to those obtained by Totani *et al.*, (٢٠٠٧). They observed a decrease in the levels of these biochemical parameters after trace acrylamide exposure. A possible explanation could reside in the different toxicodynamic mechanisms, due to the dose difference. At the level of exposure described by Totani *et al.*, (٢٠٠٧), a decrease in insulin level takes place, which indirectly can lead to a decrease in TG levels and eventually cholesterol, the capacity of the liver to process circulating lipoproteins was probably not affected seriously at that dose, unlike the dose of ٥٠ mg/kg/day used in this experiment, which leads to certain hepatic damage. Also, Teodori *et al.*, (٢٠١١) found that Acrylamide intake is associated with significantly altered levels of total cholesterol, LDL-cholesterol, triglycerides. These results are also in harmony with those of Liao *et al.*, (٢٠٠٣) indicated that curcumin lead to decreased TC, TG and LDL Also Ayoub *et al.*, (٢٠٠٦) found that turmeric decreased LDL, TC, TG and increased HDL. El-Moselhy *et al* ., (٢٠١١) indicated that treatment with curcumin, rosiglitazone or their combination for ١٥ days reduced plasma levels of TC, TG, and LDL and increased HDL levels (P < ٠.٠٠١) compared with the non-treated groups. Drinking between ٥ and ١٠ cups of green tea per day is associated with lower plasma cholesterol concentrations. Kuo *et al.*, (٢٠٠٥) reported that, the dietary inclusion of ١.٥٪ green tea leaves increased serum HDL cholesterol but lowered LDL cholesterol in rats. Gallic acid (٢٠ mg/kg bw) significantly decreased serum total cholesterol, triglyceride, LDL at the same time markedly increased plasma insulin (Nabavi *et al*., ٢٠١٣).

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تأثير بعض المركبات الكميائيه النباتية على خفض نسبة الأكريلاميد فى البطاطس المقلية وتأثيراتها البيولوجية على صورة دهون الدم

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الاكريلاميد مركب كميائى يتكون فى الاطعمه النشوية والتي يتم طهيها على درجات حرارة مرتفعه وهذه تتضمن المقرمشات ، الشيبسى ،الخبز، الخبز المقرمش هذا وقد تم اكتشافه بواسطة علماء فى السويد عام ٢٠٠٢ . الهدف الأساسي لهذا البحث هو دراسة تأثير بعض المركبات الكميائيه النباتية ومصادرها الغنية مثل الكركيومين والكركم والجاليك اسيد والشاي الأخضر على تقليل الأكريلاميد خلال عملية قلى رقائق البطاطس الشيبسى ودراسة تأثير هذه المصادر على خفض التأثير الضار للآكريلاميد على ليبدات الدم . وقد أظهرت النتائج أن المعاملة بالكركيومين بتركيز ٠.١% و ٠.٣ % والكركم بتركيز ٠.٥% ، ١% أدت إلى انخفاض نسبة الاكريلاميد فى رقائق البطاطس المقلية بينما ازداد انخفاض الاكريلاميد باستخدام الكركيومين بتركيز ٠.١% والكركم بتركيز ١% وذلك باستمرار عملية القلي من ٢٠ دقيقه إلى ٨ ساعات . على العكس أدت معاملة البطاطس بالجاليك اسيد بتركيز ٠.١ و ٠.٣ % وكذلك الشاي الأخضر بتركيز ٠.٥ و ١% لمدة٢٠دقيقه إلى رفع نسبة تكوين الاكريلاميد و بإطالة فترة القلي إلى ٨ ساعات أدت إلى خفض نسبته ولكن النسبة مازالت مرتفعه مقارنة بعينة الكنترول ماعدا الجاليك اسيد ٠.١%. أيضا أظهرت نتائج التقييم الحسي أن أفضل المعاملات كانت للكركم والكركيومين . كما تم دراسة تأثير هذه المعاملات التكنولوجية على صفات الجودة لزيت القلي وأظهرت النتائج انه لم يحدث تغير كبير فى جميع صفات الجودة حتى بعد استمرار عملية القلي لمدة ٨ ساعات ولم

Effect of some phytochemicals on reduction of acrylamide in fried potato

تخرج عن التوصيات المتعلقة بصفات زيت القلي فيما عدا رقم البيروكسيد . وقد أظهرت النتائج البيولوجيه أن المعاملة بالاكريلاميد منفردا بتركيز٦٠ملجم لكل كجم من الغذاء الاساسى أدت إلى ارتفاع الكوليسترول الكلى (TC) والدهون الثلاثية (TG) و الدهون المنخفضة الكثافة (LDL) و الدهون المنخفضة جدا في الكثافة (VLDL)، بينما أدت إلى انخفاض الدهون مرتفعة الكثافة (HDL) مقارنه بمجموعه الكنترول وباقي المجموعات المعالجة. وقد لوحظ أيضا أن نسب TC ، TG , LDL ,VLDL انخفضت بينما ارتفعت نسبة HDL فى باقي المجموعات المعالجة وزاد الانخفاض بزيادة تركيز الاضافات السابقه . وأخيرا فقد سجلت المعالجه بالاكريلاميد مع الكركيومين او الجاليك اسيد ٠.٣% أفضل المعاملات ألبيولوجيه .