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Original Article

Photoprotection and skin whitening effect of dietary soy milk in healthy young female adults

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Abstract

Background Topical soy formulations improve signs of aging and protects against ultraviolet light. We aimed to determine photoprotective and whitening effects of oral soy.

Methods Healthy volunteers drank commercial soy milk containing 20mg isoflavones twice daily for 8 weeks, and avoided consumption of isoflavone-rich food, sunscreen and lightening products. Phototest and skin colour measurement was performed at baseline and at the end of study.

Results Thirty healthy females aged 21(19-22) years with Fitzpatrick skin type III and IV participated. Soy milk significantly increased whiteness at the cheek and gluteal regions. Minimal erythema dose (MED) to UVA increased in 60% subjects, MED to UVB increased in 87%. Significant reduction in UVB induced erythema was observed with all UVB doses, UVA induced erythema decreased with higher doses.

Conclusion Short term regular consumption of soymilk showed photoprotection and skin whitening effects.

Key words
Soy milk, photoprotection, whitening, minimal erythema dose, ultraviolet light.

Introduction

Ultraviolet (UV) radiation from the sun has multiple potentially detrimental effects on the skin including skin cancers, photodermatoses, photoaggravated diseases, photodamage and photoaging. Photoprotective measures are required for prevention and treatment of these conditions. Midday sun avoidance, seeking shade, topical sunscreens, protective clothing and headgears are recommended sun protection measures.[1] However, sun-protective practices are still largely inadequate[2-4] despite sun safety education due to the inconvenience of these measures.[3] A safe and effective oral sunscreen would be ideal.

Soy (*Glycemic max)* is a legume that is high in protein and fiber. Soy milk contains 3.5% protein, 2.0% fat, 0.5% ash, 2.9% carbohydrates[5] and a high amount of isoflavone that scavenger free radicals released by UV exposure to prevent skin aging and protect against UV induced skin damage.[6] Genistein, daidzein and glycitein are 3 major types of isoflavone, soy milk contain mostly genistein. In addition to UV protection, genistein lightens the skin as it interferes with melanin synthesis pathway by inhibiting melanin production.[7-9]

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Oral genistein has been shown to protect mice's skin from UV[10] but its effect on human's skin has not been investigated. We conducted a study to determine the effect of dietary soy milk in UV protection and skin whitening in healthy young females.

Methods

This was a prospective, open label interventional cohort study performed over 8 weeks at the Faculty of Health Science, Universiti Kebangsaan Malaysia (UKM). Subjects were recruited by convenience sampling among students of the faculty. Inclusion criteria were females aged 18-35 years old with no chronic disease such as hypertension and diabetes, individuals who like soy products and able to fulfil the study requirements. Exclusion criteria were known allergy to soy products, photosensitivity or having skin that is sensitive to sunlight, routine excessive exposure to the sun (e.g. athletes), on any medicine or supplements, and smokers.

Informed consent was obtained from volunteers who fulfilled the inclusion and exclusion criteria. Subjects completed a food frequent questionnaire (FFQ)[11] to determine their usual dietary intake of soy products in the last 1 month. The FFQ consisted of 24 types of foods, portions were determined using standard measurements from Atlas of Food Exchange and Portion Size.[12] Subjects then underwent a 2 weeks washout period where they were asked to avoid soy products, other photoprotective foods and use of sunscreens. Baseline phototest and skin colour assessments were then performed. Subjects were instructed to consume 250mls of a commercial soy milk in the morning with breakfast (between 7-9am) and at noon with lunch (between 12noon to 2pm) and to continue avoiding other soy products, photoprotective foods and use of sunscreens for the next 6 weeks. At the end of the study, phototest and skin colour assessments were repeated.

The isofalvone dose required for its photoprotective effect was estimated based on an animal study performed by Wei *et al*.[10] About 40mg of isoflavone per day was given to our subjects by consuming a commercial soy milk containing 6g of protein/ 250mls. The estimation of isoflavone content in soy milk was based on protein calculation proposed by Nagata *et al*.[13] Photoprotective effects were measured by phototest with UVB and UVA to determine the degree of erythema induced on the skin by multiple doses of UV. The minimal erythema dose (MED) which is the lowest dose of UV required to induce erythema were also documented. Lower values of the degree of erythema and higher MED indicates photoprotective effects. The degree of erythema was objectively measured using a mexameter. Skin color was assessed at the right cheek to represent a sun exposed area and the right gluteal region to represent a covered area. Chromameter measured the lightness or whiteness of the skin while mexameter measured melanin or darkness.

Calculated sample size was 30, based on results from Heinrich *et al*.[13] and adjusted for 10% missing data. Ethical approval was obtained from the UKM Research Ethics Committee (UKMREC).

