P-ISSN: 2305-6622; E-ISSN: 2306-3599
International Journal of Agriculture and Biosciences
www.ijagbio.com; editor@ijagbio.com

Research Article

The Effects of Mono and Divalent Cations on Acrylamide Formation in Potato Chips

Dorin Bakhtiary

Department of Food Science and Technology, Payame Noor University (PNU), P.O. Box, 19395-3697 Tehran, Iran
***Corresponding author:** dorin.bakhtiari@gmail.com

Article History: Received: February 10, 2015 Revised: April 12, 2014 Accepted: May 04, 2015

ABSTRACT

The main objective of this work was to study the effect of soaking blanched potato slices in NaCL and CaCL2 solutions on acrylamide formation and sensorial quality of potato chips. Prior to frying, potato slices (Agria variety, diameter: 37 mm, width: 1.5 mm) were blanched in hot water at 85Ċ for 3.5 min; these slices were considered as the control. Slices of the same dimensions were blanched as in the previous step, and soaked at 25Ċ in NaCL and CaCL2 solutions of 0/1 M for 5 min. Blanched and soaked slices were fried at 180Ċ for 4.5 min. The acrylamide content was determined by LC-MS/MS. The sensory quality of potato chips was evaluated based on their crispness, aroma, flavor and overall acceptability by using 10-point hedonic scale, where 1= dislike extremely and 10= like extremely by 50 untrained panelists. Samples soaked in NaCL and CaCL2 solutions showed significant reduction in the formation of acrylamide by 46 and 55% respectively in comparison with control and CaCL2 showed more efficient in inhibiting acrylamide formation than NaCL. Results of sensory evaluation demonstrated that samples soaked in CaCL2 solution had significantly the lowest values of taste, odor and overall acceptability While NaCL soaked samples had significantly ($p< 0/05$) the highest scores of overall acceptability. It was concluded that soaking of blanched potato slices in NaCL solution (0/1 M) can be proposed as a reliable mitigation strategy to reduce acrylamide formation in potato chips with more acceptable sensory characteristics.

Key words: Acrylamide, Potato chips, Blanching, Salt solution, Sensory characteristic

INTRODUCTION

Acrylamide has been classified as a probable carcinogen by the International Agency for Research on Cancer (IARC, 1994). The detection of surprisingly high levels of acrylamide in fried or toasted potato and cereal products in April 2002 provoked extensive international research, which progressed rapidly. These processed foodstuffs are widely consumed and shown to be extremely susceptible to acrylamide formation by Maillard reaction, mainly due to the abundant presence of the free amino acid asparagines and of reducing sugars (Stadler *et al*., 2004).

Acrylamide formation in foods is influenced by several factors, including processing temperature, time, content and species of reducing sugars and amino acids, pH, moisture content and frying oils, indicating that acrylamide in foods can be decreased by changing processing technology (Ciesarova *et al*., 2006).

Potato products, such as crisps and French fries, are among the major contributors to the acrylamide daily intake, especially for children and teens (Wilson *et al*., 2006). In the past years, many strategies aiming to reduce acrylamide formation in potato products have been proposed (Amrein *et al*., 2007). The selection of potato varieties having a low concentration of free carbohydrates and the use of appropriate storage conditions are of pivotal importance (Biedermann *et al*., 2003). Many studies demonstrated that it is possible to define time-temperature processing conditions which guarantee low acrylamide concentration and the retention of sensorial properties in terms of color, flavor, and starch gelatinization (Pedreschi *et al*., 2006; Granda *et al*., 2004).

