

Original**Vietnam's New Food Culture with Textured Soybean Protein
Can Save the Earth**

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ABSTRACT *Background and purpose.* Raising livestock to meet the demand of meat for human being exerts detrimental pressure on the environment and natural resources. With the view of saving the Earth by eating less meat, meat analogs are gaining popularity worldwide. Among these foods, Textured Soybean Protein (TSP), a by-product of the oil extracting process, is rich in fiber (13.6g/100g) and a good protein source (about 56g/100g). Substituting TSP for meat in the diet may have beneficial effects in preventing lifestyle-related diseases as well as in preserving the Earth. *Purpose.* To establish a new food culture with Textured Soybean Protein and to assess the palatability of TSP dishes. *Method.* There were two phases in the study. Phase 1: The research group created new menus using TSP. From the traditional recipes, meat was replaced with TSP to make 16 menus. Menus that were considered to be the tastiest and that contained 20g of TSP were selected for use in the next phase. Phase 2: The acceptability of new dishes using TSP was assessed in comparison with the control dishes (cooked with meat). 24 ordinary people were randomly selected from the community. A sensory test was conducted, and the score for each dish was established by using a Hedonic 5-point scale. Subjects (n=24) were asked to eat 2 dishes with 40g of TSP every day for 4 weeks consecutively to evaluate their tolerance of new food in their daily dietary pattern. A questionnaire was created to elicit the subjects' opinions after 4 weeks. *Results.* The average evaluations of the 10 TSP dishes and control dishes were 3.9 and 4.2 points for overall taste. Evaluations of the TSP dishes were close to those of the control dishes, with no significant difference ($p>0.05$). The results from the questionnaire indicated that 75% of the subjects were pleased with the amount of 40g TSP in 2 dishes per day; the suggestion of having TSP dishes for 3-4 days was considered reasonable and the digestive status was acceptable for 79% of subjects. There was no significant difference in total energy intake, but lipid intake and animal protein significantly decreased ($p<0.001$). Fiber was significantly increased, by 6g ($p<0.001$). *Conclusion.* We found that TSP dishes were highly acceptable for Vietnamese people. TSP can be a good non-meat food source and provide adequate fiber and protein, which may create beneficial health effects as well as preventing detrimental effects to the environment caused by meat consumption.

KEY WORDS: Textured Soybean Protein, meat analog, livestock, environment.

INTRODUCTION

Meat-Free Monday (2009) is an international campaign which aims to raise awareness of the significant consequences of global meat consumption. Raising livestock for meat is responsible for about 14.5% of total anthropogenic greenhouse gas (GHG) emissions, including methane gas (a gas which has an effect on global warming 28 times higher than carbon dioxide) and nitrous oxide (a

molecule with a global warming potential 265 times higher than carbon dioxide) (1). Meat production currently adds 0.15 giga-metric tons of methane and 0.0065 giga-metric tons of nitrous oxide to the atmosphere annually. If the climate system is allowed to reach equilibrium with this level of GHG emission and decay (which would take about a decade for methane and about a century for N₂O), then the earth would be 0.44°C warmer. Animal agriculture is also a sector which requires a significant amount of natural resources like water and landmass when compared with other foods as

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a protein source (2). In addition, excessive consumption of meat and meat products is often associated with overconsumption of energy and fat, resulting in excess weight, obesity and an increased risk of chronic diseases, such as cardiovascular disease and type 2 diabetes. Besides, according to the Vietnamese general nutrition survey 2009-2010, the average vegetable consumption in Vietnam was about 190g/day (3). This amount was less than the RDA for adults (300g/d). There was a similar situation for fiber intake; Vietnamese consumed about 9g/day, which meets only half of the RDA recommendation at 20g/day (4). The role of fiber in controlling metabolic disease is well documented (5). Therefore, dietary treatment increasing fiber intake, decreasing meat consumption in the Vietnamese dietary pattern can be important factors in making a positive difference in slowing climate change, preserving Earth's irreplaceable natural resources, and an improving health. Textured Soybean Protein (TSP) is a meat analog which is produced through an extrusion process. The defatted thermoplastic protein is heated to 150–200°C, which denatures it into a fibrous, insoluble, porous network that can soak up as much as three times its weight in liquids. As the pressurized molten protein mixture exits the extruder, the sudden in pressure causes rapid expansion into a puffy solid that is then dried. The dried matter is called Textured Soybean Protein, which







