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Millet grain phenolics and their role in disease risk reduction and health promotion: A review

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ARTICLE INFO

Article history:
Received 23 November 2012
Received in revised form
1 February 2013
Accepted 6 February 2013
Available online 7 March 2013

Keywords:
Bioactivities
Flavonoids
Finger millet
Foxtail
Kodo
Little millet
Phenolic acids
Proso

ABSTRACT

Millets rank six in the world cereal grain production. In Africa and Asia, these underutilized grains play a major role in the food security of millions of people. In addition to being a rich source of nutrients, millet grains have an abundance of phytochemicals, particularly phenolic compounds. This review will focus on the bioactivities and health benefits of millet phenolics as revealed by *in vitro* and *in vivo* studies. Phenolic compounds in millets are found in the soluble as well as insoluble-bound forms. Both hydroxybenzoic and hydroxycinnamic acids and their derivatives are notably present in different types of millet grains in varying proportion. Meanwhile, flavonoids exist mainly in the free form. A wide variation exists in the phenolic content and antioxidant capacity of millet grains. Further, millet grain phenolics, are bioaccessible, possess bioactivities against several pathophysiological conditions and may serve as potential natural sources of antioxidants in food and biological systems. While this review also shows the existence of a substantial body of evidence for *in vitro* antioxidant activity of millet grain phenolics, there is a clear gap for *in vivo* information. However, the use of millets, as nutraceuticals and specialty foods in disease risk reduction and overall health and wellness is warranted.

Contents

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1756-4646/$ - see front matter
http://dx.doi.org/10.1016/j.jff.2013.02.004

1. Introduction

Cereals are staple foods for a large proportion of the world population. Cereal grains contribute a significant amount of energy, protein, selected micronutrients and non-nutrients in the diet of populations all over the world in both developed and developing countries (BNF, 2004). Cereal and cereal-based food products provide more than 56% of the energy and 50% of the protein consumed worldwide (BNF, 2004). Economically important cereals in the world are maize, rice, wheat, barley, sorghum, millets, oat and rye (FAO, 1997).

Millets are considered as first cereals, domesticated thousands of years ago at the beginning of human civilization. There are some evidences in Northern China showing that noodles had been made from two millet types, namely proso and foxtail millets 4000 years ago (Lu et al., 2005). The term millet is used for small seeded grains taxonomically belonging to the family *Poaceae,* but to different tribes and genera. Of the total millet produced in the world about 90% is utilized in the developing countries. The global millet production was about 27 million tonnes in 2009 (FAOSTAT, 2011). Countries in Africa and Asia produced 56% and 41% of the total world production, respectively. Contribution of millets to world cereal production is about 1%, but their vital importance as food crops with respect to the agro-ecosystems is significant (FAOSTAT, 2011). Furthermore, millets are generally consumed as whole grain products.

Whole grains serve as recognized sources of many health-promoting components. Epidemiological evidences suggest that regular consumption of whole grains and whole grain products is associated with the reduced risk of several age-related chronic diseases (Anderson, Hanna, Peng, & Kryscio, 2000; Jacobs, Meyer, Kushi, & Folsom, 1998; Jacobs, Slavin, & Marquart, 1995; Liu, 2002; Liu et al., 1999, 2000; Meyer et al., 2000; Nicodemus, Jacobs, & Folsom, 2001; Slavin, 2003). All dietary guidelines formulated by different countries have cereals and cereal products as the predominant food group recommending their consumption in the highest proportion in the diet (Canada's Food Guide, 2007; USDA, 2005).

Whole grains are rich sources of fibre, vitamins, minerals and phytochemicals such as phenolics, lignans, β-glucan, inulin, resistant starch, sterols and phytates. The additive and synergistic effects of bioactive phytochemicals in plant-based foods have been suggested for their beneficial health outcomes (Duthie, Duthie, & Kyle, 2000; Liu, 2007). Furthermore, phenolic compounds such as ferulic acids and dehydrodiferulates in whole grains may complement those in fruits and vegetables due to their unique presence in cereal grains (Shahidi & Naczk, 2004). Bound antioxidative phenolics in cereals can survive gastrointestinal digestion to reach the colon in the intact form and may provide protective effect in the colon upon release by microbial fermentation (Kroon, Faulds, Ryden, Robertson, & Williamson, 1997). This may explain the protective role of whole grains in prevention of colon cancer.

Millets are warm-season cereals that are used as food, animal feed and fodder in various parts of the world. It is estimated that about two thirds of millets produced are consumed as food while the rest is used for planting seeds, animal feed, beer and bird seeds (FAO, 1995). Millets and sorghum are often referred to as coarse grain cereals and poor man's crop due to their vast use by economically disadvantaged population segments in Asian and African countries. Furthermore, they remain underutilized cereals even in agro-ecological systems where they grow due to their minimal inclusion in the commercial food systems, and lack of research and novel product development processes. The aim of this review is to examine millet phenolics, and the *in vitro* and *in vivo* evidences attributed to reduce non-communicable disease burden and to improve health and wellness.

2. Millet types

Millet is a generic name that includes several small seeded cereals. They do not belong to a single species or a single genus. The major millet type in terms of world production is pearl millet (*Pennisetum glaucum*) which accounts for about 46% (Marathee, 1994) followed by foxtail, proso and finger millet. A number of other minor millets exist, namely kodo, little, Japanese barnyard, fonio, and teff millets. Table 1 presents common names of millets used in different countries and their taxonomy. In general, they have small kernels and hence are grouped as millets. The word millet is derived from the French word "mille" which means thousand, implying that a handful of millets may contain thousands of grains (Taylor & Emmambux, 2008). Millets are considered as one of the oldest foods cultivated from the early human civilization and a recent archeobotanical study has shown that common millet was domesticated as a staple food 10,000 years ago in Northern China (Lu et al., 2009). Today, millets rank as the sixth most important cereal in the world, and are common staple foods for populations in some Asian and African countries. In the western world, millets are primarily used as feed and forage for livestock. However, their cultivation and production as alternating crop in tobacco farms is now practiced in Canada. In addition, their use is expanding for multigrain products and applicability in niche markets for gluten-free products and organic cereals is now commonplace.

3. Nutrient composition of millets

Nutritionally, millets are equivalent to other cereal grains (FAO, 1995). The major nutrients contained are 60–70% carbohydrates, 7–11% proteins, 1.5–5% fat, 2–7% crude fibre, minerals and vitamins (Table 2). Millets are a rich source of energy and are comparable with other cereal grains. Except finger millet, other millet types have higher fat content ranging from 3.5% to 5.2% compared to other cereals. Millets are rich in iron and phosphorus. In addition, finger millet has a high calcium content of 350 mg/100 g (FAO, 1995). Furthermore, millets are rich in several phytochemicals possessing a number of bioactivities that could impart beneficial health effects to prevent and delay the occurrence of non-communicable diseases (NCDs).

4. Food and feed uses of millets

Millets are important subsistence crops in semi-arid and tropical regions in Asia and Africa due to their resistance to pests