Fiber-rich snacks improved constipation in Vietnamese elderly

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ABSTRACT

Background and Objectives: Constipation is a common condition among the elderly in nursing homes, partly due to a low fiber intake. This study utilized agar and konjac, both rich sources of dietary fiber, to develop fiber-rich snacks aimed at increasing fiber intake among the elderly. **Methods and Study Design:** This 3-week cross-over study was conducted among 20 elderly residents with constipation at Tuyet Thai Nursing Home, Vietnam (11 women, mean age 77 years; 9 men, mean age 79 years). Participants were divided into two groups receiving either control or fiber-rich snacks in alternating weeks, with a washout week in between. Two snacks were provided each day - control snacks made with tapioca and gelatin and intervention snacks in which part of the tapioca was replaced with konjac (≈3g fiber) and all gelatin with agar (≈3g fiber). Data were collected on stool status, dietary intake, and quality of life (as assessed by the Patient Assessment of Constipation Quality of Life (PAC-QOL) questionnaire). **Results:** Comparison of defecation status with the control period and the intervention period: stool frequency: 3.3 times/week and 4.9 times/week; The proportion of bowel movements with normal stool form increased from 35% to 85%; with stool constipation form decreased from 56% to 14% ($p<0.05$). Energy intake was comparable between periods, whereas fiber intake increased substantially during the intervention (11.8 ± 1.6 vs. 6.1 ± 1.2 g/day). The difference in fiber intake between the two periods was statistically significant (p <0.05), while the difference in energy intake was not statistically significant (p >0.05). The quality of life scores of the elderly during the intervention period improved significantly. **Conclusions:** Fiber-rich snacks effectively improved constipation in the elderly without affecting their energy intake.

Key Words: constipation, agar, konjac, fiber-rich snacks, nursing home

INTRODUCTION

Constipation is described with symptoms such as dry and hard stools leading to difficulty defecating with a burning sensation in the anus, prolonged defecation and straining time, or low frequency of defecation (less than 3 times/week).[1] It is a common condition in the population and is especially common among the elderly; about 18.9% of the elderly in the world are reported to suffer from constipation.[2] Furthermore, it is a serious condition among the elderly in nursing homes.[3,4] The reason is that the ages of residents in nursing homes are often relatively high, accompanied by many complex diseases and a reduced quality of life that affects eating habits and digestive ability. Prolonged constipation can lead to

complications such as fecal impaction, urinary retention, hemorrhoids, anal fissures, and fecal incontinence.[5] Many studies indicate that constipation significantly impacts quality of life.[6,7] While caring for and improving the quality of life of the elderly is an essential goal in nursing homes, it is also related to assessing the quality of these elderly care facilities. Also, the time and cost spent on care and treating constipation in nursing homes is relatively high.[8,9] It also poses additional challenges, financial burdens, and constipation management for nursing home facilities.

According to the United Nations Fund for Population Activities (UNFPA), Vietnam is currently one of the countries experiencing the fastest rate of population aging in the world. People aged 60 and over made up 11.9% of the total population in 2019, and by 2050, this number will increase to more than 25%. By 2036, Vietnam will transition from an "aging" society to an "aged" society.[10]

As a result, the demand for elderly care increased, leading to the establishment of several new nursing homes. However, along with that is the lack of experience in the management and health care of the elderly. Addressing the challenges of treating and managing health issues in the elderly can be difficult, with one common issue being constipation. This prevalent condition has not received significant attention or research in Vietnam. A study conducted in the country found that approximately 41% of elderly individuals seeking examination and treatment at geriatric hospitals suffer from constipation.[11] These individuals often share characteristics similar to those of residents in Vietnamese nursing homes, suggesting a high prevalence of constipation in this population. However, despite this burden, important evidence gaps remain. Specifically, there is a lack of well-designed randomized or cross-over trials in this setting, limited evidence on locally applicable food-based interventions, and insufficient studies that concurrently assess bowel outcomes, dietary intake, and quality of life using validated instruments.

Meanwhile, the recommended dietary fiber intake for Vietnamese adults aged 60 years and older is at least 20 g/day for men and 17 g/day for women.[12]

However, from previous studies, Vietnamese people's fiber intake ranges from 2.1 to 7.9 g per day.[13,14,15] Based on these results, low fiber intake may significantly cause constipation among the elderly at this location. Subsequently, potential dietary strategies to increase fiber intake in the elderly were investigated. During that process, we learned from the Japanese food culture that two types of foods are Konjac and Agar; they are commonly used to prepare various dishes, especially snacks. These foods are generally well accepted and widely consumed. Two foods are known for their very high fiber content, about 79.9g of fiber in

100g of Konjac powder and about 75.7g of fiber in 100g of Agar powder.[16] In Vietnam, two types of food are easily found due to suitable weather conditions for their growth and production. However, most are used by people as animal feed or as herbs and have not been widely exploited and used. We also discovered that Konjac and agar powder can replace tapioca starch and gelatin powder, which are two commonly used snacks in Vietnam.

