Scientific Research Publishing

Food and Nutrition Sciences, 2022, 13, 337-348
https://www.scirp.org/journal/fns
ISSN Online: 2157-9458
ISSN Print: 2157-944X

Effects of Soymilk on Serum Insulinemic Status and High Sensitivity C-Reactive Protein Levels in Healthy Postmenopausal Women of Bangladesh

Farjana Rahman Bhuiyan[1]*, Israt Ara Hossain[2], Khursheed Jahan[3], Liaquat Ali[2]

[1]Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN), Narayanganj, Bangladesh
[2]Department of Biochemistry & Cell Biology, Bangladesh University of Health Sciences (BUHS), Dhaka, Bangladesh
[3]Institute of Nutrition & Food Science (INFS), University of Dhaka, Dhaka, Bangladesh
Email: *farjanarb@yahoo.com, israt.ru84@gmail.com, kjahanuniv@gmail.com, liaquat304@gmail.com

How to cite this paper: Bhuiyan, F.R., Hossain, I.A., Jahan, K. and Ali, L. (2022) Effects of Soymilk on Serum Insulinemic Status and High Sensitivity C-Reactive Protein Levels in Healthy Postmenopausal Women of Bangladesh. *Food and Nutrition Sciences*, **13**, 337-348.
https://doi.org/10.4236/fns.2022.134025

Received: February 14, 2022
Accepted: April 9, 2022
Published: April 12, 2022

Abstract

Background: Postmenopausal women are at increased risk for cardiac diseases because many risk factors are aggravated by menopause. Isoflavones are phytoestrogens present in natural sources, and they may modulate risk factors favorably, involving mechanisms similar to estrogen. The study aimed to assess the effects of soymilk on serum insulinemic status and hs-C reactive protein (CRP) levels of postmenopausal women of Bangladesh. **Methods:** Thirty-six women (aged 50 ± 5 years, M ± SD) participated in a randomized, un-blind, open-ended, crossover study design for 52 days. During the study period, the patients made four visits (before and after the intervention including the washout period). The soymilk group consumed 350 mL of milk twice a day for 21 days; the milk contained ~30 mg of isoflavones. Fasting blood glucose (FBG), postprandial glucose (PPG), HbA1c, serum insulin, and hs-CRP were measured on day 0, day 21, day 31, and day 51 with a 10-day washout period. Paired t-test was performed to determine the effects of soymilk on the CVD risks among postmenopausal women and a student *t*-test was performed for group comparison. Statistical tests were considered significant at p value of ≤0.05. **Results:** The mean (±SD) BMI of the postmenopausal women was 25.14 ± 3.55 kg/m^2. In the consumption of soymilk no significant changes were found in glycemic, insulinemic, and hs-CRP levels between and within the groups. After crossover, a significant change was observed in FBG (5.18 ± 0.49 vs 5.56 ± 0.43, p = 0.005) in the soymilk group. No significant changes were observed in other parameters within or between the groups. However, FBG and hs-CRP levels were found to improve but not significantly at the end of 51 days. **Conclusions:** Soy isoflavones did not improve serum insulinemic status and hs-C reactive protein (CRP) levels among Bangladeshi postmenopausal women. Further studies need to be elucidated by considering a follow-up study with a large sample size.

Keywords

Soymilk, Isoflavones, Postmenopausal Women, Hs-C Reactive Protein, Insulinemic Status, Bangladesh

1. Introduction

Cardiovascular diseases (CVDs) are the prominent cause of mortality and morbidity among postmenopausal women in developed as well as developing countries. The incidence of CVD is lower in premenopausal women than in men; however, CVD risk in postmenopausal women is 3.4 times that in premenopausal women [1]. These differences in risk may be partially associated with increases in C reactive protein (CRP) [2]. Elevated CRP, a marker of acute inflammation, is a reliable predictor of CVD [3]. On the other hand, studies had shown that hormone therapy results in a short-term rise in CRP [4] [5].

