ELSEVIER

Trends in Food Science & Technology 44 (2015) 93–104

TRENDS IN FOOD SCIENCE & TECHNOLOGY

Review

Prenylated flavonoids, promising nutraceuticals with impressive biological activities

Xiaoman Yang[a,b], Yueming Jiang[a], Jiali Yang[a,b], Jirui He[a,b], Jian Sun[c], Feng Chen[d], Mingwei Zhang[e] and Bao Yang[a,*]

[a]Key Laboratory of Plant Resources Conservation and Sustainable Utilization, Guangdong Provincial Key Laboratory of Applied Botany, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510650, China (Tel.: +86 20 37083042; fax: +86 20 37252960; e-mail: yangbao@scbg.ac.cn)

[b]University of Chinese Academy of Sciences, Beijing 100039, China

[c]Institute of Agro-food Science & Technology, Guangxi Academy of Agricultural Sciences, Nanning 530007, China

[d]Department of Food Science and Human Nutrition, Clemson University, Clemson, SC 29634, USA

[e]Sericultural & Agri-Food Research Institute, Guangdong Academy of Agricultural Sciences/Key Laboratory of Functional Foods, Ministry of Agriculture/Guangdong Key Laboratory of Agricultural Products Processing, Guangzhou 510610, China

Prenylated flavonoids have attracted much attention as a novel type of nutraceuticals in late years. The main structural characteristics and biological activities of prenylated flavonoids are reviewed in this paper. Usually prenylated flavonoids have a low abundance in nature and are complicated to be chemically synthesized, which limits the applications in dietary supplements and medicines. Biotransformation is a promising alternative to solve this problem due to the advantages of high specificity, easy manipulation and good productivity. The key to this technique is to find an effective flavonoid prenyltransferase. Detailed information regarding biotransformation and flavonoid prenyltransferase is reviewed in this paper.

Introduction

Prenylated flavonoids are a sub-class of flavonoids, which combine a flavonoid skeleton with a lipophilic prenyl side-chain. Flavonoids are quite abundant in nature, while prenylated flavonoids are much less common. To date, prenylated flavonoids have been identified in 37 of plant genera. Prenylation usually renders flavonoids with improved bioactivities. The mechanism of action is prenylation increases the lipophilicity of flavonoids, which results in a higher affinity to biological membranes and a better interaction with target proteins (Xu *et al*., 2012). Depending on the length of prenyl side-chain and flavonoid skeletons, prenylated flavonoids have diverse structures. Flavonoids, including chalcones, flavones, flavanones and flavonols, have been found to be prenylated in plant secondary metabolites.

In planta prenylated flavonoids are considered as phytoalexins (Botta, Vitali, Menendez, Misiti, & Monache, 2005), which play a key role in physiological processes when defending against pathogenic microorganisms. As a class of bioactive compounds, prenylated flavonoids possess a wide variety of bioactivities, such as estrogenic activity, antioxidant activity, immunomodulatory activity and anticancer activity (Bruno Botta, Vitali *et al*., 2005; Cerqueira *et al*., 2003). However, the natural abundance of prenylated flavonoids is pretty low, which limits the application of these bioactive compounds in pharmaceuticals. *In vitro* synthesis is a good way to solve this problem, and chemical synthesis is the first thought coming to a researcher's mind. However, in most cases chemical synthesis is quite complicated, has low efficiency and is time-consuming for synthesis of specific prenylated flavonoids. Harsh synthesis conditions and occurrence of many byproducts make chemical synthesis difficult to be applied in large scale production. The development of cost-effective biotransformation techniques in recent years, which use flavonoids prenyltransferase as a catalysis agent, makes

* Corresponding author.

http://dx.doi.org/10.1016/j.tifs.2015.03.007

specific synthesis of prenylated flavonoids possible. The key is to find an efficient and stable flavonoid prenyltransferase. In this article, recent information regarding structural characteristics, *in vitro* bioactivities and synthesis of prenylated flavonoids is reviewed.

Structural characteristics of prenylated flavonoids

Prenylation has been detected on most of flavonoids, including chalcones, flavanones, flavones, flavonols and isoflavones (Barron & Ibrahim, 1996). Approximately 1000 prenylated flavonoids have been identified from plants. According to the number of prenylated flavonoids reported before, prenylated flavonones is the most common subclass and prenylated flavanols is the rarest sub-class. In general, *C*-prenylation on flavonoids is much more popular than *O*-prenylation (Barron & Ibrahim, 1996), which is usually synthesized by substitution of hydroxyl group on flavonoid skeleton (Fig. 1). The first reported *O*-prenylated flavonoids were 4′,5-dihydroxy-7-isopentenyloxyflavanone and 5-hydroxy-7-isopentenyloxyflavanone from *Helichrysum athrixiifolium* (Bohlmann & Gören, 1984). *C*-prenylation occurs frequently on ring A at C-6/C-8 and ring B at C-3′ and C-5′, which is usually *ortho* to a phenolic hydroxyl. *C*-prenylation at ring C is relatively rare in natural prenylated flavonoids. Fig. 2 shows the prenylation patterns at flavonoids skeleton. Among numerous prenylation groups, 3,3-dimethylallyl group is the most common pattern presented. Geranyl and farnesyl flavonoids are also well known in natural prenylated flavonoids. Further oxidation, cyclization,

