Journal of Pharmaceutical and Biomedical Analysis 87 (2014) 229–240

Contents lists available at ScienceDirect

Journal of Pharmaceutical and Biomedical Analysis

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

Review

Bioactive components of velvet antlers and their pharmacological properties

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ARTICLE INFO

Article history:
Received 30 April 2013
Received in revised form 29 July 2013
Accepted 31 July 2013
Available online 27 August 2013

Keywords:
Velvet antlers
Extraction and isolation
Analytical techniques
Bioactive components
Pharmacological effects

ABSTRACT

Velvet antler is one of the most important animal medicines, and has been used with a variety of functions, such as anti-fatigue, tissue repair and health promotion. In the past few years, the investigation on chemical compositions, bioactive components, and pharmacological effects has been performed, which demonstrates that velvet antlers could be used as an important health-promoting tonic with great nutritional and medicinal values. This review focuses on the recent advance in studying the bioactive components of velvet antlers.

Contents

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http://dx.doi.org/10.1016/j.jpba.2013.07.044

1. Introduction

In recent years, there has been an increasing awareness of the benefits of natural products, and many plant-derived medicines have been reported. For examples *Rehmannia glutinosa* is one of the earliest known edible crude herbs used for various Chinese patent medicines, such as liuwei dihuang decoction, and its active principles possess wide pharmacological actions on the blood system, immune system, endocrine system, cardiovascular system and the nervous system [1]; *Panax ginseng* is one of the most valuable herb medicines and has been used in Asia as a tonic to improve stamina and vitality [2]; the lateral roots of *Aconitum carmichaelii* is the main ingredient of the Sini decoction, a well-known formula to treat myocardial infarction [3]. However, the researches on animal medicines or functional foods are still relatively few, although animal medicines have been proven of various important components, such as proteins, peptides, fatty acids, glycosaminoglycans, prostaglandins, vitamins, minerals, dietary fiber, essential oils and carotenoids [4,5], which can be used in the prevention and treatment of various diseases.

As a typical traditional animal medicine, velvet antlers (Fig. 1) have been used for over 2000 years, and have pharmacological effects to improve immune system, physical strength, and sexual function [6,7]. Now, velvet antlers from sika deer and red deer are designated as medicinal antlers in the pharmacopeias of countries, such as China, Japan and Korea. Besides, they are also used as supplement to prevent diseases.

Generally, deer antler is used by oral administration in the formulations of decoction or medicinal liquor. The most important source of velvet antlers is antler removal from farmed deer, which has been permitted in several countries, such as China, New Zealand, Australia and Canada [8–10]. It is currently estimated that the global production of velvet antlers is near to 1300 tons/year, which is still rapidly growing to meet the requirements of medicinal markets [6].

Velvet antlers are the unique organs that display an annual cycle of full regeneration in mammals [11]. In addition, antler growth is a very rapid process, with the maximum rate of elongation recorded for wapiti (*Elaphurus davidianus*) antlers being 2.75 cm per day [12]. During this period, the constitutive tissues, such as cartilage, bone, nerves, skin, and blood vessels also grow at the same rate [13]. Therefore, antlers are considered as valuable models for studying the signaling pathways. Recent evidence suggests that antler regeneration is a stem cell-based process, and some growth factors, such as VEGF, EGF, FGF and NGF, have been proven involved in the exceptional growth [14–17], in which some undiscovered modulating factors with low abundance or short-half-life in the development of normal tissues may be over-expressed and more likely be found. Thus, the investigation on bioactive components in velvet antlers might lead to the discovery of new active factors.

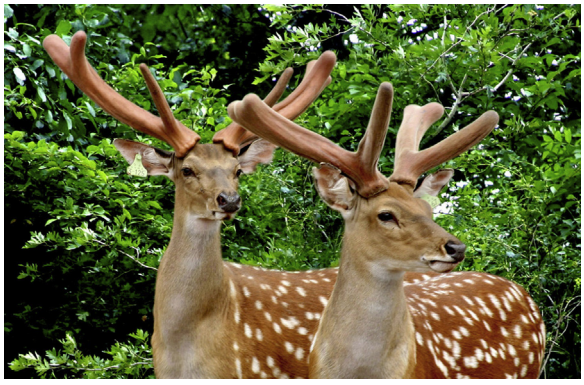

Fig. 1. Velvet antlers of farmed sika deer.

Up to now, many investigations have been undertaken to determine the chemical constituents as well as the pharmacological effects of velvet antlers. Herein, this review attempts to summarize the recent advance in studying the bioactive components of velvet antlers, which might be beneficial to encourage the in-depth study on their pharmacological effects, and provide further insight into the mechanisms associated with therapeutic effects.

2. Bioactive components

Through the in-depth study on white-tailed deer (*Odocoileus leucurus*), red deer (*Cervus elaphus*), elk (*E. davidianus*) and sika deer (*Cervus nippon*) have been studied, mineral elements [18,19] amino acids [20–24], polypeptides [31,32], proteins [17,20,23,27,28], polysaccharides [33–35], fatty acids [36], phospholipids [37] and biological base [40,56] have been proven as the bioactive components (shown in Table 1), and their contents change obviously with the growth of velvet antlers [20,26].

2.1. Amino acids, polypeptides and proteins

Velvet antlers are rich in amino acids, polypeptides and proteins, which are considered as the most prominent bioactive components.

Up to now, 19 kinds of amino acids have been isolated and identified from antlers. Jeon et al. [20] processed velvet antlers (*C. nippon*) by hydrolysis with 6 M HCl, and by using an amino-acid analyzer, they found 16 amino acids. Among them, aspartic acid, glutamic acid, proline, glycine and arginine accounted for approximately 32.5–37.2% of the total amino acids. Similarly, Wang et al. [21,22] not only extracted free amino acids, but also processed hydrolytic amino acids from velvet antlers (*C. nippon*). They found 17 free amino acids, and seven of them accounted for almost 30% of the total mass. In the case of hydrolytic products, 16 amino acids were detected and the proportions of them are similar with that of free amino acids. Li et al. [23] compared the amino acid content in different sections from sika deer (*C. nippon*), and found that the total mass percentage of 16 kinds of amino acids in velvet antlers was more than 44%.

In addition, Sunwoo et al. [24] reported that the amino acid content decreased downward from the tip to the base section of velvet antlers of wapiti (*E. davidianus*) in accordance with the theory of traditional Chinese medicine that the tip section is considered as the most valuable part of velvet antler. Therefore, the composition and content of amino acid may be one of the factors indicating the quality of velvet antlers.

Besides amino acids, Jeon et al. [20] also analyzed the crude proteins of velvet antlers of sika deer (*C. nippon*), stags on 40 days (FDG) and 60 days (SDG) after antler regeneration. They found that the crude protein was the highest in the top section, decreased markedly in other sections further down the antler. Besides, FDG had a higher content of crude protein than SDG. In the report of Je [27], antlers were harvested from elk (*E. davidianus*) stags on 65 days (VA65), 80 days (VA80) and 95 days (VA95) after regeneration, and the chemical composition of each antler was determined in five sections (top, upper, middle, base, and bottom). The crude protein content was the highest in the top section, and decreased markedly in the other sections further down the antler. In another study [28], velvet antlers of sika deer (*C. nippon*) were harvested on 40, 50 and 60 days after casting, and the analysis of crude proteins showed similar results.

Recently, many studies on the velvet antlers were performed in terms of molecular biology. These studies reveal that various growth factors and proto-oncogenes are expressed in the growing tip of antler. Lai et al. [16] detected the distribution of the growth factors, FGF-2 and VEGF, and their receptors FGFR1, FGFR2