rich in fiber (13.6g/100g) and plant protein (about 56g/100g). These features of the product are expected to have health effects and become a meat substitute. In addition, many foods made from soybeans are popular and it is a common ingredient in many Vietnamese recipes, for example: soybean sauce, tofu. Therefore, TSP, with a taste quite similar to traditional soybean foods in Vietnam is expected to have high acceptability for palatability among Vietnamese people.

METHODS

There were two phases in the study. **Phase 1: Creating new menus using TSP.** The research group conducted a pilot study to find the best cooking methods for 16 types of traditional dishes with TSP replacing the meat ingredient. These dishes were familiar to Vietnamese and did not require special cooking skills. For all dishes, the ingredients, seasoning, and sauce were kept the same, the only difference was that the meat in the recipes was replaced with TSP. We explored how much TSP could be added to the dishes and the proper amount was 20g of TSP for each dish. The 16 TSP menus were tasted and evaluated by research group members to assess palatability. Then the 10 tastiest menus were chosen to implement in the next phase of the study. Details of the cooking methods for the 10 TSP dishes are listed below.

Best 10 menus with textured soybean protein

Dishes	Instruction	Dishes	Instruction
 <p><i>Spring roll</i></p>	TSP is soaked in water for 5 mins then squeezed as dry as possible. All ingredients are washed and cut into small pieces, then mixed together with sauce added to make a mixture. Spread a rice sheet on a flat surface, put a spoonful of mixture onto the sheet and wrap it. Pre-heated oil in a pan for 3 mins, then fry the spring until they turn brown.	 <p><i>Malabar Soup</i></p>	TSP is soaked in water for 5 mins then squeezed as dry as possible. All ingredients are washed and cut into small pieces, then mixed together with sauce added to make a mixture. Spread a rice sheet on a flat surface, put a spoonful of mixture onto the sheet and wrap. Pre-heated oil in a pan for 3 mins, then fry the spring until they turn brown.
<p>Ingredients: TSP (20g), Rice paper (5g), Tree ear (5g), Cellophane noodle (7g), Mushroom (3g), Carrot (20g), Onion (20g), Duck egg (10g), Oil (5g).</p>		<p>Ingredients: TSP (20g), Spinach(80g), MSG (2g).</p>	
 <p><i>Katuk Soup</i></p>	TSP is soaked in water for 5 mins then squeezed as dry as possible. Stir-fry Katuk in a pot for 3 mins, add TSP, MSG. After 5 mins, add 500ml water and boil the soup.	 <p><i>Gourd Soup</i></p>	TSP is soaked in water for 5 mins then squeezed as dry as possible. Stir-fry sliced gourd in a pot for 3 mins, add TSP, MSG. After 5 mins, add 500ml water and boil the soup.
<p>Ingredients: TSP (20g), Katuk (80g), MSG (2g)</p>		<p>Ingredients: TSP (20g), Gourd (100g), MSG (3g).</p>	