In a recent paper, ferulic acid, hydrogen peroxide, ferulic acid combined with H_2O_2 or Fe^{2+}, tea catechin, $NaHCO_3$ and $NaHSO_3$ were used to test the eliminating capacity for acrylamide under different temperatures and it was found that combination of ferulic acid with H_2O_2 or Fe^{2+} showed highest efficiency for eliminating acrylamide (Ou *et al*., 2004). Also, Levine and Smith (2005) found that $NaHCO^3$, NH_4HCO_3, cysteine, sodium bisulfate and ascorbate could eliminate acrylamide; and citric acid,

Cite This Article as: Bakhtiary D, 2015. The effects of mono and divalent cations on acrylamide formation in potato chips. Inter J Agri Biosci, 4(3): 87-90. www.ijagbio.com

ferulic acid and NaCl decreased the amount of acrylamide produced. In addition, pre-treatment with the enzyme L-asparaginase is sufficient to reduce acrylamide content, since L-asparagine is considered to be one of the main precursors for the acrylamide formation in foods (Friedman, 2003).

Since 2002 till now, wide researches were done about the useful ways to reduce the amount of acrylamide formation in fried carbohydrate-rich foods especially potato chips (Matthaus *et al*., 2004; Knustsen *et al*., 2009). But, the major challenge in frying of potatoes is to achieve a substantial reduction of acrylamide while keeping desirable product attributes such as color, flavor, texture, and taste (Pedreschi, 2009). Because, for consumers the perceivable sensory attributes are the deciding factors in food acceptance (Pal *et al*., 1995). Therefore, the main objective of this work was to study The Effects of Mono and Divalent Cations on Acrylamide Formation and sensorial quality of potato chips.

MATERIALS AND METHODS

Materials

For this research 10 kg of potatoes (Solanum tuberosum L.), Agria variety, were purchased from Seed and Plant Improvement Institute of Iran and stored at $10^{\circ}C$ until preparing chips. For frying potatoes, refined, bleached and deodorized palm olein, was purchased from Behshahr factory. All chemicals and solvents used were purchased from Merck (Darmstadt, Germany).

Methods

Preparation of potato chips

Potato chip (Slices) Potato tubers (Variety Agria) were washed and after peeling, slices (diameter: 37 mm, width: 1.5 mm) were prepared by using a mechanical slicer (Italimport SRL, Model 90915, China).

Blanching treatment *Slices* were rinsed immediately after cutting for 1 min in distilled water to eliminate some starch adhering to the surface prior to frying. Blanched samples were prepared by heating raw slices in 4 lit of hot water at 85Ċ for 3.5 min. Blanched slices were considered as the control. After blanching potato slices were cooled in ice water for 10 min. Blanched slices were drained and fried at $180^{\circ}C$.

Soaking treatment Slices of the same mentioned dimensions were blanched in distilled water at 85Ċ for 3.5 min. The blanched potato slices were drained and soaked at 25Ċ in NaCL and CaCL2 solutions of 0/1M for 5 min. The soaked slices were drained and fried at $180^{\circ}C$.

Frying condition 100 g of each treatment were fried in an electric deep fryer with a capacity of 3 Lit of oil at $180^{\circ}C$ for 4/5 min in palm olein. After frying, the samples were dried to remove excess oil.

Acrylamide analysis

Acrylamide was determined by LC-MS/MS as described earlier (Mestdagh *et al*., 2005). After aqueous extraction, using [2, 3, 3-D3] acrylamide as internal standard, the acrylamide extract was further cleaned-up by solid phase extraction. The extract was analyzed using LC-MS/MS with positive electrospray ionization.

Sensory analysis

The sensory quality of the examined potato chips was evaluated based on their crispness, aroma, flavor and overall acceptability by using 10-point hedonic scale, where 1= dislike extremely and 10= like extremely by 50 untrained panelists.

Statistical analysis

The experiments were carried out in the completely randomized design (CRD) in triplicates. The average was compared with each other by Duncan method. Analysis of variance (ANOVA) and comparison of averages was done by SPSS 16.0 software.

RESULTS AND DISCUSSION

Results of Testing Acrylamide

As shown in figure 1, Samples soaked in NaCL and CaCL2 solutions for 5 min showed significant ($p< 0.05$) reduction in the formation of acrylamide by 46 and 55% respectively in comparison with control. CaCL2 showed more efficient in inhibiting acrylamide formation than NaCL. Similar results were reported recently (Mestdagh *et al*., 2008; Pedreschi *et al*., 2009).

