Food Research International 89 (2016) 63–73

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Review

Bioactive peptides derived from traditional Chinese medicine and traditional Chinese food: A review

Ming Liu [a,b], Yunpu Wang [a,b], Yuhuan Liu [a,b,*], Roger Ruan [c]

[a] State Key Laboratory of Food Science and Technology, Nanchang University, Nanchang 330047, China
[b] Engineering Research Center for Biomass Conversion, Ministry of Education, Nanchang University, Nanchang 330047, China
[c] Center for Biorefining and Dept. of Bioproducts and Biosystems Engineering, University of Minnesota, Paul 55108, USA

ARTICLE INFO

Article history:
Received 3 April 2016
Received in revised form 6 August 2016
Accepted 13 August 2016
Available online 15 August 2016

Keywords:
Bioactive peptides
Traditional Chinese medicine
Traditional Chinese food
Mechanisms of digestion

ABSTRACT

There is an urgent treat of numerous chronic diseases including heart disease, stroke, cancer, chronic respiratory diseases and diabetes, which have a significant influence on the health of people worldwide. In addition to numerous preventive and therapeutic drug treatments, important advances have been achieved in the identification of bioactive peptides that may contribute to long-term health. Although bioactive peptides with various biological activities received unprecedented attention, as a new source of bioactive peptides, the significant role of bioactive peptides from traditional Chinese medicine and traditional Chinese food has not fully appreciated compared to other bioactive components. Hence, identification and bioactivity assessment of these peptides could benefit the pharmaceutical and food industry. Furthermore, the functional properties of bioactive peptides help to demystify drug properties and health benefits of traditional Chinese medicine and traditional Chinese food. This paper reviews the generation and biofunctional properties of various bioactive peptides derived from traditional Chinese medicine and traditional Chinese food. Mechanisms of digestion, bioavailability of bioactive peptides and interactions between traditional Chinese medicine and traditional Chinese food are also summarized in this review.

Contents

Abbreviations: TCM, traditional Chinese medicine; TCF, traditional Chinese food; CS, *Cordyceps sinensis*; AF, *Anoectochilus formosanus*; ACE, Angiotensin-I converting enzyme.

* Corresponding author at: 235 Nanjing Dong Road, Nanchang 330047, China.
E-mail address: liuyuhuan@ncu.edu.cn (Y. Liu).

http://dx.doi.org/10.1016/j.foodres.2016.08.009
0963-9969/

1. Introduction

Recently, the relationship between diet and health has drawn ever-growing interests and a variety of bioactive peptides with different functions were reported. Bioactive peptides can be defined as specific portions of proteins that have desirable biological activities (de Castro & Sato, 2015). They are sequences of between 2 and 30 amino acids in length imparting a positive health effect to the consumer when ingested (Lafarga & Hayes, 2014). In order to explore new resources to generate bioactive peptides, new research hotspot has been focused on the traditional Chinese medicine (TCM) and traditional Chinese food (TCF).

TCM is a broad range of medical practice which shows special efficacy toward chronic diseases. However, as an important factor contributing to comprehensive curative effect, the significant role of bioactive peptides has not fully appreciated. Even the protein-rich TCM including *Cordyceps sinensis* (CS) and donkey-hide gelatin ignores some benefits of the bioactive peptides and overrate the beneficial role of other small molecular substances. Compared with other bioactive substances, bioactive peptides exert great influence in metabolic regulation even in a small dosage. Various kinds of bioactive peptides have been identified from TCM which possess the similar functions related to their traditional known efficacy, so the real efficacy in some TCM, especially protein-rich TCM, may be derived from their bioactive peptides. At the same time, TCF especially Chinese fermented food including fermented soybean products, fermented hams, fermented milk and fermented sauce have been researched for their bioactive peptides. The past decade has seen a burgeoning of literature on food-derived peptides and protein hydrolysates with diverse biological activities and both of them are valuable resources of bioactive peptides (Li-Chan, 2015).

Bioactive peptides enjoy its great popularity in the food and pharmaceutical industries. >3200 bioactive peptides have been identified in the database Biopep (http://www.uwm.edu.pl/biochemia/index.php/pl/biopep) (Minkiewicz, Dziuba, Iwaniak, Dziuba, & Darewicz, 2008) and there are many databases including EROP-Moscow (http://erop.inbi.ras.ru/), PeptideDB (http://www.peptides.be/) and PepBank (http://pepbank.mgh.harvard.edu/) concerning biologically active peptides (Nongonierma & FitzGerald, 2016), which help to synthesis different bioactive peptides of diverse functional properties according to their amino acid sequence. However, bioactivities of these peptides are latent until they released from their parental protein through fermentation and enzymatic hydrolysis (Singh, Vij, & Hati, 2014). In addition, some bioactive peptides with >4 amino acids are easy to further hydrolysis into amino acids therefore have no specific biological activity. Thus, to fully exert the efficacy of bioactive peptides in TCM and TCF, special attention should be taken into account on protecting the bioactive peptides from further digestion and other physiology barriers.

