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Review

Review on utilization and composition of coffee silverskin

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ABSTRACT

Coffee is one of the most frequently consumed drinks in the world. Coffee silverskin (CS) is the only by-product produced during the coffee beans roasting process, and large amounts of CS are produced by roasters in coffee-consuming countries. However, methods for the effective utilization of CS have not been developed. Reuse of CS, which is the primary residue from the coffee industry, is important for the environment and economy. Recently, there have been some attempts to reuse CS for biological materials and as a nutrient source for solid-state fermentation. The purpose of this review is to provide an overview about CS, its chemical composition, biological activity, and attempts at its reuse.

Contents

1. Introduction

1.1. Coffee

Coffee is one of the most frequently consumed drinks in the world. Approximately 7 million tons of green coffee beans were produced globally in 2010 (Food and Agricultural Organization). With the increase in the number of coffee consumers in both importing and exporting countries, annual coffee production has increased. Coffee is grown primarily in the area between the 25°N latitude and the 25°S

Abbreviations: CS, Coffee silverskin; CGAs, Chlorogenic acids; 5-CQA, 5-Caffeoylquinic acid; 5-HMF, 5-(Hydroxymethyl)-2-furfural.

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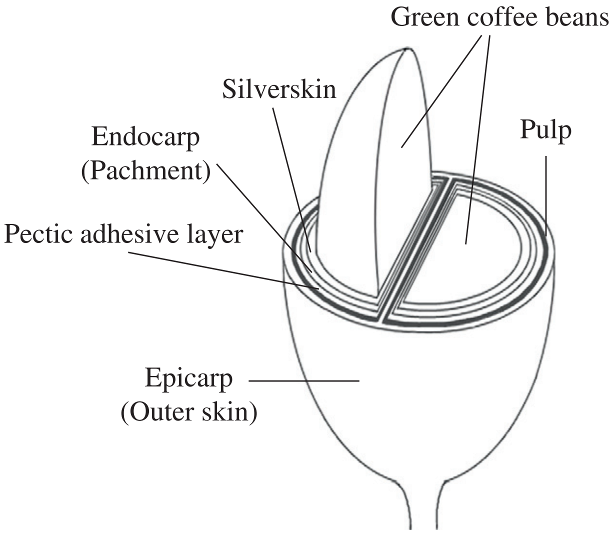

Fig. 1. Typical section of a coffee cherry.

latitude, known as "the coffee belt". More than 60 countries produce green coffee beans (Lashermes, Andrade, & Etienne, 2008; Vieira, 2008). Brazil is the global leader in production of green coffee beans, followed by Vietnam, Indonesia, Colombia, and India (Bacon, 2005; United States Department of Agriculture).

Coffee plants belong to the botanical family Rubiaceae, which includes approximately 80 species. Two major coffee species are cultivated for drinking. *Coffea arabica*, known as arabica coffee, accounts for approximately 75% of global coffee production and *C. canephora*, known as robusta coffee, accounts for approximately 24% of global coffee production (Bertrand, Ramirez, Topart, & Anthony, 2002; Casal, Oliveira, Alves, & Ferreira, 2000; van Boxtel, Berthouly, Carasco, Dufour, & Eskes, 1995). Coffee beans are roasted using dry heat at temperatures between 200 °C and 300 °C with constant agitation to ensure even heating. During roasting, the color of green coffee beans shifts to yellow, then to a suntan-like light brown, and later to a dark, oily brown color. Some of the natural sugars in the beans are transformed into CO_2 gas, and others are caramelized into the complex flavor essences that contribute to good taste and color. Chlorogenic acid lactones produced from chlorogenic acids (CGAs) by roasting green coffee beans has contributed to the bitter taste of brewed coffee (Farah, de Paulis, Moreira, Trugo, & Martin, 2006; Farah, de Paulis, Trugo, & Martin, 2005). In recent years, in addition to studies of taste and flavor, attention has been focused on the biological activities of coffee ingredient. In particular, it has been reported that CGAs have various bioactivities, such as antioxidant activity (Iwai, Kishimoto, Kakino, Mochida, & Fujita, 2004), α-amylase inhibition (Narita & Inouye, 2009, 2011), lipase inhibition (Narita, Iwai, Fukunaga, & Nakagiri, 2012), antihyperglycemic effects (Iwai et al., 2012), and other activities.

