



Research Article

Improvement of Bowel Movement in Healthy Adults Through Intake of *Natto* Powder For 4 Weeks - A Randomized, Placebo-Controlled, Double-Blind, Clinical Study

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Citation: Kikushima K, Suzuki K, Saitou K, Matsuura T, Sakurai K, et al. (2025) Improvement of Bowel Movement in Healthy Adults Through Intake of *Natto* Powder For 4 Weeks - A Randomized, Placebo-Controlled, Double-Blind, Clinical Study. Food Nutr J 10: 329. DOI: 10.29011/2575-7091.100329

Received Date: 20 August 2025; **Accepted Date:** 29 August 2025; **Published Date:** 03 September 2025

Abstract

Natto is a traditional Japanese food, made from whole soybeans fermented with *Bacillus subtilis* var. *natto*. Although *natto* bacteria regulate intestinal flora, little research has been conducted on its effects on bowel movements. This study examined the effects of *natto* powder on human health, including bowel movements, mood, fatigue, and sleep quality. This randomized, double-blind, placebo-controlled, parallel-group comparative study was conducted on 30 healthy adults. For 4 weeks, the subjects consumed either 3 g of *natto* powder or an equivalent amount of placebo powder daily. In Visual Analogue Scale, almost all items showed improvement in bowel movements in both groups. However, the change in pain during defecation was greater in the test group than in the placebo group, resulting in a significant difference between the two groups. Changes in the stool color and odor were also to be greater in the test group than in the placebo group. Additionally, we found that the test powder reduced fatigue and improved sleep quality more effectively than the placebo powder. For those not accustomed to *natto*, powdered *natto* is a convenient way to enjoy its health benefits.

Keywords: *Natto*; Fermented Foods; Bowel Movement; Clinical Trial; Traditional Food

Introduction

Fermented foods offer a wide range of health benefits. As well as being a great source of probiotics, they contain bacteria that can produce bioactive metabolites which promote health. *Natto* is a traditional Japanese food, made from whole soybeans fermented with *Bacillus subtilis* var. *natto*. *Natto* has a long history and is possibly derived from Chinese *douchi*, a food made from

fermented black soybeans, which is mentioned in *Engishiki*, a comprehensive Japanese legal compendium completed in 927 [1]. The Japanese people have long been familiar with *natto*, and the book *Honchoushokukagami* (published in 1697) states that *natto* “regulates the stomach, promotes appetite, and detoxifies,” indicating that its health benefits were recognized early on [2].

Natto has a sticky texture and distinctive flavor. In addition to the nutrients contained in soybeans, *natto* is renowned for its nutritional profile and potential health benefits. It is rich in protein, fiber, vitamins, and minerals. The sticky texture is the result of

poly- γ -glutamic acid (γ -PGA) forming during fermentation [3]. γ -PGA has been reported to offer several health benefits, including improved calcium [4] and vitamin absorption [5], enhanced sleep quality [5], and potential effects on blood glucose and lipid levels [6]. *Natto* is the richest dietary source of vitamin K2. Consuming *natto* increases the amount of vitamin K2 in the blood [7,8], which is important for bone health and blood clotting. Moreover, nattokinase, a byproduct of the fermentation, is renowned for its ability to break down blood clots and reduce blood pressure [9]. *B. natto* is non-pathogenic to humans and one of the 40 probiotics approved by the US FDA [10,11]. *B. natto* can easily reach the intestines alive [10,12]. The presence of *natto* bacteria and the enzymes and dietary fiber they produce are expected to improve intestinal flora boost immunity [13]. *Natto* bacteria also produce a powerful antibacterial substance called dipicolinic acid [14]. Dipicolinic acid has a broad antibacterial spectrum [8] and plays a role in maintaining a healthy intestinal flora. However, research on the effects of *natto* on the intestines is still insufficient.

