Scientific Papers. Series B, Horticulture. Vol. LXV, No. 2, 2021
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

KIWIFRUIT PROCESSING. A REVIEW

Elena Gabriela STAN[1], Lavinia Mihaela ILIESCU[1, 2], Florin STĂNICĂ[1, 2]

[1]Faculty of Horticulture, University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăști Blvd, 011464, Bucharest, Romania
[2]Research Center for Studies of Food Quality and Agricultural Products, University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăști Blvd, 011464, Bucharest, Romania

Corresponding author email: iliescu_lavinia@yahoo.com

Abstract

Kiwifruit (Actinidia sp.) is native to Asia and the first commercial plantations were established in New Zealand, in the early twentieth century. In our country, the first commercial orchard was planted at Ostrov Agricultural State Enterprise (CT) in 1993, by the efforts of Nicolae Cepoiu, Corneliu Petrescu and Florin Stănică. Kiwifruit has become popular worldwide for fresh consumption due to its high sensory and nutritional properties. It contains high levels of bioactive compounds such as vitamin C, vitamin E, flavonoids, antioxidants, carotenoids, minerals and fibbers. Being cultivated both in North and South hemisphere, and having a good storage life (over 6 months), fresh fruits are available through the year. Even so, kiwifruit is largely processed as juices, nectars, syrups, alcoholic drinks (cider, liqueur, brandy), candies and fruit bars, jam and marmalade, patisseries (cakes, cookies), dehydrated and lyophilized products. The aim of this paper is to present a review of the main processing possibilities for kiwifruit.

Key words*: Actinidia sp., benefits, fruits products, nutritional properties.*

INTRODUCTION

Kiwifruit is botanically known as *Actinidia deliciosa* (Beutel et al., 1990). Also known as 'China's miracle fruit', 'the horticultural wonder of New Zealand' and 'Chinese gooseberry (Nirmal et al., 2018; Iliescu et al., 2019).

This species was first found along the border of the Yangtse River valley in China and later, in 1847 and 1904, the first plants were sent to England and United States, respectively (Yerex et al., 1983).

Kiwifruit is an example of recent success in the domestication and commercialisation of a plant for food (Young et al., 1995).

According to official records, the major centre of diversity for *Actinidia* genus is the hilly region of South-Western China (Litz 2005; Nirmal et al., 2018; Stănică et Zuccherelli, 2009), but the first commercial orchards were established in New Zealand (Ferguson and Bollard, 1990; Warrington, 1990; Young et al., 1995) in 1950's (Barboni et al., 2010; Iliescu et al., 2019).

The expansion of this species throughout the world began to take place in the 1960s with the export of New Zealand plants and seeds to destinations such as Germany, Italy, Spain, India, South America, Morocco, Israel and South Africa (Yerex et al., 1983; Pinto T., 2018).

By the 1980's, other countries around the world began to produce and export kiwi.

At present, commercial growth of the fruit has spread too many countries including the United States, Italy, Chile, France, Greece, India and Japan. (FAO., 2018; Teresa Pinto, 2018).

In Romania, the first commercial orchard was planted at Ostrov Agricultural State Enterprise (CT) in 1993, by the efforts of Nicolae Cepoiu, Corneliu Petrescu and Florin Stănică, on an area of 2 ha. Hayward, Kramer, Katiuscia, Tomuri cultivars and three new selections obtained by Vitroplant Cesena: AD 20, AD 24 and AD 25 were planted (Stănică, 2009; Stănică et Zuccherelli, 2007).

MATERIALS AND METHODS

Nutritional value

This new fruit is considered a superfood and is widespread throughout the world, due to his high nutritional value characteristic flavour and high antioxidant and anti-inflammatory properties (Sanz et al., 2020).

Kiwifruit are some of the most nutrient-dense fruit and compared with other commonly consumed fruit, are particularly rich in vitamins C, E, and K, folate, carotenoids, potassium, fibre, 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 (Scăeţeanu et al., 2019).

