LWT - Food Science and Technology 58 (2014) 587–593

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Effect of natural extracts on the formation of acrylamide in fried potatoes

Gema Morales [a], Maribel Jimenez [a,*], Oscar Garcia [b], María Remedios Mendoza [b], Cesar Ignacio Beristain [a]

[a] Instituto de Ciencias Básicas, Universidad Veracruzana, Apdo. Postal 575, CP 91192, Xalapa, Veracruz, Mexico
[b] Unidad de Servicios de Apoyo en Resolución Analítica, Universidad Veracruzana, Xalapa, Veracruz, Mexico

ARTICLE INFO

Article history:
Received 12 April 2013
Received in revised form
21 February 2014
Accepted 23 March 2014
Available online 2 April 2014

Keywords:
Acrylamide
Fried potatoes
Natural antioxidant
Texture

ABSTRACT

The objective of the present work was to evaluate the effect of natural extracts on the formation of acrylamide in fried potatoes. The aqueous extracts used were obtained from wild oregano (*Origanum vulgare*), thyme (*Thymus vulgaris*), cinnamon (*Cinnamomum verum*), bougainvillea (*Bougainvillea* spp) and green tea (*Camellia sinensis*), which presented a high percentage of free radical inhibition (DPPH) (48–99%) and content of total phenolic compounds (205–547 μg EAG/μg of d.w.). Potatoes were submerged in the antioxidant extracts at a concentration of 1 g/L for 1 min, before being fried and their acrylamide concentration quantified by GC–MS. The extracts from green tea, cinnamon and oregano reduced the acrylamide level by 62%, 39% and 17%, respectively. The potatoes submerged in cinnamon and bougainvillea extracts showed differences in the color parameters compared to the control potatoes ($P < 0.05$); however, no significant differences ($P > 0.05$) were found in the texture and the peroxide values. The sensorial evaluation showed that the acceptance of the potatoes was not affected by the treatment applied. Thus, we can conclude that pre-treating potatoes with antioxidants before frying produces beneficial effects such as a reduction in acrylamide content, without any significant changes in their physicochemical, sensorial and textural properties.

1. Introduction

Acrylamide is a substance commonly used in various industries and is considered a genotoxin, neurotoxin and probable carcinogen in humans (Bong-Kyung, 2006; Tareke, Rydberg, Karlsson, Eriksson, & Törnqvist, 2002). Recently, researchers at the National Food Administration of Sweden (NFA) and the University of Stockholm reported that foods rich in carbohydrates generate significant amounts of acrylamide when subjected to high temperatures (Gökmen & Palazoğlu, 2008; Masson et al., 2007). Since this substance is harmful to health, having been classified in group 2A as "a probable human carcinogen" by the International Agency for Research on Cancer (IARC, 1994), its presence in foods is a cause for great concern. Acrylamide is produced naturally in foods with a high carbohydrate content and a low protein composition that, when subjected to processes such as frying, baking or toasting, generate this toxin mainly through the Maillard reaction (Mottram, Wedzicha, & Dodson, 2002; Stadler et al., 2002; Taeymans & Wood, 2004; Taubert, Harlfinger, Henkes, Berkels, & Schömig, 2004). The concentration of acrylamide can vary enormously in any one food item, depending on factors such as temperature, cooking time, and the amount of reducing sugars and free amino acids like asparagine (Cheong, Hwang, & Hyong, 2005). Among the food types that may present significant amounts of acrylamide are products derived from cereals (cookies, bread and tostadas), coffee and, mainly, fried potatoes (Granda, Moreira, & Tichy, 2004; Moreno, Armendáriz, Gutiérrez, Fernández, & Torre, 2007; Takatsuki, Nemoto, Sasaki, & Maitani, 2003). Up to 12, 000 μg/kg of acrylamide has been quantified in fried potatoes (Friedman, 2003). The accepted levels of acrylamide should not be higher than 0.5 μg/L in processes such as water treatment (WHO, 2003) and not over 10 μg/kg in plastics (European Commission, 1992).

