Comparative content of total polyphenols and dietary fiber in tropical fruits and persimmon

Shela Gorinstein,* Marina Zemser,* Ratiporn Haruenkit,† Rachit Chuthakorn,† Fernanda Grauer,‡ Olga Martin-Belloso,§ and Simon Trakhtenberg‖

**Department of Pharmaceutical Chemistry, School of Pharmacy, The Hebrew University of Jerusalem, Jerusalem, Israel;† Department of Agricultural Industry, Faculty of Agricultural Technology, King Mondkut Institute of Technology, Ladkrabang, Bangkok, Thailand; ‡Institute of Standards, Medical Laboratory, Ministry of Health, Jerusalem, Israel; §Food Technology Department, University of Lleida, Lleida, Spain; and ‖Institute of Cardiology, Kaplan Medical Center, Rehovot, Israel*

Recent studies have shown that dietary fiber and polyphenols of vegetables and fruits improve lipid metabolism and prevent the oxidation of low density lipoprotein cholesterol (LDL-C), which hinder the development of atherosclerosis. The goal of this study was to measure the total polyphenol and dietary fiber contents of some tropical fruits (i.e., pineapple, wax apple, rambutan, lichi, guava, and mango) and compare the results to the content of these substances in the better characterized persimmon. It was found that lichi, guava, and ripe mango (cv. Keaw) have 3.35, 4.95, and 6.25 mg of total polyphenols in 100 g fresh fruit, respectively. This is significantly higher than in persimmon, pineapple, wax apple, mature green mango, and rambutan [$P < 0.0005$ *for pineapple (Smooth Cayene variant), wax apple, persimmon, rambutan, mature green mango (cv. Keaw); the value of* $P < 0.001$ *is found only for pineapple (Phuket, Queen variant)]. The same relationship was observed for the contents of gallic acid and of dietary fiber. It can be supposed that among the studied fruit, lichi, guava, and ripe mango may be preferable for dietary prevention of atherosclerosis.* (J. Nutr. Biochem. 10:367–371, 1999) *© Elsevier Science Inc. 1999. All rights reserved.*

Keywords: persimmon; tropical fruits; total polyphenols; dietary fiber

Introduction

Coronary atherosclerosis is the main cause of morbidity and mortality in industrialized countries. Although preventive dietary strategies have led to some positive results, coronary atherosclerosis is still responsible for one of every three deaths.[1,2] Experimental, clinical, and epidemiological investigations have revealed major classical risk factors for atherosclerosis. It is widely believed that elevated levels of total cholesterol, low density lipoprotein cholesterol (LDL-C), triglycerides, apolipoproteins B and C-III, and a reduced level of high density lipoprotein cholesterol (HDL-C) and apolipoprotein A-I remain the major indicators of high risk.[3] Cholesterol plaques have been noted in every atherosclerotic lesion of both patients and experimental animals.[4–6] The lipids in plaques are derived from plasma oxidized LDL-C.[7] Recent evidence suggests that one of the important predisposing mechanisms in the development of atherosclerosis is oxidation of the cholesterol-rich LDL-C particles.[8–10] The oxidation of LDL-C enhances its atherogenicity and facilitates penetration of lipids into the arterial wall, causing the occlusion of arteries in general and coronary arteries in particular. It is now known that nutritional antioxidants in general, especially phenolic substances, can prevent lipid peroxidation.[11–13] It was shown that a low level of plasma antioxidants leads to a high mortality from coronary atherosclerosis.[14,15] Therefore, some authors propose diets rich in vegetables and fruits, which are the natural source of antioxidants.[16] Indeed, recent experiments on rats fed diets supplemented with persimmon show that this fruit

Dr. Gorinstein is affiliated with the David R. Bloom Center for Pharmacy. Address correspondence to Dr. Shela Gorinstein, School of Pharmacy, Hebrew University of Jerusalem, P.O.B. 12065, Jerusalem 91120, Israel.
Received July 17, 1998; accepted February 25, 1999.

