Effect of Dietary Soy Protein Supplement in Dyslipidemic South Indian Population: A Randomized, Double-Blind, Placebo Controlled, Parallel-Group Trial

Natesan Chidambaram[1], Subramaniyam Sethupathy[1], Nadanam Saravanan[2*], Toshiya Toda[3], Mari Mori[3], Yukio Yamori[3], Arun Kumar Garg[4] and Arun Chockalingam[5]

[1]Rajah Muthiah Medical College and Hospital; Annamalai University, Chidambaram, India
[2]Rani Meyyammai College of Nursing, Annamalai University, Chidambaram, India
[3]Institute for World Health Development, Mukogawa Women's University, Nishinomia, Japan
[4]Laboratory Medicine and Pathology at Fraser Health Authority, New Westminster, BC, Canada
[5]Dalla Lana Faculty of Public Health,University of Toronto, Toronto, Canada

Abstract

Forty subjects identified as dyslipidemic were assigned randomly to either soy powder (Soy) or red bean powder (Placebo). The soy group received daily a sachet of 18.1 g soy power containing 85 K cal and the placebo group received daily placebo sachet (23.1 g) of red bean powder containing 85.5 K cal in addition to the usual diet for four weeks. Intake of soy/placebo powder was assessed by measurement of 24-hour urinary isoflavone excretions at baseline and at the end of the intervention period. Relative to placebo, soy powder has significant effect over some Cardiovascular Disease (CVD) markers and Metabolic Syndrome (MetS) indices including abdominal circumference, triglycerides, HbA1c and insulin. These data support that the dietary consumption of soy has the property to reduce risk factors for CVD and MetS.

Keywords: Dyslipidemia; South India; Soy

Introduction

Dyslipidemia and obesity are emerging as a major public health challenge in South Asian countries. The prevalence of obesity is more in urban areas than rural. There is greater accumulation of fat at "ectopic" sites, namely the liver and the skeletal muscles. This feature leads to higher magnitude of insulin resistance, and its concomitant metabolic disorders (the metabolic syndrome) including atherogenic dyslipidemia.

Metabolic Syndrome (MetS) is a plausible precondition for type II diabetes and Cardiovascular Diseases (CVD). MetS is characterised by symptoms of obesity, insulin resistance, hypertension, dyslipidemia and diabetes mellitus. The pathophysiological mechanisms involved in MetS are complex and involved dysregulation of many biochemical and physiological regulatory mechanisms of the body. Elevated levels of Very Low Density Lipoprotein (VLDL), and Low Density Lipoprotein (LDL) with reduction of High Density Lipoprotein (HDL) seen in patients with MetS contribute to atherogenic dyslipedemia. MetS and its components are associated with increased risk of stroke and CVD.

Further, the incidence of Coronary Artery Disease (CAD) is increasing in India. Our previous findings in the South India indicated the poor dietary habits of consuming excessive carbohydrates, fats, oils and salt as well as not enough fruits, vegetables, pulses and nuts which leads to hypertension and CAD [1]. Recent data suggesting insulin resistance can predict CVD independently of the other risk factors, such as hypertension, visceral obesity, or dyslipidemia [2]. The excess burden of coronary heart diseases among Indians appears to be primarily due to dyslipidemia that is characterized by high levels of triglycerides (TG), borderline high levels of LDL and low levels of HDL [3].

Soybean is the most important nutrient of the legume family. Asian populations who consume soy foods in their daily diet have a lower incidence of CVD than those who consume a typical Western diet [4]. It was also reported that soy protein and/or isoflavones improve lipid profiles [5] and exert antiatherogenic effects [6]. Soy protein isolate is

known to reduce the risk of heart disease by lowering serum TC and TGL levels. Soybean is a rich source of vegetable protein, complex carbohydrates, polyunsaturated fat, soluble fibres, and phytoestrogens (isoflavones) that may be beneficial in the prevention of diabetes also [7]. *In vitro* studies suggest that isoflavones have antidiabetic properties such as the inhibition of the intestinal brush border uptake of glucose, a-glucosidase inhibitor actions, and tyrosine kinase inhibitory properties [8,9]. Several observational studies have also suggested that soy intake was associated with improved glycemic control or lowered risk of diabetes [10-13].

