

Original Article

Efficacy of actinidin-containing kiwifruit extract Zyactinase on constipation: a randomised double-blinded placebo-controlled clinical trial

Iona Weir PhD¹, Quan Shu PhD², Nengding Wei MD³, Chengkai Wei MD³, Yi Zhu MD³

¹Vital Foods Processors Ltd, Airport Oaks, Auckland, New Zealand

²Bioactives Research New Zealand, Mt Albert, Auckland, New Zealand

³Kaixian Traditional Chinese Medicine Hospital, Chongqing Province, PR China

Background and Objectives: Zyactinase® is an extract of green kiwifruit, formulated into the consumer healthcare products marketed as Phloe® and Kivia, used to assist in the relief of the symptoms associated with a range of digestive system dysfunction, including constipation and Irritable Bowel Syndrome (IBS). **Methods and Study Design:** A randomised, double-blind, placebo-controlled clinical trial was undertaken to determine the effects of the kiwifruit extract on bowel movement, stool formation and IBS associated symptoms amongst a subject group of generally healthy individuals experiencing a period of moderate constipation. Fifty-eight participants were randomized to the kiwifruit extract (28) or placebo (30). Selection criterion was decreased number of bowel movements (<3/week), with increased faecal hardness and IBS associated symptoms. The study ran for three weeks, with participants first undergoing a seven-day wash out period, followed by a seven-day dosing period, and then a seven-day follow up period. **Results:** There was a significant increase in the defecation frequency ($p < 0.001$), with a significant improvement in faecal score ($p < 0.01$). There was a significant difference in painful defecation and abdominal pain between the two groups ($p < 0.01$). No side effects, including diarrhoea, urgency or abdominal pain, were observed during the trial. **Conclusions:** The green kiwifruit extract significantly induced normal bowel movements with no adverse effects. The kiwifruit extract relieved constipation and the symptoms of IBS such as bloating, flatulence and abdominal pain.

Key Words: kiwifruit, constipation, IBS, actinidin, Zyactinase

INTRODUCTION

Green kiwifruit (*Actinidia deliciosa* var. Hayward) has long been known in traditional Chinese medicine as having a number of medicinal benefits, including constipation prevention and relief,¹ and has been shown to possess very high levels of vitamin C, insoluble fibre, oligosaccharides and the cysteine protease actinidin.^{2,3} Fresh green kiwifruit has previously been shown to increase laxation in the elderly,⁴ believed to be a result of the high levels of fibre in kiwifruit. Fibre has long been known to have a positive effect on bulking the stool and increasing transit times.⁵⁻⁷ Constipation is a common problem in the elderly and pregnant women, resulting from reduced gut motility.⁸⁻¹¹

Kiwifruit contains non-digestible oligosaccharides and insoluble fibre, which act as a prebiotic by being fermented to small chain fatty acids of butyrate, acetate and propionate.^{12,13} Butyrate has been identified to increase gut motility by stimulating the gut's nervous system.¹⁴ In an in vitro study of the water retention and swelling characteristics of different fruit fibre, kiwifruit fibre was demonstrated to be superior to other fruit.¹⁵ This resistance to digestion enables the oligosaccharides along with the insoluble fibre to pass unaltered through the small intestine to the colon, where they have a dual function as a prebi-

otic to stimulate growth of the gut microflora and as fibre to bulk the stool.^{13,16,17} It has previously been shown that this green kiwifruit extract stimulates the growth of the probiotic bacteria *Lactobacillus reuteri*, *Lactobacillus acidophilus*, *Pediococcus acidilactici*, and *Lactobacillus planetarium*, whilst inhibiting the growth of pathogenic bacteria including *E.coli* O157:H7 and *Salmonella typhimurium*.¹² These probiotic bacteria are believed to inhibit pathogenic bacteria, modulate the immune system, promote gut motility and protect the gut mucosa.

In previously unpublished animal studies, it was shown that the protease complex of the green kiwifruit extract Zyactinase, which contains the cysteine protease actinidin, gently stimulates gut motility whilst also aiding in protein hydrolysis of food in the gastrointestinal tract. Actinidin has been shown to aid in the digestion of proteins in the upper digestive tract¹⁸⁻²⁰ and in turn to promote gentle gastrointestinal motility.²¹ No negative side effects of

Corresponding Author: Dr Iona Weir, Vital Foods Processors Ltd, 78 Ascot Rd, Airport Oaks, Auckland, New Zealand.

Tel: +0064 9275 5073; Fax: +0064 9275 5576

Email: iona.weir@vitalfoods.co.nz

Manuscript received 13 December 2016. Initial review completed 14 January 2017. Revision accepted 21 March 2017.

doi: 10.6133/apjcn.122017.03

diarrhoea, urgency or damage to the gut mucosa were observed. Kiwifruit also contains cysteine protease inhibitors known as phytocystatins,²² and deactivation of the Zyaactinase enzyme complex by phytocystatins results in a reduced number of bowel movements, suggesting further support for a role of actinidin in promoting gut motility.

