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Determination of the Amount of Acrylamide Formation during Frying of Potato in Sesame Oil, Palm Olein and the Blend of Them

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Abstracts
The aim of this study was to investigate the effect of frying oil type on acrylamide formation in fried potatoes in Sesame oil, Palm olein and the blend of them. The samples of fried potatoes were prepared by frying the slices of Agriya potatoes in Sesame oil, Palm olein and the blend of them in the ratio of 50:50 (%v/v) at 180℃ for 4/15 minutes. The amount of acrylamide in the samples of fried potatoes was determined by GC-ECD. The experiment was carried out in the completely randomized design in triplicates. The examined samples of fried potatoes in each oil were significantly ($p< 0.05$) different with each other for the amount of acrylamide formation. The maximum amount of acrylamide was 1140 ppb in the samples for Palm olein and the minimum amount of it was 860 ppb in the samples for Sesame oil. The amount of acrylamide in fried samples in the blended oil was also 952ppb.This is due to the higher thermo oxidative stability of Sesame oil in comparison with Palm olein and the blended oil. According to the obtained results, the type of frying oil is an effective factor on acrylamide formation in fried potatoes products and the choice of suitable frying oil that has naturally high thermo oxidative stability can reduce the amount of acrylamide in fried potatoes products. And also blending of Sesame oil with Palm olein is suggested as a suitable strategy for improving thermo oxidative stability of Palm olein and consequently for reducing the amount of acrylamide formation in fried potatoes.
Keywords: Acrylamide, Fried Potato, Sesame oil, Palm olein

I. Introduction

Acrylamide has been classified as a probable carcinogen by the International Agency for Research on Cancer (IARC., 1994) and exposure to high levels having been found to cause damage to nervous system (Lopachin ., 2004) . It is formed through Maillard reaction from free asparagines and a carbonyl source (Stadler et al ., 2002) in many starch –rich foods (Tareke et al ., 2002) , and particularly high levels of acrylamide have been found in processed foods such as potato crisps , potato chips , crisp bread , bakery products , breakfast cereal and coffe (Friedman et al ., 2003) . In most foods, reducing sugars are the main carbonyl compounds reacting with free asparagines since their level is usually very high. Nevertheless, carbonyl compounds in foods may arise also from lipid oxidation, particularly during heating (Frankel. 1998). Lipid oxidation starts with the formation of hydroperoxides and proceeds via radical mechanisms. Lipid oxidation products are a huge family of relatively unstable compounds which may undergo further reactions resulting in a family of compounds of various molecular weight , flavor threshold and biological significance including aldehydes , ketones , alcohol , epoxydes , hydrocarbons (Kamal-Eldin & Appelqvist ., 1996) . Although chemical structures of lipids and carbohydrates are quite different , both Lipid oxidation products and Maillard products comprise carbonyl compounds , thus, it is not surprising that some Lipid oxidation products may react with free asparagines to form acrylamide (Capuano et al ., 2010). Zamora and Hidalgo (2008), reported that some Lipid oxidation products can degrade asparagines to acrylamide. They proposed α, β, γ, δ-diunsaturated carbonyl compounds as the most reactive followed by hydroperoxides, likely because of their thermal decomposition upon heating. Morales, Sacchi and Fogliano (2008), investigated the relationship between virgin olive oil (voo) phenol compounds and the formation of acrylamide in potato crisps. Results demonstrated that acrylamide concentration in crisps increased during frying time, but the formation was faster in the oil having the lowest concentration of phenolic compounds. Capuano, Oliviero, Acer, Gokmen and Fogliano (2010), showed that the thermal stability of the oil can markedly influence the amount of acrylamide in the final products. Products containing saturated fats, which are less prone to thermoxidation, will likely produce less acrylamide. Thermoxidative stability of oil can be improved by modification of fatty acid composition and addition of antioxidants to the oil. Fatty acid composition and functional properties of oils can be modified by hydrogenation, interesterification, and blending different kinds of oil (Chu and Kung., 1998). Unpleasant characteristic odor and possible adverse health effects of hydrogenated oil have been reported (Sundram et al., 2003). Blending different kinds of oil modifies fatty acid composition of oils without any chemical or biological process. Oil blending also introduces some antioxidants to the oil (Chung et al., 2004). Vegetable oils naturally contain antioxidants, tocotrienols in palm oil, and lignans in sesame oil. Sesame oil is highly resistant to oxidation and displays several medicinal effects (Kochhar. 2000). This oil is very stable due to the presence of a number of antioxidants such as sesamin, sesamolin,sesaminol, sesangolin, 2-episalatin and others (Kamal-Eldin et al ., 1994). Therefore, it has a long shelf-life and can be blended with less stable vegetable oils to improve their stability and longevity (Kochhar ., 2002).Palm olein the liquid fraction of palm oil has been shown as highly monounsaturated oil, which is rich in oleic acids (Nor Aini et al., 1993), is currently touted to be oxidatively stable. This oil is suitable oil for frying, it has less iodine value and therefore less amounts of poly unsaturated fatty acids (Idris. 1992). Palm olein , besides being marketed as liquid oil, can be promoted for blending with other edible oils (Lin.,2002).This is because its moderately low linoleic acid content is admirably suited for blending with oils of high poly unsaturated fatty acid content. Ideal edible oil is one in which the ratio of saturated, monounsaturated and poly unsaturated fatty acids is close to 1:1:1 (Grundy. 1988). Proper blending of palm olein and sesame oil in the optimal proportion can produce oil blends with improved thermoxidative stability, nutritional value and flavoure characteristics (Abdulkarim et al., 2010). The aims of this research were to investigate the effect of sesame oil, palm olein and the blend of them to prevent oxidation reaction and improve the oil shelf-life, and consequently to reduce the amount of acrylamide formation in fried potatoes.