J. Nutr. Biochem. 10:367–371, 1999

655 Avenue of the Americas, New York, NY 10010
0955-2863/99/$–see front matter
PII S0955-2863(99)00017-0

exercises a marked antioxidant effect that is most likely due to a relatively high content of polyphenols.[17] Some studies[12–14,17] have shown the effect of various phenols such as gallic acid, myricetin, flavan-3-ols [(+)-catechin and (−)-epicatechin], and others as antioxidants. Gallic acid occurs naturally in plants and has been found to be pharmacologically active as an antioxidant, antimutagenic, and anticarcinogenic agent.[18–20]

Some components of water-soluble dietary fiber may influence lipid metabolism. Kiryama et al.[21] found that dietary fiber effects the level of lipids in cholesterol fed rats. In recent years, one can find many tropical fruits such as guava, wax apple, lichi, rambutan, mango, and pineapple in the markets of Europe. Are these fruits rich in natural antioxidants and dietary fiber and therefore could they be recommended for dietary prevention of atherosclerosis? To answer this question, we decided to investigate the total polyphenol, gallic acid, and dietary fiber contents in the above mentioned tropical fruits and compare these levels with the content of these substances in the more studied fruit persimmon.

Methods and materials

Methods

The extraction of the crude polyphenols was achieved using aqueous methanol or ethanol. In this experiment 10 g of the edible parts of every fresh fruit were separately homogenized using a SD-45N homogenizer (Arthur H. Thomas Co., Philadelphia, PA USA) with 125 mL of 95% ethanol for 1 minute and then gently boiled in a water bath with a watch glass serving as a reflux condenser above a beaker. After this procedure the fruit samples were cooled and filtered under a vacuum using Whatman No. 1. The filtrates were reduced by evaporation under vacuum at 60°C to a volume of 10 mL and then made up to the volume of 100 mL with distilled water. The samples were passed through Chromobond C 8 (Macherey-Nagel, Düran, Germany) before reading at 725 nm. Results were calculated as milligrams of chlorogenic acid per 100 grams of fresh fruit. Total phenols were determined by the Folin-Ciocalteu method and measured at 675 nm.[22] Determination of phenolic acids was done according to Garcia-Sanches et al.[23] with our modifications and changes in the extraction procedure of the samples, using a combination of methanol, petroleum ether, and ethyl acetate. Fluorescence emission of gallic acid was measured using Model FP-770, Jasco-Spectrofluorometer (Japan Spectroscopic Co. Ltd., Hachioji, Japan) at an excitation wavelength of 260 nm and emission wavelength of 363 nm.

Materials

In this investigation, the content of total polyphenols, gallic acid, and total and soluble dietary fibers in the edible parts of six tropical fruits was studied and compared with the content of these compounds in the persimmon. The tropical fruits were purchased at a local market in Bangkok, Thailand, at the fully mature stage.

1. Guava (*Psidium guajava L.*), locally known as Klom sali, is an important fruit, which originated in the tropics of America. Shape: globular, composed of 200 to 300 g/fruit; texture: crispy when served raw; taste: mild (sweet and sour); processed guava: juice; availability: year round.
2. Lichee (*Litchi chinensis Sonn.*), also known as Hong Hua, originated in the Kwantung province in southern China. Shape: round or oval, up to 40 mm in diameter, a single seed in the middle of the fruit occupies up to half of the fruit, composed of approximately 50 g/fruit, red peel needs to be removed before eaten, aril is edible part; texture: juicy, translucent aril; taste: sweet and slightly sour; processed: canned lichee in syrup; availability: June and July.
3. Mango (*Mangifera indica L.*), locally known as Keaw, originated in the Indo-Burma area thousands of years ago. Shape: ovate-oblong, may weigh up to 1 kg (700 g); texture: firm when raw, rubbery when ripe; taste: sour when raw and sweet when ripe; processed: pickle, juice, jam; availability: March through May. There are four main groups of mango varieties. This experiment used the Indian type of Keaw, both the mature green mango and the ripe mango.
4. Pineapple (*Ananas comosus Merr.*), known as Queen variety, Phuket, is native to South America and has now spread throughout tropical world. Shape: big fruit, 1 to 2 kg/fruit, conical with a crown; texture: juicy and fibrous; taste: sweetened sour; processed: canned juice or canned slices, jam, glaze; availability: year round. Pineapple cultivars can be divided into five groups. In this experiment we used two types: the smooth Cayenne, which is characterized by pale yellow to yellow flesh, and the Queen, which is characterized by deep yellow flesh.
5. Rambutan (*Nephelium lappaceum L.*), known as Rongroen, is native to Malaysia. Shape: bright-red oval fruit about the size of a small hen's egg with a seed, hairy peel with long, soft spines, aril is edible part; texture: juicy, translucent aril; taste: sweet with a tasty acid pulp; processed: rambutan canned in syrup; availability: June through August.
6. Wax apple (*Euginia spp.*), known as Chompu Keiw, originated in the Indo-Burma area. Shape: bell-like; texture: crispy and juicy when served raw; taste: mild, slightly sweet; processing: not available; availability: June through September.
7. Persimmon (*Diospyros kaki L.*) originated in Japan with two wide spread varieties: Fuio, which has seeds, and Triumph, which is seedless. Shape: round; texture: crispy; taste: ripe-sweet, if not astringent; processing: sweetening ingredient in baked products and fruity ice creams, jellies, nectars, in dry form; availability: September through December.