In addition, kiwifruit have been shown to be a significantly better delivery vehicle for replenishing depleted vitamin C at 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 (Scăeţeanu et al., 2019).

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 two fat-soluble vitamins, vitamin E and vitamin K (as phylloquinone).

Kiwifruit compares 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. (2009b) 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. (Scăeţeanu et al., 2019).

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 contains 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 (Welma et al., 2012).

According to the Institute of Medicine, the recommended daily fibre intake for adults is 25 grams for women and 38 grams for men (Anderson et al., 2009; Lindsey et al., 2020).

However, average fibre intake for US children and adults are less than half of the recommended levels (Wong et al., 2007).

Table 1. Nutritional references for 100 g fresh fruit for the main species of *Actinidia*

Nutritional value per 100 g	UM*	*A. deliciosa*	*A. chinensis*	*A. arguta*
Energy	kcal	61 [22]	63 [22]	32 [11]
Water	g	83,1 [22]	82,4 [22]	88,0 [11]
Carbohydrates	g	14,66 [22]	14,23 [22]	9,20 [11]
Sugars	g	8,99 [21]	10,98 [21]	3,9-9,6 [1; 3; 24; 17]
Protein	g	1,14 [5]	1,23 [5]	1,70 [11]
Fiber	g	2,13-3,39 [15; 19]	2,0 [19]	2,9-4,1 [14]
Saturated fats	g	0,029 [8]	0,149 [8]	13.90-30.50 [10; 14]
Vitamins				
Vitamin A	µg	87,0 [22]	23,0 [22]	37,3-84,5 [12]
Thiamine (B1)	mg	0.027 [22]	<0.01 [22]	0,01-0,05 [9; 10; 7;17]
Riboflavin (B2)	mg	0.025 [22]	0.074 [22]	0,02-0,11 [9; 10; 7; 17]
Niacin (B3)	mg	0.341 [22]	0.231 [22]	0,50-1,55 [9; 10; 7; 17]
Vitamin B6	mg	0.63 [22]	0.079 [22]	1,10-1,90 [9; 10; 7; 17]
Vitamin C	mg	92,7 [4; 16; 21; 23]	105,4 [4; 16; 21; 23]	22,8-43,0 [16; 17; 25]
Vitamin E	mg	1,46 [4; 21; 23]	1,49 [4; 21; 23]	4.6–5.3 [6]
B9 (Folic acid)	µg	25 [22] - 29 [4; 21; 23]	34 [22]	-
Minerals				
Magnesium, Mg	mg	17[22]	12.0 [22]	10,0-23.2 [5; 20]
Phosphorus, P	mg	34 [22]	25 [22]	31,7-80,2 [5; 20]
Potassium, K	mg	300 [5; 21]	250-400 [18]	162,7-382 [5; 20]
Calcium, Ca	mg	34 [22]	17.0 [22]	51,5-120,1 [5; 20]
Copper, Cu	mg	0.13 [22]	0.15 [22]	0,05-0,16 [1 a,b; 13]
Iron, Fe	mg	0.31 [22]	0.21 [22]	0,31-1,15 [1 a,b; 13]
Zinc, Zn	mg	0.14 [22]	0.08 [22]	0,18-1,45 [1; 13]
Source				

[1] Bieniek, 2012a; [2] Bieniek, 2012b; [3] Boyes et al., 1996; [4] Chew et al., 2012; [5] Drummond, 2013; [6] Ferguson et Ferguson., 2003; [7] Gan et al., 2004; [8] Henare, 2016; [9] Jiang, 2011; [10] Jin et al., 2014; [11] Jo et al., 2007; [12] Kim et al., 2014; [13] Latocha et al., 2015; [14] Latocha, 2017; [15] Lintas et al., 1991; [16] Nishiyama et al., 2004; [17] Nishiyama et al., 2008; [18] Samadi-Maybodi et Reza Shariat, 2003; [19] Schakel et al. 2001; [20] Sivakumaran et col., 2016; [21] Stonehouse et col., 2013; [22] US Department of Agriculture, 2019; [23] Vasile Scăeţeanu et al., 2019; [24] Wojdyło et al., 2017; [25] Xiao, 1999.

