Original Article

Kiwifruit improves bowel function in patients with irritable bowel syndrome with constipation

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Irritable bowel syndrome (IBS) is a common functional disorder of the gastrointestinal system, and is characterized by abdominal pain, diarrhea (IBS/D), constipation (IBS/C), and alternating diarrhea and constipation (IBSC/A). The purpose of this study was to examine the impact of a four week kiwifruit intervention on bowel function in patients diagnosed with IBS/C. Fifty-four patients with IBS/C and 16 healthy adults participated in this study. All subjects participated in the 6 week, three phase study, which included a baseline phase (1 week), a dietary intervention period (4 weeks), and a post-intervention phase (1 week). Forty-one IBS/C patients and all healthy adults consumed two Hayward green (*Actinida deliciosa* var) kiwifruits per day for 4 weeks. Thirteen IBS/C patients in the control group took two placebo capsules per day for 4 weeks. Colon transit time was measured immediately prior to and following the intervention period. All subjects completed daily defecation records. After the 4-week intervention, weekly defecation frequency significantly increased in the IBS/C group of participants who consumed kiwifruit ($p<0.05$). Colon transit time significantly decreased ($p=0.026$) in the IBS/C group that consumed kiwi fruit. These findings suggest that kiwifruit consumption for 4 weeks shortens colon transit time, increases defecation frequency, and improves bowel function in adults diagnosed with IBS/C.

Key Words: irritable bowel syndrome/constipation, kiwifruit, colon transit time, bowel function, defecation frequency

INTRODUCTION

Irritable bowel syndrome (IBS) is a common functional disorder of the gastrointestinal system, and is characterized by abdominal pain and altered stool frequency and consistency. The three basic IBS subtypes are diarrhea (IBS/D), constipation (IBS/C), and alternating diarrhea and constipation (IBSC/A).[1] According to the Rome III criteria, individuals with IBS have recurrent abdominal pain or discomfort for at least 3 days per month that persists for at least 3 months, an onset of symptoms at least 6 months prior to diagnosis, and have two or more of the following: 1) persistent or recurrent dyspepsia; 2) a change in stool form; and 3) a change in defecation frequency.[2,3]

Current reports indicate that 10% to 20% of the general population is affected by IBS.[4] Despite being a commonly diagnosed condition, the etiology and pathogenesis remain unclear. Furthermore, optimal management of IBS is yet to be determined, thus achieving a positive outcome remains a clinical challenge.[4] At present, a multimodal approach to the management of IBS/C has been adopted. This generally includes dietary modifications, nutritional supplements, exercise, and when indicated, the use of pharmaceuticals such as 5-HT_4 receptor agonists, laxatives, or antidepressants.[5]

According to the National Cancer Institute and American Dietetic Association, the recommended daily fiber intake for adults is 20 g to 35 g.[6,7] Kiwifruit is known to contain approximately 2% to 3% dietary fiber, and is purported to possess laxative properties.[8] Kiwifruit significantly improves laxation in healthy elderly individuals and chronically constipated adults.[9] No deleterious effects of kiwifruit consumption on psychological functioning or adverse events were found in these studies. In addition, despite the fact that kiwifruit is a relatively common allergen, no participants reported suffering allergic reactions. In contrast, commercially available laxatives such as Tegaserod (the most frequently prescribed drug for IBS/C) are associated with serious adverse events including cardiovascular side effects.[10]

To date, no study has evaluated the effect of kiwifruit on physiologic bowel function in patients diagnosed with IBS/C. Hence, the purpose of this study was to assess the impact of 4 consecutive weeks of kiwifruit consumption on specific bowel characteristics in patients with IBS/C. In an earlier investigation of the effects of eating kiwifruit, Chan *et al*. (2007) enrolled subjects who had chronic constipation only, excluding patients with a history of IBS/C.[11] The study assessed the efficacy of kiwifruit fiber in improving constipation, while also assessing related

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physiologic changes. Although kiwifruit fiber intervention is common to the present study and the Chan study,the patient populations are entirely different and therefore different investigative methods were required and implemented. The present study is focused on IBS/C, and due to the high prevalence of IBS in the general population, this study and the prompt reporting of its results is warranted.

