**Okara Improved Blood Glucose Level in Vietnamese with Type 2 Diabetes Mellitus**

Lieu Thi Nguyen¹, Tu Huu Nguyen², Linh Thuy Nguyen³, Sumiko Kamoshita¹, Thao Phuong Tran¹,², Huong Thi Le², Fumio Shimura¹ and Shigeru Yamamoto¹

¹Jumonji University, Niiza, Saitama 352–8510, Japan
²Hanoi Medical University, 1st Ton That Tang, Dong Da District, Hanoi, Vietnam

(Received July 16, 2018)

**Summary** Diabetes mellitus (DM) has been increasing rapidly in Vietnam. We hypothesized that the main reason may be low fiber intake. Regarding sources, fiber comes mainly from vegetables. However, vegetables popular in Vietnam have low fiber (<2 g fiber/100 g vegetable), so it is difficult to supply sufficient fiber only from vegetables. Therefore, in this study we tried to increase fiber intake a day by using 60 g of Okara foods, containing about 6 g of fiber per day, and assess the effects on the blood glucose levels of DM patients. We contacted 300 type 2 DM outpatients at a hospital and selected 60 of them. We formed 30 pairs matched by gender, age, BMI and years with DM and divided them randomly into an intervention group and a control group. The intervention group consumed about 6 g of fiber from Okara per day for 2 wk. At the baseline and final periods, anthropometric measurements, blood withdrawal and a 3-d weighing method nutrition survey were conducted. Dietary fiber intake increased from 6.9 to 12.6 g (p<0.01) in the intervention group, but there was no change in the control group. Fasting blood glucose and fructosamine in the intervention group dropped from 6.3 to 5.4 mmol/L (p<0.05) and from 319 to 301 µmol/L (p<0.05), respectively but they remained unchanged in the control group. Vietnamese people consumed about 60 g of Okara per day from various menus and increased fiber intake to 6 g/d in 2 wk, which improved blood glucose in DM patients.

**Key Words** diabetes mellitus, Okara fiber, blood glucose, fructosamine, Vietnamese

---

Diabetes mellitus (DM) is a serious, chronic disease that occurs either when the pancreas does not produce enough insulin (a hormone that regulates blood sugar, or glucose), or when the body cannot effectively use the insulin. Diabetes and its complications bring about substantial economic loss to patients and their families and to health systems and economies (1).

The prevalence of DM is increasing worldwide: type 2 DM is the most common form of diabetes (90% of cases) and Vietnam is not an exception (2, 3). During the last decade, along with rapid economic growth and urbanization, the Vietnamese lifestyle and dietary habits have changed (4). There are studies suggesting that the risk factors for DM in Vietnam are high intake of white rice, abdominal fat, and a sedentary lifestyle (5–7).

Worldwide, the BMIs of type 2 DM patients are usually high (>25 kg/m²) (8) but some studies have reported that the BMI of Vietnamese DM is usually not high (<25 kg/m²) (5–7). Taiwan and Vietnam are located in the same region (Asia); however, according to a previous study, there are differences in the BMIs of newly diagnosed type 2 DM patients in the two countries (Taiwanese 26 and Vietnamese 23) (5). In addition, Vietnam has recently been facing the problem of “Nutrition Transition,” including changing dietary patterns, a different meal structure such as increases in meat and fat, and decreasing vegetable consumption (4). Therefore, we think that dietary factors may be more important than genetic factors.

Although it is a fact that drug therapy is mandatory for most type 2 DM patients, dietary treatment is essential in diabetes management. Meta-analysis studies have shown that increasing dietary fiber intake in patients with type 2 DM decreases HbA1c and fasting plasma glucose levels (9, 10). Nhung showed that increasing fiber intake from 6.7 g/d up to 13.1 g/d with pre-germinated brown rice was effective in controlling blood glucose and lipid levels as well as body weight in people who consume rice as a staple food (11). White rice has a higher glycemic index and less fiber than brown rice. In addition, our previous study also indicated that an increase in fiber intake from vegetables also has an effect on blood glucose of DM patients (12). Therefore, fiber may be effective in controlling blood glucose.

