NRC Research Press

REVIEW

Kiwifruit: our daily prescription for health[1]

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Abstract: Kiwifruit are unequalled, compared with other commonly consumed fruit, for their nutrient density, health benefits, and consumer appeal. Research into their health benefits has focussed on the cultivars *Actinidia deliciosa* 'Hayward' (green kiwifruit) and *Actinidia chinensis* 'Hort 16A', ZESPRI® (gold kiwifruit). Compared with other commonly consumed fruit, both green and gold kiwifruit are exceptionally high in vitamins C, E, K, folate, carotenoids, potassium, fibre, and phytochemicals acting in synergy to achieve multiple health benefits. Kiwifruit, as part of a healthy diet, may increase high-density lipoprotein cholesterol, and decrease triglycerides, platelet aggregation, and elevated blood pressure. Consuming gold kiwifruit with iron-rich meals improves poor iron status, and green kiwifruit aids digestion and laxation. As a rich source of antioxidants, they may protect the body from endogenous oxidative damage. Kiwifruit may support immune function and reduce the incidence and severity of cold or flu-like illness in at-risk groups such as older adults and children. However, kiwifruit are allergenic, and although symptoms in most susceptible individuals are mild, severe reactions have been reported. While many research gaps remain, kiwifruit with their multiple health benefits have the potential to become part of our "daily prescription for health."

Key words: Actinidia, kiwifruit, HDL-cholesterol, triglycerides, blood pressure, platelet aggregation, iron, digestion, anti-oxidant, upper respiratory tract infection.

Résumé : Le kiwi est un fruit sans égal comparativement aux autres fruits de consommation courante en ce qui a trait à son contenu en nutriment, ses bienfaits pour la santé et son caractère attrayant pour le consommateur. La recherche portant sur ses bienfaits pour la santé s'est concentrée sur les cultivars *Actinidia deliciosa* 'Hayward' (kiwi vert) et *Antinidia chinensis* 'Hort 16A', ZESPRI® (kiwi jaune). Comparativement à d'autres fruits de consommation courante, le kiwi vert et le kiwi jaune sont exceptionnellement riches en vitamines C, E et K, en folate, en caroténoïdes, en potassium, en fibres et en composés phytochimiques qui agissent en synergie pour conférer de multiples bienfaits pour la santé. Intégré dans une diète saine, le kiwi peut accroitre les HDL-C et diminuer les triglycérides, l'agrégation des plaquettes et l'élévation de la pression artérielle. La consommation de kiwi avec des aliments riches en fer améliore la condition de carence en fer, et le kiwi vert contribue à la digestion et à l'évacuation. En tant que source riche en antioxydants, il peut protéger le corps des dommages oxydants endogènes. Le kiwi peut aider les fonctions immunitaires et réduire l'incidence et la sévérité du rhume ou du syndrome grippal chez les groupes à risque comme les personnes âgées et les enfants. Cependant, le kiwi est allergénique et même si les symptômes chez la plupart des individus susceptibles sont légers, des réactions sévères ont été décrites. Même s'il reste plusieurs lacunes à combler en recherche, le kiwi et ses multiples bienfaits pour la santé a le potentiel nécessaire pour faire partie de notre « prescription quotidienne pour la santé ».

Mots-clés : Actinidia, kiwi, cholestérol-HDL, triglycérides, pression artérielle, agrégation des plaquettes, fer, digestion, antioxydant, infection des voies respiratoires supérieures.

Introduction

While the health benefits of consuming fruit are well documented (Boeing et al. 2012), kiwifruit stand out for their nutrient density, health benefits, and consumer appeal (Ferguson and Ferguson 2003). Kiwifruit are not only an exceptionally rich source of vitamin C, but also contain an array of other nutrients (Table 1) that contribute to their health effects. The various bioactive components in kiwifruit may act synergistically in affecting various physiological and metabolic processes. A growing body of scientific evidence supports kiwifruit's health benefits, including their effects on metabolic health, iron nutrition, digestion, antioxidant activity, and immune function (Singletary 2012). The question arises, should kiwifruit be part of our "daily prescription for health"?

