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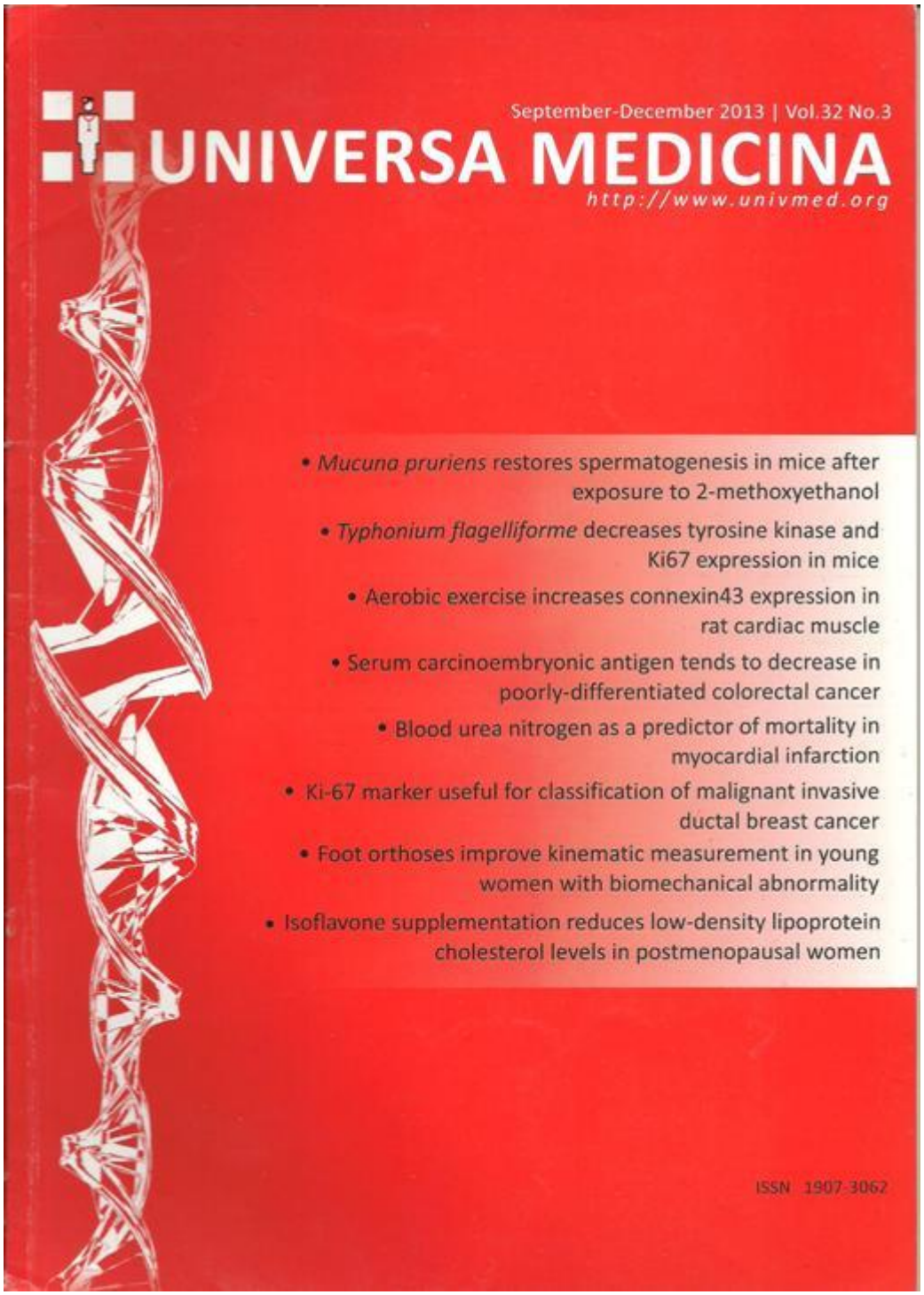

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Prices are given per year
Personal subscription : IDR 300.000,- or USD 30.00
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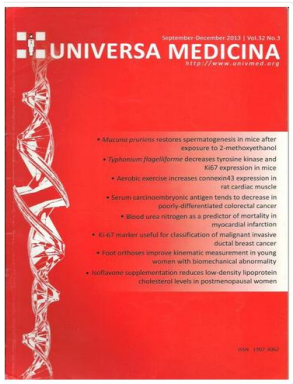

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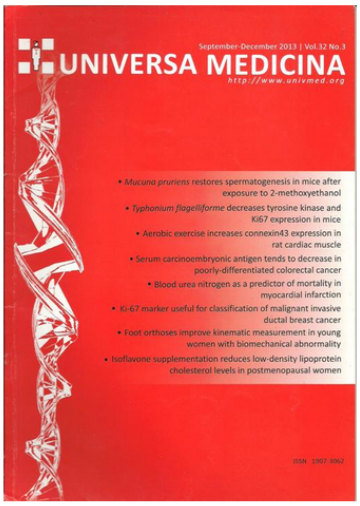
Isoflavone supplementation reduces low-density lipoprotein cholesterol levels in postmenopausal women



PDF

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Abstract

Background
Cardiovascular disease is the main cause of death in postmenopausal women. This study aimed at evaluating the effect of soy isoflavone supplementation on plasma lipid profile in postmenopausal women, since this effect is still unclear.

Methods
A double-blind randomized placebo-controlled trial was conducted from January 2010 until February 2011. In total 180 postmenopausal women were randomized into an isoflavone group and a control group of 90

UNIVERSA MEDICINA

September-December, 2013 *Vol.32 - No.3*

Isoflavone supplementation reduces low-density lipoprotein cholesterol levels in postmenopausal women

Yenny* and Pusparini**

ABSTRACT

BACKGROUND
Cardiovascular disease is the main cause of death in postmenopausal women. This study aimed at evaluating the effect of soy isoflavone supplementation on plasma lipid profile in postmenopausal women, since this effect is still unclear.

METHODS
A double-blind randomized placebo-controlled trial was conducted from January 2010 until February 2011. In total 180 postmenopausal women were randomized into an isoflavone group and a control group of 90 subjects each. The isoflavone group received tablets containing 100 mg soy isoflavones and 500 mg calcium carbonate, while the control group received 500 mg calcium carbonate only. Supplementation was given once daily for 1 year. Plasma lipid levels [triacylglycerol, total, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) cholesterols] were assessed at baseline, and after 6 and 12 months of supplementation using an enzymatic colorimetric method (Cobas c 111, Roche). Independent t-test was used for data analysis.

RESULTS
Baseline subject characteristics and lipid profile in the two groups were comparable. In the isoflavone and control groups after 6 months of supplementation LDL cholesterol levels were 124.9 ± 35.2 mg/dL vs 112 .7 ± 29.7 mg/dL (p=0.013*), respectively, and after 12 months 116.9 ± 31.7 mg/dL vs 109.1 ± 29.8 mg/dL (p=0.086). There were no significant differences in the other lipid levels at 6 and 12 months.

CONCLUSIONS
Soy isoflavone supplementation for 6 months was capable of significantly reducing LDL cholesterol levels in postmenopausal women. No significant changes in total cholesterol, triacylgycerol, and HDL cholesterol were found after isoflavone supplementation.

Key words: Soy isoflavone, serum lipids, postmenopausal

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Univ Med 2013;32:197-207

Suplementasi isoflavon menurunkan kadar kolesterol low-density lipoprotein *pada perempuan pascamenopause*

ABSTRAK

LATAR BELAKANG
Penyakit kardiovaskular merupakan penyebab utama mortalitas pada perempuan pascamenopause. Efek suplementasi isoflavon kedelai terhadap profil lipid plasma masih bersifat kontradiktif. Studi ini bertujuan untuk menilai pengaruh suplementasi isoflavone kedelai terhadap profil lipid dalam plasma pada perempuan pascamenopause.

