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Role of plant polyphenols in acrylamide formation and elimination

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ABSTRACT

Acrylamide found in thermal-treated foods has led to an intensive and persistent research effort, since it is a neurotoxic, genotoxic and probable carcinogenic compound to humans. Plant polyphenols are the most abundant antioxidants in human diet. Several researches indicated that the polyphenols affected the acrylamide formation during heating. However, the controversial effects of the polyphenols on acrylamide formation were related to their structure, concentrations, and antioxidant capacity, as well as reaction condition. Polyphenols can inhibit acrylamide formation through trapping of carbonyl compounds and preventing against lipid oxidation, while some special polyphenols can enhance the acrylamide content by providing carbonyl groups, accelerating the conversion from 3-aminopropionamide (3-APA) to acrylamide and inhibiting acrylamide elimination. This review concludes the effects of polyphenols in the Maillard reaction and food systems conducted so far, aimed to give an overview on the role of plant polyphenols in acrylamide formation and elimination.

1. Introduction

Acrylamide can be formed in thermal-treated foods, especially in the carbohydrate-rich foods, such as French fries, potato chips and bakery products. Nowadays, acrylamide has arose a worldwide attention since acrylamide has been known as a neurotoxic, genotoxic and probable carcinogenic compound.

Soon after the discovery of acrylamide in food, the Maillard reaction between reducing sugar and asparagine was considered to be mainly responsible for acrylamide formation (Stadler et al., 2002). Some possible inhibition or mitigation strategies for acrylamide formation both in the model systems and actual food systems were explored, including decreasing the heating temperature and time, choosing raw materials with fewer precursors and adding the exogenous additives. In the exogenous additives, polyphenols are widely used in acrylamide migration.

Polyphenols are naturally occurring compounds found largely in the fruits, vegetables, herbs, spices, grains and beverages with different kinds of species. So far, more than 8000 phenolic structures have been found. Plant polyphenols are characterized by the presence of an aromatic ring bearing one or more hydroxyl substituent. Based on the structure, they could be divided into several groups, for example, flavonoids, phenolic acids, hydroxycinnamic acids as well as flavolans.

Some polyphenol-rich foods, such as green tea, coffee, red wine and chocolate, are consumed by a large population in many

Abbreviations: ANN, artificial neural network; AOB, antioxidant of bamboo; 3-APA, 3-aminopropionamide; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; EGT, extracts of green tea; ESI-MS, electrospray ionization-mass spectrometry; GCE, green coffee aqueous extract; GTE, green tea aqueous extract; LC/MS, liquid chromatography coupled with tandem mass spectrometry; MLR, multiple linear regression; NMR, nuclear magnetic resonance; TP, tea polyphenols; VOO, virgin olive oil.

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countries. Recently, some plant extracts containing a large amount of polyphenols, were classified into food additives in many countries, for example, rosemary extract and antioxidant of bamboo leaves. Compared with the synthetic antioxidants of butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT), plant polyphenols are safer and more acceptable by the consumers, which is the reason why plant polyphenols represent an important component of human's daily diets.

Recently, Vinci, Mestdagh, and Meulenaer (2012) summarized the effects of antioxidants used in fried potato products on acrylamide formation. Jin, Wu, and Zhang (2013) reviewed the relationship between antioxidants and acrylamide formation and proposed that reactive carbonyl groups were the major key sites on which antioxidants influenced the acrylamide formation mainly. Plant polyphenols are crucial parts of phytochemicals, whose effects on acrylamide formation and elimination and the mechanisms about the exact influences of polyphenols on acrylamide have not been reviewed specially yet. This paper focuses on the present understanding of the influence and mechanisms plant polyphenols involved on acrylamide formation and elimination in the model system or food during heating.

2. Chemical mechanisms for acrylamide formation

Recently, researchers have proposed some hypotheses to explain the mechanisms for acrylamide formation, of which Maillard reaction and acrolein pathway are two main pathways accepted (Fig. 1). In the Maillard reaction, the Schiff base, a condensate of reducing sugar and asparagine, facilitated the decarboxylation step and formed decarboxylated Schiff base via the formation of oxazolidin-5-one by intramolecular cyclization (Yaylayan, Wnorowski, & Locas, 2003). The decarboxylated products could decompose to acrylamide via direct elimination of an imine or after hydrolyzed to form 3-APA or 3-oxopropanamide. The 3-APA was a transient but main precursor for acrylamide formation during heating (Zyzak et al., 2003). Zamora, Delgado, and Hidalgo (2009) indicated that there were diverse competitive pathways by which 3-APA was converted into acrylamide, depending on the water activity and temperature. The excess sugar could also enhance the conversion from 3-APA to acrylamide. The 3-oxopropananmide is similar to 3-APA structurally with the only distinction in the group attached to C-3. Amino group in 3-APA is replaced by aldehyde group (Perez & Yaylayan, 2008). In this