The aim of this review is to provide an overview of the scientific evidence regarding the emerging health benefits associated with consumption of kiwifruit, including studies conducted in our own research unit. Kiwifruit as an allergen source will also be reviewed. To begin with, a description of the kiwifruit, its history, and nutrient content will be provided.

Kiwifruit (*Actinidia*)

Kiwifruit are the edible berry of the woody vine *Actinidia*. There is a large and diverse range of species and cultivars of *Actinidia* with different characteristics and attributes, of which the *Actinidia deliciosa* 'Hayward' (green kiwifruit) and *Actinidia chinensis* 'Hort 16A', ZESPRI® (gold kiwifruit) are the most popular commercially available cultivars (Ferguson and Ferguson 2003). The *A. deliciosa* 'Hayward' cultivar has a small oval-shaped fruit, about the size of a large hen's egg, with translucent and vibrant green flesh containing rows of edible, black seeds covered with dull-brown hairy skin. The flesh has a tangy, sweet and sour combination of invigorating flavours (Nishiyama 2007; Zespri 2011; Singletary 2012). *Actinidia chinensis* 'Hort 16A' have a characteristic shape with a protrusion of the stylar

Received 30 August 2012. Accepted 29 October 2012.

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[1]*This review is one of a collection of papers published in the special issue on "Food as Medicine."*

Table 1. Selected nutrient composition (raw, per 100 g edible portion) of kiwifruit and other commonly consumed fruit.

Nutrient	Green kiwifruit (*Actinidia deliciosa*)	Gold kiwifruit (*Actinidia chinensis*)	Orange (naval) (*Citrus sinensis*)	Apple (*Malus domestica*) with peel	Banana (*Musa acuminata*)	Strawberries (*Fragaria* × *ananassa*)	Blueberries (*Vaccinium* spp.)
Energy (kJ)	255	251	207	218	371	136	240
Carbohydrate (g)	14.66	14.23	12.54	13.81	22.84	7.68	14.49
Fibre, total dietary (g)†	3.39	2.0	2.40	2.70	2.40	2.30	2.70
Insoluble DF (g)	2.60	1.4	1.00	2.00	1.80	1.70	2.40
Soluble DF (g)	0.80	0.5	1.40	0.70	0.60	0.60	0.30
Sugars, total (g)	8.99	10.98	8.50	10.39	12.23	4.89	9.06
Vitamin C (ascorbic acid) (mg)	92.7	105.4	59.1	4.6	8.7	58.8	9.7
Vitamin E (α-tocopherol) (mg)	1.46	1.49	0.15	0.18	0.10	0.29	0.57
Vitamin K (phylloquinone) (μg)	40.3	5.5	0	2.2	0.5	2.2	19.3
Folate (μg DFE)	25	34	34	3	20	24	6
Beta carotene (mg)	52	43	87	27	26	7	32
Lutein+zeaxanthin (mg)	122	114	129	29	22	26	80
Potassium (mg)	312	316	166	107	358	153	77
Copper (mg)	0.13	0.15	0.04	0.03	0.08	0.05	0.06

Note: Nutrient values for the edible portion of fruit (USDA 2011). DF, dietary fibre; DFE, dietary folate equivalents.

†Fibre values (Schakel et al. 2001), except gold kiwifruit: total DF (USD 2011); insoluble, soluble DF (Personal communication with L. Drummond, ZESPRI International, Ltd., Mount Maunganui, New Zealand).

end, the so-called "beak." The fruit have bright-yellow flesh surrounded by smooth, hairless, bronze coloured skin, and the flesh has a sweet, tropical taste (Nishiyama 2007; Zespri 2011; Singletary 2012).

