



Characteristics and pro-health properties of mini kiwi (*Actinidia arguta*)

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Abstract

Actinidia arguta (mini kiwi) is a variant of the fuzzy kiwifruit (*Actinidia deliciosa*) commonly found in stores. The fruits of various kiwi varieties are valued for their strong antioxidant and anti-inflammatory properties. The fruit of *A. arguta* is characterized by a rich chemical composition, palatable flavor, medicinal properties, and low caloric content, making them a valuable component of a healthy diet. Their advantage is the ability to eat the fruit with the peel, unlike fuzzy kiwis. *Actinidia* fruits are a rich source of vitamins, especially vitamins C and B₉, carotenoids, dietary fiber, and antioxidants. The total content of polyphenols in the fruit of *A. arguta* can be as high as 360 mg 100 g⁻¹ fresh weight. Consumer studies show that the fruit has been highly evaluated not only for its taste but for its appearance as well. There is increasing interest in frost-resistant and pest-resistant cultivars worldwide. This article discusses our current knowledge about the potential health benefits of *A. arguta* consumption and topics for further study.

Keywords Alkaloids · Enzymes · Fruit · Polyphenols · Vitamin C

1 Introduction

Actinidia arguta (mini kiwi) is a dioecious plant, suitable for growing in temperate climates due to its higher resistance to frost (Latocha and Olszewska-Kaczyńska 2003; Drzewiecki et al. 2016). In Chinese medicine, the fruit is used as a traditional blood glucose lowering agent and to alleviate atopic dermatitis (Liu and Liu 2016). *A. arguta* fruit is a richer source of health-promoting ingredients than popular kiwi (*A. deliciosa*) or fruit of other popular plant species (Rush et al. 2006). Thanks to these properties, it has gained the reputation as a superfood (Ferguson and Ferguson 2003). Roots of *A. arguta* have anti-tumor, anticoagulant, and anti-inflammatory properties (Teng et al. 2013). The aim of this work is to present a critical review concerning health-promoting properties of *A. arguta* fruit, covering a wide range of kiwi varieties.

2 Occurrence and cultivation

The genus *Actinidia* originates from the Asian continent. As many as 36 of the 50 species are from East Asia, Manchuria, Nepal, the Sakhalin Peninsula, and Japan. Some of the known kiwifruit species are classified per their fruit-shape: *A. deliciosa*, *A. chinensis*, *A. arguta*, *A. kolomikta*, *A. purpurea*, *A. polygama*, and *A. melanandra* (Latocha 2006a).

Per Williams et al. (2003), the first *Actinidia* crops originated at the beginning of the 20th century in New Zealand. In this country, research is ongoing to create new varieties. Recently, a new yellow-fleshed variant of *A. chinensis*, ‘Hort16A’, was developed in New Zealand (Nishiyama et al. 2005). The fruit is now known worldwide, and the main fruit producers are New Zealand, Italy, Chile, and California—USA (Latocha 2007). Mini kiwi has just started to be grown on an industrial scale, with large plantations occurring in Chile, Canada, France, Japan, the USA, and New Zealand (Okamoto and Goto 2005; Latocha 2007). Also, some species of *A. arguta* may be cultivated in Poland, as confirmed by field studies there (Kawecki et al. 2004; Kawecki and Bieniek 2008; Latocha 2008; Marosz 2009; Latocha 2010; Drzewiecki et al. 2016). Currently, there are many varieties of mini kiwi, and there are also interspecific hybrids within the genus. Several varieties are recommended for the

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establishment of mini kiwi plantations in Poland: ‘Geneva’, ‘Ananasnaja’, ‘Ken’s Red’, and ‘Jumbo’ (Latocha 2006b; Marosz 2009).

