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Review article

From the hive: Honey, a novel weapon against cancer

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ABSTRACT

Nowadays there is a folk medicine branch called apitherapy that aims to treat diseases with bee products, including honey. Honey has long been known for its medicinal and health promoting properties. It encloses numerous types of phytochemicals with high phenolic and flavonoid content, which contribute to its antioxidant and anti-inflammatory activities. Varieties and variants of polyphenols in honey showed antiproliferative property against several types of cancer. This review focuses on the latest discoveries about the key role of honey in different stages of carcinogenesis, initiation, proliferation and progression, both *in vitro* and *in vivo*, as well as on its adjuvant effect in cancer therapy. Although a possible application of honey and its active compounds as drugs against cancer is still far away from clinical practice, scientific results highlight that they could be used as immune booster for patients undergoing chemotherapy. They showed protective effects against the common exasperating and disabling side effects, mostly mucositis.

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1. Introduction

Apis mellifera leads to a variety of precious natural products into the beehive, which include pollen, propolis, royal jelly and honey. Pollen is a common ingredient of honey and propolis and it is known to be a good source of energy. Instead, propolis is a resinous substance used to seal the holes in the beehive. It has also medicinal properties, being helpful to maintain and soothe the oral cavity. Royal jelly supports the immune system and gives energy; the major components of its lipid fraction have been found to activate Transient Receptor Potential Ankyrin-1 (TRPA1). Finally, honey has been used as sweetener for centuries and as a medicinal product as well, so that nowadays it is classified as functional food [1-5].

The composition of honey is difficult to define since it is a mixture of different active compounds and it depends on several factors [6]. Therefore, different types of honey are classified depending on the floral source and/or the geographical regions from which they derive. They contain almost the same phenolic profile, including *p*-coumaric acid, eugenol, ferulic acid, caffeic acid, and flavonoids, like pinobanksin, pinocembrin, chrysin, quercetin, apigenin, naringin, in different percentage (Fig. 1, Table 1) [7]. It is noteworthy that phenolic compounds could represent potential markers for the botanical origin of honey [8-11].