HRT is used to improve the quality of life of menopausal women, but due to its high expense and probable serious side effects (*i.e.* endometrial hyperplasia, endometrial carcinoma, and uterine hemorrhage), it is now seriously thought that alternative therapy is necessary. Under this context, a baseline survey was conducted in BIRDEM [6] for determining the quantitative and qualitative intake of phytoestrogens contents of food (like soymilk, lentil, wheat, rice, fruits, beans, cabbage, onion, garlic, potato, tomato, etc.) in Bangladeshi postmenopausal women and its relation to clinical outcome. This has resulted in a renewed interest in research that investigates the health benefits of soymilk and it was found that phytoestrogens in soymilk significantly reduce menopausal symptoms. The FDA approved a food label claim that 25 g soy protein/d may help prevent coronary heart disease [7], based on reductions in lipids and lipoproteins. The result of epidemiological studies suggests that soy protein or its components (isoflavones) may protect against the atherosclerotic CVD risk factors hs-CRP, which generally increase with menopause [2]. However, the effects of phytoestrogens on insulin resistance have not had consistent results and are more difficult to interpret because insulin resistance was not the primary outcome. These limited studies on insulin resistance were also performed in different study populations, postmenopausal women with type 2 diabetes [8] and premenopausal women [9], therefore difficult to compare.

Soybean products are now marketed in Bangladesh and those can contribute to the health and wellbeing of our population. The popularization of the products is, however, slow and a major reason for the lower rate of market growth is the lack/shortage of evidence on the health consequences of these products.

Postmenopausal women create a substantial family and social burden. In Bangladesh, so far no study has addressed the reduction of postmenopausal problems through diet-based strategies. The aim of this study was to investigate the effect of soymilk on serum insulinemic status and hs-C reactive protein levels in healthy postmenopausal women of Bangladesh.

2. Materials and Methods

2.1. Subjects

The study was conducted at the Department of Biomedical Research Group (BMRG), BIRDEM, Dhaka, Bangladesh, during March-October 2012. Thirty-six postmenopausal women partook in the study. The study included those who were aged between >50 years; postmenopausal without the menstrual stage for at least one year; non-user of HRT and had an intact uterus, and also willing to obey the protocol and agreed to sign the written informed consensus. The study excluded those that were receiving any oral contraceptives or hormone replacement therapy within the last three months; those that had a menstrual period of <12 months before initiation of the study protocol; those with any chronic illness advised for hospitalization; and those who were unable to answer. The minimum sample size required was calculated using the formula [10] $(\mu 1 - \mu 2)^2 = f(\alpha, P)\sigma^2(1/n + 1/n)$; where, $\mu 1 - \mu 2 = 1$; significance level $(\alpha) = 0.05$; power $(P) = 0.09$, which gives $f(\alpha, P) = 10.5$; $\sigma = 1.0$.

2.2. Study Design

This randomized, un-blinded, open-ended, crossover study lasted for 52 days. During the study period, the patients made four visits (before and after the intervention including the washout period). All the postmenopausal women were randomly parted into two groups: Group A and Group B. The postmenopausal women of Group A received soymilk and of Group B received a conventional diet for three weeks and after the 10 days washout period, Group B received soymilk, and group A received a conventional diet for an additional three weeks (**Figure 1**).

The soymilk groups consumed 350 mL of soymilk twice a day; the milk contained ~30 mg of isoflavones. The number of isoflavones was calculated following the instructions of the Japan-Bangladesh Cultural Exchange Association [11]. An amount of 350 mL soymilk was prepared from the 100 g of bean following the standard procedure and kept in the refrigerator [11]. On the appointment date, study subjects visited the Department after overnight (8 - 12 hours) fasting. Fasting blood samples (5 mL) were drawn from the antecubital vein of the subjects. The time of drawing blood samples was recorded as 0 minutes. Then the subjects received a specific amount of soymilk for three weeks. Blood parameters (FBG, PPG, HbA1c, Fasting Insulin, and hs-CRP) were measured on day 0 and again on day 21 after taking soymilk, before and after day 31, and day 51 after the 10 days washout period. During this experiment, the subjects were requested not to take any kind of rich food and isoflavones-rich