In addition, the timing of fiber use by the elderly is also very important. It can affect other nutrients and their acceptance. We believe that dividing the amount of fiber into snacks can reduce the impact on the absorption of other nutrients in the elderly. Using snacks, we can easily prepare various dishes with appealing flavors and colors, which may help research subjects feel more attractive and accepted. In addition, a previous study conducted in Thailand found that the elderly are more likely to accept changes in snacks rather than changes in main meals.[17] Additionally, another study in the US showed that replacing regular snacks with high-fiber snacks helped increase daily fiber intake by 2.5g in children.[18] The timing of fiber consumption and its potential effects on nutrient absorption were considered in the study design. It is possible that consuming fiber-rich snacks between main meals may help optimize gastrointestinal function while minimizing potential interference with nutrient absorption. However, this remains a hypothesis and requires further investigation

Therefore, we have chosen to use Konjac powder and Agar powder to create fiber-rich snacks inspired by traditional Vietnamese dishes, aiming to alleviate constipation in elderly residents of Vietnamese nursing homes. This is the first cross-over dietary intervention study conducted in Vietnamese nursing homes.

MATERIALS AND METHODS

Research time and location

The study was conducted from November 2023 to February 2024 at Tuyet Thai Nursing Home - Dong Anh district - Hanoi – Vietnam.

Tuyet Thai Nursing Home is a residential care facility for older adults in Hanoi, Vietnam, with a capacity of over 100 residents. The facility provides comprehensive services, including daily living support, health monitoring, and nutritional care.

Subjects

Selection criteria

Elderly people at nursing homes are diagnosed with constipation based on Rome IV criteria 1

-Exclusion criteria

-The patient has a swallowing disorder.

-The patient has specific diseases of the digestive tract, such as paralytic ileus, intestinal obstruction, colorectal cancer, or irritable bowel syndrome (IBS).

-The patient has limited or no cognitive function.

-The patient has limited or no mobility.

-The patient does not consent to participate in the study.

Sample size

The sample size was calculated based on a two-period cross-over design using within-subject comparisons. A significance level of $\alpha = 0.05$ ($Z_{1-\alpha/2} = 1.96$) and a power of 80% ($Z_{1-\beta} = 0.84$) were assumed. The expected mean difference (Δ) in stool frequency was set at 1.97 bowel movements per week, based on previous randomized controlled trials of dietary fiber interventions. The within-subject standard deviation (σ^D) was estimated at 1.09 from studies reporting similar variability in stool frequency outcomes.19

Using these parameters, the minimum required sample size was calculated to be approximately 3 participants. To improve the robustness of the study and account for potential dropouts, a total of 20 participants were ultimately recruited.

Study design

This study is a cross-over design and Figure 1 shows the study design. After selecting 20 subjects, this study was conducted by a cross-over design in 3 weeks (in the first and third weeks, we provided snacks for the elderly; the second week was a washout time). One group ate control snacks in the first week (7 days – control period) and intervention snacks in the third week (7 days – intervention period). The other group ate menus vice versa. The second week was washout time. During this period, the elderly did not use control snacks and fiber-rich snacks. This phase aims to reduce the effects of the first treatment before proceeding with the second treatment. A one-week washout period was implemented between the two study periods to minimize potential carryover effects. The physiological effects of dietary fiber on bowel function are generally short-term and depend on continuous intake, with effects diminishing after cessation. Previous studies have also suggested that changes in bowel habits induced by dietary fiber are reversible within a short period after discontinuation.[20, 21] Therefore, a one-week washout period was considered sufficient to reduce residual effects.

Participants were randomly assigned to one of two sequence groups (intervention–control or control–intervention) using a simple lottery-based randomization method. The allocation

sequence was generated by an independent researcher who was not involved in data collection. To ensure allocation concealment, participant names were placed in sealed, opaque envelopes, and group assignments were determined by randomly drawing envelopes after enrollment. The envelopes were prepared and maintained by a study coordinator until assignment.

Due to the nature of the dietary intervention, participants were not informed of the study sequence, although complete blinding was not feasible. Outcome data, including stool frequency and quality-of-life measures, were collected using standardized diaries and validated questionnaires. Data entry and statistical analyses were performed by investigators who were blinded to group allocation.

In the third week, participants crossed over to receive the alternate condition. As a cross-over design was employed, all participants received both the intervention and control conditions, thereby minimizing inter-individual variability and increasing the statistical power of the study.

Participants in the intervention period received two servings of fiber-rich snacks per day, standardized across all participants. The snacks were provided between main meals (mid-morning and mid-afternoon) to minimize potential interference with regular dietary intake. Each serving contained a defined amount of dietary fiber.

