Original Article

Acute effect of soy and soy products on serum uric acid concentration among healthy Chinese men

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Background and Objectives: Soy products are essential to the daily life of the Chinese population. However, the association between soy products and serum uric acid remains unclear. Better understanding of their relationship could provide food choice information for patients with gout. This study assessed the acute effects of soy and soy products on serum uric acid. **Methods and Study Design:** Sixty healthy adult male volunteers were recruited and randomly assigned to six groups. Ten participants in each group randomly ingested one of six foods: water, soy, and four different soy products. A blood test was conducted after 3 h to examine uric acid concentration. **Results:** The serum uric acid concentration significantly increased by 21.4±23.4 μmol/L at 1 h and 16.3±19.4 μmol/L at 2 h following ingestion of whole soybeans. These changes also applied to the soy powder group. The serum uric acid concentration rapidly increased by 38.1±20.5 μmol/L at 1 h, 34.4±18.2 μmol/L at 2 h, and 24.1±24.2 μmol/L at 3 h after the ingestion of soybean milk. The maximum concentration of serum uric acid was observed at 1 h after intake of soybeans and soy products, and then gradually decreased during the subsequent 2-h period. No significant uric acid changes from ingesting bean curd cake and dried bean curd stick were detected. **Conclusions:** Ingesting different soy products resulted in different concentrations of serum uric acid, with soybeans, soybean milk, and soy powder considerably increasing serum uric acid.

Key Words: soy, soy products, uric acid

INTRODUCTION

Hyperuricemia plays a major role in the development of chronic diseases such as cardiovascular disease[1] and metabolic syndrome.[2] The prevalence of hyperuricemia in China is high, affecting 21.6% of men and 8.6% of women.[3] Approximately 18.8% of patients with this disease develop gout within 5 years.[4]

Diet is associated with serum uric acid,[5] which is the final enzymatic product of purine metabolism. Ingesting foods rich in purines may lead to increased total uric acid concentrations.[6] Thus, purine-rich foods are restricted for patients with gout. A high-protein diet typically contains large quantities of purines. Soybean is a popular food throughout Asia, including China, Japan and the Koreas, and provides plentiful high-quality protein from plant sources, thus serving as an extremely versatile alternative to meat and dairy products. However, given its high purine content, soybean and soy products are not recommended for patients with hyperuricemia and gout. Short-term intervention studies[7–8] have shown that soy protein causes a rapid increase in serum uric acid, and it is considered a risk factor for hyperuricemia.[9] It has been suggested that soy products may cause gout in Asian populations.[10] In addition, both health professionals and the general public in Asia generally believe that soy foods increase the risk of gout and can precipitate acute attacks in patients with this disease.[10] However, epidemiological studies from China have provided inconsistent results indicating that consuming soy products is associated with a lower prevalence of hyperuricemia among middle-aged Chinese men, whereas consuming animal protein and seafood is associated with a higher prevalence.[11-13]

The precise purine content of most foods, especially cooked or processed foods, is not well known. Moreover, food purine content can be altered by processing,[12] storage, and cooking.[14] For example, the purine content of Tofu is lower than that of unprocessed soybeans,[10] causing a only a small increase in serum uric acid concentrations in a Japanese study.[10] Therefore, Tofu is recommended as a moderate protein source during acute attacks in patients with gout.[15] As an essential part of the traditional Asian diet, a wide range of soy products are encountered in daily life, such as soybean sprouts, soybean cheese, miso, natto, and soybean milk. However, their association with serum uric acid remains unclear.

This study aimed to determine the acute effects of soy and soy products on serum uric acid concentrations over 3 h among healthy Chinese men. A better understanding of the association of soy and soy products with serum uric

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Manuscript received 19 May 2018. Initial review completed 24 May 2018. Revision accepted 22 August 2018.
doi: 10.6133/apjcn.201811_27(6).0010

acid could provide improved food choice information for people, especially patients with gout, thereby reducing the prevalence of gout and the associated treatment and medication costs.

METHODS

Study design

A short-term randomised controlled trial study design was employed. Informed consent for experimentation with human participants was obtained. The study protocol was approved by the ethics committee of Bengbu Medical College ([2014]017).

Sixty healthy men who had no diagnosis or family history of diseases and had not donated blood during the past month were recruited through the public advertisement of the study in a school. The participants were randomly assigned to six groups, with ten in each group. The age range and body mass index were similar among the six study groups. Each group was randomly allocated for one of six foods: water, whole soybeans, and four soy products (soybean milk, soy powder, bean curd cake, and dried bean curd stick) that were selected based on the feasibility of ingesting such products (containing 40 g of protein) at a single meal. Each group completed the trial in an isolated room. Of the 60 participants enrolled in the study, ten were excluded because of a high serum uric acid concentration (more than 420 μmol/L) before ingesting food, even though they had no diagnosed diseases. Therefore, we examined 50 participants in the final analysis.

