Original Article

Kiwifruit promotes laxation in the elderly

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Numerous anecdotal reports have suggested that kiwifruit (*Actinidia deliciosa*) has laxative effects. This could be an acceptable dietary supplement, especially for elderly people who often present with constipation. We wished to obtain objective evidence as to whether or not kiwifruit eaten regularly could promote laxation in elderly people. Thirty-eight healthy adults of age > 60 years consumed their normal diet, with or without one kiwifruit per 30 kg bodyweight for three weeks, followed by a 3-week crossover period. Daily records were taken on frequency of defecation and characteristics of the stools. Kiwifruit significantly enhanced all tested measures of laxation in these adults. The regular use of kiwifruit appeared to lead to a bulkier and softer stool, as well as more frequent stool production. Kiwifruit as a natural remedy appears palatable to most of the population and provides improved laxation for elderly individuals who are otherwise healthy. It is likely that a number of factors in the whole fruit are involved, but the nature of the stools suggest fibre is important. This study provides evidence of the potential for improvement in bowel function, health and well-being through changes in diet.

Key words: constipation, controlled trial, elderly, human, kiwifruit, laxation.

Introduction

Functional bowel disorders, including constipation, faecal impaction and faecal incontinence, are associated with common gastrointestinal diseases in the elderly and are a major source of morbidity.[1,2] Constipation is often experienced as a variety of symptoms, including reduced frequency and impacted form of the stools, and/or increased effort required to defecate.[3] Although laxative use is common among elderly people, there appears to be little evidence to guide their selection among the chemically heterogeneous group of materials available.[1] Main actions described for laxatives include holding water inside the bowel lumen (dietary fibre, osmotic laxatives), inhibition of water absorption or stimulation of secretion (stimulant laxatives), or stimulation of colonic motility (stimulant laxatives, 5HT4 agonists).[4] The high cost of laxative use to the population is increasing. Most laxatives have side-effects, albeit mild, but most constipation sufferers would prefer regular intake of some natural foodstuff that prevents the disorder rather than over-the-counter remedies.

Kiwifruit is a commonly eaten fruit in certain countries. Although anecdotal reports and dietary advice have suggested the use of kiwifruit as a laxative, no controlled human trial data are available. The aim of this study was to measure the effects of dietary supplementation with kiwifruit (*Actinidia deliciosa* var. Hayward) on various measures of laxation in elderly humans, including frequency and ease of defecation, and consistency and volume of stools. We considered it essential to do measurements in free living individuals so that the synergy, redundancy and independent effects of the whole food *in vivo* were accounted for. Our overall objective was to test the hypothesis that regular kiwifruit intake provided a functional and acceptable laxation method for the elderly.

Subjects and methods

Forty-four individuals of age greater than 60 years who responded to personal approaches to two retirement villages, staff of the University of Auckland and a church group were enrolled in the screening phase. These free-living people were all physically active and self-reliant. Criteria for exclusion were self-reported major chronic health problems and unwillingness to eat kiwifruit at the specified level for the full study period. Subject compliance and reliability were evaluated during the 1-week screening period over which subjects were asked to maintain a diary recording details of their bowel movements (Table 1). Forty-two subjects were selected for the study.

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Experimental design

A crossover experimental design was used. After the initial 1-week screening period, each subject was randomised, in the order recruited, to either abstain from kiwifruit (group I) or consume kiwifruit (group II), taking these on a daily basis for 3 weeks. Crossover occurred at the end of this phase and, for a further 3 weeks, the group that had not been eating kiwifruit now consumed it while the other group abstained. Each subject therefore acted as their own control. The daily dosage was one kiwifruit (100 g each) for every 30 kg of bodyweight. The kiwifruit were of the green, 'Hayward' variety and were supplied at an optimum ripeness for consumption. Subjects were trained through discussion, example and feedback in the use of a diary to record defecation events. The diary was collected and checked with the participant each week. A new diary and a fresh week's supply of kiwifruit were also given to the subject at this time. Note was made by the researcher if any ill health or effects of the kiwifruit were experienced. Care was taken to always ask open questions. Every time a subject defecated they were required to record the time of the event in the diary. They were also required to assess the consistency, volume and ease of passing the stools using the word descriptors detailed in Table 1. Subsequently, we assigned numerical values to the words recorded in the diary. Daily, weekly and three-weekly averages were obtained of the numerical scores assigned to these variables.