Snack consumption was supervised by nursing home staff, and adherence was monitored daily using intake records. Participants who did not consume the full portion were documented, and adherence rates were calculated. No participants were lost to follow-up during the study period.

During each study period, dietary intake was assessed using 24-hour dietary recalls collected on three non-consecutive days. Stool characteristics, including frequency and related symptoms, were recorded daily using standardized stool diaries. Quality of life (QOL) was evaluated at the beginning and end of each intervention week using the Patient Assessment of Constipation Quality of Life (PAC-QOL) questionnaire

The study was approved by the Ethics Committee of Hanoi Medical University (IRB: VN01.001/IRB0003121/FWA 00004148). Informed consent was obtained from all subjects involved in the study

Data collection procedure and instruments

Snacks in study: we have developed recipes for fiber-rich snacks based on typical snacks in Vietnamese nursing homes. We realized that Konjac and agar powder can create dishes with a texture similar to tapioca starch and gelatin powder, which are commonly used to make

snacks in Vietnam. As a result, we decided to incorporate these ingredients to boost the fiber content in snacks. In our study, we prepared two types of snacks to compare their effectiveness. Control snacks: these are typical snack menus in Vietnam. Fiber-rich snacks (intervention snacks): this snack contains 3 g of fiber sourced from Konjac powder or agar. It has a shape and structure similar to the control snack. The recipe involves substituting 3.8 g of tapioca starch with 3.8 g of Konjac powder or replacing 4 grams of gelatin with 4 g of agar powder.

Dietary intake was assessed using food records, and nutrient composition was calculated using the Japanese Standard Tables of Food Composition. This database was selected because it provides detailed information on total, soluble, and insoluble dietary fiber, which is not fully available in Vietnamese food composition tables.

Vietnamese food items were matched to their closest equivalents in the Japanese database based on ingredient composition and preparation methods. For mixed dishes and processed foods, standard recipes were used to estimate ingredient composition, and fiber content was calculated accordingly.

To ensure that the fiber-rich snacks provided to the elderly are feasible and suitable for the tastes of the elderly in Vietnam, a five-point facial hedonic scale was used to evaluate the acceptability of snacks, including appearance, aroma, texture, taste, and overall acceptability (1 = Very bad, 2 = Bad, 3= Ok; 4 = Good, 5 = Super good). The subjects of this survey are 10 elderly individuals (60 years or older) in nursing homes who had good cognitive function and did not suffer from dementia. After that, we selected menus with an average score of 3 or higher.

Assess stool condition: stool status of subjects was recorded every day using a stool status diary form with 3 factors: stool frequency, stool form, and anal burning sensation. Stool form was assessed based on a photo of “The Bristol stool form scale”. Energy and nutrient intake were assessed using the weighed food record method conducted over three consecutive days during each study period. Dietary intake data were analyzed using the Japanese Food Composition Table, which provides detailed information on total dietary fiber, including soluble and insoluble fiber contents of foods. Food ingredient data was entered and analyzed using Excel software. A 24-hour dietary record was collected for three days, including two weekdays and one weekend day. This approach was chosen because previous studies have demonstrated that three days of dietary data are sufficient to estimate habitual energy, nutrient, and dietary fiber intake.[22, 23] In addition, meals provided in the nursing home were prepared according to a standardized menu with consistent food items and portion sizes. Therefore,

dietary intake among the elderly residents was relatively stable across days. Accordingly, collecting dietary intake data over three days was considered adequate to improve the accuracy of dietary assessment while simultaneously optimizing time, manpower, and research costs. Quality of life related to constipation was assessed using the Patient Assessment of Constipation Quality of Life (PAC-QOL) questionnaire.

Continuous variables were represented by median and interquartile range or mean and standard deviation. Categorical variables were expressed as absolute (n) and relative (%) frequencies. Comparisons of stool frequency and nutrition intake amount and the QOL score between the control and intervention periods were performed using the Student's paired t-test or Wilcoxon signed-rank test. Categorical variables (stool form and anal burning pain) were compared by the chi-square test (χ^2) and Fisher's Exact test. p-values of less than 0.05 were considered statistically different for all the analyses. The above statistical procedures were performed using Stata version 17.0.

RESULTS

Table 1 shows the sensory test results of eight different types of fiber-rich snacks. Six types of snacks have an average score greater than or equal to 3, while Snack 2 and Snack 8 have scores of 2.94 and 2.98, respectively. From this result, the 6 best snacks with mean scores ≥3 were selected for use in the study.

Table 2 shows the age and gender characteristics of the subjects. Among the 20 study participants, there were 11 women with an average age of 77 ± 10 years, while there were 9 men with an average age of 79 ± 9 years.