We hypothesize that the daily intake of soybean products as a dietary supplement may reduce lipid levels among dyslipidemic people whose daily consumption of soy products is low/nil. In an intervention study, the beneficial effects of a soybean diet on CVD risk factors in Japanese immigrants living in Hawaii are well proved [14]. Therefore, in the present study, we designed an intervention study to investigate the effects of soy protein on lipid levels such as Total Cholesterol (TC) , TGL, cholesterol fractions, CVD risk factors such as blood pressure (BP), weight, abdominal circumference, body mass index and MetS indices such as fasting plasma glucose, HbA1C, Insulin and HOMA- IR among dyslipidemic south Indian population.

Citation: Chidambaram N, Sethupathy S, Saravanan N, Toda T, Mori M, et al. (2015) Effect of Dietary Soy Protein Supplement in Dyslipidemic South Indian Population: A Randomized, Double-Blind, Placebo Controlled, Parallel-Group Trial. J Hypertens (Los Angel) 4: 206. doi:10.4172/2167-1095.1000206

Subjects

A total of 40 dyslipidemic people identified at random from age-gender registers of Rajah Muthiah Medical College Hospital, Annamalai Nagar, Tamil Nadu, India. They are recruited by letter to participate in a health survey. Inclusion criteria as dislipidemia is set as serum serum TGL>200 mg/dl or HDL<40 mg/dl or LDL>130 mg/dl [15]. Exclusion criteria included the presence of any other chronic illness that could affect blood lipid concentration or limit the individual's ability to participate in the study, and the use of cholesterol-lowering drugs and any medication known to affect lipid concentrations. The study design was approved by the Institutional Ethical Committee, Annamalai University, India and written informed consent was obtained from each participant.

Study Design

The study was performed as a 4-week randomized, double-blind, placebo controlled, parallel-group trial with a follow-up examination at the end of the study. During the health survey, anthropometric measurements were measured for height, weight, abdominal circumference and BP. Height and weight were measured in bare feet and in right clothing. BP was measured at the right arm after 10 minutes rest in a seated position using an automated BP measurement system (HEM-970; OMRON, Kyoto, Japan) and these measurements were repeated three times. Five ml of overnight fasting blood samples were collected, and lipid profile was measured using ERBA SMARTLAB automated biochemistry Analyser. Twenty four- hour urine specimens were collected using a standard aliquot cup that allowed the participants to repeatedly collect an exact portion of voided urine [16,17]. These urine specimens were used for the analyses of isoflavones using high-performance liquid chromatography (HPLC) and for creatinine [16]. The analytical methods used for isoflavones were described by Uesugi et al. [18]. A structured questionnaire to obtain information about demographic characteristics, medical history and medication use were used for face-to-face interviews [16].

Forty subjects identified as dyslipidemic were assigned randomly to either soy powder (Soy) or red bean powder (Placebo). The soy group received daily a sachet of 18.1 g soy power containing 85 K cal and the placebo group received daily placebo sachet (23.1 g) of red bean powder containing 85.5 K cal, in addition to the usual diet for four weeks. Intake of soy/placebo powder was assessed by measurement of 24-hour urinary isoflavone excretions at baseline and at the end of

the intervention period. Randomization was done based on chance by which study participants are assigned to a treatment group to minimizes the differences among groups by equally distributing people with biochemical characteristics among the two groups before intervention. The researchers did not know which treatment is better. A double-blind procedure was used to guard against both experimenter bias and placebo effects. The subjects of the experiment and the persons administering the experiment did not know the critical aspects of the experiment. Table 1 shows the percentage compositions of nutrients in soy powder and placebo powder.

Statistical Analysis

Statistical analyses were conducted with SPSS 16.0 for Windows (SPSS Japan Inc., Tokyo, Japan). Data were analyzed using the Student's t test and paired Student's t-test by group for the variables. Data are expressed as the mean ± SEM. Values of $p < 0.05$ were considered significant.

