International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(4): 1169-1174

Received: 01-05-2019
Accepted: 05-06-2019

Sivasakthi T
Research Scholar, Community Science College and Research Institute, TNAU, Madurai, Tamil Nadu, India

Amutha S
Dean, Community Science College and Research Institute, TNAU, Madurai, Tamil Nadu, India

Hemalatha G
Professor and Head, Community Science College and Research Institute, TNAU, Madurai, Tamil Nadu, India

Murugan M
Professor, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Prabaharan K
Assistant Professor, Department of Agricultural Economics, Agricultural College and Research Institute, TNAU, Madurai, Tamil Nadu, India

Vellaikumar S
Assistant Professor, Department of Biotechnology, Agricultural College and Research Institute, TNAU, Madurai, Tamil Nadu, India

Correspondence
Amutha S
Dean, Community Science College and Research Institute, TNAU, Madurai, Tamil Nadu, India

Impact of pretreatments on reduction of acrylamide formation in fried potato chips

Sivasakthi T, Amutha S, Hemalatha G, Murugan M, Prabaharan K and Vellaikumar S

Abstract
Potato chips are very popular product especially among younger generations. This could be a potential source of acrylamide, a toxic compound which could develop during frying and baking processes. The main objective of this study to evaluate the acrylamide reduction potential of mint leaves solution, ginger and garlic paste solution and lemon juice in fried potato chips. Potatoes slices were fried at two different temperature and time combination such as 160º C for 7 mins and 180ºC for 4 mins by using refined peanut oil. Prior to frying, potato slices were treated in following ways *i.e.* rinsing in distilled water plus blanching in hot water at 100º C for 2 mins plus immersion 0.5 and 1.0 per cent of in mint leaves solution (T_1), ginger garlic paste solution (T_2) and lemon juice (T_3) for 1 h. The fried potato chips were analysed for acrylamide content, moisture, total oil content, Starch, reducing sugars, colour and sensory parameters. The result of the study showed, that the sample treated with 1.0 per cent of lemon juice (T_3) and fried at 160ºC for 7 min had maximum acrylamide inhibitory effect. Frying time and temperature had the greatest influence on acrylamide formation. There is no significant impact of pretreatment on other chemical parameters such as moisture, total oil content and starch as well as in sensory parameters.

Keywords: Acrylamide, potato chips, lemon juice, ginger garlic paste, mint leaves

Introduction
Potato (*Solanum tuberosum* L.) popularly known as 'The king of vegetables', has emerged as fourth most important food crop in India after rice, wheat and maize. Indian vegetable basket is incomplete without Potato. In India, potatoes have been utilized largely for consumption as fresh potatoes and the major part of potato harvest (approx. 68.5%) goes to domestic table consumption. Whereas, in the developed countries, table potato utilization is merely 31%, rest being frozen French fries (30%), chips and shoestrings (12%) and dehydrated products (12%) (Singh, *et al.,* 2016) [1].

Chips and snacks have become part of the daily diet for rural and urban in India. Acrylamide has been found to occur in many fried starchy foods especially potato chips and French fries. Acrylamide is a chemical compound that is formed from food components during high temperature heat treatment (frying, baking, roasting and grilling) as a result of the maillard reaction between reducing sugars (glucose and fructose) and amino acids (asparagine).

It is of great concern in recent days as it is known to be a possible carcinogen. It was discovered in foods during the year 2002 by Swedish National Food Agency (SNFA). Acrylamide formation in foods was influenced by several factors, including processing temperature, time, content and species of reducing sugars and amino acids, pH, moisture content and frying oils, etc. (Pedreschi *et al.,* 2005) [3] Many of the studies have been conducted to develop possible mitigation strategies to limit acrylamide levels in various foods, especially fried potato products (Granda *et al.,* 2005, gokmen and senyuva, 2007) [4, 5]. The mitigation strategies include lowering reducing sugars and free asparagine in the raw materials by changing processing technology. Therefore, the main purpose of this investigation was to confirm the Acrylamide lowering effect of mint leaves solution, ginger garlic paste solution and lemon juice on fried potato chips.