Previous clinical results investigating the use of Zyaactinase formulations^{15,23,24} in occasional functional constipation found the green kiwifruit extract significantly increased spontaneous bowel movements in the first week ($p < 0.05$) and improved associated Irritable Bowel Syndrome (IBS) symptoms of flatulence, bloating and abdominal pain. Therefore, the primary aim of this clinical trial was to quantify any changes in frequency of bowel movements in response to the kiwifruit extract and secondly to assess the effects of the kiwifruit extract on symptoms of participants with moderate constipation and correlate the clinical outcome with changes in faecal score and associated symptoms.

METHODS

Sample

The formulated kiwifruit product used in this study contains Zyaactinase, a patented (WO2012158048A1) freeze-dried green kiwifruit extract. Each capsule of Zyaactinase contains a minimum of 23% fibre (insoluble and soluble) and 3000 Enzyme Units per gram. This is determined by azocasein spectrophotometric routine testing of each batch of Zyaactinase powder to ensure it meets these minimum requirements. The capsules contain Zyaactinase (81.8%), plus excipients isomalt (15.5%), silica dioxide (2%) and magnesium stearate (0.7%).

The experimental product dosing regime was six 360 mg capsules per day taken as two capsules three times a day before meals for a total daily dose of 2160 mg/day. The placebo capsules contained isomalt coloured with green food colouring to match the colouring of the experimental product capsules.

Participants

A 60 subject double-blinded placebo based clinical trial was carried out using both self-control and group-control models. This study was conducted in China at the Kaixian Traditional Chinese Medicine Hospital. Seventy participants with constipation were recruited into the clinical trial from a three hundred-subject pool. During the run-in period there were twelve dropouts due to non-compliance, consent withdrawal and spontaneous resolution of constipation. This resulted in 30 participants in the placebo group and 28 in the experimental group, with an age range of 23–65 years old. The clinical trial was designed, conducted and reported in accordance with the principles of Good Clinical Practice guidelines with Institutional Review Board (IRB) ethics approval (HCT-WND2058). Before participating in the trial, patients were reviewed and signed an informed-consent document that had been approved by the IRB of the Kaixian Traditional Chinese Medicine Hospital. The trial was conducted in accordance with the protocol. This study was completed as part of a larger research program on Zyaactinase in China which included animal toxicology, animal efficacy testing and clinical trial safety and efficacy testing. In order to fulfill

regulatory requirements for product registration, for all of these studies isomalt was used as the placebo.

Selection criteria

Participants were recruited from normal healthy participants who had recently undergone a change in bowel movement and had developed constipation defined as no more than three bowel movements a week. Following informed consent, participants were selected based on the criteria that they had bowel movements of no more than 3 per week over the previous week, with these movements being of greater faecal hardness than normal, and no organic pathological changes with continuous constipation (not intermittent or alternating with diarrhoea). These participants also reported IBS associated symptoms such as tenesmus, bloating and abdominal pain.

Exclusion criteria

Excluded participants were long-term constipation participants who had regularly taken laxatives for constipation; participants with constipation resulting from surgery in the past 30 days; participants who experienced serious organic pathological changes resulting in the induction of defecation difficulty or acute gastrointestinal infections within the past 30 days; female participants who were pregnant or experiencing menstruation; or participants with serious systemic diseases or other concomitant treated diseases.

Clinical assessment

The clinical assessment was carried out in accordance with the clinical trial protocol assessment form, with participants selected based on their medical history documentation and through an interview with a doctor. The age of the participants ranged from 23–65 years old. At the first interview, a consent form was signed, and a Quality of Life (QOL) questionnaire completed. The selected participants for the trial were put through a training course on how to classify faecal characteristics, abdominal discomfort and bowel movement frequency. All participants were trained to immediately identify any possible side effects and to contact a trial doctor in the event a side effect was experienced. Doctors also checked side effects on a daily basis. Side effects that were of particular interest included diarrhoea, abdominal pain, abdominal discomfort, bloating, flatulence, urgency, hydrogen sulphide or ammonia smelling faeces or other abnormal smells, and any rectal bleeding.

Faecal characteristic score criteria

The Bristol Stool Chart System was used to measure faecal characteristics based on the Rome III Criteria as detailed below (Table 1). It should be noted that the numbering used when referring to constipation varies from that of the traditional Bristol Stool Chart for overall faecal characteristics.

Abdominal discomfort score (as based on the Rome III Criteria)

The Rome III Criteria System 25 was used as the basis to measure the abdominal discomfort as detailed below (Table 2). Variables measured included tenesmus, discomfort

Table 1. Revised Rome III criteria for faecal characteristics[†]

Class	Stool description
Class 0 (score 0)	Snake or sausage like, smooth and soft; sausage-like, but there are cracks in the surface; soft conglomeration with clear edge (easy to be excreted)
Class I (score 1)	Sausage-like, with conglomeration; loose, massive with rough edge, slurry-like stool
Class II (score 2)	Separated hard group, like stone (difficult to be excreted)

[†]The Rome III criteria numbering system was adapted from the traditional numbering system of type (class) 1 to type 7, in order to allow easier statistical analysis by changing the score for each class. The definition of each stool class is shown next to the score for direct comparison. Thus Class 0 is equivalent to normal stool characteristics and class 2 equivalent to hard stools indicative of constipation.

during bowel movement, abdominal discomfort and/pain, bloating and flatulence. It should be noted that the numbering has been adapted from that of the traditional Rome III IBS Criteria.