Kiwifruit were originally native to southern China, where they grow wild. The plant was first introduced to New Zealand as seeds by missionaries in 1904. In China, it had a number of common names, including "mihoutao" or monkey peach, as wild monkeys were known to enjoy eating the ripe fruit. In New Zealand it quickly became known as the Chinese gooseberry, as the fruit were perceived to have a gooseberry flavour and they were originally from China (Ferguson 2004; Nishiyama 2007). The cultivar 'Hayward,' the mainstay of the kiwifruit industry, is a direct descendant of those first seeds. It was first developed by Hayward Wright in the 1920s in Avondale (Zespri 2011), with exports to the United States starting in the 1950s (Ferguson 2004). It was during this time, as a result of political connotations due to the Cold War, that the name kiwifruit was proposed and adopted (Ferguson 2004; Ministry for Culture and Heritage 2011). In 2000, the yellow-fleshed fruit 'Hort 16A' (ZESPRI®) was introduced into the world market and shattered the perception that the flesh of kiwifruit is only green. Today the kiwifruit industry is one of New Zealand's horticultural success stories, and the fruit is grown in many countries, notably Italy, China, Chile, France, Greece, Japan, and the United States (Nishiyama 2007). New cultivars are becoming commercially available for example the kiwiberry (*Actinidia arguta*) and other variants of green and gold kiwifruit, but for the purpose of this review the focus will be on *Actinidia deliciosa* 'Hayward' and *Actinidia chinensis* 'Hort 16A', ZESPRI® (hereinafter referred to as green or gold kiwifruit, respectively).

Composition of kiwifruit

Kiwifruit are some of the most nutrient-dense fruit and compared with other commonly consumed fruit, are particularly high in vitamins C, E, and K, folate, carotenoids, potassium, fibre (Table 1), and contain a range of phytochemicals (Ferguson and Ferguson 2003). Both green and gold kiwifruit contain almost double the amount of vitamin C found in oranges and strawberries; traditionally known as good sources of vitamin C. In addition, kiwifruit have been shown to be a significantly better delivery vehicle for replenishing depleted vitamin C tissue levels, compared with supplemental vitamin C, in a mouse model (Vissers et al. 2011). Green kiwifruit has a higher total dietary and insoluble fibre content than other commonly consumed fruit. Its soluble fibre content is lower than that of oranges, but compares well with apples, bananas, and strawberries. Both green and gold kiwifruit contain significant levels of 2 fat-soluble vitamins, vitamin E and vitamin K (as phylloquinone). Kiwifruit compare well with avocado (1.5 compared with 2.07 mg vitamin E/100 g), the only other fruit high in vitamin E (USDA 2011). It has been assumed that vitamin E in kiwifruit is restricted to the seeds and therefore not bioavailable (Ferguson and Ferguson 2003). However, this seems to be a myth, as Fiorentino et al (2009*b*) showed that α-tocopherol is found in the flesh of the kiwifruit, and consumption of both green and gold kiwifruit resulted in increased plasma vitamin E concentrations (Chang and Liu 2009; Hunter et al. 2012). The potassium in kiwifruit is comparable with that of bananas, well known for their high potassium content, and more than double that of other fruit. Gold kiwifruit are a good source of folate; similar to that of oranges, but higher than other fruit. Apart from oranges, both green and gold kiwifruit are better sources of carotenoids, including β-carotene, lutein, and zeaxanthin, than other fruit. The carotenoids contribute to the colour of the kiwifruit, but the unique green colour of green kiwifruit is attributed to the retention of chlorophyll during ripening (1 mg of chlorophyll/100 g), which masks the yellow colour of the carotenoids (McGhie et al. 2002; Nishiyama 2007). Kiwifruit also contain a range of other phytochemicals/polyphenols, although many of the phenolics and flavonoids in kiwifruit are yet to be identified, as to date they have been un-extractable (Tarascou et al. 2010). The taste of kiwifruit is influenced by the balance of sugar and organic acids. Green kiwifruit is lower in sugar (Table 1) and higher in organic acids and calcium oxalate (Perera et al. 1990) (tangy sour taste) compared with gold kiwifruit (mild sweet taste).