Food preparation

Whole soybeans, soy powder, bean curd cake, and dried bean curd stick were purchased from a large supermarket on the day before the trial. Whole soybeans were cleaned and soaked in water in an electric cooker for 7 h, and then boiled for 30 minutes for the whole soybean group. Whole soybeans were cleaned and soaked in water in a soybean milk machine for 7 h, and then liquefied using the machine for the soybean milk group. Soy powder was mixed with 500 mL of water for the soy powder group. Fresh bean curd cake was placed in boiling water for a few seconds and then a small amount of salt and vinegar was added after draining it for the bean curd cake group. Dried bean curd sticks were soaked in water for 2 h until they softened and then dipped in boiling water for a few seconds, with a small amount of salt and vinegar added after draining for the dried bean curd stick group. Each product amount was equivalent to 40 g of protein and was administered in a 500-mL suspension.

Blood sample collection

Participants were asked to fast overnight prior to blood collection. A venous catheter was used for blood collection. Participants ingested the target food between 7:15 and 7:30, and blood was collected before and at 1, 2, and 3 h after ingestion. The blood was stored at 4°C and transported to the Second Affiliated Hospital of Bengbu Medical College, where it was immediately tested for serum uric acid concentration using the colorimetric enzymatic method (HITACHI 7180; Hitachi, Tokyo, Japan).

Statistical analysis

Statistical analysis was performed using SPSS 17.0. Data are expressed as mean ± standard deviation (SD). A t test was used to determine changes from the baseline at different time points. A p value of <0.05 was considered significant.

RESULTS

Table 1 shows that there were no significant changes from baseline in serum uric acid concentration at 1, 2, and 3 h after ingesting water, bean curd cake, and dried bean curd stick (p>0.05). Following ingestion of whole soybean, the serum uric acid concentration significantly increased by 21.4±23.4 μmol/L at 1 h and 16.3±19.4 μmol/L at 2 h and remained at a high level at 3 h, although it did not achieve statistical significance. These significant changes also applied to the soy powder group. The serum uric acid concentration increased by 38.1±20.5 μmol/L, 34.4±18.2 μmol/L, and 24.1±24.2 μmol/L at 1, 2, and 3 h, respectively, after ingestion of soybean milk. The maximum serum uric acid concentration was observed at 1 h after ingestion of soybeans or soy products, namely, approximately 6.8% for whole soybeans, 7.8% for soy powder, and 11.6% for soybean milk, and then gradually decreased during the subsequent 2-h period.

The serum urea concentration rapidly decreased significantly over the 3-h period after the ingestion of water (Table 2). A significant increase in serum urea concentration was observed from the baseline after the ingestion of whole soybeans, soybean milk, soy powder, bean curd cake, and dried bean curd stick (p<0.05). The maximum serum urea concentration was observed at 3 h after ingestion. Bean curd cake and dried bean curd stick showed a relatively slow rising speed and low rising peak.

Table 1. Changes in serum uric acid concentration after ingesting different foods (μmol/L)[†]

Group	n	0 h	Changes from baseline[‡]		
			1 h	2 h	3 h
Water	8	349±25.6	6.50±19.1	3.8±18.7	-4.0±30.5
Whole soy bean	9	326±47.7	21.4±23.4*	16.3±19.4*	11.7±20.1
Soy bean milk	9	344±41.9	38.1±20.5**	34.4±18.2***	24.1±24.2*
Soy powder	9	344±61.1	26.6±11.3***	24.6±14.4**	12.2±25.1
Bean curd cake	7	319±68.4	7.00±39.1	6.29±23.6	-2.29±23.5
Dried bean curd stick	8	345±53.2	3.13±6.60	1.63±7.46	-12.0±15.9

[†]Data are presented as mean±SD.
[‡]A t test was used to determine differences from the baseline at different times.
$^{*}p$<0.05, $^{**}p$<0.01, $^{***}p$<0.001.

Table 2. Changes of serum urea after ingesting different foods (mmol/L)[†]

Group	n	0 h	Changes from baseline[‡]		
			1 h	2 h	3 h
Water	8	4.12±1.05	-0.20±0.19*	-0.27±0.21**	-0.33±0.22**
Whole soy bean	9	3.98±1.34	0.14±0.17*	0.42±0.18***	0.51±0.20***
Soy bean milk	9	3.79±0.61	0.21±0.27*	0.54±0.44**	0.50±0.46*
Soy powder	9	4.14±0.96	0.087±0.13	0.35±0.32*	0.21±0.23*
Bean curd cake	7	3.56±0.74	-0.02±0.18	0.16±0.16*	0.32±0.25*
Dried bean curd stick	8	3.67±0.76	-0.06±0.16	0.03±0.24	0.20±0.21*

[†]Data are presented as mean±SD.
[‡]A t test was used to determine differences from the baseline at different times.
*p<0.05, **p<0.01, ***p<0.001.

We further examined the serum uric acid concentration induced by bean curd cake or dried bean curd stick according to pretrial serum uric acid concentrations (Table 3). The changes induced by these soy products in participants with normal serum uric acid concentrations seemed to differ from those observed in participants with high serum uric acid. Bean curd cake induced a significant decrease in serum uric acid at 1 h in participants with high serum uric acid concentrations.

