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Thermal process contaminants: acrylamide, chloropropanols and furan

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Heat induces chemical changes that may lead to the formation of toxic compounds, so-called thermal process contaminants. Intensive scientific studies on these compounds have been conducted over the past decade. Researchers have gained increasing insight in understanding the presence, formation, and potential risk to public health posed by the compounds formed during heat processing of foods. From a food safety point of view, occurrence of thermal process contaminants in foods is still one of the major concerns for consumers, health authorities and industry. Therefore, there is a strong need to minimize their formation in different foods. This review highlights the latest developments regarding the formation and elimination of acrylamide, furan, chloropropanols and their esters in foods.

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Introduction

Thermal processing is an important treatment for food preservation, especially in the manufacture of shelf stable foods with specific nutritional properties. Also, it is indispensable for determining the sensory properties, in particular color, flavor and texture in fried, baked, and roasted products. Heat treatments induces chemical change and a plethora of new molecules are generated in foods, some of which have been claimed to be health-promoting antioxidants and antimutagens [1]. On the other hand, it may lead to the formation of heat-induced toxic compounds, so called thermal process contaminants, that exert adverse toxicological effects, create potential health risks to humans. Acrylamide, chloropropanols, and furan are well-known as thermal process contaminants in foods [2–4]. This review highlights the latest research findings on these thermal process contaminants.

Acrylamide

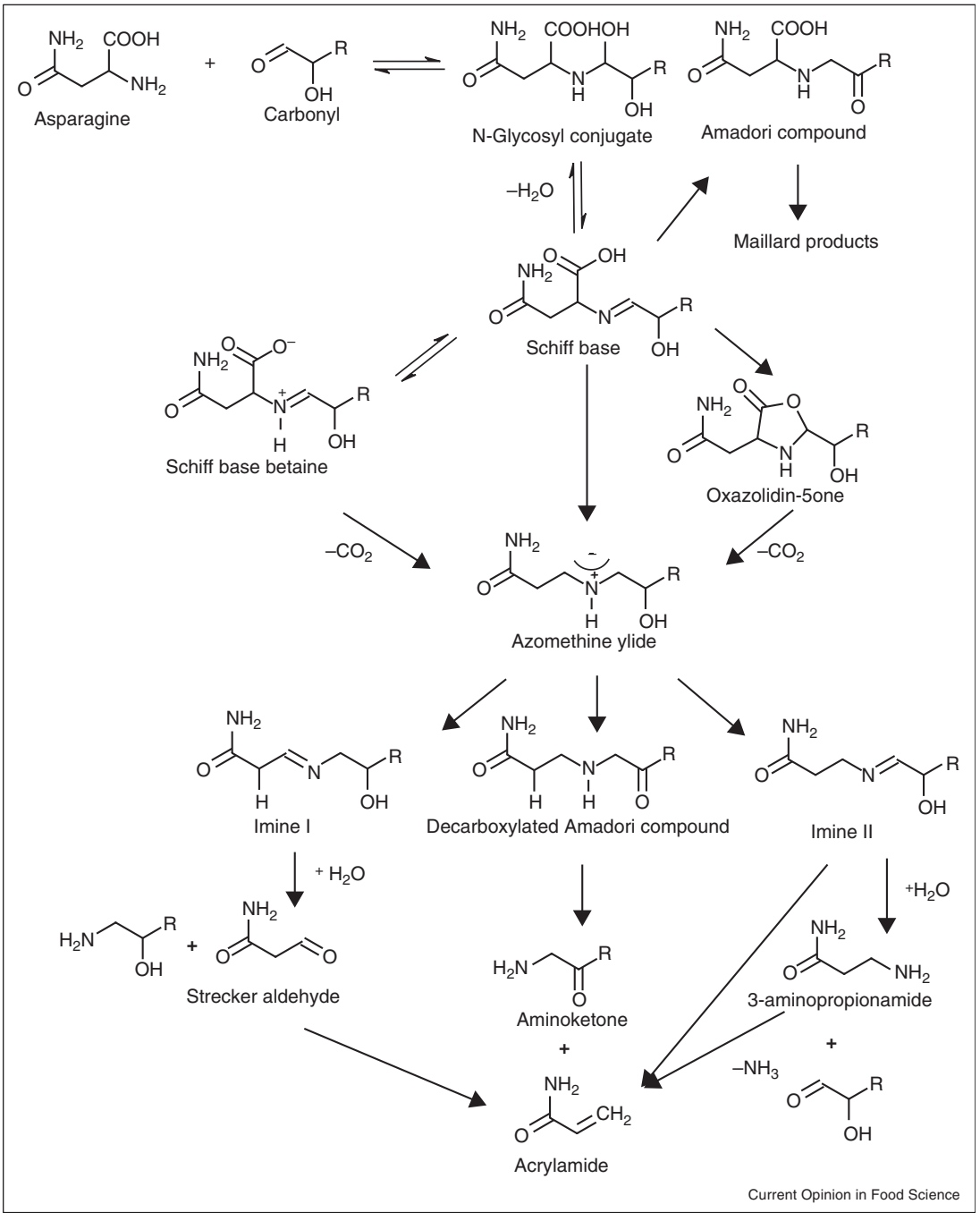
In April 2002, a report by the Swedish Authorities on the presence of acrylamide (2-propenamide) in a wide range of fried and oven cooked foods [2] attracted worldwide attention, due to the fact that acrylamide is classified as probably carcinogenic to humans (Group 2A) by the IARC [5]. Initial surveys have shown that relatively high concentrations of acrylamide are found potato chips, French fries, pan-fried potato products, crisp bread, and coffee [1]. The main pathway of acrylamide formation in foods is linked to the Maillard reaction and, in particular, the amino acid asparagine (Figure 1) [6].

