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INFLUENCE OF POTATO VARIETY AND TYPE OF OIL USED IN FRYING POTATOES ON ACRYLAMIDE LEVEL

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Abstract
French fries are very consumed food products in fast-foods, restaurants, as well in consumer households. During frying process, the chemical contaminant acrylamide is formed, which is the result of the reaction between the amino group of asparagine and the carbonyl group of reducing carbohydrates (mainly glucose, fructose and maltose).
The aim of this study was to investigate the influence of potato variety (Asinaria, Marvis) and type of oil (sunflower, palm) used on the level of acrylamide formed in potatoes fried in fast-food conditions. The acrylamide content was determined by GC-MS/MS using the SPE technique. For both potato varieties, the use of sunflower oil when frying potatoes led to a higher acrylamide level (288.11 ÷ 295.86 µg/% d.m.) compared to French fries fried in palm oil (227.44 ÷ 242.82 µg/% d.m.).
The acrylamide level was correlated with the content of reducing sugars in the composition of the potato variety. The Asinaria variety which had the highest content of reducing carbohydrates (3.92% d.m.) determined the highest level of acrylamide. Correlations between the level of acrylamide and color parameters L and a* were found: as the level of acrylamide increased, the color parameter L* decreased and the parameter a* increased. The potato variety and type of oil used for frying influenced the acrylamide level formed in French fries.*

Keywords: acrylamide, French fries, frying oil, palm oil, potatoes, sunflower oil.

1. INTRODUCTION

French fries are popular foods consumed in fast foods, restaurants, canteens and also in consumer households. These products being subjected to the frying process at temperatures higher than 150°C produces, on the one hand, various changes, such as aroma, taste, color, and on the other hand, the predisposition to form acrylamide, a chemical contaminant formed when starchy products are prepared at temperatures above 120°C, in low moisture conditions. During frying, lipid oxidation and the Maillard reaction play an important role in the formation of acrylamide which affects the quality of the products obtained. Also, the absorption of oil during deep frying of food influences the quality of the final product. Studies showed that higher levels of acrylamide in French fries may be due to the different composition of potato varieties in reducing carbohydrates (glucose and fructose) and in asparagine, considered the main precursors in the formation of acrylamide (Yang et al., 2016; Mesías et al., 2017; Muttucumaru et al., 2017). In the study conducted by Yang et al.

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(2016) it was observed a relationship between acrylamide levels of French fries obtained from 3 different varieties of potatoes (Kennebec, Red Pontiac and Agria) and the sucrose content of these fresh varieties. In studies realized by Yang et al. (2016) and Medeiros Vinci et al. (2012), it was observed that the concentration of asparagine is higher in some potato varieties compared to the reducing sugar content, so that the reducing sugar content is the limiting factor in the formation of acrylamide.

Also, the acrylamide content of French fries is influenced by the vegetable oil used for frying and its lipid profile (Abd Razak et al., 2021). Oils which contain an equilibrated proportion of saturated and unsaturated fatty acids in its composition are more stable to oxidation and recommended for frying. Many types of vegetables oils can be used for deep-frying, but the most used oils are sunflower and palm oils. The cooking parameters are factors which influence the acrylamide content of French fries, increasing with frying temperature and time (Yang et al., 2016).

Potato products, including French fries are the main contributors to total dietary exposure to acrylamide (EFSA, 2015). In order to reduce acrylamide levels, it is necessary to ensure food safety and reduce the presence of this contaminant in food, so the European Commission has implemented Regulation 2158/2017 which establish the mitigation measures and benchmark levels for the reduction of acrylamide in food (EC, 2017). There are recommendations for food business operators to keep the frying temperature between 160 and 175°C, and potato-based products to be cook until a golden yellow color. The benchmark level specified in this Regulation is 500 μg/kg for French fries (ready-to-eat).

The objective of this study was to investigate the influence of potato variety and cooking oil used to fry potatoes in a fryer on the acrylamide content of French fries obtained. The correlation between the acrylamide content and the color parameters was also investigated.

2. MATERIALS AND METHODS

Chemicals, reagents and standards

For this study, native acrylamide (min. 99% purity) purchased from Restek (Benner Circle, Bellefonte, USA) was used. The internal standard (IS) of labelled acrylamide (1,2,3-^{13}C labeled acrylamide, min. 99% purity) was obtained from Cambridge Isotope Laboratories (Andover, MA, USA). All other chemicals, reagents and solvents were of analytical grade. For extraction, SPE cartridges supplied by Biotage (Uppsala, Sweden) were used: Isolute® Multimode (1000 mg, 6 mL) and Isolute® ENV$^+$ (500 mg, 6 mL).