1.2. Coffee silverskin

Fig. 1 shows the structure of the fruit (coffee cherry) of the coffee tree (Saenger, Hartge, Werther, Ogada, & Siagi, 2001). The coffee cherry is oval and approximately 10 mm in size. Green coffee beans exist inward in the coffee cherry and are covered by a thin seed skin known as coffee silverskin (CS), an endocarp called the parchment, a pectic adhesive layer, pulp, and epicarp (outer skin) in the order (Saenger et al., 2001). Green coffee beans are generally produced via two processes, purification and thresh process (Bytof, Knopp, Schieberle, Teutsch, & Selmar, 2005; Bytof et al., 2007; Casal et al., 2004; Knopp, Bytof, & Selmar, 2006). For the purification process, two methods generally are used. One is the "washed" or "wet" method and the other is "unwashed", "natural" or "dry" method. In general, more CS is obtained from green coffee beans purified by the dry method than from those purified by the wet method. The outer skin, pulp, pectic adhesive layer, and parchment are completely removed from the green coffee beans in these two processes. However, a portion of CS remains with the green coffee beans after their treatment. The green coffee beans with attached CS are exported to consuming countries from producing countries, and the beans are roasted by suppliers in the consuming countries. Thus, CS is the only by-product produced in the roasting process, and large amounts of CS are produced by large-scale coffee roasters in consuming countries.

Many research groups are focusing on the utilization of coffee wastes that are by-products of the coffee brewing process as source of sugars, minerals and fibers; as alternative renewable energy sources (bio-diesel oil and bio-ethanol); and as electrode materials (Al-Hamamre, Foerster, Hartmann, Kroger, & Kaltschmitt, 2012; Kondamudi, Mohapatra, & Misra, 2008; Mussatto, Carneiro, Silva, Roberto, & Teixeira, 2011; Rufford, Hulicova-Jurcakova, Zhu, & Lu, 2008). Studies on the utilization of coffee waste have advanced worldwide (Esquivel & Jimenez, 2012; Murthy & Naidu, 2012; Mussatto, Machado, Martins, & Teixeira, 2011), but methods for the effective utilization of CS have not been developed. Thus, most CS is disposed of as industrial waste. CS is the only by-product of the coffee bean roasting process, and CS can only be collected in large amounts from roasting factories. Therefore, CS is a resource that may be easy to reuse, and it can be regarded as biomass that is expected to be utilized in the future.

2. Chemical composition of CS

2.1. Dietary fiber in CS

CS ingredients and the amounts thus far reported are summarized into Table 1. Dietary fiber is important for nutrition and health and is used as a therapeutic material for physiological problems such as diabetes and hyperlipidemia (Saura-Calixto, Garcia-Alonso, Goni, & Bravo, 2000). It is thought that dietary fiber will help in preventing cardiovascular disorders by arteriosclerosis or the serious complications of diabetes, because this controls the absorption of cholesterol and fat into the body by adsorbing them. CS has a high dietary fiber (50–60%), which includes 15% soluble dietary fiber and 85% insoluble dietary fiber (Borrelli, Esposito, Napolitano, Ritieni, & Fogliano, 2004; Napolitano, Fogliano, Tafuri, & Ritieni, 2007; Napolitano et al., 2006; Pourfarzad, Mahdavian-Mehr, & Sedaghat, 2013). Napolitano et al. (2007) investigated CS dietary fiber obtained from four types of *C. arabica* samples from Ethiopia, Santos, India, and Costa Rica, and three types of *C. canephora* samples from Ivory Coast, Vietnam, and Cameroon. They reported that there were no significant differences in the dietary fiber and soluble dietary fiber contents between all samples tested. The dietary fiber content of CS is higher than that of dietary plant foods such as apple (28.43%), Broccoli (28.94%), cabbage (22.41%), carrot (28.4%), wheat bran (41.97%), oat bran (28.60%), and potato (2.85%) (Anderson & Bridges, 1988; Chen, Rubenthaler, Leung, & Baranowski, 1988; Southgate, 1978). It has been reported that insoluble dietary fiber shortens intestinal transit, thereby allowing less time for carbohydrates to be absorbed (Montonen, Knekt, Jarvinen, Aromaa, & Reunanen, 2003). Insoluble dietary fiber is considered effective for prevention and remedial treatment of diabetes by controlling the carbohydrate absorption time (Hayashi et al., 2010; van de Laar et al., 2005). Therefore, CS consumption may be effective for the prevention and treatment of diabetes. However, this is the possibility suggested from the results obtained from an in vitro experiment, and in vivo experiment is necessary in order to confirm the presence or absence of the effects. Before that, it is necessary to confirm that there is no toxicity from intake of CS for humans. Recently, Lang et al. reported that 2-*O*-β-D-glucopyranosyl-carboxyatractyligenin, which is a kind of aminoglycoside and inhibits