MATERIALS AND METHODS

A total of 60 patients diagnosed with IBS/C according to the Rome III criteria[2] and 16 healthy adults took part in this study. Individuals who had previously undergone gastrointestinal surgery, were allergic to kiwifruit, or were using laxatives were excluded from the study. For the duration of the study period, subjects maintained their normal dietary habits, physical activity levels, and refrained from taking any medication-based laxatives, vitamin/mineral supplements, or commercial health foods.

The study protocol was approved by the Human Ethics Committee of Taipei Medical University Hospital. Informed, written consent was obtained from all subjects. All subjects participated in the 6 week, three phase study which included a baseline phase (1 week), a dietary intervention period (4 weeks), and a post-intervention phase (1 week). Participants with IBS/C were assigned to the kiwifruit treatment (IBS/CK) and placebo (IBS/CC) groups in a ratio of 3 to1. Patients with IBS were assigned consecutive numbers corresponding to the time they were enrolled in the study. Thereafter, among every four consecutive patients, the first three were assigned to the IBS/CK treatment group, and the fourth patient was assigned to the IBS/CC placebo group. A total of 45 IBS/C patients were in the experimental treatment group and 15 IBS/C patients were in the placebo group. Additionally, 16 healthy patients served as a positive control group (HK) whose bowel function would not be expected to change as a result of consuming kiwifruit (Figure 1). During the dietary intervention phase, 45 IBS/C treatment group patients (IBS/CK group) and 16 healthy participants (HK) consumed two Hayward green kiwifruits (*Actinida deliciosa*) per day for 4 weeks, while the remaining 15 IBS/C patients (IBS/CC group) took two placebo capsules containing 0.75 g glucose powder orally once daily for 4 weeks. All participants were asked to complete a defecation diary in which they recorded fecal characteristics as instructed by a clinical nurse and investigator. Specifically, the participants were required to complete a diary noting the frequency of defecation, fecal volume (weight), consistency, and color. A numerical rating scale was used to describe the level of defecation and the fecal characteristics for each defecation episode. Mean fecal volume and defecation frequency were calculated weekly.

During the baseline and post-intervention phases, colon transit time was measured using the method of Metcalf *et al*.,[12] using SITZMARKS radiopaque markers (Konsyl Pharmaceuticals, Maryland, TX). Each capsule contained 24 radiopaque polyvinyl chloride markers measuring 1 × 4.5 mm in one of three shapes: an O shape, double-D shape, or tri-chambered shape. At the beginning of the study (day 1), all subjects were given one capsule containing the O-shaped markers. On days 2 and 3, subjects ingested the second and third capsules containing the double-D and tri-chambered-shaped markers, respectively. Abdominal and pelvic radiographs were obtained on days four and seven of both the baseline and post-intervention phases of the study.

To evaluate “life stress” and “feeling after defecation,” a questionnaire was administered to each patient prior to the start of the study, and after the dietary intervention. For the evaluation of life stress, patients were asked to choose one of the following four options: 1) high pressure, 2) medium pressure, 3) low pressure, and 4) no pressure. Similarly, patients rated post-defecation feelings as: 1) nothing, 2) uncomfortable, 3) abdominal pain, and 4) incomplete defecation.