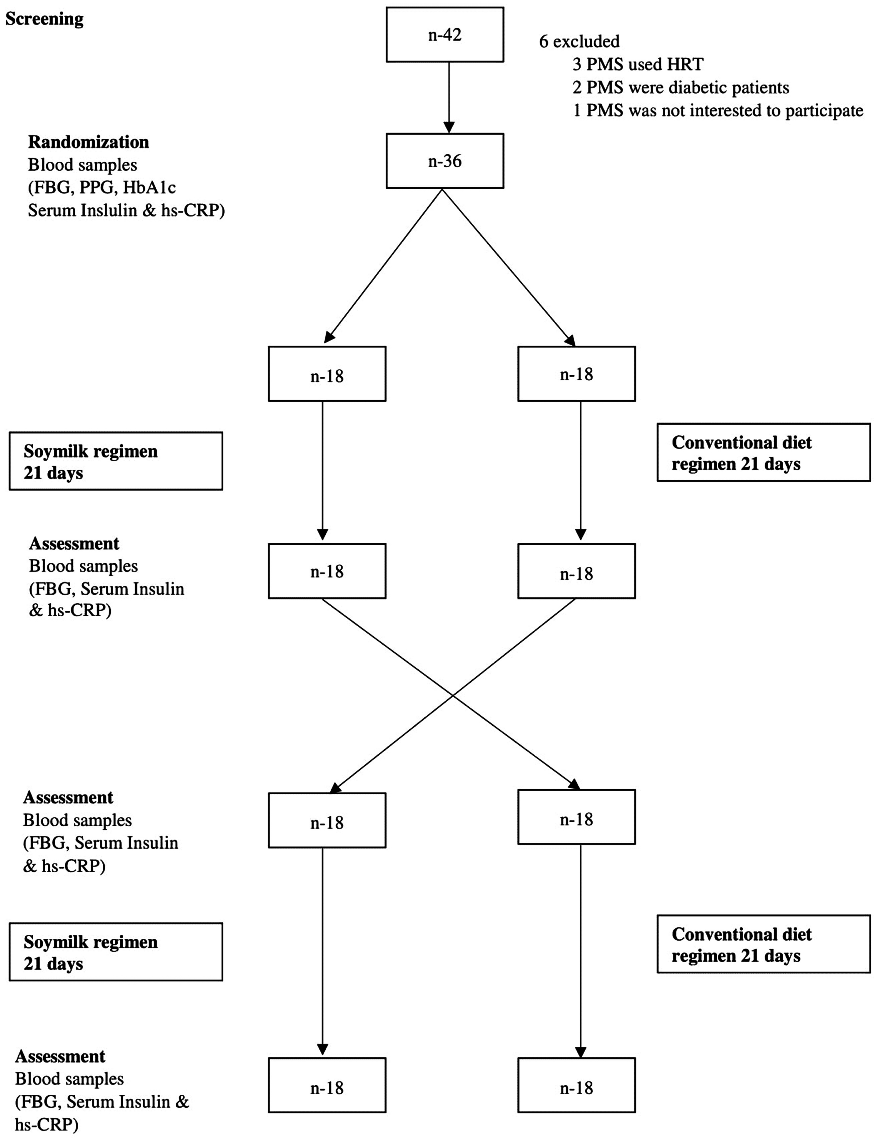

Figure 1. Design and conduct of the study.

foods, like mung, masoor dals, soybean, raw garlic, green bean, potatoes, sweet potatoes, nuts, chickpeas, wheat flour, grapefruit, dates, egg, and nut.

The blood samples were taken in a heparin-containing tube and centrifuged immediately. The serum was separated from the blood samples and stored at −30˚C for biochemical analysis.

2.3. Laboratory Analyses

Fasting serum glucose was analyzed using the glucose oxidase method (Randox, UK). The high-performance liquid chromatography (HPLC) method (Variant II, Bio-Rad Laboratories, Hercules, CA, USA) was used for measuring glycated haemoglobin (HbA1c). Serum insulin and hs-CRP were determined by ELISA technique using commercial kits (DRG-International, Germany) and their optical density (OD) was measured by ELISA plate reader (Multiscan FC, USA). The inter- and intra-assay coefficient of variation (% CV) for FSG, insulin and hs-CRP were 3.35%, 4.33% and 5.12% and 2.1%, 3.11% and 4.01% respectively. Insulin secretory function (HOMA%B) and insulin sensitivity (HOMA%S) were calculated from fasting serum glucose and fasting serum insulin values by homeostasis model assessment (HOMA) using HOMACIGMA software. Insulin resistance was quantified by homeostasis model assessment of insulin resistance (HOMA-IR) and calculated according to the formula: HOMA-IR = Fasting serum insulin (μIU/mL) × fasting serum glucose (mmol/L)/22.5 [12].