Actinidia arguta is a berry weighing about 6–14 g (Drzewiecki et al. 2016). The fruit is characterized by a smooth, edible, non-hairy peel, which has a green coloration, but for some varieties there is a red blush (Krupa and Latocha 2008). Fruits are characterized by intense sweet taste like that of tropical fruits (Fisk et al. 2006). Williams et al. (2003) compared it to the taste of ripe bananas, pineapples, strawberries, and melon. Fruits are usually eaten raw with the skin on, and can also be used to make jams, juices, and wine, among other products (Nishiyama et al. 2005; Latocha 2008; Latocha et al. 2011, 2014). During heat treatment, the fruit loses its attractive green color due to their natural acidity and the conversion of chlorophyll to pheophytin (Nishiyama et al. 2005). Due to its short shelf life, fruit should be collected immature when still hard. Ready-to-eat fruits can be stored in the refrigerator for one to two weeks, whereas frozen fruits can be stored for seven to 10 weeks (Fisk et al. 2006; Latocha 2006a). Therefore, compared to the popular kiwi (*A. deliciosa*) that can be stored for up to half a year, it is a very short time. One of the commercial barriers is also high susceptibility of mini kiwi to dehydration during storage and transport (Strik 2005; Fisk et al. 2006).

3 Important bioactive ingredients in mini kiwifruit and their effects

Actinidia arguta fruit is considered a superfood due to its high antioxidant and anti-inflammatory activity. Antioxidants contained in *Actinidia* fruits reduce oxidative stress and support the cardiovascular system (Leontowicz et al. 2016a). Polyphenols provide better protection against chronic diseases such as cardiovascular diseases, cancer, diabetes, vascular diseases, and neurodegenerative diseases (Ganesan and Xu 2017). Studies have shown that alkaloids extracted from the *A. arguta* fruit can improve the physical strength of mice and thus increase their level of physical activity (Liu and Liu 2016). This suggests that fruit extracts may be used as dietary supplements.

4 Vitamin C

Vitamin C participates in many important biochemical reactions and changes in the human body (Fig. 1). Notably, it can create a redox-reversible oxidation and reduction system (Janda et al. 2015). It is one of the main antioxidants in human body fluids, which may, for example, lead to the disappearance of asthmatic symptoms in children (Kim et al. 2009). It also protects cells from oxidative stress (Zhang

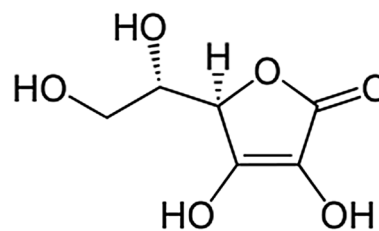


Fig. 1 Structural formula of L-ascorbic acid

et al. 2014) and plays an important role in protecting the body against cardiovascular diseases (Janda et al. 2015).

Vitamin C content in kiwifruit is about 70 mg 100 g⁻¹ fresh weight (FW) and is higher than that in apples or grapefruit (Fig. 2), strawberries, lemons, oranges, currants, or raspberries (Janda et al. 2015). Vitamin C content in *A. arguta* fruit is higher than in traditional kiwi. Ferguson and MacRae (1991) found that the content of this compound in *A. arguta* fruit was about 100 mg 100 g⁻¹ FW. According to Kabaluk et al. (1997), these fruits can contain from 25 to 155 mg vitamin C 100 g⁻¹ FW. According to Nishiyama et al. (2004a, b), depending on the studied *A. arguta* genotype, the vitamin content was very variable and fluctuated from 37 to 185 mg 100 g⁻¹ FW. In the Japanese variant ‘Mitsuko’, it ranged from 22.8 to 222.1 mg 100 g⁻¹ FW (Kim et al. 2012). Latocha (2007) and Chesoniene (2000) have shown that in some varieties of *A. kolomikta*, the vitamin C content can be as high as 1164 mg 100 g⁻¹ FW.

Carr et al. (2013) have tested the bioavailability of vitamin C in *A. chinensis*, giving nine non-smoking men one vitamin C tablet (260 mg) daily or an equivalent fruit dose. After six weeks of the study, the authors showed comparable relative bioavailability of vitamin C from both sources; there were no statistically significant differences in plasma, urine, semen, leukocyte, and muscle tissue concentrations of vitamin C in both groups (Carr et al. 2013).