Kiwifruit is known to contain approximately 2% to 3% dietary fibre comprised of one-third soluble fiber and two thirds insoluble fibre (Mishra et al., 2012; Lindsey et al., 2020). Nutritional references of kiwifruit is summarized in Table 1.

This makes kiwifruit a premier choice for anyone looking to live a healthier life or even simply bolster their immune system.

Health benefits of kiwifruit consumption

Food scientists and nutrition specialists agree that fruits and vegetables, consumed daily, contribute to reducing risks of certain diseases, including cancer and cardio and cerebro-vascular diseases (Liu et al., 2000).

The various antioxidants (polyphenol, ascorbic acid, carotenoids, and tocopherols) present in fruits and vegetables contribute to these beneficial effects (Peschel et al., 2006).

Recent studies also have confirmed the health benefits associated with its consumption (Baranowska-Wojcik´ et Szwajgier, 2019; Lopez-Sobaler´et al., 2016). Antioxidants contained in kiwifruit reduce oxidative stress and support the cardiovascular system (Leontowicz et al., 2016). In addition to its low caloric content, wealth of vitamins and its high phenolic content (Baranowska-Wojcik´ and Szwajgier, 2019) provide protection against heart diseases, cancer, diabetes, vascular diseases and central nervous system diseases (Tyagi et al., 2017), making this fruit a valuable component of a healthy diet and may also be used as a dietary supplement (Baranowska-Wojcik´and Szwajgier, 2019; Sanz et al., 2020).

As a source of ascorbic acid and polyphenols, the kiwifruit aids in lowering the risk of arteriosclerosis, cardiovascular diseases, and some forms of cancer (Puri et al., 2018) in irritable bowel syndrome (Chang et al., 2010) and also protect the cells *in vitro* from oxidative DNA damage (Teresa., 2018).

There is growing evidence that kiwifruit have beneficial effects on digestive health and general wellbeing, a potentially important characteristic in the light of the increasing proportion of the elderly population in ageing societies that experience impaired bowel function, changes in gastrointestinal function and gastrointestinal discomfort (Donaldson et al., 2018).

A consumption of kiwifruit plays a protective role against reactive oxygen species (ROS) due to the presence of great content of antioxidants (Duo et al., 2009; Skinner et al., 2013), enhance iron retention (Stonehouse et al., 2013), have beneficial effects on digestion (Lintas et al., 1991) and may decrease cardiovascular disease incidence (Stonehouse et al., 2013; Scăeţeanu et al., 2019).

Kiwifruit have also been proposed to decrease gastric symptoms of indigestion such as bloating (Chan et al., 2007).

Kiwifruit have been shown to relieve constipation in several clinical trials (Eady et al., 2019; Chan et al., 2007; Barbara et al., 2005).

The laxative effect of kiwifruit has been attributed to its fibre content, which is approximately 2-3% of its dry weight.

As described earlier, the fibre content of kiwifruit is approximately two-thirds insoluble and one third soluble fibre (Mishra et al., 2012; Lindsey et al., 2020).

Allergens

Although the popularity of kiwifruit is constantly growing due to its pleasant taste, low caloric value and beneficial effects on health, there are also some contra-indications addressed especially to people who are more sensitive, allergic or intolerant to some fruit compounds (Lucas et al., 2003; Vasile Scăeţeanu et al., 2019).

According to some studies, people who are allergic to birch pollen are also allergic to kiwi (Eriksson et al., 2003); and approximately 12-17% of people allergic to natural rubber latex may develop an allergy to kiwifruit (Kim and Hussain, 1999; Lucas et al., 2003).

The main allergens identified in kiwifruit are actinidine (Act d 1), protein kiwellin (Act d 5), thaumatin-like proteins (Act d 2) and oxalates (Bublin et al., 2004; Hassan and Venkatesh, 2015; Henare, 2016; Maddumage et al., 2013; Nguyen, 2012).

