Potato Chips and Roasted Bread Induced Chromosomal Aberrations and Micronuclei Formation in Albino Rats

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Abstract: Detection of high concentrations of acrylamide (AA) in heated starch rich foodstuffs raises health concerns, particularly for children, because AA is relatively high in child-favoured foods such as potato chips, French fries, roasted bread and cereals. So, we investigated the genotoxic and cytotoxic potentials of potato chips (FP) and roasted bread (RB) and the possible protective effect of curcumin (Cur) in albino rat bone-marrow cells, using chromosomal aberrations (CAs) and micronucleus (Mn-PCEs) assays.Animals feed on diet contained 15 % or 30 % of fried potato chips and/or fried bread and supplemented with/without 1%curcumin addition for 2 months. Results showed that, treatment with Cur alone did not induce significant increases in CAs and Mn-PCEs in comparison to the control level. Meanwhile, diet supplemented with 30 % of FP and/orb yielded13,16 and 8.33 damaged cell / 100 metaphase spreads and 18.67, 21.16 and 12.83 Mn-PCEs / 2500 PCEs, respectively. All the above increases were highly significant (P<0.001). Moreover, fried potato chips and/or fried bread caused cytotoxic action in the form of a significant reduction in the proportion between polychromatic erythrocytes to normochromatic erythrocytes. Meanwhile, addition of 1% Cur powder induced significant decrease in CAs and Mn-PCEs frequencies in comparison to those induced by FP and/or RB alone.The decreaseswere dose dependent.It is concluded that, curcumin exhibited antimutagenic properties against the mutagenicity induced by FP and/or RB which make it a promising chemopreventive agents.

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Key wards: Acrylamide, Curcumen, Chromosomes, Micronucleus, Rat, Potatoes chips, Roaster bread.

1. Introduction:

Frying food in fats and oils is a popular food preparation method. Recently, a huge public concern was generated after detecting a considerable concentration of the genotoxic and carcinogenic acrylamide in starch-containing foods cooked at high temperatures as fried potatoes, potato chips and the brown roasted bread (**Mottram *et al*., 2002; Tareke *et al*., 2002; Becalski *et al*., 2003 and Taubert *et al*., 2004**).

Epidemiological studies gave an evidence for cancer risk factor in correlation with consumption of the fried potatoes and the acrylamide content in foods with the incidences of cancer in various body organs. Analysis of epidemiological data showed a parallel link between high consumption of fried potatoes cooked at high temperatures and risk of bladder cancer in a case-control study in Uruguay (De Stefani*et al*., **2008**); risk of lung cancer among Canadian women due to evaporated burned oils (**Hu *et al*., 2002**); risk of laryngeal cancer in a case-control study from Italy and Switzerland (**Bosetti *et al*., 2002**); cancer risk of oral cavity, pharynx, esophagus, larynx, breast, colon and rectum (**Pelucchi *et al*., 2004**) and risk of renal cell carcinoma from a population-based Swedish case-control study (Mucci*et al*., 2004); risk of pancreatic cancer inan Italian case--control study(**Pelucchi *et al*., 2011**).

Experimentally, acrylamide induced single and double-strand DNA breaks and DNA adducts (Koyama ***et al*., 2011**). Moreover, acrylamide possessed mutagenic activity as revealed by chromosomal aberration, sister-chromatid exchange and micronucleus assays. Acrylamide induced chromosomal aberrations in L5178Y mouse lymphoma cells (**Moore *et al*., 1987**),in bone marrow and spleen cells of mice and rats (Krishna and Theiss, 1995), in spermatogenic cells (**Schmid *et al*., 1999**) and in Chinese hamster V79 cells (**Oliveira *et al*., 2009**). Acrylamide also decreased the mitotic activity of rat bone marrow cells (Yener **and** Dikmenli, 2011). Moreover, acrylamide induced sister-chromatid exchangesin spleen cells (**Backer *et al*., 1989**), in mice bone marrow cells (**Russo *et al*., 1994**) and in Chinese hamster V79 cells (**Oliveira *et al*., 2009**). In addition to that, acrylamide proved to be a potent micronuclei inducer in bone marrow cells of mice and rats (**Krishna and Theiss , 1995; Dobrzynska and Gajewski, 2000; Paulsson *et al.*, 2002; Abramsson-Zetterberg, 2003;Yener and** Dikmenli; 2009;Koyama ***et al*., 2011**), in spleen cells of mice (**Backer *et al*., 1989; Krishna and Theiss, 1995**), in peripheral blood erythrocytes of mice (Russo *et al*., 1994), in mice sper-