5 Polyphenols

Actinidia fruits are a valuable source of polyphenols that are used both in industry and for health (Wang 2013; Lee et al. 2015; An et al. 2016), with higher total polyphenol content than apples, grapefruits, lemons, and peaches (Table 1). Polyphenols are classified as phytochemicals, widely used for both medicinal and cosmetic purposes. There are currently over 8000 polyphenols identified (Lima et al. 2014). Phenolic acids, flavonoids, and tannins are the most common types in the human diet (Lima et al. 2014). They are strong antioxidants and may exhibit chemo-resistance (Jing et al. 2008), anti-inflammatory and anti-carcinogenic properties,

Fig. 2 Mean content of vitamin C in various fruit species, mg 100 g⁻¹ fresh weight (Teng et al. 2013)

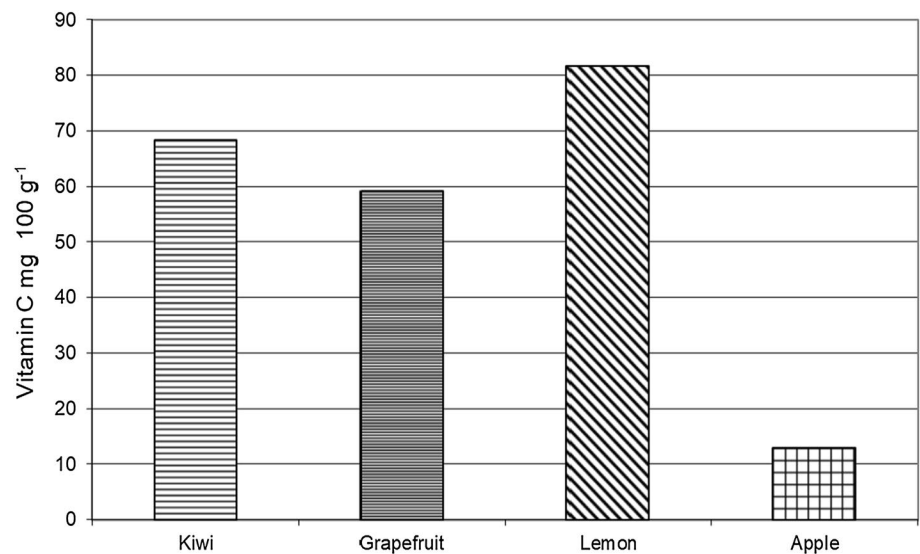


Table 1 Total phenolic content in selected fruits (mg GAE 100 g⁻¹ FW^x)

Fruit	Phenolic content	Fruit	Phenolic content
<i>A. kolomikta</i> ^z	430.03 ± 21.85	Grape (green) ^y	23.20 ± 1.58
<i>A. arguta</i> ^z	362.18 ± 19.87	Cherry ^y	114.56 ± 4.72
Apple (green delicious) ^y	68.29 ± 2.12	Banana (royal) ^y	25.55 ± 0.60
Avocado ^y	21.86 ± 1.25	Pineapple ^y	94.04 ± 1.47
Blueberry ^y	46.24 ± 2.03	Papaya ^y	27.52 ± 2.48
Grapefruit ^y	60.35 ± 3.68	Plum (red) ^y	73.04 ± 5.63
Lemon ^y	61.47 ± 0.57	Mango (Hainan) ^y	35.02 ± 1.43
Peach ^y	27.58 ± 1.57	Orange (South Africa) ^y	77.23 ± 0.08

^zZuo et al. (2012)

^yFu et al. (2011)

^xFW: fresh weight; GAE: gallic acid equivalent; ± standard deviation

as well as protect against certain types of cancer and reduce the risk of diabetes (Kamiloglu et al. 2015).

As indicated by various authors, the content of polyphenols in *A. arguta* fruit is very variable and largely dependent on variety and genotype (Latocha et al. 2010), as well storage conditions (Krupa et al. 2011). The total content of polyphenols in these fruits according to Latocha et al. (2010) was 79 mg 100 g⁻¹ FW, whereas Wang (2013) found that the polyphenol content could be almost three times higher (214.8 mg 100 g⁻¹ FW). Zuo et al. (2012) in turn showed that *A. kolomikta* fruit can contain up to 430 mg 100 g⁻¹ FW, while in *A. arguta* fruit it was greater than 360 mg 100 g⁻¹ FW (Table 1). The consumption of *Actinidia* fruit with peel can have better health effects, as the skin was found to have a 15 times higher concentration of phenolic compounds compared to fruit pulp (Table 2). Also, Latocha et al. (2015) showed significantly higher content of phenolic compounds in the skin than in the flesh of all studied varieties of *A. arguta*. According to the authors, the content of polyphenols in the peel and flesh ranged from 91.0 to 332.9 mg

Table 2 Total content of phenolic compounds in different fruit parts (mg 100 g⁻¹ FW^z) (Kim et al. 2009)

Fruit	Skin	Flesh
<i>Actinidia arguta</i>	2660	180
Apple	300–600	30–100
Peach	50–120	20–60

^zFW: fresh weight

gallic acid equivalents (GAE) 100 g⁻¹ FW and from 16.9 to 28.6 mg GAE 100 g⁻¹ FW, respectively.