Results

Table 2 shows the baseline values of all parameters analysed in this study after randomisation. Table 3 shows the values of the parameters at the end of the trial. Significant difference in abdominal circumference and isoflavone by creatinine were observed after the intervention in the Soy group. Table 4 shows the systolic blood pressure (SBP), diastolic blood pressure (DBP), Heart Rate (HR), weight, abdominal circumference, body mass index (BMI) of the two groups at baseline and after the intervention. There was no significant change in SBP, DBP and HR in the soy group and in the placebo group. The body weight was maintained throughout the study in both groups. Abdominal circumference was significantly ($p < 0.001$) decreased in the soy group whereas no significant change in the placebo group. There was no significant change in the BMI.

Table 5 shows the effect of the Soy powder and the placebo powder on serum TC, serum TGL, serum HDL, serum LDL and isoflavone by creatinine. Serum TGL and HDL-C significantly decreased in the Soy group (TGL; $p < 0.001$) and HDL-C; $p < 0.05$) but not in the Placebo group. Twenty-four-hour urinary isoflavone excretions at baseline and at the follow-up survey in the two groups are shown in the same table. A significant difference in isoflavone by creatinine was observed before and after the intervention in the Soy group ($p < 0.01$).

Table 6 shows the effects of the Soy powder and the placebo powder

S.No	Nutrient	Soy Powder		Red Kidney Bean Powder	
		per 100 g	per one pouch (18.2 g)	per 100 g	per one pouch (23.1 g)
1	Energy	467 Kcal	85.0 Kcal	370 Kcal	85.5 Kcal
2	Protein	37.7 g	6.9 g	20.3 g	4.7 g
3	Fat	20.6 g	3.7 g	1.9 g	0.4 g
4	Carbohydrate	32.6 g	5.9 g	67.9 g	15.7 g
5	Sodium	47.567 mg	8.7 mg	171.825 mg	39.7 mg
6	Salt	0.121 g	0.02 g	0.436 g	0.10 g
7	Water	4.2 g	0.76 g	6.3 g	1.46 g
8	Minerals	4.9 g	0.89 g	3.6 g	0.83 g
9	Dietary fibre	17.3 g	3.1 g	21.6 g	5.0 g
10	Calcium	160 mg	29.1 mg	87 mg	20.1 mg
11	Isoflavone (as aglycone)	395.89 mg	72.1 mg	Nil	

Table 1: Contents of Soy and bean powders.

S.No	Parameter	Placebo powder Group (n=20)	Soy Powder Group (n=20)	P value
1.	Systolic BP (mm Hg)	130.55 ± 3.83	126.45 ± 5.16	0.240
2.	Diastolic BP (mm Hg)	80.20 ± 2.50	72.95 ± 3.02	0.902
3.	Heart rate (BPM)	81.45 ± 3.13	81.30 ± 2.29	0.428
4.	Weight (Kg)	67.48 ± 2.47	65.05 ± 2.35	0.701
5.	Abdominal circumference (cm)	89.00 ± 1.96	94.70 ± 2.11	0.611
6.	Body mass index	25.51± 0.86	25.82 ± 0.73	0.850
7.	Serum cholesterol (mg/dl)	169.20 ± 6.86	181.30 ± 11.51	0.340
8.	Serum triglyceride (mg/dl)	188.40 ± 10.07	169.95 ± 10.87	0.932
9.	Serum HDL (mg/dl)	41.60 ± 0.76	43.05 ± 0.75	0.980
10.	Serum LDL (mg/dl)	92.95 ± 6.25	94.75 ± 6.40	0.723
11.	Isoflavone by creatinine	1.04 ± 0.45	1.20 ± 0.48	0.441
12.	Fasting blood sugar (mg/dl)	156.05 ± 14.89	164.95 ± 18.28	0.772
13.	HbA1C (%)	7.08 ± 0.25	7.35 ± 0.27	0.475
14.	Insulin (µ IU/mL)	23.10 ± 3.05	15.53 ± 1.48	0.021*
15.	HOMA IR	8.50 ± 1.14	5.56 ± 0.43	0.009*

Values are expressed as mean ± SEM. * indicates p<0.05

Table 2. Baseline values of the analysed parameters after randomisation.