Trial design

The participants were started on the following regime: Prior to the start of the dosing period, there was a seven day run-in period (week 1), in which the participants were prevented from using any dietary supplement or medicine for the relief of constipation. Following the run-in period, there was a seven-day (week 2) dosing period. For the dosing phase (7 days) of the trial each of the 58 participants were given six capsules a day, either of the placebo or of the formulated kiwifruit extract. Over this dosing period the number of bowel movements, abdominal discomfort and faecal characteristics were assessed and statistically analysed. For the seven-day follow-up period (week 3) all of the 58 participants were not allowed to consume any product for constipation, with symptoms as described above continually monitored.

All participants were initially assessed by a doctor to determine their degree of constipation and during the run-in week visited the doctor on a daily basis. Once the dosing phase of the trial started all participants were contacted twice daily via a combination of phone calls and visits by/to the medical practitioners involved in the trial. The condition of each subject, their frequency of bowel movement, abdominal discomfort and faecal characteristics were recorded daily. During this two-week trial period, the participants maintained their previous diet, which had been assessed as a normal diet.

Data analysis

SPSS11.5 was used to analyse the mean and Standard Deviation of the above parameters obtained before and after the trial. Self-comparison data and group-comparison data was analysed using paired-t test and

group-t test, respectively. Sex proportionality was analysed by χ^2 and exact probabilities.

Results determination

A positive result was indicated if it met the following criteria:

Self-comparison

Defecation frequency was statistically significantly increased and the score of either defecation condition or faecal characteristic was obviously reduced after trial in comparison with those before trial.

Group-comparison

Any of the defecation frequency, defecation condition, and faecal characteristics parameters was significantly improved.

RESULTS

Safety

Throughout the trial, doctors assessed potential side effects, especially diarrhoea, abdominal pain, bloating, flatulence, urgency, abnormal smelling faeces, and any rectal bleeding daily. No negative side effects were observed by any subject or by the medical practitioners who examined them. In particular, there was no indication of diarrhoea or abdominal cramping.

Change in faecal frequency

The change in faecal frequency as measured by the number of bowel movements per week is shown in Figure 1. The clinical trial had three phases to it, a run-in, a dosing phase and a follow-up phase. During the run-in period there was a slight, but not significant difference between the placebo and active groups. During this run-in period, two participants were withdrawn from the active group due to spontaneous recovery. During dosing for the active group there was a significant difference in the num-

Table 2. Revised Rome III criteria for abdominal discomfort[†]

Class	Discomfort (feeling) description
Class 0 (score 0)	Normal Defecation
Class I (score 1)	Only a sense of tenesmus and abdominal discomfort, mild bloating
Class II (score 2)	Obvious sense of tenesmus and discomfort, and/or urine was frequent while quantity little, and signs of bloating and flatulence
Class III (score 3)	Frequent abdominal pain, or anal burning sensation, impacted to defecation, obvious bloating and flatulence

[†]The Rome III criteria numbering system was adapted from the traditional numbering system for describing abdominal discomfort. The definition of each stool class is shown next to the score for direct comparison. Thus Class 0 is equivalent to normal bowel function and class 3 equivalent to chronic constipation.

ber of bowel movements per week ($p < 0.001$). There was also a slight but not significant increase in the frequency of bowel movements per week in the placebo group ($p > 0.05$). During the follow-up phase, in which neither group was dosed, there is still a significant difference ($p < 0.01$) between the active and placebo group. The placebo effect was gone, however, by the follow-up period with the number of bowel movements per week reduced to the level observed during the run-in period.

Change in faecal score based on the Bristol stool chart

The results shown in Figure 2 represent the mean faecal scores (based on the Bristol stool chart) achieved within each of the three periods (wash-out, dosing, follow up). A faecal score of 0 is the ideal, and as can be seen, consumption of 2160 mg/day of the kiwifruit extract returns the participants to near normal faeces within the seven-

day dosing period, and is retained during the follow up period.

The baseline faecal score (day 7 of washout) was 1.9 with a standard error of the mean at 0.04. Throughout the dosing stage there is a potent placebo effect resulting in a softening of the stool. There is however a greater softening of the stool in the active group as shown by a statistical significance ($p > 0.01$) for faecal score.

During the follow-up period, faecal scores remained low for the active group, indicating a continued apparent benefit from having taken the kiwifruit extract capsules the week before. There remains a statistically significant difference ($p < 0.01$) between the active and the placebo group during the follow-up period. For the placebo group the score increased and thus the faecal stools were becoming harder again.