According to Latocha and Olszewska-Kaczyńska (2003), the content of flavonoids in *A. arguta* fruit can vary from 20 to 30 mg 100 g⁻¹ FW. Leontowicz et al. (2016a, b) showed that the contents of anthocyanins belonging to the flavonoid group ranged from 0.72 mg 100 g⁻¹ FW ('Weiki') to 7.2 mg 100 g⁻¹ FW ('Jumbo') in varieties of *A. arguta* and was similar to the content of these compounds in apples, avocados, or bananas (Kruger et al. 2014). According to

Wojdyło et al. (2017), the total content of phenolic compounds ranged from 2443.30 to 6679.18 mg 100 g⁻¹ of dry matter ('Jumbo' and 'Ananasnaja', respectively).

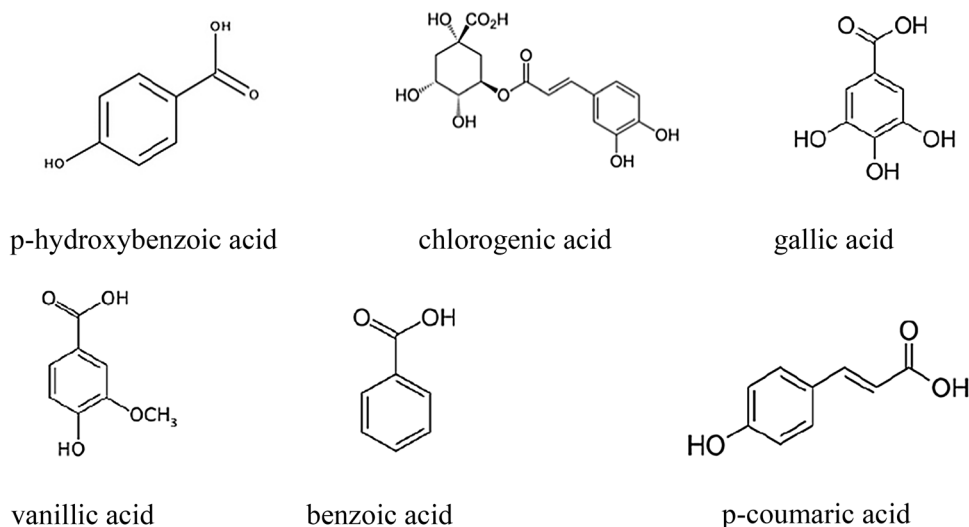
Many individual polyphenolic compounds contained in *A. arguta* fruit have been identified. Krupa and Latocha (2007) detected the presence of p-hydroxybenzoic acid, chlorogenic acid, gallic acid, vanillic acid, benzoic acid, p-coumaric acid, and L-epicatechin in the fruit of *Actinidia* and its hybrids (Fig. 3). Lim et al. (2006) isolated various compounds from *A. arguta* fruit: protocatechuic acid, caffeic acid, β-D-glucopyranoside, aesculin, coumarin, and three flavonoids (quercetin, quercetin 3-O-P-D-galactopyranoside, and quercetin 3-O-α-rhamnopyranosyl (1 → 6)-O-β-D-glucopyranoside). In five varieties of *A. arguta* ('Ananasnaja', 'Geneva', 'Weiki', 'Issai', and 'Jumbo') and two of its crosses ('Bingo' and 'Ken's Red'), Wojdyło et al. (2017) identified 23 polyphenolic compounds: quercetin-3-O-rutinoside-7-O-glucoside, quercetin-3-O-galactoside, quercetin-3-O-rutinoside-7-O-rhamnoside, quercetin-3-O-rutinoside, quercetin-3-O-glucoside, quercetin-3-O-hexose, kaempferol-3-O-rutinoside, quercetin-3-O-acetyl-rhamnoside-(1 → 6)-galactoside, kaempferol-3-O-galactoside, quercetin-3-O-acetyl-galactoside, quercetin-3-O-acetyl-rhamnoside-(1 → 6)-glucoside, kaempferol-3-O-glucoside, kaempferol-3-O-acetyl-rhamnoside-(1 → 6)-galactoside, quercetin-3-O-acetyl-rutinoside, kaempferol-3-O-acetyl-glucoside, kaempferol-3-O-acetyl-rhamnoside-(1 → 6)-glucoside, p-coumaroylquinic acid, caffeoyl-hexose, neochlorogenic acid, chlorogenic acid, cryptochlorogenic acid, trans-p-coumaroylquinic acid, and cyanidin 3-O-sambubioside. Montefiori et al. (2009) defined the positive correlation of kiwifruit color with anthocyanin content (calculated as cyanidin and delphinidin). Of the varieties tested, 'Purpura' not only exhibited the greatest diversity of anthocyanins but also the highest contents (2.61 to 206.09 μg g⁻¹ FW).