Materials and Methods
Raw materials
Potatoes of Kufri Jyoti, a processed variety was purchased from CPRI (Central Potato Research Institute), Ooty, Tamil Nadu. Refined peanut oil, ginger, garlic, mint and lemon were purchased from the local market.

Chemicals
Acrylamide (standard), HPLC-grade methanol, HPLC-grade acetonitrile and HPLC grade hexane were purchased from Sigma-Aldrich. The deionised Milli-Q water was obtained from a Millipore purification system (Milli-Q Integral Water Purification System), petroleum ether, anthrone, ethanol, perchloric acid, lead acetate, potassium oxalate and cuprous oxide of reagent grade.

Preparation of potato slices
The potatoes were washed with tap water and peeled manually. Further, it was cut into slices of approximately 1.0 mm thickness using vegetable slicer. Slices were washed with distilled water immediately after cutting to remove some starch found at surface of the slices. Then the slices were subsequently blanched by heating potato slices in hot distilled water at 100ºC for 1 min (potato slices-to-water ratio was 1:5 w/v).

Pre-treatments
Blanched slices were soaked for 1 h in distilled water containing mint leaves solution (T_1), ginger and garlic paste solution (T_2) and lemon juice (T_3) of 0.5 and 1.0 per cent. (potato slices-to-solution ratio was 1:10 w/v).

Frying conditions
Potato slices were deep-fried in hot refined peanut oil contained in electrical fryer (American Micronic Instruments, India) at two different temperature and time combination *i.e* 160ºC for 7 mins and 180ºC for 4 mins. Frying temperature was kept almost constant (±1ºC). The potato slices and oil ratio was 1:10 (w/v)

Acrylamide analysis
Preparation of standard solutions
The acrylamide analysis was done by method given by Meghavarnam and Janakiraman (2018) [6]. Acrylamide standard stock solution (1 mg /m1) were prepared by dissolving 10 mg of the acrylamide in 10 mL of MilliQ water and it was protected from light and stored in a refrigerator at 4ºC. All working solutions were prepared freshly by dilution of stock solution in MilliQ water.

Extraction of sample for high performance liquid chromatography (HPLC) analysis
One gram of potato chips were taken and finely ground in a pestle and mortar. The ground potato chips were transferred into a separating funnel and 10 mL of methanol was added. Then it was shaken vigorously for 15 mins. The homogenates was filtered and centrifuged at 10000 g for 10 mins; the centrifuged sample was filtered again through Whatman No.1 filter paper. The homogenate was defatted (twice) with 10 mL of hexane by allowing the homogenate to stand in water bath (30ºC) for 30 mins. The obtained extracts were filtered through 0.2 µm a nylon syringe filter, which was used for analysis.
The quantification of acrylamide in potato chips was performed using HPLC system (Shimadzu LC10ATVP series) equipped with a C18 column and diode array detector set at isocratic conditions with 97 per cent acetonitrile and 3 per cent 5mM trifluoroacetic acid as mobile phase at 1 mL/ min flow rate and detection carried out at 210 nm at 28ºC. Peak areas of the standards were used to interpolate acrylamide concentrations in the samples (Fig. 1). All analyses were performed in triplicates and the average results are expressed as micrograms per kilogram sample.

Moisture content
The moisture content of the sample was estimated by hot air oven method as per the procedure described by AOAC (2000) [7]. The sample was dried at 110^0C and was continued till a constant reading was obtained. The moisture was expressed as percentage.

Total oil content
Total oil content was determined in triplicate by solvent extraction using the Soxhlet method (AOAC, 2000) [7], performing the extraction procedure with petroleum ether. Oil uptake was reported as a percentage on a moisture free basis.