2.4. Statistical Analysis

Statistical tests were considered significant at the p-value of ≤ 0.05. Results were expressed as M ± SD for descriptive analysis. A paired t-test was performed to determine the effects of soymilk on the CVD risks among postmenopausal women. Besides, a student t-test was performed for group comparison. The statistical package for social science (SPSS) software (Windows version 16.0) was used for the analysis and interpretation of data.

2.5. Ethical Aspects

Informed written consent was obtained from all the participants after a full explanation of the nature, purpose, and procedures used for the study. Ethical approval was obtained from the ethics and research review committees of the Diabetic Association of Bangladesh.

3. Result

The mean age of the postmenopausal women was 50 ± 5 years, and the mean duration of their menopause was 4 ± 2.71 years. Of the study subjects, 94.4% came from the urban area. The mean duration of years of education was 8 ± 4 years. Nearly half (41.7%) of the menopausal women had a monthly family expenditure of Tk 5000 - 10,000/-, and 27.4% were homemakers.

The biochemical characteristics of the study subjects (n = 36) were given in **Table 1**. Variables were expressed as Mean ± SD, **Figure 2** shows the distribution of the study subjects according to different BMI categories (adapted from WHO guideline, 2004) [13]. The mean (±SD) BMI was 25.14 ± 3.55 kg/m^2. Of

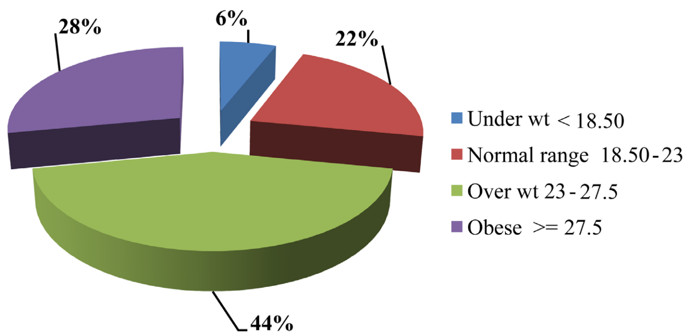

Figure 2. Percentage of BMI of the study subjects according to WHO guideline, 2004.

Table 1. Baseline characteristics of the study subjects (n = 36).

Variable	Mean ± SD
Body mass index (kg/m^2)	25.14 ± 3.55
Systolic blood pressure (mmHg)	114 ± 11.61
Diastolic blood pressure (mmHg)	75 ± 10.03
Fasting blood glucose (mmol/L)	5.37 ± 0.68
Postprandial glucose (mmol/L)	6.42 ± 1.02
HbA1c (%)	5.92 ± 0.61
Fasting Insulin (µIU/ml)	17.08 ± 9.41
HOMA-IR	4.06 ± 2.19
HOMA%B	160 ± 80.22
HOMA%S	48 ± 20.95
hs-CRP (mg/l)	2.25 ± 1.23

Results are expressed as mean ± SD, number (%).

the postmenopausal women, 28% were at increased risk, and 44% were at acceptable risk.

The effects of soymilk on glycemic, insulinemic, and hs-CRP levels of postmenopausal women were shown in Table 2. No significant changes were observed between the two groups.

After crossover, a significant change was observed in FBG (5.56 ± 0.43 vs 5.18 ± 0.49, $p = 0.005$) in the soymilk group. No significant changes were observed in other parameters within or between the groups (Table 3).

Levels of serum insulin, HOMA-IR, HOMA%B, HOMA%S, and hs-CRP were estimated for each subject at the beginning of the study and at the end of 51 days. FBG and hs-CRP levels were found to improve but not significantly (Table 4).

4. Discussion

Since inflammation is believed to have a part in the pathogenesis of cardiovascular diseases, the measurement of inflammatory markers has been projected as a process to recover the prediction of the risk of these events. hs-CRP proved to be the strongest and most significant predictor of the risk of probable cardiovascular events. In the present study, the intake of soymilk (~30-mg dietary isoflavones) by the postmenopausal women slightly altered the level of hs-CRP but not significantly. This result coincides with results of some double-blind, placebo-controlled, randomized, crossover intervention studies [14] [15] [16] [17] where 50 - 100 mg of dietary isoflavones did not show any effect on hs-CRP in healthy postmenopausal women. Results of another study revealed that dietary isoflavones intake significantly reduced serum CRP and iron stores in menopausal women [18].

