



Acrylamide formation in vegetable oils and animal fats during heat treatment



G. Daniali^a, S. Jinap^{a,b,*}, P. Hajeb^a, M. Sanny^a, C.P. Tan^c

^a Department of Food Science, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

^b Department of Food Safety, Institute of Food Security, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

^c Department of Food Technology, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

ARTICLE INFO

Article history:

Received 2 April 2015

Received in revised form 26 May 2016

Accepted 28 May 2016

Available online 28 May 2016

Keywords:

Acrylamide

Vegetable oils

Animal fats

LC–MS/MS

Oxidation values

ABSTRACT

The method of liquid chromatographic tandem mass spectrometry was utilized and modified to confirm and quantify acrylamide in heating cooking oil and animal fat. Heating asparagine with various cooking oils and animal fat at 180 °C produced varying amounts of acrylamide. The acrylamide in the different cooking oils and animal fat using a constant amount of asparagine was measured. Cooking oils were also examined for peroxide, anisidine and iodine values (or oxidation values). A direct correlation was observed between oxidation values and acrylamide formation in different cooking oils. Significantly less acrylamide was produced in saturated animal fat than in unsaturated cooking oil, with 366 ng/g in lard and 211 ng/g in ghee versus 2447 ng/g in soy oil, followed by palm olein with 1442 ng/g.

© 2016 Published by Elsevier Ltd.

1. Introduction

Acrylamide (2-propenamide) is a hydrophilic compound that has been classified as a probable human carcinogen. It is present in numerous fried foods such as potato crisps, French fries, breakfast cereals, coffee beans, snacks and bakery products. Acrylamide is a common toxic compound produced in oil after the frying of food (Matthaus, Haase, & Vosmann, 2004; Mestdagh, Poucke, Detavernier, Cromphou, & Peteghem, 2005).

Acrylamide is mainly produced by the Maillard reaction involving asparagines and reducing (Mottram, Wedzicha, & Dodson, 2002). The Maillard reaction occurs when free amino group with a reducing sugar to form Amadori products. In the next step, the degradation of Amadori products follows; the products are hydrolyzed to form 3-aminopropionamide, which can degrade to a further extent through the elimination of ammonia to form acrylamide when heated. Alternatively, the decarboxylated Schiff base can decompose directly to form acrylamide via elimination of an imine (Zyzak et al., 2003). There are some similarities in the formation of acrylamide, through Maillard and lipid pathway. First, amino acids in both of the reactions are sources of ammonia. Furthermore, both of the pathways require the carbonyl source in

order for acrylamide formation to occur (Yasuhara, Tanaka, Hengel, & Shibamoto, 2003; Zyzak et al., 2003).

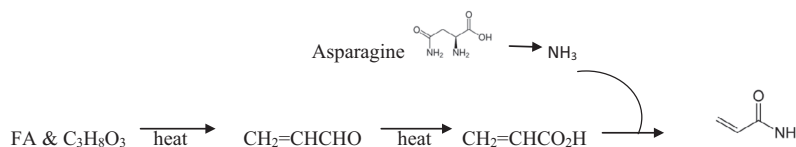
Acrylamide is formed in frying oil due to the degradation of the oil or to the interaction between carbonyl groups and other components (such as amino acids from the food) under high temperature (Aladedunye & Przybylski, 2011). These reactions are found to be related to the degradation and interaction between oxidants and other components and the formation of certain toxic compounds in deep fat frying oil after heat processing (Ou et al., 2010). Also, certain secondary lipid oxidation products may convert amino acids into either their corresponding Strecker aldehydes or vinylogous derivatives, depending on the amount of oxygen present in the reaction (Hidalgo & Zamora, 2007; Zamora, Gallardo, & Hidalgo, 2007), thereby suggesting that a potential route for the contribution of these secondary lipid oxidation products to acrylamide formation in thermally treated foods. Under appropriate conditions, oxidized proteins will result in the degradation of asparagine to acrylamide and contribute to the formation of this contaminant during food processing.

Previous studies have shown that degradation products of amino acids can also be produced during the Maillard reaction (Stadler et al., 2004; Tareke, Rydberg, Karlsson, Eriksson, & Törnqvist, 2002). There are several reports regarding acrylamide formation from asparagine with carbonyl compounds. Heating asparagine with octanal, 2-octanone or 2,3-butanedione may result in the formation of various amounts of acrylamide

* Corresponding author at: Department of Food Science, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.

E-mail addresses: jinap@upm.edu.my, sjinap@gmail.com (S. Jinap).

