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Antioxidant and hypolipidaemic effects of a novel yam–boxthorn noodle in an in vivo murine model

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Abstract

Yam–boxthorn noodle, a newly developed functional noodle, was prepared by mixing wheat flour, yam and boxthorn for the purpose of lowering serum cholesterol and oxidation status in vivo. To determine whether yam–boxthorn noodle exhibits hypolipidaemic and antioxidant effects in vivo, we examined the changes in triglyceride (TG), total cholesterol (TC), high density lipoprotein-cholesterol (HDL-C), low density lipoprotein-cholesterol (LDL-C) serum and oxidation levels in the serum and visceral organs of BALB/c females after continuously consuming the test diets for 5 weeks. The TG, TC, TG/HDL-C and TC/HDL-C serum levels in the experimental group decreased in a dose-dependent manner when the yam–boxthorn noodle concentration in the AIN 76 diet rose from 3 to 30%. However, the HDL-C and LDL-C serum levels did not significantly change. The TBARS oxidation index of the heart, liver and kidney significantly decreased compared with that of control group. The increase in tissue antioxidant capacity varied in magnitude: heart > liver > kidney. The total antioxidant status in the serum significantly increased in the 3% yam–boxthorn noodle diet experimental group. These experiments demonstrate that the functional noodle, yam–boxthorn noodle, exhibits hypolipidaemic and antioxidant effects in an in vivo murine model. Further, these results suggest that the functional ingredients in the yam and boxthorn, traditionally used as medicinal plants and functional foods, present greater health benefits than that of traditional noodles. These results will be important and useful for the future exploitation of traditional materials to develop a novel functional food for safeguarding health of hyperlipidaemia patients.

Keywords: Yam–boxthorn noodles; Hypolipidaemic effect; Antioxidant capacity; In vivo murine model

1. Introduction

In vivo oxidation products, namely free radicals and reactive oxygen species (ROS), have been associated with the etiology and/or progression of a number of diseases and ageing (Moskovitz, Yim, & Chock, 2002). Coronary risk factors, including hypercholesterolemia (especially total cholesterol and low density lipoprotein cholesterol), hyperlipidemia (e.g. triglyceride), age, hypertension, diabetes mellitus, and smoking, are associated with enhanced oxidative stress (Ide et al., 2002). Atherosclerosis is suggested to be linked to the oxidation of lipoproteins, primarily LDL, in the vascular wall (Sentman et al., 2001). However, total antioxidant capacity (TAC) is significantly reduced in stroke patients compared with controls (Gariballa, Hutchin, & Sinclair, 2002). It has proven that propofol (known to possess antioxidant activity) increases tissue antioxidant capacities (such as red blood cell, liver, kidney, heart, lung) during anesthesia (Runzer, Ansley, Godin, & Chambers, 2002). Clearly, hyperlipidemia (high in TC, TG, LDL-C) and in vivo oxidation stress are detrimental to health. However, hypolipidaemic

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and antioxidant effects can prevent diseases. Both rats and mice have been used to study atherosclerosis and exogenous cholesterol or steroid metabolism. Injection of poloxamer-407 (P-407), a hyperlipidaemic and atherogenesis inducer, into rats and mice causes significant hypercholesterolemia and hypertriglyceridemia in a dose-dependent manner (Palmer, Emeson, & Johnston, 1997). There is a 55% or higher homology in the amino acid sequence between the BALB/c mouse apolipoprotein A-II (apoA-II) and human apoA-II (Miller, Lee, LeBoeuf, & Shively, 1987), suggesting their similarities in lipoprotein cholesterol metabolism. In addition, mice and humans show similar changes in serum steroid following oophorectomy and orchiectomy (Brunner et al., 1986). These experiments may support the usefulness of murine models for the study of hypolipidaemic effects in vivo.