Table 2. Effect of Soymilk on glycemic, insulinemic and hs-CRP levels of subjects during 0 - 21 days (n = 18 in each group).

Parameters	0 day	21 days	p value
hs-CRP (mg/l)			
Control Group	2.39 ± 1.32	2.29 ± 2.10	0.838
Soymilk Group	2.10 ± 1.15	2.28 ± 1.54	0.505
p-value	0.487	0.982	
FBG (mmol/l)			
Control Group	5.28 ± 0.65	5.39 ± 0.69	0.467
Soymilk Group	5.46 ± 0.72	5.33 ± 0.57	0.369
p-value	0.442	0.774	
S Insulin (pmol/L)			
Control Group	111.80 ± 44.33	107.42 ± 34.55	0.684
Soymilk Group	107.68 ± 42.13	102.27 ± 47.17	0.435
p-value	0.777	0.711	
HOMA-IR			
Control Group	2.07 ± 0.79	2.01 ± 0.62	0.736
Soymilk Group	2.02 ± 0.77	1.91 ± 0.86	0.422
p-value	0.842	0.707	
HOMA%B			
Control Group	147.49 ± 64.81	136.95 ± 45.17	0.484
Soymilk Group	132.14 ± 49.76	130.19 ± 43.88	0.797
p-value	0.431	0.652	
HOMA%S			
Control Group	56.23 ± 23.79	54.63 ± 16.88	0.762
Soymilk Group	57.57 ± 23.89	62.89 ± 27.99	0.393
p-value	0.867	0.291	

Results are expressed as mean ± SD; Paired t-test was used for comparing day 0 vs day 21 values; Student's t-test was used for group comparison; $p < 0.05$ was considered statistically significant; hs-CRP = high sensitivity C-Reactive Protein, FBG = Fasting blood glucose; HOMA%B = β cell function assessed by homeostasis model assessment; HOMA%S = insulin sensitivity assessed by homeostasis model assessment; HOMA-IR = insulin resistance assessed by homeostasis model assessment.

Table 3. Effect of Soymilk on glycemic, insulinemic and hs-CRP levels of subjects during 31 - 51 days (n = 18 in each group).

Parameters	31 days	51 days	p value
hs-CRP (mg/l)			
Control Group	2.12 ± 0.99	1.97 ± 1.13	0.446

Continued

Soymilk Group	1.93 ± 1.21	2.42 ± 1.71	0.201
p-value	0.625	0.356	
FBG (mmol/l)			
Control Group	5.39 ± 0.51	5.23 ± 0.49	0.338
Soymilk Group	5.56 ± 0.43	5.18 ± 0.49	***0.005***
p-value	0.297	0.761	
S Insulin (pmol/L)			
Control Group	103.76 ± 34.12	103.75 ± 38.73	0.999
Soymilk Group	119.92 ± 41.39	109.49 ± 38.35	0.243
p-value	0.210	0.658	
HOMA-IR			
Control Group	1.95 ± 0.65	1.93 ± 0.72	0.915
Soymilk Group	2.25 ± 0.75	2.03 ± 0.71	0.177
p-value	0.206	0.678	
HOMA%B			
Control Group	128.30 ± 28.16	136.94 ± 39.04	0.418
Soymilk Group	135.21 ± 41.65	144.92 ± 35.15	0.343
p-value	0.564	0.524	
HOMA%S			
Control Group	56.70 ± 18.50	58.27 ± 19.64	0.792
Soymilk Group	50.02 ± 18.90	55.79 ± 21.09	0.205
p-value	0.292	0.718	

Results are expressed as mean ± SD; Paired t-test was used for comparing day 0 vs day 21 values; Student's t-test was used for group comparison; $p < 0.05$ was considered statistically significant; hs-CRP = high sensitivity C-Reactive Protein, FBG = Fasting blood glucose; HOMA%B = β cell function assessed by homeostasis model assessment; HOMA%S = insulin sensitivity assessed by homeostasis model assessment; HOMA-IR = insulin resistance assessed by homeostasis model assessment.