Anti-inflammatory, antioxidant, antiatherosclerotic, normalizing blood plasma, anti-allergic, and anti-edematous activities are associated with the presence of polyphenolic compounds (apart from other antioxidants present in the fruit of *A. arguta*) (Haminiuk et al. 2012; Santhakumar et al. 2018). Fruits also exhibit antiviral and antifungal properties, as well as lowering plasma cholesterol levels and anti-asthmatic effects (Ganesan and Xu 2017). The consequence is the limitation of diseases in which oxidative stress and inflammation play an important role.

Anthocyanins block the cell cycle in various stages of tumor growth mainly due to the high antioxidant activity of anthocyanin-rich fruit extracts (Jing et al. 2008; Dai et al. 2009; de las Hazas et al. 2016). For example, Zuo et al. (2012) combined the high content of phenolic compounds and flavonoids in anthocyanin-rich kiwifruit with the antiproliferative effect of fruit extracts on human cancer cells (e.g., HepG2 and HT-29). Also, Zuo et al. (2012) demonstrated that the extract of some kiwi varieties inhibited proliferation of human HepG2 and HT-29 tumor cells. The authors stated that the *A. arguta* extract exhibited a higher antiproliferative activity towards HT-29 and CaCo-2 cells compared to *A. chinensis* and *A. kolomikta*, which can be partially attributed to the high antioxidant activity of *A. arguta*.

Other researchers have shown that *A. arguta* extract prepared with n-butyl alcohol effectively inhibited the growth of human esophageal cancer cells Eca-109 (Zhang et al. 2007; Guo et al. 2011). Recent studies have shown that extracts may inhibit the proliferation of A549 cells (lung cancer) during the G0-G1 stage and significantly reduce the percentage of living cells in the S-stage (Wang et al. 2010). Cyboran-Mikołajczyk et al. (2018) found that *A. arguta* leaf extract prevented diseases associated with oxidative stress. Ingredients in the extract protected against oxidative damage

Fig. 3 Structural formulae of selected phenolic acids present in *A. arguta* fruit



in mouse erythrocytes. The extract had little effect on the size and grading of follicular lymphoma in mice and did not affect its resistance to drugs (Cyboran-Mikołajczyk et al. 2018).

Some studies also suggest the beneficial effect of consuming *A. arguta* fruit on blood cholesterol levels (Leontowicz et al. 2014, 2016b). Per the study of Leontowicz et al. (2014), involving a group of 36 rats fed with lyophilized fruit (5%) for six weeks, proper cholesterol levels in the blood plasma were maintained even though animals were regularly administered with cholesterol (1%). A significant improvement in blood lipid profile was demonstrated by decreased total cholesterol, LDL cholesterol, and triglycerides, and increased HDL-cholesterol levels. In another study, Leontowicz et al. (2016b) compared the health effects of *A. arguta* cultivated in Poland with those of Asian varieties: ‘Hayward’ and ‘Bidan’, by evaluating selected metabolic markers in rats. For 42 days, the researchers administered 1% cholesterol and 5% mixed varieties of *A. arguta* supplemented with 1% cholesterol to 71 ‘Wistar’ male rats. Their study showed an increase in total antioxidant activity of the rats’ blood plasma (methods using 2,2-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid)—ABTS, Ferric-reducing/antioxidant power—FRAP, 1,1-diphenyl-2-picrylhydrazyl—DPPH) and normalization of ALP (Alkaline phosphatase) in animals fed a diet supplemented with lyophilized kiwifruit, compared to the group of cholesterol-fed animals without fruit.

