Primary Maillard reaction, lycopene isomerization during tomato /pepper processing and bioactivities

Transformation de la tomate et du piment : production des produits initiaux de la réaction de Maillard, isomérisation du lycopène, impact sur leurs bioactivités

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Tomatoes and peppers are important economic crops and are widely comsumed in the world. Many studies have shown that the intake of tomatoes/peppers and their processed products can significantly improve health benefits and reduce the risk of various diseases. However, the key bioactive compounds have not yet been clearly determined. During processing or storage, it is easy to occur Maillard reaction because they are rich in reducing sugers and amino acids. Therefore, Amadori compounds (N-(1-deoxy-2-D-fructose)-L-amino acid) as primary Maillard reaction products could be their biologically active compounds. Lycopene from tomato has many stereo (spatial) isomers, and the transformation from the all-trans configuration to cis configurations during processing can increase its bioaccessibility. When tomatos, peppers and even onions are processed and intaken together, the effects of Amadori compound and transformation of lycopene spatial configuration on the health benefits of products may be more complicated. In view of the questions above, in this paper primary Maillard reaction, potential bioactivities of Amadori compounds, compounds from onions on the cis(Z)-isomerization of lycopene were systematically studied, and also to develop functional foods rich in various bioactive ingredients such as high Z-lycopene, Amadori compounds and flavonoids taking tomato, pepper and onion as raw materials. The main results are as follows: (1) Simultaneous detection of various Amadori compounds and study of the changes of Amadori compound during processing of fruits and vegetables: Capillary electrophoresis method based on dynamic ligand exchange and on-line sweeping was successfully applied to detect five Amadori compounds without UV-Visible absorption by UV detector (236 nm). This method avoids the complicated extraction protocols and derivatization procedures. Hydrophilic interaction chromatography-triple quadrupole tandem mass spectrometry method can be used for simultaneous quantitative analysis of eight Amadori compounds in various fruit and vegetable products with limit of detection 0.02-0.09 mg/L and recovery rate 84.78%-109.14%. Different tranditional cooking methods (steaming, frying and baking) had different effects on the content of Amadori compounds in fruits and vegetables such as tomatoes, and the change of Amadori compound content caused by steaming was the smallest in fruits and vegetables. For different baking methods, the effect of baking at high temperature with short time on the contents of Amadori compounds was minimal. (2) Effects of Amadori compounds on in vitro antioxidant and ACE inhibitory activities of pepper powders: Among eight Amadori compounds, Fru-Met, Fru-His, Fru-Phe and Fru-Arg in antioxidant tests such as FRAP, ORAC, ABTS and DPPH showed good antioxidant potential; Fru-Glu, Fru-His and Fru-Arg had ACE inhibitory potential. Total Amadori compounds were 5-10 times higher than total phenolic compounds in pepper powders. Multivariate-partial least squares regression (PLS) and correlation analysis of contents of Amadori compounds and polyphenol compounds and antioxidant activities of pepper powder (Fe3+ reducing abilities, ABTS, DPPH, Folin-Ciocalteu and β-carotene inhibition)

indicated that the Amadori compounds are a type of antioxidants more important than phenolic compounds in pepper powders, especially Fru-Phe and Fru-His. In addition, the increase of Amadori compound contents during drying red bell pepper caused an increase of anti-ACE activity. (3) Effects of food ingredients and heating conditions on lycopene isomerization and bioaccessibility: During preparation of tomato-onion-extra virgin olive oil sauces, the addition of onion can significantly promote Z-isomerization of lycopene, sulfur-containing compounds such as diallyl disulfide (DADS) in onions played this role, and blanching of onions can significantly reduce this promoting effect. The addition of onion or DADS was more favorable for the formation of 5-Z-lycopene relative to 9-Z and 13-Z isomers. When both onion and EVOO were added simultaneously, microwave heating promoted the Z-isomerization of lycopene and increased the partition factor of total lycopene (between tomato sauce and oil) more effectively than conventional heating. However, when only onion or EVOO was added, microwave heating can only increase the partition factor and not promote Z-isomerization of lycopene. Three-component D-mixture formulation design consist of tomato (75%), onion (20%) and EVOO (5%) showed that their interaction can significantly affect lycopene isomerization. Whereas, only the linear mixture had a significant influence on the partition factor and bioaccessibility of lycopene isomers. Bioaccessibilities of lycopene isomers in every tomato-based sauce formulation decreased in the order: 13-Z-lycopene> 9-Z-lycopene> 5-Z-lycopene> all-E-lycopene. Correlation analysis showed that the positive effect of components, especially onion on total-lycopene diffusion and bioaccessibility may be because the components increased the Z-isomerization of lycopene during heating tomato-based purees. (4) Preparation of tomato-based sauces with ‘three high’ biologically active compounds (high Z-lycopene, Amadori compounds and flavonoid) and studying the bioaccessibility of these compounds: After addition of self-made sweet (bell) pepper powder, especially 8% into the puree consisted with tomato puree-onion puree-EVOO (75: 25: 5), the content of Amadori compounds and flavonoids in the prepared tomato sauces was 8-10 folds and 2-3 times higher than that of commercially available tomato-based sauces, respectively; the ratio of Z-lycopene was much higher than that of tomato puree but lower than commercially available tomato-based sauces (containing onions). The addition of bell pepper powder could increase the bioaccessibility of lycopene isomers, especially the bioaccessibility from small intestine phase (D-bioaccessibility). Amadori compounds contributed this effect. Fru-Arg, Fru-Phe and Fru-His in tomato-based sauces had high bioaccessibility (over 45%), and the D-bioaccessibility of Amadori compounds was greater than their J-bioaccessibility (from jejunal phase). The bioaccessibility of four quercetin-derived flavonoids in the sauces was above 30%, and their D-bioaccessibility was lower than the J-bioaccessibility. The capsaicinoids in the prepared ‘hot’ tomato-based sauces were about 10 times higher than those of commercially available tomato-based sauces, and the bioaccessibility of capsaicinoids was 6%-18%, and their D-bioaccessibility was lower than the J-bioaccessibility. In summary, this paper deepens people’s understanding about bioactive compounds in fruits and vegetables, and is helpful for fruit and vegetable processing. The finding of naturally existed catalyst for lycopene isomerization in onion is very meaningful for green preparation of high Z-lycopene. This study also provides a dietary guide for cooking of tomato, onion even garlic in daily life. Using various fruits and vegetables such as tomato, pepper and onion as raw materials to develop the natural tomato-based products provides a new perspective for functional foods, and also is meanful for the comprehensive processing of fruits and vegetables.

Mots-clés : Amadori compounds, Z-lycopene, antioxidant activity, angiotensin converting enzyme ; bioaccessibility

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