Thematic Article

Candidate foods in the Asia–Pacific region for cardiovascular protection: nuts, soy, lentils and tempe

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Cross-cultural and intervention studies increasingly point the way to seeds like nuts, soy and lentils, and products of them like tempe being cardioprotective. Soy and its products (like tofu, tempe, soy drinks and soy desserts) are historically and currently some of the most important foods in the Asian region where diets remain predominantly plant-based. The mechanisms by which these seeds may protect populations against cardiovascular disease are several. They include the minimisation of classical risk factors like positive energy balance leading to obesity, hypertension, dyslipidemia and insulin resistance with hyperglycaemia. However, in addition, they provide compounds like n-3 fatty acids, isoflavones and arginine which are only now recognised for their ability to optimise other pathways which connect lifestyle to cardiovascular disease – like oxidant status, vascular reactivity and myocardial electrical stability and proneness to dysrhythmia. Thus, once an Asian food culture changes on its emphasis on these plant foods, it may place its consumers at cardiovascular risk.

Key words: cardiovascular, China, diabetes, glycemic index, hypertension, Indonesia, Japan, lentils, lipids, nuts, soy, tempe, tofu.

Introduction

Cardiovascular disease (CVD) has become the major contributor of mortality in the Asia–Pacific region.[1] The growing prevalence of cardiovascular risks through diabetes, obesity, dyslipidemia and hypertension is evident.[1] Changes of food habits and practices, like shifting away from traditionalities, are, amongst others, contributors to the development of CVD.[2] While nutrient factors such as fat, dietary fibre and unrefined carbohydrate, and their cause-effect relations with CVD are well documented; the roles of non-nutrient factors, such as isoflavones in cardiovascular protection have only recently gained recognition.

Nuts, soy, lentils and tempe (fermented soybeans), which are consumed widely in the Asia–Pacific region, can be considered as candidate foods for cardiovascular protection because they have a favourable fatty acid composition, low glycemic indices, high contents of dietary fibre, folate and vitamin B12, and, especially for soy and tempe, high levels of isoflavones. This paper reviews evidence and findings on the potential roles of nuts, soy, lentils and tempe in preventing CVD. Discussion is focused on available human studies. Animal studies are also briefly considered on a basis for the future development of clinical trials in nutrition.

Understanding nutritional composition of nuts, soybeans, lentils and tempe

Nuts, soy(beans), lentils and tempe can be considered nutritious. They contain relatively high protein with different levels of fat and dietary fibre. They also contain different levels of vitamins and minerals (Table 1).[3–7] With respect to cardiovascular health, recommendations for the consumption of nuts, soy, lentils and tempe should also consider their non-nutrient components like phytoestrogens, or their specific nutrient components like arginine,[8] polyunsaturated fatty acids,[9] folate and vitamin B12,[10] which are now known to be protective against CVD. This approach can be achieved by the development of Food-Based Dietary Guidelines.[11]

Potential roles of nuts, soy, lentils and tempe for cardiovascular protection

Available studies reveal potential roles of nuts, soy, lentils and tempe in reducing cardiovascular risks. Different protective mechanisms have been documented in various review articles (Table 2).[8–10,12]

Nuts for cardiovascular protection

Nuts are low in saturated fatty acids and high in monounsaturated and polyunsaturated fatty acids. Monounsaturated fatty acids (MUFA) represent the major unsaturated fatty acids in most nuts (walnuts are rich in polyunsaturated fatty acid [PUFA]), and contribute on average about 62% of the energy from fat. Together PUFA and MUFA in nuts contribute 91% of the energy from fat.[9] The evidence on the hypolipidemic properties of nuts is mainly based on their favourable fatty acids composition. Predictive equations for plasma cholesterol developed from well-controlled feeding studies agree that saturated fatty acids (SFA) raise blood cholesterol concentrations, while PUFA lower them.

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Table 1. Nutritional composition of nuts, soybeans, lentils and tempe, expressed per 100 g*

Component	Nuts	Soybeans	Lentils	Tempe
Energy (kJ)	720–2960	545	420	626
Energy (kcal)	170–705	130	100	149
Carbohydrate (g)	6–37	11	17	19.7
Protein (g)	2–24	11	8	18.3
Fat (g)	3–74	6	1	4
Fibre (g)	6–14.5	1	4	7.2
Iron (mg)	0.9–7	3	2	9
Calcium (mg)	20–250	75	10	129
Phosphorus (mg)	70–590	180	80	154
Thiamine (mg)	0.06–1	0.2	0.1	0.28
Riboflavin (mg)	0.04–0.9	0.1	0.04	0.65
Niacin (mg)	0.2–16	0.6	0.4	2.52
Folate (μg)	0–96	–	5	NA
Vitamin B12 (μg)	–	–	–	3.9
Vitamin E (mg)	0.5–21	–	–	NA

*Taken from References 3–7. NA, information not available.