matids (**Collins *et al*., 1992; Russo *et al*., 1994**) and in human lymphoblastoid TK6 cells (**Koyama *et al*., 2006**).

Curcumin powder a yellow pigment obtained from ground dried rood rhizomes of curcuma plant (*Curcuma longa*), commonly used as natural food additive as a spice and food coloring agent. Previous studies showed that curcumin is able to inhibit the genotoxic and histochemical changes induced in the experimental animals by various chemical agents. Curcumin significantly reduced the percentages of micronucleated polychromatic erythrocytes in bone marrow cells of mice (**Azuine *et al.*, 1992**) and inhibited chromosomal aberrations, micronuclei formation, and sister chromatid exchanges (SCEs) incidences in mouse bone marrow cells induced by benzo(a)pyrene (**Shukla *et al*., 2002 and 2003**) and lead acetate (**El-Ashmawy *et al.*, 2006**). Moreover, curcumin reduced the levels of benzo[a]pyrene-DNA adducts in liver, lung, and forestomach (**Thapliyal and Maru, 2001; Thapliyal *et al*., 2002**) and DNA damage induced by benzo[a]pyrene in human peripheral blood lymphocyte cells as revealed by single cell gel electrophoresis assay (**Polasa *et al*., 2004**). In addition, Curcumin has been shown to inhibit chemical carcinogenesis (Thangapazham ***et al*., 2006; Garg *et al.*, 2008**) and chemical mutagensis (**Alaikov *et al.*, 2007; Peng *et al*., 2010**).

The aim of the present work was to investigate the frequencies of damaged cells (DC) and micronuclei in polychromatic erythrocytes (Mn-PCEs)induced by feeding female rats with diets containing fried potato chips and roasted bread for a long time. Another trial was carried out to reduce the induced chromosomal aberrations through feeding the animals with the same diets supplemented with 1 % curcumin powder.

2- Material and methods

2-A- Animals and treatments:

The experiments were carried out on 90 adult female albino rats 3-4 months age and 130-150 g in weight. The adult female animals were purchased from Helwan Farms of the Egyptian Organization for Vaccines and Biological Preparations, Cairo. Rats were accommodated according to the protocol of animal welfare of Ain Shams University. Animals were acclimatized for one week and the commercial food and tap water were supplemented ad libitum during the acclimatization and the experimental period. Animals were divided into groups 6 animals each. Table (1) shows animal groups, treatment schedule and the composition of diet for each animal group. Animals feed on diet contained 15 % or 30 % of fried potato chips and/or fried bread and supplemented with/without 1% curcumin addition for 2 months.

2-B-Chemicals

AA with 99% purity was purchased from sigma chemical company. It is white powder, water-soluble vinyl monomer. With molecular formula:C_3H_5NO and chemical formula : CH_2=$CHCONH_2$. Curcumin powder was obtained from the local herbal shop.

2-C- Preparation of fried potatoes and roasted bread

The fried potatoes chips were prepared according to the protocol regularly applied in the home: potatoes were washed with the tap water and the covering skin removed with a sharp knife and the potatoes pulps trimmed into thin slices (chips) with a thickness about 1 to 2 mm approximately. Commercial frying oil currently consumed by the native Egyptians was chosen from the supermarket.