Considering the contribution of coffee to daily acrylamide intake, acrylamide content of coffee should be limited. A recent study investigated the formation of acrylamide concentrations and the degradation of Robusta coffee bean polyphenols and its antioxidant activity during different roasting conditions [7]. Increasing the air velocity regardless of the temperature resulted in the intensification of acrylamide formation, while increasing the roasting air humidity lowers acrylamide formation, but only at high roasting temperature. Low velocity and humidity of roasting air at 203 °C provided relatively low levels of acrylamide with moderate degradation of polyphenols and antioxidant properties deterioration in coffee beans having pleasant and full flavor. Another study reported yeast fermentation as a promising technique to reduce acrylamide content of instant coffee [8]. Incubation the instant coffee with sucrose and *Saccharomyces cerevisiae* reduces acrylamide concentration by about 70%.

French fries and potato chips seem to have the highest levels of acrylamide, therefore, take special attention. Truong *et al.* [9] reported that sweet potato French fries, fried at 165 °C for 2, 3, and 5 min, contained acrylamide 124.9, 255.5, and 452.0 ng/g fresh weight, respectively. Blanching the sweet potato strips and using processing aids, additives, such as sodium acid pyrophosphate and $CaCl_2$, were found to be effective in reducing acrylamide formation up to 7 times in those French fries.

The effect of different pretreatments, including chemical reagents and air frying, on the formation of acrylamide in fried potatoes was investigated [10]. Air-frying reduced acrylamide content by about 90% compared with conventional deep-oil-frying. Deep-oil fried potatoes pretreated

Figure 1



Formation pathways of acrylamide [6].

with solutions of nicotinic acid, citric acid, glycine at 1%, and NaCl at 2% presented much lower acrylamide levels, up to 80–90% reduction, than non-pretreated samples. Another study showed that proline, sarcosine and glycine reduces acrylamide formation depending on their concentration up to 60%, 80%, and 52% in ripe olives, respectively [11]. Sarcosine at 100 mM was suggested as a good candidate for reducing the acrylamide content in ripe olives due to its limited effect on the sensory characteristics.

A combined conventional and vacuum process was proposed as a new baking technology to mitigate acrylamide formation in biscuits [12•]. The dough that was partially