Table 2. Putative protective mechanisms of nuts, soy, lentils and tempe against cardiovascular disease risks

Type of food	Putative protective mechanism(s)
Nuts	High levels of unsaturated fatty acids, anti-oxidant vitamin E and arginine
Soy	High levels of isoflavones, favourable ratio of linoleic to linolenic acid
Lentils	High fibre, low glycemic indexes, high levels of folate
Tempe	High levels of isoflavones and vitamin B12

In well-controlled feeding studies, nuts were used with other food sources aiming to modify fatty acid composition. Inclusion of nuts in the diet led to high MUFA and PUFA contents, with reduction in total- and low-density lipoprotein (LDL-) cholesterol concentrations by approximately 4–16% and 9–20%, respectively.[9] Using a randomised, controlled, parallel design to compare almond-based, olive oil-based and dairy-based diets over a 4-week period after a 1-week baseline period, Spiller *et al.* found that, in the almond-based diet group, there was significant reduction in total- and LDL-cholesterol concentrations, but not in the olive oil-based and dairy-based diet groups.[13] The high-density lipoprotein (HDL-) cholesterol concentrations in the almond-based diet subjects remained constant. Iwamoto *et al.* also demonstrated that inclusion of moderate quantities of walnuts without an overall increase in total dietary fat and energy in Japanese diet could decrease serum total cholesterol concentrations and favourably modify the lipoprotein profile.[14]

In a further analysis, Kris-Etherton *et al.* were able to demonstrate that the observed cholesterol lowering effect of diet containing nuts was ≥ 25% greater than the estimated values using prediction formula based on the fatty acid changes.[9] This analysis indicates that there are non-fat hypocholesterolemic factors in nuts. Nuts are also high in arginine, a precursor for nitric oxide (NO); anti-oxidant vitamin E, and folic acid, a homocysteine-lowering vitamin. Arginine, vitamin E and folic acid are known as cardioprotective nutrients. There is a need to undertake further nutrition trials on nuts and CVD risks.

A recent review by Fraser draws further attention to the mounting evidence in favour of nuts as cardioprotective foods.[8]

Legumes for cardiovascular protection

Lentils and soy(beans) are categorised as legumes, and legumes play an important role in the traditional diet of many countries in the Asia–Pacific region. Lentils are an excellent source of dietary fibre. One serving of beans (approximately 90 g = ½ cup boiled) provides 2–4 g of a mix of soluble and insoluble fibre.[7] The hypocholesterolemic effect of high-fibre, high-bean diets has been demonstrated by Anderson *et al.*[15] Furthermore, beans have very low glycemic indices (Fig. 1).[12] Low-glycemic-index foods help control glycemic response.[16] Consumption of low-glycemic index diets have less risk for diabetes than high-glycemic index diets.[17]

Hyperhomocysteinemia has been well documented as an independent risk factor for vascular diseases. Subjects with hyperhomocysteinemia have a two to threefold increase in risk of developing CVD or venous thrombosis. A review paper on vitamin deficiency-related CVD risks was also discussed in a previous section. Lentils are also a good source of folate, a homocysteine-lowering vitamin. One serving size of lentils (approximately 90 g = ½ cup boiled) can provide up to 179 μg of folate,[7] which is equivalent to approximately 45% of the recommended dietary allowance (RDA) for folate (400 μg/day). Further studies should demonstrate that lentils and other legumes to lower serum-homocysteine.