Results

Thirty healthy female subjects with median age of 21 (19-22) years and Fitzpatrick skin type III and IV participated in the study. The average soy products intake based on FFQ was 66.66±111.50 g/day, while the average intake of isoflavone was 22.82±39.40 mg/day. The most common types of dietary soy products and the amount consumed were commercial soy milk,

Table 1 The effect of soy milk on skin whiteness and darkness

Site	*Whiteness (N=30)*			*Darkness (N=30)*		
	Week 0 Median (IQR)	*Week 6 Median (IQR)*	*p value*	*Week 0 Median (IQR)*	*Week 6 Median (Q1,Q3)*	*p value*
Face	30.00 (2.89)	30.80 (3.61)	0.01	42.73 (3.78)	40.41 (4.63)	0.01
Gluteal	28.07 (8.52)	29.93 (8.22)	0.00	44.81 (9.63)	43.53 (9.72)	0.00

Figure 1 Type and amount of dietary soy products

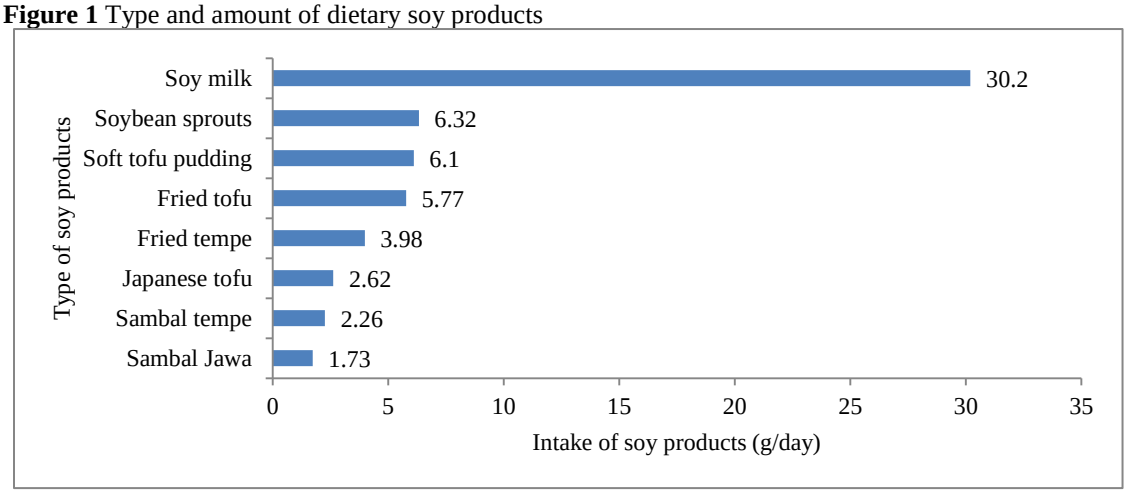
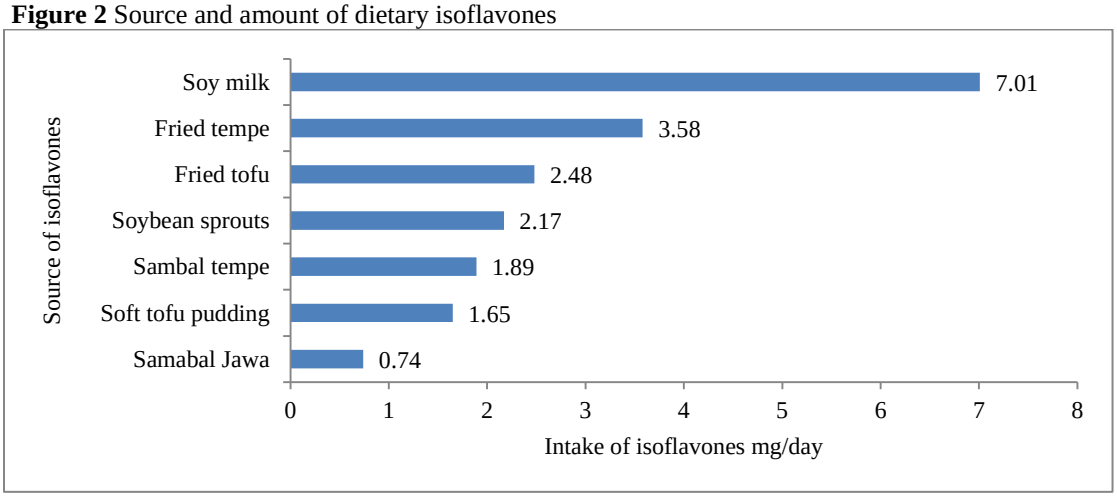


Figure 2 Source and amount of dietary isoflavones



soy bean sprout, soft tofu pudding and fried tofu. **(Figure 1)**. Soy milk was the most consumed soy product (30.20 g/day) and the highest source of dietary isoflavone (7.01mg/day). The source and amount of dietary isoflavones are summarised in **Figure 2**.

Table 2 and 3 show changes in UVA and UVB induced erythema on the skin before and after soy milk consumption. Erythema was reduced with all doses of UVA and UVB. The reductions were significant with higher doses UVA at 4.5 and 5.0 J/cm^2. Erythema with all doses of UVB ranging from 32 to 130 mJ/cm^2 were significantly reduced.