This experimental design was based on a preliminary crossover trial conducted in 48 healthy volunteers (18 men and 30 women) aged 18–50 years (Mean = 33 ± 1 years) with a mean body mass index (BMI) of 24.9 ± 0.5 kg/m^2. For this trial, a 1-week screening phase was followed by two 6-week experimental periods. There was no wash out period between treatments. Each bowel movement was rated for consistency (runny = 1, soft = 2, medium = 3, hard = 4), volume (small = 1, medium = 2, lots = 3) and ease (easy = 1, OK = 2, hard = 3). For each day, frequency of defecation was recorded and, where this was greater than one, a daily score for consistency and ease was estimated along with a total volume score. Average scores for each variable for the first and second 3-week phases within each 6-week period are shown in Table 2 for the two groups of subjects. Within each 6-week period, frequency, volume and consistency were similar ($P > 0.08$) for the two 3-week phases. A statistically significant reduction in ease ($P = 0.010$) was seen over the first 6 weeks in the group consuming kiwifruit first, but this was not evident in the other group when they consumed kiwifruit. For the responses averaged over 6 weeks, comparison of the two groups shows that kiwifruit consumption is associated with significant softening of the stools and increase in bulk and ease of bowel movement, but is not associated with increased frequency of bowel movements (Table 2). The results indicate that a wash out period is not necessary.

The results of the preliminary study suggested that 22 elderly subjects per group (90%) would be required to demonstrate a statistically significant change in consistency on the assumption of a similar response in elderly subjects. For the elderly subjects the word scale used to describe volume and ease was increased to five categories to improve discrimination.[5] Ethical approval was gained from the Auckland University of Technology Human Ethics Committee for both the preliminary study and the elderly study.

Statistical analysis

The methods of Hills and Armitage[6] were used to assess interaction between treatment effects and carry over or

Table 1. Descriptors and subsequent numerical rating scale for stool consistency and volume and ease of bowel motion in elderly subjects

	Numerical rating				
	1	2	3	4	5
Consistency	Runny	Soft	Medium	Hard	
Volume	Very small	Small	Medium	Greater	Lots
Ease	Very easy	Easy	OK	Hard	Difficult

Table 2. Preliminary crossover trial of effects of kiwifruit consumption on laxation in 18–50-year-old subjects

		Period 1		Period 2		
	Group†	1st 3 weeks	2nd 3 weeks	1st 3 weeks	2nd 3 weeks	P‡
Frequency	I	1.26 ± 0.03	1.18 ± 0.04	1.29 ± 0.03	1.29 ± 0.03	0.06
	II	1.33 ± 0.03	1.40 ± 0.04	1.30 ± 0.04	1.26 ± 0.04	
Consistency	I	2.92 ± 0.03	2.90 ± 0.03	2.56 ± 0.03	2.59 ± 0.03	< 0.0001
	II	2.41 ± 0.03	2.34 ± 0.03	2.82 ± 0.03	2.84 ± 0.03	
Volume	I	2.33 ± 0.07	2.27 ± 0.08	2.53 ± 0.07	2.50 ± 0.07	0.004
	II	2.55 ± 0.07	2.70 ± 0.07	2.46 ± 0.06	2.38 ± 0.07	
Ease	I	1.73 ± 0.03	1.77 ± 0.03	1.55 ± 0.02	1.52 ± 0.03	< 0.0001
	II	1.47 ± 0.02	1.35 ± 0.02§	1.64 ± 0.02	1.68 ± 0.03	

Values are presented as Mean ± SEM. †No kiwifruit for 6 weeks followed by kiwifruit consumption (Group I, $n = 22$) and vice-versa (Group II, $n = 26$). ‡Difference between the two groups for changes over the two 6-week periods. §Significantly different from 1st 3 weeks, $P = 0.010$.

period effects. The treatment effect was assessed by comparing the responses in the two groups using the two-sample *t*-test. *P*-values less than 0.05 were reported as significant. Statistical analyses were performed using SAS version 6.12 (SAS Institute, Cary, NC, USA). Data are reported as Mean ± SEM.

Diet and laxative use

Volunteers were encouraged to eat their usual diet with the only variation being the addition or subtraction of kiwifruit. A weekly food variety score[7] was determined at the start, changeover and end of the study to assess intra-individual variation in the diet during the study period. Subjects were asked to record any laxative use during the study period.

Assessment of adverse effects

At the end of the study all subjects were given the opportunity to comment verbally and in written form on both adverse and positive effects.

Results

Of the 42 subjects who were recruited for the study of the elderly, 38 (13 men and 25 women) returned complete sets of data. The characteristics of these subjects are detailed in Table 3. Kiwifruit consumption was associated with a significant increase in frequency of defecation ($P = 0.012$), volume or bulk of stool produced ($P = 0.002$) and softness or looseness of bowel motions ($P < 0.0001$; Table 4). A significant treatment period interaction ($P = 0.009$) was observed for ease of bowel movement where, during the first period, subjects consuming kiwifruit rated their bowel movements similarly to those not taking kiwifruit, while during period two, those consuming kiwifruit found defecation significantly easier ($P < 0.0001$). Nine of the 16 volunteers in Group II completed a full week of diary entries during the screening period. Ease of defecation for these subjects decreased from 2.66 ± 0.18 during this baseline period to 2.47 ± 0.17 during the period of kiwifruit consumption ($P = 0.046$ by paired *t*-test). The treatment responses during the first, second and third weeks of each period analysed separately show a similar pattern to the averaged response, except that a significant increase in frequency of defecation with kiwifruit consumption does not occur until the third week (data not shown).