This potent placebo effect can be seen more dramatical-

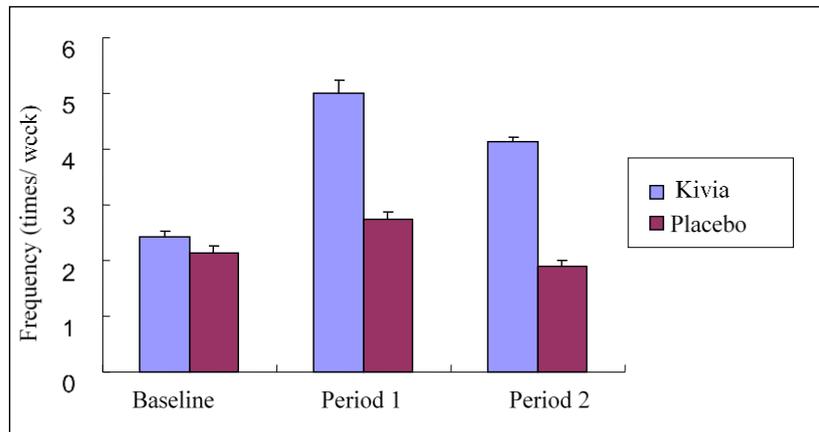


Figure 1. Change in weekly faecal frequency. The graph represents the change in the number of bowel movements per week. The baseline represents the first week washout. Period 1 (7 days) represents the dosing period with either Kivia at 2160 mg per day, or with the same quantity of the placebo. Period 2 (7 days) represents the week following dosing in which no capsules were consumed by either group. There is a statistically significant difference ($p < 0.01$) between the Kivia group and the placebo group in both periods. In the first period this significant difference was calculated as $p < 0.001$. The error bars shown represent the Standard Error of the Mean. During the dosing period there is a small placebo effect, but this is gone by the follow up period.

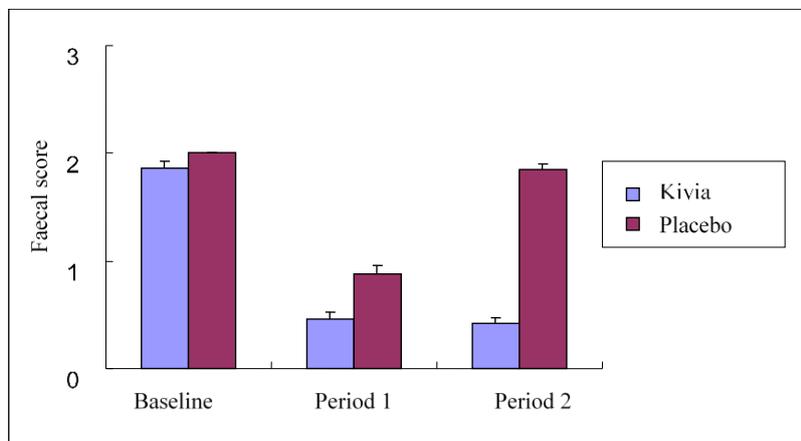


Figure 2. Change in Faecal Characteristics. The graph represents the change in the mean of the faecal score. The error bars shown represent the Standard Error of the Mean. The baseline faecal score was 1.9 with a standard error of the mean at 0.04. Week 1 represents the dosing period with either Kivia at 2160 mg per day, or with 2160 mg per day of the placebo. Period 2 represents the follow-up stage (second week) in which no capsules were consumed. As can be seen in the first week taking the capsule there is a potent placebo effect, however by the second week when no capsules are being consumed there is an apparent benefit from having taken the Kivia capsules the week before. For both groups the faecal score went from 1.9 near 0, a dramatic improvement in faecal score. By the second week, when no capsules were being consumed the faecal score remained very low for the Kivia group, but for the placebo group was increasing again and thus the stools were becoming harder again. There remains a statistically significant difference ($p < 0.01$) between the Kivia group and the placebo group during the follow-up period.

ly in Figure 3, in which the daily changes in faecal score are plotted. There is a reversal of the placebo effect at the end of the dosing period versus the continued benefit in the active group for 2 days before the score begins to return to the pre-dosing level. Note the consistency of the results with those for abdominal discomfort below.

Changes in abdominal discomfort score

The abdominal discomfort score is defined as changes in feeling of tenesmus, bloating, abdominal pain and flatulence. As can be seen in figure 4, the active significantly improved the abdominal discomfort score both during the dosing phase and the follow-up period ($p < 0.01$). The consumption of 2160 mg/day of the kiwifruit extract returned participants to near normal within the seven-day dosing

period, and this effect is retained during the follow up period. Both figures 4 and 5 show the results for the abdominal discomfort score, a common IBS symptom. Figure 4 represents the weekly mean scores for abdominal discomfort, while figure 5 shows the daily changes in abdominal discomfort scores. This day-to-day plotted data (Figure 5) demonstrates the potent placebo effect that comes with investigating a medical condition that has a psychosomatic element to it.