	<p>TSP is soaked in water for 5 mins then squeezed as dry as possible. Chop carrot, onion into cubes. Leave the peel of tomato and fry it for 5 mins to make a tomato sauce. Add carrot, onion to the sauce and continue cooking the mixture for 5 mins. When the vegetables become tender, add TSP. To finish, stir the mixture for about 5 mins.</p>		<p>TSP is soaked in water for 5 mins then squeezed as dry as possible. Stir-fry bean sprouts with oil in a pan for 3 mins then add loofah. Cook the vegetables well for about 3 mins. Add TSP, MSG to the pan, continue to stir the mixture for 3 mins.</p>
<p>Ingredients: TSP (20g), Tomato (30g), Western onion (40g), Carrot (40g), Soybean oil (2g), Fish sauce (3g)</p>		<p>Ingredients: TSP (20g), Bean sprout (30g), Loofah gourd (100g). Oil (3g).</p>	
	<p>TSP is soaked in water for 5 mins then squeezed as dry as possible. Stir-fry mustard greens in a pot for 3 mins, add TSP, MSG. After 5 mins, add 500ml water and boil the soup.</p>		<p>Fry TSP in a pan without oil for 5 mins. Soak cabbage and carrot in salt water for 10 mins, then slice cabbage, carrot. Mix vegetables and fried TSP. Add Kewpie sauce to the mixture before eating.</p>
<p>Ingredients: TSP (20g), Mustard green (80g), MSG (2g).</p>		<p>Ingredients: TSP (20g), Cabbage (80g), Carrot (15g), Kewpie sauce.</p>	
	<p>TSP is soaked in water for 5 mins then squeezed as dry as possible. Boil a pot of water then put morning glory into it for 3 mins. Take the well-cooked morning glory out. Fry garlic in a pan with oil, add morning glory, salt, and stir for 3 mins before add TSP. Continue to stir the mixture for 5 mins.</p>		<p>TSP is soaked in water for 5 mins, then squeezed as dry as possible. Stir-fry loofah in a pot for 10 mins, add jute plant, TSP, MSG. After 5 mins, add 500ml water and boil the soup.</p>
<p>Ingredients: TSP (20g), Morning glory (80g), Garlic (5g), Soybean oil (3g)</p>		<p>Ingredients: TSP (20g), Jute plant (80g), Loofah (50g) MSG (3g)</p>	

Phase 2: Assessing the palatability and tolerance of new dishes using TSP: There were 24 ordinary people who participated in this phase. The subjects were randomly selected in a community near Hanoi. We prepared two kinds of food samples, including 10 menus with TSP and 10 menus with meat (control dishes), each TSP dish and its parallel control dish were placed on the same table for the subjects to taste. The score for each dish in terms of appearance, aroma, taste, texture, overall was recorded by using the Hedonic 5-point scale (1. Dislike very much, 2. Dislike moderately, 3. Neither like nor dislike, 4. Like moderately, 5. Like very much). After finished the sensory test, all subjects were asked to eat 2 dishes with 40g of TSP every day for 4 weeks consecutively. The two TSP dishes were prepared and delivered daily to the subjects to eat at lunch and dinner. A nutrition survey (3 non-consecutive days) was conducted one week before and throughout the 4-week intervention period, using a food diary record. From the record, parameters including total energy, total protein, animal protein/total protein, carbohydrate, lipid, and fiber were analysed to assess the change in daily diet after adding the TSP dishes. At the end of the study, a questionnaire was created to interview the subjects about their tolerance for the new foods. Statistical analyses were conducted by paired

Student t-test using SPSS software version 20

QUESTIONNAIRE	
<p><i>Q1. Could you describe how did you feel about the amount of 40g TSP in 2 dishes which were delivered to eat daily for 4 weeks?</i> A. Too much. B. Enough. C. Too little.</p>	<p><i>Q3. What would you suggest for frequency of using TSP product in your diet per week?</i> A. 1-2 days per week B. 3-4 days per week C. 5-6 days per week D. 7 days per week</p>
<p><i>Q2. What would you suggest as a proper amount of TSP in each dish?</i> A. Higher than amount served B. The same as amount served C. 3/4 served amount D. Half of amount served</p>	<p><i>Q4. After 4 weeks eating TSP dishes, how was your digestive status?</i> A. Non-ulcer dyspepsia B. Digest comfortably C. Feel hungry faster D. Others</p>
<p><i>Thank you very much for completing the questionnaire!</i></p>	

RESULTS

Table 1 shows the number of subjects and average age by gender. There were 24 subjects (9 males and 15 females) who participated into the study. The average age was about 63 years old. Table 2 shows the comparison of the sensory test between 10 TSP dishes and 10 control dishes. The average score of the 10 TSP dishes and control dishes were 3.9 and 4.2 points for overall taste, 4.1 and 4.4 points for appearance, 3.9 and 4.3 points for aroma and 3.8 and 4.4 points for basic taste, and 3.9 and 4.4 points for texture, respectively. The palatability of TSP dishes was close to that of the control dishes (cooked with meat) with no significant difference

($p>0.05$) among the 10 dishes of each kind of food sample. Among the 10 TSP dishes, spring roll and stir-fry bean sprouts with loofah were the two dishes the highest overall taste scores.