Stool status

Baseline stool frequency during the first study period did not differ significantly between the two sequence groups (AB: control–intervention; BA: intervention–control) (4.5 ± 2.17 vs. 3.5 ± 1.65 stools/week, $p = 0.26$), indicating comparable baseline conditions between sequences.

Figure 2 illustrates the comparison of stool frequency between the control period and the intervention period. During the control period, the average frequency of stools was 3.3 ± 1.8 times per week, which increased to 4.9 ± 1.9 times per week during the intervention period. The difference in stool frequency between these two periods is statistically significant ($p < 0.05$).

Figure 3 compares the stool form between the control and intervention periods. During the control period, constipation accounted for 56%; diarrhea accounted for 9%. These two data

both decreased during the intervention period to 14% and 1%, respectively. In contrast, the percentage of normal stool form during the control period was 35%; this figure increased sharply to 85% during the intervention period. The difference in stool form between the two stages is statistically significant (p <0.05)

Figure 4 illustrates the comparison of anal burning pain during defecation across two periods. In the control period, when using a snack, 25% of bowel movements were reported as no pain, 55% experienced moderate pain, and 20% reported severe pain. In contrast, during the intervention period, the percentages reported 75% of bowel movements were no pain, 24% experienced moderate pain, and only 1% reported severe pain. The difference in anal burning pain between the two periods is statistically significant (p <0.001).

Quality of life

Figure 5 illustrates the quality of life scores of the elderly. The baseline scores for the control and intervention groups were 81 and 83, respectively, indicating no significant difference between the two groups (p >0.05). At the end of the control period, the score was 90, while during the intervention period, it increased to 105. The difference in quality of life scores between the two groups was statistically significant (p <0.05)

To account for baseline differences in quality of life (QOL) scores, an analysis of covariance (ANCOVA) was performed with the final QOL score as the dependent variable and baseline QOL score as a covariate. After adjustment, the intervention was associated with a significantly higher final QOL score compared with the control condition (adjusted mean difference = 10.8 points; 95% CI: 5.3–16.3; p = 0.001). Baseline QOL score was a significant predictor of final QOL (β = 0.87, p <0.001)

Energy and nutrition intake survey

Table shows that energy intake was 1638.37 kcal (IQR: 1271.66 – 1795.89) during the control period and 1602.92 kcal (IQR: 1487.04 – 1715.32) during the intervention period (p = 0.19). Protein intake was 76.72 ± 10.95 g and 74.55 ± 11.82 g in the control and intervention periods, respectively (p = 0.21). Lipid intake was 37.14 g (IQR: 31.5 – 43.8) during the control period and 37.03 g (IQR: 25.23 – 47.23) during the intervention period (p = 0.40). Carbohydrate intake was 239.32 ± 34.91g during the control period and 233.34 ± 32.10 g during the intervention period (p = 0.27).

Figure 6 illustrates a comparison of fiber intake between the intervention period and the control period. During the control period, the average fiber intake was 6.1 ± 1.2 g per day,

while the average intake during the intervention phase increased to 11.8 ± 1.6 g per day. This difference in fiber intake between the two periods was statistically significant (p <0.05).

DISCUSSION

The current research provides evidence that fiber-rich snacks containing konjac and agar positively improve constipation in elderly individuals in nursing homes, and the subjects readily accepted these interventions. The age group of the participants is known to be prone to such issues. This is a novel intervention study in Vietnam, and initially, both the participants and staff at the nursing home were skeptical about the efficacy of increasing fiber intake in treating constipation. However, throughout the study, the period consuming fiber-rich snacks showed significant improvement in their bowel movements in terms of frequency, stool form, and anal burning pain compared to the control period. No participants dropped out during the intervention period.

On one hand, the frequency of bowel movements in the elderly increased when they consumed fiber-rich snacks, with a rise of 1.6 times per week compared to the control snacks. This result was higher than a previous study by Hsiao-Ling Chen et al. (an increase of 1.2 times) but lower than a study conducted in China (an increase from 2 to 4 times).[24,25] Although this study also used glucomannan fiber from Konjac, the differences in results could be attributed to variations in the total amount of fiber consumed across studies. In the current study, participants consumed 11.8 g of fiber daily, whereas the other two studies only focused on the additional fiber intake (4.5 g and 3 g). Overall, all studies have demonstrated the clear benefits of fiber in improving constipation. However, controlling the total fiber intake per day is essential in constipation management. In this study, we also monitored stool consistency based on the Bristol Stool Form Scale. The results showed that with increased fiber intake, a greater frequency of normal stool consistency was observed. This result is consistent with findings from previous studies by Yoshiaki Kato and Debbie Sutton.[26,27] Besides, the sensation of anal burning pain during defecation will be lessened. Current research indicates that 75% of individuals experienced anal burning pain when using control snacks, while this figure dropped to 25% when intervention snacks were consumed. These results of the study can be demonstrated by the role of fiber. Fiber is an important ingredient in the diet, especially playing a major role in maintaining healthy digestive function. Fiber is divided into two main types: soluble fiber and insoluble fiber.[28] Each type of fiber has a different mechanism of action and effects on the digestive system. When soluble fiber enters the body, it can dissolve in water to form a gel, helping to retain water in the intestines, soften stools,