Kiwifruit improve metabolic health markers

Metabolic abnormalities such as dyslipidaemia (increased total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), lower high-density lipoprotein cholesterol (HDL-C)), hypertension, vascular inflammation, abnormal glucose metabolism, and haemostatic disorders all play important roles in the pathophysiology of the major causes of morbidity and mortality such as diabetes, cardiovascular disease (CVD), stroke, and dementia (Dzau et al. 2006; DeFronzo and Abdul-Ghani 2011; Gorelick et al. 2011). A few studies have investigated the effects of green or gold kiwifruit on some of these metabolic markers. We have recently shown in hypercholesterolaemic men, that the consumption of 2 green kiwifruit per day for 4 weeks as part of a healthy diet favourably affected plasma HDL-C, TC/HDL-C ratio, and apolipoprotein B/apolipoprotein A1 ratio, compared with a healthy control diet (Gammon et al. 2012). Studies have shown

that the apolipoprotein B/apolipoprotein A1 ratio is a superior measure of lipoprotein-related vascular disease risk to the TC/HDL-C ratio (Walldius et al. 2004; McQueen et al. 2008). It is an index of pro-atherogenic and anti-atherogenic lipoproteins in plasma, with apolipoprotein B concentration being correlated with plasma LDL-C, and apolipoprotein A1 concentration being correlated with plasma HDL-C (Hegele 2009).

In carriers of the apolipoprotein E4 (*APOE4*) allele, TG concentrations also decreased significantly compared with the healthy control diet (Gammon et al. 2012). These findings are supported by 3 other studies showing that the consumption of 1–3 green or gold kiwifruit per day for 4–8 weeks increased HDL-C, decreased TC/HDL-C ratio (Chang and Liu 2009), and decreased TG (Duttaroy and Jorgensen 2004; Brevik et al. 2011) compared with baseline concentrations. The improvements in dyslipidaemia may be due to the independent and (or) synergistic actions of various constituents of kiwifruit such as polyphenols, vitamin C, and vitamin E (Gammon et al. 2012).

Karlsen et al. (2012) showed that consumption of 3 green kiwifruit per day for 8 weeks significantly reduced diastolic (DBP) and systolic (SBP) blood pressure in male smokers compared with the control treatment (habitual diet), with the greatest effects (–15 mm Hg SBP, –13 mm Hg DBP; 1 mm Hg = 133.322 Pa)) seen amongst hypertensive subjects. Additionally, they observed a reduction in angiotensin-converting enzyme (ACE) activity. ACE is a key regulator of BP through the renin–angiotensin system, and this effect has previously been observed in vitro with kiwifruit extracts (Jung et al. 2005). Gammon et al. (2012) did not show an improvement in blood pressure; however, only 2 of the participants in that study were hypertensive.

Kiwifruit, both green and gold, may have antithrombotic effects by decreasing platelet aggregation. Three studies have shown that decreased collagen and (or) adenosine diphosphate (ADP)-induced in-vitro platelet aggregation (Duttaroy and Jorgensen 2004; Brevik et al. 2011; Karlsen et al. 2012). However, interestingly enough, in the Brevik et al. (2011) study, the inhibition seen in association with consuming one gold kiwifruit per day disappeared when consuming 2 gold kiwifruit per day. The authors were unable to explain this discrepancy, and argued that it may have been due to unknown confounding factors. However, considering that this was a randomised cross-over study this is unlikely, and raises the question whether the effect seen with one kiwifruit per day was due to chance. Since 2 other studies showed reduced platelet aggregation with 2 or 3 kiwifruit a day (Duttaroy and Jorgensen 2004; Karlsen et al. 2012), further research to confirm this effect is warranted.

With regard to other metabolic markers, none of the 3 studies that measured high sensitivity C-reactive protein (hs-CRP), a marker of systemic inflammation, showed any effect of kiwifruit (Brevik et al. 2011; Gammon et al. 2012; Karlsen et al. 2012). Neither Brevik at al. (2011) nor Gammon et al. (2012) saw any effects on plasma glucose concentrations, but this may be due to the trials being of insufficient duration and the subject groups having normal glucose metabolism and therefore little potential for change.

