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Effects of Korean black raspberry supplementation on oxidative stress and plasma antioxidant capacity in healthy male smokers

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ABSTRACT

Oxidative stress has been implicated in the pathophysiology of chronic diseases and cigarette smoking is known to be one of the major sources of oxidants. In this study, we investigated whether Korean black raspberry (BR) supplementation could reduce smoke-induced oxidative stress in healthy male smokers. Thirty nine healthy male smokers received either 30 g of freeze-dried BR or placebo for four weeks. Anthropometric and dietary data, smoking history, blood lipid profiles, lipid peroxidation, DNA damage, and antioxidant enzyme activities were assessed at baseline and after supplementation. There was no difference of age, smoking history, anthropometry, and nutrient intake between groups. BR supplementation had no effect on plasma lipid profiles, LDL oxidation, and DNA damage. However, it significantly increased the activity of the antioxidant enzymes, glutathione peroxidase and catalase, and reduced plasma lipid peroxidation. In conclusion, BR supplementation may decrease cigarette smoke-induced oxidative stress through increase of endogenous antioxidant enzyme activities.

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Abbreviations: BR, black raspberry; TC, total cholesterol; TG, triglyceride; ox-LDL, oxidized-LDL; GPx, glutathione peroxidase; SOD, superoxide dismutase; CAT, catalase; SBP, systolic blood pressure; DBP, diastolic blood pressure

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1. Introduction

Cigarette smoke has been shown to promote chronic diseases such as coronary heart disease, lung diseases, and cancer by inducing oxidative stress as well as chemical carcinogenesis (Caramori et al., 2011; Thun, Henley, & Calle, 2002; Zieske et al., 2005). In addition, several studies have reported that cigarette smokers tend to have lower intake of fruit and vegetable and lower serum dietary antioxidant concentration compared to non-smokers (Kim et al., 2004; Wei, Kim, & Boudreau, 2001). Therefore, it is generally accepted that the health threat caused by cigarette smoke is related to increased susceptibility to additional oxidative stress and decreased antioxidant capacity in serum (Kim et al., 2004; Wei et al., 2001).

Oxidative stress occurs when the levels of reactive oxygen species (ROS) increase beyond the capacity of the ROS-scavenging antioxidant system resulting in damage to DNA, proteins, and lipids (Riley, 1994). ROS is known to play a crucial role in the progression of many chronic diseases such as atherosclerosis and diabetes as well as the aging process (Vayndorf, Lee, & Liu, 2013; Vendemiale, Grattagliano, & Altomare, 1999). Endogenous antioxidant enzymes including catalase (CAT), superoxide dismutase (SOD), glutathione peroxidase (GPx), and antioxidant molecules such as reduced glutathione serve as a natural defense system against oxidative stress. Exogenous intake of dietary antioxidants including vitamins A, C, and E also has been shown to provide protection from oxidative stress (Dilsiz, Olcucu, Cay, Naziroglu, & Cobanoglu, 1999; Ramesh, Sureka, Bhuvana, & Hazeena Begum, 2010; Soerjomataram et al., 2010). Furthermore, several studies have reported that high intake of fruits or vegetables enhanced not only exogenous but endogenous antioxidant enzyme activities (Lotito & Frei, 2006; Shih, Yeh, & Yen, 2007). For that, researchers have investigated whether fruits, vegetables, or natural antioxidant supplementation could decrease the smoke-induced oxidative stress through changing endogenous and exogenous antioxidant systems (Brown, Morrice, Arthur, & Duthie, 1996; Chan et al., 2012; Hermsdorff et al., 2012).

Korean black raspberry (BR) has been used for centuries to treat various diseases including prostate, liver and kidney disease as well as impotence and allergic diseases (Heo, 1994; Jeon et al., 2008; Lee, 1966; Shin, Kim, Lee, Eom, & Kim, 2002). BR contains diverse antioxidants including anthocyanins, quercetin, phenolic acid, organic acids, flavonoids, gallotannin, ellagitannin, and triterpenoids (Ku & Mun, 2008; Yoon et al., 2002; Yoon, Wee, Moon, Ahn, & Park, 2003). Recently, BR was shown to alleviate exercise-induced oxidative stress in mice (J. E. Lee et al., 2011) and to decrease oxidant-induced apoptosis of osteoblasts (Lee & Choi, 2006). Other studies demonstrated the effectiveness of BR in enhancing the male reproductive and antioxidant system (Jeon et al., 2008; S. Lee et al., 2011). These data support the hypothesis that BR could be a significant source of antioxidant components to protect from smoke-induced oxidative stress. In the present study, we investigated whether dietary supplementation of BR could decrease oxidative stress in healthy male smokers by enhancing antioxidant capacities.

2. Subjects and methods

2.1. Study population

Forty healthy male participants aged 20–30 years who smoke cigarettes were recruited for the study; 39 of the participants completed the study. The study participants were recruited based on their smoking history (more than 4 years of smoking) and the number of cigarettes they smoked per day (more than 10 cigarettes per day). The participants had not previously taken medication for cardiovascular disease, diabetes, renal or liver disease, and all the participants had a normal body weight ($20 < BMI < 25$). To eliminate the confounding factors of excessive alcohol intake and exercise, male volunteers were excluded if they reported habitual alcohol consumption of over 10 glasses of alcoholic drinks or exercising for over 5 hours per week. All participants were recommended to limit coffee, tea, or fruit juice intake to quantities less than 1 glass per day and to maintain their smoking habits for the duration of the study. The procedures used were in accordance with institutional guidelines and approved by the Chung-Ang University Institutional Review Board (Seoul, Korea). Informed consent was obtained from all study participants before study onset.

2.2. Study design

This randomized, placebo-controlled clinical trial was designed as shown in Fig. 1. Participants were recruited based on criteria including smoking history, number of cigarettes smoked per day, and medication. After 1-week washout period, participants consumed either BR or placebo supplement for 4 weeks and were asked to maintain their normal dietary intake, lifestyle, and smoking habits.

2.3. BR and placebo preparation

The BR and placebo supplements were obtained from the Rural Development Administration and prepared as described in Table 1. The placebo supplement consisted of sugar and starch and had equivalent calories to the BR supplement. Subjects were divided into 2 groups: BR group (n = 20) consumed 30 g of freeze-dried BR per day for 4 weeks, and the placebo-controlled group (n = 19) consumed equivalent amounts of placebo for 4 weeks.

Table 1 – Components of the Korean black raspberry supplement.

Components	Amount	
	BR	Placebo
Freeze-dried *Rubus C. Miquel* (g)	30	
Water (g)	200	200
Carboxymethyl cellulose (g)	0.5	1.5
Methyl-ρ-hydroxybenzoate (mg)	100	100
Sucrose (g)		20
Sweet rice flour (g)		4
Red No. 40 (mg)		10
Blue No. 1 (mg)		0.7

BR, black raspberry.