Seven of the 38 participants reported regularly using laxatives. The laxatives taken daily were nulax, caloxyl and mucolax, lactulose and isogel, and codalax, and two people took senokot daily and one reported having normacol once a week. They were asked to continue their normal use of the laxatives both with and without kiwifruit so that the only change in their consumption was the dose of kiwifruit. Similarly, those who had kiwifruit as a regular part of their diet were asked to not have them during the no kiwifruit period. This was reinforced at the weekly visit. Participants or the interviewer at the weekly visit recorded in the diary any change in diet or laxative use. This was noted for five of the participants. Two replaced kiwifruit with other fruit, one stopped eating Nutrigrain™ and two stopped taking laxatives when eating kiwifruit.

The food variety score (Table 5) was not significantly different between the two groups at the start of the study ($P = 0.8$) and, within each group, did not change significantly during the study ($P > 0.29$ by repeated measures ANOVA). The overall mean score was 29 ± 1 (range 17–47), which rates as good to very good, according to the criteria of Savige *et al.*[7] Women consistently reported a slightly higher score, but this did not reach significance.

Participants were asked about their normal activity level when they joined the study. A Likert scale of one to eight, from inactive to very active, was used. The median value was six with the 25% and 75% quartiles being five and seven, respectively, reflecting the active, free-living lifestyle of the participants.

Reported beneficial and adverse effects

Thirty-one participants provided written comments on the changes in bowel movement, laxative or food changes or

Table 3. Characteristics of elderly subjects

	Men ($n = 13$)	Women ($n = 25$)
Age (years)	71 ± 3	74 ± 2
Height (m)	1.72 ± 0.03	1.61 ± 0.02
Weight (kg)	79.7 ± 3.5	63.4 ± 2.1
BMI (kg/m^2)	27.5 ± 1.2	25.6 ± 1.0

Values are the Mean ± SEM. BMI, body mass index.

Table 4. Scores for frequency and ease of bowel motion and consistency and volume of stools for two three-week periods of a crossover trial of kiwifruit consumption in elderly subjects

	Group†	Period 1	Period 2	*P*‡	*P* (interaction)
Frequency	I	1.17 ± 0.07	1.43 ± 0.11	0.012	0.63
	II	1.24 ± 0.11	1.24 ± 0.09		
Consistency	I	2.69 ± 0.09	2.28 ± 0.11	< 0.0001	0.07
	II	2.59 ± 0.10	2.83 ± 0.08		
Volume	I	3.24 ± 0.21	3.97 ± 0.28	0.002	0.66
	II	3.57 ± 0.29	3.35 ± 0.24		
Ease	I	2.33 ± 0.13	1.90 ± 0.11	< 0.0001	0.009
	II	2.38 ± 0.12	2.70 ± 0.11		

Values are presented as Mean ± SEM. †No kiwifruit for 6 weeks followed by kiwifruit consumption (Group I, $n = 22$) and vice-versa (Group II, $n = 26$). ‡*t*-test for differences between groups I and II for changes between periods 1 and 2.

Table 5. Food variety scores of elderly subjects

	Group I (n = 22)	Group II (n = 16)
At start of study	28.2 ± 1.8	29.5 ± 1.6
At change over	29.4 ± 1.6	28.5 ± 2.0
At end of study	31.3 ± 1.4	27.2 ± 1.7

Values are the Mean ± SEM.

differences that they had observed during the trial period between having or not having kiwifruit. Twenty-seven reported at least one of the following: will continue to eat kiwifruit, motions either softer, easier or more frequent with kiwifruit or other beneficial differences. Three participants reported an adverse effect, namely: 'gone off eating kiwifruit in quantity', 'increase in flatulence', and 'pain in knee and ankle joints'. Four reported that they had not noticed any change or difference.

