

**PREVENTIVE ACTIONS OF ACRYLAMIDE
FORMATION AS A CHEMICAL HAZARD
DURING DEEP FAT FRYING OF
POTATO STRIPS**

By

OSAMA AHMED MOHAMED EL-SAYED

**B.Sc. Agric. Sci. (Food Science), Fac. Agric., Cairo Univ., 2000
M.Sc. Agric. Sci. (Food Science), Fac. Agric., Cairo Univ., 2013**

THESIS

**Submitted in Partial Fulfillment of the
Requirements for the Degree of**

DOCTOR OF PHILOSOPHY

In

**Agricultural Science
(Food Science)**

**Department of Food Science
Faculty of Agriculture
Cairo University
EGYPT**

2022

Name of Candidate: Osama Ahmed Mohamed El-sayed **Degree:** Ph.D.

Title of Thesis: Preventive actions of acrylamide formation as a chemical hazard during deep fat frying of potato strips

Supervisors: Dr. Yahia Ibrahim Mohamed Sallam
Dr. Mohamed Mohamed Ahmed El-nikeety
Dr. Amal Hasanien Mahmoud

Department: Food Science

Approval: 14 / 8 / 2022

ABSTRACT

Acrylamide is a chemical contaminant that is driven from heat induced reaction between asparagine and reducing sugars during process. This study is aimed to investigate the most effective pre-frying treatment as a preventive action on acrylamide formation during frying of potato strips. Acrylamide was determined in potato strips samples using High Performance Liquid Chromatography with UV detector (HPLC-UV) technique. Immersing samples in boiled water (BW) treatment was carried out for 30, 60 and 90 sec. Also, exposing samples to water vapor (WV) treatment was carried out for 30, 60 and 90 Sec. Exposing samples to microwave treatment was occurred by exposing potato strips to different microwave powers P_1 (385 W), P_2 (540 W) and P_3 (700 W) for 30, 60 and 90 sec. of each power level. Soaking was carried out using four different solutions *i.e.*, sodium chloride, sodium acid pyrophosphate, citric acid, and ascorbic acid for three different concentrations of each solution *i.e.*, 5, 10 and 15 gm/L for 30, 60 and 90 min. to study the effect of soaking on reducing sugars content before deep fat frying as well as acrylamide formation after deep fat frying of potato strips. Antioxidants treatment was carried out by adding four different antioxidants *i.e.*, BHA, TBHQ, mixed tocopherols, and rosemary extract to palm stearin before frying to study their effect on acrylamide formation in fried potato strips. Results showed that the pre-treatments with P_1 (385 W) contain higher acrylamide content than other treatment used showing significant difference ($p < 0.05$). Meanwhile, P_3 (700 W) contained lowest acrylamide content with significant differences ($p < 0.05$) followed by water vapor at any exposure time used except at 30 sec. Also, results showed no significant differences ($p < 0.05$) between each following pair of treatments: WV/30 sec. and P2/30 sec., P2/30 sec. and BW/60 sec., P1/90 sec. and WV/60 sec. and P2/90 sec. and BW/90 sec. Soaking prior to frying of potato strips in 10 gm/L citric acid solution for 60 and 90 min., soaking in 10 gm/L ascorbic acid solution for 90 min, soaking in 15 gm/L sodium chloride solution for 90 min. or 15 gm/L sodium acid pyrophosphate, citric acid, and ascorbic acid for 60 and 90 min. led to lowering acrylamide content to the accepted level (500 $\mu\text{g}/\text{kg}$) as identified by EU. Arylamide content of fried potato strips was tended to decrease gradually by using different antioxidants *i.e.*, BHA, TBHQ, mixed tocopherols and rosemary extract showing that the most effective antioxidant to reduce acrylamide content is rosemary followed by mixed tocopherols. It could be concluded that treatment prior to frying is very important to decrease acrylamide formation in fried potato strips.

Keywords: Potato strips, acrylamide, reducing sugars, boiling water, water vapor, microwave, soaking, and antioxidants.

CONTENTS

	Page
INTRODUCTION	1
REVIEW OF LITERATUR	5
1. Acrylamide formation mechanism	5
2. Acrylamide health risks and risk assessment	7
3. Different aspects affecting acrylamide formation in fried potato	10
a. Agronomical aspects	10
1. Potato cultivar	10
2. Soil properties and fertilization	12
3. Climate conditions during tuber maturity	13
4. Storage	14
b. Processing aspects	16
1. Quality control of incoming potatoes	16
2. Washing and peeling	17
3. Cutting	17
4. Blanching process	18
5. Microwave treatment	20
6. Soaking in solutions	23
7. Antioxidants treatment	25
8. Enzymes treatment	26
9. Fermentation	26
10. Drying	27
11. Frying conditions	27
MATERIALS AND METHODS	31
1. MATERIALS	31
2. METHODS	31
a. Preparation of potato strips	31
b. Frying process	32
c. Heat treatments	32
1. Boiling water blanching treatment	32
2. Water vapor blanching treatment	32
3. Microwave treatments	33
d. Soaking treatments	33
e. Antioxidants treatments	33

f. Chemical analysis	34
g. Statistical analysis	38
RESULTS AND DISCUSSION	39
1. Chemical composition of potato strips	39
2. Heat treatments	40
a. Blanching using boiled water (BW) treatment	40
b. Blanching using water vapor (WV) treatment	42
c. Microwave powers treatment	45
3. Soaking Process	55
a. Soaking in sodium chloride (NaCl) solution	55
b. Soaking in sodium acid pyrophosphate	63
c. Soaking in citric acid solution	69
d. Soaking in ascorbic acid	77
4. Antioxidant treatment	87
a. Determination of antioxidants activity	87
b. Total polar compound (TPC) percentage (%)	90
c. Effect of antioxidants on acrylamide formation	94
SUMMARY	101
REFERENCES	115
ARABIC SUMMARY	