It is known that that the ripening process of fruits continues after harvest. This process leads to significant changes in the content of the natural antioxidants. To determine the exact concentration of total polyphenols and gallic acid in the fruits, only ripe fruits were used in this experiment.

Statistics

The results of this investigation are means of five measurements. To verify the statistical significance of all parameters, the values of means, 95% confidence intervals (CI) of means, and ±SEM were calculated. To compare several groups, analysis of variance (ANOVA) was used. *P*-values of less than 0.05 were considered statistically significant.

Results

Total polyphenols

The mean total polyphenols in persimmon was 1.45 mg/100 g of fresh fruit. According to results of the investigation of the tropical fruits they can be divided into two groups: In the first, the total polyphenols content is approximately equal to persimmon's content and in the second it is significantly higher. The following four tropical fruits are from the first group, having a relatively low content of total polyphenols (means ± SEM and CIs of means): 1.34 ± 0.04 (1.21–

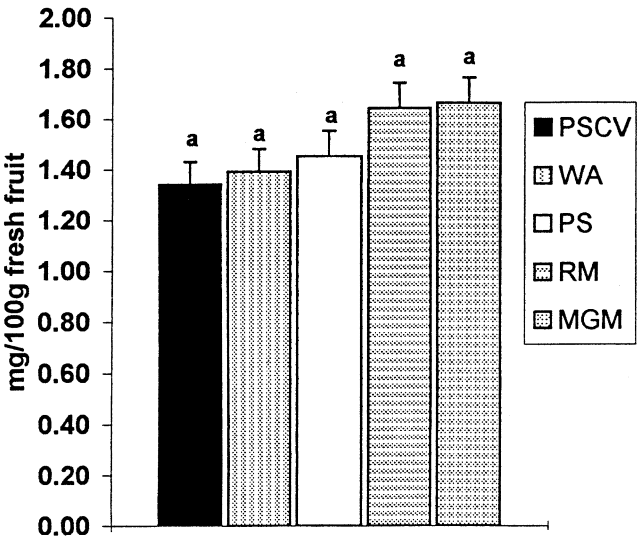

Figure 1 Total polyphenol content in: (■) pineapple smooth Cayenne variant (PSCV), (▩) wax apple (WA), (□) persimmon (PS), (▩) rambutan (RM), and (▩) mature green mango (MGM). Mean ± SD (vertical lines). Bars with the same letters are not statistically significant.

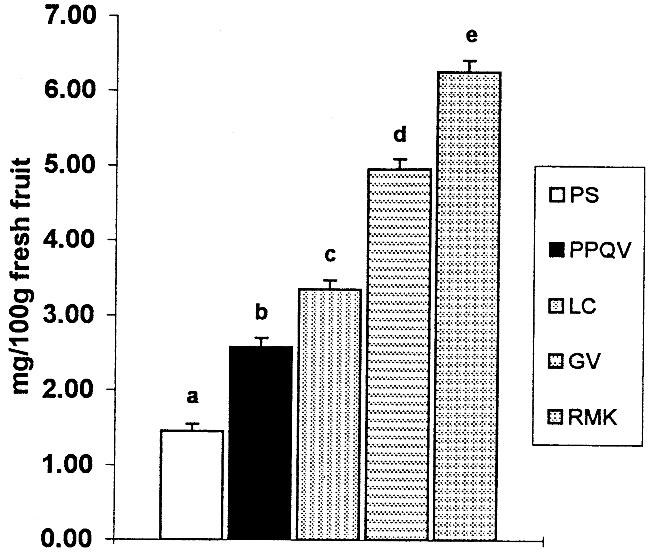

Figure 2 Comparison of total polyphenol content in: (□) PS with (■) pineapple Queen variant (PPQV), (▩) lichi (LC), (▩) guava (GV), and (▩) ripe mango Keaw (RMK). Mean ± SD (vertical lines). Bars with different letters are statistically significant.