Most patients with allergic reactions to kiwifruit experience localized symptoms of irritation and discomfort in the oral mucosa, but more severe systemic reactions such as rash, redness, and hives have also been observed (Ferguson et al., 2003; Lucas et al., 2007; Lucas et al., 2014; Nishiyama et al., 2004;

Pastorello et al., 1998; Popovic et al., 2013). Most allergic symptoms occur within minutes of eating kiwi fruit (Bublin, 2013).

Some studies (Watanabe and Takahashi, 1998) have shown that *A. arguta* fruits have a lower oxalate content than those of *A. deliciosa* species.

According to Chen et al. (2006), thermal processing reduces the risk of causing allergic reactions in people who are sensitive or intolerant to the consumption of fresh kiwi.

Storage possibilities

Being cultivated both in North and South hemisphere and having a good storage life (over 6 months), fresh fruits are available through the year when harvested at correct maturity and at optimal storage conditions (temperature, gas composition, relative humidity, ethylene concentration). In Figure 2. processing possibilities of kiwifruit can be observed.

Kiwifruits that are intended for sale within 3-4 months are stored under normal atmospheres (Brigati and Donati, 2003), whereas fruits that are to be kept for longer times are stored under modified atmospheres. Earlier MAP with 3% O_2 and 3% CO_2 was used, but afterwards oxygen concentrations reduced and CO_2 concentrations were increased owing to the reason that higher CO_2 concentrations reduce fruit respiration and hence ripening (Sozzi et al., 1980).

Presently kiwifruits are stored under 4.5% to 5.0% CO_2 and 1.8% to 2.0% O_2 in CA storage (Brigati and Donati, 2003). ULO (Ultra Low Oxygen) technique have also been used but it did not seem to be suitable for kiwifruit as it results in development of off-flavours and thus reduced storage life (Brigati and Donati, 2003).

Within cool storage relative humidity is maintained above 94% to 95% that helps to reduce weight loss by 2% to 7% (Nardin and Galliano, 1988).

Kiwifruits are sensitive to ethylene and concentrations as low as 0.1-1.0 ppm can induce softening (Monzini and Gorini, 1986). In cool storage, ethylene concentrations are kept below 0.05 ppm in order to prevent softening (Guroo et al., 2017).

Processing

Kiwifruits are mostly eaten fresh, although some kiwifruits are also processed into juices, alcoholic beverages (cider, liqueur, brandy), purees, candied fruit and bars, jam and marmalade, dehydrated and lyophilized products, cakes or pastries, kiwifruit leathers (Cassano et al., 2007; Guroo et al., 2017). In Figure 2, processing possibilities of kiwifruit can be observed.

The freeze-drying process, using lower temperatures and reduced pressure, is more expensive, but allows a much better retention of bioactive ingredients (Morais et al., 2018; Tylewic et al., 2020).

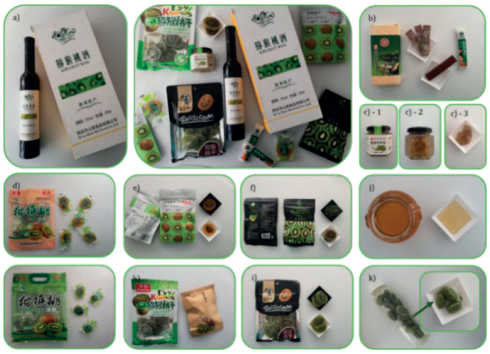
Actinidia deliciosa - the green kiwifruit is not usually processed due to the fact that the chlorophyll responsible for the attractive green colour gets destroyed during processing (Torreggiani et al., 1994).

Also, the characteristic flavour of green kiwifruit gets lost. *Actinidia chinensis* - the golden kiwifruit has become an alternative to food processors. In terms of processing, 'Jintao' variety has shown good results, the yellow colour of the fruit survives well in processed products like juices and jams (Guroo et al., 2017).