Starch
Starch content of the sample was estimated using anthrone method described by Sadasivam and Manickam (2008) [8].

Reducing sugars
The sugar content of the samples was determined by Shaffer - Somogyi micro method described by McDonald and Foley (1960) [9].

Colour
Colour values of potato chips were measured using a chromometer using the Hunter L*, a*, b* values. L* value indicate the intensity of colour towards lightness. The negative a* shows the greenness while positive a* shows trend towards redness. The positive b* value indicating tendency toward yellowness of potato chips while negative b* value indicate blue colour of chips.

Sensory evaluation
The potato chips were evaluated organoleptically for various quality attributes such as colour, texture, flavour, taste and overall acceptability by a panel of 15 semi trained judges using 9 point hedonic scale ranging from like extremely to dislike extremely.

Statistical analysis
All the experiments were carried out in triplicate and statistical analysis was performed using AGRES for Window version 7.0. The statistical significance of data was tested applying analysis of variance (ANOVA) and the test of mean was compared by least significant difference (LSD); level of significance was 0.05.

Results and Discussion
Acrylamide content
The acrylamide lowering effect of mint leaves solution, ginger garlic paste solution and lemon juice was shown in table 1. The potato slices treated with mint leaves solution did not found to have much effect on acrylamide reduction, which may be due to the less pronounced lowering effect of pH as compared to others treatment. The mitigation appeared to be higher in the chips treated with lemon juice followed by chips treated with ginger garlic paste solution and mint leaves solution. The acrylamide formation was less pronounced in the sample treated with 1.0 per cent of all the three treatments (T_1, T_2, T_3) when compared with 0.5 per cent. Similarly the formation of acrylamide was lowered in the chips fried at 160ºC for 7 mins when compared with the chips fried at

180ºC for 4 mins. The potato slices treated with lemon juice of 1.0 per cent concentration and fried at 160ºC for 7 min had low acrylamide content which is about 580±20.38µgKg^{-1}. Similar result was reported by Jung *et al.,* (2003) [10], who found that dipping potato strips in 10 and 20 g/l citric acid solutions induced 73.1 per cent and 79.7 per cent reduction of acrylamide formation in the French fries when fried at 190ºC. Also, this result was coincident with that reported by Pedreschi *et al.,* (2006) [11], who reported potato strips immersion in citric acid solution of 10g/l reduced the acrylamide formation after frying. This may be due to lowering the pH with citric acid before frying was an efficient way to considerably diminish acrylamide formation in potato chips. These results suggest that there may be ways to reduce or prevent acrylamide formation by changing processing methods.

Table 1: Acrylamide content (µgKg-1) of pre-treated potato chips

Treatment and concentration		Frying temperature and time	
		160º C (7 min)	**180º C (4 min)**
T_1	0.5 %	1168 ± 47.06	1306 ± 23.66
	`1%	1052 ± 42.10	1187 ± 7.91
T_2	0.5%	1073 ± 29.98	1292 ± 47.74
	`1%	927 ± 30.91	1018 ± 41.29
T_3	0.5%	724 ± 22.84	956 ± 4.30
	`1%	580 ± 20.38	715 ± 19.33

Values represent means of three replicates± standard deviation

Source	Temperature (D)	Concentration (C)	Treatments (T)	Interaction (D×C)	Interaction (C×T)	Interaction (D×T)	Interaction (D×C×T)
SED	10.443	10.443	12.790	14.769	18.088	18.088	25.581
CD(0.05)	21.554**	1.554**	26.399**	30.483**	37.333^{NS}	37.333**	52.798**