METODE
Sebuah uji klinik acak tersemar ganda dengan menggunakan kontrol dilakukan antara bulan Januari 2010 – Februari 2011. Sebanyak 180 perempuan pascamenopause dirandomisasi menjadi grup isofalvone (n = 90 subjek) memperoleh tablet berisi 100 mg isoflavone and 500 mg kalsium karbonat, and grup kontrol memperoleh 500 mg kalsium karbonat. Suplementasi diberikan 1x/hari selama 1 tahun. Kadar lipid plasma {kolesterol total, triacylglycerol, *kolesterol* low-density lipoprotein *(LDL), and kolesterol* high-density lipoprotein *(HDL) diukur pada awal studi, bulan ke-6 and 12 pascasuplementasi dengan menggunakan* enzymatic colorimetric method *(Cobas c 111, Roche). Uji t independen digunakan untuk analisis data.*

HASIL
Tidak terlihat adanya perbedaan karakteristik subjek and profil lipd pada awal studi antara kedua grup. Setelah suplementasi isoflavon selama 6 and 12 bulan menunjukkan kadar kolesterol total, triacylcholesterol and kolesterol HDL lipid serum tidak ada perbedaan yang bermakna antara kedua kelompok perlakuann. Kadar kolesterol LDL pada kelompok isoflavon and kontrol setelah suplementasi 6 bulan besarnya 124.9 ± 35.2 mg/dL vs 112 .7 ± 29.7 mg/dL (p= 0,013), and 116,9 ± 31,7 mg/dL vs 109,1 ± 29,8 mg/dL (p= 0,086).*

KESIMPULAN
Suplementasi isoflavone kedelai selama 6 bulan mampu menurunkan kadar kolesterol LDL secara bermakna pada perempuan pascamenopause. Tidak terlihat adanya penurunan yang bermakna dari suplementasi isoflavone terhadap kadar kolesterol total, triacylgycerol, *and kolesterol HDL.*

Kata kunci: *isoflavon kedelai, lipid serum, pascamenopause*

INTRODUCTION

Cardiovascular disease is the main cause of death in women throughout the world. The US National Vital Statistics Reports indicate that 24% of women aged 45–74 years die from cardiovascular disease.[1]

Menopause is one of the risk factors for cardiovascular disease. Estrogen deficiency in menopause is associated with significant changes in lipoprotein metabolism, characterized by increased plasma lipid levels (dyslipidemia) during the postmenopausal years.[2] The dyslipidemia is marked by increased total cholesterol (TC), low density lipoprotein (LDL) cholesterol and/or decreased high density lipoprotein (HDL) cholesterol.[3] The prevalence of dyslipidemia in postmenopausal women is 39%.[4] Preventive measures to reduce the increase in plasma lipids is frequently associated with a decreased risk of cardiovascular disease.[2]

Deaths from cardiovascular disease are lower in Asian countries, as compared with those in Western countries, with their very different dietary patterns; one outstanding difference is that Asian populations consume more soybeans.[5] Soybean products are beginning to attract interest because of their pleiotropic effects and their utilization for prevention of many disease conditions, such as metabolic diseases, chronic inflammatory diseases, and cancers, due to their isoflavone content.[6] Estimated soybean isoflavone intake in Asian countries is 25-50 mg per day (expressed as aglycone equivalent),[7] whereas isoflavone intake of American women is less than 1 mg per day.[8] This difference in dietary pattern leads to the suggestion of a role of isoflavones on cardiovascular events.

Isoflavones are plant estrogens (phytoestrogens), most abundantly found in soybeans, and composed mainly of genistein, daidzein, and glycitein. They are structurally similar to 17-â-estradiol, causing them to bind to estrogen receptors (ER), thus mimicking the effects of estrogens on target organs. There are 2 types of estrogen receptor expressed in different tissues, with ERα receptors being expressed in the uterus, hypotalamus/pituitary, and skeleton, whereas ERâ receptors are expressed in the ovaries, cardiovascular system, and the brain. The affinity of genistein for ERâ is from 20 to 30 times higher than for ERα, and is comparable to the affinity of 17-â-estradiol for these receptors.[9] The abovementioned properties of soybean isoflavones enable these micronutrients to replace the functions of estrogens in postmenopausal women.

There are various theories on the mechanism of action of soy isoflavones in lowering the plasma lipid levels. According to one theory, soy isoflavones activate ERβ and decrease lipoprotein lipase activity, thus decreasing lipogenesis and adipocyte differentiation. Another mechanism may be through peroxisome proliferator activated receptors (PPAR α and PPARγ) that control the transcription of genes involved in the regulation of fatty acid metabolism, and as tyrosine kinase inhibitors that inhibit phosphorylation of several elements required for adipocyte differentiation.[10,11]

The soy isoflavones vary in their effect on prevention of cardiovascular disease, particularly reduction of plasma lipid levels. A meta-analysis conducted by Zhan et al. showed that an intake of soy proteins with an isoflavone content of ≥ 80 mg/day may reduce total cholesterol, LDL cholesterol, and triacylglycerol levels by 3.8%, 5.3%, and 7.3%, respectively, while increasing HDL cholesterol by 3%.[12] A meta-analysis by Prediger et al.[13] showed that isoflavone-containing soy proteins result in a significant decrease in total cholesterol levels (by 5.34 mg/dL, or 2.4%). However, no significant effect was shown with regard to LDL cholesterol, HDL cholesterol, or triglycerides. A systematic review showed that isoflavones have a slightly significant effect on triglycerides in comparison with placebo (mean difference – 0.46 mmol/L), but have no statistically significant effect on total cholesterol, LDL cholesterol, and HDL cholesterol.[14] The abovementioned meta-analyses included all subjects and were not exclusively for postmenopausal women. The objective of the present study was to evaluate the effect of soy isoflavone supplementation for 12 months on plasma lipid levels (total cholesterol, triacylglycerol, LDL cholesterol, and HDL cholesterol) in postmenopausal women.

METHODS

Design of the study

This experimental study was designed as a double-blind randomized placebo-controlled clinical trial. The study was conducted in the catchment area of the District Health Center, Mampang Prapatan, South Jakarta, from January 2010 until February 2011.

Study subjects

The inclusion criteria used in this study were: women 47 – 60 years of age, being at post-

menopause (having had no menstrual periods for minimally 1 year and maximally 10 years), the menopause being a natural menopause (not induced by total hysterectomy, bilateral oophorectomy, radiation, or chemotherapy), not taking drugs and supplements during the last 6 months (hormonal drugs such as glucocorticoids, anticoagulants, antihyperlipidemic drugs, antihypertensive drugs, isoflavone-containing supplements, and oral antidiabetics), agreeing to participate in the study by signing informed consent, capable of walking unassisted, and able to communicate. The subjects were excluded from the study if they had malignant disease (such as mammary, cervical, and endometrial cancers) or severe psychotic disorders, such as schizophrenia. The calculated sample size per group was 90, which was estimated to be adequate to detect a 30% difference in the mean lipid profile values between the treatment groups using a two-tailed test, an alpha of 0.05, and a power of 80%.

The Mampang Prapatan District in South Jakarta consists of five *kelurahan* (villages), from which four were selected by multistage cluster random sampling. From the four selected *kelurahan*, two *Rukun Warga* (RW) were chosen, and from each RW five *Rukun Tetangga* (RT, a kind of neighborhood association) were taken. In total 40 RTs were selected. From each RT a list of postmenopausal women was made. By simple random sampling the study subjects were selected from among the postmenopausal women in each of the 40 RTs. The sample sizes in each RT was determined proportionally according to the available numbers of postmenopausal women.

Intervention

The soybean isoflavone extract was imported from Hui Song Pharmaceuticals, China. The supplement tablets used in this study were prepared, packed, and labelled by PT. Ikapharmindo Putramas, Indonesia. Each supplement tablet contained 250 mg soybean extract, equivalent to 100 mg isoflavone aglycones (comprising genistein 56%, daidzein 41%, and glycitein 3%) and 500 mg calcium carbonate. The placebo (control) tablets contained 500 mg calcium carbonate. The form, color, and flavor of the supplement and control tablets were identical.

The supplements were assigned to the two groups in a double-blind manner. The tablets in each group were given once daily by the oral route after breakfast, between 07.00 – 10.00 Western Indonesian Time (WIB). The supplementation was given by cadres at home visits, when the supplements were taken directly in front of the cadres. A checklist was used to note daily tablet consumption and any complaints arising during supplementation.