However, high prices currently fetched by yellow-fleshed kiwifruit reduces the processing options. For the fruits that do not meet quality standards of the fresh fruit market, processing can be an alternative for adding value to the product.

Small quantities of fruit that do not meet grade standards are used for cosmetics or nutraceuticals (Guroo et al., 2017).

Although in our country the foods based on kiwi fruit are quite few, worldwide the range of commercial products is very wide. In Figure 1 some of the products found on the shelves of Chinese stores are presented: a) kiwi cider; b) bars and jellies; c) 1-3 jam; d) - i) candied or dehydrated fruits; j) kiwi honey; k) lyophilized fruits.



Source: Lavinia Iliescu, 2019

Figure 1. Kiwifruit products, China 2019

The fruits of *Actinidia deliciosa* are less used in the production of products, such as juices or jams, than those of Actinidia chinensis, due to chlorophyll, which is destroyed during processing (Torreggiani et al., 1994).

Guine and Seabra (2017), created two types of kiwi-based nutritional bars (plain and walnut) and analysed consumer preferences. They capitalized on the pulp of kiwi fruit not in accordance with marketing and consumption fresh (in terms of shape and size).

To evaluate the sensory profile, the following attributes were analyzed on a 5-point hedonic scale: consistency, texture, intensity of kiwi flavor, kiwi taste, acidity, sweet taste and homogeneity.

A preference test was also performed to identify the preferred sample of consumers. The conclusions of the study were - simple kiwi bars were much more appreciated, especially in terms of color, consistency, texture and homogeneity (Guinea and Seabra, 2017).

In order to assess the sensory properties of some dehydrated kiwi fruits, at different temperatures (50°C, 60°C, 70°C and 80°C), descriptive sensory profile tests were performed, the evaluated sensory attributes being: colour intensity, aroma intensity, sweet taste, sour taste and bitter taste, texture, general appearance (Correia et al., 2017). Chakraborty et al. (2020), using a hedonic scale of 9 points, determined the degree of consumer acceptance for freeze-dried kiwi fruit and obtained the following results: for sweet taste an acceptance rate of 68.18%, for sour taste - 90.91%, salty taste - 100%, bitter taste - 100%, aroma - 95.45%, texture - 77.27% and for the overall impression - 81.82%.

Hussein et al. (2017) analyses consumers' perception of natural kiwi juice, which can be considered a functional drink, due to its high content of antioxidants and vitamins. Consumer preferences on the colour, taste, aroma and overall appearance of natural kiwi juice indicate the possibility of widespread marketing of this product.

For kiwi products such as jams, marmalades, jams, the combination with other types of fruit can improve the colour and flavour of dishes.

In studies on consumer perception, Reddy et al. (2015), analysed parameters such as - general appearance, taste, aroma, texture, colour, consistency, aftertaste, overall acceptability.

Regarding the drinks obtained from kiwifruit, Hande and Chavan (2019) mentioned in their study some results on consumer preferences regarding colour, appearance, consistency, aroma and overall appreciation of products.

A major impact on consumers' perception of products is also the packaging or the form of presentation, which can influence the association between colour and flavour (Wan et al., 2014).