*Significant level at 0.05%, NS- Non significant

T_1 Mint leaves solution

T_2 Ginger garlic paste solution

T_3 Lemon juice solution

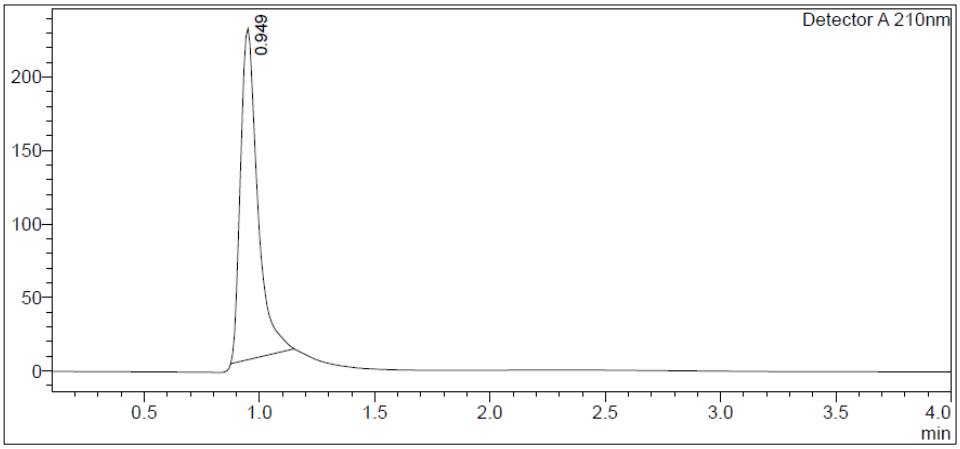

Fig 1: Chromatogram of acrylamide standard (1ppm)

Moisture content

The effect of frying temperature, time and treatment on moisture content of deep fried potato chips are given in table 2. There is no significant difference was observed among the treatments and concentration. It was observed that, there is low moisture content in the chips fried at 160ºC for 7 mins when compared with the chips fried at 180ºC for 4 mins. This may be due to the prolonged heating of potato slices in the oil, leads to evaporation of moisture found in the potato slices. The chips fried at 160ºC for 7 mins showed the moisture content between 2.72±0.047 to 3.50±0.104 per cent. Similarly the chips fried at 180ºC for 4 mins had the moisture content between 3.50±0.037 to 3.70±0.0126 per cent. It is inferred that, the moisture content decreased when the frying time is increased. Albuquerque *et al.,* (2012) [12], studied the moisture, fat, salt and fatty acid profile of different brands of potato crisps. The result of the study indicated that, the moisture content of the potato crisps varied from 1.50g/100g to 3.56g/100g, which is in line with the above findings.

Table 2: Moisture content (%) of the pre-treated potato chips

Treatment and concentration		Frying temp. and time	
		160º C (7 min)	**180º C (4 min)**
T_1	0.5 %	2.72±0.047	3.56±0.056
	`1%	2.95±0.119	3.70±0.126
T_2	0.5%	2.84±0.005	3.50±0.037
	`1%	3.30±0.022	3.60±0.149
T_3	0.5%	2.95±0.005	3.70±0.086
	`1%	3.50±0.104	3.63±0.128

Values represent means of three replicates± standard deviation

Source	Temperature (D)	Concentration (C)	Treatments (T)	Interaction (D×C)	Interaction (C×T)	Interaction (D×T)	Interaction (D×C×T)
SED	0.029	0.029	0.036	0.041	0.051	0.051	0.072
CD(0.05)	0.061**	0.061**	0.075**	0.086**	0.106^{NS}	0.106**	0.150**

*Significant level at 0.05%, NS- Non significant

Total oil content

The total oil contents of deep fried potato chips are reported in table 3. The total oil content of potato chips fried at 160ºC for 7 min and 180ºC for 4 mins ranged from 24.21±0.953 % to 29.40±0.636 %. The total oil content was high in the chips fried at 160ºC for 7 mins than that of 180ºC for 4 mins. This is because the long time exposure of potato slices in the oil leads to more penetration. There was no significant difference observed among the treatments. The potato chips treated with 1.0 per cent of all the treatments (T_1, T_2, T_3) had more oil content than that of 0.5 per cent. The total oil content was low in the sample treated with 0.5 per cent of lemon juice and fried at 180ºC for 4 mins (24.21±0.953 %). Similarly the total oil content was more in the sample treated with 1.0 per cent mint leaves solution and fried at 160ºC (29.40±0.636 %). The factor that could have affected differences in the oil contents is thickness of potato slices. The oil content of the chips decreased almost as the slice thickness was increased. Thin slices lose more moisture and gain more oil due to diffusion effects. These results are in collaboration with Albuquerque *et al.*,(2012) [12], who reported the total oil content of fried potato chips of different brands was varied between 20.0-42.8g/100g.