and promote the movement of stools through the colon. Insoluble fiber does not dissolve in water and has the effect of increasing stool volume. In addition, it stimulates intestinal motility, increasing the speed of stool movement through the intestines. Not only that, fiber is also known as a prebiotic; it creates an environment and provides food for probiotics, thereby improving intestinal motility and digestive health.[29] Meanwhile, in fiber-rich snacks, glucomannan and agar are two types of fiber, which explains the improved stool frequency and structure. And softer stools help reduce the burning sensation in the anus when defecating.

In this study, we monitored and recorded the dietary fiber and energy intake of the elderly. These data were then analyzed according to the Japanese food composition table. We utilized the Japanese food composition table because it comprehensively calculates both soluble and insoluble fiber in foods, whereas the Vietnamese composition table only includes cellulose. The results recorded that fiber intake increased from 6.1g to 11.8g per day (p <0.05), and the total energy intake of the elderly did not show a significant change when replacing the usual snack with the fiber-rich snack. The energy intake during the control period was 1638.37 kcal (IQR: 1271.66 – 1795.89) kcal/day, while during the intervention period, it was 1602.92 kcal (IQR: 1487.04 – 1715.32) kcal/day (p >0.05). This result aligns with another study where a fiber-rich snack was provided to children (2 snacks per day), and their energy intake did not significantly change from 1529 kcal/day to 1572 kcal/day, with an increase of 2.5g of fiber per day.[18] However, in our study, the results were more favorable, as most of the elderly participants consumed all of the fiber-rich snacks, unlike the study by Mary Brauchla, where only an increase of 2.5g of fiber was achieved despite providing 10-12 g of fiber from snacks daily. Although many previous studies have shown that increasing dietary fiber content can reduce daily energy intake, this was not the case in our study and Mari Brauchla's study. This is because we all use snacks in our research prepared with a variety of colors and appearances, were more easily accepted and satisfied by the older adults in the study and helped improve their energy intake. This aligns with findings from prior studies, which indicate that a variety of snacks and their palatability enhance the satisfaction of older adults and lead to increased intake.[29] The differences between our study and Mary Brauchla's study may be attributed to several factors, particularly that our study conducted a sensory test to select the most suitable snack for the participants, whereas the study by Brauchla did not. Additionally, the fixed time for providing and consuming the fiber-rich snacks in our study helped establish a routine for the elderly, unlike the other study, which did not specify a time frame. These findings highlight the importance of establishing a routine and using appropriate snacks to achieve

effective intervention outcomes. Furthermore, many scientific sources indicate that the use of laxative medications can cause side effects such as loss of appetite, diarrhea, abdominal pain, and nausea, which may reduce energy intake and worsen nutritional status.[30] In contrast, increasing fiber intake through fiber-rich snacks has a positive role in improving the stool condition of elderly individuals without these adverse effects. That contributes to affirming the role of nutrition as a safe measure in improving digestive condition.

In this study, we decided to increase the amount of 3 g of fiber in each snack, and a total of 6 g of fiber was increased per day in 2 snacks. We decided to increase fiber to 6 g per day with reference to previous studies showing that increasing fiber from 5-10 g per day will effectively improve constipation. In addition, for subjects whose daily fiber consumption is relatively low, it is recommended to increase fiber intake slowly in the first 1-2 weeks (5-10 g/day). For each fiber-rich snack, using 3 g of fiber from konjac or agar is the appropriate amount. Adding more can make the food structure dense and hard, which is unsuitable for the elderly.

Moreover, the quality of life (QOL) scores changed as follows: during the control period, the score increased from 81 to 90, and during the intervention period, it increased from 83 to 105. These QOL results are consistent with previous studies showing improvements in quality of life following improvement in constipation.[19] However, the magnitude of improvement observed in the current study appears to be greater than that reported in some previous studies. It also emphasizes that choosing a healthy and appropriate diet will contribute to improving the quality of life of older people.[31] In addition, potential measurement error and bias related to self-reported outcomes should be considered. Stool frequency and quality of life (PAC-QOL) were assessed using participant-reported diaries and questionnaires, which may be subject to recall bias, reporting bias, and variability in individual interpretation. Although participants were provided with standardized instructions to record their outcomes, some degree of measurement error cannot be excluded.