Table 4. Changes of glycemic, insulinemic and hs-CRP status at baseline and after day 51 of intervention in postmenopausal women (n = 36).

Variables	Baseline	End-point	p value
hs-CRP (mg/l)	2.14 ± 1.16	2.24 ± 1.63	0.559
FBG (mmol/L)	5.42 ± 0.59	5.29 ± 0.56	0.061
S Insulin (pmol/L)	110.79 ± 40.26	105.73 ± 39.22	0.249
HOMA-IR	2.07 ± 0.73	1.97 ± 0.72	0.202

Continued

HOMA%B	135.78 ± 47.50	137.25 ± 40.47	0.789
HOMA%S	55.13 ± 21.18	57.90 ± 21.56	0.304

Results are expressed as mean ± SD; Paired t-test was used for hypothesis testing, $p < 0.05$ was considered statistically significant; hs-CRP = C-reactive protein, FBG = Fasting blood glucose; HOMA%B = β cell function assessed by homeostasis model assessment; HOMA%S = insulin sensitivity assessed by homeostasis model assessment; HOMA-IR = insulin resistance assessed by homeostasis model assessment.

After menopause glucose metabolism changes in women happen within the setting of decreasing estrogen levels, rolling age, and altered abdominal fat distribution. Numerous investigations have confirmed that insulin resistance is significantly higher in postmenopausal women compared to their premenopausal counterparts. These issues may affect these women to generate cardiovascular disease and type-2 diabetes [19]. *In vitro* and animal studies have suggested that soy protein and isoflavones have promising effects on glucose and insulin regulation, but intervention studies in humans are limited.

However, this study result is similar to the results of some other intervention studies where dietary isoflavones did not show any effect on glycemic and insulin resistance in the postmenopausal women who had been treated for breast cancer [20] and among postmenopausal Chinese women with prediabetes [21]. Nevertheless, other trials showed no significant benefits in any of the glycemic parameters after 03 months of high dose (160 mg) isoflavones in healthy postmenopausal women [19].

Results of another study revealed that soy phytoestrogen or its subgroup isoflavones favorably alters glycemic control and insulin resistance in postmenopausal women with type 2 diabetes [22]. A study showed that fasting glucose and insulin levels were significantly affected by isoflavones treatments after 6 months in Taiwanese postmenopausal women [23].

The recognition of the physiologic effects of dietary soy is a complicated issue because soy protein contains many components, such as isoflavones, phytate, saponins, and β-conglycinin, each of which may be accountable for the beneficial consequence. Differing results between the present study and others may be influenced due to the lack of extraction of isoflavones in soymilk, failure to quantify individual isoflavones quantity, calculated total isoflavones using literature assessment [11], and the shortage period of intervention. Besides this, the present study also had a couple of limitations, such as study design, the short period of intervention, usages of literature-based value, and failure to monitor the patients.

5. Conclusion

In the present study, we were unable to show improvement in any inflammatory markers or glycemic status in generally healthy postmenopausal women of Bangladesh after consuming soymilk. However, the comparatively small sample size and short duration of follow-up are strong limitations, and thus the null results can be treated only as preliminary and should be interpreted with caution. If the prolonged practices of the regimen can be run, there is a possibility of the beneficial effect of soymilk on CVD risks among Bangladeshi postmenopausal women.

Acknowledgements

We highly acknowledge Dr. Farzana Salah, Head, Department of the Community Nutrition, Bangladesh University of Health Sciences (BUHS), for her guidance during conducting the research. We also thank the postmenopausal women who participated in the study. We acknowledge the Diabetic Association of Bangladesh for the technical support.

Authors' Contributions

FRB: contributed her intellectual ability to conception and design of the research, analysis, and interpretation of data; drafting the article, revising it critically for important intellectual content; and final approval of the version to be published. IRH: contributed her intellectual skill in the analysis and interpretation of data. KJ: contributed her intellectual skill in the revision of the manuscript. LA: revision of the manuscript for important intellectual content. All of the above authors clearly fully read and approved the final manuscript.

Funding

The study was partly supported by the Research and Development (R & D) fund and the award no. 39.012.002.02.01.017.2014/R & D-16/90 from the Ministry of Science and Technology (MOST), Government of the People's Republic of Bangladesh.

Conflicts of Interest

The authors declare that they have no competing interests.