Measurement of physical characteristics

Height in kg was measured by means of a portable microtoise at an accuracy of 0.1 cm. Weight in kg was determined using Sage portable scales at an accuracy of 0.1 kg. Body mass index (BMI) was calculated by dividing the weight in kg by the square of the height in m. Threshold values for BMI were according to the criteria issued in 2013 by the Department of Health of the Republic of Indonesia *(Depkes RI)*. The *Depkes RI* BMI threshold criteria for women are as follows: underweight (<18 kg/m^2), normal weight (18-25 kg/m^2), overweight (25–27 kg/m^2), obese (>27 kg/m^2). In the present study, BMI values were categorized into normal/ underweight $\leq$24.9 kg/m^2 and overweight $\geq$ 25 kg/m^2.[15]

Laboratory analysis

A 10 mL venous blood sample was collected from each subject after a 12-hour fast for determination of lipid levels (total cholesterol, triacylglycerol, HDL cholesterol, and LDL cholesterol). Normal lipid levels according to the Adult Treatment Panel III (ATP III) guidelines are: total cholesterol <200 mg/dL, triacylglycerol <150 mg/dL, LDL cholesterol <130 mg/dL, HDL cholesterol > 40 mg/dL.[16] Blood samples were collected three times, i.e. before soy isoflavone supplementation (baseline), after 6 months of

supplementation, and after 12 months of supplementation. The venous blood samples were centrifuged at 2000 RPM for 10 minutes. The obtained serum was frozen at -70°C pending laboratory investigations, which were performed simultaneously for samples of all subjects before supplementation and after 6 and 12 months of supplementation. Total cholesterol, triacylglycerol, LDL cholesterol, and HDL cholesterol were assessed by means of an enzymatic colorimetric method (Cobas c 111, Roche).

Assessment of compliance

Subject compliance in this study was determined by observing the subjects taking the supplementation tablets in front of the cadres, by counting the tablets remaining in the bottle at the end of each month, and by measuring blood soy isoflavone levels at baseline and at the completion of the study. The subjects were categorized as drop-outs if they failed to take supplements for 7 consecutive days or if the total tablets consumed was < 90% (151 tablets) for the 6-month trial. For the 12-month trial, the criteria were 14 consecutive days or < 90% (328 tablets), respectively.

Statistical analysis

Normality of data distribution was determined by means of the Kolmogorov-Smirnov test. The independent t-test was used to find differences between the isoflavone and control groups in subject characteristics, total cholesterol, triacylglycerol, LDL cholesterol and HDL cholesterol at baseline, after 6 months, and after 12 months. A p of <0.05 was considered statistically significant. The software used for statistical analysis was the Statistical Program for Social Sciences (SPSS) version 17.

Ethical clearance

The study protocol was approved by the Committee on Research Ethics of the Faculty of Medicine, Trisakti University.

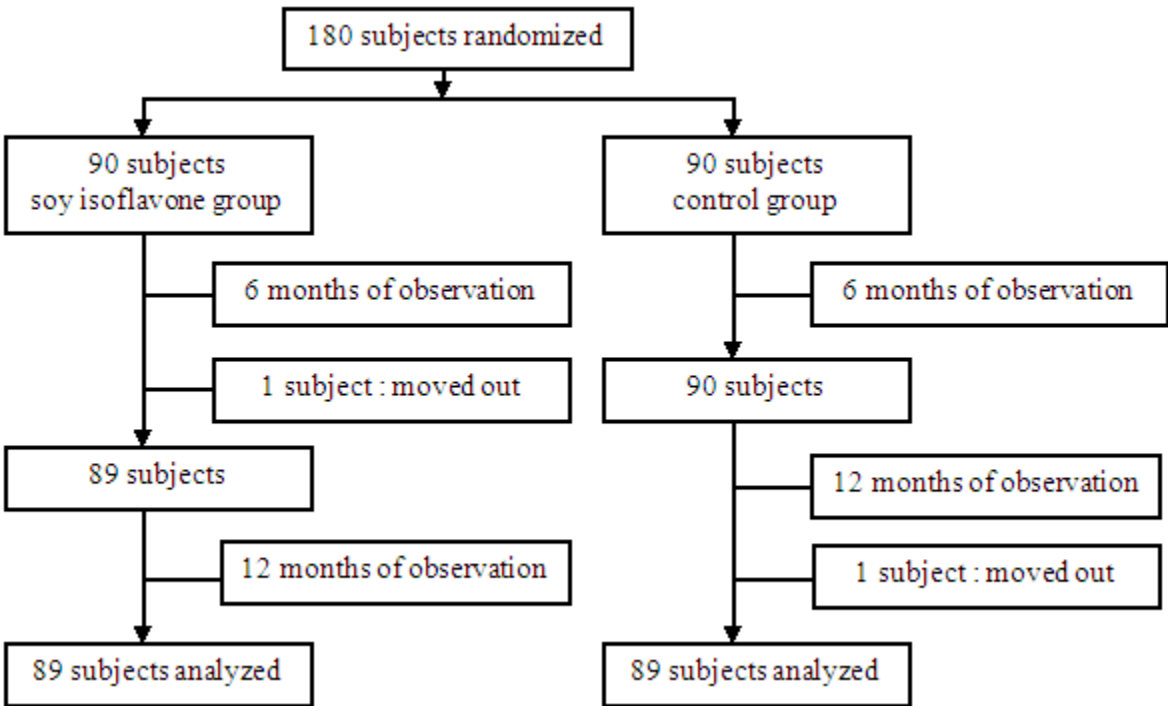

Figure 1. Flow of subject participation during study

Table 1. Distribution of demographic and physical characteristic of the subjects at baseline by treatment groups

Characteristic	Isoflavone (n = 90)	Control (n = 90)	p
Age (years) [a)]	53.4 ± 3.5	53.5 ± 3.5	0.833
Duration of menopause (years) [a)]	4.5 ± 2.1	4.4 ± 2.4	0.683
Marital status [b)]			
Married	59 (65)	64 (71)	0.395
Not married/widowed	31 (35)	26 (29)	
Educational level [b)]			
Low (none - primary school)	60 (66.7)	62 (68.9)	0.726
Medium (junior – senior high)	27 (30)	27 (30)	
High (academy/university)	3 (3.3)	1 (1.1)	
Employment [b)]			
Employed	49 (54.5)	35(38.9)	0.242
Unemployed	41(45.5)	55 (61.1)	
Blood pressure [a)]			
Systolic (mmHg)	125.44 ± 22.93	124.08 ±19.57	0.665
Diastolic (mmHg)	78.56 ± 13.37	78.64 ±11.90	0.964
Body mass index (kg/m^2) [a)]	26.79 ± 4.75	26.67 ± 4.73	0.863
Total cholesterol (mg/dL) [a)]	209.91 ±38.35	204.15 ± 34.78	0.290
Triacyglycerol (mg/dL) [a)]	121.82 ± 82.49	108.74 ±42.19	0.178
LDL cholesterol (mg/dL) [a)]	134.07 ± 34.76	125.51 ± 32.09	0.086
HDL cholesterol (mg/dL) [a)]	55.38 ± 11.44	58.90 ±12.64	0.050

[a)]Values are mean ± standard deviation; [b)] number of subjects (%); [c)] p values calculated by independent t-test

RESULTS

At the start of the study, 180 women postmenopausal women meeting the inclusion and exclusion criteria were randomized into two groups, i.e. the isoflavone group and the control group, each comprising 90 women. After 6 months of supplementation, one subject in the isoflavone group dropped out, as she moved out of the study area, whereas no drop-outs occurred in the control group.

At the completion of the study, after 12 months of supplementation, there were no drop-outs in the soy isoflavone group, whereas in the control group one subject dropped out, because she returned to her native village to get married. The data collected for statistical analysis were from 178 subjects (89 in each group). The flow of subject participation may be seen in Figure 1.

The distribution of subject characteristics at baseline between the isoflavone and control groups is presented in Table 1. Mean age was 53.4 ± 3.5 years in the isoflavone group vs 53.5 ± 3.5 years in the control group, duration of menopause was 4.5 ± 2.1 years vs 4.4 ± 2.4 years, most subjects were married (65% vs 71%), and of low educational level (66.7% vs 68.9%). In the isoflavone group 54.5% were employed, while in the control group 61.1% were unemployed.

The independent t-test did not find any significant differences between the isoflavone group and the control group in the baseline distribution of the various variables, either demographic or physical, including plasma lipids, with all p values being above significance level. This indicates that the randomization performed in this study had successfully distributed all variables uniformly between the two groups, except for the treatment variable.