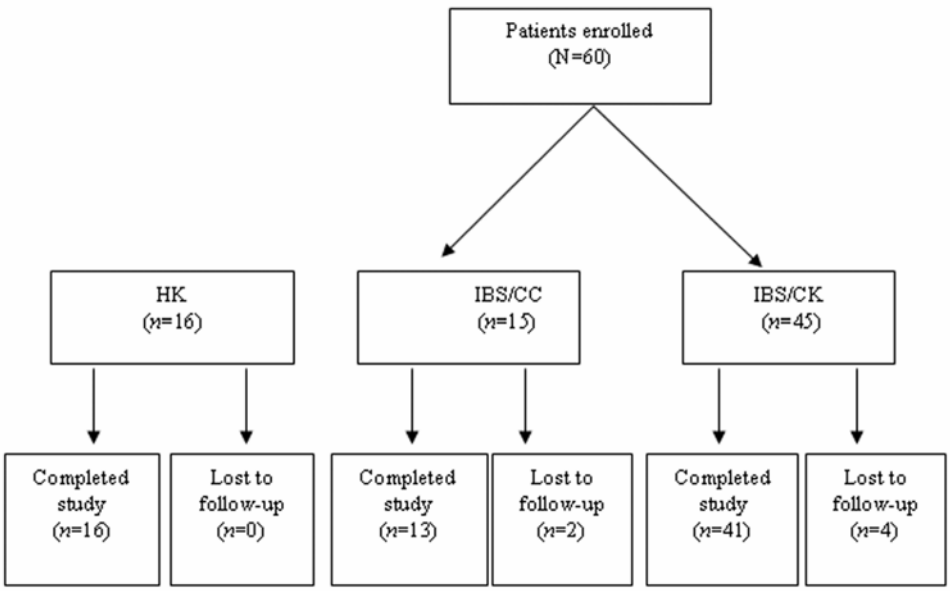

Figure 1. Trial flow chart. HK: healthy controls; IBS/CK: irritable bowel syndrome with constipation-consumed kiwifruit; IBS/CC: irritable bowel syndrome with constipation- placebo control.

Statistical analysis

Continuous variables were compared by one-way ANOVA, while categorical variables were compared by chi-square test or Fisher's exact test. When multiple group comparisons were significant, Scheffé's post-hoc test was used. Baseline and final examination data were compared by paired t-test or McNemar's test. Changes in defecation frequency and fecal volume over time among the three groups were compared by repeated measures ANCOVA after adjusting for age, colon transit time, defecation frequency, and post-defecation feelings at baseline. Mean time-activity curves were plotted with least-square means ± standard error for defecation frequency. All statistical assessments were two-sided and evaluated at the 0.05 level of significant difference. All statistical analyses were performed using SPSS statistical software (version 15.0, SPSS Inc, Chicago, IL, USA).

RESULTS

Seventy individuals completed the study; 41 IBS/C patients who received the kiwifruit intervention; 13 IBS/C patients who received the placebo; and 16 healthy adult volunteers. Four patients in the IBS/CK group and two from the IBS/CC group were lost to follow-up (Figure 1). The demographic and baseline data for all participants are summarized in Table 1. The majority of patients were

Table 1. Demographic and baseline characteristics of patients with irritable bowel syndrome constipation (IBS/C) and healthy controls subjects

	HK (n = 16)	IBS/CC (n = 13)	IBS/CK (n = 41)	p value
Age (years)	30.7±13.3	22.8±3.4†	28.6±8.3	0.032*
Gender (male/female)	3/13	0/13	2/39	0.102
Height (cm)	162.8±5.4	161.5±3.5	161.0±6.9	0.488
Body weight (kg)	60.2±8.5	54.1±7.9	55.4±6.0	0.565
BMI (kg/m^2)	22.5±2.8	20.7±3.1	21.3±2.0	0.876
Colon transit time (h)	29.8±20.1	54.6±12.2†	43.7±18.6†	0.002*
Weekly defecation frequency (times/wk)	5.5±1.4	2.7±0.9†	3.2±1.3†	<0.001*
Fecal volume (weight; g/d)	190.1±84.5	139.2±58.1	165.1±154.6	0.592
Life stress level				0.979
High	1 (6.3)	1 (7.7)	3 (7.9)	
Median	9 (56.3)	8 (61.5)	21 (55.3)	
Low	5 (31.3)	4 (30.8)	11 (28.9)	
None	1 (6.3)	0 (0)	3 (7.9)	
Feelings post-defecation				<0.001*
Nothing	11 (68.8)	2 (15.4)	1 (2.6)	
Uncomfortable	0 (0)	5 (38.5)	11 (28.9)	
Abdominal pain	2 (12.5)	1 (7.7)	17 (44.7)	
Incomplete defecation	3 (18.8)	5 (38.5)	9 (23.7)	

Data are presented as mean ± standard deviation or number (percentage).
Abbreviations: BMI, body mass index; HK = healthy adults who received the kiwifruit intervention; IBS/CK: patients with IBS/C who received the kiwifruit intervention; IBS/CC: patients with IBS/C who received the placebo intervention.
Continuous variables were compared by one-way ANOVA, while categorical variables were compared by chi-square test.
†Indicates a statistically significant difference between the highlighted group and the HK group as determined by Scheffé's test ($p < 0.05$).
*Indicates a statistically significant overall difference ($p < 0.05$).