References

[1] Witteman, J.C.M., Grobbee, D.E., Kok, F.J., Hofman, A. and Valkenburg, H.A. (1989) Increased Risk of Atherosclerosis in Women after the Menopause. *British Medical Journal*, **298**, 642-644. https://doi.org/10.1136/bmj.298.6674.642

[2] Hanson, L.N., Engelman, H.M., Alekel, D.L., Schalinske, K.L., Kohut, M.L. and Reddy, M.B. (2006) Effects of Soy Isoflavones and Phytate on Homocysteine, C-Reactive Protein, and Iron Status in Postmenopausal Women. *The American Journal of Clinical Nutrition*, **84**, 774-780. https://doi.org/10.1093/ajcn/84.4.774

[3] Ridker, P.M., Glynn, R.J. and Hennekens, C.H. (1998) C-Reactive Protein Adds to the Predictive Value of Total and HDL Cholesterol in Determining Risk of First Myocardial Infarction. *Circulation*, **97**, 2007-2011. https://doi.org/10.1161/01.CIR.97.20.2007

[4] Sanada, M., Tsuda, M., Kodama, I., Sakashita, T., Nakagawa, H. and Ohama, K.

(2004) Substitution of Transdermal Estradiol during Oral Estrogen-Progestin Therapy in Postmenopausal Women: Effects on Hypertriglyceridemia. *Menopause*, **11**, 331-336. https://doi.org/10.1097/01.GME.0000094211.15096.B4

[5] Yilmazer, M., Fenkci, V., Fenkci, S., *et al.* (2003) Hormone Replacement Therapy, C-Reactive Protein, and Fibrinogen in Healthy Postmenopausal Women. *Maturitas*, **46**, 245-253. https://doi.org/10.1016/S0378-5122(03)00217-2

[6] Saleh, F. (2004-2005) Dietary Management of Menopausal Syndrome: Role of Phytoestrogens. MPhil Thesis (Nutrition), INFS, Dhaka.

[7] Food and Drug Administration (2002) Code of Federal Regulations. 21CFR101.82, References Health Claims: Soy Protein and Risk of Coronary Heart Disease. US Government Printing Office, Washington DC, 144-146. https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm?fr=101.82.

[8] Boonkasemsanti, W., Reinprayoon, D., Pruksananonda, K., *et al.* (1996) The Effect of Transdermal Oestradiol on Bleeding Pattern, Hormonal Profiles and Sex Steroid Receptor Distribution in the Endometrium of Norplant Users. *Human Reproduction*, **11**, 115-123. https://doi.org/10.1093/humrep/11.suppl_2.115

[9] Blakesmith, S.J., Lyons-Wall, P.M., George, C., Joannou, G.E., Petocz, P. and Samman, S. (2003) Effects of Supplementation with Purified Red Clover (*Trifolium pratense*) Isoflavones on Plasma Lipids and Insulin Resistance in Healthy Premenopausal Women. *British Journal of Nutrition*, **89**, 467-474. https://doi.org/10.1079/BJN2002807

[10] Bland, M. (2000) An Introduction to Medical Statistics. 3rd Edition, Oxford University Press, New York.

[11] Jessore, S. (2011) Japan Bangladesh Cultural Exchange Association (JBCEA).

[12] Matthews, D.R., Hosker, J.P., Rudenski, A.S., Naylor, B.A., Treacher, D.F. and Turner, R.C. (1985) Homeostasis Model Assessment: Insulin Resistance and Beta-Cell Function from Fasting Plasma Glucose and Insulin Concentrations in Man. *Diabetologia*, **28**, 412-419. https://doi.org/10.1007/BF00280883

[13] WHO Expert Consultation (2004) Appropriate Body-Mass Index for Asian Populations and Its Implications for Policy and Intervention Strategies. *The Lancet*, **363**, 157-163. https://doi.org/10.1016/S0140-6736(03)15268-3

[14] Ho, S.C., Chan, A.S.Y., Ho Y.P., So, E.K.F., Sham, A., Zee, B. and Woo, J.L.F. (2007) Effects of Soy Isoflavone Supplementation on Cognitive Function in Chinese Postmenopausal Women: A Double-Blind, Randomized, Controlled Trial. *Menopause*, **14**, 489-499. https://doi.org/10.1097/gme.0b013e31802c4f4f

