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Effect of Microwave Frying on 3-MCPD and Glycidyl Ester Content of Potato Strips

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ABSTRACT

The study aims to investigate the effect of microwave frying power and time on 3-MCPD and glycidyl ester contents of oils absorbed by fried potatoes. For this purpose, potato sticks were fried with three different refined vegetable oils (canola, corn, sunflower) at two power settings (350 W, 700 W) for two time periods (3 and 5 minutes). The fried potato oil samples were evaluated for their 3-MCPD and glycidyl ester content using alkali transesterification with DGF Standard Method C-VI 18 (10). Results have shown that microwave frying with different vegetable oils resulted in the formation of different 3-MCPD ester patterns. Microwave power and time did not change significantly the content of glycidyl ester s of potatoes fried with canola oil.

Introduction

3-Monochloropropane-1,2-diol (3-MCPD) esters are contaminants that are formed during the high-temperature processing of fat-based food matrices (Hrncirik and van Duijn, 2011). 3-MCPD esters were identified in 1980 by Velíšek et al. (1980) in acid-hydrolysed vegetable proteins. The existence of these contaminants was evidenced in refined vegetable oils, as reported by Zelinková et al. (2006). Glycidyl esters were also defined as food processing contaminants, which were firstly identified in edible oils in 2010 (Weisshaar and Perz, 2010). Both 3-MCPD and glycidyl esters are predominantly formed during the deodorization step of the oil refining process (Cheng et al., 2017) where lipids such as triacylglycerols (TAG) and diacylglycerols (DAG) react with the chlorides at high temperature (180-200 °C) processing (Sim et al., 2020). In literature, palm oil has been reported to contain the highest amount of 3-MCPD esters (2.91 ppm) among different refined vegetable oils (EFSA; 2016). Since processing temperature is the most crucial factor which induces the formation of 3-MCPD and glycidyl esters, to date some papers have been published that highlight the impact of heating or frying temperature on 3-MCPD and glycidyl ester formation (Goh et al., 2021). Various kinds of research were carried out on the formation of 3-MCPD and glycidyl esters during deep-fat frying (Wong et al., 2017; Arisseto et al., 2017).

Microwave ovens have attained great interest because of their fast heating advantage and ease of use for consumers. Microwave ovens have also found their usage in frying purposes to recover the properties of the foodstuff. There are several reports indicating the advantages of microwave frying on product quality, such as lower acrylamide formation (Sahin et al., 2007) and lesser oil uptake in potato strips (Oztop et al., 2007). No research has been conducted that investigates the relation between microwave frying and 3-MCPD and glycidyl ester concentration of the fried product. Hence, the current research aimed at determining the effect of microwave frying on 3-MCPD and glycidyl ester content of microwave-fried potato sticks using different power settings and time.

Materials and methods

Reagents and standards

Methanol, toluene, tert-butyl methyl ether (tBME), diethyl ether, hexane, sodium methoxide, ethyl acetate, iso-octane, sodium chloride, sodium bromide, phenyl boronic acid, sodium sulphate and

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d5-3-MCPD-1,2-bis-palmitoyl ester, 3-MCPD and glycidol were purchased from Sigma (St-Louis, USA).

Microwave frying and oil extraction

The microwave frying process was carried out in a microwave oven (Arçelik, MD 574 S, 17 L, 2450 Hz), using three vegetable oils (sunflower, canola, corn). Frozen potato strips (SuperFresh Kerevitas Gıda San. ve Tic. A.Ş., Turkey) were purchased from a local market. Microwave frying was performed in a glass plate with 400 ml of oil each time. Oil was first heated to 170 ± 3 °C in the microwave oven, then potato slices were placed in hot oil. Frying was performed at 350 W and 700 W for three and five minutes. Following frying, oils of potatoes were extracted by Soxhlet extraction using *n*-hexane. Oil samples were stored in a nitrogen atmosphere at -18 °C until the analysis.

