LWT - Food Science and Technology 148 (2021) 111765

Contents lists available at ScienceDirect

LWT

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

Acrylamide content in French fries prepared with vegetable oils enriched with β-cyclodextrin or β-cyclodextrin-carvacrol complexes

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ARTICLE INFO

Keywords:
ORAC
GC-MS
Rancimat
Extra virgin olive oil
Sunflower oil

ABSTRACT

Acrylamide is carcinogenic for humans. Foods rich in carbohydrates cooked at high temperatures have a high content of this substance. Potatoes are one of the most consumed foods in the world and French fries are one of their most common cooking methods. French fries represent 10–49% of the acrylamide intake in the European Union and around 55% in USA. The aim of this study was to evaluate the effect that β-cyclodextrin and β-CD-carvacrol complexes, acting as an ingredients into the vegetal oils used in the frying process, had in the concentration of acrylamide, antioxidant activity, oxidation stability, color, volatile compounds and sensory analysis of French fries. Both compounds increased the antioxidant activity and the oxidation stability of the potatoes. The addition of β-carvacrol into the oil (sunflower and extra virgin olive oil) reduced up to 40% the formation of the acrylamide in the frying process. The addition of β-cyclodextrin reduced the content of acrylamide (15%) when the temperature of frying was 185 °C and the oil used was extra virgin olive oil. Consumers did not detect the type of oil and/or the treatment and prefers a product fried at 175 °C instead 185 °C.

1. Introduction

Acrylamide is a neurotoxic and genotoxic substance for humans (Dearfield et al., 1995; Erkekoglu & Baydar, 2014) and it is classified as potential carcinogenic molecule for humans by the European Food Safety Authority (EFSA, 2015). Several studies have demonstrated that foods rich in carbohydrates will have a high acrylamide content when produced by using a thermal process at temperatures above 120 °C and low moisture through Maillard reactions (Elmore et al., 2015; Taubert, Harlfinger, Henkes, Berkels, & Schömig, 2004; Y. Zhang & Zhang, 2007). Besides, carbohydrate-rich foods, acrylamide can be also found in coffee, dairy products for babies and children, fruit and vegetables, and meat and fish products (Rannou, Laroque, Renault, Prost, & Sérot, 2016).

Potatoes (*Solanum tuberosum* L.) are one of the most consume food in the European diet; they are cooked using many different heat treatments and sold under many different formats. Children is the segment of population with the biggest consumption of French fries and potato chips (Molina Périz, Mañes, & Manyes, 2016).

In Spain, a yearly consumption of ~2.4 kg of processed potatoes is estimated (MAPAMA, 2017), so it is essential to identify potential carcinogenic or dangerous substances, including acrylamide, for humans in this type of foods.

In 2015, the European Food and Safety Authority (EFSA) published that the daily intake of acrylamide causing a low, but measurable, increase in the occurrence of cancer in humans is 170 μg kg^{-1} body weight, bw, (EFSA, 2015).

In 2017, the European commission published regulation 22017/2158 establishing mitigation measures and benchmark levels to reduce acrylamide in foods, identifying a benchmark level of 500 μg kg^{-1} for French fries. These strategies can be implemented by mitigation approach, such as good hygiene practice and application of procedures based on hazard analysis and critical control point (HACCP) principles (European Commission, 2017). However, it is necessary to highlight that home-cooking practices for food preparation have not been considered in the estimation of this risk (Mesias, Delgado-Andrade, Holgado, & Morales, 2018). It is very important not only to establish maximum values for the residues of these potentially toxic compounds but also to offer recommendations about their home preparation/cooking.

Mesías and Morales (2015) analyzed the acrylamide content in 18

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https://doi.org/10.1016/j.lwt.2021.111765
Received 8 September 2020; Received in revised form 13 May 2021; Accepted 19 May 2021
Available online 25 May 2021

Table 3
Sensory analysis of the French fries under study at two deep-frying temperatures, 175 and 185 °C (EVOO: extra virgin olive oil; SO: sunflower oil; β-CD: β-cyclodextrin; β-CARV: β-carvacrol + β-cyclodextrin).

Factor	Appearance	Color	Odor	Flavor	Liking
ANOVA[†]	***	***	***	***	***
SO/175	4.4 a[‡]	3.9 a	4.5 a	3.3 c	4.3 ab
SO/β-CD/175	4.2 a	4.0 a	4.0 ab	3.5 bc	4.0 b
SO/β-CARV/175	4.3 a	4.1 a	4.2 a	3.8 b	4.3 ab
SO/185	2.8 b	2.5 c	2.8 c	2.7 d	2.2 c
SO/β-CD/185	3.0 b	1.9 d	2.8 c	3.0 c	2.3 c
SO/β-CARV/185	3.0 b	1.7 d	2.5 c	2.6 d	2.1 c
EVOO/175	4.7 a	3.9 a	4.8 a	4.6 a	5.0 a
EVOO/β-CD/175	4.6 a	3.4 b	4.1 ab	4.2 ab	4.4 ab
EVOO/β-CARV/175	4.7 a	3.9 a	4.5 a	4.5 a	4.5 ab
EVOO/185	2.7 b	2.3 c	3.1 bc	2.5 d	2.7 c
EVOO/β-CD/185	2.8 b	2.2 c	2.8 c	2.6 d	2.9 c
EVOO/β-CARV/185	2.8 b	2.0 c	3.1 bc	2.6 d	2.7 c

[†]NS: not significant at $p < 0.05$; *, **, and ***, significant at $p < 0.05$, 0.01, and 0.001, respectively.
[‡]Values (mean of 3 replications) followed by the same letter, within the same column, were not significantly different ($p < 0.05$), according to the Tukey's least significant difference test.

flavor, and even overall liking) (Table 3).

4. Conclusion

The acrylamide content in French fries was reduced by 40% by adding β-carvacrol (1 g L^{-1}) in the frying oil (sunflower and extra virgin olive oil). The addition of β-cyclodextrin led to a 15% reduction in acrylamide concentration, but only when the potatoes were fried at 185 °C and using EVOO. In the rest of the conditions, there were no statistically significant differences. Furthermore, the addition of these compounds increased antioxidant activity, reduced oxidation, and reduced the browning of French fries during the frying process. The main conclusion we can draw from the affective sensory analysis carried out is that the temperature conditioned the choice of consumers. Consumers did not detect the type of oil and/or the treatment it was carrying (β-cyclodextrins and β-carvacrol), or in other words, this was not an enough reason for which to choose their choice.

CRediT authorship contribution statement

Antonio José Pérez-López: Conceptualization, Methodology, Investigation, Supervision, Writing – review & editing. **Luis Noguera-Artiaga:** Methodology, Investigation, Writing – review & editing. **Santiago López-Miranda González:** Conceptualization, Methodology, Investigation, Supervision, Writing – review & editing. **Pablo Gómez-San Miguel:** Methodology, Investigation, Writing – review & editing. **Borja Ferrández:** Methodology, Investigation, Writing – original draft. **Ángel Antonio Carbonell-Barrachina:** Methodology, Investigation, Supervision, Writing – review & editing.

Declaration of competing interest

All authors have participated in conception, design, analysis and interpretation of the data, drafting the article, revising it critically for important intellectual content, and approval of the final version.

This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue.

The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript.

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