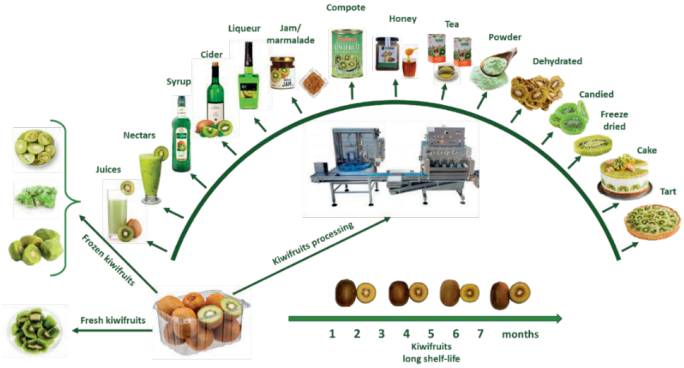


Figure 2. Processing possibilities of kiwifruit

According to Soufleros et al. (2001), the sensory evaluation of kiwi wines and the statistical analysis of the results showed that: the sweetness is significantly affected only by the amount of sugars, while the role of alcohol is marginal. Sensory alcohol is significantly influenced by sugars, alcohol and CO2, while carbon dioxide, viewed as a sensory indicator, was not found to be statistically influenced by any chemical factor examined.
The conclusions of the studies showed that the acceptability of kiwi wines is higher if they contain 10% vol. alcohol, more than 30 g/l sugars and 0.5 bar CO_2 (Soufleros et al., 2001).

CONCLUSIONS

Kiwifruit contains high levels of bioactive compounds such as vitamin C, vitamin E, flavonoids, antioxidants, carotenoids, minerals and fibbers, he becoming popular worldwide for fresh consumption due to its high sensory and nutritional properties.
Even fresh fruits are available through the year (being cultivated both in North and South hemisphere, and having a good storage life – over 6 months), kiwifruit is largely processed. The main processing possibilities for kiwifruit worldwide are juices, nectars, syrups, alcoholic drinks (cider, liqueur, brandy), candies and fruit bars, jam and marmalade, patisseries (cakes, cookies), dehydrated and lyophilized products.

REFERENCES

Anderson J.W., Baird P., Davis R.H., Stefanie F., Mary K., et al. (2009) Health benefits of dietary fiber. *Nutr Rev* 67:188-205.

Baranowska-Wojcik, ´ E., & Szwajgier, D. (2019). Characteristics and pro-health properties of mini kiwi (*Actinidia arguta). Horticulture, Environment, and Biotechnology*, 60, 217–225.

Barbara G., Stanghellini V., Brandi G., Cremon C., Di Nardo G., et al. (2005). Interactions between commensal bacteria and gut sensorimotor function in health and disease. Am J Gastroenterol 100: 2560-2568.

Barboni T., Cannac M., Chiaramonti N. (2010). Effect of cold storage and ozone treatment on physicochemical parameters, soluble sugars and organic acids in *Actinidia deliciosa. Food Chemistry* 121 946–951, www.elsevier.com/locate/foodchem, DOI: 10.1016/j.foodchem.2010.01.024.

Beutel J.A. Kiwifruit. In: J. Janick, J.E. Simon, editors. (1990). Advances in new crops. Portland: Timber *Press;. p. 309–316.*

Bieniek A. (2012a). Mineral composition of fruits of *Actinidia arguta* and *Actinidia purpurea* and some of their hybrid cultivars grown in northeastern Poland. Pol J Environ Stud 21(6):1543–1550. http:// www.pjoes.com/pdf/21.6/Pol.J.Environ.Stud.Vol.21. No.6.1543- 1550.pdf. Accessed 15 Feb 2017.

Bieniek A. (2012b). Yield, morphology and biological value of fruits of *Actinidia arguta* and *Actinidia purpurea* and some of their hybrid cultivars grown in north-eastern Poland. Acta Sci Pol Hortoru 11: 117-130. http://www.acta.media.pl/pl/action/getfull.php?id=3139. Accessed 15 Feb 2017.

Boyes S., Strübi P., Marsh H. (1996). Sugar and organic acid analysis of *Actinidia arguta* and rootstock-scion combinations of *Actinidia arguta*. *Lebensm Wiss Technol* 30:390–397

Brigati S, Donati I. (2003). Actinidia: Search results for their applications in the field of conservation and commercial distribution. *Societa Orticola Italiana Verona*, Italy. pp: 277-290.

Bublin M., Kiwifruit allergies (2013). *Advances in Food and Nutrition Research*, 68, 321-340.

Bublin, M., Mari, A., Ebner, C., Knulst, A., Scheiner, O., Hoffmann-Sommergruber, K., Breiteneder, H., Radauer, C. (2004). IgE sensitization profiles toward green and gold kiwifruits differ among patients allergic to kiwifruit from 3 European countries. *J. Allergy Clin. Immunol*. 114, 1169–1175.