This paper focuses on the bioactive peptides isolated from TCM and TCF, with special emphasis on generation of them and mechanism of their digestion. Finally, their interactions and research trends are discussed.

2. Generation of bioactive peptides from TCM and TCF

2.1. Protein sources of bioactive peptides

The potential of bioactive peptides from TCM, has gained increased research interest worldwide. Bioactive peptides with various biological properties have been successfully isolated from animal materials such as donkey-hide gelatin, skin of Chinese frog and even venom (Chen & Lariviere, 2010; Cheng et al., 2012; Jin et al., 2009), herbal medicines derived from species such as *Aster tataricus*, alfalfa leaf and *Anoectochilus formosanus* (Kuan, Lee, Hung, Yang, & Sheu, 2012; Xie, Huang, Xu, & Jin, 2008; Yu et al., 2015), and from fungal materials including *CS* and *Ganoderma* (Huang, Siu, Wang, Cheung, & Wu, 2013; Tran et al., 2014). Raw and fresh TCM materials, rather than dried, processed or powered materials, are often used to obtain bioactive peptides to prevent protein denaturation and degradation from processing (Fu et al., 2013). Researchers have mainly focused on nucleosides, *exo*-polysaccharides, and sterols, despite that CS is also a potential source of bioactive peptides (Shashidhar, Giridhar, Udaya Sankar, & Manohar, 2013). Moreover, some bioactive peptides from frogs and venoms show strong anti-microbial and anti-inflammatory properties, confirming that peptides and their parent proteins may exhibit relevant intrinsic properties (Evaristo et al., 2015; Qinghua et al., 2006).

TCF, especially traditional fermented food, have played an important role as nutritious foods in the diet of the people from olden times. Fermentation is an effective method used to produce bioactive peptides. Fermented TCF, including fermented soybean, meat, and milk products, exerts health benefits because of their bioactive peptides (Iwaniak, Minkiewicz, Darewicz, Protasiewicz, & Mogut, 2015; Saadi, Saari, Anwar, Abdul Hamid, & Ghazali, 2015). Fermented soybean products, including traditional and oriental products, such as natto, tempeh, miso, sufu, and douchi, exhibit significantly higher anti-oxidative activities than non-fermented soybean substrates (Xu, Du, & Xu, 2015). Some have suggested that the presence of a short chain peptides are responsible for the enhanced antioxidant activity of these fermented soybean products (Ren, Liu, Endo, Takagi, & Hayashi, 2006). TCF also contains many food-derived fibrinolytic enzymes (Mine, Kwan Wong, & Jiang, 2005). Fermented meat products and wine are also sources of bioactive peptides (Dang, Gao, Ma, & Wu, 2015; Fernández-Mar, Mateos, García-Parrilla, Puertas, & Cantos-Villar, 2012).

2.2. Methods for generating bioactive peptides

2.2.1. Enzymatic hydrolysis

Bioactive peptides are mainly produced through enzymatic hydrolysis. Proteases catalyze the hydrolysis of peptide bonds in proteins and may act on ester and amide bonds (Fig. 1). Under acidic pH conditions, proteins digestion is initiated in the stomach by pepsin. Then, the digesta are further hydrolyzed by pancreatic enzymes such as pepsin, trypsin and chymotrypsin and membrane peptidases resulting in peptides of various lengths. All proteases have a certain degree of specificity for the substrate, generally based on the sequence of amino acids directly surrounding the bond that is cleaved (de Castro & Sato, 2015). The MEROPS database (http://merops.sanger.ac.uk/) contains vast information regarding peptidases. The degree of hydrolysis and other hydrolysis conditions, including pH, temperature, time, flow rate, and combination of several proteases, considerably influence the molecular weight distribution and fractions of peptides; these factors ultimately affect the biological activities of the peptides (Sarmadi & Ismail, 2010; Su, Ren, Yang, Cui, & Zhao, 2011; You, Zhao, Cui, Zhao, & Yang, 2009). The bioactivity levels of peptides are mainly determined based on their compositions and amino acid sequences; hence, the bioactivity mainly depends on protein source and structure, rather than hydrolysis procedures. For example, soy milk, soybean, natto, and soy sauce, which contain β-conglycinin, are abundant sources of antioxidant peptides (Gibbs, Zougman, Masse, & Mulligan, 2004; Singh et al., 2014). The relationship between the protein structure and biological activities of peptides remains unclear because of lack of sufficient data on how peptides work in vivo; therefore, such relationship must be further investigated.