Most of the research on this aspect is focused mainly on the reduction of acrylamide in fried potatoes, since they are widely consumed all over the world. The techniques currently applied to achieve said reduction are based on the modification of frying conditions (Granda et al., 2004), as well as the addition of other compounds such as amino acids (Cheong et al., 2005), acids (Jung,

* Corresponding author. Tel.: +52 (228) 8 41 89 00; fax: +52 (228) 8 41 89 32.
E-mail addresses: maribjimenez@uv.mx, marijife@hotmail.com (M. Jimenez).

http://dx.doi.org/10.1016/j.lwt.2014.03.034
0023-6438/

Choi, & Ju, 2003; Kita, Brathen, Knutsen, & Wicklund, 2004), ions (Mestdagh, De Wilde, Delporte, Van, & De Menulenaer, 2008) and enzymes (Taeymans & Wood, 2004; Zyzak et al., 2003). However, many of these methods affect their color, taste and texture. Recent studies have reported a reduction of acrylamide levels through the addition of plant extracts to food products. Becalski, Lau, Lewis, and Seaman (2002) could decrease the amount of the toxin by adding rosemary (*Rosmarinus officinalis*) to the oil used for frying potatoes. Zhang, Chen, Zhang, Wu, and Zhang (2007) evaluated the effect of an antioxidant extract from bamboo leaves on the formation of acrylamide, achieving a decrease of 74% of the neurotoxin in fried potatoes, whereas Zhang and Zhang (2007) obtained an 83% reduction of acrylamide in bread by combining the extract from bamboo leaves with green tea.

Plant extracts mainly contain phenolic compounds (Manzocco, Anese, & Nicoli, 1998) such as flavonoids, cinnamic acids, coumarins, phenolic acids, lignans and tannins, which all have antioxidant activity and are probably responsible for decreasing toxin levels. Many reports indicate that marjoram, thyme, cinnamon and bougainvillea contain total phenolic compounds that confer antioxidant activity (Shibamoto & Moon, 2009). Flowers of bougainvillea exhibited the highest DPPH radical scavenging activity and the major flavonoid found in flowers was quercetin and apigenin (Kaisoon, Siramornpun, Weerapreeyakul, & Meeso, 2011). Therefore, the objective of this study was to evaluate the reduction of acrylamide in fried potatoes through their immersion in extracts from diverse plants such as wild oregano, thyme, cinnamon, bougainvillea and green tea.

2. Material and methods

2.1. Reagents

1,1-diphenyl-2-picrilhydrazil (DPPH), Folin–Ciocalteu reagent, acrylamide (99%), L- ascorbic acid (>99.8%), gallic acid and L-glucose were acquired from Sigma–Aldrich (Mexico). All reagents and solvents were of analytic grade.

2.2. Raw material

The dried plants used, wild oregano (*Origanum vulgare*), thyme (*Thymus vulgaris*), cinnamon (*Cinnamomum verum*), bougainvillea (*Bougainvillea* spp) and green tea (*Camellia sinensis*) belonging to the trademarks Catarinos® and La Merced®, were purchased in a local supermarket.

2.3. Preparation of extracts

Fifty grams of the each dry plant were homogenized using an orbital shaker (MaxQ™, Thermo Scientific, USA) at 200 rpm with 200 mL of distilled water at 60 °C during 24 h then were filtered with Whatman No.1 filter paper. The extracts were frozen with liquid nitrogen and lyophilized, (being obtained, 1–2 g of powder) (lyophilizer Labconco 4.5 L, Kansas, USA) for subsequent analysis.