In Japan, *natto* is commonly eaten for breakfast alongside rice. While over 70% of Japanese people enjoy *natto* and consider worth eating for its numerous health benefits [15], some people may need time to get used to its taste [16]. For those unfamiliar with *natto*, powdered *natto* is one of the best ways to enjoy this intriguing superfood. In this study, we examined the effect of *natto* powder on the human health including bowel movement, mood, fatigue, and sleep quality. A randomized, double-blind, placebo-controlled, parallel-group comparative study was conducted on 32 healthy adults between the ages of 30 and 70 to examine the effects of *natto* powder intake on intestinal regulation. For 4 weeks, the subjects consumed either 3 g of *natto* powder or an equivalent amount of placebo powder daily. Their bowel movements and health status were evaluated using a questionnaire before and after the intervention.

Materials and Methods

The study was conducted by User Life Science Co., Ltd. (Fukuoka, Japan) commissioned by Yamada Foods Co., Ltd. (Akita, Japan). All examinations were conducted by mail correspondence. All studies strictly adhered to the Declaration of Helsinki (revised in Fortaleza in 2013) and the Ethical Guidelines for Medical and Health Research Involving Human Subjects, which were published by the Japanese government in 2021. Written informed consent was obtained before the study, by carefully explaining the purpose and methods of the study and confirming that all subjects recognized them and were participating in the study of their own volition. The study protocol is registered at the UMIN Clinical Trials Registry (UMIN-CTR; ID = UMIN000056978).

In this study, a randomized, double-blind, placebo-controlled, parallel-group comparative trial was conducted to verify the intestinal effects of *natto* powder consumption in healthy adults. Subjects were carefully chosen following the selection and the exclusion criteria. Selection criteria: (1) those with age between 30-70 years old, (2) those regarded as generally healthy, (3) those submitting the agreement for participating in the trial by their

own will, and (4) those who are aware of constipation. Exclusion Criteria: (1) those who has regularly took any other functional foods, drugs or supplements for the similar effects to our tests, (2) those who changed or began to take any health foods in the past 4 weeks, (3) those working at the nighttime or by the day and night shift, (4) those who needed to have any medical treatments such as hormone replacement therapy, drug treatment, exercise therapy or food therapy and so on, (5) those who had previously had severe disorders of sugar metabolism, lipid metabolism, liver function, renal function, heart, circulatory organ, respiratory organs, endocrine system, immune system, or neurological diseases, (6) those who had a history of alcoholic or drug addiction, (7) those who had risk of allergic reaction against the food, (8) those who were pregnant or lactating at the informed consent, or wanted to become pregnant during the trial period, (9) those who participated in another human clinical trial within 1 month prior to the time of consent, and (10) those who are judged inappropriate by the primary investigator of the study.

A randomization coordinator unrelated to the trial randomly divided the 32 subjects into test and control groups of 16 subjects each, using stratified randomization by age and BMI (body mass index) to ensure that there was no significant bias between the two groups. Each subject took either 3 g of *natto* powder or 3 g of placebo powder made from the same soybeans per day for 4 weeks (28 days). The test powder and the placebo powder were provided by Yamada Foods Co., Ltd. The appearance and smell of the test powder and the placebo powder are indistinguishable. The test powder was made from *Ryuhou* soybean grown in Akita, Japan, fermented by bacterium *Bacillus subtilis natto* isolated from the Shirakami Mountains, a World Natural Heritage site. The nutritional information for 1 g of the test powder is as follows: energy 4 kcal, protein 0.4 g, fat 0.2 g, carbohydrates 0.3 g (of which sugars 0.1 g and dietary fiber 0.2 g), and salt equivalent 0.2 mg. The placebo powder was not fermented by *Bacillus natto* and was dried in the same manner as the test powder.

The initial measurement was performed in mid-February 2025, and the final measurement was conducted in mid-March. Changes in the subjects' condition were evaluated using a questionnaire consisting of the following 5 items: a visual analogue scale to evaluate stool consistency (VAS-S), a mood scale (POMS2) for adults, the Chalder Fatigue Scale (CFS), the OSA Sleep Inventory-MA version (OSA-MA) and a VAS to evaluate fatigue severity (VAS-F). All these tests were performed at the initial and final measurements, which were taken with intervals of 28 days, before and after the intervention.