After oil boiling, the potatoes slices were dropped into the boiled oil till the surface of slices turned into golden brown in color. Similarly, the bread of whole wheat seed was fried by the same way.The fried potatoes slices and the roasted bread were fragmented into powder and added to the commercial diet in appropriate percentages.

2-D- Chromosomal aberrations assay:

Metaphase chromosomal spreads were prepared from bone marrow cells by air-drying technique previously postulated by **Hliscs *et al.* (1997)**. Animals were injected intraperitoneally with colchicine (1 cc/ 200g b.w. from 0.04 % colchicine powder in dH_2O) 2 hrs perior to chromosomal preparation. Animals killed by cervical dislocation and bone marrow of femur was aspirated for chromosomal preparation. The prepared slides were stained with 5% Giemsa stain. Chromosomal aberrations were scored and recorded among 100 well-spread metaphase /animal. Moreover, mitotic index was calculated by counting the dividing cells among 2000 cells/ animal and expressed in percentage.

2- E- Micronucleus assay:

Micronucleus assay in polychromatic erythrocytes of bone marrow was carried out by the method of **Schmid (1976)** from bone marrow of the femur. The bone marrow was flushed in the form of a fine cell suspension into a centrifuge tube containing 1 ml of fetal calf serum. The cell suspension was centrifuged at 1000 r.p.m. for 5 min and the supernatant was discarded. The pellet was resuspended in a drop of serum for slides preparing. The air-dried slides were stained with Giemsa. A total of 2,500 polychromatic erythrocytes (PCEs) were scored per animal to determine the frequency of Mn-PCEs. In addition, the ratio of PCE to NCE was recorded.

2-F- Statistical analysis:

All the data were analyzed with Student's *t*-test and a *P*- value (P<0.05) was considered statistically significant.

3- Results and Discussion

In the present study, diet supplemented with 30 % of FP and/or RB exhibited 13, 16 and 8.33 damaged cell / 100 metaphase spreads and 18.67, 21.16 and 12.83 Mn-PCEs / 2500 PCEs, respectively. Furthermore, animals feed on FP induced higher incidences of damaged cells and micronuclei in comparison tothose feed on RB (Tables 2 and 3). This observation could be explained through the fact that, animals treated with fried potatoes were subjected to the effect of both the oxidative compounds of boiled oil and the brown crust which containing acrylamide. Experimentally, **Becalski *et al.* (2003)** prepared acrylamide in model reactions through heating mixtures of amino acids and glucose in ratios similar to those found in potatoes. They recorded a high concentration of acrylamide in FP (3700 ng/g) than in RB (14 ng/g).

The fried potatoes and the roasted bread possibly induced the chromosome breaking activity through three mechanisms. Firstly, the natural antioxidants content present in oils and potatoes are declined through frying process at high temperatures. The process of food frying destruct the natural antioxidants present in oil and potatoes as (alpha-tocopherol and phenolic compounds) which led to the lipid peroxidation in liver microsomes of rats after feeding with the fried potatoes (**Quiles *et al.*, 2002 and Yen *et al.*, 2010**).This assumption was ascertained by **Andrikopoulos *et al.* (2002)**. They observed that the fried oil content of antioxidants was deteriorated during eighth successive frying of virgin olive oil, sunflower oil and a vegetable shortening. Where, the retention of tochopherols ranged from 85-90% (first frying) to 15-40 (eighth frying) except for tocopherols of sunflower oil, which almost disappeared after the sixth frying and the retention of total phenolics ranged from 70-80% (first frying) to 20-30% (eighth frying).In addition, **Battino *et al.* (2002)** observed another effect for the intake of deep fried oils. They observed that, the intake of such altered oil by rats mainly affected the respiratory chain components (Coenzyme Q, cytochromes) of the mitochondrial membranes which considered as another source for genotoxicity.