Table 1. Baseline characteristics of the subjects

	Number	Age (Mean±SD)
Male	9	60.3±3.6
Female	15	64±6.8
Total	24	62.7±6.0

Table 2. The comparison of sensory test between TSP dishes and control dishes in 10 different menus.

Name of dishes	Food samples	Sensory test									
		Appearance (Mean±SD)	P	Aroma (Mean±SD)	P	Taste (Mean±SD)	P	Textured (Mean±SD)	P	Overall (Mean±SD)	P
Spring roll	TSP dish	4.2±0.4	ns	4.3±0.4	ns	4.3±0.4	ns	4.2±0.4	ns	4.3±0.4	ns
	Control	4.5±0.4		4.4±0.4		4.4±0.4		4.5±0.4		4.4±0.4	
Malabar Soup	TSP dish	3.8±0.4	*	3.8±0.4	ns	3.6±0.5	*	3.9±0.6	ns	3.7±0.4	*
	Control	4.3±0.4		4.2±0.3		4.3±0.4		4.3±0.4		4.1±0.3	
Tomato Sauce with vegetables	TSP dish	3.8±0.4	ns	3.3±0.5	*	3.6±0.4	ns	3.6±0.4	ns	3.6±0.4	ns
	Control	4.4±0.4		4.3±0.4		4.4±0.4		4.3±0.4		4.2±0.3	
Green Mustard Soup	TSP dish	4.2±0.5	ns	4.1±0.5	ns	3.9±0.5	ns	3.9±0.5	ns	3.9±0.5	ns
	Control	4.4±0.4		4.3±0.4		4.4±0.4		4.4±0.4		4.2±0.3	
Stir-fry Morning Glory	TSP dish	4.3±0.3	ns	3.9±0.4	ns	3.9±0.4	ns	4.0±0.3	ns	3.9±0.3	ns
	Control	4.5±0.5		4.3±0.4		4.5±0.4		4.3±0.5		4.4±0.4	
Katuk	TSP dish	4.1±0.3	ns	3.8±0.5	ns	3.7±0.5	*	4.2±0.5	ns	3.9±0.4	ns
	Control	4.7±0.4		4.5±0.4		4.5±0.4		4.6±0.4		4.5±0.4	
Stir-fry Bean Sprouts,Loofah	TSP dish	4.2±0.4	ns	4.2±0.4	ns	4.2±0.4	ns	4.2±0.4	ns	4.2±0.4	ns
	Control	4.5±0.4		4.4±0.4		4.4±0.4		4.5±0.4		4.4±0.4	
Gourd Soup	TSP dish	4.1±0.4	ns	3.8±0.5	ns	3.7±0.3	ns	4.2±0.5	ns	3.9±0.4	ns
	Control	4.6±0.3		4.4±0.4		4.4±0.4		4.6±0.4		4.4±0.4	
Salad	TSP dish	3.8±0.4	ns	3.6±0.4	ns	3.7±0.5	*	3.6±0.5	ns	3.6±0.4	ns
	Control	4.4±0.4		4.1±0.2		4.2±0.3		4.1±0.2		4.2±0.3	
Jute Plant Soup	TSP dish	4.2±0.3	ns	3.9±0.3	ns	3.7±0.3	ns	3.9±0.3	ns	3.8±0.2	ns
	Control	4.2±0.3		4.1±0.3		4.4±0.4		4.1±0.3		4.2±0.3	
Average	TSP dish	4.1±0.4	ns	3.9±0.4	ns	3.8±0.5	ns	3.9±0.4	ns	3.9±0.4	ns
	Control	4.4±0.4		4.3±0.2		4.4±0.4		4.4±0.4		4.2±0.3	

* Significant difference by paired Student t-test between TSP dishes and Control dishes at $p < 0.05$.