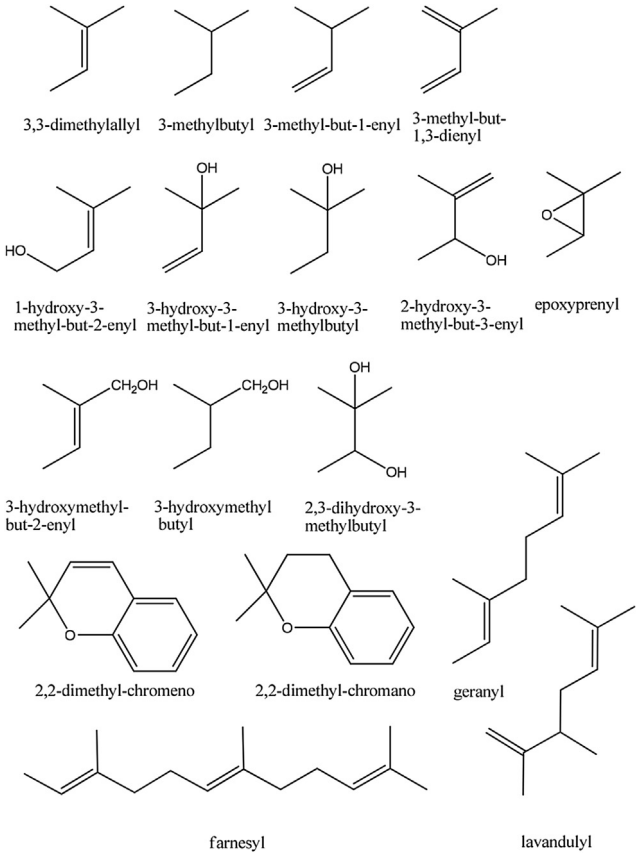

Fig. 2. Prenylation patterns occurred on flavonoids.

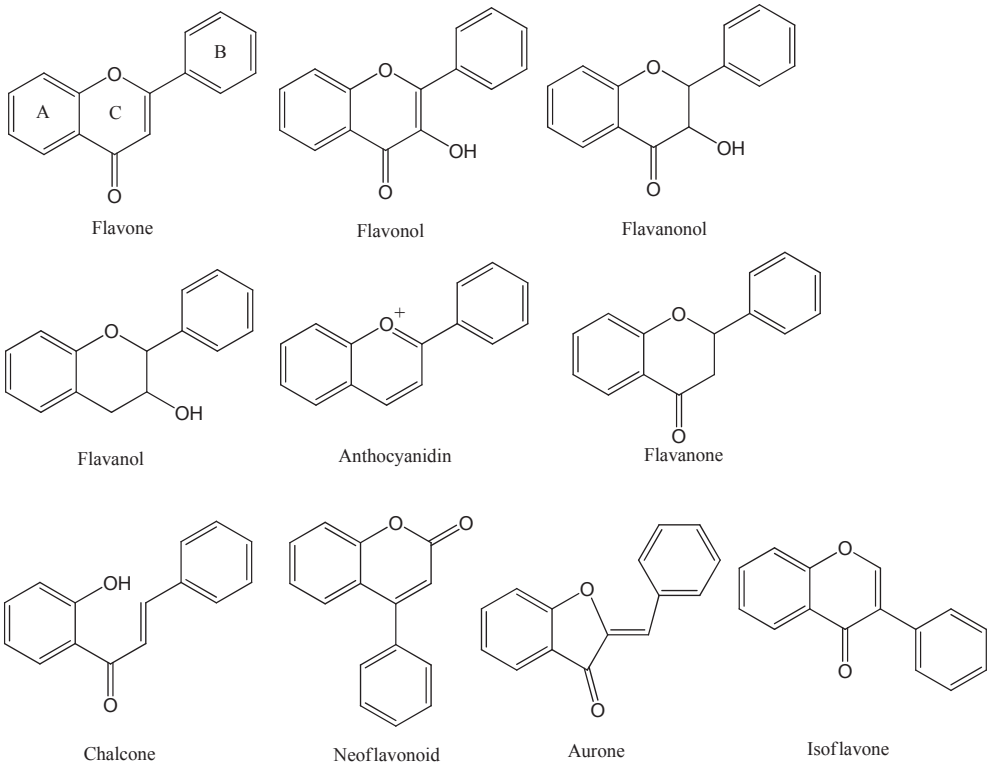

Fig. 1. Flavonoid skeletons.