In particular, this study has shown the potential of fiber from konjac and agar. These are two sources of fiber-rich foods that can be chosen in addition to the options of vegetables and fruits. They can be used to prepare dishes that suit the taste of the elderly in Vietnam. However, it is not yet popular in Vietnam, possibly due to the lack of diversity in culinary culture and processing methods. By learning the methods of using konjac and agar powder in snacks from Japan, we have applied and improved according to Vietnamese culinary culture and found the acceptance of the elderly in this study. Thereby, it also offers a solution to

diversify the recipes using Konjac and Agra, which will make Konjac and Agra commercial products more popular.

Although a relationship between fiber-rich snack consumption and improved constipation in elderly individuals was established, this study has certain limitations. The primary outcome (stool frequency) demonstrated a large effect size (Cohen's d $\approx$ 1.7), and post hoc power analysis indicated very high statistical power (>99%) to detect this effect despite the relatively small sample size. However, the study may have been underpowered to detect smaller effects in secondary outcomes, which generally require larger sample sizes. Although no statistically significant residual effects were detected, the relatively small sample size may have limited the ability to identify subtle carryover effects. Therefore, the possibility of small residual effects cannot be completely ruled out. Furthermore, the study did not comprehensively examine the intervention's impact on overall nutritional status or its potential effects on gut microbiota composition. In addition to evaluating interventions to alleviate constipation, other indicators such as stool transit time, hydration status, stool water content, and gut microbiota could be assessed. However, due to limited research resources, we were unable to comprehensively evaluate all of these factors in this study. In addition, the study was conducted in a single nursing home and over a relatively short intervention period, which further restricts external validity and limits the ability to draw conclusions regarding long-term effectiveness.

In future research, we aim to include larger sample sizes and adopt more comprehensive assessments, including additional biomarkers and dietary components. Expanding the study to community-dwelling older adults would also provide valuable insight into the applicability of fiber-rich snacks beyond institutional settings.

Conclusion

Fiber-rich snacks formulated with konjac or agar powder demonstrated effectiveness in alleviating constipation in the elderly without significantly altering energy intake.

SUPPLEMENTARY MATERIALS

All supplementary tables and figures are available upon request from the editorial office, and are also accessible on the journal's webpage (apjcn.qdu.edu.cn).

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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Table 1. Sensory test of 8 snacks (n=10)

	Appearance	Aroma	Texture	Taste	Overall acceptability	Mean
Snack 1	4.0 ± 0.6	3.8 ± 0.6	4.3 ± 0.6	4.3 ± 0.6	4.3 ± 0.6	4.2 ± 0.7
Snack 2	3.2 ± 0.6	2.8 ± 0.4	2.8 ± 0.4	3.0 ± 0.0	2.9 ± 0.3	2.9 ± 0.4
Snack 3	3.8 ± 0.6	3.4 ± 0.5	3.6 ±0.7	3.3 ± 0.5	3.5 ± 0.5	3.5 ± 0.5
Snack 4	4.7 ± 0.5	4.9 ± 0.3	4.5 ± 0.5	4.3 ± 0.5	4.5 ± 0.7	4.6 ± 0.5
Snack 5	4.8 ± 0.4	5.0 ± 0.0	3.1 ± 0.3	4.1 ± 0.8	4.4 ± 0.5	4.2 ± 0.8
Snack 6	4.3 ± 0.5	4.3 ± 0.7	3.1 ± 0.3	3.4 ± 0.5	3.5 ± 0.6	3.7 ± 0.7
Snack 7	3.3 ± 0.7	4.2 ± 0.7	4.5 ± 0.5	4.5 ± 0.5	4.5 ± 0.5	4.2 ± 0.8
Snack 8	3.3 ± 0.5	3.4 ± 0.7	2.5 ± 0.5	2.7 ± 0.5	3.0 ± 0.5	2.9 ± 0.6

Data are shown in Mean ± SD

Table 2. Gender and age characteristics of the subject

	Women	Men
Gender [N (%)]	11 (55%)	9 (45%)
Age [Mean ± SD (Min-Max)]	77 ± 10 (62 – 94)	79 ± 9 (67 – 91)

Table 3. Comparison of energy intake between the control and intervention periods

Intake	Control period	Intervention Period	*p* value
Energy (kcal/day)	1638.37 (1271.66 – 1795.89)	1602.92 (1487.04 – 1715.32)	0.19
Protein (g)	76.72 ± 10.95	74.55 ±11.82	0.21
Lipid (g)	37.14 (31.5 – 43.8)	37.03 (25.23 – 47.23)	0.40
Carbohydrate (g)	239.32 ± 34.91	233.34 ± 32.10	0.27

Data are presented as mean ± SD for normally distributed variables (protein and carbohydrate) and as median (interquartile range) for non-normally distributed variables (energy and lipid).
Paired Student's t-test or Wilcoxon signed-rank test was applied as appropriate