Secondly, the boiling of oils at high temperatures induced the formation of genotoxic oxidative compounds (**Dung *et al.*, 2006**). Deep fat frying is a popular food preparation method because it produces desirable fried food flavor, golden brown color and crisp texture (**Warner, 1999**). Throughout, deep frying of oils, the oxidation process of oils is occurred and the genotoxic derivatives like linoleic acid hydroperoxides and squalene compounds are produced (**Chaiyasit *et al.*, 2007**). **Hageman *et al.* (1989 and 1990)** found that, linoleic acid hydroperoxides extracted from deep-frying fat samples induced mutagenicity to Salmonella tester strains TA97 and TA100, in presence of S9 mix. Moreover, consumption of heated oils by rats enhanced cell proliferation of the esophagus lining epithelium cells (**Hageman *et al.*, 1991**). Moreover, **Kalogeropoulos and Andrikopoulos (2004)** detected the genotoxic agents, squalene compounds that produced during deep-frying of potatoes.

Thirdly, the formation of the chemical compound known as acrylamide during heating of starch with the amino acid asparagine in the brown crust of fried potatoes and roasted bread (**Pedreschi and zuniga, 2009**). Asparagines, is the major amino acid in potatoes and cereals, which acts as a crucial participant in the production of acrylamide (**Mottram *et al.*, 2002**). Moreover, **Tareke *et al.* (2002)** detected a moderate level of acrylamide (5-50 microg/kg) in heated protein-rich foods and higher contents (150-4000 microg/kg) in carbohydrate-rich foods, such as fried potatoes. Furthermore, the acrylamide content consistently increased with increasing temperature and processing times (**Taubert *et al.*, 2004; Majcher and Jeleń, 2007**).

Acrylamide acts as an indirect genotoxic agent andcannot induce chromosomal damage but it converted to the mutagenic metabolite glycidamide in the liver cells.Glycidamide is potent genotoxic agent (**Puppel *et al.*, 2005**). It induced DNA adducts in normal human bronchial epithelial cells and Big Blue mouse embryonic fibroblasts, (Besaratinia and Pfeifer, 2004),in V79 Chinese hamster cells (Martins ***et al.*, 2007**) and inmouse lymphoma cells (**Mei *et al.*, 2008**).

On the other hand, diet supplement contains several natural substances capable of inhibiting genotoxic chemicals either directly by scavenging the reactive substances or indirectly by promoting mechanisms, which enhance detoxification of mutagenic agents.

Curcumin significantly reduced the percentages of damaged cells from 3.67±0.8 to 2.33±0.8 damaged cells/100 metaphase and from 13±1.34 to 8±1.03 damaged cells/100 metaphase induced by 15% and 30% FP, respectively. Similarly, curcumin significantly reduced the percentages of damaged cells from 3.67±0.8 to 2.33±0.8 damaged cells/100 metaphase and from 13±1.34 to 8±1.03 damaged cells/100 metaphase induced by 15% and 30% FP, respectively. Furthermore, it inhibited the mean frequencies of micronuclei induced by 30% FP from 18.67±1.02 to 11.17±0.98 Mn-PCEs / 2500 PCEsand 30% RB from

12.83±0.79 to 9.17 ±1.25 Mn-PCEs / 2500 PCEs as presented in tables 2&3.

Curcumin may beinduced its antigenotoxicity via liver antioxidant enzymes superoxide dismutase, catalase and glutathione peroxidase (**Reddy and Lokesh, 1994**) which lowered lipid peroxidation and protected rats from iron-induced lipid peroxidation. Curcumin pretreatment protect mice from DNA damage and carcinogenicity induced by benzo(a)pyrene and isothiocyanate via superoxide dismutase, catalase and glutathione peroxidase production (**Thapliyal and Maru, 2001**), **Thapliyal *et al*. (2001 and 2002)** and **Polasa *et al*. (2004)**.Another possible mechanism for antigeneotoxicity of curcumin via reducing the activity of cytochrome P450 (CYP450) isozymes CYP 1A1, 1A2 and 2B1 in liver, lung, and forestomach and elevating the activity of hepatic glutathione S-transferase (**Singh and Sharma, 2011**).