Table 2 presents the total cholesterol, triacylglycerol, LDL cholesterol, and HDL cholesterol levels after supplementation for 6

Table 2. Mean lipid profiles after 6 months and 12 months of supplementation by treatment groups

Cholesterol (mg/dL)	Isoflavone (n=89)	Control (n-89)	p
After 6 months supplementation			
Total cholesterol	208.2 ± 37.4	198.2 ± 35.6	0.070
Triacylglycerol	129.6 ± 89.1	119.2 ± 55.9	0.347
LDL cholesterol	124.9 ± 35.2	112.7 ± 29.7	0.013*
HDL cholesterol	59.5 ± 14.4	61.7 ± 13.7	0.296
After 12 months supplementation			
Total cholesterol	197.0 ± 37.3	188.5 ± 34.8	0.114
Triacylglycerol	123.8 ± 74.7	106.3 ± 46.3	0.060
LDL cholesterol	116.9 ± 31.7	109.1 ± 29.8	0.086
HDL cholesterol	55.9 ± 14.1	58.0 ± 12.3	0.309

Values are mean ± S.D.; p values calculated by independent t-test; *significance
HDL = high density lipoprotein; LDL= low density lipoprotein

and 12 months. The total cholesterol level in the isoflavone group vs control group after supplementation for 6 months was 208.2 ± 37.4 mg/dL vs 198.2 ± 35.6 mg/dL (p=0.070), while after 12 months it was 197.0 ± 37.3 mg/dL vs 188.5 ± 34.8 mg/dL (p=0.114). There was therefore a reduction in total cholesterol levels at 6 and 12 months, both in the isoflavone group and control group, but the reduction was statistically not significant.

As for triacylglycerol and HDL cholesterol levels in the isoflavone and control groups after 6 months and 12 months of supplementation, they increased at 6 months, but decreased again at 12 months approaching baseline levels, both in the isoflavone and control groups, but the changes were statistically not significant.

Only for LDL cholesterol levels in the isoflavone vs control groups was there a significant decrease after 6 months of supplementation (124.9 ± 35.2 mg/dL vs 112.7 ± 29.7 mg/dL (p= 0.013*). However, a further reduction after 12 months of supplementation was statistically not significant (116.9 ± 31.7 mg/dL vs 109.1 ± 29.8 mg/dL (p= 0.086) (Figure 2).

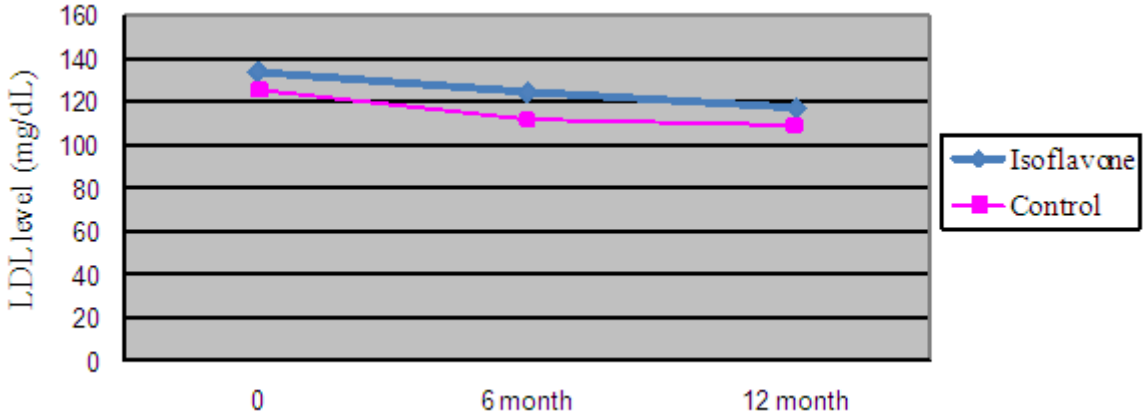

Figure 2. Levels of LDL cholesterol at baseline, at 6 months and 12 months in the isoflavone group and control group. A significant reduction is seen at 6 months

ADVERSE EVENTS

There were no life-threatening adverse events during the conduct of this study. There were no subjects who dropped out for clinical reasons. The complaints reported in both groups were knee pain, leg pain and leg ache, paresthesia, back pain, headache, and increased appetite.

DISCUSSION

The results of this study showed that administration of soy isoflavones at 100 mg/day to postmenopausal women significantly reduced their LDL cholesterol levels after 6 months of supplementation (9.2 mg/dL or 6.86%). After 12 months of supplementation LDL cholesterol decreased steadily but nonsignificantly. There were no reductions in other serum lipid levels at 6 and 12 months. These results did not markedly differ from those of the studies by Yang et al.[17] and Taku et al.[18]

The study conducted by Yang et al.[17] on 130 healthy postmenopausal Taiwanese women showed that soy isoflavone supplementation for 6 months succeeded in significantly reducing the levels of total cholesterol in the isoflavone and control groups by 4.5 and 3.06%, respectively, and the LDL levels by 4.67 and 5.09%, respectively, in patients with total cholesterol levels of >200 mg/dL. In our study the reduction in LDL levels was higher than that in the study by Yang et al.[17] (6.86% vs 5.09%), which presumably was the result of the larger dose of soy isoflavones which we used (100 mg vs 70 mg). Apart from LDL, our study did not find any effect of isoflavones on other serum lipid levels. The marked differences of Yang's study with ours were in the open labeled study design, which was randomized but used no controls, and involved women of normal weight. The meta-analytic study performed by Taku et al.[18] evaluated the effects of soy protein intake on lipid profiles in men and in premenopausal as well as postmenopausal women. The meta-analysis indicated that soy isoflavones significantly reduced serum total cholesterol and LDL cholesterol levels, but not HDL cholesterol and triacylglycerol levels.

The study by Mangano et al.[19] was conducted on 131 healthy women over 60 years of age, who were overweight, and had moderate hypercholesterolemia. The aim of the study was to evaluate the long term effects on serum lipids and inflammatory markers of soy protein supplementation (18 g/day) and/or soy isoflavones (105 mg/day aglycone equivalent), either separately or in combination. After a one-year intervention no significant effect was seen of the soy protein and isoflavone interventions on serum lipids, lipids ratio, or inflammatory markers. In subjects who were equol producers, significant effects of respectively -5.9% and -7.2% were found on the total cholesterol/HDL and LDL/HDL ratios.

The optimal effective dose of soy isoflavones capable of exerting a therapeutic effect is to date still not known with certainty. Various studies on the effect of isoflavones in reducing serum lipids have used varying values for the dose and duration of therapy, e.g. 35 mg (6 months),[17] 60 mg (12 weeks),[20] and 164 mg (10 weeks).[21] The dose of soy isoflavone extract used in our study was 100 mg/day (aglycone equivalent).

The studies investigating the effect of isoflavones on reduction of serum lipids in postmenopausal women generally use soy proteins with a certain isoflavone content, thus leading to uncertainty whether the reduction in serum lipids are due to the soy protein itself or to its isoflavone content. One of such studies was performed by Jassi et al.,[20] where in spite of a reduction in serum lipids of the controls after soy protein supplementation, no significant changes were seen in the isoflavone group, indicating that apart from isoflavones, soy protein has other components that are responsible for the hypocholesterolemic effect after soy protein administration.

Our study found no reduction in serum lipid

levels other than LDL cholesterol, either after 6 months or 12 months of supplementation, similar to the findings of Yang et al.[17] and Taku et al.[18] The nonsignificant reduction in LDL cholesterol after 6 months of supplementation in our study may be the result of the unsupervised dietary intake of the subjects, or of the longer duration of supplementation, which was continued after plateau levels had been attained. This view is supported by a review performed by Manach et al.[22] on studies evaluating the bioavailability of soy isoflavones for 1-3 months, indicating that continuous supplementation does not increase blood isoflavone levels.

The absence of isoflavone effects on serum lipids is also seen with several other studies. The study by Ho et al.[23] was a one-year study conducted on 203 postmenopausal Chinese women. These investigators are of the opinion that the weakly estrogenic effect obtained from an isoflavone dose of 40-80 mg/day or from the usual intakes in Asian populations is inadequate to counteract the effects of postmenopause in increasing cholesterol levels. The study was conducted on postmenopausal women with mean age of 54 years and mean duration of menopause of 4 years, thus resembling our study subjects. The study of Ho et al.[23] differed from ours in the source of isoflavones (The Netherlands) and the percentages of the isoflavone components (genistein 14.7%, daidzein 46.4%, and glycetein 38.8%). Furthermore, although their study used the same duration of supplementation as in our study (1 year), the study by Ho et al.[23] did not determine plasma lipids at 6 months. Therefore, any significant changes in LDL cholesterol levels at 6 months would escape observation.