Any problems that occurred during the trial were considered adverse events. However, events that were recognized before informed consent was obtained, or that were predictable based on the subjects past daily experiences and conditions before the trial began, were not considered adverse events. Subjects were instructed to report any adverse events that occurred following the intervention.

The mean values and standard errors for each measurement for the

test and placebo groups were calculated. To compare values before and after the trial, a paired *t*-test was performed. Additionally, an independent *t*-test was performed on the scores of the test and the placebo groups at the pre- and the post-intervention, respectively. The significance level was set at 5% for two-sided tests in both analyses, and values below 5% were considered significant (**p* < 0.05; ***p* < 0.01).

Results

Completion status

No adverse events were reported during the trial period. Two subjects withdrew from the study for reasons unrelated to the trial: one male from the test group and one male from the placebo group. This left 15 subjects in each group who completed the study. The remaining 30 subjects were analyzed for VAS-S, POMS2 and CFS. The analyzed subjects’ data is shown in Table 1. There were no significant differences between the two groups in any of the profiles.

Group	Male	Female	Age (years)	Height (cm)	Weight (Kg)	BMI
Test group (n = 15)	8	7	53.8 (1.5)	164.5 (2.0)	60.0 (2.5)	22.0 (0.6)
Placebo group (n = 15)	7	8	53.2 (2.3)	164.9 (2.5)	63.8 (3.5)	23.5 (0.8)
P-value between two groups	-	-	0.8	0.9	0.4	0.2
() denotes standard error						

Table 1: Profiles of the subjects who completed the trial.

Additionally, 2 subjects from the placebo group were excluded from the OSA-MA analysis due to incomplete documentation, resulting in 15 subjects from the test group and 13 subjects from the placebo group being included. One subjects from the test group was excluded from the VAS-F analysis, resulting in 14 test group subjects and 15 placebo group subjects being included.

VAS-S

The VAS-S is a questionnaire-style survey that evaluates the consistency and shape of stools using the Visual Analogue Scale (VAS) method. The questionnaire consists of six items: pain during defecation, sensation of incomplete evacuation, straining during defecation, stool color, stool volume, and stool odor. For each test item, a 100 mm long horizontal straight line is drawn, with the

left endpoint (0 mm) representing poor condition and the right endpoint (100 mm) representing excellent condition. Subjects self-assess their current stool condition by drawing a short vertical line on the long horizontal line. The VAS score was determined by measuring the distance from the left end point to the vertical short line made by the subjects (1 mm = 1). Higher scores indicate better condition.

The results showed an increase in scores of all items in both the test group and the placebo group (Table 2). When comparing before and after scores in each group, significant differences (*p* < 0.05) were observed in all items except for stool odor in the placebo group. Additionally, significant differences were observed in post- intervention scores for pain during defecation (*p* < 0.05) when comparing the two groups.

	Group	Mean score at pre- intervention	P-value between two groups	Mean score at post- intervention	P-value between two groups	P-value between pre- and post- intervention
Pain during defecation	Test group (n = 15)	64.9 (7.6)	0.7	93.7 (2.3)	0.03*	0.002**
	Placebo group (n = 15)	60.4 (7.2)		79.9 (5.4)		0.02*
Sensation of incomplete evacuation	Test group (n = 15)	39.3 (6.6)	0.2	69.3 (6.5)	0.4	0.001**
	Placebo group (n = 15)	29.6 (3.9)		60.9 (5.7)		<0.001**
Straining during defecation	Test group (n = 15)	41.5 (6.4)	0.2	69.1(6.6)	0.3	0.002**
	Placebo group (n = 15)	31.4 (4.2)		59.9 (6.4)		<0.001**
Stool color	Test group (n = 15)	49.9 (5.1)	0.3	77.0 (5.6)	0.07	0.004 **
	Placebo group (n = 15)	46.1 (4.6)		61.0 (5.8)		0.008**
Stool volume	Test group (n = 15)	28.7 (4.1)	0.08	61.3 (7.3)	1	<0.001**
	Placebo group (n = 15)	36.2 (5.2)		60.7 (4.3)		0.002**
Stool odor	Test group (n = 15)	34.2 (4.0)	0.8	59.8 (5.4)	0.4	0.005**
	Placebo group (n = 15)	45.1 (4.3)		53.1 (4.3)		0.06
() denotes standard error < * p < 0.05 ** p < 0.01						

Table 2: Change in the visual analogue scale to evaluate stool consistency (VAS-S) before and after the intake of test or placebo powder for 4 weeks.