1.47), 1.39 ± 0.04 (1.26–1.52), 1.64 ± 0.04 (1.57–1.77), and 1.66 ± 0.04 (1.53–1.79) mg/100 g of fresh fruit for pineapple (smooth Cayene variant), wax apple, rambutan, and mature green mango, respectively. The next four tropical fruits are from the second group, having a significantly higher total polyphenols content (means ± SEM and CIs of means): 2.58 ± 0.05 (2.42–2.74), 3.35 ± 0.05 (3.19–3.51), 4.95 ± 0.05 (4.79–5.11), and 6.25 ± 0.05 (6.09–5.41) mg/100 g of fresh fruit for pineapple (Queen), lichi, guava, and ripe mango, respectively. *Figure 1* shows graphically the comparative content of total polyphenols in persimmon and tropical fruits with a relatively low concentration of these substances. The differences in the concentrations of total polyphenols in persimmon, pineapple (smooth Cayene variant), wax apple, rambutan, and mature green mango were not statistically significant. *Figure 2* shows graphically the comparative content of total polyphenols in persimmon, pineapple (Queen), lichi, guava, and ripe mango. The difference in the concentration of total polyphenols in ripe mango was statistically significant and higher than in pineapple (smooth Cayene variant), wax apple, rambutan, and mature green mango, which are the tropical fruits with relatively high content of these compounds ($P < 0.0005$ in all four cases).

Gallic acid

The gallic acid content in the tropical fruits was in the range of 147.2 to 397.4 g/100 g of fresh fruit. *Table 1* summarizes the results of gallic acid measurements in all studied tropical fruits. As in the case of total polyphenols, the lowest content of gallic acid was in pineapple (smooth Cayenne) and the highest in ripe mango (cv. Keaw). Analysis of this table demonstrates that the content of gallic acid in persimmon was significantly higher than in pineapple (smooth Cayenne) and wax apple ($P < 0.005$ and 0.005, respectively). However, the content of gallic acid in lichi, guava, and ripe mango (cv. Keaw) was significantly higher than in persimmon ($P < 0.025$, 0.0005, and 0.0005, respectively).

Total and water soluble dietary fiber

The content of total dietary fiber in the tropical fruits was in the range of 0.54 to 5.6 g/100 g of fresh fruit. As in the case of total polyphenols and gallic acid, the highest content of total dietary fiber was in lichi, ripe mango (cv. Keaw), and guava. *Table 2* summarizes the results of total dietary fiber investigation in all studied tropical fruits. Analysis of this table demonstrates that the content of total dietary fiber in persimmon was significantly higher than in pineapple (smooth Cayene), wax apple, and pineapple (Phuket Queen variant; $P < 0.0005$, 0.0025, and 0.0025, respectively).

Table 1 The content of gallic acid in some fruits (μg/100 g of fresh fruit)

Fruits	Means ± SEM and CI	P-value versus persimmon
Pineapple (smooth cayenne variant)	147.2 ± 10.1 (121.2–173.2)	$P < 0.005$
Wax apple	153.7 ± 10.1 (127.7–179.7)	$P < 0.005$
Persimmon	221.2 ± 11.9 (190.2–252.2)	—
Rambutan	231.4 ± 11.9 (200.4–262.4)	$P < 0.3$
Mature green mango (cv. Keaw)	231.6 ± 11.9 (200.6–262.6)	$P < 0.3$
Pineapple (Phuket Queen variant)	238.4 ± 11.9 (207.4–269.4)	$P < 0.2$
Lichi (cv. hong hua)	307.2 ± 12.4 (275.3–339.2)	$P < 0.025$
Guava (cv. klom sali)	374.3 ± 13.1 (340.6–408.0)	$P < 0.0005$
Ripe mango (cv. Keaw)	397.4 ± 13.1 (360.7–431.4)	$P < 0.0005$

CI–confidence intervals of means.

Table 2 The content of total and soluble dietary fibers (g/100 g of fresh fruit)

