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Effect of different home-cooking methods on acrylamide formation in pre-prepared croquettes

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ABSTRACT

This study compared the effects of different heating methods such as roasting, pan-frying, deep-frying and microwave treatment on the formation of acrylamide (AA) in ready-to-eat croquettes. The experiment was performed with ten commercially available pre-cooked flour-based croquettes with meat filling for home-cooking reheated according to the information on the labels. The AA content was determined by the reversed phase-high performance liquid chromatography (RP-HPLC) method coupled to a diode array detector (DAD). Browning development and water activity along with free asparagine and sugar content were also monitored. Before preparation, all products showed the lowest (190 μg/kg) acrylamide content. The highest acrylamide content was found when microwave heating was used. The mean AA content in all samples prepared in this way was significantly higher (420 μg/kg) than that of roasting (360 μg/kg), deep-frying (298 μg/kg) or pan-frying (285 μg/kg) ($p < 0.05$). The manner in which heat is transmitted to a food appears to have a significant impact on the rate of acrylamide formation. Among the domestic methods used, microwave treatment was more favourable for AA formation in products. The use of microwave heating for thermal processing of carbohydrate-rich food should be limited by consumers to prevent excessive acrylamide formation.

1. Introduction

Process contaminants are chemical substances which are absent in raw foods or raw materials used to make food products and are only formed when components within the food or raw materials undergo chemical changes during processing. The presence of these contaminants in processed foods cannot be entirely avoided. However, technological processes can be adjusted and optimized in order to reduce the levels of their formation. The impact of chemical contaminants on consumer health and well-being is often apparent only after many years of prolonged exposure at low levels (e.g. cancer). An example of such chemical contamination of food is acrylamide (AA) (Anese et al., 2013).

It is believed that acrylamide has the potential to increase the risk of cancer. It is formed when foods containing asparagine (a natural amino acid) and sugars (either present naturally or added) are heated at temperatures higher than 120 °C (Anese et al., 2013; Geng et al., 2008; Keramat et al., 2011). AA has been found in a wide range of commercially-processed and home-cooked foods, mainly potato- and grain-based products. High levels of this compound have also been found in many ready-to-eat products, which were heat-treated at home. As with commercially processed foods, acrylamide levels in home-prepared foods tend to increase with an increasing cooking time and temperature (Claeys et al., 2005; Dybing et al., 2005; Michalak et al., 2011; Skog et al., 2008; Stadler and Scholz, 2004).

Countries and regions differ in food choices and cooking methods. In addition, dietary habits and the time devoted to home cooking are changing due to the increased availability of ready-made foods and changes in lifestyles. The number of meals fully prepared at home is decreasing in favour of an increased consumption of pre-prepared and fast foods. A significant source of dietary acrylamide are foods cooked and prepared at home, by catering services or served in restaurants (Anese et al., 2009; Skog et al., 2008). Approximately 50% of acrylamide intake may be derived from such sources, but quantitative data are scarce (Dybing et al., 2005; Stadler and Scholz, 2004).

Nevertheless, based on data obtained from different studies, it seems reasonable not to ignore the potential for reducing acrylamide exposure through better home cooking procedures. Not only where to buy the food, but also how to cook it in order to retain as much nutrition as possible should be considered. Therefore, the purpose of the study was to compare the effects

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of different home-cooking methods, such as roasting, pan-frying, deep-frying and microwave treatment on acrylamide formation in some ready-to-eat foods. The study will enable a better understanding of domestic cooking methods causing acrylamide formation in pre-prepared foods.

2. Materials and methods

2.1. Food samples

The experiment was performed with ten commercially-available pre-cooked flour-based croquettes with meat filling for home-cooking (the same kind of products obtained from different producers). The purchased croquettes were similar in size (9 ± 0.5 cm in length, 3 ± 0.5 cm in width and 2 cm in thickness) and weight (120 ± 10 g). The major ingredients of croquettes were wheat flour, water, meat (20–22% pork or beef), rapeseed oil, breadcrumbs (wheat flour, salt, yeast), soy protein, rice flour, salt, onion, egg material, sugar, spices, preservative – potassium sorbate, raising agents – sodium carbonate, yeast, maltodextrin and flavouring substances. All products were packed in modified atmosphere and were obtained from a local retailer. The samples were heated and analysed immediately after buying. The characteristics of the samples (before final preparation), as reported on labels and own study, are shown in Table 1.

Table 1
Croquette characteristics based on labels and own studies.

	Energy (kJ/100 g)	Protein (g/100 g)	Carbohydrate (g/100 g)	Fat (g/100 g)	Glucose[a] (g/100 g)	Fructose[a] (g/100 g)	Sucrose[a] (g/100 g)	Asp[a] (mg/100 g)
Croquettes before final preparation	1090 ± 50	10.0 ± 2.1	22.0 ± 5.3	15.0 ± 3.0	1.80 ± 0.1	1.40 ± 0.1	0.80 ± 0.1	1.92 ± 0.4

Data are expressed as mean values ± standard deviations (SDs) of ten independent samples analyzed in triplicate ($n = 30$).
Asp: asparagine.
[a] Content based on own studies.

2.2. Sample preparation

Directly after purchasing, products were heated with domestic methods according to the information on the labels by pan-frying (5 min at 180 °C), deep-frying (5 min at 180 °C), roasting (10 min at 200 °C) and microwaving (10 min at 200 °C). The deep-frying of all croquettes was performed in a Philips HD 6158/55 Deep Fryer (Amsterdam, Netherlands) domestic fryer (200 g in 2 L of hot oil). The oil temperature during frying was monitored by immersing a thermocouple in the fryer. Pan-frying was performed in a saucepan using 100 g portions of products fried in 100 mL of hot oil. The temperature of the heating medium was measured using an automatic temperature control system for domestic appliances. Fresh sunflower oil was used in both experiments. The roasting of croquettes was performed in a domestic oven (Miele H 6560 BP, Gütersloh, Germany) with precise temperature control. Microwaving was performed in a Miele M637-45 ECR STAL microwave (Gütersloh, Germany) with automatic monitoring and control of internal temperature. The microwave heating of croquettes was performed using one of the combination mode programs (Medium high microwave power – 77% with low grill power – 23%). The temperature, operating power of the microwave and heating time were 200 °C, 700 W and 10 min, respectively. After heating, the products were drained with a wire screen and cooled to 20 °C at room temperature. All samples were ground and mixed in a blender (8000 FP664 Moulinex, Grupe SEB, Warsaw, Poland) to assure a homogeneous distribution of potential hotspots.

2.3. Reagents and chemicals

The acrylamide standard, the standard sugars (fructose, glucose and sucrose) and the nor-leucine were of 99.8%, >99.0% and ≥99.9% purity, respectively. All chemicals were of HPLC analytical grade and were obtained from Sigma–Aldrich (St. Louis, MO, USA) and from Merck (Darmstadt, Germany).

2.4. Determination of free asparagine

The content of free asparagine in the croquettes before final preparation was analysed according to Davies (2002). Asparagine