Table 3: Total oil content (%) of the pre-treated potato chips

Treatment and concentration		Frying temp. and time	
		160º C (7 min)	**180º C (4 min)**
T_1	0.5 %	28.14±1.085	24.30±0.021
	`1%	29.40±0.636	27.14±0.676
T_2	0.5%	26.80±0.411	25.80±0.092
	`1%	27.60±1.214	28.20±0.355
T_3	0.5%	28.12±0.025	24.21±0.953
	`1%	28.60±0.360	26.65±0.984

Values represent means of three replicates± standard deviation

Source	Temperature (D)	Concentration (C)	Treatments (T)	Interaction (D×C)	Interaction (C×T)	Interaction (D×T)
SED	0.232	0.232	0.284	0.32858	0.40242	0.40242
CD (0.05)	0.479**	0.479**	0.587^{NS}	0.678**	0.830^{NS}	0.830**

*Significant level at 0.05%, NS- Non significant

Starch content

The starch content of the fried potato chips is presented in table 4. There is significant difference was observed between the frying temperatures. A slight decreasing trend was noticed in the starch content of the potato chips fried at 180ºC. There is no significant difference was noted among the treatments and concentration. The starch content of the potato chips was high (52.65 ±0.950g/100g) in the sample treated with mint leaves solution (T_1) of 0.5 per cent concentration and fried at 160ºC for 7 mins. Similarly the potato chips treated with ginger garlic paste solution (T_2) of 0.5 per cent concentration and fried at 180ºC had less (49.00 ±0.927g/100g) starch content.

Table 4: Starch content (g/100 g) of the pre-treated potato chips

Treatment and concentration		Frying temp. and time	
		160º C (7 min)	**180º C (4 min)**
T_1	0.5 %	10.52 ± 0.284	9.28 ±0.301
	`1%	10.65 ± 0.019	9.52 ±0.309
T_2	0.5%	11.00 ± 0.258	10.20 ±0.175
	`1%	11.19 ± 0.222	10.40 ±0.309
T_3	0.5%	10.20 ± 0.378	9.92 ±0.313
	`1%	10.71 ± 0.299	9.20 ±0.296

Values represent means of three replicates ± standard deviation

Source	Temperature (D)	Concentration (C)	Treatments (T)
SED	0.157	0.157	0.192
CD (0.05)	0.324**	0.324^{NS}	0.398^{NS}

*Significant level at 0.05%, NS- Non significant

Reducing sugars

Reducing sugar is an important factor which plays a major role in the colour and acrylamide content of the potato chips. The reducing sugar content (table 5) of potato chips varied from 1.28±0.029 to 3.08±0.008g/100g. There is no significant difference was noted between frying temperatures on reducing sugar content of fried potato chips. A slight deference was observed among the treatments and concentration. Here the reducing sugar content was less in the chips treated with lemon juice (T_3) than that of T_1 and T_2. Similarly when corresponding to the concentration, the chips treated with 1.0 per cent of all the treatments had less reducing sugar content than that of 0.5 per cent. This may be due to that, soaking potato slices in lemon juice lead to a higher leaching of one important acrylamide precursor such as glucose. These findings agreed with those of Amany and

shaker (2013) [13], who found that, soaking of potato slices before frying in distilled water (contains 1% citric acid), led to remarkable decrease in glucose contents (30-45%) of potato slices comparing to control sample (Unsoaked).