Figure 5, the interaction plot for the daily changes in abdominal discomfort, shows the placebo group, who in the first week had a significant drop in abdominal discomfort, an effect that disappears by the second week. For the dosing group, on the other hand, the benefit remains for two days before commencing a return to pre-

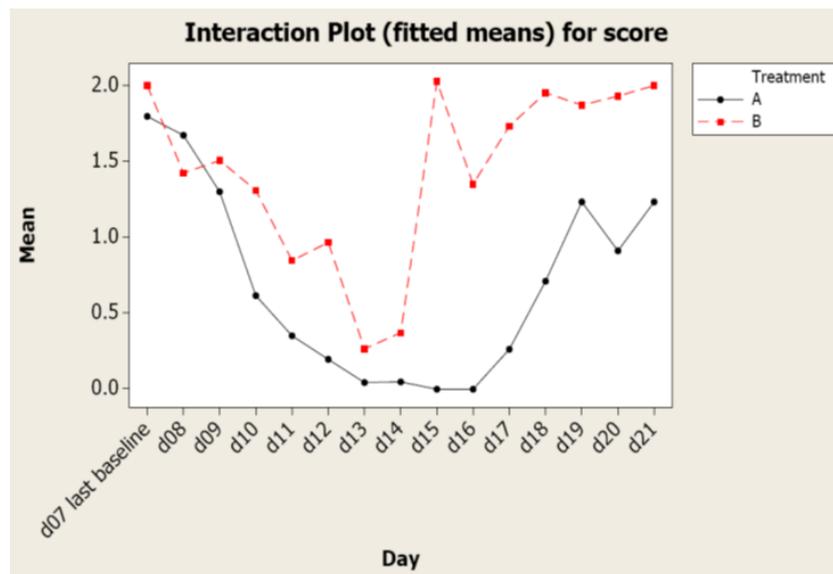


Figure 3. Daily Changes in the Faecal Score. Figure 3 represents the daily changes in the mean of the faecal score as determined by the Bristol stool chart criteria (Table 1). Dosing A = Kivia and Dosing B = Placebo. Days 8 to 14 represents the dosing period with either Kivia at 2160mg per day, or with 2160 mg per day of the placebo. Days 15 to 21 represent the follow-up stage (second week) in which no capsules were consumed. There is a reversal of the placebo effect at the end of the dosing period (day 14) back to the original faecal score prior to consumption of the placebo capsules. Whilst for the active group it takes several days to increase to a value of 1, but never to the original value of 1.9.

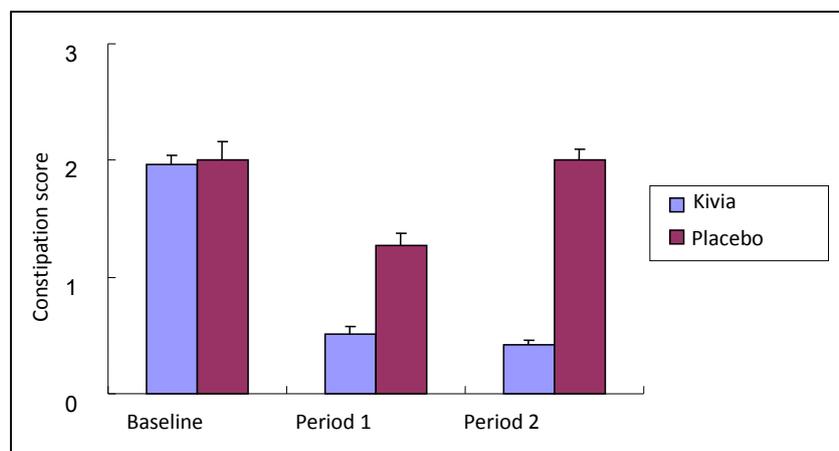


Figure 4. Changes in the mean of the abdominal discomfort. The graph shows the mean weekly abdominal discomfort score as determined by the Rome III criteria as described in the Method section. The error bars shown represent the Standard Error of the Mean. The baseline represents the washout period, period 1 represents the seven day dosing period and period 2 the seven day follow up period. An abdominal discomfort score of 0 is normal, and as can be seen in the graph, consumption of 2160 mg per day of Kivia returns the participants to near normal sensation within the seven-day dosing period, and is retained during the follow up period. There is a statistically significant difference ($p < 0.01$) between the Kivia group and the placebo group for both period 1 and period 2.