Samples

For this study *Asinaria* and *Marvis* varieties of potatoes obtained from the National Research and Development Institute for Potato and Sugar Beet Brașov, Romania were used. Both varieties of potatoes were harvested in 2020 and experiments were realized in February 2021.

Sunflower and palm oils acquired from a local supermarket from Bucharest, Romania were used for frying potatoes.

Sample preparation

Asinaria and *Marvis* varieties of potatoes were peeled and cut at the dimension of 9 mm x 9 mm, with a length between 60 and 80 mm. After peeling, potatoes were rinsed in tap water, and the excess water from the potato surface was removed using absorbent paper. For this experiment, samples of potatoes were fried in fast-food conditions, using a temperature-controlled fryer with

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two unites of customized 4 L capacity stainless (Hendi Blue Line). The fryer was heated gradually at 170°C before frying, and maintained at this temperature for 30 min. The potato: oil ratio (w/w) used was 1:4.
Potatoes were fried at 170°C, for 6 min. After frying, potatoes were taken out with the basket and were shaken to lose the oil in excess. Samples were transferred in a plate and let to cool, after which it were ground and homogenized in a laboratory mixer (Büchi, Labortechnik AG, Germany). Grounded samples were put in a centrifuge tube and kept in the freezer at -20°C before analyses.

Acrylamide determination
Acrylamide extraction was performed with the solid-phase extraction technique, while its quantification was performed with a GC-MS/MS system based on the method described by Negoiță et al. (2020). The internal standard method was used for acrylamide quantification.
In order to determine acrylamide, two calibration curves in the range of 0.05 - 3 mg/L were used, for which the correlation coefficients were higher than 0.999. The method presented a good recovery between 85.64 and 109.22%. The limit of detection for French fries samples was 10.29 µg/kg, while the limit of quantification was 30.87 µg/kg.

Determination of moisture content
For all French fries samples, the moisture content was determined gravimetrically in an oven heated at 105°C to constant weight for 24 h according to the AOAC method (AOAC, 1995). The moisture content was determined in duplicate and results were expressed as mean ± standard deviation (SD).

Determination of reducing sugar content
The reducing sugar content of French fries samples was determined based on Schoorl method. Results were expressed as g% dry matter (d.m.).

Color determination
The color of French fries samples was determined by using a Konica Minolta spectrophotometer (Universal Software V4.01 Miniscan XE Plus) in the CIE Lab space. The color parameters *L** (lightness), *a** (greenness- redness) and *b** (blueness– yellowness) were determined on different points of the grounded sample of French fries. For each sample 10 measurements were done and results were expressed as mean ± SD.

Statistical analysis
All samples were analyzed in duplicate and the results were expressed as mean ± SD. The acrylamide content was expressed in µg/kg, also in µg/% d.m.. In the case of moisture content, results were expressed in %, while the reducing sugars content was expressed in g % d.m. For color parameters, 10 measurements were done and the result was as well expressed as mean ± SD.

3. RESULTS AND DISCUSSIONS
For this study, the influence of potato variety and type of vegetable oils used for frying potatoes on the level of acrylamide formed in French fries fried in fast-food conditions was investigated. All samples were prepared in the same conditions, being fried at the temperature of 170°C for 6 min.
The moisture content, reducing sugars and acrylamide content were determined for all samples analyzed and results are presented in table 1.

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Table 1. Moisture content, acrylamide and reducing sugars content of French fries samples

Potatoes and vegetable oils		Moisture content, %	Acrylamide		Reducing sugars, g% d.m.
			µg/kg	µg/% d.m.	
Asinaria	Sunflower oil	56.74 ± 0.96	1279.89 ± 15.17	295.86	3.92 ± 0.15
	Palm oil	53.23 ± 0.99	1129.58 ± 12.19	242.82	
Marvis	Sunflower oil	53.48 ± 0.87	1340.28 ± 22.20	288.11	3.20 ± 0.16
	Palm oil	49.88 ± 4.21	1139.95 ± 24.54	227.44	

The moisture content of French fries samples ranged between 49.88% and 56.74%. Bradshaw and Ramsay (2017) stated that the moisture content of par-fried potatoes should be less than 70% in order to prevent disintegration of the interior and the crust of the final product. In the study realized by Mesias et al. (2019) the average moisture content of French fries samples from different restaurants was 45.83%.

The acrylamide content of food products is influenced by the quantity of acrylamide precursors, asparagine and reducing sugars, found in the raw materials. The reducing sugars content of *Asinaria* variety of potatoes was higher than the one of *Marvis* variety, the acrylamide level being correlated with the reducing sugars content when expressing it µg/% d.m.