Fruits	Means ± SEM and CI			
	Total fiber (range)	*P-value	Soluble fiber (range)	*P-value
Pineapple (smooth cayenne variant)	0.54 ± 0.07 (0.36–0.72)	$P < 0.0005$	0.26 ± 0.05 (0.13–0.39)	$P < 0.0025$
Wax apple	0.77 ± 0.09 (0.46–1.00)	$P < 0.0025$	0.35 ± 0.05 (0.22–0.48)	$P < 0.005$
Persimmon	1.48 ± 0.11 (1.20–1.76)	—	0.72 ± 0.08 (0.52–0.92)	—
Rambutan	1.64 ± 0.12 (1.33–1.95)	$P < 0.2$	0.81 ± 0.08 (0.61–1.01)	$P < 0.25$
Mature green mango (cv. Keaw)	1.27 ± 0.1 (1.01–1.53)	$P < 0.15$	0.62 ± 0.08 (0.42–0.82)	$P < 0.2$
Pineapple (Phuket Queen variant)	0.61 ± 0.07 (0.43–0.79)	$P < 0.0025$	0.29 ± 0.05 (0.16–0.42)	$P < 0.005$
Lichi (cv. hong hua)	2.20 ± 0.12 (1.89–2.51)	$P < 0.005$	1.05 ± 0.1 (0.79–1.31)	$P < 0.05$
Guava (cv. klom sali)	5.60 ± 0.18 (5.14–6.04)	$P < 0.005$	2.7 ± 0.12 (2.39–3.01)	$P < 0.0005$
Ripe mango (cv. Keaw)	3.10 ± 0.15 (2.71–3.49)	$P < 0.0005$	1.51 ± 0.1 (1.25–1.77)	$P < 0.0025$

*P, versus persimmon.
CI–confidence intervals of means.

However, the content of total dietary fiber in lichi, guava, and ripe mango (cv. Keaw) was significantly higher than in persimmon ($P < 0.005$, 0.0005, and 0.0005, respectively). The content of soluble fiber in these tropical fruits was in the range of 0.26 to 2.7 g/100 g of fresh fruit. As in the case of total dietary fiber, the highest content of soluble fiber was in lichi, ripe mango (cv. Keaw), and guava. *Table 2* summarizes the results of the soluble fiber investigation in all studied tropical fruits. Analysis of this table demonstrates that the content of the soluble fiber in persimmon was significantly higher than in pineapple (smooth Cayenne), pineapple (Phuket Queen variant), and wax apple ($P < 0.0025$, 0.005, and 0.005, respectively), whereas the content of the soluble fiber in lichi, ripe mango (cv. Keaw), and guava was significantly higher than in persimmon ($P <$ 0.05, 0.0025, and 0.0005, respectively).

Discussion

It has been established that phenolic substances in the diet can exert an antioxidant effect, preventing development of atherosclerosis.[11,12,18,19] The natural sources of these compounds are vegetables and fruits. In this modern age of extensive trade, many tropical fruits are found on tables of the European and North American consumers. Most of these fruits are very tasty. Learning whether these tropical fruits instead of the traditional ones should be included in the diet to prevent atherosclerosis is of great interest. To find the answer, it was decided to measure the content of total polyphenols, gallic acid, and total and soluble fiber in the most popular tropical fruits: guava, wax apple, lichi, pineapple (Phuket, Queen variant), pineapple (Smooth Cayene variant), rambutan, ripe mango (cv. Keaw), and mature green mango (cv. Keaw). The results of this investigation show that the content of total polyphenols in ripe mango (cv. Keaw), guava, and lichi is statistically significantly higher than in all other studied tropical fruits and persimmon ($P < 0.0005$ in all cases). The same is true regarding gallic acid and total and soluble dietary fibers. Only three of the studied tropical fruits (ripe mango, guava, and lichi) have a higher content of total polyphenols, gallic acid, and total and soluble dietary fibers. Therefore, it can be concluded that lichi, guava, and ripe mango could be preferable for dietary prevention of atherosclerosis. However, the final answer will be known only after completion of our experiment on laboratory animals fed diets supplemented with these fruits.