Various studies have shown that *A. arguta* fruits have an antidiabetic effect. Kurakane et al. (2011) demonstrated that *A. arguta* fruit can inhibit α -glucosidase activity and/or glucose uptake by inhibiting maltase activity, resulting in lowered blood glucose concentrations in mice and rats. This suggests the antidiabetic effect of the ingredients present in the *A. arguta* fruit.

In studies involving rats’ cortical neurons, Cho et al. (2012) found that ethanol leaf extract and *A. arguta* stems inhibited glutamate-induced neuronal death. The results suggest that the extract from these fruits can play a therapeutic role in the prevention of neurodegeneration in ischemic brain disease.

Several studies have shown that a water-soluble *A. arguta* extract called PG102 may be an effective therapeutic agent for treating atopic dermatitis (Park et al. 2007; Lee et al. 2015; Bae et al. 2016). Similar studies on dogs were conducted by Ho et al. (2009). Another study conducted on 16 rats showed that kiwifruit had a positive effect on wound healing (Mohajeri et al. 2010). The fruit greatly accelerated the healing of wounds and ulcers, indicating it could help with burns and bed sores (Mohajeri et al. 2010). Park et al. (2011) isolated linoleic and α -linolenic acids, as well as ethyl linoleate, from *A. arguta* dried fruits to test their anti-allergic effect. These compounds have been found to be potent inhibitors of the induction of Calimycin (A23187)-induced

IL-4 production in rats’ basophilic leukemia cells (RBL-2H3), and thus act as anti-allergens.

6 Alkaloids

Liu and Liu (2016) extracted a mixture of alkaloids from *A. arguta* fruit. The authors reported the total content of extracted alkaloids in the obtained formulation was equal to 77.6%. However, no estimate of the total alkaloid content in the tested fruit, or no information on the structure of individual alkaloids in the formulation, was provided in this paper. However, alkaloids isolated from *A. arguta* fruit in the work of Liu and Liu (2016) elevated mice ‘endurance to exercise’. This suggests that *A. arguta* fruit can be used to formulate consumer-specific dietary supplements (e.g., people performing high-intensity work, competitive sports, or intense physical activity). Further qualitative and quantitative analyses of the alkaloids present in *A. arguta* fruit, as well as the detailed role of these compounds in the human body, should be considered.

7 Carotenoids

Carotenoids, being very effective lipophilic antioxidants, have a high activity against reactive oxygen species and free radicals. Thanks to these properties, they protect against many diseases, among which the most serious are cancers and atherosclerosis (Rao and Rao 2007). These compounds are often used to color food products to obtain yellow to red. Oftentimes, they are used in vegetable dyes, in addition to anthocyanins, in the food industry (Castaneda-Ovando et al. 2009). *A. arguta* fruit contains primarily xanthophyll, carotenes, lutein, and zeaxanthin (Fig. 4). The content of these compounds depends on the variety: lutein content may range from $3.98 \mu\text{g g}^{-1}$ in ‘Bingo’ to $11.61 \mu\text{g g}^{-1}$ in ‘Weik’ (Table 3).

Studies have shown that *A. arguta* fruits contain far more lutein than other fruits (Kim et al. 2009). The popular variety ‘Hayward’ (*A. deliciosa*) contains twice less lutein

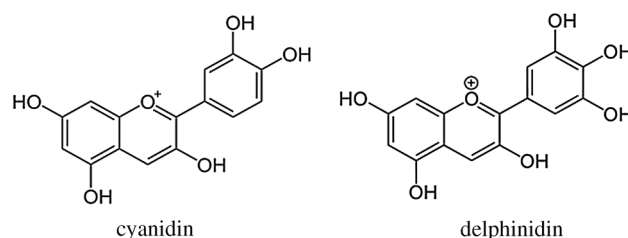
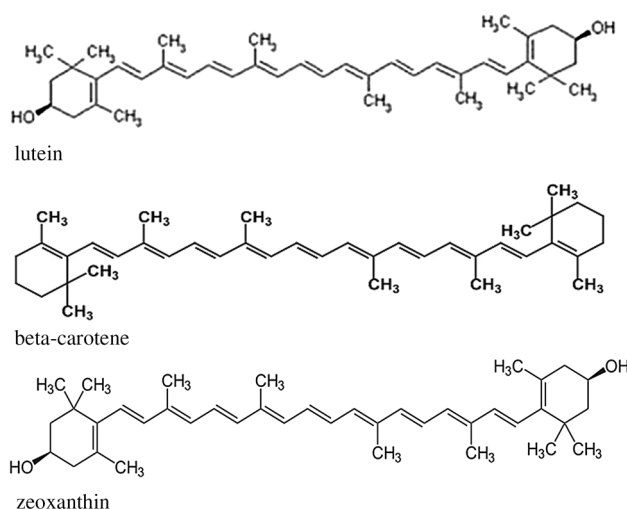