The main source of fiber in Vietnamese cuisine is vegetables. However, the amount of fiber in the vegetables widely in Vietnam used is low (average less than 2 g fiber/100 g vegetables) (13). So it is difficult for people to eat large amounts of vegetables every day to reach sufficient fiber intake. According to a Vietnamese general national survey (2010), the average consumption of vegetables was about 190 g/person/d (4). This was less than the Vietnamese recommended daily allowances.
Okara Improved Blood Glucose Level in Vietnamese with Type 2 Diabetes Mellitus

...for adults (300 g/d) and less than the Vietnamese clinical treatment guideline for type 2 DM patients (300–500 g/d). In addition, a variety of foods rich in fiber will provide interest in the daily diet. For these reasons, we focused on raising fiber intake from Okara, a fiber-rich food. One hundred grams of Okara contains 9.7 g fiber, greater than many kinds of vegetables.

Okara remains as pureed soybeans are filtered in the production of soy milk and tofu and contains a large proportion of fiber. Okara contains three beneficial components: insoluble dietary fiber, β-conglycinin and isoflavones. Studies on rats have shown that a diet containing higher amounts of a higher amount of β-conglycinin and isoflavones has an effect on blood glucose control. However, Okara contains only a small amount of these ingredients (β-conglycinin and isoflavones), so we think that fiber would be the main factor to consider when using Okara with humans.

Okara is used as animal feed in Vietnam but Japanese eat it in their daily meals in various dishes. Hence, we wanted to take advantage of abundant Okara sources in Vietnam to make various new menus, which would help to increase fiber intake by DM patients. Two previous studies indicated that increasing fiber intake by about 6 g to reach 12–13 g fiber intake has a positive effect on blood control. In this study, we set a target of about 6 g Okara fiber/d with each Okara menu containing 2 g fiber and each main meal including one Okara dish. The purpose of the present study, therefore, was to find out whether 6 g Okara fiber/d for 2 wk decreases blood glucose in type 2 DM.

MATERIALS AND METHODS

Setting and study subjects. The study was designed as a randomized controlled trial and was conducted in April 2017. This research was approved by Hanoi Medical University (HMU)’s ethics committee (number 65, approval date is 28th March 2017). The study population consisted of type 2 DM outpatients being treated at a hospital located in Hanoi City (northern Vietnam). After screening data for about 2,000 type 2 DM outpatients at the hospital, we selected about 300 type 2 DM who met the inclusion criteria: (1) type 2 DM outpatients aged 45–70 y old and with a diabetic history of more than 2 y at Dong Da hospital; (2) patients were receiving only oral medication and had not changed oral medication for 3 mo; (3) they did not suffer from other diseases (except hypertension and dyslipidemia). Through contact by phone and direct meetings at the out-patient clinic, 60 subjects who agreed to participate in this study were enrolled. Then 30 matched pairs were created by sex, age, BMI and years with DM. The subjects were divided into 2 groups: an Okara group and a control group.

We made 10 Okara menus (staple dishes, main dishes and side dishes). The 10 menus were fried rice with Okara; rice porridge with Okara; Okara hamburger; meatballs with Okara; stir fried piper lolot rolls with pork and Okara; omelette with Okara; cabbage rolls with Okara; stir fried bean sprouts with Okara; miso soup with Okara; and Okara patties. For example, for the hamburger we mixed 60 g meat and 30 g Okara. As another example, to 50 g rice porridge, we added 20 g Okara. Okara patties were made with 70 g Okara, 5 g starch and 30 g tofu and 20 g mayonnaise.

Each menu contains about 2 g fiber from 20 g Okara. Three Okara dishes per day provide sufficient fiber (6 g); maintaining this diet for 2 wk was expected to decrease blood glucose levels in subjects in this study. We carried out a pilot study on 12 people at HMU to assess the taste of the Okara dishes. Okara menus were thus modified to be acceptable to Vietnamese. About source of Okara is also considered to decrease bias in this study.