The study conducted by Rios et al.[24] on 47 postmenopausal women aged 47–66 years, receiving 40 mg isoflavones vs casein for 6 months, aimed at evaluating the effect of soy isoflavone supplementation on lipid profile, also did not show any significant effects. The small sample size of the study and the occurring changes in dietary pattern and in physical exercise may presumably account for its nonsignificant results.

No life-threatening adverse events were found in our study, in agreement with the meta-analytic results of Qin et al.[14] The reported complaints in our study subjects were knee pain, leg pain and leg ache, paresthesia, back pain, headache, and increased appetite, whereas in the meta-analysis by Qin et al.[14] the complaints were gastrointestinal (bloating and constipation). In the study conducted by Steinberg et al.[25] using soy hypocotyl isoflavones at 80–120 mg, a significant increase in blood urea nitrogen was found after a 2-year supplementation.

The strengths of our study are in the double-blind randomized controlled design, sufficiently large sample size, low drop-out rate (1%), and high compliance of participants up to the completion of the supplementation (99.9%).

A limitation of this study is the lack of control on daily food consumption by the subjects, so that the study results may have been affected by the consumption of foods high in isoflavones or fatty acids. It should also be borne in mind that the isoflavone extract used in our study was from China, with a presumably different composition than isoflavone extracts from other countries, while the processing method may also affect the isoflavone content.[26]

Further pharmacokinetic studies on isoflavones are required in Indonesian postmenopausal women, since the bioavailability of drugs is affected by absorption and metabolism, leading to variable effects due to polymorphisms in the genes encoding metabolic enzymes.[27] In addition, studies are needed to detect genetic polymorphisms of the ERβ gene in Indonesian postmenopausal women. According to one study, [28] the genotype deriving benefits from isoflavones are the AA AluI genotype of ERβ (associated with increased risk for cardiovascular disease) and the Tsp509I SNP in the ERβ ex splice variant of the AA genotype, with increased plasma HDL cholesterol levels after soy isoflavone supplementation.[28]

The reduction in LDL cholesterol in our study is greater than that in the statement of the American Heart Association (AHA) advisory paper (6.86% vs 3%), but the effect lasted only up to 6 months postsupplementation. Our study supports the AHA advisory statement that the effect of isoflavones in reducing cardiovascular risk factors (serum lipids) in postmenopausal women is "minimal at best".[29]

CONCLUSIONS

Soy isoflavone supplementation reduced LDL cholesterol levels in postmenopausal women significantly after six months, but non-significantly after twelve months. No significant difference was found on the effect of isoflavones in decreasing total cholesterol, triacylgycerol, and HDL cholesterol levels, both at 6 months and at 12 months.

ACKNOWLEDGEMENTS

The investigators thank all study participants for their cooperation, and the Dean of the Faculty of Medicine, Trisakti University, for the funding of this study. We also thank Ikapharmindo Pharmaceuticals for preparing the supplements for this trial.

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Isoflavone supplementation reduces low-density lipoprotein cholesterol levels in postmenopausal women

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WORD COUNT	5813	TIME SUBMITTED	24-DEC-2025 07:56PM
		PAPER ID	119642263

UNIVERSA MEDICINA

September-December, 2013 Vol.32 - No.3

Isoflavone supplementation reduces low-density lipoprotein cholesterol levels in postmenopausal women

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ABSTRACT

BACKGROUND
Cardiovascular disease is the main cause of death in postmenopausal women. This study aimed at evaluating the effect of soy isoflavone supplementation on plasma lipid profile in postmenopausal women, since this effect is still unclear.

METHODS
A double-blind randomized placebo-controlled trial was conducted from January 2010 until February 2011. In total 180 postmenopausal women were randomized into an isoflavone group and a control group of 90 subjects each. The isoflavone group received tablets containing 100 mg soy isoflavones and 500 mg calcium carbonate, while the control group received 500 mg calcium carbonate only. Supplementation was given once daily for 1 year. Plasma lipid levels [triacylglycerol, total, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) cholesterols] were assessed at baseline, and after 6 and 12 months of supplementation using an enzymatic colorimetric method (Cobas c 111, Roche). Independent t-test was used for data analysis.

RESULTS
Baseline subject characteristics and lipid profile in the two groups were comparable. In the isoflavone and control groups after 6 months of supplementation LDL cholesterol levels were 124.9 ± 35.2 mg/dL vs 112 .7 ± 29.7 mg/dL (p=0.043*), respectively, and after 12 months 116.9 ± 31.7 mg/dL vs 109.1 ± 29.8 mg/dL (p=0.086). There were no significant differences in the other lipid levels at 6 and 12 months.

CONCLUSIONS
Soy isoflavone supplementation for 6 months was capable of significantly reducing LDL cholesterol levels in postmenopausal women. No significant changes in total cholesterol, triacylgycerol, and HDL cholesterol were found after isoflavone supplementation.

Key words: Soy isoflavone, serum lipids, postmenopausal

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Univ Med 2013;32:197-207

Suplementasi isoflavon menurunkan kadar kolesterol low-density lipoprotein *pada perempuan pascamenopause*

ABSTRAK

LATAR BELAKANG

Penyakit kardiovaskular merupakan penyebab utama mortalitas pada perempuan pascamenopause. Efek suplementasi isoflavon kedelai terhadap profil lipid plasma masih bersifat kontradiktif. Studi ini bertujuan untuk menilai pengaruh suplementasi isoflavone kedelai terhadap profil lipid dalam plasma pada perempuan pascamenopause.

METODE

Sebuah uji klinik acak tersemar ganda dengan menggunakan kontrol dilakukan antara bulan Januari 2010 – Februari 2011. Sebanyak 180 perempuan pascamenopause dirandomisasi menjadi grup isofalvone (n = 90 subjek) memperoleh tablet berisi 100 mg isoflavone and 500 mg kalsium karbonat, and grup kontrol memperoleh 500 mg kalsium karbonat. Suplementasi diberikan 1x/hari selama 1 tahun. Kadar lipid plasma (kolesterol total, triacylglycerol, *kolesterol* low-density lipoprotein *(LDL), and kolesterol* high-density lipoprotein *(HDL) diukur pada awal studi, bulan ke-6 and 12 pascasuplementasi dengan menggunakan* enzymatic colorimetric method *(Cobas c 111, Roche). Uji t independen digunakan untuk analisis data.*

HASIL

Tidak terlihat adanya perbedaan karakteristik subjek and profil lipd pada awal studi antara kedua grup. Setelah suplementasi isoflavon selama 6 and 12 bulan menunjukkan kadar kolesterol total, triacylcholesterol and kolesterol HDL lipid serum tidak ada perbedaan yang bermakna antara kedua kelompok perlakuann. Kadar kolesterol LDL pada kelompok isoflavon and kontrol sebelum suplementasi 6 bulan besarnya 124.9 ± 35.2 mg/dL vs 112 .7 ± 29.7 mg/dL (p= 0,013), and 116,9 ± 31,7 mg/dL vs 109,1 ± 29,8 mg/dL (p= 0,086).*

KESIMPULAN

Suplementasi isoflavone kedelai selama 6 bulan mampu menurunkan kadar kolesterol LDL secara bermakna pada perempuan pascamenopause. Tidak terlihat adanya penurunan yang bermakna dari suplementasi isoflavone terhadap kadar kolesterol total, triacylgycerol, *and kolesterol HDL.*

Kata kunci: *isoflavon kedelai, lipid serum, pascamenopause*

INTRODUCTION

Cardiovascular disease is the main cause of death in women throughout the world. The US National Vital Statistics Reports indicate that 24% of women aged 45–74 years die from cardiovascular disease.[1]

Menopause is one of the risk factors for cardiovascular disease. Estrogen deficiency in menopause is associated with significant changes in lipoprotein metabolism, characterized by increased plasma lipid levels (dyslipidemia) during the postmenopausal years.[2] The dyslipidemia is marked by increased total cholesterol (TC), low density lipoprotein (LDL) cholesterol and/or decreased high density lipoprotein (HDL) cholesterol.[3] The prevalence of dyslipidemia in postmenopausal women is 39%.[4] Preventive measures to reduce the increase in plasma lipids is frequently associated with a decreased risk of cardiovascular disease.[2]

Deaths from cardiovascular disease are lower in Asian countries, as compared with those in Western countries, with their very different dietary patterns; one outstanding difference is that Asian populations consume more soybeans.[5] Soybean products are beginning to attract interest because of their pleiotropic effects and their utilization for prevention of many disease conditions, such as metabolic diseases, chronic inflammatory diseases, and cancers, due to their isoflavone content.[6] Estimated soybean isoflavone intake in Asian countries is 25-50 mg per day (expressed as aglycone equivalent),[7] whereas isoflavone intake of American women is less than 1 mg per day.[8] This difference in dietary pattern leads to the suggestion of a role of isoflavones on cardiovascular events.