In summary, both green and gold kiwifruit as part of a healthy diet may beneficially affect metabolic markers, particularly in individuals with metabolic abnormalities such as dyslipidaemia and hypertension. Further randomised controlled human interventions are required to confirm these findings and to elucidate the bioactive constituents and mechanisms underlying the observed benefits.

Kiwifruit supports iron nutrition

Consuming kiwifruit may also be of benefit in treating iron deficiency as recently shown in our research unit (Beck et al. 2011). Iron deficiency is the most common nutritional deficiency worldwide (FAO/WHO 2004) and is associated with a number of adverse health consequences (Food and Nutrition Board: Institute of Medicine 2001). In a randomised controlled trial we observed significant improvements in iron status in young women with mild iron deficiency when 2 gold kiwifruit, compared with a banana, were consumed with an iron fortified breakfast cereal (16 mg ferrous sulfate) meal daily for 16 weeks (Beck et al. 2011). Serum ferritin increased and soluble transferrin receptor and soluble transferrin receptor : serum ferritin ratio decreased significantly with the addition of kiwifruit compared with banana (Beck et al. 2011). The improvement in iron status may be ascribed to the high content of vitamin C, carotenoids, citric acid, or a combination of synergistic nutritional factors in gold kiwifruit. Vitamin C is a well-known enhancer of iron absorption (Diaz et al. 2003), and citric acid has been shown to be additive to the effects of vitamin C on iron absorption (Ballot et al. 1987). The carotenoids lutein and zeaxanthin have also been shown to enhance iron absorption (Garcia-Casal 2006). Further research is needed to confirm these effects in other population groups at risk of iron deficiency, including pregnant women, children, and adolescents, but also in those being treated for iron deficiency anaemia.

Kiwifruit aids digestion

Historically, green kiwifruit have been well acknowledged for the beneficial effect they have on digestion and laxation. Recent studies have demonstrated significant results in the treatment of constipation in healthy elderly (Rush et al. 2002; Chan et al. 2007) and in patients with irritable bowel syndrome (Chang et al. 2010). Insoluble dietary fibre, with its water-retaining abilities, increases faecal bulk and softens stools, and it is through this mechanism that kiwifruit appear to act. Green kiwifruit are high in both soluble and insoluble fibre, comparing favourably with a number of other popular fruit (Table 1). However there is some evidence that as the fruit ripens, there is increasing solubilisation of polymers within the cell walls of kiwifruit, resulting in a unique and greatly increased ability to hold water (Redgwell et al. 1992). These ripening-induced changes also result in enhanced viscosity due to solubilisation of the pectic polysaccharides in the cell walls (Redgwell et al. 1997). The ensuing lubricating effect has been identified as an important attribute of soluble fibre in other effective treatments of constipation (Marlett et al. 2000).

Kiwifruit also contain a very active proteolytic enzyme, actinidin, which is postulated to have a beneficial impact on the gastric and intestinal digestion of proteins. In-vitro studies have shown that actinidin, acting in concert with the gastric and intestinal proteases pepsin and pancreatin, enhances protein digestion in both the stomach and the small intestine (Kaur et al. 2010*a*, 2010*b*). Rutherfurd et al. (2011) recently showed in an in-vivo investigation in rats that actinidin from green kiwifruit significantly increased the gastric digestion of some food proteins. It is therefore reasonable to suggest that kiwifruit as part of a meal could act as a digestive aid by a variety of actions: more effective digestion of dietary protein, increased faecal bulking and softness, and better lubrication assisting the propulsion of contents along the colon.