One week before intervention day, all the patients were assembled to be introduced to the research, to sign consent forms and to be instructed on how to record dietary items by the weighing method. During this week, patients recorded all the food they consumed 3 non-consecutive days.

After conducting a dietary record for 3 d, both groups received nutrition education about dietary guidelines for DM patients, especially the role of fiber, and were given nutrition education materials. For the Okara group only, participants received further instruction on Okara menu cooking methods to increase fiber intake. Subjects also tasted Okara dishes and gave positive feedback about implementing the study. Subjects were encouraged to maintain their usual vegetable and fruit intakes. All the patients underwent anthropometric measurements and blood tests and submitted dietary records to the researchers at this time (baseline data).

For the next 2 wk, the Okara group included the Okara menus in their diet but the control group continued their diet without Okara. All patients recorded dietary information for the last 3 d of the research period. During the whole study period, investigators contacted the subjects every day by telephone and found that the rough intake of Okara was close to the results of the nutrition survey during the last 3 d.

After 2 wk, all patients were assembled to collect final data on anthropometric measurements, blood tests and dietary records during the research period.

The control group also received Okara cooking method instruction after the study in order to ensure equitable treatment, in keeping with ethical requirements.

Anthropometric measurement. Weight, height, and waist and hip circumferences and body fat percentage were measured twice, at the beginning and on the last day, and the average value was calculated for each individual. Body weight and height were measured in light clothing and without shoes. Body mass index (BMI) was computed as the ratio of weight (kg) per height squared (m²). Waist circumference was measured at the minimum circumference between the umbilicus and iliac crest; hip circumference was measured at the widest circumference around the buttocks. Waist-hip ratio was calculated as waist circumference (cm) divided by hip circumference (cm). Body weight, percent body fat, percent muscle and visceral fat were measured by bioelectrical impedance using a body fat analyzer Tanita.
Table 1. Comparison of physical characteristics at baseline and final of control and Okara group.

| Variables          | Control group |          | Okara group |          |
|--------------------|---------------|----------|-------------|----------|
|                    | Baseline      | Final    | Baseline    | Final    |
| Age (y)            | Male (n=9)    | Female (n=17) | Male (n=6) | Female (n=17) |
|                    | 61.7±2.2      | 64.2±4.8 | 61.7±2.2    | 64.2±4.8 |
| Weight (kg)        | Male (n=9)    | Female (n=17) | Male (n=6) | Female (n=17) |
|                    | 66.1±6.4      | 53.8±7.2 | 59.0±14.0   | 54.8±6.6 |
| Height (m)         | Male (n=9)    | Female (n=17) | Male (n=6) | Female (n=17) |
|                    | 1.64±0.06     | 1.53±0.04 | 1.61±0.07   | 1.54±0.05 |
| BMI (kg/m²)        | Male (n=9)    | Female (n=17) | Male (n=6) | Female (n=17) |
|                    | 24.6±2.9      | 23.0±3.3 | 22.6±4.3    | 23.1±2.2 |
| Waist/hip ratio    | Male (n=9)    | Female (n=17) | Male (n=6) | Female (n=17) |
|                    | 13.5±2.7      | 6.3±2.0  | 10.8±5.5    | 6.6±1.5  |
| Hip (cm)           | Male (n=9)    | Female (n=17) | Male (n=6) | Female (n=17) |
|                    | 90.8±5.7      | 86.1±9.5 | 83.9±12.8   | 85.1±5.6 |
| Waist (cm)         | Male (n=9)    | Female (n=17) | Male (n=6) | Female (n=17) |
|                    | 98.0±4.7      | 93.5±6.5 | 94.5±7.6    | 92.4±4.9 |
| Waist/hip ratio    | Male (n=9)    | Female (n=17) | Male (n=6) | Female (n=17) |
|                    | 0.93±0.05     | 0.92±0.05 | 0.88±0.07   | 0.92±0.05 |

Values are mean±standard deviation (SD).