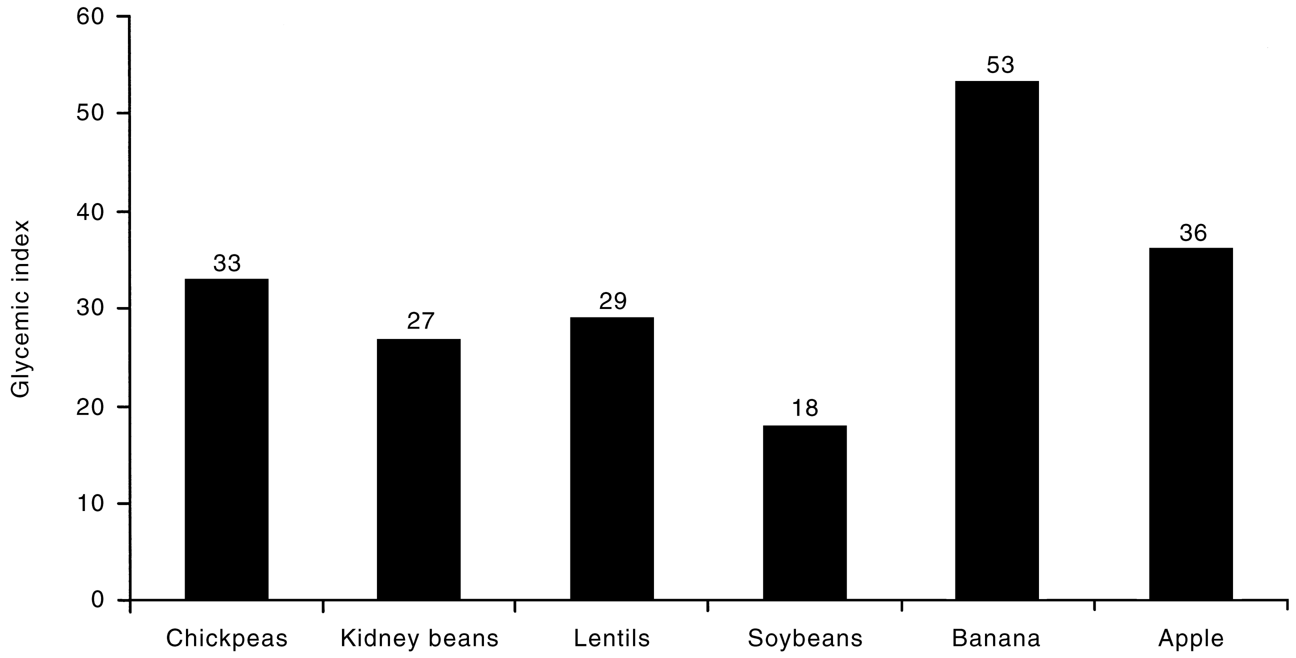

Figure 1. Glycemic indexes of soybeans and other legumes. Taken from Reference 12.

Soy for cardiovascular protection

The most frequent reported evidence for bioactive substances of soy which are cardiovascular protective is isoflavones. Isoflavones are naturally occurring oestrogenic compounds in plants, and therefore they are classified as phytoestrogens. All legumes contain isoflavones. However, soybeans are much richer in dietary isoflavones than other legumes.[18,19] In soybeans and soy products, the isoflavones genistein and daidzein are mostly available as their glycones, genistin and daidzin. After ingestion, soybean isoflavones are hydrolised by intestinal glycosidases to release the aglycones, genistein and daidzein.[18] Daidzein is metabolised by the bacteria in the large intestine to form the isoflavan equol (oestrogenic) or *O*-desmethylangolensin (non-oestrogenic), and genistein is metabolized to form *P*-ethyl phenol (non-oestrogenic).[19]

Many studies have investigated the potential roles of soy foods and or their phytoestrogens on cardiovascular disease[20,21] and hormone-dependent health problems in women like breast cancer,[22] and osteoporosis.[23] Clinical trials often use dietary intervention with soy proteins, without reference to other soy components to study clinical outcomes. Nevertheless, contemporary trials have applied soy and other phytoestrogen-rich foods to investigate clinical outcomes and biomarkers.[23,24] This approach has increased the credibility and awareness of food–health relationships, in different cultural settings.

One of the proposed mechanisms for soy protein reducing risk for CVD is its hypocholesterolemic effect. A meta-analysis of 38 clinical trials concluded that intake of 31–47 g soy protein per day was able to reduce serum total and LDL-cholesterol and triglycerides by 9.3%, 12.9% and 10.5%, respectively (Fig. 2).[25] The changes in serum total and LDL-cholesterol concentrations were directly related to the initial serum cholesterol concentrations. Subjects with initial normal serum cholesterol levels and mild hypercholesterolemia did not show significant reduction in serum total cholesterol concentrations (Fig. 3).[25] The hypocholesterolemic effect of soy protein is similar to that of several hypocholesterolemic drugs like resins, niacin and statins, and comparable to that achieved by the American Heart Association (AHA) Step 2 diet.[19]

Nagata *et al.* observed on the relationship between soy products and serum total cholesterol in Japanese men and women.[26] Soy products included in the analysis were tofu, miso, deep-fried tofu and fried beancurd, dried beancurd, fermented soybeans, soy milk and boiled soybeans. These soy products contributed to total soy product intake of 64 g (equivalent to 8 g soy protein) and 54 g (equivalent to 7 g soy protein) for men and women, respectively. A negative trend was observed for decreasing serum total cholesterol concentrations with an increasing intake of soy products in both men and women (Fig. 4).