The acrylamide inhibiting mechanism for NaCL and CaCL2 may be due to its complexation with amines and some intermediates of the Maillard reaction products as reported before (Delgado-Andrade *et al*., 2004; O'Brien and Morrissey, 1997). Recently, evidence was found that cations such as Ca2+ or Mg2+ would change the reaction path from the Maillard reaction toward dehydration of glucose (Gokmen and Senyuva, 2007).

Also it has been reported that Na+ or Ca2+ could interact with asparagines to prevent the formation of acrylamide (Park *et al*., 2005; Lindsay and Jang, 2005; Gokmen and Senyuva, 2007). On the other hand, the addition of NaCl, CaCl2 might also change the oil uptake (Bunger et al., 2003; Rimac-Brncic et al., 2004; Pedreschi et al., 2007). This could therefore be an additional factor, possibly influencing the formation of acrylamide in fried foodstuffs.

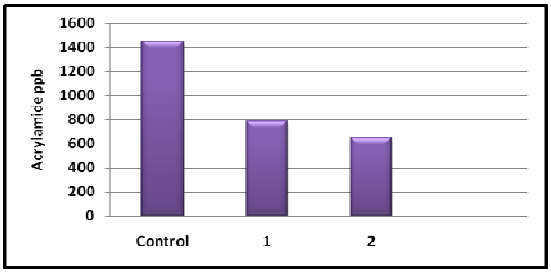

Fig. 1: Acrylamide content of control and blanched potato strips dipped in NaCL and CaCL2 solutions (0/1 M).Control corresponds to potato strips blanched in hot water at 85Ċ for 3.5 min and numbers 1and 2 indicate the blanched potato strips soaked for 5 min at 25Ċ in NaCL and CaCL2 solutions respectively

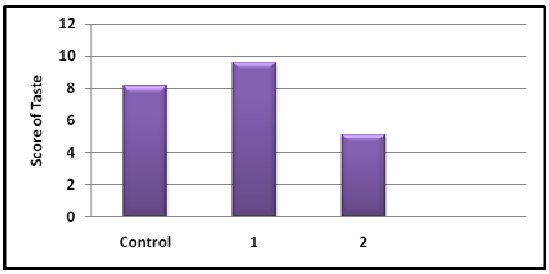

Fig. 2: Average of taste in control and blanched potato strips dipped in NaCL and CaCL2 solutions (0/1 M). Control corresponds to potato strips blanched in hot water at 85Ċ for 3.5 min and numbers 1 and 2 indicate the blanched potato strips soaked for 5 min at 25Ċ in NaCL and CaCL2 solutions respectively.

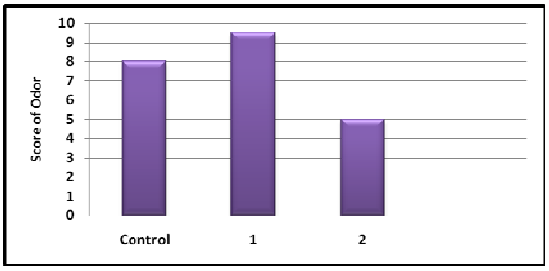

Fig. 3: Average of odor in control and blanched potato strips dipped in NaCL and CaCL2 solutions (0/1 M). Control corresponds to potato strips blanched in hot water at 85Ċ for 3.5 min and numbers 1 and 2 indicate the blanched potato strips soaked for 5 min at 25Ċ in NaCL and CaCL2 solutions respectively.

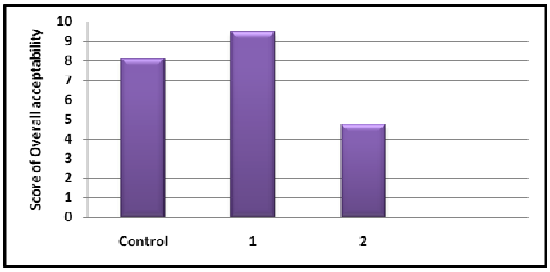

Fig. 4: Average of overall acceptability in control and blanched potato strips dipped in NaCL and CaCL2 solutions (0/1 M). Control corresponds to potato strips blanched in hot water at 85Ċ for 3.5 min and numbers 1and 2 indicate the blanched potato strips soaked for 5 min at 25Ċ in NaCL and CaCL2 solutions respectively.

