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Steam cooking significantly improves in vitro bile acid binding of beets, eggplant, asparagus, carrots, green beans, and cauliflower☆

Talwinder S. Kahlon*, Mei-Chen M. Chiu, Mary H. Chapman

Western Regional Research Center, United States Department of Agriculture–Agriculture Research Service (USDA-ARS), Albany, CA 94710, USA

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Abstract

Cholesterol-lowering potential of foods and food fractions have been evaluated by determining their bile acid–binding potential. Reducing bile acid recirculation lowers cholesterol by reducing fat absorption and use of cholesterol to synthesize bile acid. Secondary bile acids increase the risk of cancer. Bile acid–binding potential is related to lowering the risk of heart disease as well as cancer prevention. Previously, we have reported bile acid binding by several uncooked vegetables. However, most vegetables are consumed after cooking. How cooking would influence in vitro bile acid binding of various vegetables was investigated using a mixture of bile acids secreted in human bile under physiologic conditions. Eight replicate incubations were conducted for each treatment simulating gastric and intestinal digestion, which included a substrate only, a bile acid mixture only, and 6 with a substrate and bile acid mixture. Cholestyramine (a cholesterol-lowering, bile acid–binding drug) was the positive control treatment, and cellulose was the negative control. Relative to cholestyramine, in vitro bile acid binding on a dry matter basis was, for beets, 18%; okra, 16%; eggplant, 14%; asparagus, 10%; carrots, 8%; green beans, 7%; cauliflower, 6%; and turnips, 1%. These results point to the significantly different ($P \leq .05$) health-promoting potential of these vegetables (from highest to lowest, beets, okra, eggplant, asparagus, carrots and green beans, cauliflower, turnips) as indicated by their bile acid binding on a dry matter basis. Steam cooking significantly improved in vitro bile acid binding of beets, eggplant, asparagus, carrots, green beans, and cauliflower compared with previously observed bile acid–binding values for these vegetables uncooked. Inclusion of steam-cooked beets, okra, eggplant, asparagus, carrots, green beans, and cauliflower in our daily diet as health-promoting vegetables should be encouraged. These vegetables, when consumed regularly, may lower the risk of premature degenerative diseases (heart disease and cancer), improve public health, and advance human nutrition research.
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Keywords: In vitro; Bile acid binding; Beets; Okra; Eggplant; Asparagus; Carrots; Green beans; Cauliflower; Turnips

1. Introduction

The United States Department of Agriculture (USDA) Food and Nutrition Information Center's Food Guide Pyramid—Steps to a Healthier You (http://www.mypyramid.gov) recommends the consumption of colorful vegetables and low-fat food products along with daily active life and maintenance of desirable body weight [1]. Some of the vegetables listed by the USDA food pyramid include asparagus, beets, carrots, cauliflower, eggplant, green beans, okra, and turnips. Vegetarians or those consuming vegetables as a major portion of their daily diet along with less energy from saturated fat and animal products are at a lower risk of coronary heart disease and cancer. Vegetables are a good source of dietary fiber, antioxidants, phytonutrients, provitamins,

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* Corresponding author. Tel.: +1 510 559 5665; fax: +1 510 559 5777.
E-mail address: tsk@pw.usda.gov (T.S. Kahlon).

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polyphenols, and minerals. Antioxidants in beets and green beans [2,3], probiotics and immune-protecting phytochemicals of asparagus [4-6], hydroxycinnamic acid of eggplant [7], and glucosinolates of cauliflower [8,9] have been associated with health-promoting effects. Phytonutrients in the vegetables have been shown to stimulate natural detoxifying enzymes in the body and lower the risk of atherosclerosis and cancer [10,11]. Toxic metabolites in the gut and secondary bile acids increase the risk of colorectal cancer [12]. The healthful, cholesterol-lowering (atherosclerosis amelioration) or detoxification-of-harmful-metabolites (cancer prevention) potential of food fractions could be predicted by evaluating their in vitro bile acid binding, based on positive correlations found between in vitro and in vivo studies showing that cholestyramine (bile acid–binding, cholesterol-lowering drug) binds bile acids, whereas cellulose does not show this effect [13-16]. Atherosclerosis and cancer are major public health problems in the developed world and are becoming prevalent in the emerging world with greater affluence because of outsourcing of jobs and globalizing of industrial production facilities to the lower-cost-labor countries. To lower the risk of diet- and lifestyle-related premature degenerative diseases and to advance human nutrition research, relative bile acid–binding potential of foods and fractions need to be evaluated. Bile acids are acidic steroids synthesized in the liver from cholesterol. After conjugation with glycine or taurine, they are secreted into the duodenum. Bile acids are actively reabsorbed by the terminal ileum and undergo an enterohepatic circulation [17]. Binding of bile acids and increasing their fecal excretion has been hypothesized as a possible mechanism by which food fractions lower cholesterol [18-20]. The bile acids are needed for the absorption of dietary fat from the gastrointestinal tract. The dietary fat is a precursor of cholesterol synthesis in the body. By binding bile acids, food fractions prevent their reabsorption and stimulate plasma and liver cholesterol conversion to additional bile acids [21-24]. Excretion of toxic metabolites and secondary bile acids could lower the risk of cancer [12]. Bile acid binding of grain fractions, ready-to-eat cereals, and various dry beans has been observed to be proportional to their dry matter (DM) content [25-28]. The in vitro bile acid binding of uncooked vegetables on a DM basis has been reported relative to cholestyramine: for okra, 16%; beets, 11%; asparagus, 4%; and 1% for eggplant, turnips, green beans, carrots, and cauliflower [29]. Vegetables are normally cooked before consumption; how cooking would influence their bile acid binding has not been previously reported.