Isoflavones are plant estrogens (phytoestrogens), most abundantly found in soybeans, and composed mainly of genistein, daidzein, and glycitein. They are structurally similar to 17-â-estradiol, causing them to bind to estrogen receptors (ER), thus mimicking the effects of estrogens on target organs. There are 2 types of estrogen receptor expressed in different tissues, with ERα receptors being expressed in the uterus, hypotalamus/pituitary, and skeleton, whereas ERâ receptors are expressed in the ovaries, cardiovascular system, and the brain. The affinity of genistein for ERâ is from 20 to 30 times higher than for ERα, and is comparable to the affinity of 17-â-estradiol for these receptors.[9] The abovementioned properties of soybean isoflavones enable these micronutrients to replace the functions of estrogens in postmenopausal women.

There are various theories on the mechanism of action of soy isoflavones in lowering the plasma lipid levels. According to one theory, soy isoflavones activate ERβ and decrease lipoprotein lipase activity, thus decreasing lipogenesis and adipocyte differentiation. Another mechanism may be through peroxisome proliferator activated receptors (PPAR α and PPARγ) that control the transcription of genes involved in the regulation of fatty acid metabolism, and as tyrosine kinase inhibitors that inhibit phosphorylation of several elements required for adipocyte differentiation.[10,11]

The soy isoflavones vary in their effect on prevention of cardiovascular disease, particularly reduction of plasma lipid levels. A meta-analysis conducted by Zhan et al. showed that an intake of soy proteins with an isoflavone content of ≥ 80 mg/day may reduce total cholesterol, LDL cholesterol, and triacylglycerol levels by 3.8%, 5.3%, and 7.3%, respectively, while increasing HDL cholesterol by 2%.[12] A meta-analysis by Prediger et al.[13] showed that isoflavone-containing soy proteins result in a significant decrease in total cholesterol levels (by 5.34 mg/dL, or 2.4%). However, no significant effect was shown with regard to LDL cholesterol, HDL cholesterol, or triglycerides. A systematic review showed that isoflavones have a slightly significant effect on triglycerides in comparison with placebo (mean difference – 0.46 mmol/L), but have no statistically significant effect on total cholesterol, LDL cholesterol, and HDL cholesterol.[14] The abovementioned meta-analyses included all subjects and were not exclusively for postmenopausal women. The objective of the present study was to evaluate the effect of soy isoflavone supplementation for 12 months on plasma lipid levels (total cholesterol, triacylglycerol, LDL cholesterol, and HDL cholesterol) in postmenopausal women.

METHODS

Design of the study

This experimental study was designed as a double-blind randomized placebo-controlled clinical trial. The study was conducted in the catchment area of the District Health Center, Mampang Prapatan, South Jakarta, from January 2010 until February 2011.

Study subjects

The inclusion criteria used in this study were: women 47 – 60 years of age, being at post-

menopause (having had no menstrual periods for minimally 1 year and maximally 10 years), the menopause being a natural menopause (not induced by total hysterectomy, bilateral oophorectomy, radiation, or chemotherapy), not taking drugs and supplements during the last 6 months (hormonal drugs such as glucocorticoids, anticoagulants, antihyperlipidemic drugs, antihypertensive drugs, isoflavone-containing supplements, and oral antidiabetics), agreeing to participate in the study by signing informed consent, capable of walking unassisted, and able to communicate. The subjects were excluded from the study if they had malignant disease (such as mammary, cervical, and endometrial cancers) or severe psychotic disorders, such as schizophrenia. The calculated sample size per group was 90, which was estimated to be adequate to detect a 30% difference in the mean lipid profile values between the treatment groups using a two-tailed test, an alpha of 0.05, and a power of 80%.

The Mampang Prapatan District in South Jakarta consists of five *kelurahan* (villages), from which four were selected by multistage cluster random sampling. From the four selected *kelurahan,* two *Rukun Warga* (RW) were chosen, and from each RW five *Rukun Tetangga* (RT, a kind of neighborhood association) were taken. In total 40 RTs were selected. From each RT a list of postmenopausal women was made. By simple random sampling the study subjects were selected from among the postmenopausal women in each of the 40 RTs. The sample sizes in each RT was determined proportionally according to the available numbers of postmenopausal women.

Intervention

The soybean isoflavone extract was imported from Hui Song Pharmaceuticals, China. The supplement tablets used in this study were prepared, packed, and labelled by PT. Ikapharmindo Putramas, Indonesia. Each supplement tablet contained 250 mg soybean extract, equivalent to 100 mg isoflavone aglycones (comprising genistein 56%, daidzein 41%, and glycitein 3%) and 500 mg calcium carbonate. The placebo (control) tablets contained 500 mg calcium carbonate. The form, color, and flavor of the supplement and control tablets were identical.

The supplements were assigned to the two groups in a double-blind manner. The tablets in each group were given once daily by the oral route after breakfast, between 07.00 – 10.00 Western Indonesian Time (WIB). The supplementation was given by cadres at home visits, when the supplements were taken directly in front of the cadres. A checklist was used to note daily tablet consumption and any complaints arising during supplementation.

Measurement of physical characteristics

Height in kg was measured by means of a portable microtoise at an accuracy of 0.1 cm. Weight in kg was determined using Sage portable scales at an accuracy of 0.1 kg. Body mass index (BMI) was calculated by dividing the weight in kg by the square of the height in m. Threshold values for BMI were according to the criteria issued in 2013 by the Department of Health of the Republic of Indonesia *(Depkes RI)*. The *Depkes RI* BMI threshold criteria for women are as follows: underweight (<18 kg/m^2), normal weight (18-25 kg/m^2), overweight (25–27 kg/m^2), obese (>27 kg/m^2). In the present study, BMI values were categorized into normal/ underweight ≤24.9 kg/m^2 and overweight ≥ 25 kg/m^2.[15]

Laboratory analysis

A 10 mL venous blood sample was collected from each subject after a 12-hour fast for determination of lipid levels (total cholesterol, triacylglycerol, HDL cholesterol, and LDL cholesterol). Normal lipid levels according to the Adult Treatment Panel III (ATP III) guidelines are: total cholesterol <200 mg/dL, triacylglycerol <150 mg/dL, LDL cholesterol <130 mg/dL, HDL cholesterol > 40 mg/dL.[16] Blood samples were collected three times, i.e. before soy isoflavone supplementation (baseline), after 6 months of

supplementation, and after 12 months of supplementation. The venous blood samples were centrifuged at 2000 RPM for 10 minutes. The obtained serum was frozen at -70°C pending laboratory investigations, which were performed simultaneously for samples of all subjects before supplementation and after 6 and 12 months of supplementation. Total cholesterol, triacylglycerol, LDL cholesterol, and HDL cholesterol were assessed by means of an enzymatic colorimetric method (Cobas c 111, Roche).

Assessment of compliance

Subject compliance in this study was determined by observing the subjects taking the supplementation tablets in front of the cadres, by counting the tablets remaining in the bottle at the end of each month, and by measuring blood soy isoflavone levels at baseline and at the completion of the study. The subjects were categorized as drop-outs if they failed to take supplements for 7 consecutive days or if the total tablets consumed was < 90% (151 tablets) for the 6-month trial. For the 12-month trial, the criteria were 14 consecutive days or < 90% (328 tablets), respectively.