II. Materials and Methods

2.1 Materials

For this research 10 kg of Agria potatoes were purchased from Seed and Plant Improvement Institute of Iran and stored at $10^{℃}$ until preparing chips. For frying these samples, two different kinds of edible oil of original plant were used in this research. Refined, bleached and deodorized palm olein and sesame oil void of synthetic antioxidants were purchased from Behshahr factory and Gohardane Aafagh factory respectively. All chemicals and solvents used were purchased from Merck (Darmstadt, Germany).

2.2 Labratorial production of potato chips

First, Agria potatoes were washed and after peeling, slices with a thickness of 1/5mm were prepared. Slices were soaked in cold water for 1 minute to eliminate superficial starch and then dried with paper towel. 100g of slices were fried in an electric deep frier with a capacity of 3Lit of oil at $180^{℃}$ for 4/15 minutes in sesame oil, palm olein and their mixture in the ratio of 50:50 (%v/v). After frying, the samples were dried to remove excess oil and were frozen at $-18^{℃}$ till used for acrylamide analysis.

2.3 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).

2.3.1 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.

2.3.2 Manner of derivatization

The collected acetonitrile layer was brominated based on a procedure described by Tareke and Rydberg (2002). For this aim, potassium bromide, hydrobromic acid and saturated bromine water were used. Obtained solution was kept in the refrigerator at $4^{℃}$ 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 (30m × 0/25mm × 0/25µm) of GC/ECD (Table 1). 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 obtained by using this curve.

GC-ECD Parameters	
Column temperature	80-240 Ċ
Injection temperature	250 Ċ
Detector temperature	280 Ċ
Injection volume	1 μL

Table 1.GC-ECD Device Parameters

2.4 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.

III. Results and Discussion

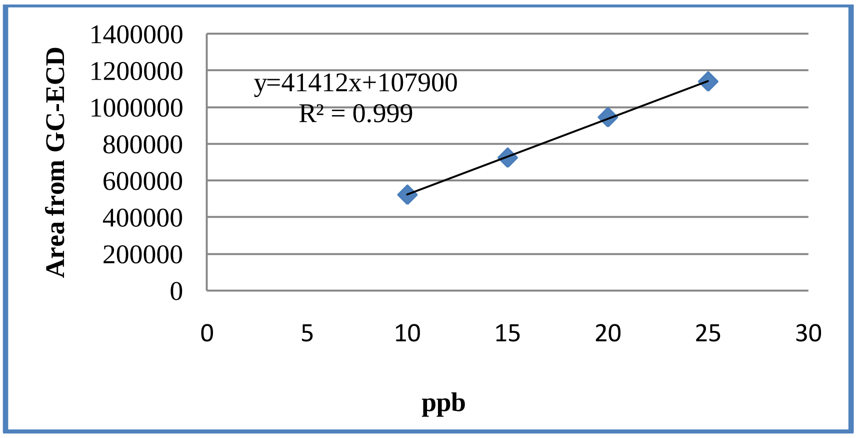

Figure1. GC-ECD Calibration Curve

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 and one of the effective ways to reduce the acrylamide concentration in potato chips is, choosing suitable frying oil that has naturally high thermoxidative stability (Ehling et al., 2005; Capuano et al., 2010).