POMS2

The Mood Scale (POMS2) is a questionnaire designed to evaluate mood in adults. For each question, subjects rate themselves on a five-point scale from 0 to 4, with 0 indicating ‘not at all’ and 4 indicating ‘very much’. The questions are classified into seven scales and a Total Mood Disturbance (TMD) score, which comprehensively represents negative mood. For the five scales (AH: Anger-Hostility; CB: Confusion-Bewilderment; DD: Depression-Dejection; FI: Fatigue-Inertia; and TA: Tension-Anxiety), lower scores indicate a better state. For the other two scales, VA (Vigor-Activity) and F (Friendliness), higher scores are better. A higher TMD score indicates higher levels of negative emotion.

Comparison before and after the intervention showed a significant difference ($p < 0.05$) in VA (vitality) in the test group (Table 3). In the placebo group, a significant difference was observed in FI (fatigue-lethargy). No significant differences were observed between the two groups in all items.

	Group	Mean score at pre-intervention	P-value between two groups	Mean score at post-intervention	P-value between two groups	P-value between pre- and post-intervention
Anger-Hostility	Test group (n = 15)	3.9 (1.1)	0.7	4.5 (1.2)	0.3	0.4
	Placebo group (n = 15)	3.3 (0.8)		2.9 (0.6)		0.5
Confusion-Bewilderment	Test group (n = 15)	4.1 (1.0)	0.9	3.5 (1.0)	0.9	0.2
	Placebo group (n = 15)	4.0 (0.9)		3.7 (1.0)		0.6
Depression-Dejection	Test group (n = 15)	4.2 (1.2)	0.7	3.5 (1.0)	0.7	0.4
	Placebo group (n = 15)	3.5 (0.9)		2.9 (0.9)		0.4
Fatigue-Inertia	Test group (n = 15)	5.1 (1.2)	0.7	4.2 (1.0)	1	0.07
	Placebo group (n = 15)	5.9 (1.3)		4.3 (1.0)		0.03 *
Tension-Anxiety	Test group (n = 15)	5.9 (1.4)	1	6.1 (1.5)	0.8	0.8
	Placebo group (n = 15)	5.9 (0.9)		5.7 (0.9)		0.7
Vigor-Activity	Test group (n = 15)	7.9 (1.3)	0.7	9.8 (1.5)	0.8	0.04 *
	Placebo group (n = 15)	8.7 (1.2)		9.2 (1.4)		0.5
Friendliness	Test group (n = 15)	11.1 (1.2)	0.6	12.9 (1.1)	0.1	0.07
	Placebo group (n = 15)	10.2 (1.1)		10.4 (1.0)		0.8

TMD score	Test group (n = 15)	15.3 (6.0)	0.9	12.1 (5.9)	0.8	0.2
	Placebo group (n = 15)	14.9 (4.8)		10.3 (4.5)		0.09
() denotes standard error 0.01 < * p < 0.05						

Table 3: Change in the Mood Scale (POMS2) before and after the intake of test or placebo powder for 4 weeks.

CFS

The Chalder Fatigue Scale (CFS) is a questionnaire that evaluates subjective fatigue. Consisting of 14 items, it asks subjects to self-evaluate on a 4-point scale ranging from 0 (none) for the best condition to 3 (very high) for the worst. A higher total score indicates a higher degree of fatigue. Both the test group and the placebo group showed a decrease in scores after intake, and a significant difference was obtained in the pre- and post-comparison ($p < 0.05$) (Table 4). However, no significant difference was observed between the two groups.