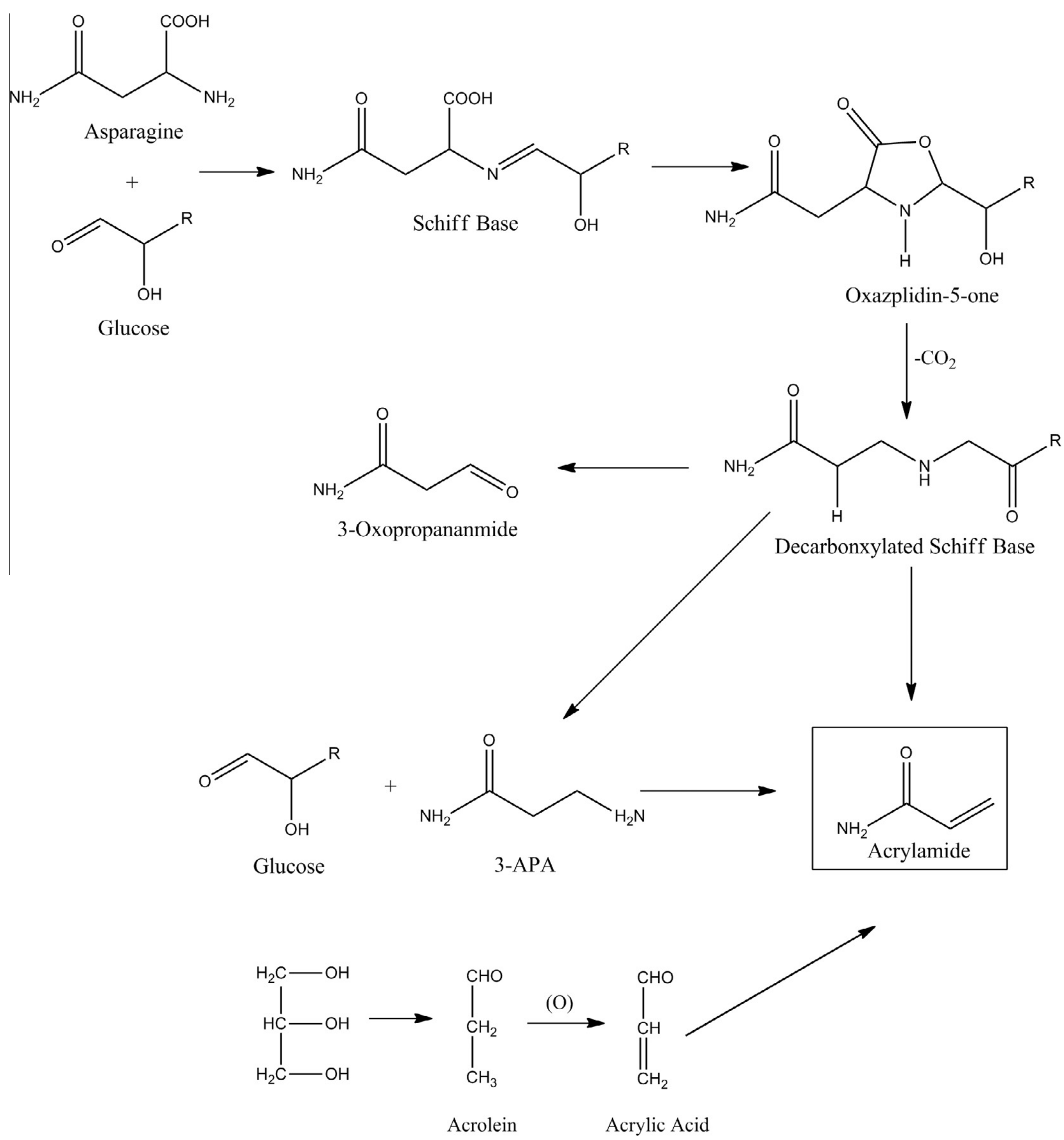

Fig. 1. Formation mechanisms of acrylamide via Maillard reaction and acrolein way.

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