Table 2 Erythema induced by phototest with multiple doses of UVA before and after soy milk consumption

UVA dose (J/cm^2)	*Erythema N=30*		
	Week 0 Median (IQR)	*Week 6 Median (IQR)*	*p value*
2.0	14.10(2.65)	13.43 (2.61)	0.09
2.8	14.99 (3.35)	14.15 (3.20)	0.05
3.5	14.88 (3.81)	14.35 (3.71)	0.74
4.3	14.77 (3.43)	14.30 (2.34)	0.02
5.0	15.91 (3.74)	14.07 (2.18)	0.00

Table 3 Erythema induced by phototest with multiple doses of UVB before and after soy milk consumption

UVB dose (mJ/cm^2)	*Erythema (N=30)*		
	Week 0 Median (IQR)	*Week 6 Median (IQR)*	*p value*
32	14.92(3.81)	14.41(3.76)	0.03
44	15.45(3.15)	14.40(2.24)	0.03
56	15.66(3.33)	14.47(3.30)	0.05
68	15.87(3.42)	15.03(2.32)	0.01
80	16.51(3.68)	14.99(3.09)	0.00
52	15.81(4.71)	14.42(3.44)	0.01
72	16.41(4.92)	15.43(2.40)	0.04
91	16.85(4.22)	15.63(3.18)	0.00
111	17.55(3.47)	15.20(2.75)	0.00
130	17.63(3.54)	16.19(2.27)	0.00

The MED to UVA increased in 18(60%) of subjects, while the MED to UVB increased in 26 (87%). Skin color measurements on the cheek and gluteal region showed a significant increase in whitening and reduction in darkness at both sun exposed and covered areas. Whiteness of face increased from 30.00 to 30.80 unit, p=0.01 while at the gluteal region, increment from 28.07 to 29.93 unit, (p=0.00) was observed **(Table 1)**. Synchronously, the measurement of skin darkness/ melanin on the face decreased from 42.73 to 40.41 unit, p=0.0. The gluteal region showed a decline in the melanin measurement from 44.81 to 43.53 unit, p= 0.00 **(Table 2)**. There were no adverse effects reported throughout the study.

Discussion

The amount of soy isoflavone intake in our study population was slightly lower to that reported in Japan,[15,16] Hong Kong, Singapore,[15] China[17] and Korea.[18] Asian diets in general are richer in isoflavones compared to Western diet and the sources of isoflavones differ as well.[19-21] Isoflvones are mainly derived from peas, beans, coffee, tea, nuts and grains in the west while soy is the major source of isoflavones in Asia.[19] Soy milk was by far the most favoured product by our subjects compared to soy prepared by fermentation or traditional recipes. Most reports on isoflavone intake in Asia were on middle aged population that consumed more concentrated forms of soy like tofu, paste and curd,[16,22,23] this explains the lower value seen in our younger population that consumed soy mainly as a drink.

Genistein and daidzein in soy have both antioxidant and anti- inflammatory effect against UV induced cell damage that results in skin aging and predisposes to skin cancer.[10,24,25] Genistein inhibits mitogen-activated protein kinases in keratinocytes and fibroblasts which is responsible for stimulation of matrix metalloproteinases to produce collagenase, gelatinase and stromelysin-1. These enzymes break down collagen, elastin and other components of the dermal matrix that results in skin aging.[26-28] Soybean trypsin inhibitor (STI) and Bowman-Birk protease inhibitor (BBI) are soy proteins that inhibit activation of keratinocytes' protease-activated receptor 2 (PAR-2).[8,9] Activation of this receptor will initiate transfer of melanosomes from melanocytes to keratinocytes by phagocytosis. In addition, soy isoflavones are potent inhibitors of tyrosinase, the crucial enzyme in melanin synthesis.[29] Lightening of skin color occurs due to reduced melanin production and reduction in the number of melanosomes in keratinocytes.

Topical soy formulations has been shown to reduce pigmentation, improve signs of aging like wrinkling and elasticity of the skin and protects against UVA and UVB.[7,10,27,30,31] Oral

formulations produces the same pigmentary and aging effects.[10,30] The benefit of oral forms of soy genistein and daidzein against UVA and UVB have been demonstrated in vivo and in vitro in mice and human skin cell culture.[10,24,25,30] It has not been documented in humans to the best of our knowledge. Our results revealed the photoprotective effect of dietary soy against UV in healthy young adults. Better protection was achieved against UVB as significant reduction in UVB induced erythema was observed from low doses. Protection against UVA was observed only at higher doses. Skin whitening was another effect seen at both sun exposed and covered areas. A limitation of our study is, quantity of isoflavone in soy milk was estimated based on its protein content, it was not objectively measured. However, our results illustrate soy isoflavone‘s potential as oral sunscreen with added benefits of skin lightening and reduction in skin aging. The optimal dose of isoflavone or genistein and daidzein, and a detailed side effect profile in long term use need to be further determined. In conclusion, dietary soy milk is protective against UVA and UVB and whitens the skin. Its potential as oral sunscreen and skin whitening agent needs to be further evaluated.

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