	Group	Mean score at pre-intervention	P-value between two groups	Mean score at post-intervention	P-value between two groups	P-value between pre- and post-intervention
Fatigue	Test group (n = 15)	18.5 (2.2)	0.6	12.3 (2.1)	0.9	0.03 *
	Placebo group (n=15)	16.6 (2.8)		12.7 (2.1)		0.04 *
() denotes standard error 0.01 < * p < 0.05						

Table 4: Change in the Chalder Fatigue Scale (CFS) before and after the intake of test or placebo powder for 4 weeks.

OSA-MA

The OSA Sleep Inventory MA Version is a psychological scale designed to evaluate sleep introspection upon waking in middle-aged and elderly individuals. This questionnaire consists of 16 items organized into five factors: Factor 1: Sleepiness upon waking, Factor 2: Initiation and maintenance of sleep, Factor 3: Frequent dreaming, Factor 4: Refreshing, and Factor 5: Sleep length. Higher scores indicate better sleep quality.

A comparison of the results before and after intake showed a significant change in factor IV (fatigue recovery) in the placebo group ($p < 0.05$) (Table 5). However, no significant differences were observed in any of the items, including factor IV, when comparing the test and placebo groups.

	Group	Mean score at pre- intervention	P-value between two groups	Mean score at post-intervention	P-value between two groups	P-value between pre- and post-intervention
Factor 1	Test group (n=15)	18.5 (1.6)	0.4	22.0 (1.7)	0.1	0.2
Sleepiness upon waking	Placebo group (n=13)	16.2 (2.2)		18.3 (1.5)		0.3
Factor 2	Test group (n=15)	14.3 (1.4)	0.09	19.5 (1.8)	0.4	0.05
Initiation and maintenance of sleep	Placebo group (n=13)	18.0 (1.5)		17.3 (1.9)		0.8

Factor 3	Test group (n=15)	21.2 (2.3)	0.7	22.4 (1.7)	0.7	0.6
Frequent dreaming	Placebo group (n=13)	19.9 (1.8)		21.4 (2.4)		0.8
Factor 4	Test group (n=15)	17.4 (2.0)	0.9	22.4 (1.6)	0.3	0.06
Refreshing	Placebo group (n=13)	17.1 (2.2)		19.7 (1.7)		0.04*
Factor 5	Test group (n=15)	21.2 (1.9)	0.4	20.1 (1.7)	0.8	0.7
Sleep length	Placebo group (n=13)	19.0 (1.5)		20.7 (1.9)		0.1
() denotes standard error 0.01 < * p < 0.05						

Table 5: Change in the OSA Sleep Inventory (OSA-MA) before and after the intake of test or placebo powder for 4 weeks.

VAS-F

VAS-F is a questionnaire-style survey that evaluates mental and physical fatigue using the Visual Analogue Scale (VAS) method. The questionnaire consists of 12 questions. For each item, the subject self-evaluates their current mental and physical fatigue on a scale of 0 (does not apply at all) to 100 (applies most), by drawing a short vertical line on a long horizontal line.

In the test group, significant differences were observed in the scores before and after the intervention in the items of overall fatigue, drowsiness, and refreshment, while in the placebo group, significant differences were observed in the items of tension and irritability (Table 6). When comparing the changes between the two groups, no statistically significant differences were observed between the groups in all items.

	Group	Mean score at pre- intervention	P-value between two groups	Mean score at post-intervention	P-value between two groups	P-value between pre- and post-intervention
Overall fatigue	Test group (n = 14)	50.9 (7.1)	0.8	35.1 (6.8)	0.4	0.05 *
	Placebo group (n = 15)	47.5 (7.4)		43.0 (6.1)		0.5
Mental fatigue	Test group (n = 14)	46.6 (7.8)	0.6	36.1 (7.5)	0.5	0.2
	Placebo group (n = 15)	51.5 (6.4)		43.7 (6.4)		0.4
Physical fatigue	Test group (n = 14)	51.5 (7.5)	0.9	36.3 (7.2)	0.7	0.06
	Placebo group (n = 15)	50.1 (7.9)		40.9 (6.7)		0.2
Perceived stress	Test group (n = 14)	44.2 (8.6)	0.8	37.6 (7.7)	0.6	0.4
	Placebo group (n = 15)	47.3 (6.8)		42.6 (5.9)		0.6