Figure 1 illustrates the tolerance of TSP dishes after 4 weeks consumption. Each pie chart stands for one question in the questionnaire. For 40g TSP in the diet, 75% of subjects could tolerate it, the remaining subjects answered that it was too much for them. There was 54% who suggested 40g of TSP as a reasonable amount to eat and 21% wanted the amount of TSP increased to more than 40g, 12% suggested ¾ of the amount served in the study. Almost all subjects (76%) answered that they would like to have TSP dishes 3-4 days per week. There were about 80% of subjects whose digestive status was normal without any problems of constipation, diarrhoea and or non-ulcer dyspepsia.

Using TSP dishes in the daily diet for 4 weeks did not cause significant changes in total energy intake, total protein, or carbohydrate ($p>0.05$) (Shown in Table 3). Although the amount of total protein was slightly increased (no significant different) but animal protein was dramatically decreased from 29 g to about 17g ($p<0.001$), which changed the ratio of animal protein/total protein from 51% to 28%. In addition, subjects' lipid intake was also reduced significantly with $p=0.001$. The data indicated that fiber intake was significantly increased (6g) when compared with the diet without TSP dishes.

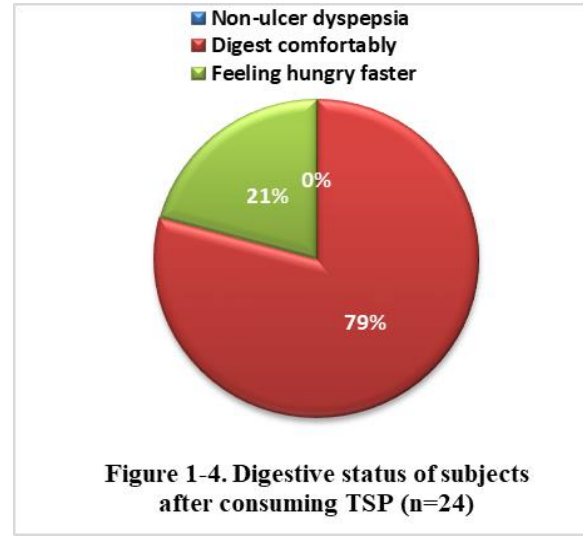
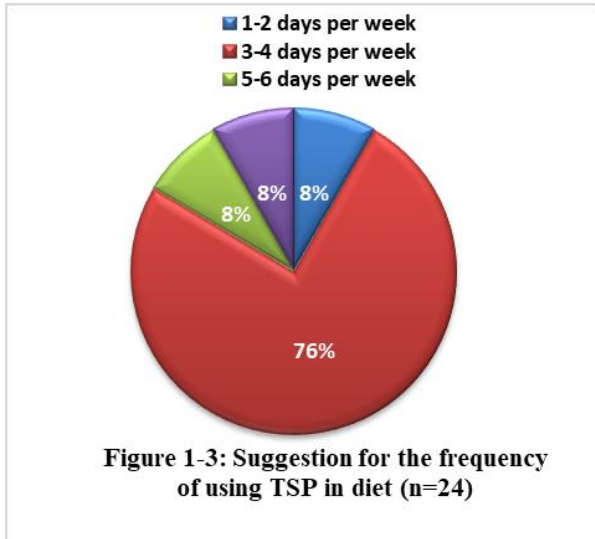
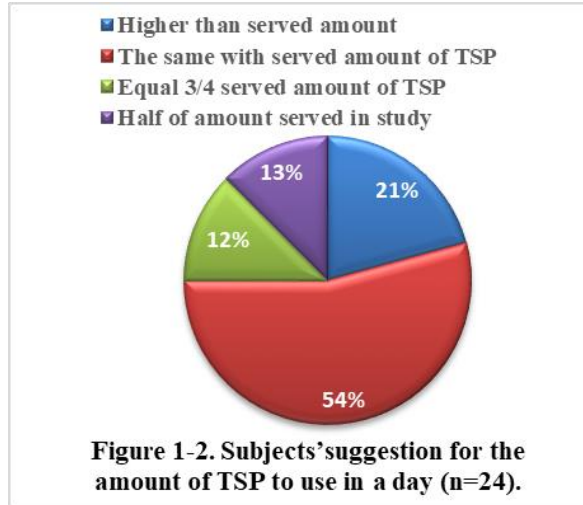
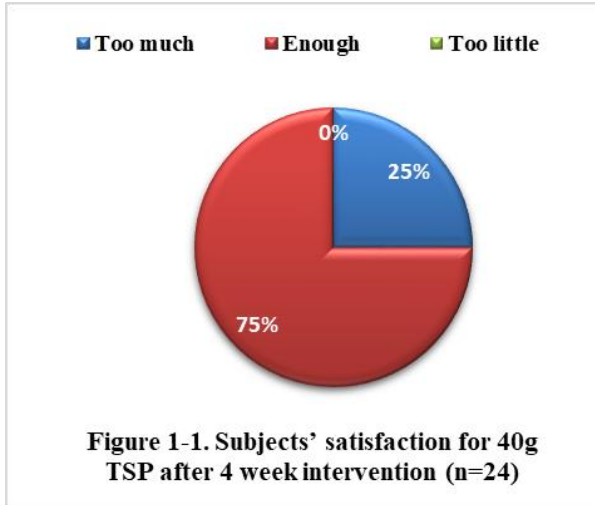