S.No	Parameter	Placebo powder Group (n=20)	Soy Powder Group (n=20)	P value
1.	Systolic BP (mm Hg)	128.98 ± 3.24	127.15 ± 5.48	0.044*
2.	Diastolic BP (mm Hg)	80.38 ± 3.15	76.15 ± 3.33	0.707
3.	Heart rate (BPM)	77.70 ± 2.83	83.85 ± 3.37	0.456
4.	Weight (Kg)	67.04 ± 2.48	64.32 ± 2.27	0.822
5.	Abdominal circumference (cm)	86.40 ± 1.47	84.65 ± 2.86	0.026*
6.	Body mass index	25.60 ± 0.85	25.36 ± 0.68	0.648
7.	Serum cholesterol (mg/dl)	179.25 ± 5.85	187.35 ± 17.18	0.129
8.	Serum triglyceride (mg/dl)	215.05 ± 10.36	127.55 ± 11.33	0.439
9.	Serum HDL (mg/dl)	41.35 ± 0.67	41.20 ± 0.74	0.710
10.	Serum LDL (mg/dl)	94.00 ± 5.60	120.65 ± 15.47	0.128
11.	Isoflavone by creatinine	3.64 ± 2.24	57.77 ± 12.88	0.000*
12.	Fasting blood sugar (mg/dl)	165.10 ± 17.03	160.95 ± 14.12	0.798
13.	HbA1C (%)	6.53 ± 0.41	6.43 ± 0.33	0.942
14.	Insulin (µ IU/mL)	23.71 ± 3.04	16.66 ± 1.53	0.030*
15.	HOMA IR	7.61 ± 1.00	5.96 ± 0.47	0.035*

Values are expressed as mean ± SEM. * indicates p<0.05

Table 3. Effects of the Soy powder and the placebo powder on the analysed parameters after the intervention (4 weeks).

	Placebo group (n=20)					Soy group (n=20)					Significance
	Baseline		4 weeks			Baseline		4 weeks			
	Mean	Std. Error Mean	Mean	Std. Error Mean	P	Mean	Std. Error Mean	Mean	Std. Error Mean	P	
Systolic BP (mm Hg)	130.55	3.83	128.98	3.24	0.733	126.45	5.16	127.15	5.48	0.762	NS
Diastolic BP (mm Hg)	80.20	2.50	80.38	3.15	0.945	72.95	3.02	76.15	3.33	0.061	NS
Heart rate (BPM)	81.45	3.13	77.70	2.83	0.034	81.30	2.29	83.85	3.37	0.446	NS
Weight (Kg)	67.48	2.47	67.04	2.48	0.050	65.05	2.35	64.32	2.27	0.437	NS
Abdominal circumference (cm)	89.00	1.96	86.40	1.47	0.140	94.70	2.11	84.65	2.86	0.000	***
Body mass index	25.51	0.86	25.60	0.85	0.565	25.82	0.73	25.36	0.68	0.092	NS

Significance: *** - p<0.001 compared with the baselines.

Table 4: Effects of the Soy powder and the placebo powder on systolic blood pressure (BP), diastolic BP, heart rate, weight, abdominal circumference, body mass index.

on fasting blood sugar, HbA1C, insulin and HOMA IR. No significant change in the fasting blood sugar was observed in both groups. HbA1C in the soy group was significantly (p<0.05) decreased whereas no significant change was observed in the Placebo group. Serum insulin level was significantly (p<0.001) increased in the Soy group whereas as no change was observed in Placebo group. There was no significant difference was observed in HOMA-IR.

Discussion

The results of this study demonstrate a protective role of soy protein on some CVD markers and some MetS indices following four-week supplementation to the dyslipidemic people. The change in 24-hour urinary isoflavone excretion indicates that subjects consumed the Soy/placebo well with the prescribed sachets.