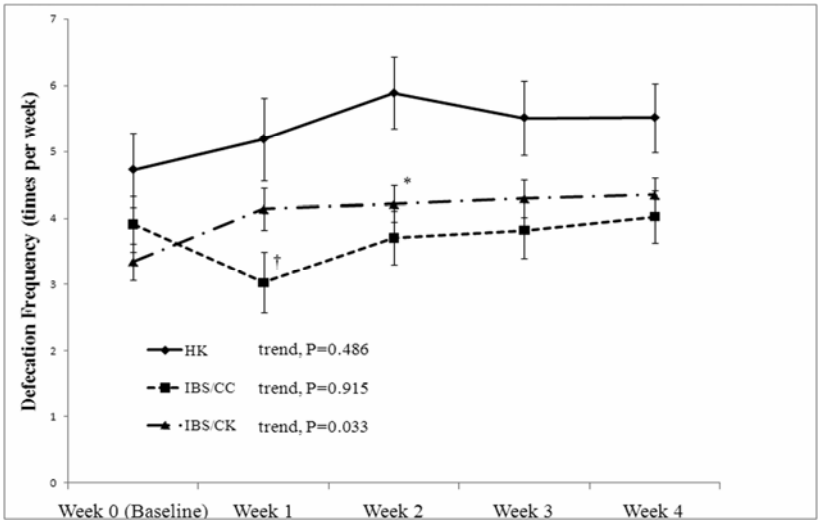

Figure 2. Changes in defecation frequency in patients with irritable bowel syndrome with constipation (IBS/CK) and healthy controls (HK) who consumed kiwifruit twice a day for 4 weeks, and in patients with irritable bowel syndrome with constipation who took a placebo for 4 weeks (IBS/CC). Data are presented as least-square means ± standard error. *Indicates a significant difference between the HK and IBS/CK group as determined by ANCOVA (p <0.05). †Indicates a significant difference between the IBS/CC and IBS/CK group as determined by ANCOVA (p <0.05).

female (65 female, 5 male), which is consistent with published reports of female gender as a risk factor for IBS.[13] Also noteworthy, although IBS prevalence in Asian countries is approximately 5% to 10% regardless of gender, female patients more commonly have constipation-predominant (IBS/C) symptoms.[13] Patients in the IBS/CC group were significantly younger compared to patients in the HK group. At baseline, weekly defecation frequency was lower (both, p <0.05) and colon transit time longer (both, p <0.05) in both the IBS/CK and IBS/CC groups compared to the HK group. No differences in fecal volume or life stress were noted between the groups. Significantly more patients in the IBS/CK group reported feeling uncomfortable or had abdominal pain after defecation than those in the other two groups (p <0.05). Patients in the IBS/CC group primarily reported being uncomfortable or having feelings of incomplete defecation post-defecation.

Changes in defecation frequency over the 4-week study period for each group of participants are summarized in Figure 2. There was a significant increase in defecation frequency over time in the IBS/CK group (p = 0.033). Defecation frequency was significantly higher in the IBS/CK group compared to the IBS/CC group after 1 week of treatment (p <0.05). Defecation frequency was significantly lower in the IBS/CK group compared to the HK group after 2 weeks of treatment (p <0.05). No significant difference was observed in fecal volume change over the 4-week study period for each group of participants and no difference was detected among groups (Figure 3).

According to paired t-test, colon transit time significantly decreased in the IBS/CK group after the 4-week intervention (p <0.05, Table 2). No significant differences were detected in the IBS/CC group. No differences in life stress or post-defecation feelings were apparent after the intervention period in any group.