Table 2. Comparison of biochemical parameters at baseline and final of control and Okara group.

| Variables          | Control group |          | Okara group |          |
|--------------------|---------------|----------|-------------|----------|
|                    | Baseline      | Final    | Baseline    | Final    |
|                    | Male (n=9)    | Female (n=17) | Male (n=6) | Female (n=17) |
| FBG (mmol/L)       | 6.9±1.4       | 7.0±1.7  | 5.4±1.5     | 5.3±1.2  |
|                    | 7.0±1.6       |          | 6.3±1.6     |          |
| Fructosamine (µmol/L) | 309±44      | 311±36  | 331±28      | 301±22*  |
|                    | 311±38        |          | 319±25      | 301±29*  |

Values are mean±standard deviation (SD).

Results of significance differ between the baseline and final data (of same gender) within same group (p<0.05).

Blood collection. Intravenous fasting blood samples were taken in the morning at baseline and final (after 2 wk). The blood samples were separated by centrifugation and kept frozen for analyses of glucose and fructosamine. Blood collection and analyses were done at HMU Hospital.

Nutrition survey. A nutrition survey was conducted for 3 d by the weighing method before and during the intervention period. Each patient was given a scale to weigh the foods they ate and wrote dietary records by themselves. Energy and nutrient intakes were calculated based on the Vietnamese Food Composition Table 2007 (13). Fiber in Okara was calculated by using the data published in the Japanese Food Composition Table 2010 (16).

Statistical analysis. Quantitative variables were checked for normal distribution and compared by the Student t-test (paired and unpaired). p-values of less than 0.05 were considered statistically different for all the analyses. The above statistical procedures were performed using Stata Version 12.0.

RESULTS

Seven of 60 subjects dropped out of the study; thus 49 patients (23 in interventions and 26 in controls) completed the follow-up. In the intervention group (Okara group), 2 subjects did not have time to prepare the Okara menus, 2 subjects had serious illnesses and another had already eaten before coming to have blood glucose checked. In the control group, 2 patients withdrew because they lost interest in the study, and 2 others cited personal reasons for dropping out.

Table 1 shows the comparison of physical characteristics at baseline and final of control and Okara groups. The average BMI in all the groups was 23.2–23.7, which was within the normal range. There are no significant differences in values between the control and Okara
Table 3. Energy and nutrient intakes of control and Okara groups at baseline and final.

| Variables           | Control group (n=26) | Okara group (n=23) |
|---------------------|----------------------|--------------------|
|                     | Male (n=9)           | Male (n=6)         | Female (n=17) | Female (n=17) |
|                     | Female (n=17)        | Female (n=9)       |               |               |
| Energy (kcal)       | 1.574±486 1.255±251 | 1.765±738 1.330±305 | 1.630±254 1.338±214 | 1.524±303 1.409±216 |
| Energy (kcal/kg BW) | 23±76 23±35         | 26±114 25±42       | 28±18 24±32  | 26±22 26±32  |
| Protein (g/d)       | 68.5±28.1 66.2±53.1 | 93.0±46.7 61.5±14.9 | 81.4±13.2 66.3±11.0 | 83.9±24.3 68.2±14.3 |
| Protein (g/kg BW)   | 1.0±4.4 1.2±7.4     | 1.4±7.2 1.1±2.0    | 1.4±0.9 1.2±1.7 | 1.4±1.7 1.3±2.1 |
| Lipid (g/d)         | 56.3±27.1 36.5±12.4 | 53.6±38.6 34.7±8.3 | 39.4±22.4 24.8±9.0 | 42.4±1 28.9±8.3 |
| Lipid (g/kg BW)     | 0.9±4.2 0.7±1.7     | 0.8±6.0 0.6±1.1    | 0.7±1.6 0.5±1.4 | 0.5±1.8 0.5±1.2 |
| Carbohydrate (g/d)  | 227±81 176±41       | 227±97 191±59      | 237±20 212±52 | 202±47 219±42 |
| Carbohydrate (g/kg BW) | 3.4±6.4 3.3±5.7 | 3.4±15.0 3.5±8.2 | 4.0±1.5 3.8±7.9 | 3.4±3 4.0±6.3 |