Kiwifruit has antioxidant effects

Kiwifruit are exceptionally rich in vitamin C (Table 1) (Nishiyama et al. 2004; Latocha et al. 2010), a well characterised antioxidant (Bendich et al. 1986). Kiwifruit also contain a wide range of other antioxidants such as vitamin E, lutein, zeaxanthin, and an array of phytochemicals, many of which have antioxidant properties (Fiorentino et al. 2009*a*). Regular consumption of either green or gold kiwifruit significantly increased plasma vitamin C (Collins et al. 2003; Prior et al. 2007; Beck et al. 2011; Brevik et al. 2011; Hunter et al. 2012), vitamin E (Chang and Liu 2009; Hunter et al. 2012), and lutein/zeaxanthin (Bohn et al. 2010; Beck et al. 2011; Hunter et al. 2012) concentrations. Many disease states such as CVD and cancer have a common underlying mechanism of oxidative damage caused by reactive oxygen species. Diets that are

high in fruit and vegetables augment the body's antioxidant defences and protect against oxidative damage (Lampe 1999). Several assays have been developed to measure the total antioxidant capacity in foods and in vivo. Compared with other fruits, the in vitro antioxidant capacity of kiwifruit ranges from average to high, depending on the assay used (Szeto et al. 2002; Wolfe et al. 2008; Fiorentino et al. 2009*a*). However, owing to mounting evidence that these in-vitro values do not predict in vivo antioxidant capacity (USDA 2010), it is more important to consider the in-vivo effects. Prior et al. (2007) showed that consuming green kiwifruit with a meal was associated with increased plasma antioxidant capacity postprandially, and may therefore play a role in preventing postprandial oxidative stress (Prior et al. 2007). Collins et al. (2001) showed for the first time a significant decrease in oxidative DNA damage in ex vivo human lymphocytes following the consumption of a single large quantity of green kiwifruit juice. Subsequent studies showed enhanced resistance towards oxidative DNA damage in lymphocytes with the consumption of lower doses (1–3 gold or green kiwifruit per day) over a longer period (3–4 weeks) (Collins et al. 2003; Brevik et al. 2011). The magnitude of the effects did not differ whether 1 or 3 kiwifruit were consumed in these studies. Kiwifruit may improve oxidative defence processes through up-regulation of genes related to DNA repair (Bohn et al. 2010). Lipid peroxidation was reduced with the consumption of gold kiwifruit (4 kiwifruit per day for 4 weeks) (Hunter et al. 2012). However, Brevik et al. (2011) could not corroborate this effect on lipid peroxidation with a smaller quantity of gold kiwifruit (1–2 kiwifruit per day for 4 weeks).

In summary, the regular consumption of green or gold kiwifruit may increase antioxidant capacity and protect the body from endogenous oxidative damage in vivo. The long-term benefits of this to human health remain to be proven, but in the meantime, regular kiwifruit consumption may add to protection from CVD and cancer through its effects on oxidative stress.

Kiwifruit reduce the incidence and symptoms of the "common cold and flu"

One of the most common illnesses that healthy humans have to deal with on a regular basis is upper respiratory tract infection (URTI), which typically presents as colds and influenza (flu) (Eccles 2005). Adults experience on average 1–4, and children, owing to their developing immune systems, 4–8 bouts of cold- and flu-like episodes per year (Monto and Sullivan 1993; Proud and Chow 2006). URTI causes major disruption to daily living and is associated with direct and indirect costs related to health care and loss of productivity through absence from work and school (Wald et al. 1991). Since no cure exists, optimising the immune system through adequate nutrition (Lampe 1999; Grimm and Calder 2002; Hunter et al. 2011) could be an important strategy for the prevention and treatment of URTI.