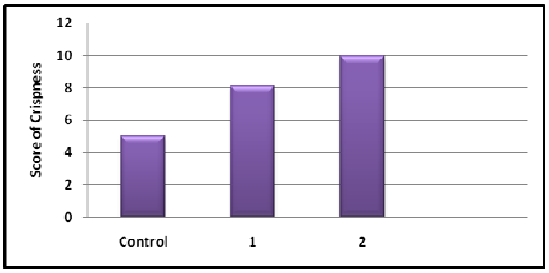

Fig. 5: Average of crispness in control and blanched potato strips dipped in NaCL and CaCL2 solutions (0/1 M). Control corresponds to potato strips blanched in hot water at 85Ċ for 3.5 min and numbers 1 and 2 indicate the blanched potato strips soaked for 5 min at 25Ċ in NaCL and CaCL2 solutions respectively.

Results of sensory evaluation

Results of this study showed that significant (P<0/05) differences occurred in the sensory characteristics of examined potato chips.

Samples soaked in NaCL solution had significantly (P<0.05) the highest scores of taste, odor and overall acceptability while CaCL2 soaked samples had the lowest (Figures 2, 3 and 4). These results confirm previous findings (Varela *et al*., 2007; Pedreschi *et al*., 2007).

Calcium chloride can cause a bitter aftertaste (Varela *et al*., 2007). Consequently, this pre-treatment may also cause unwanted sensorial defects.

Soaking of potato strips in salt solutions previous to frying could reduce significantly the oil absorption and increased texture parameters in the fried potatoes (Bunger *et al*., 2003). According to the obtained results of this study soaking of blanched potato slices in NaCL and CaCL2 solutions improve significantly the crispness of texture in fried potatoes in comparison with control. And samples soaked in CaCL2 solution had significantly (P<0.05) the highest scores of crispness (Figure 5). Similar results were reported recently (Varela *et al*., 2007; Pedreschi *et al*., 2007).

Conclusion

Results of current investigation showed that soaking of blanched potato slices at 25Ċ in NaCL and CaCL2 solutions for 5 min before frying reduced dramatically acrylamide formation of potato chips by 46 and 55% respectively in comparison with blanched potato slices as a control. Although that CaCL2 showed more efficient in inhibiting acrylamide formation than NaCL but potato slices soaked in CaCL2 solution had the weakest scores of taste, odor and overall acceptability while NaCL soaked samples had the highest values of overall acceptability. According to this fact that for consumers, the perceivable sensory attributes are the deciding factors in food acceptance, it was concluded that soaking of blanched potato slices in NaCL solution (0/1 M) can be proposed as a reliable mitigation strategy to reduce acrylamide formation in fried potato with more acceptable sensory characteristics for consumers.

REFERENCES

Amrein TM, L Andres, F Escher and R Amado, 2007. Occurrence of acrylamide in selected foods and mitigation options. Food Addit Contam, 24: 13-25.

Biedermann-Brem S, A Noti, K Grob, D Imhof, D Bazzocco and A Pfefferle, 2003. How much reducing sugar may potatoes contain to avoid excessive acrylamide formation during roasting and baking. Eur. Food Res. Technol, 217: 369-373.

Bunger A, P Moyano and V Rioseco, 2003. NaCl soaking treatment for improving the quality of french-fried potatoes. Food Res Int, 36: 161-166.

Ciesarova Z, E Kiss and E Kolek, 2006. Study of factors affecting acrylamide levels in model systems. Czech J Food Sci, 24: 133-137.

Delgado-Andrade C, I Seiquer, R Nieto and MP Navarro, 2004. Effects of heated glucose-lysine and glucose-methionine model-systems on mineral solubility. Food Chem, 87: 329-337.