Tension	Test group (n = 14)	40.1 (7.6)	0.6	32.2 (7.6)	0.9	0.3
	Placebo group (<i>n</i> = 15)	44.8 (6.2)		33.1 (5.8)		0.04*
Drowsiness	Test group (n = 14)	57.1 (5.7)	0.6	32.8 (5.9)	0.3	0.002**
	Placebo group (<i>n</i> = 15)	51.8 (6.9)		41.9 (5.6)		0.1
Boredom	Test group (n = 14)	35.5 (6.5)	0.9	30.6 (5.9)	1	0.6
	Placebo group (<i>n</i> = 15)	36.1 (5.4)		30.2 (5.4)		0.3
Willingness	Test group (n = 14)	53.5 (5.7)	0.4	63.8 (5.9)	0.2	0.2
	Placebo group (<i>n</i> = 15)	45.7 (5.8)		54.3 (5.1)		0.3
Hunger	Test group (n = 14)	55.8 (5.2)	0.9	45.2 (7.6)	0.8	0.1
	Placebo group (<i>n</i> = 15)	55.2 (4.3)		47.9 (5.2)		0.3
Thirst	Test group (n = 14)	45.6 (6.4)	0.3	32.2 (6.5)	0.3	0.1
	Placebo group (<i>n</i> = 15)	54.7 (4.2)		41.8 (5.1)		0.1
Irritability	Test group (n = 14)	42.6 (7.8)	0.7	29.6 (6.5)	0.4	0.1
	Placebo group (<i>n</i> = 15)	46.1 (5.9)		36.8 (5.9)		0.02*
Refreshment	Test group (n = 14)	40.4 (6.7)	0.7	60.0 (5.1)	0.1	0.03*
	Placebo group (<i>n</i> = 15)	44.5 (5.6)		48.0 (5.7)		0.7
() denotes standard error 0.01 < * p < 0.05 ** p < 0.01						

Table 6: Change in the visual analogue scale to evaluate fatigue severity (VAS-F) before and after the intake of test or placebo powder for 4 weeks.

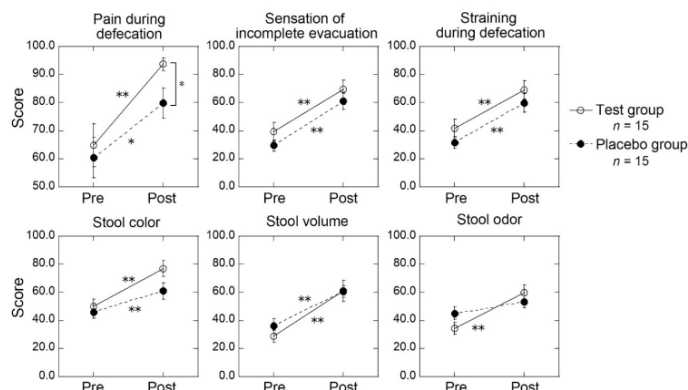


Figure 1: Change in the visual analogue scale to evaluate stool consistency (VAS-S) before and after the intake of test or placebo powder for 4 weeks. Higher scores indicate better condition. Most items in both the test and the placebo group showed significant increase ($0.01 < p < 0.05$, $**p < 0.01$) after the trial, except for the stool odor in the placebo group. When comparing the test and the placebo groups, significant difference was detected in post intervention scores for pain during defecation ($* p < 0.05$). Error bar: standard error.

Discussion

Natto has long been considered a health food in Japan, with various health benefits attributed to it [13]. However, despite the fact that *natto* bacteria live in the intestines, little research has been conducted on how *natto* affects intestinal regulation. In this trial, we examined the effects of taking *natto* powder on the bowel movements and health status of subjects with constipation. The subjects took 3g of either the test powder or the placebo powder for 4 weeks. No adverse events were reported during the intervention, suggesting that the test powder can be regarded as generally safe. The effects of the test powder were evaluated using a questionnaire consisting of 5 items. At the initial measurement, no significant differences were observed between the test group and the placebo group for any of the test items, indicating that there was no bias between the groups.