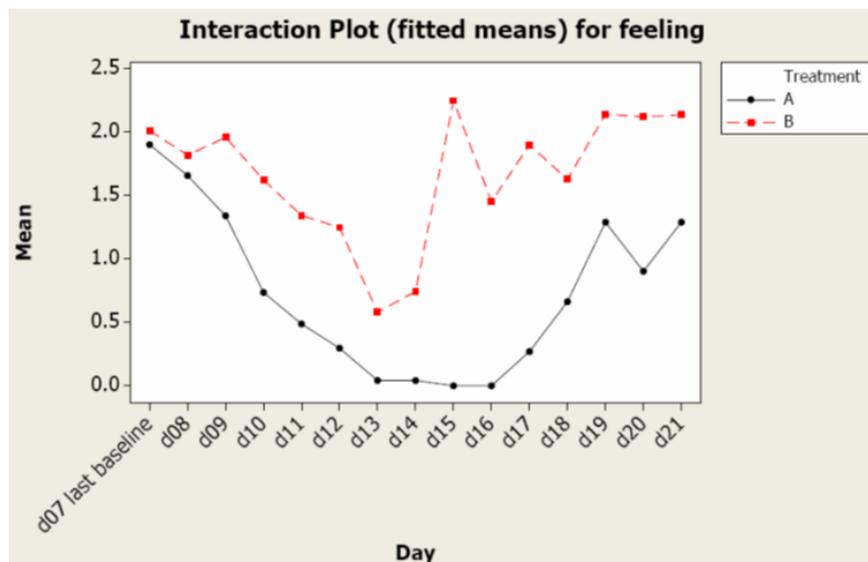


Figure 5. The interaction plot represents the daily changes in the mean of the abdominal discomfort (feeling) score as determined by the Rome III Criteria described in the Method section. Dosing A = Kivia and Dosing B = Placebo. Days 8 to 14 represents the dosing period with either Kivia at 2160 mg per day, or with 2160mg per day of the placebo. Days 15 to 21 represent the follow-up stage (second week) in which no capsules were consumed. Both groups had a significant decrease in abdominal discomfort score during the dosing phase. Within 24 hours of ceasing dosing (day 14) the placebo group return to the original score prior to consumption of the placebo capsules. Whilst for the active group there is a gradual increase in abdominal discomfort score, but does not reach the original score.

dosing levels. The data indicates that when dosing with a placebo is stopped, the placebo effect declines and the prolonged benefit of the kiwifruit extract on abdominal discomfort can be observed. This is further supported by the consistency with the results for faecal characteristic as described above.

DISCUSSION

The formulated green kiwifruit extract has been shown to significantly increase the number of bowel movements, soften the stool and improve the associated IBS symptoms of bloating, tenesmus, flatulence and abdominal pain. For this subject population, this significant improvement occurred within the first 24 hours of consumption of the kiwifruit extract, thereby indicating that the relief of constipation was likely not only due to the prebiotics and the fibre but also due to the protease complex gently stimulating gut motility. Even though a placebo effect was observed in this clinical trial, the kiwifruit extract significantly ($p < 0.05$) increased bowel movement frequency (Figure 1), improved abdominal discomfort (Figure 4) and softened the stool (Figure 2). Furthermore, the improvement across these parameters continued seven days past the dosing phase and remained significantly improved in comparison to the run-in phase. These results show the efficacy of the kiwifruit extract not only for treating constipation in the short-term but also indicates that the benefits are retained after cessation of dosing.

In this clinical trial, no negative side effects were observed. During the recruitment phase, participants were pre-screened for allergic response to kiwifruit and were eliminated from the selection process. The only side effect noted in the general public following market sales of formulated Zyactinase products (Phloe, Kivia) has been an approximate 0.03% incidence of hives, which has been attributed to a low level allergenic response to kiwifruit. It should be noted that Zyactinase is a complex of at least

five enzymes (3000 E/U per g) from kiwifruit including actinidin, considered to be the principal allergen in kiwifruit.²⁶

As part of this study, we explored the efficacy of the green kiwifruit extract in relieving the symptoms of constipation as well as those generally associated with IBS. It is important to note that in order to be diagnosed with moderate constipation using the Rome III criteria, participants specifically must not fulfil the criteria for IBS. The main differentiating factor between these two diagnoses is the presence, in IBS, of abdominal pain or discomfort that is relieved with defecation. This criterion needs to be considered in regard to this clinical trial. Clinical trials into IBS are very difficult to undertake and achieve statistical significance due to the problems with recruiting IBS sufferers, differentiating true IBS from moderate constipation and in circumventing the powerful placebo effect involved in conditions that have a partial psychosomatic component to their origin.²⁷⁻³⁰ For this clinical trial, in order to crossover between the stringent Rome III criteria for moderate constipation and to explore whether the product had potential for alleviating constipation predominant IBS, symptoms of both conditions were analysed.

In designing a clinical trial for testing the efficacy of a natural product for dosing of constipation and IBS associated symptoms, both with a psychosomatic component to their severity; we were prepared to have to contend with a considerable placebo effect. However, this placebo effect was found to be significant not only for the frequency and abdominal discomfort but also for stool characteristics. Within 24 hours of starting the placebo, participants were experiencing an increase in bowel movement, improvement in abdominal discomfort and a softening of the stool, suggesting that the natural resolution of constipation may have been experienced by at least some of those on placebo. However, this statistically significant improvement ($p < 0.05$) in the placebo group was lost over several days

upon cessation of the placebo capsules. Although it was anticipated that there would be a strong placebo effect on abdominal discomfort and to a lesser extent bowel movement, it was not expected that there would be a significant change in stool form. These results unmistakably show a significant change in bowel movement, abdominal discomfort and stool form, suggesting that all three factors may be psychologically influenced. This study clearly shows the need to use placebo controls when investigating the efficacy of a compound for improving bowel function. The psychological link between these bowel habit parameters is plainly demonstrated by the daily trend in response as can be seen by examination of the two interaction graphs for abdominal discomfort and faecal characteristics (Figures: 3 and 5) indicating a direct correlation between these two parameters. Our rationale for proposing that there was a strong placebo effect was that within 24 hours of taking the placebo capsules there was an increase in bowel movement and abdominal discomfort, with both decreasing upon cessation of taking the capsules. This seems too rapid a change to be due to isomalt and secondly even at ten-fold the isomalt dose used in this study no change was observed of any parameter during in vivo efficacy testing (unpub). This finding is confirmed by the analysis of the data for abdominal discomfort showing the residual plots (Figure 5), which suggest the improvement in abdominal discomfort is a result of the dosing of this kiwifruit extract.