References

1 Hennekens, C.H. and Gaziano, J.M. (1993) Antioxidants and heart disease: Epidemiology and clinical evidence. *Clin. Cardiol.* **16,** 110–115
2 Gaziano, J.M. (1994). Antioxidant vitamins and coronary artery disease risk. *Am. J. Med.* **3,** 18S–28S
3 Castelli, W.B., Garrison, R.J., Wilson, P.W.F., Abbott, R.D., Kalousdian, S., and Kannel, W.B. (1986). Incidence of coronary heart disease and lipoprotein cholesterol levels. The Framingham Study. *J. Am. Med. Assoc.* **256,** 2835–2838
4 Faggiotto, A., Ross, R., and Harker, L. (1984). Studies of hypercholesterolemia in the nonhuman primate. I. Changes that lead to fatty streak formation. *Atherosclerosis* **4,** 323–340
5 Faggiotto, A. and Ross, R. (1984). Studies of hypercholesterolemia in the nonhuman primate. II. Fatty streak conversion to fibrous plaque. *Atherosclerosis* **4,** 341–356
6 Freedman, D., Newman, W.I., Tracy, R., Voors, A.E., Srinivasan, S.R., Webber, L.S., Restrepo, C., Strong J.P., and Berenson, G.S. (1988). Black-white differences in aortic fatty steaks in adolescence and early adulthood. The Bogalusa heart study. *Circulation* **77,** 856–864
7 Steinberg, D., Parthasarathy, S., Carew, T., Khoo, J., and Witztum, J. (1989). Beyond cholesterol: Modifications of low density lipoprotein that increases its atherogenicity. *N. Engl. J. Med.* **320,** 915–924
8 Witztum, J.L. and Steinberg, D. (1991). Role of oxidized low density lipoprotein in atherogenesis. *J. Clin. Invest.* **88,** 1785–1792
9 Aviram, M. (1993). Modified forms of low density lipoprotein and atherosclerosis. *Atherosclerosis* **98,** 1–9
10 Steinbrecher, U.P., Zhang, H., and Londheed, M. (1990). Role of oxidactivity modified LDL in atherosclerosis. *Free Rad. Biol. Med.* **9,** 155–168
11 Kappus, H. (1985). Lipid peroxidation: Mechanisms, analysis, enzymology and biological relevance. In *Oxidative Stress* (H. Sies, ed.), pp. 273–310, Harcourt, Brace, Jovanovich, San Diego, CA, USA
12 Frankel, E.N., Kannar, J., German, J.B., Parks, E., and Kinsella, J.E. (1993). Inhibition of oxidation of human low density lipoproteins by phenolic substances in red wine. *Lancet* **341,** 454–457
13 Frankel, E.N., Waterhouse, A.L., and Kinsella, J.E. (1993). Inhibition of human LDL-C oxidation by resveratrol. *Lancet* **341,** 1103–1104
14 Rankin, S.M., Whalley, C.V., Hoult, J.R., Jessup, W., Wilkins, G., Collard, J., and Leake, S. (1993). The modification of LDL by the flavonoids myricetin and glossypatin. *Biochem. Pharmacol.* **45,** 67–75
15 Gey, K.F., Stahelin, H.B., and Eichholzer, M. (1993). Poor plasma status of carotene and vitamin C is associated with higher mortality

from ischemic heart disease and stroke. Basel Prospective Study. *Clin. Investig.* **71,** 3–6

16 Lorgeril, M., Renaud, S., Mamelle, N., Salen, P., Martin, J.L., Monjaur, I., Guidollet, J., Touboul, P., and Delaye, J. (1994). Mediterranean alpha-linolic acid-rich diet in secondary prevention of coronary heart disease. *Lancet* **343,** 1454–1459

17 Gorinstein, S., Kulasek, G., Bartnikowska, E., Leontowicz, M., Zemser, M., Morawiec, M., and Trakhtenberg, S. (1998). The influence of persimmon peel and persimmon pulp on the lipid metabolism and antioxidant activity of rats fed cholesterol. *J. Nutr. Biochem.* **4,** 223–227

18 Gunckel, S., Santander, P., Gordano, G., Ferreira, J., Munoz, S., Nunez-Vergara, L.J., and Squella, J.A. (1998). Antioxidant activity of gallates: An electrochemical study in aqueous media. *Chem. Biol. Interact.* **114,** 45–59

19 Wilson, T., Porcari, J.P., and Harbin, D. (1998). Cranberry extract inhibits low density lipoprotein oxidation. *Life Sci.* **62,** 381–386

20 Shahrzad, S. and Bitsch, I. (1998). Determination of gallic acid and its metabolites in human plasma and urine by high-performance liquid chromatography. *J. Chromatogr. Biomed. Sci. Appl.* **705,** 87–95

21 Kiryama, S., Okazaki, J., and Joshida, A. (1969). Hypocholesterolemic effect of polysaccharides and polysaccharide-rich foodstuffs in cholesterol fed rats. *J. Nutr.* **97,** 382–388

22 Singleton, V.L. and Rossi, J.A., Jr. (1965). Colorimetry of total phenolics with phosphomolybdic phosphotungstic acid reagents. *Am. J. Enol. Vitic.* **16,** 144–158

23 Garcia-Sanchez, F., Carnero, C., and Heredis, A. (1988). Fluorometric determination of p-coumaric acid in beer. *J. Agric. Food Chem.* **36,** 80–82