The objective of this study was to evaluate healthful potential of steam-cooked beets (*Beta vulgaris*), okra (*Abelmoschus esculentus*), eggplant (*Solanum malongena*), asparagus (*Asparagus officinalis*), carrots (*Daucus carota*), green beans (*Phaseolus vulgaris*), cauliflower (*Brassica oleracea botrytis*), and turnips (*Brassica rapa rapifera*), as determined by their bile acid binding on an equal DM basis, with a bile acid mixture observed in human bile under duodenal physiologic pH of 6.3.

2. Methods and materials

Fresh beets, okra, eggplant, asparagus, carrots, green beans, cauliflower, and turnips were obtained from a local grocery supermarket. All the vegetables were washed, cut into bite-size pieces, and steam cooked in a double boiler to a ready-to-be-eaten tenderness; steaming cooking time for beets, okra, and green beans was 15 minutes; for eggplant, asparagus, carrots, cauliflower, and turnips, 10 minutes (Table 1). All the cooked vegetables were dried to a constant weight at 68°C for 48 hours in a steam-heated forced-air food dryer (Proctor 062; Proctor and Schwartz, Inc, Horsham, Pa). Dry samples were ground in a Thomas-Wiley Mini Mill (Arthur Thomas, Philadelphia, Pa) to pass a 0.4-mm screen. Total dietary fiber (TDF) of the test samples was determined by method 985.29 [30]. A brief description of the TDF method is as follows: Duplicate test portions of dried foods (fat-extracted if containing >10% fat) were gelatinized with Termamyl (heat-stable α-amylase) and then enzymatically digested with protease and amyloglucosidase to remove protein and starch. Four volumes of ethyl alcohol were added to precipitate soluble dietary fiber. Total residue was filtered and washed with 78% ethyl alcohol, 95% ethyl alcohol, and acetone. After drying, residue was weighed. One duplicate was analyzed for protein, another was incinerated at 525°C, and ash was determined. Total dietary fiber = weight residue − weight (protein + ash).

Samples were analyzed for nitrogen by method 990.03 [31], with a Virio Macro Elemental Analyser (Elementar Analysen systeme GmbH, Hanau, Germany), crude fat with petroleum ether by an accelerated solvent extractor (ASE 200 Dionex Corp, Sunnyvale, Calif), ash by method 942.05 [31], and moisture by method 935.29 [31]. Cholestyramine, a bile acid–binding anionic resin (a drug that lowers cholesterol and binding bile acids), was the positive control treatment; cellulose (a non–bile acid-binding fiber) was the negative control. Both were obtained from (Sigma, St Louis, Mo).

Table 1
Dry matter content of steam-cooked beets (*B vulgaris*), okra (*A esculentus*), eggplant (*S malongena*), asparagus (*A officinalis*), carrots (*D carota*), green beans (*P vulgaris*), cauliflower (*B oleracea botrytis*), and turnips (*B rapa rapifera*)

Source	Cut to size[a]	Steamed (min)	DM (%)
Beets	0.5- to 0.75-in cubes	15	10.03
Okra	0.5- to 0.75-in pieces	15	8.84
Eggplant	0.5- to 0.75-in cubes	10	7.07
Asparagus	1.0- to 2.0-in pieces	10	5.99
Carrots	0.5- to 0.75-in pieces	10	13.84
Green beans	1.0- to 1.5-in pieces	15	8.63
Cauliflower	1.0- to 2.0-in florets	10	7.33
Turnips	0.5- to 0.75-in cubes	10	9.95

[a] Fresh vegetables (400-500 g) were washed, trimmed, and cut into bite-size pieces and steamed in a double boiler; DM was determined after drying at 68°C for 48 hours in a food dehydrator.