Statistical analysis

Normality of data distribution was determined by means of the Kolmogorov-Smirnov test. The independent t-test was used to find differences between the isoflavone and control groups in subject characteristics, total cholesterol, triacylglycerol, LDL cholesterol and HDL cholesterol at baseline, after 6 months, and after 12 months. A p of <0.05 was considered statistically significant. The software used for statistical analysis was the Statistical Program for Social Sciences (SPSS) version 17.

Ethical clearance

The study protocol was approved by the Committee on Research Ethics of the Faculty of Medicine, Trisakti University.

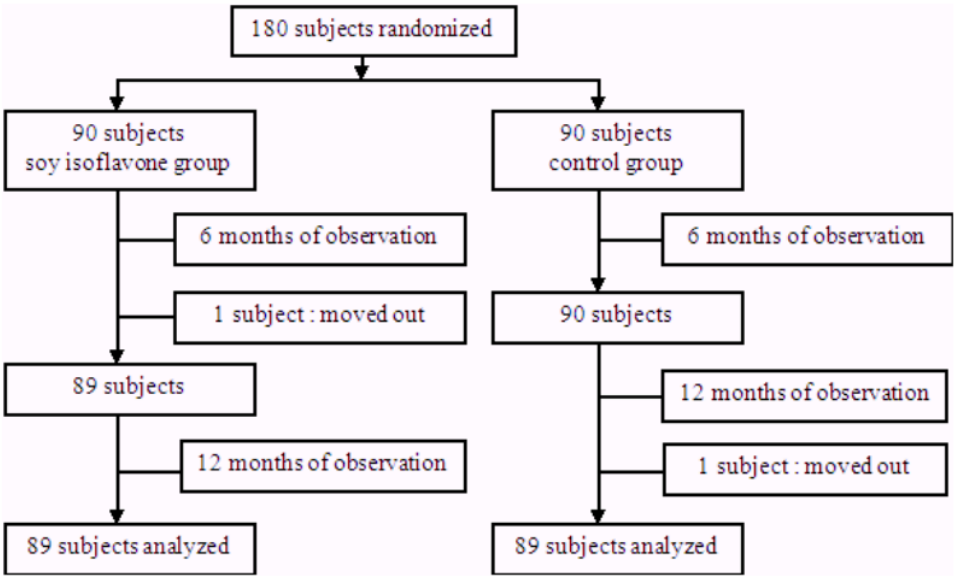

Figure 1. Flow of subject participation during study

Table 1. Distribution of demographic and physical characteristic of the subjects at baseline by treatment groups

Characteristic	Isoflavone (n = 90)	Control (n = 90)	p
Age (years) [a)]	53.4 ± 3.5	53.5 ± 3.5	0.833
Duration of menopause (years) [a)]	4.5 ± 2.1	4.4 ± 2.4	0.683
Marital status [b)]			
Married	59 (65)	64 (71)	0.395
Not married/widowed	31 (35)	26 (29)	
Educational level [b)]			
Low (none - primary school)	60 (66.7)	62 (68.9)	0.726
Medium (junior – senior high)	27 (30)	27 (30)	
High (academy/university)	3 (3.3)	1 (1.1)	
Employment [b)]			
Employed	49 (54.5)	35(38.9)	0.242
Unemployed	41(45.5)	55 (61.1)	
Blood pressure [a)]			
Systolic (mmHg)	125.44 ± 22.93	124.08 ±19.57	0.665
Diastolic (mmHg)	78.56 ± 13.37	78.64 ±11.90	0.964
Body mass index (kg/m^2) [a)]	26.79 ± 4.75	26.67 ± 4.73	0.863
Total cholesterol (mg/dL) [a)]	209.91 ±38.35	204.15 ± 34.78	0.290
Triacyglycerol (mg/dL) [a)]	121.82 ± 82.49	108.74 ±42.19	0.178
LDL cholesterol (mg/dL) [a)]	134.07 ± 34.76	125.51 ± 32.09	0.086
HDL cholesterol (mg/dL) [a)]	55.38 ± 11.44	58.90 ±12.64	0.050

[a)]Values are mean ± standard deviation; [b)] number of subjects (%); [c)] p values calculated by independent t-test

RESULTS

At the start of the study, 180 women postmenopausal women meeting the inclusion and exclusion criteria were randomized into two groups, i.e. the isoflavone group and the control group, each comprising 90 women. After 6 months of supplementation, one subject in the isoflavone group dropped out, as she moved out of the study area, whereas no drop-outs occurred in the control group.

At the completion of the study, after 12 months of supplementation, there were no drop-outs in the soy isoflavone group, whereas in the control group one subject dropped out, because she returned to her native village to get married. The data collected for statistical analysis were from 178 subjects (89 in each group). The flow of subject participation may be seen in Figure 1.

The distribution of subject characteristics at baseline between the isoflavone and control groups is presented in Table 1. Mean age was 53.4 ± 3.5 years in the isoflavone group vs 53.5 ± 3.5 years in the control group, duration of menopause was 4.5 ± 2.1 years vs 4.4 ± 2.4 years, most subjects were married (65% vs 71%), and of low educational level (66.7% vs 68.9%). In the isoflavone group 54.5% were employed, while in the control group 61.1% were unemployed.

The independent t-test did not find any significant differences between the isoflavone group and the control group in the baseline distribution of the various variables, either demographic or physical, including plasma lipids, with all p values being above significance level. This indicates that the randomization performed in this study had successfully distributed all variables uniformly between the two groups, except for the treatment variable.

Table 2 presents the total cholesterol, triacylglycerol, LDL cholesterol, and HDL cholesterol levels after supplementation for 6

Table 2. Mean lipid profiles after 6 months and 12 months of supplementation by treatment groups

Cholesterol (mg/dL)	Isoflavone (n=89)	Control (n-89)	p
After 6 months supplementation			
Total cholesterol	208.2 ± 37.4	198.2 ± 35.6	0.070
Triacylglycerol	129.6 ± 89.1	119.2 ± 55.9	0.347
LDL cholesterol	124.9 ± 35.2	112.7 ± 29.7	0.013*
HDL cholesterol	59.5 ± 14.4	61.7 ± 13.7	0.296
After 12 months supplementation			
Total cholesterol	197.0 ± 37.3	188.5 ± 34.8	0.114
Triacylglycerol	123.8 ± 74.7	106.3 ± 46.3	0.060
LDL cholesterol	116.9 ± 31.7	109.1 ± 29.8	0.086
HDL cholesterol	55.9 ± 14.1	58.0 ± 12.3	0.309

Values are mean ± S.D.; p values calculated by independent t-test; *significance
HDL = high density lipoprotein; LDL= low density lipoprotein

and 12 months. The total cholesterol level in the isoflavone group vs control group after supplementation for 6 months was 208.2 ± 37.4 mg/dL vs 198.2 ± 35.6 mg/dL (p=0.070), while after 12 months it was 197.0 ± 37.3 mg/dL vs 188.5 ± 34.8 mg/dL (p=0.114). There was therefore a reduction in total cholesterol levels at 6 and 12 months, both in the isoflavone group and control group, but the reduction was statistically not significant.

As for triacylglycerol and HDL cholesterol levels in the isoflavone and control groups after 6 months and 12 months of supplementation, they increased at 6 months, but decreased again at 12 months approaching baseline levels, both in the isoflavone and control groups, but the changes were statistically not significant.

Only for LDL cholesterol levels in the isoflavone vs control groups was there a significant decrease after 6 months of supplementation (124.9 ± 35.2 mg/dL vs 112.7 ± 29.7 mg/dL (p= 0.013*). However, a further reduction after 12 months of supplementation was statistically not significant (116.9 ± 31.7 mg/dL vs 109.1 ± 29.8 mg/dL (p= 0.086) (Figure 2).