The use of isomalt as an excipient in the capsules has been of contention due to its potential laxative and flatulence inducing side effects.³¹ Isomalt was used as the positive control in all of the in vitro testing into prebiotic benefits of Zyactinase¹² and was not found to be significantly higher than that of the negative control (water). Furthermore, isomalt was also used as the positive control at a comparable dose in both our animal efficacy dosing studies and Phase I/IIa clinical trials with no observable difference to the negative control (unpub). We therefore surmised that isomalt was not at a dose high enough as an excipient to promote laxation or cause flatulence.

Kiwifruit has been extensively investigated for gastrointestinal benefits. A cross-over study of 48 elderly participants in New Zealand demonstrated that one kiwifruit per 30 kg of bodyweight for 3 weeks significantly increased the number of bowel movements, stool volume and comfort of defecation ($p < 0.01$).⁴ Similar findings were found in a repeated measures clinical study of constipated participants¹ and with IBS-C participants.³² A double-blinded placebo-controlled clinical trial conducted in Los Angeles, of 89 participants with occasional constipation used a water-soluble powder format of the green kiwifruit extract Zyactinase for four weeks. The findings of the Los Angeles clinical trial mirror those of this Chinese based clinical trial and those of other Kiwifruit clinical studies,^{1,4,31,32} demonstrating clinical significance ($p < 0.05$) for gently enhancing bowel movement frequency, and for reducing abdominal pain and flatulence in participants with occasional constipation.²³

To date, four open-label clinical trials and five randomised, placebo controlled, double blinded clinical trials with a total of more than 600 participants investigating the role of Zyactinase in digestive health have been con-

ducted.^{23,24} Each of these clinical trials observed a statistically significant ($p < 0.05$) improvement over the placebo in the resolution of constipation for participants whose baseline bowel movement frequency was at or below three spontaneous bowel movements per week. The consistency across these clinical trials on Zyactinase mirrors that of the clinical trials undertaken on fresh kiwifruit in the increase in bowel movements and improvement in associated symptoms.

Conclusion

In conclusion, the green kiwifruit extract was found to significantly induce normal bowel movements with no adverse effects. The kiwifruit extract relieved constipation and the symptoms of IBS such as bloating, abdominal pain and tenesmus as well as flatulence. These improvements in gut function continued into the follow-up period, suggesting that the kiwifruit extract has long-term gut health benefits in normalizing gut function.

AUTHOR DISCLOSURES

Dr Iona Weir was the Chief Scientific Officer of Vital Food Processors Ltd at the time this project was executed. This clinical study was sponsored by Vital Foods Processors Ltd.

REFERENCES

1. Chan AO, Leung G., Tong T, Wong NY. Increasing dietary fiber intake in terms of kiwifruit improves constipation in Chinese patients. *World J Gastroenterol.* 2007;13:4771-5. doi: 10.3748/wjg.v13.i35.4771
2. Ferguson AR, Ferguson LR. Are kiwifruit really good for you? *Acta Hort.* 2003;610:131-7. doi: 10.17660/ActaHortic.2003.610.16
3. Ferguson AR; Kiwifruit: a botanical review. *Horti Rev.* 1984;6:1-64.
4. Rush EC, Patel M, Plank LD, Ferguson LR. Kiwifruit promotes laxation in the elderly. *Asia Pac J Clin Nutr.* 2002;11:164-8. doi: 10.1046/j.1440-6047.2002.00287.x
5. Burkitt DP, Walker AR, Painter NS. Effect of dietary fibre on stools and the transit times, and its role in the causation of disease. *Lancet.* 1972;2:1408-12.
6. Davies GJ, Crowder M, Reid B, Dickerson JW. Bowel function measurements of individuals with different eating patterns. *Gut.* 1986;27:164-9.
7. Francis CY, Whorwell PJ. Bran and irritable bowel syndrome: time for reappraisal. *Lancet.* 1994;344:39-40.
8. Anderson AS. Dietary factors in the aetiology and dosing of constipation during pregnancy. *Br J Obstet Gynaecol.* 1986; 93:245-9. doi: 10/1111/j.1471-0528.1986.+607901.x
9. Talley NJ, O'Keefe EA, Zinsmeister AR, Melton LJ 3rd. Prevalence of gastrointestinal symptoms in the elderly: a population based study. *Gastroenterology.* 1992;102:895-901. doi: 10.1016/0016-5085(92)90175-X
10. Towers AL, Burgio KL, Locher JL, Merkel IS, Safaeian M, Wald A. Constipation in the elderly: influence of dietary, psychological, and physiological factors. *J Am Geriatr Soc.* 1994;42:701-6. doi:10.1111/j.1532-5415.1994.tb06527.x
11. Norton C. Constipation in older patients: effects on quality of life. *Br J Nurs.* 2006;15:188-92. doi: 10.12968/bjon.2006.15.4.20542
12. Weir IE, Peng P, Bian M, Matharu K, Shu Q. Kivia stimulates the probiotic gut microflora whilst inhibiting pathogenic microflora. *Int J Probiotics Prebiotics* 2008;3: 231-8.
13. Blatchford P, Bently-Hewitt KL, Stoklosinski H, McGhie T, Geary R, Gibson G, Ansell J. In vitro characterisation of