	Placebo group (n=20)					Soy group (n=20)					Significance
	Baseline		4 weeks			Baseline		4 weeks			
	Mean	Std. Error Mean	Mean	Std. Error Mean	P	Mean	Std. Error Mean	Mean	Std. Error Mean	P	
Serum cholesterol (mg/dl)	169.20	6.86	179.25	5.85	0.136	181.30	11.51	187.35	17.18	0.741	NS
Serum triglyceride (mg/dl)	188.40	10.07	215.05	10.36	0.057	169.95	10.87	127.55	11.33	0.000	***
Serum HDL (mg/dl)	41.60	0.76	41.35	0.67	0.795	43.05	0.75	41.20	0.74	0.045	*
Serum LDL (mg/dl)	92.95	6.25	94.00	5.60	0.836	94.75	6.40	120.65	15.47	0.075	NS
Isoflavone by creatinine	1.04	0..45	3.64	2.24	0.529	1.20	0.48	57.77	12.88	0.001	**

Significance: * - p<0.05, ** - p<0.01 and *** - p<0.001 compared with the baselines.
Table 5: Effects of the Soy powder and the placebo powder on serum cholesterol, serum triglyceride, serum high density lipoprotein (HDL), serum (low density lipoprotein (LDL) and isoflavone by creatinine.

	Placebo group (n=20)					Soy group (n=20)					Significance
	Baseline		4 weeks			Baseline		4 weeks			
	Mean	Std. Error Mean	Mean	Std. Error Mean	P	Mean	Std. Error Mean	Mean	Std. Error Mean	P	
Fasting blood sugar (mg/dl)	156.05	14.89	165.10	17.03	0.558	164.95	18.28	160.95	14.12	0.723	NS
HbA1C (%)	7.08	0.25	6.53	0.41	0.215	7.35	0.27	6.43	0.33	0.021	*
Insulin (μ IU/mL)	23.10	3.05	23.71	3.04	0.001	15.53	1.48	16.66	1.53	0.000	***
HOMA IR	8.50	1.14	7.61	1.00	0.383	5.56	0.43	5.96	0.47	0.204	NS

Significance: *p<0.05 and ***p<0.001 compared with the baselines.
Table 6: Effects of the Soy powder and the placebo powder on fasting blood sugar, HbA1C, insulin and HOMA IR.

As regard the limitation of this study, the number of subjects enrolled, no differences were observed in SBP, DBP, HR, weight and BMI between and within groups, but this may be due to the short treatment period, which reduced the statistical significance of the outcomes.

Four-week supplementation of Soy in dyslipidemic subjects significantly decreased abdominal circumference, which is in accordance with Liu et al. [19] who observed that greater consumption of soy protein was inversely associated with the presence of abdominal obesity in men and women. In subjects with overweight and with android fat distribution, sixteen-week soy protein treatment showed a significant increase in muscle mass and reduction in waist circumference [20].

On soy diet to women with MetS, significant reduction in TGL was observed by Acharjee et al. [21]. Adding whole soy flour to a cafeteria diet, to male adult Wistar rats significantly reduced the serum concentrations of TGL [22]. In a mouse model of obesity induced by a high-fat diet, cooked soy bean powder and fermented soy bean product diet significantly reduced the TC and TGL levels. Diets containing soy based food products, which are rich sources of isoflavonoids, are helpful for controlling the lipid metabolism under high fat diet conditions [23]. In a double blind, randomized, placebo controlled trial, soy derived isoflavone (70 mg/day for 12 weeks) significantly reduced the TGL levels in Korean postmenopausal women [24]. In a randomized crossover study, soy bread (3 week) or a soy beverage (3 week) containing 20 g soy protein with 99 and 93 mg isoflavones per day significantly reduced the TGL level [25]. In the present study, four-week supplementation of soy in dyslipidemic subjects significantly decreased the serum TGL level. Serum TC and HDL-C didn't significantly change through the study period, probably the limited number of subjects studied has negatively influenced this outcome.