Discussion

These data confirm the anecdotal assumption that kiwifruit enhances various parameters of laxation, including frequency and ease of defecation, stool bulk and softness in elderly subjects. The most definitive indicators of the laxative effects of kiwifruit (of those that we assessed) were consistency and volume, with kiwifruit producing a looser or softer stool and greater bulk. The preliminary study we carried out in subjects under 50 years of age also demonstrated that kiwifruit increased volume and softness of the stools with greater ease of defecation. Although double blinding of the trials was impossible because of the nature of kiwifruit, the crossover design meant that each subject acted as their own control. The possibility that the total fibre intake of the individuals could change during the study was examined by analysing the food variety index data. There was no significant change in this index, which was recorded at three points during the study. In the weekly discussion with each participant no changes in meal pattern or composition were noted. Additionally, the non-invasive nature of our trial design meant that we were able to recruit subjects up to the age of 93 who would have been unlikely volunteers otherwise.

Four of the subjects who self-reported claimed that kiwifruit made no difference to their normal pattern, while 16 claimed that it enhanced regularity, ease and consistency of their motions. These claims appeared to be supported by the numeric data. We note that the subjects received the same attention whether or not they were in the kiwifruit arm, and that they received no payment for the study. There were no obvious characteristics that enabled us to distinguish individuals who would from those who would not respond to kiwifruit. It is important to recognise that there is a proportion of the population who show an allergic response to kiwifruit.[8] Two of the subjects who completed the study reported that they would not be eating kiwifruit again, in contrast to a number who commented that they would continue with a kiwifruit regime. We believe that we can conclude that kiwifruit provides a useful dietary adjunct that could well serve a role to maintain regularity in elderly people who otherwise have no major bowel problems. Nevertheless, it may not be appropriate in a small proportion of the population, for various reasons.

Major nutrients present in a 100 g Hayward kiwifruit include 232 kJ energy derived from 11.8 g carbohydrate (99% sugar) and 1.37 g protein in association with 1.59 g dietary fibre, 118 mg vitamin C and 2.5 mg vitamin E (NZ Institute for Crop and Food Research). Hayward kiwifruit has been reported as the most nutrient dense of all fruits.[9] The whole fruit (minus skin) was consumed, making it difficult to isolate mechanisms, and there are a number of different agents that may enhance laxation (either separately or together) in kiwifruit. It is of interest that one study participant who was resistant to prune juice appeared to be susceptible to kiwifruit action. In general, it is considered that there are four classes of laxatives: bulkers, osmotic regulators, stimulant laxatives and faecal softeners.[10] Kiwifruit would seem to be acting through increasing faecal bulk and softening.

One of the novel compounds in kiwifruit that has been suggested to interact in laxation is actinidin, a proteolytic enzyme belonging to the class of thiol-proteases. Indeed, a kiwifruit-derived dietary supplement, supposed to contain high levels of actinidin, is currently being web-marketed as a laxative. However, we can find no evidence to substantiate such a claim, nor is there good precedent for a protease acting as a laxative. Given that actinidin may be one of the most effective allergens in kiwifruit,[8] it would be unfortunate if this was also the laxative property.

It has been suggested that difficulty and infrequency of passing stools is most often due to insufficient dietary fibre, and simply increasing fruits, vegetables and whole grains in the diet may remedy the problem without physician consultation.[11] Kiwifruit contains a number of components that might potentially promote laxation. Dietary fibre represents about 1.6% of kiwifruit by weight[12] and the dietary changes in total amount of dietary fibre intake for the elderly people in this study would be insignificant. However, kiwifruit plant cell walls (dietary fibre) have some unusual properties.[13,14] In particular, the cell walls swell considerably *in vivo* during fruit ripening, being around three to four times greater in ripe than in unripe fruit.[15] This may suggest that kiwifruit dietary fibre has an exceptionally high water-holding capacity, an important parameter in faecal bulking and enhancement of laxation.[16] Furthermore, cell wall material from ripe kiwifruit forms viscous suspensions in water.[13] It is of interest that Marlett *et al.*[17] have reported that the well-established laxation properties of psyllium seed husk most likely relate to a very viscous cell wall polysaccharide.

It seems that some non-digestible oligosaccharides such as inulin may also have some laxative properties.[18,19] Recently, a number of oligosaccharides (G3-20) of both pectic and hemicellulosic origin, have been isolated and characterised from ripe kiwifruit (unpublished data, Schroeder and Redgwell, 2000). The role of such oligosaccharides has

never been examined, nor has the digestibility of such compounds been reported. They would also be possible candidates for providing the laxation properties of kiwifruit. Further studies to examine the roles and interaction of oligosaccharides, fibre, actinidin and cell wall materials in kiwifruit would aid the understanding of the laxative properties of kiwifruit. A recommendation that kiwifruit be consumed to aid laxation is justified.

Kiwifruit appears palatable to most of the population as a natural remedy and provides improved laxation for elderly individuals who are otherwise healthy. It is likely that a number of factors in the whole fruit are involved, but the nature of the stools suggest fibre is important. This study provides evidence of the potential for improvements in bowel function, health and well-being through changes in diet.

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