The underlying mechanism of hypolipidemic effect of soy is complex. Several mechanisms have been reported in human and animal studies: increase faecal bile acid excretion and bile cholesterol saturation index, up-regulate the expression of LDL receptors, affect gene expression, and relatively high proportion of polyunsaturated to saturated fatty acids.[18,20]

Other mechanisms of cardioprotective effect of soy phytoestrogens are through their anti-oxidative properties.[27,28] Oxidative damage to LDL is involved in atherogenesis by accelerating platelet aggregability, injuring arterial wall and increasing lipid accumulation by macrophages.[29]

Soycreme (10.6% protein; 180 mL of a 1:1 soycreme-water mixture) administered to cerebrovascular disease patients was able to protect LDL from copper-induced peroxidation.[27] Another randomised, controlled, cross-over study of a soy-containing vegetarian burger with low [0.9 mg (3.5 µmol) daidzein and 1.0 mg (3.7 µmol) genistein] or high [21.2 mg (84 µmol) daidzein and 34.8 mg (129 µmol) genistein] isoflavone content was undertaken by Wiseman *et al.*[28]

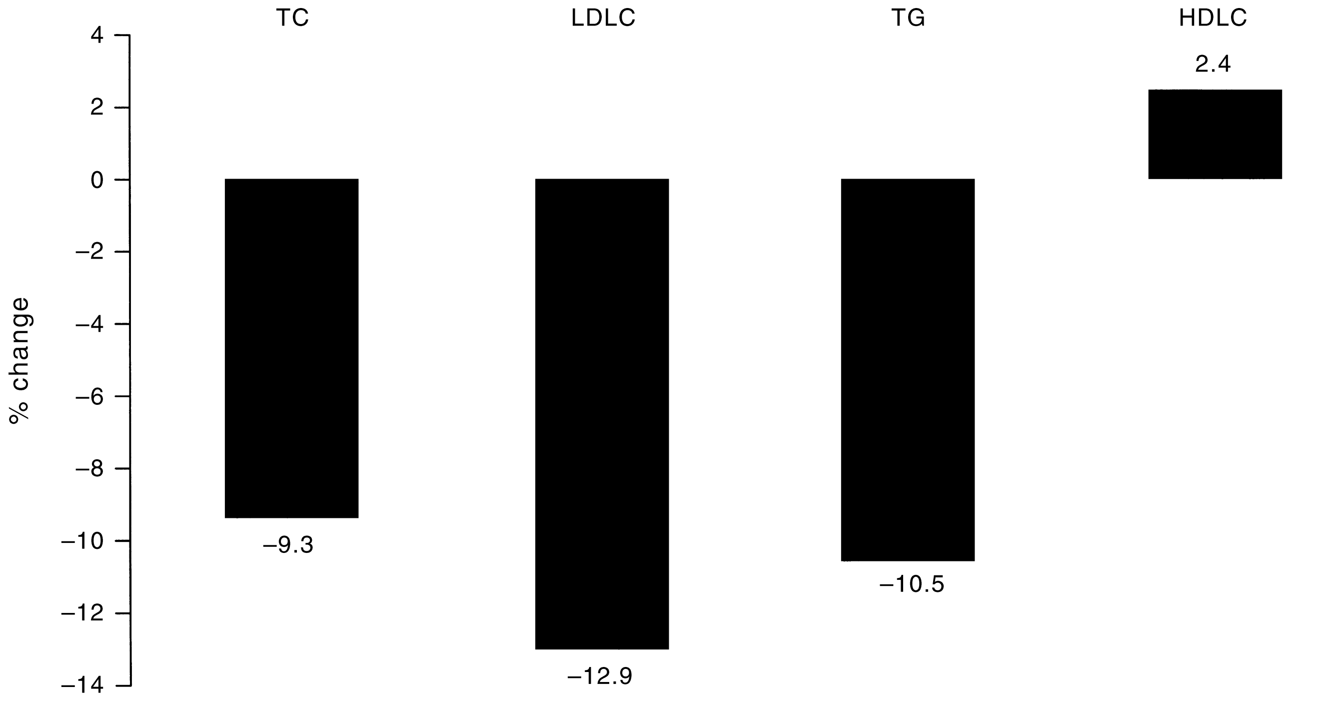

Figure 2. Associations between intake of 31–47 g soy protein/day with net changes in serum lipid concentrations. TC, total cholesterol; LDLC, low-density lipoprotein cholesterol; HDLC, high-density lipoprotein cholesterol. Taken from Reference 25.

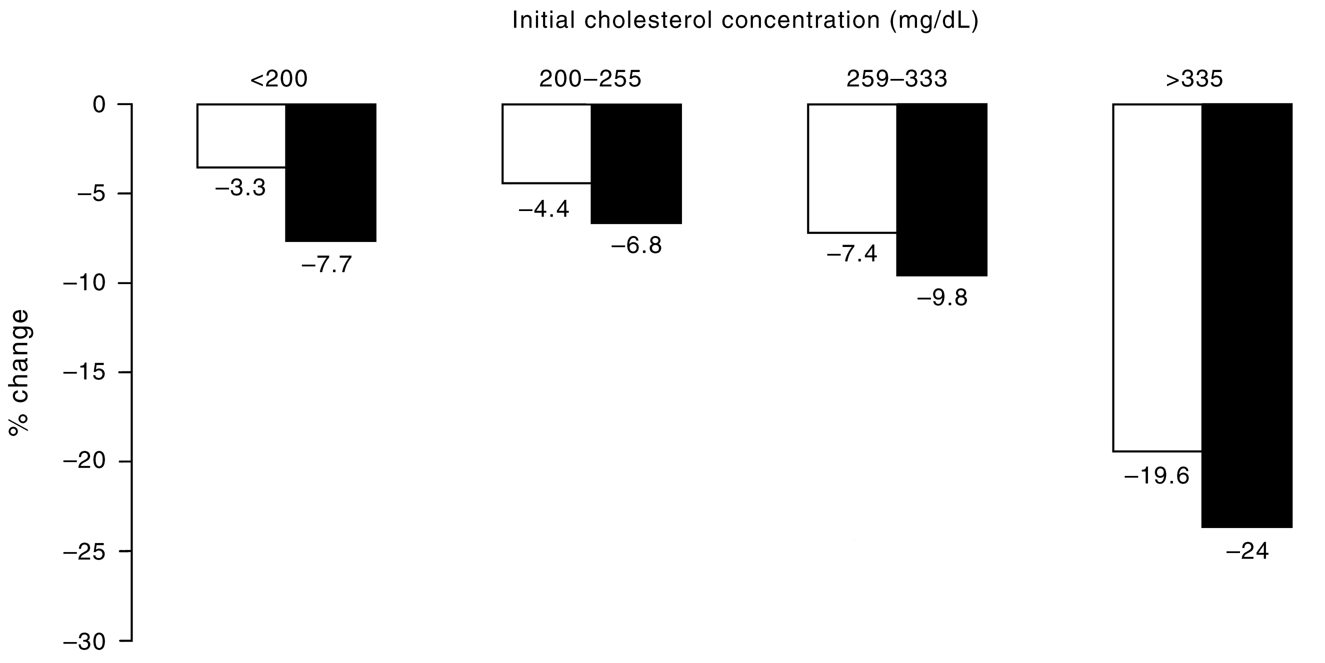

Figure 3. Degree of changes in serum total-cholesterol and LDL-cholesterol concentrations with soy protein supplementation according to quartiles of the initial cholesterol concentration. (■), low-density lipoprotein cholesterol; (□), cholesterol. Taken from Reference 25.

The study demonstrated that, plasma F_2-isoprostane 8-*epi*-prostaglandin $F_{2\alpha}$ (8-*epi*-$PGF_{2\alpha}$), a biomarker of in vivo lipid peroxidation, concentrations were significantly lower in subjects after the high isoflavone treatment than after low isoflavone treatment. Furthermore, the lag-time for copper-ion-stimulated LDL oxidation ex vivo was significantly longer in subjects after the high isoflavone treatment than after low isoflavone treatment.