In the present study, four-week supplementation of soy to dyslipidemic subjects showed no significant change in fasting blood sugar and HOMA-IR but showed significant decrease in the HbA1C and significant increase in insulin. In a randomized, controlled, double blind, parallel group study in twenty-five type 2 diabetic patients on tube feeding, soy protein based, multi fibre diabetes specific food for 12 weeks, HbA1C decreased over time [26]. A randomized, double blind, crossover trial of dietary supplementation with phytoestrogens (soy protein 30 g/day, isoflavones 132 mg/day) versus placebo (cellulose 30 g/day) for 12 weeks, separated by a 2 week washout period, to postmenopausal women with type 2 diabetes, the phytoestrogen supplementation demonstrated significantly lower mean values of HbA1C [27]. Genistein, one of the main isoflavones in soybeans, administered to streptozotocin induced diabetic rats significantly increased the plasma insulin and decreased the HbA1C level [28]. Six week intervention with either lifestyle intervention (increased physical activity and a low calorie diet) or a regimen with a low calorie, high soy protein drink with a low glycemic index to forty two patients who are pre diabetic and have impaired fasting glucose showed a significant increase in insulin in soy protein drink group [29].

Conclusion

Our findings confirmed that dietary intake of soy protein which has isoflavones (phytoesterogen) for four-weeks has beneficial effect on CVD markers and some MetS indices including abdominal circumference, triglycerides, HbA1c and insulin in dyslipidemic subjects in south India. This study further merits that, this is the first soy intervention study in India, where soy beans are not commonly eaten and risks of metabolic diseases are very high in contrast to soy eating Asian populations such as Japanese and Koreans. Further studies are needed to obtain more results that are conclusive.

Acknowledgment

Number 20256001).

Conflict of Interest

None

References

1. Chidambaram N, Sethupathy S, Saravanan N, Mori M, Yamori Y, et al. (2014) Relationship of sodium and magnesium intakes to hypertension proven by 24-hour urianalysis in a South Indian population. J Clin Hypertens (Greenwich) 16: 581-586.

2. Ray S, Bairagi AK, Guha S, Ganguly S, Ray D, et al. (2012) A simple way to identify insulin resistance in non-diabetic acute coronary syndrome patients with impaired fasting glucose. Indian J Endocrinol Metab 16: S460-464.

3. Enas EA, Chacko V, Pazhoor SG, Chennikkara H, Devarapalli HP (2007) Dyslipidemia in South Asian patients. Curr Atheroscler Rep 9: 367-374.

4. Beaglehole R (1990) International trends in coronary heart disease mortality, morbidity, and risk factors. Epidemiol Rev 12: 1-15.

5. Anderson JW, Johnstone BM, Cook-Newell ME (1995) Meta-analysis of the effects of soy protein intake on serum lipids. N Engl J Med 333: 276-282.

6. Potter SM (1998) Soy protein and cardiovascular disease: the impact of bioactive components in soy. Nutr Rev 56: 231-235.

7. Jenkins DJ, Kendall CW, Marchie A, Jenkins AL, Augustin LS, et al. (2003) Type 2 diabetes and the vegetarian diet. Am J Clin Nutr 78: 610S-616S.

8. Vedavanam K, Srijayanta S, O'Reilly J, Raman A, Wiseman H (1999) Antioxidant action and potential antidiabetic properties of an isoflavonoid containing soyabean phytochemical extract (SPE). Phytother Res. 13: 601-608.

9. Akiyama T, Ishida J, Nakagawa S, Ogawara H, Watanabe S, et al. (1987) Genistein, a specific inhibitor of tyrosine-specific protein kinases. J Biol Chem 262: 5592-5595.

10. Goodman-Gruen D, Kritz-Silverstein D (2001) Usual dietary isoflavone intake is associated with cardiovascular disease risk factors in postmenopausal women. J Nutr 131: 1202-1206.

11. Yang G, Shu XO, Jin F, Elasy T, Li HL, et al. (2004) Soyfood consumption and risk of glycosuria: a cross-sectional study within the Shanghai Women's Health Study. Eur J Clin Nutr 58: 615-620.

12. Villegas R, Gao YT, Yang G, Li HL, Elasy TA, et al. (2008) Legume and soy food intake and the incidence of type 2 diabetes in the Shanghai Women's Health Study. Am J Clin Nutr 87: 162-167.

13. Nanri A, Mizoue T, Takahashi Y, Kirii K, Inoue M, et al. (2010) Soy product and isoflavone intakes are associated with a lower risk of type 2 diabetes in overweight Japanese women. J Nutr 140: 580-586.