LIST OF TABLES

No.	Title	Page
1.	Chemical composition of raw potato strips (on dry weight base).	39
2.	Effect of blanching using boiled water (BW) on reducing sugars content in potato strips prior to frying.	41
3.	Effect of blanching by boiled water (BW) on acrylamide content of deep fat fried potato strips.	42
4.	Effect of blanching by water vapor (WV) on reducing sugars content (on dry weight bases) in potato strips prior to frying.	43
5.	Effect of blanching by water vapor (WV) on acrylamide content of deep fat fried potato strips.	44
6.	Effect of different microwave powers on reducing sugars content of potato strips prior to frying (on dry weight basis).	47
7.	Effect of different microwave powers pre-frying treatment on acrylamide content of deep fat fried potato strips.	51
8.	Statistical analysis of different pre-frying heat treatments.	53
9.	Effect of soaking in different NaCl concentrations (gm/L) on reducing sugars percentage of potato strips prior to frying (on dry weight basis).	56
10.	Effect soaking in different NaCl concentrations (gm/L) on Acrylamide content ($\mu\text{g}/\text{Kg}$) of deep fat fried potato strips.	59
11.	Effect of soaking in different sodium acid pyrophosphate concentrations (gm/L) on reducing sugars percentage of potato strips before frying (on dry weight basis).	64

No.	Title	Page
12.	Effect of soaking in different sodium acid pyrophosphate concentrations (gm/L) on Acrylamide content ($\mu\text{g/Kg}$) of deep fat fried potato strips.	67
13.	Effect of soaking in different citric acid concentrations (gm/L) on reducing sugars content of potato strips prior to frying.	71
14.	Effect of soaking in different citric acid concentrations (gm/L) on Acrylamide content ($\mu\text{g/Kg}$) of deep fat fried potato strips.	74
15.	Effect of soaking in different ascorbic acid concentrations (gm/L) on reducing sugars content of potato strips prior to frying.	78
16.	Effect of soaking in different solution types and concentrations (gm/L) on reducing sugars content of potato strips prior to frying.	81
17.	Effect of soaking in different ascorbic acid concentrations (gm/L) on acrylamide content ($\mu\text{g/Kg}$) of deep fat fried potato strips.	82
18.	Effect of soaking in different solution types and concentrations (gm/L) on acrylamide content ($\mu\text{g/kg}$) of fried potato strips.	86
19.	Effect of different antioxidants concentrations on percentage of DPPH [•] scavenging activity (%).	88
20.	Antioxidants treatment effect on percentage of total polar compounds (TPCs) in frying fat.	92
21.	Effect of antioxidants treatment on acrylamide formation ($\mu\text{g/kg}$) during deep fat frying of potato strips.	95
22.	Changes in acrylamide content of fried potato strips as affected by different antioxidants.	100

LIST OF FIGURES

No.	Title	Page
1.	Proposed mechanism for acrylamide formation as a side reaction of the Maillard reaction.	6
2.	Effect of BW and WV pre-frying treatments on acrylamide content of deep fat fried potato strips.	45
3.	Effect of microwave powers on reducing sugars content of potato strips before frying.	48
4.	Effect of microwave treatments on acrylamide content of deep fat fried potato strips.	52
5.	Effect of all pre-frying heat treatments on acrylamide content of deep fat fried potato strips.	54
6.	Effect of soaking in different NaCl concentrations (gm/L) on reducing sugars (%) of potato strips prior to frying.	57
7.	Effect of soaking in different NaCl concentrations (gm/L) on acrylamide content ($\mu\text{g}/\text{kg}$) of fried potato strips.	60
8.	Effect of soaking in different sodium acid pyrophosphate concentrations (gm/L) on reducing sugars content (%) of potato strips prior to frying.	65
9.	Effect of soaking in different sodium acid pyrophosphate concentrations (gm/L) on acrylamide content ($\mu\text{g}/\text{kg}$) of fried potato strips.	68
10.	Effect of soaking in different citric acid concentrations (gm/L) on reducing sugars content (%) of potato strips prior to frying.	72

No.	Title	Page
11.	Effect of soaking in different citric acid concentrations (gm/L) on acrylamide content ($\mu\text{g}/\text{kg}$) of fried potato strips.	75
12.	Effect of soaking in different ascorbic acid concentrations (gm/L) on reducing sugars content (%) of fried potato strips.	79
13.	Effect of soaking in different ascorbic acid concentrations (gm/L) on acrylamide content ($\mu\text{g}/\text{kg}$) of fried potato strips.	83
14.	Linear relationships between the antioxidant's concentrations and DPPH• inhibition activities.	89
15.	Antioxidants treatment effect on percentage of total polar compounds (TPCs) in frying fat.	93
16.	Antioxidants treatment effect on Acrylamide formation ($\mu\text{g}/\text{kg}$) during deep fat frying of potato strips.	96