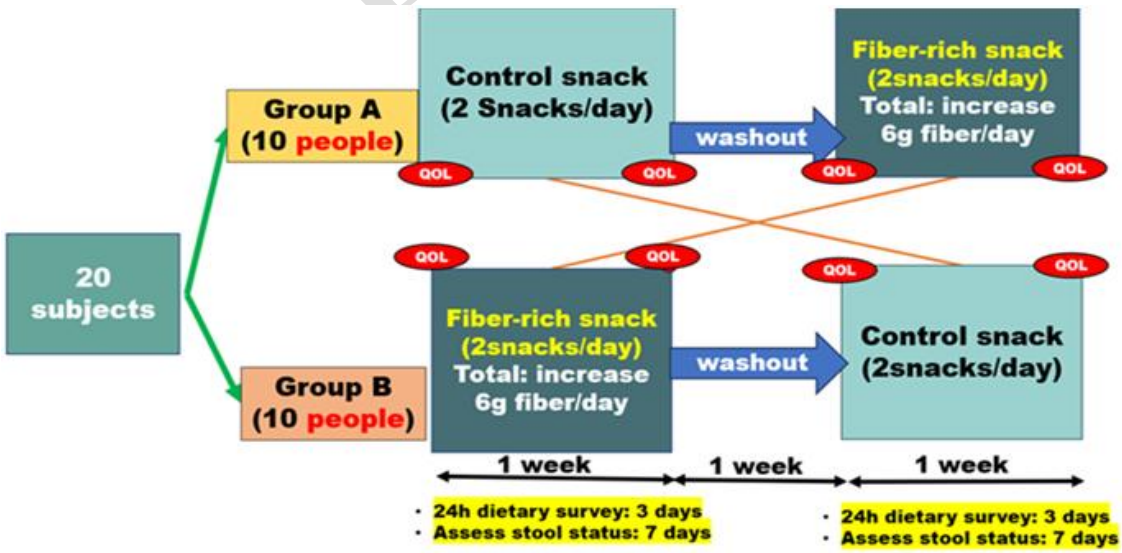

Figure 1. Study design

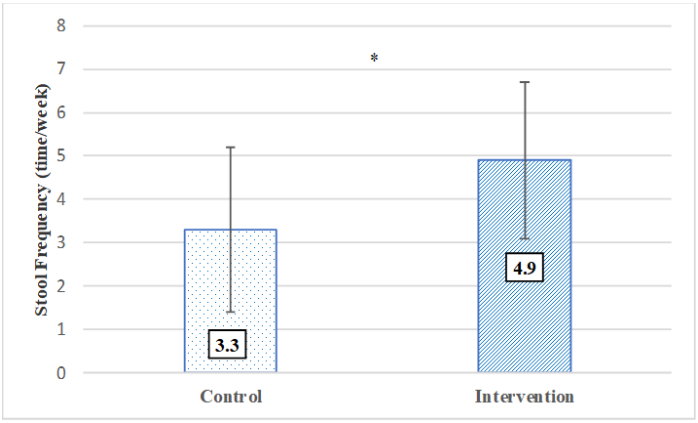

Figure 2. Comparison of stool frequency between the control and intervention periods (times/week) (n=20). Data are expressed in mean ± SD; * Significant difference by Student paired t-test p <0.05

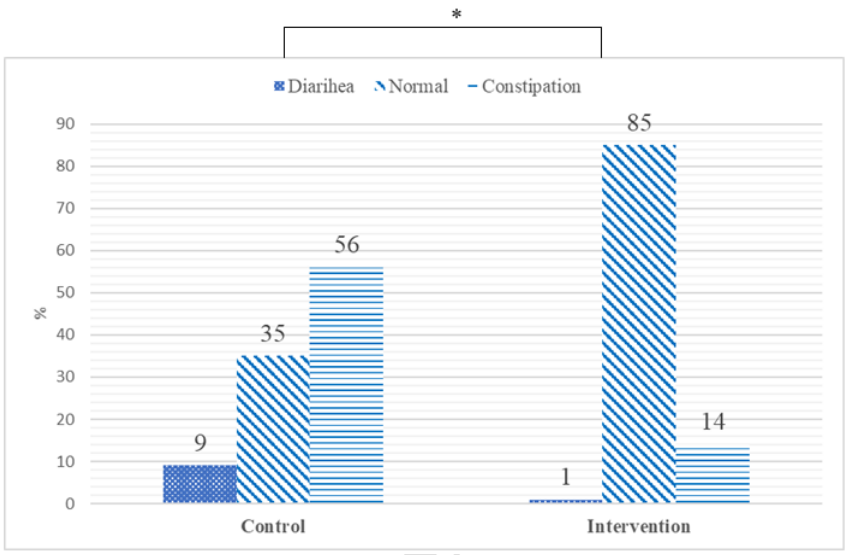

Figure 3. Comparison of stool form according to the Bristol Stool Form Scale between control and intervention periods (n=20). *Significant difference by Fisher's exact test I < 0.05