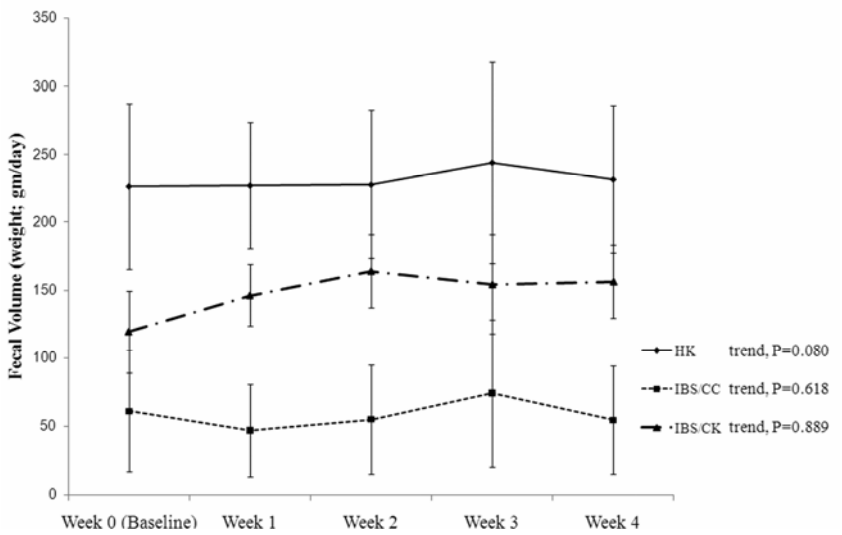

Figure 3. Changes in fecal volume in patients with irritable bowel syndrome with constipation (IBS/CK) and healthy controls (HK) who consumed kiwifruit twice a day for 4 weeks, and in patients with irritable bowel syndrome with constipation who took a placebo for 4 weeks (IBS/CC). Data are presented as least-square means ± standard error.

Table 2. Summary of changes in colon transit time in patients with irritable bowel syndrome with constipation (IBS/CK) and healthy controls (HK) who consumed kiwifruit twice a day for 4 weeks and in patients with irritable bowel syndrome with constipation who took a placebo for 4 weeks (IBS/CC)

	HK		p value	IBS/CC		p value	IBS/CK		p value
	Before	After		Before	After		Before	After	
Colon transit time (h)	29.8±20.1	17.3±17.5		54.6±12.2	51.9±14.3		43.7±18.6	35.5±16.7	
Difference of colon transit time (h)	12.07±24.68		0.079	2.77±14.13		0.493	8.14±18.75		0.012*
Life stress level			0.368			0.149			0.066
High	1 (6.3)	3 (18.8)		1 (7.7)	0 (0)		3 (7.9)	10 (26.3)	
Median	9 (56.3)	7 (43.8)		8 (61.5)	6 (46.2)		21 (55.3)	15 (39.5)	
Low	5 (31.3)	5 (31.3)		4 (30.8)	4 (30.8)		11 (28.9)	10 (26.3)	
None	1 (6.3)	1 (6.3)		0 (0)	3 (23.1)		3 (7.9)	3 (7.9)	
Feeling post-defecation			0.287			0.549			0.650
Nothing	11 (68.8)	10 (62.5)		2 (15.4)	3 (23.1)		1 (2.6)	5 (13.2)	
Uncomfortable	0 (0)	3 (18.8)		5 (38.5)	3 (23.1)		11 (28.9)	7 (18.4)	
Abdominal pain	2 (12.5)	1 (6.3)		1 (7.7)	1 (7.7)		17 (44.7)	17 (44.7)	
Incomplete defecation	3 (18.8)	2 (12.5)		5 (38.5)	6 (46.2)		9 (23.7)	9 (23.7)	

Data presented as mean ± standard deviation or number (percentage).
Continuous variables were compared by paired t-test, while categorical variables were compared by McNemar's test.
*Indicates a statistically significant before and after intervention difference (p <0.05).

DISCUSSION

In the present study, we examined the effects of a 4 week kiwifruit dietary intervention on symptoms in patients diagnosed with IBS/C according to the Rome III criteria. We found that consumption of two kiwifruit per day over this period resulted in significantly decreased colon transit time, increased defecation frequency, and improved bowel function in these patients. In the positive control (HK) group, no significant changes in fecal volume and weekly defecation frequency were observed over the intervention period, nor was any difference in colon transit time found. However, it is of note that a significant increase in defecation frequency over the intervention period was evident in the IBS/CK treatment group only. These results are in agreement with the previously reported positive impact of kiwifruit intervention in constipated elderly and adult individuals. Specifically, Rush *et al*.[9] found that a 4 week kiwifruit intervention resulted in bulkier and softer stool and increased stool production. In addition to assessing defecation frequency and fecal volume, we also assessed colon transit time in the present study, which is a more objective measure of laxation.

The benefits of kiwifruit as a treatment for constipation were also demonstrated in a study by Chan *et al*.[11] who investigated the effects of kiwifruit consumption in Chinese patients with constipation only for 6 months or more, including straining, hard stools, and sensation of incomplete evacuation; the study excluded patients with a history of constipation-predominant IBS according to the Rome II criteria. Although the results of the present study were equally positive, its study population had been diagnosed with IBS/C, a different diagnosis with a more complex set of bowel function symptoms including abdominal pain, altered stool frequency and consistency, and dyspepsia. Patient populations of the two studies also came from different regions of China, which studies have shown to vary markedly in terms of prevalence of constipation and IBS/C.[13] Furthermore, owing to the targeting of different groups of patients, the criteria for evaluating/assessing the outcomes were also different.