Noodles are popular and one of the most important staple foods in many countries around the world. Traditional noodles are made from simple ingredients, namely, wheat flour, water, salt, and alkali (Baik & Lee, 2003). However, nutritional compositions having health benefits in noodles have seldom been discussed. Even though the consumption of functional foods increases yearly, noodles for hyperlipidaemic patients have not yet been developed and evaluated. However, some ingredients or materials may potentially enhance hypolipidaemic functions in traditional foods, such as cereals and their products. In recent years, sorghum flour fermentation has been used as a functional ingredient in composite breads, particularly in the sourdough bread making process (Hugo, Rooney, & Taylor, 2003). A valuable oil, phytosterol, from wet-milled corn fibre and grain sorghum, has been reported to lower serum LDL-cholesterol levels (Singh et al., 2003; Singh, Moreau, & Hicks, 2003). Cereal brans, such as rice bran, oat bran, dehulled barley and β-glucan-enriched barley, have also demonstrated relatively high bile acid binding values in vitro, possibly related to their insoluble dietary fibre (IDF) or protein anionic, cationic, physical and chemical structure, composition, metabolites, or their interaction with binding sites (Kahlon & Woodruff, 2003). The bile acid binding hypothesis involves increased fecal excretion, regarded as a possible dietary fibre mechanism for lowering cholesterol (Lund, Gee, Brown, Wood, & Johnson, 1989). One of the Taiwanese yams, *Dioscorea japonica* Thunb var. pseudojaponica Yamamoto, consistently improves the cholesterol profile in the plasma and liver of adult BALB/c mice fed a 50% yam diet (Chen, Wang, Chang, & Wang, 2003). Some functional steroidal saponins existing in yams have been isolated and identified (Du, Liu, Fu, Xia, & Xia, 2002; Yang, Lu, & Hwang, 2003; Yin et al., 2003). The anti-hypercholesterolemia saponin mechanism in yams is probably related to its inhibitory activity against cholesterol absorption (Ma et al., 2002).

Oxidative stress, an imbalance between oxidant production and antioxidant defences in favour of the former, has been shown to be involved in the atherogenesis process (Ide et al., 2002), ageing (Moskovitz et al., 2002), cholestatic liver disease (Ljubuncic, Tanne, & Bomzon, 2000), cancer, neurodegenerative, and cardiovascular diseases (Squier, 2001). It has been found that oxidative stress processes in connection with continued systemic inflammatory response syndrome (SIRS) may promote the development of multiple organ failure (MOF) (Motoyama et al., 2003). Oxidation and antioxidant balance in the body is a crucial factor in the pathophysiology of various diseases (Basu & Eriksson, 2000). It was found that circulatory vitamin E, an antioxidant, may surge plasma isoprostanes and prostaglandins produced by the oxidant-antioxidant imbalance (Basu & Eriksson, 2000). The storage protein and mucilage of yam tubers (*Dioscorea batatas*) may play roles as antiradicals and antioxidants (Hou, Hsu, & Lee, 2002; Hou et al., 2001). Dried wolfberries (*Lycium barbarum*), also called boxthorn or matrimony-vine, fruits of a Chinese medicinal plant, increase the superoxide dismutase (SOD), catalase (CAT) and total antioxidant capacity in experimental mice (Li, Yang, Ren, & Wang, 2002). The glycoconjugates of these plants can inhibit low density lipoprotein (LDL) peroxidation (Huang, Tian, Wang, Dong, & Wu, 2001). Total flavonoids from *L. barbarum* L. show the scavenging effect on active oxygen radicals and inhibit the heat output from PMA-stimulated PMN (polymorphonuclear leukocyte) and L1210 cells (Huang, Tan, Shen, & Lu, 1998). They also have protective effects on lipid peroxidation in liver mitochondria and red blood cells in rats (Huang, Lu, Shen, & Lu, 1999).

From the researches mentioned above, some natural materials, especially yam and boxthorn, may have hypolipidaemic and antioxidant effects that prevent coronary diseases. A novel functional product, yam–boxthorn noodle, for the purpose of lowering serum cholesterol and oxidation status in vivo, was developed to meet the needs of desirable functional characteristics. The aims of this study were to examine both the hypolipidaemic and antioxidant effects of yam–boxthorn noodles, a newly developed noodle enriched with yam (*Dioscorea alate* L.) and boxthorn (*L. barbarum*), on female BALB/c mice through a five week feeding trial in an in vivo murine model.

2. Materials and methods

2.1. Sample preparation and nutrition analysis

The yam–boxthorn noodle, a newly developed noodle in Taiwan, was enriched with yam (*D. alate* L.) and boxthorn (*L. barbarum*). A new variety of *Dioscorea alata* L.