Kiwifruit is an excellent source of various nutrients and phytochemicals associated with a healthy immune system, such as vitamins C, E, and K, folate, carotenoids, potassium, and polyphenols (Table 1) (Hunter et al. 2011; Skinner 2012). A small number of animal, in vitro cell based, and human studies provide supporting evidence that kiwifruit may enhance immune function and immune responses as reviewed by Hunter et al (2011) and Skinner et al (2011). In brief, kiwifruit may improve the markers of innate and adaptive immune function. Phagocytosis and levels of immunoglobulins (IgA, IgG, and IgM) were increased after supplementing mice with a kiwifruit extract for 30 days (Ma et al. 2006). An extract prepared from gold kiwifruit pasteurised purée resulted in significantly enhanced measures of innate and adaptive immune cell function of human blood cells ex vivo, namely increased phagocytosis, oxidative burst, and natural killer cell activity (innate), and increased T-cell activation and cytokine production in response to a recall antigen (adaptive) (Skinner et al. 2011). Kiwifruit may also affect the immune system through antioxidant effects by protecting immune cells from oxidative damage and consequent loss of membrane integrity and fluidity resulting in alterations in signalling within and between immune cells (reviewed by Hunter et al. (2011)).

Two recent New Zealand studies (Adaim et al. 2010; Hunter et al. 2012) investigated the effects of regular consumption of gold kiwifruit on the incidence and symptoms of URTI in older adults (≥65 years) (Hunter et al. 2012) and pre-school children (2–5 years) (Adaim et al. 2010), 2 groups at high risk if they contract colds and flu. Both groups were enrolled in separate cross-over randomised controlled trials involving consumption of gold kiwifruit compared with the consuption of banana (control fruit with relatively similar energy content, but lower nutritional value). The older adults consumed the equivalent of 4 gold kiwifruit or 2 bananas daily (Hunter et al. 2012) for 4 weeks and the pre-school children consumed 2 servings of gold kiwifruit or 1 banana for 5 days/week for 4 weeks at the day care facility they attended (Adaim et al. 2010). In older adults, the duration of sore throat and head congestion was significantly reduced when gold kiwifruit was consumed, compared with banana (sore throat: mean of 2 days compared with 5.4 days, $P = 0.02$; head congestion: <1 day compared with 4.7 days, $P = 0.03$). Similarly, the severity score for head congestion was significantly lower whilst consuming gold kiwifruit, compared with banana (1.3 compared with 6.7 out of 10, $P = 0.01$) (Hunter et al. 2012). In the pre-schooler study, the odds of contracting a cold or flu-like illness was reduced by almost half when kiwifruit were consumed, compared with banana (odds ratio (OR; 95% CI): 0.55 (0.32, 0.94), $P = 0.03$). Severity scores for physiological and functional symptoms and the incidence of certain URTI symptoms (poor appetite, feeling unwell, low energy, crying, headaches, sore throats) were significantly lower when consuming kiwifruit, compared with banana (Adaim et al. 2010). In the older adult study, consumption of gold kiwifruit resulted in significant increases in plasma vitamin C, α-tocopherol, lutein/zeaxanthin, and erythrocyte folate concentrations, which may have contributed to the reduction in duration and severity of URTI symptoms (Hunter et al. 2012).

Further research is needed to confirm these results in other at risk groups to clarify whether these effects of gold kiwifruit on URTI are in fact due to improved immune function, which nutrients or bioactive compounds are responsible, and whether other kiwifruit cultivars produce similar effects.

Tolerance and allergic effects of kiwifruit

Green kiwifruit have been recognised as a food allergen for over 2 decades, with the first acute case of kiwifruit allergy reported in 1981 (Lucas et al. 2003). Clinical characteristics of kiwifruit allergy range from mild symptoms localised to the oral mucosa in the majority of individuals, to severe anaphylactic reactions, particularly in children (Lucas et al. 2004). Kiwifruit allergy is also known to occur as a consequence of cross-reactions with pollens and latex (Lucas et al. 2004). Several protein components in kiwifruit have been identified as potential allergenic agents. Actinidin (Act c 1, 30 kDa), the most abundant protein in green kiwifruit, is the most recognised major kiwifruit allergen (Palacin et al. 2008). However, Lucas et al. (2007) failed to show that actinidin was a major allergen in a UK population, indicating that the major allergenic component may be different in different populations. Gold kiwifruit is also an allergen source, although it contains very low levels of actinidin, it shares some other common allergens and immunoglobulin E (IgE) cross-reactivity with green kiwifruit (Bublin et al. 2004). Thus, people allergic to green kiwifruit are at risk of reacting to gold kiwifruit (Bublin et al. 2004). Very little information is available in the literature on the prevalence of kiwifruit allergy. A cross-sectional study among school children in France suggested

that kiwifruit allergy was as common as egg and peanut allergies (Rance et al. 2005).