Data are mean±SD. Control group were compared to Okara group by unpaired Student t test.
similar to that of a meat-only hamburger. As another example, the taste of the porridge which is added more Okara was not spoiled. Okara patties were also very well accepted, because DM patients are not encouraged to eat sweet cakes but our Okara patties are not only tasty but also the energy intake is very low. Therefore, subjects did not have to worry about maintaining a low carbohydrate diet. In addition, the cabbage rolls with Okara received favorable comments because an umami taste was created by the combination of foods as pork, cabbage, tomato, fish sauce and Okara. This menu increased fiber intake from Okara and vegetables significantly. As a result of good cooking methods 70% of the subjects ate more than 60 g Okara per day and 20% of them consumed 50 g/d although we suggested 60 g/d. After 2 wk of the intervention, we asked the subjects whether they liked the dishes. More than 90% of the subjects answered that they liked them. According to the nutrition survey for 3 d at the baseline and the last 3 d, energy intake did not change, indicating that the Okara dishes did not adversely affect subjects’ taste for other foods in the menus. We think Okara is readily accepted and may become a new food culture in Vietnam in the future.

We suggested that the intervention group consume 60 g Okara (about 6 g fiber) a day and they took 5.7 g. Total fiber intake was 12.6±2.8 g. This was still much smaller than the recommended dietary allowance for Vietnamese (20–22 g/d) (21). Nevertheless, we observed a very favorable effect of Okara on blood glucose. There are studies that have also observed a similar favorable effect in type 2 DM patients by increasing fiber intake to reach 12–13 g (17, 12). These results may suggest that the fiber requirement is not so high as the Dietary Recommendation Intake for Vietnamese (20–22 g/d) but we need further studies to find the proper requirement.

Our participants were patients who cared about the diet for type 2 DM and had some knowledge about nutrition. Understanding that the amount of fiber in Okara was good for their health, they readily accepted Okara. In this study the period of intervention was only 2 wk because the turnover rate of fructosamine is 2–3 wk. Fortunately, we could see a clear decrease in it in the intervention group. Energy intake was estimated by the weighing method for 3 nonconsecutive days, which placed a heavier burden on the subjects but brought reliable results about patients’ actual intake. We found that the energy ratio of protein, fat and carbohydrate (P : F : C ratio) was about 19% : 23% : 58%. The energy intakes and P : F : C ratio in the two groups met the Vietnamese clinical treatment guideline (15).

There is a report that shows that there were no significant differences in fructosamine levels between males and females in both groups (6). Although the number of male and female subjects was different in this study, we likewise did not observe differences in blood biochemistry.

Another possible conclusion from the results of this study is that perhaps one of the main factors in the low BMI of Vietnamese type 2 DM is high white rice intake together with low fiber intake. Our study may be useful for the prevention of type 2 DM in Vietnam in the future.

In conclusion, we found in this study that Vietnamese people were satisfied with new menus with about 60 g of Okara prepared by various cooking methods and could increase their fiber intake about 6 g/d for 2 wk, which improved blood glucose in type 2 DM patients.

Acknowledgments

The authors would like to thank all the participants for their cooperation and Dong Da hospital, Hanoi Medical University Hospital, Nutrition Counseling Clinic—The Institute for preventive medicine and public health—HMU for their assistance. We are extremely grateful to students in the bachelor of nutrition course who provided assistance in the collection of data in Vietnam. This study was supported by Jumonji University and US-Japan Medical Science Program. Finally, we also would like to thank Andrew Durkin, Prof. Emeritus of Indiana University, for editing our English.