Clearly, the anti-oxidant action of soy containing naturally occurring amounts of isoflavone phytoestrogens may be significant with respect to risk of atherosclerosis, CVD, and cancer.

Tempe for cardiovascular protection

Tempe, a traditional Indonesian fermented soy food, has been considered nutritious and healthy.[6] In Indonesian culture, tempe is popular not only because of its nutrition value, in addition, tempe tastes well with other foods. Therefore, tempe containing mixed-dishes, like *nasi gudeg* (a traditional mixed-dish from Central Java) and *nasi rames*, are popular in Indonesian culture. As a protein-rich plant food, tempe can be consumed as a meat alternative. The current socioeconomic crisis in Indonesia has caused tremendous decline in animal protein consumption among the poor. However, at-risk communities have to some degree, retained the consumption of traditional soy foods like tofu and tempe.[30] With the growing prevalence of CVD and its risk factors in Indonesia, and findings about the hypolipidemic and anti-oxidative effects of soy phytoestrogens, it is important to consider tempe as a candidate food for cardiovascular protection.

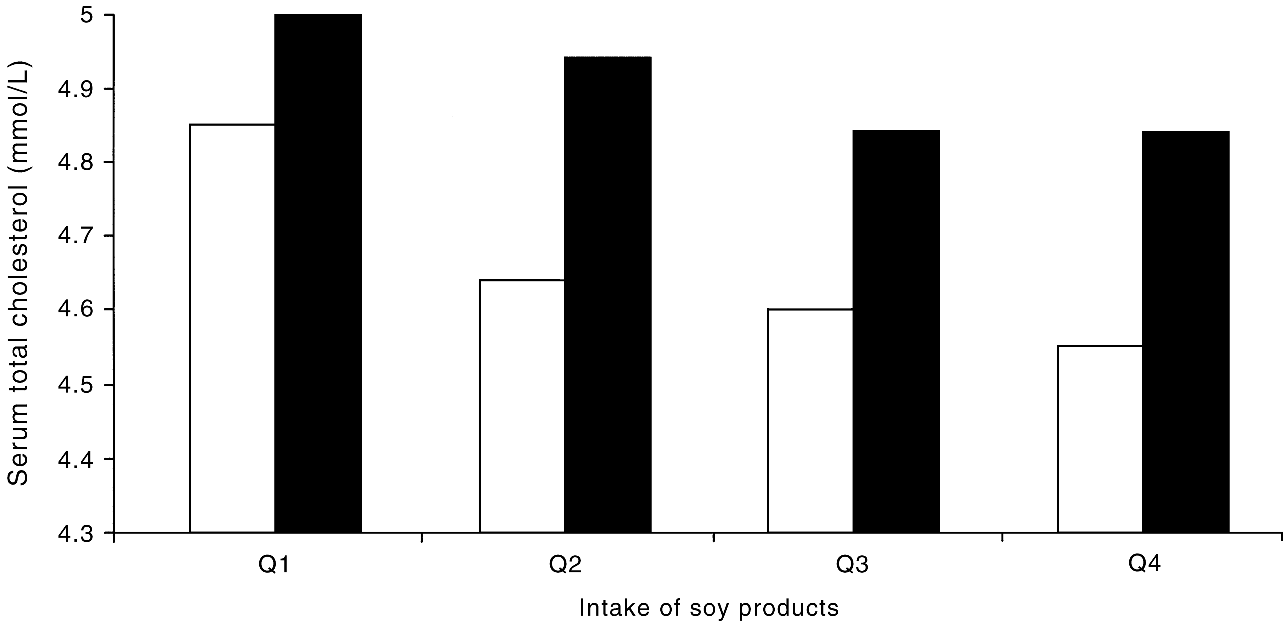

Figure 4. Associations between intake of soy products (according to quartile) and serum total-cholesterol concentration in Japanese men and women. (■), women ($P < 0.0001$); (□), men ($P < 0.0002$). Q1, 23.3 and 24.7 g/day; Q2, 39.5 and 44.9 g/day; Q3, 54.1 and 63.6 g/day; Q4, 91.7 and 108.2 g/day, in women and men, respectively. Taken from Reference 26.