[15] Greany, K.A., Nettleton, J.A., Wangen, K.E., Thomas, W. and Kurzer, M.S. (2008) Consumption of Isoflavone-Rich Soy Protein Does Not Alter Homocysteine or Markers of Inflammation in Postmenppausal Women. *European Journal of Clinical Nutrition*, **62**, 1419-1425. https://doi.org/10.1038/sj.ejcn.1602885

[16] Rebholz, C.M., Reynolds, K., Wofford, M.R., Chen, J., Kelly, T.N., Mei, H., Whelton, P.K. and He, J. (2013) Effect of Soybean Protein on Novel Cardiovascular Disease Risk Factors: A Randomized Controlled Trial. *European Journal of Clinical Nutrition*, **67**, 58-63. https://doi.org/10.1038/ejcn.2012.186

[17] Hall, W.L., Vafeiadou, K., Hallund, Jesper., Bügel, S., Koebnick, C., Reimann, M., Ferrari, M., Branca, F., Talbot, D., Dadd, T., Nilsson, M., Dahlman-Wright, K., Gustafsson, J.-A., Minihane, A.-M. and Williams, C.M. (2005) Soy-Isoflavone-Enriched Foods and Inflammatory Biomarkers of Cardiovascular Disease Risk in Postmenopausal Women: Interactions with Genotype and Equol Production. *The American Journal of Clinical Nutrition*, **82**, 1260-1268.

https://doi.org/10.1093/ajcn/82.6.1260

[18] Hanson, L.N., Engelman, H.M., Alekel, D.L., Schalinske, K.L., Kohut, M.L. and Reddy, M.B. (2006) Effects of Soy Isoflavones and Phytate on Homocysteine, C-Reactive Protein, and Iron Status in Postmenopausal Women. *The American Journal of Clinical Nutrition*, **84**, 774-780. https://doi.org/10.1093/ajcn/84.4.774

[19] Charles, C., Yuskavage, J., Carlson, O., John, M., Tagalicud, A.S., Maggio, M., Muller, D.C., Egan, J. and Basaria, S. (2009) Effects of High-Dose Isoflavones on Metabolic and Inflammatory Markers in Healthy Postmenopausal Women. *Menopause*, **16**, 395-400. https://doi.org/10.1097/gme.0b013e3181857979

[20] Nikander, E., Tiitinen, A., Laitinen, K., Tikkanen, M. and Ylikorkala, O. (2004) Effects of Isolated Isoflavonoids on Lipids, Lipoproteins, Insulin Sensitivity, and Ghrelin in Postmenopausal Women. *The Journal of Clinical Endocrinology & Metabolism*, **89**, 3567-3572. https://doi.org/10.1210/jc.2003-032229

[21] Liu, Z.-M., Chen, Y.-M., Ho, S.C., Ho, Y.P. and Woo, J. (2010) Effects of Soy Protein and Isoflavones on Glycemic Control and Insulin Sensitivity: A 6-Mo Double-Blind, Randomized, Placebo-Controlled Trial in Postmenopausal Chinese Women with Prediabetes or Untreated Early Diabetes. *The American Journal of Clinical Nutrition*, **91**, 1394-1401. https://doi.org/10.3945/ajcn.2009.28813

[22] Jayagopal, V., Albertazzi, P., Kilpatrick, E.S., Howarth, E.M., Jennings, P.E., Hepburn, D.A. and Atkin, S.L. (2002) Beneficial Effects of Soy Phytoestrogen Intake in Postmenopausal Women with Type 2 Diabetes. *Diabetes Care*, **25**, 1709-1714. https://doi.org/10.2337/diacare.25.10.1709

[23] Cheng, S.-Y., Shaw, N.-S., Tsai, K.-S. and Chen, C.-Y. (2004) The Hypoglycemic Effects of Soy Isoflavones on Postmenopausal Women. *Journal of Women's Health*, **13**, 1080-1086. https://doi.org/10.1089/jwh.2004.13.1080

Abbreviations

hs-CRP: high sensitivity-C Reactive Protein
FBG: Fasting Blood Glucose
PPG: Postprandial Glucose
BMI: Body Mass Index
WHO: World Health Organization
BIRTAN: Bangladesh Institute of Research and Training on Applied Nutrition