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Color development and acrylamide content of pre-dried potato chips

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Abstract

The objective of this work was to study the development of color formation in pre-dried potato slices during frying and acrylamide formation in the final potato chips. Color measurement was done by using an inexpensive computer vision technique which allowed quantifying representatively and precisely the color of complex surfaces such as those of potato chips in $L^*a^*b^*$ units from RGB images. Prior to frying, potato slices (Desirée variety, diameter: 37 mm, width: 2.2 mm) were blanched in hot water at 85 °C for 3.5 min. Unblanched slices were considered as the control. Slices of the same dimensions were blanched as in the previous step, and then air-dried until reaching a moisture content of 60% (wet basis). These samples were called pre-dried potato slices. Potato slices were fried at 120 °C, 140 °C, 160 °C and 180 °C until reaching moisture contents of ~1.8% (total basis) for color quantification. Acrylamide concentration was determined only in final chips fried at 120 °C, 150 °C and 180 °C and compared with that of two brands of commercial chips produced in Chile (Moms and Frito Lay). Color values in $L^*a^*b^*$ units were recorded at different sampling times during frying at the four mentioned temperatures using the total color difference parameter (ΔE). Pre-drying did not affect the color of potato chips considerably when compared against blanched chips; however when fried at 180 °C, pre-dried potato chips present 44%, 22%, 44% lower acrylamide content than that of the control, Moms and Frito Lay chips, respectively.

Keywords: Potato chips; Frying; Color; Pre-drying; Blanching; Acrylamide

1. Introduction

Potato chips have been a popular salty snack for 150 years whose consumption yearly in US is around 1.2 billion of pounds (Clark, 2003). Potato chips are thin potato slices that are dehydrated by deep fat frying to a moisture content of 0.02 kg/kg or less (Baumann & Escher, 1995). Potato chips have an oil content that ranges from 35% to 45% (wet basis) and gives the product a unique texture–flavor combination that makes them so desirable (Garayo & Moreira, 2002; Mellema, 2003). Dehydration in hot oil at temperatures between 160 °C and 180 °C is characterized by high drying rates that are critical for ensuring favorable structural and textural properties of the final product (Baumann & Escher, 1995).

Color development only begins when sufficient amount of drying has occurred in potato slices and depends also on the drying rate and the heat transfer coefficient during the different stages of frying. Color is visually considered one of the most important parameters in the definition of

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quality of fried potatoes (Scanlon, Roller, Mazza, & Pritchard, 1994) and is the result of the Maillard reaction that depends on the content of reducing sugars and amino acids or proteins at the surface, and the temperature and time of frying (Márquez & Añón, 1986).

Color of fried potatoes has been measured usually in units $L^*a^*b^*$ using either a colorimeter or specific data acquisition and image processing systems. $L^*a^*b^*$ is an international standard for color measurements, adopted by the Commission Internationale d'Eclairage (CIE) in 1976. L^* is the luminance or lightness component, which ranges from 0 to 100, and parameters a^* (from green to red) and b^* (from blue to yellow) are the two chromatic components, which range from −120 to 120 (Papadakis, Abdul-Malek, Kamdem, & Yam, 2000). In the $L^*a^*b^*$ space, the color perception is uniform which means that the Euclidean distance between two colors corresponds approximately to the color difference perceived by the human eye (Hunt, 1991).

Computer vision (CV) is a technology for acquiring and analyzing an image of a real scene by computers to obtain information or to control processes (Brosnan & Sun, 2004). Digital image processing is the core of CV with numerous algorithms and methods capable objectively of measuring and assessing the appearance quality of several agricultural products (Mery & Pedreschi, 2005). CV has been used in the food industry for quality evaluation, detection of defects, identification, grading and sorting of fruits and vegetables, meat and fish, bakery products and prepared goods, among others.

In the last years, some simple CV systems have been used to measure objectively the color of fried potatoes since they provide some obvious advantages over a conventional colorimeter, namely, the possibility analyzing the whole surface of the chip, and quantifying local characteristics such as brown spots and other defects. Color of potato chips has been measured using computerized video image processing by mean of gray level values (Scanlon et al., 1994). A computer-based video system was developed to quantify the color of potato chips in the $L^*a^*b^*$ color space (Segnini, Dejmek, & Öste, 1999). Marique, Kharoubi, Bauffe, and Ducatillon (2003) modeled the color classification of potato chips by image analysis and artificial neural networks obtaining correlation coefficients of 0.972 for training data and of 0.899 for validation data. A pattern recognition approach was used for classification of potato chips processed under six different conditions obtained good classification performance (Pedreschi, Mery, Mendoza, & Aguilera, 2004).

Reports of the presence of acrylamide in a range of fried and oven-cooked foods have caused worldwide concern because this compound has been classified as probably carcinogenic in humans (Rosen & Hellenäs, 2002; Tareke, Rydberg, Karlsson, Eriksson, & Tornqvist, 2002). In April 2002, Swedish researchers shocked the food safety world when they presented preliminary findings of acrylamide in some fried and baked foods, most notably potato chips and French fries, at levels of 30–2300 μm/kg (Pedreschi, Kaack, & Granby, 2004; Pedreschi, Kaack, & Granby, 2006). The data published so far indicate that a temperature >100 °C is required for acrylamide formation (Becalski, Lau, Lewis, & Seaman, 2003). Tareke et al. (2002) showed that acrylamide was formed by heating above 120 °C certain starch-based foods, such as potato chips, French fries, bread and processed cereals.

Acrylamide could be formed from food components during heat treatment as a result of the Maillard reaction between amino acids and reducing sugars (Mottram & Wedzicha, 2002; Stadler et al., 2002). Asparagine, a major amino acid in potatoes and cereals, is a crucial participant in the production of acrylamide by Maillard reaction at temperatures above 100 °C (Friedman, 2003). Since potato products are especially high in asparagine, it is now thought that this Maillard reaction is most likely responsible for the majority of the acrylamide found in potato chips and French fries. Both potato variety and field site had a noticeable influence upon acrylamide formation. In addition to food composition, other factors involved in acrylamide formation are the processing conditions (pretreatments, temperatures and times).

The blanching step previous to frying in potato chip production improves the color and texture, and could reduce in some cases the oil uptake by gelatinization of the surface starch (Califano & Calvelo, 1987). Drying of potatoes before frying using microwave, hot-air treatment and baking has resulted in a significant reduction in oil content of different products (Krokida, Oreopolou, Maroulis, & Marinos-Kouris, 2001; Moreira, Castell-Perez, & Barrufet, 1999; Moyano, Ríoseco, & Gonzaléz, 2002). Air dehydration leads to a lower moisture content which also reduces the oil absorption (Talburt, Weaver, Reeve, & Kueneman, 1987). The drying step that follows the blanching step reduces the amount of oil absorbed and improves the crispness of the potato chips (Pedreschi & Moyano, 2005a).

The objectives of this research were (i) to study color development in blanched and pre-dried potato chips at different oil temperatures using an inexpensive implemented CV system; (ii) to study the effect of blanching and pre-drying over the acrylamide content in potato chips fried at three oil temperatures.

2. Materials and methods

2.1. Materials

Potatoes (variety Desirée, ∼23% of dry solids; 0.3% reducing sugars) and vegetable oil (Chef, COPRONA, Chile) were the raw materials. Potatoes stored at 8 °C and 95% of relative humidity were washed and peeled before cutting. Slices of thickness of 2.2 mm were cut from the pith of the parenchymatous region of potato tubers using an electric slicing machine (Berkel, model EAS65). A circular cutting mold was used to make circular slices with a diameter of 37 mm.