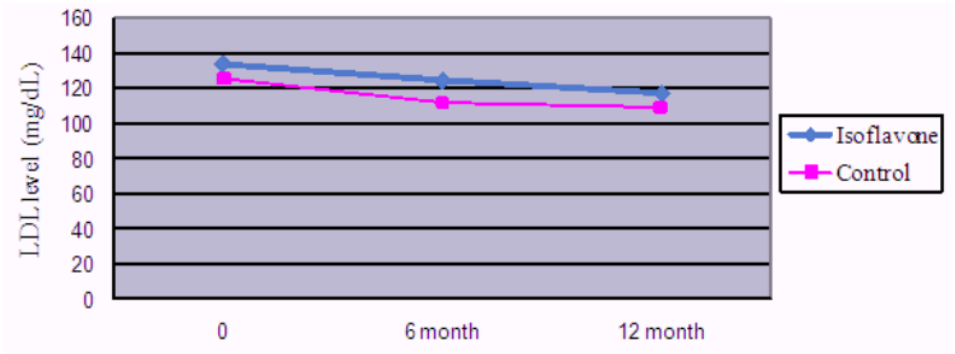

Figure 2. Levels of LDL cholesterol at baseline, at 6 months and 12 months in the isoflavone group and control group. A significant reduction is seen at 6 months

ADVERSE EVENTS

There were no life-threatening adverse events during the conduct of this study. There were no subjects who dropped out for clinical reasons. The complaints reported in both groups were knee pain, leg pain and leg ache, paresthesia, back pain, headache, and increased appetite.

DISCUSSION

The results of this study showed that administration of soy isoflavones at 100 mg/day to postmenopausal women significantly reduced their LDL cholesterol levels after 6 months of supplementation (9.2 mg/dL or 6.86%). After 12 months of supplementation LDL cholesterol decreased steadily but nonsignificantly. There were no reductions in other serum lipid levels at 6 and 12 months. These results did not markedly differ from those of the studies by Yang et al.[17] and Taku et al.[18]

The study conducted by Yang et al.[17] on 130 healthy postmenopausal Taiwanese women showed that soy isoflavone supplementation for 6 months succeeded in significantly reducing the levels of total cholesterol in the isoflavone and control groups by 4.5 and 3.06%, respectively, and the LDL levels by 4.67 and 5.09%, respectively, in patients with total cholesterol levels of >200 mg/dL. In our study the reduction in LDL levels was higher than that in the study by Yang et al.[17] (6.86% vs 5.09%), which presumably was the result of the larger dose of soy isoflavones which we used (100 mg vs 70 mg). Apart from LDL, our study did not find any effect of isoflavones on other serum lipid levels. The marked differences of Yang's study with ours were in the open labeled study design, which was randomized but used no controls, and involved women of normal weight. The meta-analytic study performed by Taku et al.[18] evaluated the effects of soy protein intake on lipid profiles in men and in premenopausal as well as postmenopausal women. The meta-analysis indicated that soy isoflavones significantly reduced serum total cholesterol and LDL cholesterol levels, but not HDL cholesterol and triacylglycerol levels.

The study by Mangano et al.[19] was conducted on 131 healthy women over 60 years of age, who were overweight, and had moderate hypercholesterolemia. The aim of the study was to evaluate the long term effects on serum lipids and inflammatory markers of soy protein supplementation (18 g/day) and/or soy isoflavones (105 mg/day aglycone equivalent), either separately or in combination. After a one-year intervention no significant effect was seen of the soy protein and isoflavone interventions on serum lipids, lipids ratio, or inflammatory markers. In subjects who were equol producers, significant effects of respectively -5.9% and -7.2% were found on the total cholesterol/HDL and LDL/HDL ratios.

The optimal effective dose of soy isoflavones capable of exerting a therapeutic effect is to date still not known with certainty. Various studies on the effect of isoflavones in reducing serum lipids have used varying values for the dose and duration of therapy, e.g. 35 mg (6 months),[17] 60 mg (12 weeks),[20] and 164 mg (10 weeks).[21] The dose of soy isoflavone extract used in our study was 100 mg/day (aglycone equivalent).

The studies investigating the effect of isoflavones on reduction of serum lipids in postmenopausal women generally use soy proteins with a certain isoflavone content, thus leading to uncertainty whether the reduction in serum lipids are due to the soy protein itself or to its isoflavone content. One of such studies was performed by Jassi et al.,[20] where in spite of a reduction in serum lipids of the controls after soy protein supplementation, no significant changes were seen in the isoflavone group, indicating that apart from isoflavones, soy protein has other components that are responsible for the hypocholesterolemic effect after soy protein administration.

Our study found no reduction in serum lipid

levels other than LDL cholesterol, either after 6 months or 12 months of supplementation, similar to the findings of Yang et al.[17] and Taku et al.[18] The nonsignificant reduction in LDL cholesterol after 6 months of supplementation in our study may be the result of the unsupervised dietary intake of the subjects, or of the longer duration of supplementation, which was continued after plateau levels had been attained. This view is supported by a review performed by Manach et al.[22] on studies evaluating the bioavailability of soy isoflavones for 1-3 months, indicating that continuous supplementation does not increase blood isoflavone levels.

The absence of isoflavone effects on serum lipids is also seen with several other studies. The study by Ho et al.[23] was a one-year study conducted on 203 postmenopausal Chinese women. These investigators are of the opinion that the weakly estrogenic effects obtained from an isoflavone dose of 40-80 mg/day or from the usual intakes in Asian populations is inadequate to counteract the effects of postmenopause in increasing cholesterol levels. The study was conducted on postmenopausal women with mean age of 54 years and mean duration of menopause of 4 years, thus resembling our study subjects. The study of Ho et al.[23] differed from ours in the source of isoflavones (The Netherlands) and the percentages of the isoflavone components (genistein 14.7%, daidzein 46.4%, and glycetein 38.8%). Furthermore, although their study used the same duration of supplementation as in our study (1 year), the study by Ho et al.[23] did not determine plasma lipids at 6 months. Therefore, any significant changes in LDL cholesterol levels at 6 months would escape observation.

The study conducted by Rios et al.[24] on 47 postmenopausal women aged 47–66 years, receiving 40 mg isoflavones/g casein for 6 months, aimed at evaluating the effect of soy isoflavone supplementation on lipid profile, also did not show any significant effects. The small sample size of the study and the occurring changes in dietary pattern and in physical exercise may presumably account for its nonsignificant results.

No life-threatening adverse events were found in our study, in agreement with the meta-analytic results of Qin et al.[14] The reported complaints in our study subjects were knee pain, leg pain and leg ache, paresthesia, back pain, headache, and increased appetite, whereas in the meta-analysis by Qin et al.[14] the complaints were gastrointestinal (bloating and constipation). In the study conducted by Steinberg et al.[25] using soy hypocotyl isoflavones at 80–120 mg, a significant increase in blood urea nitrogen was found after a 2-year supplementation.

The strengths of our study are in the double-blind randomized controlled design, sufficiently large sample size, low drop-out rate (1%), and high compliance of participants up to the completion of the supplementation (99.9%).

A limitation of this study is the lack of control on daily food consumption by the subjects, that the study results may have been affected by the consumption of foods high in isoflavones or fatty acids. It should also be borne in mind that the isoflavone extract used in our study was from China, with a presumably different composition than isoflavone extracts from other countries, while the processing method may also affect the isoflavone content.[26]

Further pharmacokinetic studies on isoflavones are required in Indonesian postmenopausal women, since the bioavailability of drugs is affected by absorption and metabolism, leading to variable effects due to polymorphisms in the genes encoding metabolic enzymes.[27] In addition, studies are needed to detect genetic polymorphisms of the ERβ gene in Indonesian postmenopausal women. According to one study,[28] the genotype deriving benefits from isoflavones are the AA AluI genotype of ERβ (associated with increased risk for cardiovascular disease) and the Tsp509I SNP in the ERβ ex splice variant of the AA genotype, with increased plasma HDL cholesterol levels after soy isoflavone supplementation.[28]

The reduction in LDL cholesterol in our study is greater than that in the statement of the American Heart Association (AHA) advisory paper (6.86% vs 3%), but the effect lasted only up to 6 months postsupplementation. Our study supports the AHA advisory statement that the effect of isoflavones in reducing cardiovascular risk factors (serum lipids) in postmenopausal women is "minimal at best".[29]

CONCLUSIONS

Soy isoflavone supplementation reduced LDL cholesterol levels in postmenopausal women significantly after six months but non-significantly after twelve months. No significant difference was found on the effect of isoflavones in decreasing total cholesterol, triacylgycerol, and HDL cholesterol levels, both at 6 months and at 12 months.

ACKNOWLEDGEMENTS

The investigators thank all study participants for their cooperation, and the Dean of the Faculty of Medicine, Trisakti University, for the funding of this study. We also thank Ikapharmindo Pharmaceuticals for preparing the supplements for this trial.

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