2.4. Analysis of antioxidant extracts

2.4.1. 1,1-Diphenyl-2-picrilhydrazil (DPPH)

The capacity for capturing free radicals was determined using the radical 1,1-diphenyl-2-picrilhydrazil (DPPH) (Brand-Williams, Cuvelier, & Berset, 1995). To 0.1 mL of a concentration of 1 mg/L from the sample in methanol, 2.9 mL of the methanol solution of DPPH (36 μg/mL) were added and the mixture was shaken vigorously. The vials remained at ambient temperature for 30 min, before measuring absorbance at 517 nm with a UV–VIS spectrophotometer (Cary 100, Varian, Palo Alto, CA, USA). These determinations were performed in duplicate.

2.4.2. Determination of total phenolic compounds

The quantification of total phenolic compounds with the Folin–Ciocalteau colorimetric reaction employed the method of Spanos and Wrolstad (1990). To 50 μL of the sample (1 mg/mL dissolved in distilled water), 2.5 mL of the Folin–Ciocalteu reagent (diluted 1/10) and 2 mL of Na_2CO_3 (75% p/v) were added and the mixture incubated at 45 °C for 15 min. Absorbance was measured at 765 nm with a UV–VIS spectrophotometer (Cary 100, Varian, Palo Alto, CA, USA), the final results being expressed as equivalent micrograms of gallic acid per microgram of dry weight (μg EAG/μg dw) by interpolation from the calibration curve with a range of 20–1000 μg/mL of gallic acid ($y = 0.0011x + 0.0688$, $R^2 = 0.9835$).

2.4.3. Percentage of reducing power

The determination of the reducing power percentage was made according to the method of Oyaizu (1986). To 0.125 mL of the sample at a concentration of 1 mg/mL, 1.25 mL of phosphate buffer (200 mM, pH 6.6) and 1.25 mL of potassium ferricyanide (1%) were added. The mixture was incubated at 50 °C for 20 min. Then, 1.25 mL of 10% trichloracetic acid was added to the mixture, which was centrifuged at 650 *g* for 10 min. An aliquot of 2.5 mL was taken, 2.5 mL of distilled water and 0.5 mL of ferric chloride were added, and the absorbance measured at 700 nm with a UV–VIS spectrophotometer (Cary 100, Varian, Palo Alto, CA, USA). The results were reported as the percentage of reducing power. Absorbance of ascorbic acid at a concentration of 1 mg/mL was considered 100% for reference.

2.5. Preparation and analysis of potatoes

2.5.1. Preparation of potatoes

In the experiment were used 10 kg of potato *Solanum tuberosum* L. var. Atlantic obtained from the local market. The potatoes were washed and disinfected. The bare was carried out with a peeler friction and was removed black or green spots. Potatoes were cut into slices approximately 1.5 ± 0.2 mm thick, with a manual cutter. After, samples were subjected to immersion treatment in antioxidant extracts, then were fried and immediately after the antioxidant and peroxide value were analyzed.

2.5.2. Quantification of total reducing sugars and pH in potatoes

The quantification of total reducing sugars was made through the colorimetric method proposed by Somogyi and Norton (1952). To quantify the reducing sugars in the extracts, their clarification was first carried out. This was done by adding 1.0 mL of the extract (1 g/L) to 0.9 mL of sub-acetate of lead, 1.5 m/L of saturated sodium sulfate solution, 0.15 mL of glacial acetic acid, and 0.12 mL of zinc acetate and potassium ferrocyanide. This mixture was centrifuged for 5 min, and the reducing sugar content in the supernatant determined by interpolation from the calibration curve of L-glucose (10–100 μg/mL) ($y = 0.0082x + 0.0649$, $R^2 = 0.9979$). The pH measurements were performed using a potentiometer according to the method 943.02 (AOAC, 1998).

2.5.3. Extraction, identification and quantification of acrylamide

The extraction was performed with the technique proposed by Biedermann et al. (2002). From the extract obtained, 2.0 μl of each sample were injected in duplicate. A gas chromatograph (trademark Hewlett-Packard, model 1800B, GCD System, Santa Clara, CA, USA), equipped with a column CP-WAX 52CB (VARIAN) (60 m × 0.25 mm × 0.25 μm), was used for the analysis. The initial temperature of 80 °C was maintained for 5 min and subsequently