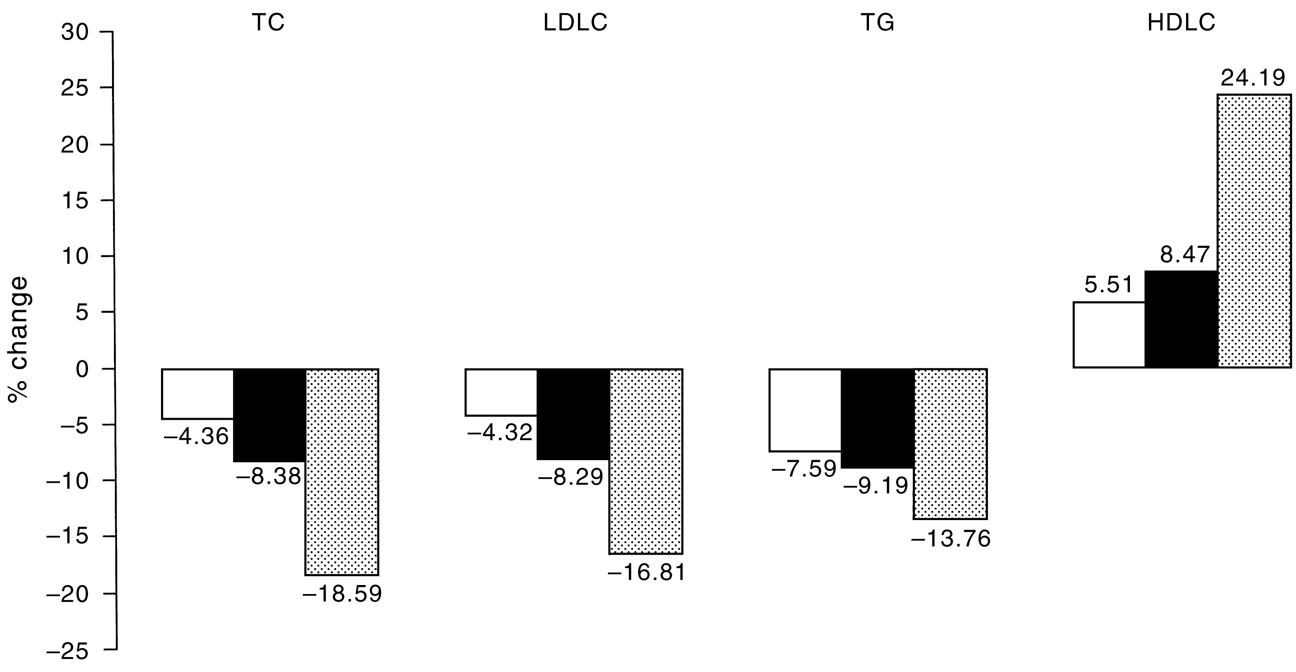

Figure 5. Changes in lipid profiles after 2-week treatment with standard diet and tempe-A5, standard diet and tempe, or standard diet alone. (□), standard diet; (■), standard diet plus tempe; (▩), standard diet plus tempe-A5. TC, total cholesterol; LDLC, low-density lipoprotein cholesterol; HDLC, high-density lipoprotein cholesterol. Taken from Reference 31.

Hypolipidemic effects of tempe have been reported by Brata-Arbai.[31] In her study, 75 dyslipidemic subjects were assigned to receive either a standard diet, a standard diet plus tempe, or a standard diet plus tempe-A5 (a mixture of tempe, flour, lecithin, mixed vegetable oils, and fibre) for 2 weeks. After a 2-week treatment, reduction of serum total cholesterol and LDL-cholesterol was significantly higher in subjects with standard diet plus tempe-A5 than those with standard diet plus tempe or standard diet alone. Serum HDL-cholesterol increased by approximately 24% in subjects treated with standard diet plus tempe-A5, which was much higher than those treated with standard diet plus tempe or standard diet (approximately 9% and approximately 6%, respectively) (Fig. 5). There is also evidence to indicate that tempe may inhibit atherogenesis through its anti-oxidative properties.[32]

Despite unknown exact mechanisms for the hypolipidemic and anti-oxidative properties of tempe, there are indications that retention of traditional foods like tempe may contribute to cardiovascular health among at-risk Indonesians. Further clinical trials are needed to observe whether current findings can be repeated in different cultural settings.

Conclusions

After many years of aversion by authorities to the encouragement of people to have fat containing foods like nuts and soy, and their products, they are now recognised as a wide variety of seeds which can play a major role in protection against CVD, especially when they retain all of their components. Future dietary guidelines must acknowledge the value of these foods for health, not only where they are culturally relevant, but also where culture fusion is underway.

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