It is concluded that, curcumin, the yellow pigment commonly used as a spice and food coloring agent obtained from rhizomes of *Curcuma longa* exhibited antimutagenic properties.

Table (1): Categorization of the animal groups from according the percentage of diet content of fried potato chips, roasted bread, Curcumin and commercial diet for two months.

	Treatment (Group / 6 animals)	Diet Composition (%)				
		Fried Potato hips	Roasted bread	Curcumin	Acrylamide	Commercial Diet
	Control 1	-	-	-	-	100
	Control 2	-	-	1	-	99
	Positive Control	-	-	-	1	99
Without Curcumin	FP 15%	15	-	-	-	85
Without Curcumin	RB 15%	-	15	-	-	85
Without Curcumin	FP+RB 15%	15	15	-	-	70
Without Curcumin	FP 30 %	30	-	-	-	70
Without Curcumin	RB 30 %	-	30	-	-	70
Without Curcumin	FP + RB 30 %	30	30	-	-	40
With Curcumin	FP 15%	15	-	1	-	84
With Curcumin	RB 15%	-	15	1	-	84
With Curcumin	FP+RB 15%	15	15	1	-	69
With Curcumin	FP 30 %	30	-	1	-	69
With Curcumin	RB 30 %	-	30	1	-	69
With Curcumin	FP + RB 30 %	30	30	1	-	39

Control 1 = Includes animals feed only on the commercial diet

Control 2 = Included animals feed on commercial diet and supplemented with 1 g turmeric

RB = Roasted bread

FP = Fried potatoes chips

Table (2): Average of damaged metaphases induced in bone marrow cells of animals feed on diet contained 15 % or 30 % of fried potatoes chips and/or fried bread and supplemented with/without curcumin addition for 2 months.

	Treatment	Number of damaged cells			Mitotic index	
		Total	Mean %	SE ±	Mean%	SE ±
	Control	10	1.67	0.61	3.83	0.30
	1% Curcumin	4	0.67	0.21*	4.33	0.33*
	1%AA	133	22.16	0.91*****	1.16	0.16
Without Curcumin	FP 15%	22	3.67	0.80*	3.00	0.25*
Without Curcumin	RB 15%	16	2.67	0.66*	3.50	0.42*
Without Curcumin	FP + RB 15%	30	5.00	0.85***	2.83	0.30**
Without Curcumin	FP 30%	78	13.0	1.34*****	2.00	0.25****
Without Curcumin	RB 30%	50	8.33	0.95*****	2.50	0.34**
Without Curcumin	FP + RB 30%	96	16.0	1.46*****	1.33	0.21*****
With Cur-cumin	FP 15%	14	2.33	0.80[a]	3.50	0.34[a]
With Cur-cumin	RB 15%	12	2.00	0.51[b]	4.00	0.36[b]
With Cur-cumin	FP + RB 15%	24	4.00	0.89[c]	3.00	0.36[c]
With Cur-cumin	FP 30%	48	8.00	1.03[g]	2.50	0.22[e]
With Cur-cumin	RB 30%	30	5.00	1.12[f]	3.00	0.45[g]
With Cur-cumin	FP + RB 30%	71	11.83	1.1[h]	1.50	0.22[i]

AA = Acrylamide FP = fried potatoes chips RB= fried breadSE=Standard error

*P>0.05 compared with control **P<0.05 compared with control ***P<0.01 compared with control ****P<0.001 compared with control *****P<0.0001 compared with control [a]P>0.05 compared with 15% FP [b]P>0.05 compared with 15%RB [c]P>0.05 compared with 15% FP +RB[d]P<0.001 compared with 30%FP

[e]P>0.05 compared with 30% FP [f]P<0.05 compared with 30%RB[g]P>0.05 compared with 30%RB [h]P<0.05 compared with 30% FP +RB[i]P<0.05 compared with 30% FP +RB

Table (3): Frequency of micronucleated erythrocytes and PCE/NCE ratioinduced in bone marrow cells of rats feed on diet contained fried potatoes chips and/or fried bread and supplemented with/without curcumin addition.