14. Kanda T, Sagara M, Hirao S, Lin LJ, Negishi H, et al. (2000) Soy bean diets decrease cardiovascular risk factors in Japanese immigrants living in Hawaii. The Third International Soybean Processing and Utilization Conference. Dawn of the Innovative Era for Soybeans. Proceedings: 199-200.

15. Nitin Nahar, Simmi Dubey, Ankur Joshi, Sameer Phadnis, VK Sharma (2012) Association of anthropometric indices of obesity with diabetes, hypertension and dyslipidemia: a study from central India. Indian J Med Specialities 3: 6-11.

16. WHO Collaborating Center on Primary Prevention of Cardiovascular Diseases, and Cardiovascular Disease Unit, WHO (1986) "Cardiovascular Disease and Alimentary Comparison (CARDIAC) Study Protocol and Manual of Operations." WHO Collaborating Center on Primary Prevention of Cardiovascular Diseases and WHO, Shimane/Geneva.

17. Yamori Y, Nara Y, Kihara M, Mano M, Horie R (1984) Simple method for sampling consecutive 24-hour urine for epidemiological and clinical studies. Clin Exp Hypertens A 6: 1161-1167.

18. Uesugi T, Fukui Y, Yamori Y (2002) Beneficial effects of soybean isoflavone supplementation on bone metabolism and serum lipids in postmenopausal japanese women: a four-week study. J Am Coll Nutr 21: 97-102.

19. Liu J, Sun LL, He LP, Ling WH, Liu ZM, et al. (2014) Soy food consumption, cardiometabolic alterations and carotid intima-media thickness in Chinese adults. Nutr Metab Cardiovasc Dis 24: 1097-1104.

20. Maesta N, Nahas EA, Nahas-Neto J, Orsatti FL, Fernandes CE, et al. (2007) Effects of soy protein and resistance exercise on body composition and blood lipids in postmenopausal women. Maturitas 56: 350-358.

21. Acharjee S, Zhou JR, Elajami TK, Welty FK (2015) Effect of soy nuts and equol status on blood pressure, lipids and inflammation in postmenopausal women stratified by metabolic syndrome status. Metabolism 64: 236-243.

22. Andrade GF, de Almeida Cd, Espeschit AC, Dantas MI, Benjamin Ldos A, et al. (2013) The addition of whole soy flour to cafeteria diet reduces metabolic risk markers in wistar rats. Lipids Health Dis 12: 145.

23. Kim J, Choi JN, Choi JH, Cha YS, Muthaiya MJ, et al. (2013) Effect of fermented soybean product (Cheonggukjang) intake on metabolic parameters in mice fed a high-fat diet. Mol Nutr Food Res 57: 1886-1891.

24. Kim, Lee H, Lee O, Lee KH, Lee YB, et al. (2013) Isoflavone supplementation influenced levels of triglyceride and luteunizing hormone in Korean postmenopausal women. Arch Pharm Res 36: 306-313.

25. Ahn-Jarvis J, Clinton SK, Riedl KM, Vodovotz Y, Schwartz SJ (2012) Impact of food matrix on isoflavone metabolism and cardiovascular biomarkers in adults with hypercholesterolemia. Food Funct 3: 1051-1058.

26. Vaisman N, Lansink M, Rouws CH, van Laere KM, Segal R, et al. (2009) Tube feeding with a diabetes-specific feed for 12 weeks improves glycaemic control in type 2 diabetes patients. Clin Nutr 28: 549-555.

27. Jayagopal V, Albertazzi P, Kilpatrick ES, Howarth EM, Jennings PE, et al. (2002) Beneficial effects of soy phytoestrogen intake in postmenopausal women with type 2 diabetes. Diabetes Care 25: 1709-1714.

28. Lee JS (2006) Effects of soy protein and genistein on blood glucose, antioxidant enzyme activities, and lipid profile in streptozotocin-induced diabetic rats. Life Sci 79: 1578-1584.

29. König D, Kookhan S, Schaffner D, Deibert P, Berg A (2014) A meal replacement regimen improves blood glucose levels in prediabetic healthy individuals with impaired fasting glucose. Nutrition 30: 1306-1309.