Table 5: Reducing sugars content (g/100g) of the pre-treated potato chips

Treatment and concentration		Frying temp. and time	
		160º C (7 min)	180º C (4 min)
T_1	0.5 %	2.91±0.053	3.08±0.008
	`1%	2.00.±0.015	2.17±0.057
T_2	0.5%	2.82±0.060	2.97±0.016
	`1%	1.95.±0.075	2.03±0.040
T_3	0.5%	1.49±0.013	1.52±0.026
	`1%	1.01±0.037	1.28±0.029

Values represent means of three replicates± standard deviation

Source	Temperature (D)	Concentration (C)	Treatments (T)	Interaction (D×C)	Interaction (C×T)	Interaction (D×T)	Interaction (D×C×T)
SED	0.146	0.146	0.179	0.206	0.253	0.253	0.358
CD(0.05)	0.301 NS	0.301 NS	0.369 NS	0.426 NS	0.522 NS	0.522 NS	0.738 NS

*Significant level at 0.05%, NS- Non significant

Colour value

The effect of frying temperature and time on the colour value of potato chips are given in table 5 The potato chips fried at 160ºC for 7 mins had significantly higher L* value than the value corresponding to the potato chips fried at 180ºC for 4 mins. Similar result was obtained by Abong *et al.*, (2011) [14], who reported the crisps color (lightness) got decreased and redness increased (browning) when the temperature increased from 160 to 180°C. Among the treatments the potato chips treated with lemon juice (T_3) had more L* value followed by ginger garlic paste solution (T_3) and mint leaves solution (T_1). Citric acid found in the lemon juice reduce the pH of potato slices, the protonation of asparagine amino groups will takes place at low pH. This would block the nucleophilic addition of asparagine with a carbonyl compound, preventing the formation of the corresponding Schiff base, a key intermediate in the maillard reaction. Hence the potato chips processed by immersing in lemon juice had high L* value. When corresponding to concentration, the potato chips treated with 1.0 per cent concentration of all (T_1, T_2, T_3) the treatments had high L* value than that of the chips treated with 0.5 per cent concentration. This may be due to the higher concentration of all the solution react more with potato slices and reduce the pH, which prevents the millard reaction. A higher L* value indicates a light colour which is desirable in potato chips.

The negative value is an indication of greenish color rather than red. There is no significant difference was observed in a* value for all the treatments, frying temperature and concentration. Here the potato chips fried at 180ºC for 4 mins as well as 160ºC for 7 mins irrespective of the treatments and concentration had negative values, which indicates greenness. There is no redness in the potato chips, indicating that less millard reaction occurred in all the treatments.

The b* value indicates the blue-yellow chromaticity of the sample. The yellowness was observed in the potato chips treated with mint leaves solution (T_1). When, the frying temperature higher, the chromatic parameter b* value of potato chips increases considerably due to browning reactions that takes place during frying. Finally, the chromatic color component b* value increases with frying time and as with the other chromatic component their values tend to increase faster as the frying temperature increases.

Table 6: Colour value of the pre-treated potato chips

Treatment and concentration		Frying temp. and time					
		160º C (7 min)			180º C (4 min)		
		L*	a*	b*	L*	a*	b*
T1	0.5 %	36.87±1.030	-5.18±0.122	-1.56±0.043	48.03±0.303	-6.30±0.239	2.94±0.065
	`1%	40.75±1.432	-4.84±0.192	-1.83±0.054	50.32±1.774	-3.34±0.057	1.81±0.038
T2	0.5%	41.98±1.589	-5.33±0.161	-3.39±0.104	52.80±0.714	-3.11±0.087	-3.85±0.118
	`1%	46.45±1.968	-4.30±0.140	-3.29±0.050	57.75±2.030	-1.56±0.003	-2.81±0.061
T3	0.5%	52.80±0.538	-6.44±0.209	-1.30±0.032	60.20±2.496	-2.13±0.027	-4.55±0.078
	`1%	57.75±2.447	-2.02±0.069	-2.74±0.035	62.66±2.655	-2.06±0.004	-3.47±0.056