- the fermentation profile and prebiotic capacity of gold-fleshed kiwifruit. *Benef Microbes*. 2015;6:829-39. doi: 10.3920/BM2015.0006
14. Parker SG, Rosendale D, Paturi G, Herath TD, Stoklosinski H, Phipps JE, Hedderley D, Ansell J. In vitro utilization of gold and green kiwifruit oligosaccharides by human gut microbial populations. *Plant Foods Hum Nutr*. 2012;67:200-7. doi: 10.1007/s11130-012-0293-1
 15. Sims IM, Monro JA. Fiber: composition, structures and functional properties. In: Boland M, Moughan PJ, editors. *Advances in food and nutrition research: nutritional benefits of kiwifruit*. Waltham: Elsevier, Amsterdam; 2013. pp. 81-100.
 16. Bongers MEJ, de Lorijn F, Reitsma JB, Groeneweg M, Taminiou JAJM, Benninga MA. The clinical effect of a new infant formula in term infants with constipation: a double-blind, randomized cross-over trial. *Nutr J*. 2007;6:8. doi: 10.1186/1475-2891-6-8
 17. Rosendale DI, Blatchford PA, Sims IM, Parkar SG, Carnachan SM, Hedderley D, Ansell J. Characterizing kiwifruit carbohydrate utilization in vitro and its consequences for human faecal microbiota. *J Proteome Res*. 2012;11:5863-75. doi: 10.1021/pr300646m
 18. Kaur L, Rutherford SM, Moughan PJ, Drummond L, Boland MJ. Actinidin enhances protein digestion in the small intestine as assessed using an in vitro digestion model. *J Agric Food Chem*. 2010;58:5074-80.
 19. Kaur L, Boland M. Influence of kiwifruit on protein digestion. In: Boland M, Moughan PJ, editors. *Advances in food and nutrition research: nutritional benefits of kiwifruit*. Waltham: Elsevier, Amsterdam; 2013. pp. 149-67.
 20. Boland M. Kiwifruit proteins and enzymes: actinidin and other significant proteins. In: Boland M, Moughan PJ, editors. *Advances in food and nutrition research: nutritional benefits of kiwifruit*. Waltham: Elsevier, Amsterdam; 2013. pp. 59-80.
 21. Drummond L, Gearry RB. Kiwifruit modulation of gastrointestinal motility. In: Boland M, Moughan PJ, editors. *Advances in food and nutrition research: nutritional benefits of kiwifruit*. Waltham: Elsevier, Amsterdam; 2013. pp. 219-32.
 22. Rassam M, Laing WA. Purification and characterization of phytocystatins from kiwifruit cortex and seeds. *Phytochemistry*. 2004;65:19-30. doi: 10.1016/j.phytochem.2003.09.019
 23. Udani, JK, Bloom, DW. Effects of kivia powder on gut health in patients with occasional constipation: a randomized, double-blind, placebo-controlled study. *Nutr J*. 2013;12:78. doi: 10.1186/1475-2891-12-78
 24. Uebaba K, Urata T, Suzuki N, Arai T, Strong JM, Oono S, Hayashi H. Mild Laxative and QOL- improving effects of kiwi fruit extract in the elderly. *Jpn J Compl Alternative Med*. 2009;6:97-103. doi: 10.1625/jcam.6.97
 25. Drossman DA. The functional gastrointestinal disorders and the Rome III process. *Gastroenterology*. 2006;130:1377-90. doi: 10.1053/j.gastro.2006.03.008
 26. Dearman RJ, Beresford L, Foster ES, McClain S, Kimber I. Characterization of the allergenic potential of proteins: an assessment of the kiwifruit allergen actinidin. *J Appl Toxicol*. 2014;34:489-97. doi: 10.1002/jat.2897
 27. Thomas RH, Allmond K. Linaclotide (linzess) for irritable bowel syndrome with constipation and for chronic idiopathic constipation. *P T*. 2013;38:154-60.
 28. Beth Israel Deaconess Medical Centre. Genetic marker for placebo response identified in IBS patients. *Science Daily*: October 23, 2013.
 29. Shah E and Pimental M. Placebo Effect in clinical trial design for irritable bowel syndrome. *J Neurogastroenterol Motil*. 2014;20:163-70. doi: 10.5056/jnm.2014.20.2.163
 30. Thompson WG. Placebos: a review of the placebo response. *Am J Gastroenterol*. 2000;1637-43. doi: 10.1111/j.1572-0241.2000.02179.x
 31. Gostner A, Schäffer V, Theis S, Menzel T, Lührs H, Melcher R et al. Effects of isomalt consumption on gastrointestinal and metabolic parameters in healthy volunteers. *Br J Nutr*. 2006;95:40-50.
 32. Chang CC, Lin YT, Lu YT, Liu YS, Liu JF. Kiwifruit improves bowel function in patients with irritable bowel syndrome with constipation. *Asia Pac J Clin Nutr*. 2010; 19:451-7.