Figure 1. Assessing the acceptability of TSP dishes among subjects after 4 weeks.

Table 3. Comparison of the changes in daily diet before and after using TSP dishes for 4 weeks.

Variables	Baseline (n=24)	Final (n=24)	P
Energy (kcal/day)	1223±174	1182±151	0.2
Total protein (g/day)	57.6±13.8	62.4±9.3	0.08
Protein (%E)	(18.8%)	(21.1%)	
Animal protein	29.2±11.8	17.3±8.1	<0.001*
Protein animal/Total protein (%)	50.6%	27.7%	
Lipid (g/day)	37.8±15.6	26.5±9.2	0.001*
Lipid (%E)	27.8%	20.2%	
Carbohydrate (g/day)	174.9±35.2	160.5±30.8	0.09
Carbohydrate(%E)	57.2%	54.3%	
Fiber (g)	6.0±2.5	11.9±3.5	<0.001*

* Significant difference by paired Student t-test at p <0.05.

DISCUSSION

The study found that the 10 new TSP dishes were highly evaluated by the subjects scores comparable to the meat recipes ($p>0.05$). In addition, by using dishes with 40g of TSP for each day substituted for meat in the traditional Vietnamese recipes for 4 weeks, subjects can significantly increase their fiber intake (by 6g) compared with their normal diet. It is interesting to note that, although the total energy, total protein and carbohydrate were not significantly changed after consuming TSP in the daily diet, animal protein and lipid witnessed a strong decrease ($p<0.001$).