Cassano A, Donato L, Drioli E. (2007). Ultrafiltration of kiwifruit juice: Operating parameters, juice quality and membrane fouling. *J Food Eng* 79: 613-621.

Cassano A, Donato L, Drioli E. (2007). Ultrafiltration of kiwifruit juice: Operating parameters, juice quality and membrane fouling. *J Food Eng* 79: 613-621.

Chan AOO, Leung G, Tong T, Wong NYH (2007) Increasing dietary fiber intake in terms of kiwifruit improves constipation in Chinese patients. World J Gastroenterol 13: 4771-4775.

Chang CC, Lin YT, Lu YT, et al. (2010). Kiwifruit improves bowel function in patients with irritable bowel syndrome with constipation. *Asia Pac J Clin Nutr*;19(4):451–457.

Chang, W.H., and Liu, J.F. (2009). Effects of kiwifruit consumption on serum lipid profiles and antioxidative status in hyperlipidemic subjects. Int. *J. Food Sci. Nutr.* 60(8): 709–716. doi:10.3109/09637480802063517. PMID:19919518.

Chen, L., Lucas, J.S., Hourihane, J.O., Lindemann, J., Taylor, S.L., Goodman, R.E.. Evaluation of IgE binding to proteins of hardy (*Actinidia arguta*), gold (*Actinidia chinensis*) and green (*Actinidia deliciosa*) kiwifruits and processed hardy kiwifruit concentrate, using sera of individuals with food allergies to green kiwifruit. *Food and chemical toxicology* 2006 v.44 no.7 pp. 1100-1107. DOI: 10.1016/j.fct.2006.01.005

Chew S.C., Loh S.P., Khor G.L. (2012). Determination of folate content in commonly consumed Malaysian foods, *International Food Research Journal*, 19(1), 189-197.

Correia P.M.R., Guine R.P.F., Correia A.C., GONÇALVES F., BRITO M.F.S., Ribeiro J.R.P., (2017). Physical, chemical and sensory properties of

kiwi as influenced by drying conditions. *Agricultural Engineering International*: CIGR Journal, 19(3): 203–212.

Donaldson B, Rush E, Young O, Winger R. (2014). Variation in gastric pH may determine kiwifruit's Effect on functional GI disorder: an in vitro study. *Nutrients* 6(4):1488–1500. https:// doi.org/10.3390/nu6041488.

Drummond L. (2013). The composition and nutritional value of kiwifruit. *Adv Food Nutr Res* 68:33–57. https://doi.org/10.1016/ B978-0-12-394294-4.00003-1.

Du G., Li M., Ma F., Liang D. (2009). Antioxidant capacity and the relationship with polyphenol and vitamin C in Actinidia fruits, *Food Chemistry*, 113, 557-562.

Eady SL, Wallace AJ, Butts CA, Hedderley D, Drummond L, et al. (2019). The effect of "Zesy002" kiwifruit (*Actinidia chinensis var. chinensis*) on gut health function: A randomised cross-over clinical trial. *J Nutr Sci* 8: e18.

Eriksson N.E., Werner S., Foucard T., Moller C., Berg T., Kiviloog J. (2003). Self-reported hypersensitivity to exotic fruit in birch pollen-allergic patients. Allergology International, 52, 199-206.

Ferguson A. R. (1990). The kiwifruit in China. In I. J. Warrington & G. C. Weston (Eds.), Kiwifruit: Science and management (pp. 155–164). Auckland: Ray Richards in Association with the New Zealand Society of Horticultural Science.

Ferguson A. R., Bollard E. (1990). Domestication of the kiwifruit. In I. J. Warrington & G. C. Weston (Eds.), Kiwifruit: Science and management (pp. 165–246). Auckland: *Ray Richards in Association* with the *New Zealand Society of Horticultural Science*

Ferguson AR, Ferguson LR. (2003). Are kiwifruit really good for you? *Acta Hortic* 610:131–138. https://doi.org/10.17660/ ActaHortic.610.16.