(Becalski, Lau, Lewis, & Seaman, 2003). Glycolaldehyde and glycer-aldehyde produce approximately 2 times and 1.75 times more acrylamide than glucose with asparagine respectively (Yaylayan, Wnorowski, & Perez Locas, 2003). Although according to Zamora and Hidalgo (2008), the presence of primary lipid oxidation products, or even unoxidized lipids under oxidizing conditions, is the only prerequisite needed to observe a positive contribution of lipids to acrylamide formation during food heating. It has been known for over half a century that α -amino acid produces ammonia via Strecker degradation in the presence of a carbonyl compound (Schonberg & Moubasher, 1952). Acrylic acid, which is an oxidation product of acrolein and glycerol, produces a significant amount of acrylamide with ammonia (Yasuhara et al., 2003). A fatty acid (such as pure linoleic acid and linolenic acid hydroperoxides) backbone showed by Ewert, Granvogl, and Schieberle (2014) to be the key precursor structure for acrolein formation. The hypothesized formation mechanisms of acrylamide from amino acids and lipids are shown below:



When oil is heated at temperatures above the smoke point, glycerol is degraded to acrolein and the formation of acrolein is known to increase directly with the increase in unsaturation in the oil. The oil is hydrolyzed into glycerol and fatty acids and acrolein is produced by the elimination of water from glycerol by a heterolytic acid-catalysed carbonium ion mechanism followed by oxidation (Uchida et al., 1999). Acrolein can also be produced as a result of oxidation of polyunsaturated fatty acids and their degradation products. Acrolein is also found to form in vivo by the metal-catalysed oxidation of polyunsaturated fatty acids, including arachidonic acid (Esterbauer, Schaur, & Zollner, 1991).

According to Pedreschi, Kaack, and Granby (2006) the free asparagines and the reducing sugars (acrylamide precursor) can leach out from the surface layer of cut potato to the media. It has also been shown by Mestdagh et al. (2005) that acrylamide precursor could indeed be transferred to the frying oil.

The objectives of this study are to determine the effect of asparagine on the formation of acrylamide in vegetable oils and animal fats and to assess the formation of acrylamide from asparagine in vegetable oils and animal fats having different oxidation values. Further detection of the acrylamide level present in oils has been carried out through the use of the analytical method.

2. Materials and methods

2.1. Materials

Sesame, soy bean, sunflower, corn, olive and palm olein oils, animal fat ghee and lard had been purchased from a local market (Serang, Malaysia). Isotopic [$^{13}\text{C}_3$] acrylamide (isotopic purity, 99%) used as an internal standard was obtained from Cambridge Isotope Laboratories (Andover, MA, USA) at the concentration of

1 mg/ml and diluted to 50 ppb to form a working solution, which was used in the sample, standard and spiking acrylamide preparation. Acrylamide (standard for GC, assay $\geq 99.8\%$) was obtained from Sigma–Aldrich (Hong Kong, China) in powder form, whereas Oasis MCX 3 cc (60 mg) liquid phase and Oasis HLB 3 cc (60 mg) solid phase extraction cartridges were purchased from Waters Corporation (Waters, Milford, MA, USA). Certified reference material (CRM) toasted bread was purchased from European reference materials (ERM) (Geel, Belgium). Other chemicals were obtained from Fisher Scientific (Leicestershire, UK).

2.2. Experimental design

A model system was designed to study the influence of asparagine concentrations on the formation of acrylamide in cooking oils. Four different concentrations of asparagine were examined (0.1, 0.2, 0.3, 0.5 mg) in two types of vegetable oil (soybean and sunflower oil) and one type of animal fat (lard). The information

obtained (the best amount of asparagine, 0.2 mg according to Table 3) was used to determine the acrylamide concentration in different vegetable oils and animal fats (sesame, soy bean, sunflower, corn, olive, palm olein oils, animal fat ghee and lard). Ten grams each of cooking oil and animal fat were mixed with 0.2 mg asparagine, transferred into a Petri dish and heated up at 180 °C (180 °C is the actual temperature in the probe oven when it was set at 188 °C) for 30 min. After cooling, the acrylamide concentration was determined. The experiment was replicated thrice. The oxidation values (peroxide value, iodine value and anisidine value) of the oils were measured before and after heat treatment. Correlations were drawn between the oxidation values and acrylamide formation for both oils and fats.

2.3. Instrumentation

Liquid chromatography–mass spectrometry (LC–MS–MS) analysis was performed on a TSQ Quantum Ultra (Thermo Scientific, San Jose, CA, USA) triple quadrupole mass spectrometer which was connected to an Accela High Speed LC quaternary high pressure pump and an Accela autosampler (Thermo Finnigan, San Jose, CA, USA). An atmospheric pressure chemical ionization (APCI) source was used to produce and introduce ions into the mass spectrometer, equipped with X-calibur software (Thermo Scientific, San Jose, CA, USA) for separation, detection and quantification. The analytical column was a porous graphitic carbon Hypercarb column (2.1 mm \times 50 mm ID; 5 μm) (Thermo Electron, Bellafonte, PA, USA) maintained at 45 °C. The mobile phase was 100% water and the flow rate was maintained at 150 $\mu\text{l}/\text{min}$. The injection volume was 10 μl . Acrylamide was analyzed using the APCI in positive ion mode. Selective reaction monitored mode (SRM) was acquired with the characteristic fragmentation transitions m/z 72 > 55

Download English Version:

<https://daneshyari.com/en/article/1185043>

Download Persian Version:

<https://daneshyari.com/article/1185043>

[Daneshyari.com](https://daneshyari.com)