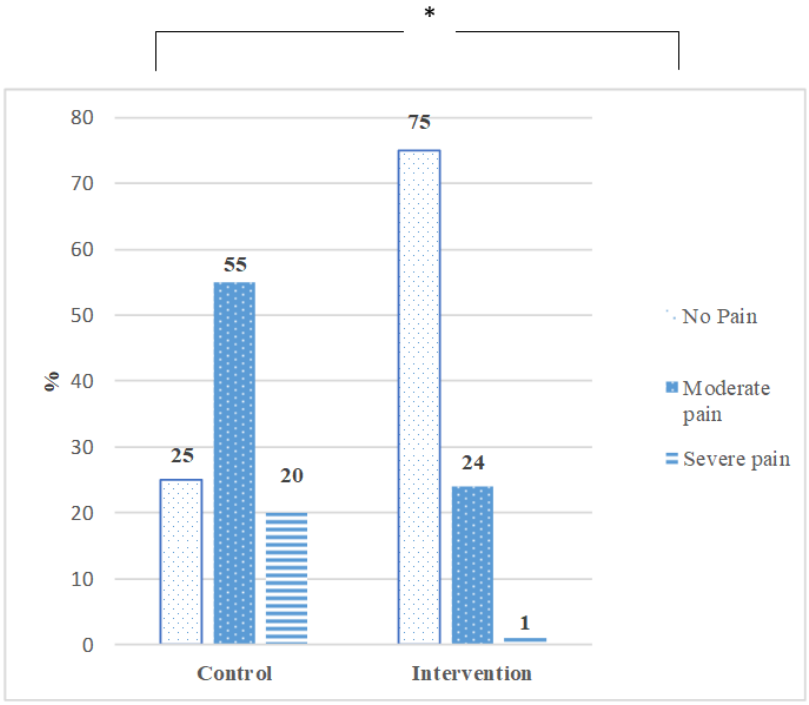

Figure 4. Comparison of anal burning pain between control period and intervention period (n=20 subject). *Significant difference by Chi-squared test p <0.05

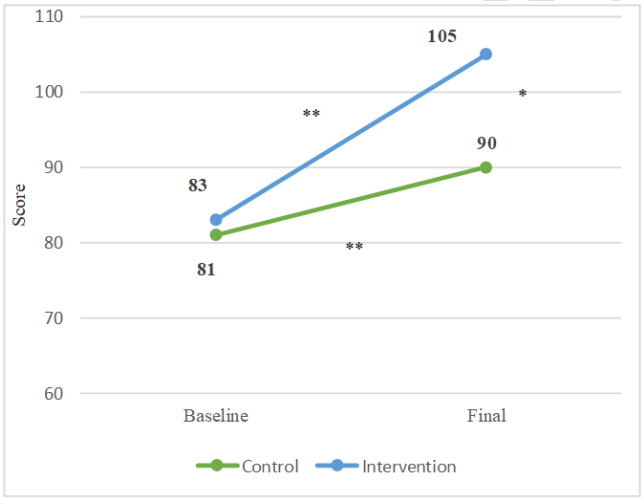

Figure 5. Quality of life scores of elderly people with constipation. *Significant difference by Student pair t-test; **Significant difference by Student t-test

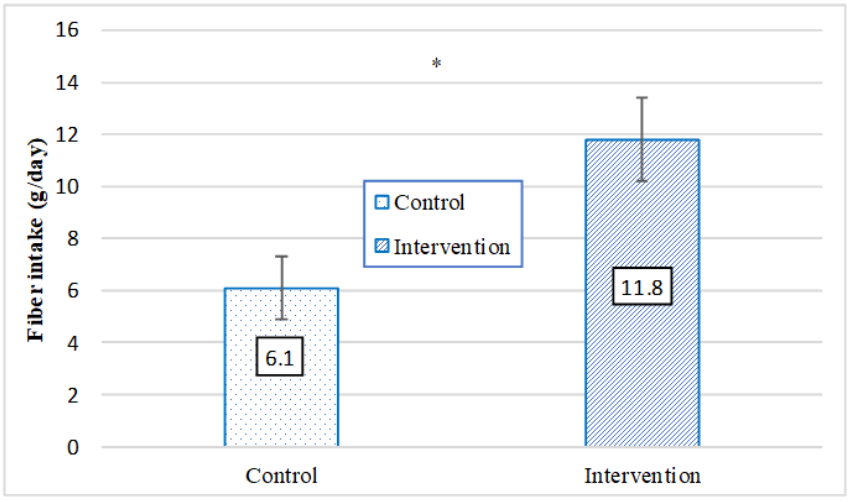

Figure 6. Comparison of fiber intake between the control period and the intervention periods. *Significant difference by Student pair t-test (p <0.05)