L* = Lightness (0= black, 100=white), a* = redness/greenness (+ = red, - = green), b* = yellowness/blueness (+ = yellow, - = blue) Values represent means of three replicates± standard deviation

Sensory evaluation

The sensory characteristics of fried potato chips are given in table 7. There was no significant difference observed in flavor of potato chips irrespective of treatments, frying temperature and time. However the colour and texture appears to be significantly affected by frying temperature and time. Similarly the taste of chips was affected by treatments, concentration, frying temperature and time.

It was noticed that the colour of potato chips got decreased when the frying temperature increased. It could also noticed that, the highest values of color were recorded for lemon juice treatments (0.5 % and 1.0 %) comparing to other treatments. These results are in agreement with those reported by Amany and Shaker (2013) [13], who found that, fried potato slices pretreated by immersion in acid solution (citric acid 1%) was characterized by an appropriate golden-yellow color. Zaid (2015) [15] reported that, the highest colour (lightness) values were recorded for the potato chips treated with citric acid solution (0.5 %, 1% and 2%) comparing to control, where their recorded color value were 9.27, 9.05 and 8.83, respectively.

Regarding to the texture the chips fried at 180ºC had more crispy texture than the chips fried at 160oC irrespective of the treatment and concentration. The flavor of the fried potato chips was highly acceptable irrespective of the treatments, concentration, frying temperature and time

Concerning to taste results, the highest taste values were recorded for fried potato chips treated by mint leaves solution (T_1) and fried at 180ºC followed by ginger garlic paste solution (T_2). While the lowest value was recorded for the chips treated with lemon juice (T_3) treatments (1.0 %) and fried at 160ºC. These findings are agreed with those of Jung *et al.*, 2006, who reported that sensory quality of French fries got decreased when the added citric acid reached the level of 2 per cent (w/w). The result also coincided with the result reported by Zaid (2015) [15] who reported that, the highest taste values were recorded for fried potato chips treated by tomato juice either separated or combined which recorded 8.72 and 8.66, respectively. The lowest values were recorded for citric acid treatments (0.5%, 1% and 2%) where their taste values were 7.38, 7.22 and 7.00 respectively.

Regarding to the overall acceptability, the potato chips treated with mint leaves solution (T_1), ginger garlic paste solution (T_2) and fried at 180ºC was highly acceptable. These results are in harmony with the study conducted by Gaikwad and Athmaselvi (2016) [16] who reported, the sample with 0.2% citric acid solution soaking foe 20 mins, gave values with less overall acceptability than control.

Table 7: Sensory evaluation of pre-treated potato chips

Frying temp. and time	Treatment and con.		Colour and Appearance	Texture	Taste	Flavour	Overall acceptability
160º C (7 min)	T_1	0.5 %	8.7±0.483	8.0±0.500	8.0±0.707	8.0±0.866	8.0±0.866
		`1%	8.7±0.483	8.4±0.527	8.1±0.781	8.2±0.833	8.0±0.866
	T_2	0.5%	8.5±0.527	8.0±0.816	8.0±0.666	8.0±0.816	8.3±0.823
		`1%	8.8±0.421	8.0±0.666	8.0±0.816	8.4±0.516	8.5±0.527
	T_3	0.5%	9.0±0	8.0±0.816	7.8±0.788	8.2±0.788	8.0±0.816
		`1%	9.0±0	8.7±0.483	8.0±0.866	8.2±0.788	8.0±0.666
180º C (4 min)	T_1	0.5 %	8.0±0.707	8.0±0.666	8.7±0.483	8.0±0.500	8.5±0.527
		`1%	8.2±0.833	8.0±0.707	8.7±0.483	8.2±0.788	8.5±0.527
	T_2	0.5%	8.0±0.666	8.2±0.788	8.5±0.527	8.0±0.707	8.5±0.527
		`1%	8.4±0.516	8.5±0.527	8.5±0.527	8.5±0.527	8.5±0.527
	T_3	0.5%	8.5±0.527	8.5±0.527	8.0±0.707	8.2±0.833	8.0±0.866
		`1%	8.5±0.527	8.7±0.483	8.0±0.707	8.2±0.833	8.2±0.833