In the VAS-S, which evaluates stool consistency and shape, scores for nearly all items increased within 4 weeks. Significant differences were observed between the pre- and post-measurement scores of these items in both the test and placebo groups. We speculate that the increase in the placebo group is not simply due to the placebo effect. In previous studies in which we examined bowel movements using the same method [17,18], we did not observe a statistically significant difference between the pre- and post-measurement scores in the placebo group, as was observed in this study. Several studies have reported that soybeans or their derivatives including lecithin, which is a mixture of phospholipids, have effects on the intestinal regulation [19-21]. In our study, pain during defecation improved after the 4-week intervention in both groups, but the change in the test group was greater than in the placebo group,

resulting in a significant difference between the two groups that was not evident prior to the intervention. Additionally, the changes in the stool color and odor were greater in the test group than in the placebo group, suggesting the possibility that *Bacillus subtilis natto* and their metabolites reach the intestines and change the stool condition. *Natto* consumption is known to improve the intestinal environment [22]. A clinical study conducted on healthy adults who consumed *natto* showed that it maintained healthy intestinal flora, increased organic acids, and reduced putrefactive products, such as skatole and ammonia [23]. The probiotic effects of *natto* help relieve constipation. Based on these results, we hypothesize that the bacteria and metabolites in the test powder may regulate bowel movements and reduce pain during defecation.

Not only in the stool conditions, but significant changes in fatigue were observed in both groups using CFS. Soybeans are a significant source of lecithin. A previous clinical study suggested that consuming soy lecithin increases vigor in middle-aged women experiencing fatigue [24]. Therefore, the lecithin contained in both test and placebo powders may be responsible for these changes. Although no significant difference was observed between the two groups, the test group showed a greater change in score. This suggests that the test product may be more effective at alleviating fatigue. This finding is supported by the results of the VAS-F study, in which only the test group experienced a significant decrease in overall fatigue and refreshment scores. A clinical trial of subjects with peripheral neuropathy found that vitamin K2 alleviated associated symptoms, including fatigue [25]. Although no direct mechanisms have been found to show that vitamin K2 directly alleviates fatigue, we hypothesize that vitamin K2, which is plentiful in *natto*, plays a role in calcium absorption and utilization [26], contributing to bone health, energy levels, and reduced fatigue.

In the OSA-MA study, sleep quality improved after the intervention, as indicated by increased scores on all items in the test group except sleep length. The VAS-F study also showed that drowsiness improved statistically significantly only in the test group. Previous studies have shown that taking *natto* capsules daily for eight weeks improves sleep quality and reduces feelings of stress [27]. The authors of the paper hypothesized that *natto* bacteria activate serotonin production by stimulating enterochromaffin (EC) cells in the intestinal tract, thereby promoting melatonin synthesis in the pineal gland. Additionally, we speculate that the sticky component of *natto*, called γ -PGA, improves sleep quality. Studies have shown that γ -PGA supplementation significantly increases serum concentrations of glutamate and GABA [28]. GABA acts as an inhibitory neurotransmitter and sleep inducer [29]. The intestinal environment and sleep influence each other reciprocally [30]. Good sleep improves the intestinal environment and, conversely, a well-organized intestinal environment improves sleep quality. The results of our study demonstrated that *natto* has a positive effect on brain-gut interaction.

Conclusion

In this study, we demonstrated that taking *natto* powder regulates bowel movements and reduces defecation pain. Additionally, we

found that the test powder can reduce fatigue and improve sleep quality possibly by maintaining healthy intestinal flora. However, in the VAS-S test in particular, statistically significant changes in scores were observed in many items in the placebo group, as well as in the test group. This is thought to be due to the effects of the indigents of soybeans, the raw material of *natto*. Nevertheless, one conclusion we can certainly draw from the study is that *natto* is more effective for these items. To clarify this further, using a placebo made from a different raw material is needed to determine whether the observed changes are unique to *natto* or common to soybeans. Further research is needed to confirm these promising results and elucidate the underlying mechanisms.

Conflict of Interest

This study was conducted by User Life Science Co., Ltd. with funding and samples provided by Yamada Foods Co., Ltd.

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