Fig. 4 Structural formulae of some anthocyanins present in *A. arguta* fruit

Table 3 The content of selected carotenoids in selected mini kiwi (*Actinidia arguta*) and *Actinidia deliciosa* (Hayward) fruits ($\mu\text{g g}^{-1}$ DW^z) (Leontowicz et al. 2016b)

Kiwifruit	Lutein	Zeaxanthin	Xanto- phylls + caro- tenes
'Bingo' (<i>A. arguta</i>)	3.98 ± 0.04	0.26 ± 0.07	38.0 ± 3.54
'M1' (<i>A. arguta</i>)	5.44 ± 0.67	0.21 ± 0.06	38.0 ± 3.43
'Anna' (<i>A. arguta</i>)	7.01 ± 0.31	0.24 ± 0.03	46.0 ± 3.87
'Weik' (<i>A. arguta</i>)	11.61 ± 0.96	0.57 ± 0.11	59.0 ± 4.62
'Jumbo' (<i>A. arguta</i>)	8.58 ± 0.47	1.03 ± 0.06	58.0 ± 5.43
'Geneva' (<i>A. arguta</i>)	8.30 ± 0.74	0.58 ± 0.26	46.0 ± 4.18
'Hayward' (<i>A. deliciosa</i>)	6.73 ± 0.67	n.d. ^y	30.0 ± 2.18

^zDW: dry weight; $\pm$ standard deviation^yn.d.: not detected**Fig. 5** Structural formulae of carotenoids present in *A. arguta* fruit

(0.418 mg 100 g⁻¹ FW) than the other five varieties of *A. arguta* ('Hirano', 'Gassan', 'Issai', 'Mitsuko', and 'Ananasnaya') (0.746–0.933 mg 100 g⁻¹ FW) (Nishiyama et al. 2005). The high content of β -carotene in *A. arguta* fruits, along with the high lutein content, can have a beneficial effect on the human eye. Based on a US study, it was found that consumption of 4 mg lutein per day resulted in improved visual acuity in patients with macular degeneration (Bernstein et al. 2001) (Fig. 5).

8 Fiber fractions

The fiber and raw fiber, differentiated in terms of structure and physical and chemical properties, are non-starch carbohydrates that are valuable plant components. Compared with other fruits, *A. arguta* fruit is a rich source of dietary fiber

Table 4 Dietary fiber content in selected fruits and berries (g kg⁻¹ DW^z) (Park et al. 2015)

Fruit	Dietary fiber
Apple	12.2 ± 1.1
Banana	15.5 ± 1.4
Strawberry	20.7 ± 2.1
Kiwi (<i>Actinidia deliciosa</i>)	24.7 ± 2.2
Mango	12.9 ± 1.0
Orange	13.0 ± 1.1
Peach	20.7 ± 2.1
Orange	13.0 ± 1.1
Red grapefruit	13.2 ± 1.1
Red plum	22.2 ± 2.1
White grape	13.2 ± 1.1

^zDW: dry weight; $\pm$ standard deviation**Table 5** Total content of dietary fiber and its fractions (% DW^z) (Leontowicz et al. 2016b)

Kiwifruit	Total	Insoluble	Soluble
'Bingo' (<i>A. arguta</i>)	25.86 ± 0.07	20.43 ± 0.06	5.43 ± 0.0
'M1' (<i>A. arguta</i>)	27.11 ± 0.01	21.40 ± 0.06	5.71 ± 0.04
'Anna' (<i>A. arguta</i>)	24.75 ± 0.01	18.26 ± 0.07	$6.50 \pm 0.07a$
'Weik' (<i>A. arguta</i>)	24.58 ± 0.01	17.61 ± 0.13	6.97 ± 0.13
'Jumbo' (<i>A. arguta</i>)	19.78 ± 0.08	14.02 ± 0.01	5.76 ± 0.09
'Geneva' (<i>A. arguta</i>)	19.86 ± 0.14	14.09 ± 0.14	5.77 ± 0.01
'Hayward' (<i>A. deliciosa</i>)	12.09 ± 0.04	6.97 ± 0.13	5.12 ± 0.09