Serial / Treatment		The frequency of MN			PCE/NCE	
		Total Mn/15000PCEs	Mean Mn/2500PCEs	SE ±	Mean%	SE ±
	Control	20	3.33	0.56	53.50	0.84
	1% Curcumin	15	2.5	0.65*	56.00	0.77*
	1%AA	238	39.66	1.14****	30.83	1.08****
Without Curcumin	FP 15%	35	5.83	0.98*	46.83	1.08***
Without Curcumin	RB 15%	50	8.33	1.17**	49.67	0.56**
Without Curcumin	FP + RB 15%	70	11.67	1.30***	44.50	1.23****
Without Curcumin	FP 30%	112	18.67	1.02****	35.50	1.38****
Without Curcumin	RB 30%	77	12.83	0.79****	43.17	0.60****
Without Curcumin	FP + RB 30%	130	21.16	1.62****	29.83	0.87****
With Cur-cumin	FP 15%	30	5.00	1.81[a]	51.67	0.66[b]
With Cur-cumin	RB 15%	17	2.83	0.79[c]	52.33	0.42[c]
With Cur-cumin	FP + RB 15%	46	7.67	1.17[d]	50.50	0.84[e]
With Cur-cumin	FP 30%	67	11.17	0.98[f]	38.17	1.25[g]
With Cur-cumin	RB 30%	55	9.17	1.25[h]	44.67	0.76[i]
With Cur-cumin	FP + RB 30%	105	17.5	0.92[j]	31.50	1.17[k]

AA = Acrylamide FP = fried potatoes chips RB= fried breadSE=Standard error
*P>0.05 compared with control **P<0.01 compared with control ***P<0.001 compared with control ****P<0.0001 compared with control [a]P>0.05 compared with 15% FP [b]P<0.01 compared with 15%FP[c]P<0.01 compared with 15%RB [d]P<0.05 compared with 15% FP +RB[e]P<0.01 compared with 15% FP +RB[f]P<0.001 compared with 30%FP[g]P>0.05 compared with 30%FP[h]P<0.05 compared with 30%RB [i]P>0.05 compared with 30%FP[j]P<0.05 compared with 30% FP +RB[k]P>0.05 compared with 30% FP +RB

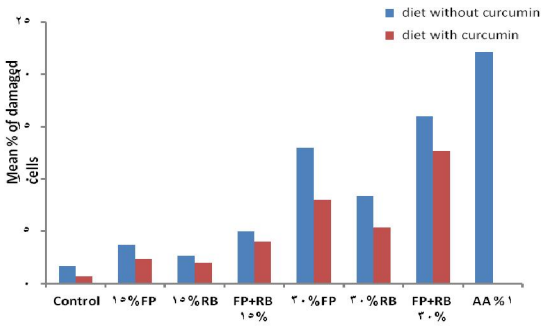

Fig. (1): Mean percent of damaged cells induced after fedding animals on diet contained 15 % or 30 % of fried potatoe chips and/or fried bread and supplemented with/withoutcurcmin.

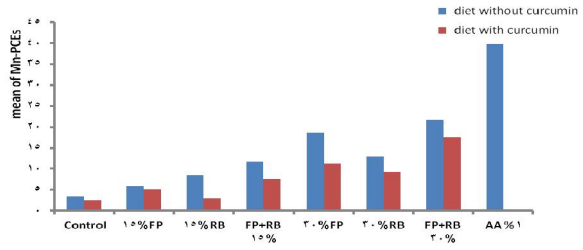

Fig. (2): Mean of Mn-PCEs induced after fedding animals on diet contained 15 % or 30 % of fried potatoe chips and/or fried bread and supplemented with/without curcmin.

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