DISCUSSION

The present study explored the effect of soy and soy products on serum uric acid among Chinese men through a short-term randomised controlled trial. The results indicated that different types of soybean products had different effects on serum uric acid among healthy men.

In this study, we found that soybean ingestion resulted in a significant increase in serum uric acid, which was similar to the findings of Garrel et al.[7] However, differences were observed in the rate of increase. In our study, the maximum serum uric acid concentration was found at 1 h after soybean intake, after which it gradually decreased during the subsequent 2 h period, whereas the maximum concentration was reached at 2 h in the study by Garrel et al. This discrepancy was probably related to the different sexes of the participants. Ten healthy men per group took part in our study, whereas six female and four male volunteers were included in the study of Garrel et al. Estrogen is believed to protect women against hyperuricemia and gout, and could therefore cause a delay in reaching the maximum concentration induced by soybean ingestion. However, the specific foods also differed, given that the whole soybeans and soy products used in our study are eaten by people in daily life, whereas soy protein was used by Garrel et al. Moreover, differences in protein content (80 g in Garrel et al vs 40 g in this study) could cause a delay in the soybean-induced uric acid peak. Another study similarly demonstrated that soybean ingestion (80 g of protein) led to an increase in serum urate concentration of approximately 10%.[8]

To our knowledge, this was the first study using a randomised controlled trial study design to examine the effects of soy and soy products on serum uric acid among a Chinese population. Its results indicated that soy could cause an acute increase of serum uric acid concentration in this population. We observed that different soy products exhibited different uric acid effects. No significant uric acid increases were found for bean curd cake and dried bean curd stick, whereas soybean milk and soy powder produced a considerable increase in serum uric acid. These characteristics of soy and soy products should be taken into account by patients with hyperuricemia or gout when choosing foods. Furthermore, these results may provide useful scientific evidence for clinical nutritionists and endocrinologists when consulting with their patients or developing dietary guidelines for them. However, uric acid can also act as an endogenous anti-oxidant and neuroprotective agent,[16-17] which could provide a protective effect against the development of dementia and Parkinson's disease.[18-19] The trade-off of increasing uric acid might need to be re-evaluated.

Although we used 40 g of soy protein, only half the amount in other studies, this amount far exceeds the typical consumption of soy protein at a single meal, at least among the Chinese population. Notably, the effect of soy products on serum uric acid could differ between participants with normal serum uric acid and those with high serum uric acid. However, the effect of decreased uric acid observed in participants with high serum uric acid after bean curd cake ingestion could be associated with a regression effect (i.e., uric acid fluctuated naturally and usually returned to normal), rather than a genuine soy

Table 3. Changes of serum urate for different serum uric acid concentrations[†]

Group		n	0 h	Changes from baseline[‡]		
				1 h	2 h	3 h
Bean curd cake	Normal serum uric acid	7	319±68.4	7.0±39.1	6.3±23.6	-2.3±23.5
	High serum uric acid	3	457±18.2	-6.67±2.08*	-11.7±9.61	-24.3±11.4
Dried bean curd stick	Normal serum uric acid	8	345±53.2	3.13±6.60	1.63±7.46	-12.0±15.9
	High serum uric acid	2	546±115	-10.5±2.12	-45.0±79.2	2.0±24.0

[†]Data are presented as mean±SD.
[‡]A t test was used to determine differences from the baseline at different times.
*p<0.05.

product–mediated effect. Therefore, it is prudent to extend the association of soy products with increased uric acid from healthy people to patients with hyperuricemia or gout.

We also unexpectedly observed that beer intake could increase serum uric acid concentration. Six of the ten participants in different groups who exhibited high serum uric acid had one common behaviour, namely, they had drunk more than one bottle of 4%-alcohol beer on the night before the trial. Beer consumption is also associated with a high risk of gout,[20] and restricted beer intake may help prevent hyperuricemia.[21]

The limitations of this study should be acknowledged. First, only acute effects were examined in this study, with long-term effects remaining unexplored. Second, we did not determine specific purine content, but rather only calculated the protein content according to the Chinese food nutrients table from 2004. Uric acid is mainly produced by the conversion of the purine derivative hypoxanthine to xanthine, and then of xanthine to uric acid by xanthine oxidase. Specific dietary purine sources may also affect urate levels.[22] Third, many other soy products were not included in this study, including soybean sprouts, soybean cheese, vegetarian chicken, and Tofu. A study from Japan[10] reported that the ingestion of Tofu only slightly increased plasma uric acid concentrations in normal individuals (5%), but there was no increase in gout patients. Further study is required to investigate the acute and long-term effects of other soy products on serum uric acid.

In summary, ingesting different soy products had different effects on serum uric acid concentrations in healthy men. Clinicians should provide the necessary consultations to vulnerable populations.

ACKNOWLEDGEMENTS

We express our deep appreciation to those who participated in the study, and thank Professor Peng Bi (University of Adelaide) for offering valuable suggestions.

AUTHOR DISCLOSURES

No potential conflict of interest is reported by the authors. This work was supported by the National Natural Science Foundation of China (81703227) and Key Program of Natural Science Foundation for Colleges in Anhui Province (KJ2017A231).

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