During the 4-week treatment phase of the present study, all participants regularly recorded fecal characteristics, including frequency of defecation, fecal volume (weight), consistency, and color. A numerical rating scale was applied to describe the level of defecation and the fecal characteristics for each defecation episode. Mean fecal volume and defecation frequency were calculated weekly. During the baseline and post-intervention phases, colon transit time was measured using the marker method of Metcalf *et al*.[12] and analyzed with abdominal and pelvic radiographs. In addition, we assessed subjects' stress levels and their feelings after defecation; although subjective, this information helped to evaluate each individual's condition and response to treatment. The main outcome measures were changes in defecation frequency and fecal volume over time, which were compared among the three groups by repeated measures analysis of covariance after adjusting for age, colon transit time, defecation frequency, and post-defecation feelings at baseline. Chan's study had different measurement. In the 4-week treatment phase of Chan's study, patients kept a diary in which they recorded symptoms of complete spontaneous bowel motion (CSBM), level of straining, stool form, and frequency of taking a rescue medication. Patient satisfaction with bowel habits were assessed weekly. Transit time was evaluated by a modified Metcalf method. Anorectal physiology tests (i.e., colonic transit and anorectal manometry) were performed before and after treatment. The main outcome measure was changes in CSBM during the treatment phase compared to the baseline phase. Although the focus of the above two studies was different, both Chan's and the present study reported positive results with the dietary kiwifruit intervention.

Kiwifruit appears to be a safe and effective dietary intervention for facilitating laxation. It has been reported that the cell walls within a ripe kiwifruit swell to three to four times the size of the cell walls in an unripe fruit[14] indicating that the dietary fiber in kiwifruit has a high water-holding capacity. This is an important characteristic that facilitates fecal bulking and enhanced laxation.[14] Actinidin, a proteolytic enzyme of thiol-proteases, has also recently been identified in kiwifruit. This enzyme is thought to facilitate laxation via stimulating receptors in the colon, which increases colonic motility.[15] Hence it would appear that kiwifruit exerts a laxative effect due to both the high dietary fiber content and the action of actinidin.

The limitations of this study include the small number of subjects and the short duration. Additional controlled, blinded clinical studies are needed to further evaluate the impact of kiwifruit on IBS/C, as this is an easy and inexpensive means of managing an otherwise complex medical condition. The psychological impact of this common medical condition was only briefly explored in this study. Considering the well established negative impact of IBS on quality of life, future studies should include a more comprehensive analysis of the participants 'quality of life.

In conclusion, our findings suggest that kiwifruit (taken as a routine dietary constituent) appears to be a safe and effective natural laxative for patients diagnosed with IBS/C.

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AUTHOR DISCLOSURES

The authors have no conflicts of interest to declare.

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Original Article

Kiwifruit improves bowel function in patients with irritable bowel syndrome with constipation

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攝取奇異果可以改善便秘型大腸激躁症患者之腸道功能

大腸激躁症(IBS)為一類腸胃功能失調的慢性疾病，常見的症狀包括腹痛、腹瀉、便秘或者腹瀉與便秘交替等。本研究的目的為探討 4 週奇異果的介入是否可以改善便秘型大腸激躁症(IBS-C)的患者腸道之功能。共有 54 位 IBS-C 與 16 位健康受試者參與本實驗，每位受試者均參加 6 週的實驗，包括 1 週的實驗適應期，4 週的介入期及 1 週的後介入期。其中 41 位便秘型大腸激躁症患者及健康者每天攝取 2 顆奇異果(Hayward green (*Actinida deliciosa* var))，持續 4 週。其餘 13 位便秘型大腸激躁症患者則給予 2 顆安慰劑，亦持續 4 週。介入前後檢測受試者之腸道蠕動狀況(腸道通過時間)，並每天自行記錄其排便的狀況。結果顯示，經過 4 週奇異果介入後，可以顯著增加便秘型大腸激躁症患者其排便的頻率($p<0.05$)，腸道通過時間亦顯著降低($p<0.05$)。故本研究的結論為，每日攝取 2 顆奇異果，連續 4 週，可以增加腸道的蠕動，縮短腸道通過時間，增加排便頻率，進而改善便秘型大腸激躁症患者的腸道健康。

關鍵字: 便秘型大腸激躁症、奇異果、腸道通過時間、腸道功能、排便頻率