Intervention studies with kiwifruit showed that the kiwifruit were well tolerated without any adverse side-effects (Duttaroy and Jorgensen 2004; Chang and Liu 2009; Beck et al. 2011; Gammon et al. 2012). Gammon et al. (2012) reported that the consumption of 2 green kiwifruit every day for 4 weeks was rated as easy or very easy by the majority of participants (89.4%), even those who had not regularly consumed kiwifruit before the study. The most common side-effect reported, which is also seen as a positive effect, was more frequent bowel movements (Beck et al. 2011; Gammon et al. 2012).

Summary points and conclusions

- Both green and gold kiwifruit are some of the most nutrient-dense fruit and, compared with other commonly consumed fruit, are particularly rich in vitamins C, E, K, folate, carotenoids, potassium, fibre, and contain several phytochemicals (USDA 2011).
- The consumption of gold kiwifruit with an iron rich meal may be an effective strategy for improving the iron status in women with mild iron deficiency (Beck et al. 2011).
- The regular inclusion of green or gold kiwifruit as part of a healthy diet may favourably affect lipid profiles (increase HDL-C, decrease TC/HDL-C ratio, and TG concentrations) (Duttaroy and Jorgensen 2004; Chang and Liu 2009; Brevik et al. 2011; Gammon et al. 2012) and have anti-thrombotic effects (decrease platelet aggregation) (Duttaroy and Jorgensen 2004; Brevik et al. 2011; Karlsen et al. 2012).
- Individuals with hypertension may benefit from regular consumption of kiwifruit with regard to its anti-hypertensive effects, possibly mediated through inhibition of ACE activity (Karlsen et al. 2012).
- Green kiwifruit as part of a meal could act as a digestive aid due to more effective digestion of dietary protein, increased faecal bulking and softness, and better lubrication assisting the propulsion of contents along the colon.
- Regular consumption of green and gold kiwifruit may increase antioxidant capacity in vivo and protect the body from endogenous oxidative damage (Collins et al. 2001; Brevik et al. 2011). Consumption of kiwifruit with a meal may play a role in preventing oxidative stress associated with consumption of that meal (Prior et al. 2007).
- Daily consumption of gold kiwifruit for 4 weeks were shown to reduce the incidence of cold- or flu-like illness in young children and to reduce the severity of cold- or flu-like symptoms in both young children and older adults, 2 groups at higher risk of contracting colds and flu (Adaim et al. 2010; Hunter et al. 2012).
- Both green and gold kiwifruit are allergenic (Bublin et al. 2004; Lucas et al. 2005), and their effects as a food allergen should not be underestimated. Although symptoms in most individuals with kiwifruit allergy are mild (localised to the oral mucosa), they are capable of causing severe reactions, particularly in children (Lucas et al. 2004).

The numerous potential health benefits of kiwifruit may be ascribed to the whole food approach where various bioactive compounds within the food matrix act synergistically to produce multiple and enhanced health effects.

Although it is apparent that kiwifruit have many health benefits, research in this area is still in its emerging phase. The strongest evidence is for its digestive effects, but there are still many research gaps with regard to other health benefits. These research gaps need to be addressed in randomised, controlled human trials using appropriate study populations with sufficient statistical power.

The daily consumption of kiwifruit may be an effective strategy for preventing disease and postponing pharmacological interventions. Kiwifruit may therefore be part of "our daily prescription for health."

Conflict of interest

The authors have previously received funding from ZESPRI® International Ltd. for research on kiwifruit.

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