^zDW: dry weight; $\pm$ standard deviation

(Table 4). In kiwi, the main source of dietary fiber is cellulose, polysaccharides, pectins, hemicelluloses, glucuronoxylans, and xyloglucans. The kiwi variety 'Hayward' was characterized by significant lignin content, but the authors did not provide a numerical value (Hunter et al. 2010).

According to Leontowicz et al. (2016b), all varieties of *A. arguta* are characterized by high fiber content, especially its insoluble fraction, which has a significant influence on the normalization of intestinal motility (Table 5). The presence of fine seeds rich in dietary fiber is beneficial for the digestive system, favoring better digestion and decreasing the risk of constipation (Nishiyama et al. 2004a, b). It also alleviates and helps in diarrhea, as it stimulates intestinal receptors, leading to increased intestinal peristalsis (Udani and Bloom 2013). Chang et al. (2010) conducted studies in patients with irritable bowel syndrome. Forty-five patients were given two kiwis (*A. deliciosa*) daily for four weeks, while 15 patients and 16 healthy subjects were given two capsules per day containing 0.7 g glucose. At the end of the experiment, the patients given kiwis showed an increased frequency of stool deposition and improvement in bowel

function. Similar results were found by Rush et al. (2006) in a group of 38 patients consuming one kiwi per day for three weeks.

9 Enzymes

Among the interesting proteins contained in the *A. arguta* fruit, actinidain (cysteine protease) is noteworthy. This enzyme facilitates the digestion of proteins in the digestive tract (Rush et al. 2006). In vitro studies (Kaur et al. 2010), as well as studies involving rats (Montoya et al. 2014), have shown that the enzyme supports digestion of proteins present in bovine, zein, gluten, and soy protein isolate.

Actinidain can act on the body adversely, causing an allergic reaction (Pastorello et al. 1997). There is usually a syndrome of oral allergies in the form of itching and swelling of the tongue, throat, and mouth (Guo et al. 2011; Maddumage et al. 2013). Symptoms may be accompanied by itching of the eyes and ears. Skin lesions in the form of acute urticaria, contact urticaria, atopic dermatitis, and contact dermatitis have also been observed (Gawrońska-Ukleja et al. 2012). In addition to actinidain, two other allergenic proteins have been identified in kiwifruit: thaumatin and kiwellin (Gawrońska-Ukleja et al. 2012). Thaumatin is responsible for cross reactions with mold spores and mite allergens (Balińska-Miśkiewicz 2014). Kiwellin is a protein rich in cysteine that is found in the edible part of the fruit and is associated with the cell wall (Hamiaux et al. 2014); it accounts for 20–30% of the total soluble protein in kiwifruit (Boland 2013). It is subject to endoproteolytic processing by actinidain, resulting in a peptide of approximately 4 kDa (Bublin 2013). Kiwellin was also identified at high concentrations in the gold kiwifruit (*A. chinensis*), showing IgE binding capacity similar to that reported in the green kiwi (*A. deliciosa*) (Tuppo et al. 2008; Maddumage et al. 2013). The content and activity of the discussed proteins differ according to the variety of *A. arguta* fruit (Nishiyama et al. 2004b; Gawrońska-Ukleja et al. 2012), so further studies on these allergens are required.

10 Conclusions

Actinidia arguta fruit is becoming increasingly popular and is being consumed more in Poland and in other European countries. Both the health benefits of this fruit and the ease of cultivation of some varieties (resistance to low temperatures) contribute to this. *A. arguta* fruit contains many active substances with an antioxidant effect, so their consumption can reduce the risk of many diseases, including dangerous, mortal diseases of the blood system or cancer. The high content of polyphenols and vitamin C in the fruit of *A. arguta*

affects the immune system by reducing the risk of colds due to its anti-inflammatory effect, while the content of specific enzyme proteins aids digestion. With its high fiber content, the consumption of *A. arguta* fruit normalizes intestinal peristalsis and promotes the regulation of metabolism.

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