Vietnam has recently been facing problems of nutrition transition, which negatively affect the meal structure such as increased meat, saturated fat, sweetened beverages and decreased vegetable consumption. According to the Vietnamese general nutrition survey 2009-2010, the average vegetable consumption was about 190g/day (3). This amount was less than the Vietnamese RDA for adults (300g/d) (6). With the same situation for fiber intake, Vietnamese consumed about 9g/day which meets only half of the RDA recommendation of 20g/day (4). Considerable evidence has shown the effectiveness of increasing fiber intake in controlling lifestyle-related diseases. Meta-analysis studies have proved that increasing fiber intake in patients with DM decreased glucose levels (7). From another angle, meat consumption in Vietnam 2015 was 33.2kg per capita, but dramatically surged to 46.8kg per capita in 2019 (8). Eating red meat is increasingly being viewed as a guilty pleasure which may lead to adverse effects on consumers as well as on the environment. Components in meat that might be carcinogenic include heme iron, N-nitrous compounds in many processed meats, and heterocyclic aromatic amines and polycyclic aromatic hydrocarbons, which are formed when meat is cooked at high temperatures; red and processed meats might increase risk because they are usually rich in saturated fatty acids, which raise low-density lipoprotein cholesterol, and processed meat might also raise blood pressure because it is usually high in salt (2). A 4-year observational study in the US showed that subjects who consumed the highest levels of both unprocessed and processed red meat had the highest risk of all causes of mortality, cancer mortality and cardiovascular disease mortality. After adjusting for other risk factors, the researchers calculated that 1 additional serving per day of unprocessed red meat over the course of the study raised the risk of total mortality by 13%. An extra serving of processed red meat (such as bacon, hot dogs, sausage and salami) raised the risk by 20%. The researchers estimated that substituting 1 serving per day of other foods like fish, poultry, nuts, legumes, low-fat dairy and whole grains for red meat could lower the risk of mortality by 7% to 19%. If the participants had all consumed fewer than half a serving per day (about 42g) of red meat, the scientists calculated, 9.3% of the deaths in men and 7.6% of the deaths in women could have been prevented (9). Lifestyle-related diseases such as diabetes, dyslipidemia, cardiovascular diseases have been reaching alarming proportions as a result of these above dietary risk factors. Dietary treatment plays an essential role in controlling these diseases.

Regarding sources, fiber comes mainly from vegetables, but most vegetables in Vietnam are low in

fiber with less than 2 g fiber/100g of vegetable. So, it is really difficult to supply sufficient fiber only from vegetables.

Textured Soybean Protein (TSP), a soy product which is rich in fiber (13.6g/100g) and can provide interest in the daily diet. Hence, we wanted to take advantage of TSP products in Vietnam to make various menus which would help to increase fiber intake. There were new 16 dishes using TSP as a replacement for meat that were created in Vietnamese cooking style. After adjusting the taste, the 10 tastiest dishes were chosen to use in an intervention study. Evaluations of TSP dishes were close to those of the control dishes with no significant difference ($p>0.05$) with 3.9 and 4.2 points for overall taste. These results were compared with a study conducted in Japan about a sensory test of Indonesian fermented soybeans (Tempeh) (10). In this study, 10 new dishes were made by replacing main ingredients like meat, fish, dairy product with Tempeh. The average evaluations of tempeh dishes and 10 control dishes were 3.5 and 3.7 points for overall taste. In this present study, the consumption of TSP dishes in the diet resulted in an increase in dietary fiber of 6g/day, which was higher than the fiber increase in the study using Tempeh (2g/day) (10). There was a similar result in increasing the amount of fiber in our study and a study using Okara (6g/day) (7) and as well as a study using pre-germinated brown rice (about 7g) (11).

Another implication from the results of this study is that by using TSP dishes, subjects can reduce their meat consumption by nearly half, from 29g/day to 17g/day. Although meat consumption decreased significantly after consuming TSP dishes, the total amount of protein and total energy in the diet remained unchanged. This change in the structure of the diet is recognized as a positive change which helps preserve the environment. To be specific, when livestock digest food, the bacteria in their digestive tract will ferment plants and release a huge amount of methane gas (CH₄). When the animals burp, this gas is emitted into the air. The emissions from livestock, largely from burping cows and sheep and their manure, currently make up almost 15% of global emissions, which accelerates global warming more than cars, planes and all other forms of transport put together. In a study, Mekonnen and Hoekstra (2010) showed that the water footprint of any animal product is larger than the water footprint of a wisely chosen crop product with equivalent nutritional value. They calculated that the water footprint of a 150g soy burger produced in the Netherlands appears to be about 160 liters, whereas the water footprint of an average 150g beef burger is nearly 15 times larger (12). It is obvious that consumers can reduce their water footprint by reducing their volume of meat consumption.

To conclude, there is a strong relationship between eating meat, health and the environment. People should understand the effects of what they chose in their daily diet in order to make a wise choice. TSP product could be accepted as an edible ingredient which can be included in the daily diet for many good health purposes and to protect the environment as well.

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