Impact of Soaking in Salt Solutions after Blanching on Acrylamide Formation and Sensorial Quality of Potato Chips

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ABSTRACT

The main objective of this work was to study the effect of soaking blanched potato slices in different salt solutions on acrylamide formation and sensorial quality of fried potato. Prior to frying, potato slices (Agria variety, diameter: 37 mm, width: 1.5 mm) were blanched in hot water at 85°C 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 25°C in KCL, NaCL and CaCL2 solutions of 0/1 M for 5 min. Blanched and soaked slices were fried at 180°C for 4.5 min. The acrylamide content was determined by GC-ECD. The sensory quality of the 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 KCL, NaCL and CaCL2 solutions showed significant reduction in the formation of acrylamide by 32, 46 and 55% respectively in comparison with control. CaCL2 showed more efficient in inhibiting acrylamide formation than KCL and NaCL. Results of sensory evaluation demonstrated that samples soaked in CaCL2 solution 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 fried potato with more acceptable sensory characteristics.

KEYWORD

Acrylamide, Potato chips, Blanching, Soaking, 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 H2O2 or Fe2+, tea catechin,NaHCO3 and NaHSO3 were used to test the eliminating capacity for acrylamide under different temperatures and it was found that combination of ferulic acid with H2O2 or Fe2+ showed highest efficiency for eliminating acrylamide (Ou et al., 2004). Also, Levine and Smith (2005) found that NaHCO3, NH4HCO3, cysteine, sodium bisulfite and ascorbate could eliminate acrylamide; and citric acid, 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 effect of soaking of blanched potato slices in different salt solutions on acrylamide formation and sensorial quality of fried potato.

**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°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 l of hot water at 85°C 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°C.

- **SOAKING TREATMENT**
  
  Slices of the same mentioned dimensions were blanched in distilled water at 85°C for 3.5 min. The blanched potato slices were drained and divided into three portions and were soaked at 25°C in KCL, NaCl and CaCl2 solutions of 0/1 M for 5 min. The soaked slices were drained and fried at 180°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°C for 4/5 min in palm olein. After frying, the samples were dried to remove excess oil.

- **DETERMINATION OF ACRYLAMIDE**
  
  Method of measuring acrylamide by Gas Chromatography which is equipped with an electron capture detector (ECD) is based on extraction of the acrylamide from defatted sample with sodium chloride and derivatization of acrylamide with bromine and then tracking it by an electron capture detector (ECD).

  - **MANNER OF EXTRACTION**
    
    The samples were prepared for acrylamide analysis using a procedure described by Lehotay and Mastovska (2006). In the first stage, 5/6 g of the homogeneous sample were mixed with 500 ng/g of meta acrylamide as an internal standard, 5 mL of hexane solution and distilled water and acetonitrile in the equal ratio by vortex mixer for 15 minutes. Then, 5 g of sodium sulfate anhydrous and sodium chloride were added to it. The mixture was centrifuged at 4500 rpm for 5 minutes and after using ultrasonic for 30 minutes, the acetonitrile layer was separated completely.

  - **MANNER OF DERIVATIZATION**
    
    The collected acetonitrile layer was brominated based on a procedure described by Tareke and Rydber (2002). For this aim, potassium bromide, hydrobromic acid and saturated bromine water were used. Obtained solution was kept in the refrigerator at 4°C for a day. Then, the excess of bromine became colorless by adding some drops of sodium thiosulfate solution and this solution was extracted twice with 65 mL of ethyl acetate. The obtained organic phase was dried with 1 g of sodium sulfate and transferred in to rotary vacuum evaporator. Then the solution was concentrated under the nitrogen gas till a volume of 250 µL. Finally, 1 µL from each of prepared samples was injected into the capillary column (30 m x 0.25 mm x 0.25 µm) of GC/ECD. Four standard solutions of acrylamide were prepared with volumes of 10, 15, 20, 25 mL and were extracted and brominated on the basis of procedure described for the samples. The calibration curve was generated by injecting 1 µL from each of acrylamide standards into the GC/ECD and acrylamide concentration formed in the samples was determined by using this curve (Figure1.)

<table>
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<th>Table 1. GC-ECD Device Parameters</th>
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<td><strong>Column temperature</strong></td>
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<td><strong>Detector temperature</strong></td>
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<td><strong>Injection volume</strong></td>
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![Fig.1. GC-ECD Calibration Curve](image)
- SENSORY EVALUATION
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 SPSS16.0 software.

RESULTS AND DISCUSSION
- RESULTS OF TESTING ACRYLAMIDE
As shown in figure 2, Samples soaked in KCL, NaCL and CaCL2 solutions for 5 min showed significant (p< 0.05) reduction in the formation of acrylamide by 32, 46 and 55% respectively in comparison with control. CaCL2 showed more efficient in inhibiting acrylamide formation than KCL and NaCL. Moreover, the formation of acrylamide appeared to be significantly lower in NaCL soaked slices compared to samples for KCL. Similar results were reported recently (Mestdagh et al., 2008; Pedreschi et al., 2009).

The acrylamide inhibiting mechanism for KCL, 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 asparagine 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 or KCL might also change the oil uptake (Burger et al., 2003; Rimac-Brnic et al., 2004; Pedreschi et al., 2007). This could therefore be an additional factor, possibly influencing the formation of acrylamide in fried foodstuffs.

- 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. Moreover, control was more acceptable for panelists in taste, odor and overall acceptability than the KCL soaked samples (Figures 3, 4 and 5). These results confirm previous findings (Varela et al., 2007; Pedreschi et al., 2007).

Potassium chloride and Calcium chloride can cause a bitter aftertaste (Varela et al., 2007). Consequently, these pre-treatments 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 KCL, 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. Moreover, NaCL soaked samples appeared to be more acceptable for panelists in crispness than the samples for KCL (Figure 6). 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 25°C in KCL, NaCL and CaCL2 solutions for 5 min before frying reduced dramatically acrylamide formation of potato chips by 32, 46 and 55% respectively in comparison with blanched potato slices as a control. Although that CaCL2 showed more efficient in inhibiting acrylamide formation than KCL and 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