Honey exhibits antibacterial and antioxidant activities, which

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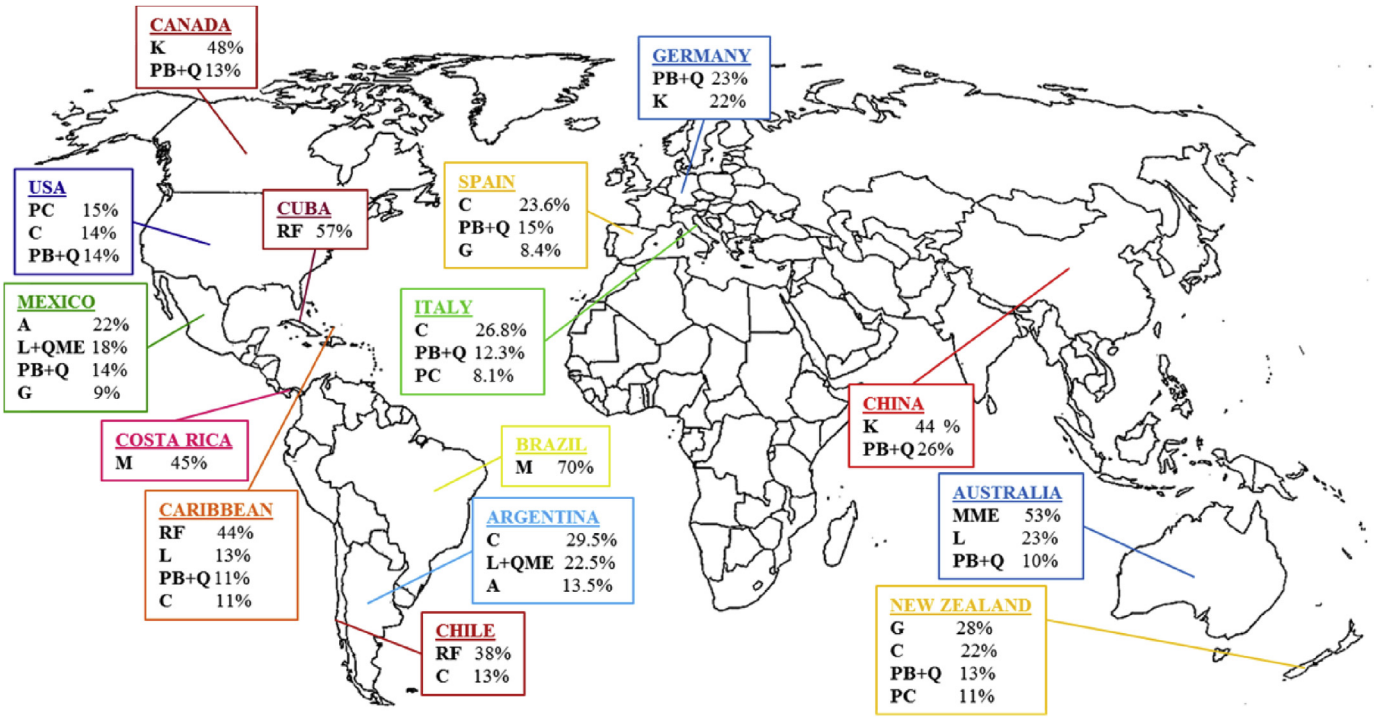
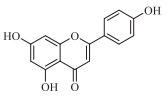
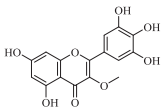
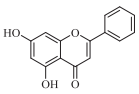
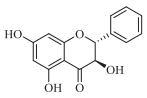
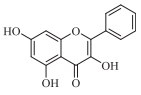
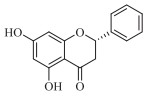
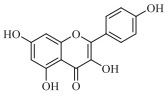
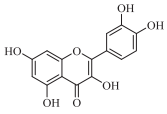
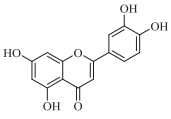
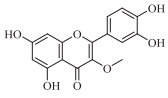
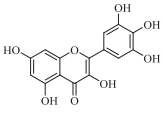
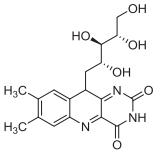


Fig. 1. Around the world: differences in honey composition.

Table 1
Main phenolic compounds present in honey.

Cmpnd	Name	Structure	Country	Cmpnd	Name	Structure	Country
A	Apigenin		Argentina, Mexico	**MME**	Myricetin 3-methyl ether		Australia
C	Chrysin		Argentina, Chile, Caribbean, Italy, New Zealand, Spain, USA	**PB**	Pinobanksin		Australia, Canada, Caribbean, China, Germany, Italy, Mexico, New Zealand, Spain, USA
G	Galangin		Spain, Mexico, New Zealand	**PC**	Pinocembrin		Italy, New Zealand, USA
K	Kaempferol		China, Canada, Germany	**Q**	Quercetin		Australia, Canada, Caribbean, China, Germany, Italy, Mexico, New Zealand, Spain, USA
L	Luteolin		Argentina, Australia, Caribbean, Mexico	**QME**	Quercetin 3-methyl ether		Argentina, Mexico
M	Myricetin		Brazil, Costa Rica	**RB**	Riboflavine		Caribbean, Chile, Cuba

depend on its different composition [12-16]. The major antibacterial properties are assigned to the level of produced hydrogen peroxide, increasing the relative activity of 2 enzymes, glucose oxidase and catalase [17]; although, recent studies have shown that manuka honey (MH) exhibits a non-peroxide antibacterial activity, exclusively attributable to methylglyoxal [18-20]. Using electron