As it can be noticed from table 1, the acrylamide content of French fries samples exceeded the benchmark level of 500 µg/kg established by the Commission Regulation 2017/2158. In the case of *Marvis* variety, the acrylamide content was higher than when *Asinaria* variety was used for frying. Also, when using for frying sunflower oil, the acrylamide level of French fries samples was higher than when palm oil was used. This can be the result of the fatty acids composition of sunflower and palm oil which play an important role in lipid oxidation. The acrylamide concentration is linked with the unsaturation of the vegetable oil used for frying. Sunflower oil contains a high proportion of unsaturated fatty acids which are more susceptible to oxidation (Abd Razak et al., 2021), like this the acrylamide content of French fries being higher when this oil was used. As a result of oil oxidation, 2,4-decadienal is formed which may interact with reducing sugars present in potatoes and resulting acrylamide as a product of asparagine conversion (Karademir et al., 2019). In a study realized by Zhang et al. (2015) it was shown that another factor that might influence the acrylamide content of French fries is the heat transfer coefficient of frying oil. The acrylamide content is directly correlated with the heat transfer coefficient of the oil used for frying which increase the thickness of the crust, where acrylamide is mostly formed.

In order to eliminate the moisture content factor, the acrylamide level was also calculated according to the moisture content of the end product, results being expressed in µg/100 g d.m.

When expressing the acrylamide content in d.m., for both potato varieties, the use of sunflower oil when frying potatoes led to a higher acrylamide content (288.11 ÷ 295.86 µg/% d.m.) compared to French fries fried in palm oil (227.44 ÷ 242.82 µg/% d.m.).

Color parameters

Color is an important factor which can be correlated with the acrylamide content of food products. Usually, the color is the decisive factor when choosing the end-point of French fries. The browning process of food products is a result of the Maillard reaction and is directly correlated with the acrylamide content of food products.

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Figure 1 shows the acrylamie content and the color parameters *L** and *a** of French fries samples fried in sunflower and palm oils. A correlation between the acrylamide content expressed in µg/% d.m. and the color parameters *L** and *a** was found. When the level of acrylamide when using the same oil increased, the color parameter *L** decreased and the parameter *a** increased. No correlation was found between the acrylamide content and the color parameters *b**.

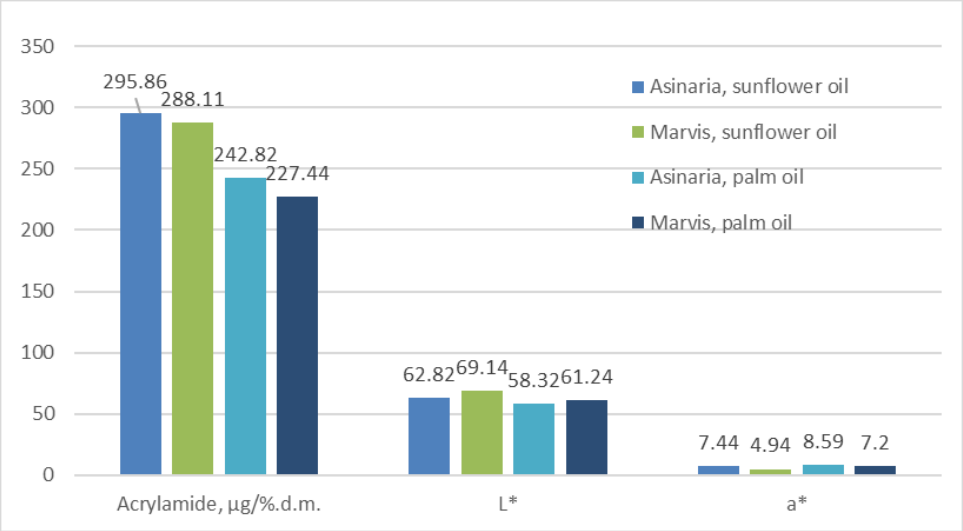

Figure 1. Variation of acrylamide content (µg/% d.m.) and color parameters L* and a* of French fries samples

4. CONCLUSIONS

Results of this study showed that the variety of potatoes and the type of oil used, influence the acrylamide level formed in French fries. The *Asinaria* variety which had the highest content of reducing carbohydrates (3.92% d.m.) determined the highest level of acrylamide. The acrylamide content of French fries fried in sunflower oil was higher than when palm oil was used. The acrylamide content of French fries was correlated with the color parameters *L** and *a**.

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