According to the effective role of potato variety (Becalski et al.,2004), properties of cultivar and fertilization (Xiaohui et al.,2009), storage conditions of potatoes (Hebeisen et al.,2007), temperature and frying time (Pedreschi et al.,2004) and pretreatment procedures (Viklund et al.,2010) on the amount of acrylamide formation in final product, so, in this study it had been tried to attribute the observed changes in the amount of acrylamide concentration in fried potatoes samples to the effect of frying oil types by fixing other mentioned effective factors. Regarding to the results of this research, the examined samples of fried potatoes in each frying oil including sesame oil, palm olein and the blend of them were significantly ($p< 0.05$) different with each other for the amount of acrylamide formation (Figure 2). This indicates that the type of frying oil is an important factor on the amount of acrylamide formation in potato chips. The obtained results were similar to previous finding (Ehling et al., 2005; Elleuch et al., 2006; Capuano et al., 2010).

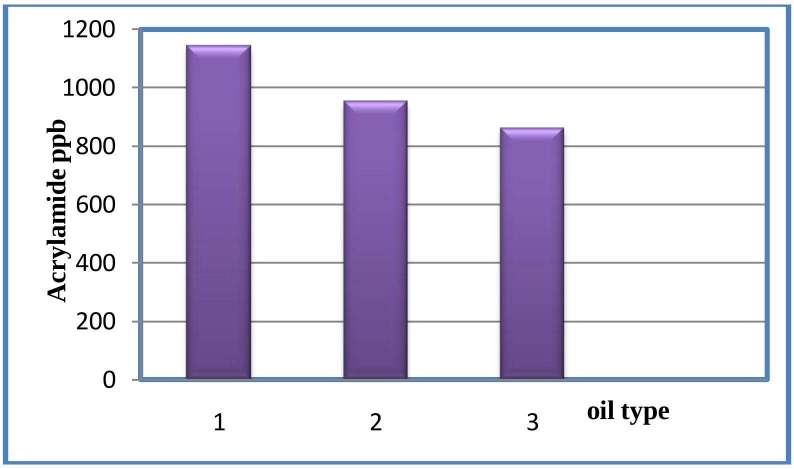

Figure 2 . Average ppb of acrylamide formed in fried potatoes in (1= palm olein, 2= blended oil, 3= sesame oil)

Figure (2) shows that the maximum amount of acrylamide was 1140 ppb in the samples for Palm olein and the minimum amount of that was 860 ppb in the samples for Sesame oil . The amount of acrylamide in fried samples in the blended oil was also 952 ppb. According to this fact that the formation of acrylamide by oils is due to the reaction between carbonyl compounds derived from lipid thermoxidation products with free asparagine of potato (Hidalgo & Zamora., 2007; Capuano et al., 2010), so, the reason of the least formation of acrylamide concentration in the fried potatoes in sesame oil in comparison with the samples for palm olein and the blended oil is due to the higher thermo oxidative stability of Sesame oil in comparison with both other mentioned oil. This result confirms previous findings by Ehling et al., 2005 and Capuano et al., 2010. Sesame oil is more stable to the thermoxidation than other vegetable oils due to the presence of unique and powerful antioxidants called lignin compounds such as sesamin, sesamolin, sesaminol, sesangolin, 2-episalatin (Kamal-Eldin et al., 1994 ; Shya & Hwang., 2002) that they exist just in sesame oil (Chung et al., 2004) . And also , in this study when sesame oil was added to the palm olein in the ratio of 50:50 (%v/v), the amount of acrylamide formation in fried potatoes in palm olein reduced from 1140 ppb to 952 ppb in the samples for blended oil. This is due to the improvement thermoxidative stability of palm olein by adding sesame oil and the presence of its natural and powerful antioxidants in blended oil (Abdulkarim et al., 2010; Gulla & Waghray., 2012). This result was similar to previous finding that the presence of natural antioxidant components in frying oil can reduce the concentration of acrylamide formation in crisps by improving thermoxidative stability of frying oil (Morales et al., 2008).

IV. Conclusions

According to the obtained results, the type of frying oil is an effective factor on acrylamide formation in fried potatoes products. The choice of suitable frying oil that has naturally high thermo oxidative stability can reduce the amount of acrylamide in fried potatoes products. And also blending of Sesame oil with Palm olein is suggested as a suitable strategy for improving thermo oxidative stability of Palm olein and consequently for reducing the amount of acrylamide formation in fried potatoes.

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