Analysis of 3-MCPD and glycidyl esters

The 3-MCPD and glycidyl ester content was determined according to the DGF Standard Method C-VI 18 (10) (DGF, 2009). The chromatographic analysis was performed with a gas chromatography-mass spectrometry instrument (Agilent, USA) and the elution was done with a capillary column (Restek Rxi-5 ms column, 30 m × 0.25 mm × 0.25 μm). The injector was run in a splitless mode. The injection temperature was 250 °C. The carrier gas was helium with a constant flow rate of 1.18 mL/min. The oven temperature programme was set as follows: 80 °C was raised to 155 °C with a rate of 5 °C/min and then it was raised to 300 °C with 60 °C/min and held for 5 minutes. The temperature of the ion source and interface in a mass spectrometer was 200 and 280 °C, respectively. The ion traces m/z 147 and 150 were selected as ions for the quantification of 3-MCPD and 3-MCPD-d5. The quantification was performed according to DGF C-VI 18 (10) via isotope-labelled standards.

Results and discussion

The 3-MCPD ester content of the oils absorbed by the potato sticks during microwave frying at both 350 and 700 W is as given in Table 1. Bound 3-MCPD content of the sticks varied between 0.28-1.21 mg/kg, 0.40-1.26 mg/kg and 0.51-1.13 mg/kg fried in corn, sunflower and canola oils, respectively. The change in microwave powers and times brought about slight variations in samples fried with sunflower, corn and canola oils. The increase in time and power decreased the 3-MCPD ester content of sticks fried with corn oil; nevertheless, an increasing trend with intense heating conditions was observed when frying with sunflower oil. 3-MCPD and glycidyl ester formation during frying has been previously investigated in several types of research. Both formation and degradation of the esters have been reported to occur synchoronously throughout frying (Goh et al., 2021).

The glycidyl ester concentrations of the oils absorbed by the potatoes during microwave frying at 350 and 700 W are given in Table 2. Bound glycidol content of the sticks varied between 0.13-0.40 mg/kg, 0.01-0.14 mg/kg and 0.09-0.15 mg/kg fried in corn, sunflower and canola oils, respectively. Potatoes fried with corn oil exhibited higher glycidyl ester values than the other two oils, during microwave treatment, similar to 3-MCPD ester contents. The change in microwave power and time did not result in any significant alteration in the oils of sticks fried in canola oil. However, slight changes were observed in the samples fried with corn and sunflower oils with microwave parameters.

Table 1. The 3-MCPD ester content of microwave-fried potatoes fried with corn, sunflower, and canola oils at 350 and 700 W (mg/kg)

Microwave power	Time	Oil type		
		Corn	Sunflower	Canola
350 W	3 min	1.21 ± 0.25^{c}	0.40 ± 0.06^{a}	0.55 ± 0.17^{a}
	5 min	0.82 ± 0.13^{b}	0.62 ± 0.07^{ab}	0.84 ± 0.00^{b}
700 W	3 min	0.67 ± 0.08^{b}	0.83 ± 0.36^{bc}	1.13 ± 0.17^{c}
	5 min	0.28 ± 0.00^{a}	1.26 ± 0.17^{c}	0.51 ± 0.02^{a}

Values in each column with different letters are significantly different at $p<0.05$.

Table 2. The glycidyl ester content of microwave-fried potatoes fried with corn, sunflower, and canola oils at 350 and 700 W (mg/kg)

Microwave power	Time	Oil type		
		Corn	Sunflower	Canola
350 W	3 min	0.13±0.07[a]	0.14±0.01[d]	0.15±0.08[a]
	5 min	0.40±0.23[b]	0.07±0.05[b]	0.11±0.00[a]
700 W	3 min	0.18±0.09[a]	0.01±0.00[a]	0.09±0.00[a]
	5 min	0.16±0.08[a]	0.10±0.00[c]	0.13±0.00[a]

Values in each column with different letters are significantly different at *p<0.05*.

Conclusions

The results reported herein expose the first knowledge about the effect of microwave frying on 3-MCPD and glycidyl ester content of microwave-fried potato sticks. The findings given herein were mainly higher than the occurrence values of the 3-MCPD and glycidol for corresponding oils reported in EFSA data (2016). The GE values were below the established regulatory limit of 1000 µg/kg (Commission Regulation EU 2020/1322). Similarly, 3-MCPD ester values were mainly below the limit of 1250 µg/kg except for the sunflower oil-fried in the most intense conditions. The results of the current research showed that different vegetable oils caused dissimilar effects on the 3-MCPD ester content of potato sticks. Microwave power and time did not affect the glycidyl ester content of potatoes fried with canola oil.

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