Friedman M, 2003. Chemistry biochemistry and safety of acrylamide. J Agric Food Chem, 51: 4504-4526.

Granda C, RG Moreira and SE Tichy, 2004. Reduction of Acrylamide Formation in Potato Chips by Low-temperature Vacuum Frying. J Food Sci, 69: 405-411.

Gokmen V and HZ Senyuva, 2007. Acrylamide formation is prevented by divalent cations during the Maillard reaction. Food Chem, 103: 196-203.

IARC, 1994. Acrylamide. Monographs on the evaluation of carcinogenic risks to humans: Some industrial chemicals. 60: 389-433.

Knutsen SH, S Dimitrijevic, EL Molteberg, VH Segtnan, L Kaabera and T Wicklund, 2009. The influence of variety, agronomical factors and storage on the potential for acrylamide formation in potatoes grown in Norway, LWT-Food Science and Technology, 42: 550-556.

Levine RA and RE Smith, 2005. Sources of variability of acrylamide levels in a cracker model. J Agric Food Chem, 53: 4410-4416.

Lindsay RC and S Jang, 2005. Chemical intervention strategies for substantial suppression of acrylamide formation in fried potato products. Chem. Safety Acrylamide Food, 561: 393-404.

Matthaus B, NU Hasse and K Vosmann, 2004. Factors affecting the concentration of acrylamide during deep-fat frying of potatoes. Eur J Lipid Sci Technol, 106: 793-801.

Mestdagh FJ, B De Meulenaer, C Van Poucke, C Detavernier, C Cromphout and C Van Peteghem, 2005. Influence of oil type on the amounts of acrylamide generated in a model system and in French fries. J Agric Food Chem, 53: 6170-6174.

Mestdagh F, P Castelein, C Van Peteghem and B De Meulenaer, 2008. Importance of oil Degradation components in the Formation of Acrylamide in Fried Foodstuffs. J Agric Food Chem, 56: 6141-6144.

O'Brien J and PA Morrissey, 1997. Metal ion complexation by products of the maillard reaction. Food Chem, 58: 17-27.

Ou SY, QL Lin, Y Wang, CH Huang and XS Huang, 2004. Effect of several additives on destroying acrylamide. China Oils Fats, 29: 61-63.

Park Y, H Yang, JM Storkson, KJ Albright and RC Lindsay, 2005. Controlling acrylamide in mathematical model of acrylamide formation. Chem. Safety Acrylamide Food, 561: 343-356.

Pal D, S Sachdeva and S Singh, 1995. Methods for determination of sensory quality of foods: A critical appraisal. J Food Sci Technol, 32: 357-367.

Pedreschi F, 2009. Acrylamide Formation and Reduction in Fried Potatoes. Processing Effects on Safety and Quality of Foods, 231-252.

Pedreschi F, K Kaack and K Granby, 2006. Acrylamide content and colour development in fried potato strips. Food Res Int, 36: 40-46.

Pedreschi F, K Kaack, K Granby and E Troncoso, 2007. Acrylamide reduction under different pretreatments in french fries. J Food Eng, 79: 1287-1294.

Rimac-Brncic S, V Lelas, D Rade and B Simundic, 2004. Decreasing of oil absorption in potato strips during deep fat frying. J Food Eng, 64: 237-241.

Stadler RH, F Robert, S Riediker, N Varga, T Davidek, S Devaud, T Goldmann, J Hau and I Blank, 2004. In-depth mechanistic study on the formation of acrylamide and other vinylogous compounds by the Maillard reaction. J Agric Food Chem, 52: 5550-5558.

Varela P, A Salvador and SM Fiszman, 2007. The use of calcium chloride in minimally processed apples: A sensory approach. Eur. Food Res Technol, 224: 461-467.

Wilson KM, EB Rimm, KM Thompson and LA Mucci, 2006. Dietary acrylamide and cancer risk in humans: a review. J Verbr Lebensm, 1: 19-27.