Conclusion

The experimental findings revealed that, the potato chips treated with lemon juice (T_3) of 1.0 per cent and fried at 160ºC had less acrylamide content. Hence the lemon juice is the best natural ingredient that had an excellent acrylamide mitigation effect without affecting nutrient of potato chips. It is also concluded from the result obtained that the acrylamide content can be reduced by frying the potato chips at low temperature (160ºC).

References

1. Singh B, Raigond P, Joshi A, Mehta A and Singh, BP. A Manual on Potato Processing in India. CPRI Technical Bulletin No. 48 (Revised). ICAR-Central Potato Research Institute, Shimla, India, 2016, 1-74.
2. SSEC-Swedish Scientific Expert Committee Report. Acrylamide in Food-Mechanisms of formation and influencing factors during heating of foods. 2002.
3. Pedreschi F, Moyano P, Kaack K, and Granby K. Color changes and acrylamide formation in fried potato slices. Food Res. Int. 2005; 38:1-9.
4. Granda C, Moreira RG. Kinetics of acrylamide formation during traditional and vacuum frying of potato chips. J Food Process Eng. 2005; 28:478-493.
5. Gokmen V, Senyuva HZ. Effects of some cations on the formation of acrylamide and furfurals in glucose-asparagine model system. Eur. Food Res. Technol. 2007; 225:815-820.
6. Meghavarnam AK, Janakiraman S. Evaluation of acrylamide reduction potential of L-asparaginase from Fusarium culmorum (ASP-87) in starchy products. LWT - Food Sci. & Tech. 2018; 89:32-37.
7. AOAC-International Official Method of Analysis, Edn 10, Association of Analytical Chemists, Washington, DC, USA, 2000.
8. Sadasivam S and Manickam A. Biochemical Methods. Edn 3, New Age International Publishers, New Delhi. 2008; 1:203-204.
9. McDonald and Efoley JBY. J. Asson. Offic. Agric. Chem. 1960; 43:645.
10. Jung MY, Choi DS, Ju JW. A novel technique for limitation of acrylamide formation in fried and baked corn chips and in French fries. J Food Sci. 2003; 68:1287-1290.
11. Pedreschi F, Kaack K and Granby K. Acrylamide content and colour development in fried potato strips. Food Res. Int. 2006; 36:40-46.
12. Albuquerque TG, Silva AS, Santos L, Costa HS. An update on potato crisps contents of moisture, fat, salt and fatty acids (including trans-fatty acids) with special emphasis on new oils/fats used for frying. International Journal of Food Sciences and Nutrition. 2012; 63(6):713–717.
13. Amany MMB, Skaker MA. Reduction of acrylamide formation, polymer compounds and oil uptake in potato slices during frying. Curr. Res. Microbiol. Bio technol. 2013; 1(3):111-118.
14. Abong GO, Okoth MW, Imungi JK, Kabira JN. Effect of slice thickness and frying temperature on colour, texture and sensory properties of crisps made from four Kenyan potato cultivars. American journal of food technology. 2011; 6(9):753-762.
15. Zaid FOFA. The effect of using some treatments on reduction of acrylamide formation in processed potatoes. Journal of environmental science, toxicology and food technology. 2015; 9(11):46-53.
16. Gaikwad KY, Athmaselvi KA. Effect of Soaking Pre-treatments on Different Characteristics of Fried Potato Chips. Biosciences Biotechnology Research Asia. 2016; 13(2):1133-1136.