REFERENCES

1) Roglic G. World Health Organization (eds). 2016. Global Report on Diabetes. World Health Organization, Geneva, Switzerland.
2) Khue NT. 2015. Diabetes in Vietnam. Ann Glob Health 81: 870–873.
3) Son NTLD, Kusama K, Yamamoto S. 2006. A community-based picture of type 2 diabetes mellitus in Vietnam. J Atheroscler Thromb 13: 16–20.
4) National Institute of Nutrition. 2010. General Nutrition Survey 2009–2010, 4th ed. Medical Publishing House (Vietnam), Ha Noi.
5) Yamamoto S, Le DSN, Hsu TF, Huang KC, Nguyen VH, Wong Y, Huang PC. 2013. Vietnamese may develop type 2 diabetes with smaller increases in body mass index and waist circumference than Taiwanese. Int J Diabetol Vasc Dis Res 1: 1–5.
6) Duc Son LNT, Hanh TTM, Kusama K, Kunii D, Sakai T, Hung NTK, Yamamoto S. 2005. Anthropometric characteristics, dietary patterns and risk of type 2 diabetes mellitus in Vietnam. J Am Coll Nutr 24: 229–234.
7) Le Nguyen TD, Tran TM, Kusama K, Ichikawa Y, Nguyen TK, Yamamoto S. 2003. Vietnamese type 2 diabetic subjects with normal BMI but high body fat. Diabetes Care 26: 1941–1947.
8) Tobias DK, Pan A, Jackson CL, O’Reilly EJ, Ding EL, Willett WC, Manson JE, Hu FB. 2014. Body-mass index and mortality among adults with incident type 2 diabetes. N Engl J Med 370: 233–244.
9) Post RE, Mainous AG, King DE, Simpson KN. 2012. Dietary fiber for the treatment of type 2 diabetes mellitus: a meta-analysis. J Am Board Fam Med 25: 16–23.
10) Silva FM, Kramer CK, de Almeida JC, Steemburgho T, Gross JL, Azevedo MJ. 2013. Fiber intake and glycemic control in patients with type 2 diabetes mellitus: a systematic review with meta-analysis of randomized controlled trials. Nutr Rev 71: 790–801.
11) Nhung BT. 2014. Pre-germinated brown rice reduced both blood glucose concentration and body weight in Vietnamese women with impaired glucose tolerance. J Nutr Sci Vitaminol 60: 183–187.
Thao TP, Linh NT, Nishiyama H, Sakai S, Shimura F, Yamamoto S. 2017. Higher vegetable intake improved blood glucose level in Vietnamese with type 2 diabetes mellitus. *Int J Clin Nutr Diet* 3: 5.

National Institute of Nutrition. 2007. *Vietnamese Food Composition Table*, 5th ed. Medical Publishing House (Vietnam), Ha Noi.

National Institute of Nutrition. 2016. *Nutrition Pyramid for Adult 2016–2020*.

Anh NQ. 2015. *Clinical Treatment Guideline*, 1st ed. Medical Publishing House (Vietnam), Ha Noi.

Ministry of Education, Culture, Sports, Science and Technology, Japan. 2010. *Standard Tables of Food Composition in Japan Fifth Revised and Enlarged Edition*, p 62.

Hosokawa M, Katsukawa M, Tanaka H, Fukuda H, Okuno S, Tsuda K, Iritani N. 2016. Okara ameliorates glucose tolerance in GK rats. *J Clin Biochem Nutr* 58: 216–222.

Ismaiel M, Yang H, Cui M. 2017. Evaluation of high fibers okara and soybean bran as functional supplements for mice with experimentally induced type 2 diabetes. *Pol J Food Nutr Sci* 10.1515/pjfns-2017-0033.

Weickert MO, Pfeiffer AFH. 2008. Metabolic effects of dietary fiber consumption and prevention of diabetes. *J Nutr* 138: 439–442.

Li B, Qiao M, Lu F. 2012. Composition, nutrition, and utilization of okara (soybean residue). *Food Rev Int* 28: 231–252.

Ministry of Health and National Institute of Nutrition. 2012. *Recommended Dietary Allowances for Vietnamese*. Medical Publishing House.