Fiorentino, A., D'Abrosca, B., Pacifico, S., Mastellone, C., Scognamiglio, M., and Monaco, P. (2009°). Identification and assessment of antioxidant capacity of phytochemicals from kiwi fruits. *J. Agric. Food. Chem.* 57(10): 4148–4155. doi:10.1021/jf900210z. PMID:19358604.

Gan Z, Zhang D, Zhang Z, Chen Q, Liu H, Ma Z. (2004). Nutritional components and aging - delaying action of some wild berries in Changbai mountainous area. J Xi'an Jiaotong Univ (Med Sci) 25(4):343–345. http://caod.oriprobe.com/articles/7549413/

Guine R.P.F., Seabra S. (2017). Development of nutritive snacks: kiwi bars. FOODBALT, 140-143. DOI: 10.22616/foodbalt.2017.036.

Hande A.M., Chavan K.D. (2019). Sensory quality of whey based kiwi (*Actinidia deliciosa*) fruit beverage. *International Journal of Chemical Studies*, 7(4): 2076-2080.

Hassan A.K.G., Venkatesh Y.P. (2015). An overview of fruit allergy and the causative allergens. *Eur Ann Allergy Clin Immunol*, Vol 47, N 6, 180-187.

Henare S.. (2016). "The nutritional composition of kiwifruit (*Actinidia* spp.)", In Nutritional composition of fruit cultivars, *Elsevier*, pp. 337.

Hunter, D.C., Skinner, M.A., Wolber, F.M., Booth, C.L., Loh, J.M., Wohlers, M., et al. (2012). Consumption of gold kiwifruit reduces severity and duration of selected upper respiratory tract infection symptoms and increases plasma vitamin C concentration in healthy older adults. *Br. J. Nutr*. doi:10.1017/S0007114511006659.

Hussein A.M.S., Hegazy N.A., Kamil M.M., OLA S.S.M. (2017). Formulation and Evaluation of Some Healthy Natural Juice Blends. *Asian Journal of Scientific Research*, 10 (3): 160-168. DOI: 10.3923/ajsr.2017.160.168.

Iliescu L., Stănică F., Stan A., Bezdadea-Cătuneanu I., Mihai C. (2019). Fruits physico-chemical parameters of some Romanian kiwifruit hybrids influenced by different cold storage technologies. *Fruit Growing Research*, Vol. XXXV. DOI 10.33045/fgr.v35.2019.16.

Jiang CJ. (2011). Development of *Actinidia arguta* as food materials and components available for prevention of lifestyle-related diseases, and its function mechanism. Msc Thesis, Iwate University Graduate School Department of Agronomy Department of Biological Resources Science (Yamagata University).

Jo Y.S., K.C. Ma, H.S. Cho, J.O. Park, S.C. Kim and W.S. Kim (2007). 'Chiak', a New Selection of *Actinidia arguta*. *Acta Hort*. 753, *ISHS*. 259-262. DOI: 10.17660/ActaHortic.2007.753.31.

Kim I-J, Hong D-G, Lee S-J, Park Y-S, Chang Y. (2014). Fruit of *Actinidia arguta* breed development, cultivation and use http:// www.ares.gangwon.kr/upload/ebook/20.pdf. Accessed 20 Jan 2017.

Kim K.T., Hussain H. (1999). Prevalence of food allergy in 137 latex allergic patients, *Allergy and Asthma Proceeding*, 20, 95-97.

Latocha P, Debersaques F, Decorte J. (2015). Varietal differences in mineral composition of kiwiberry (*Actinidia arguta*). *Acta Hortic* 1096:479–486.

Latocha P. (2017). The Nutritional and Health Benefits of Kiwiberry (*Actinidia arguta*) – a Review. *Plant Foods Hum* Nutr 72:325–334 DOI 10.1007/s11130-017-0637-y.

Leontowicz, H., Leontowicz, M., Latocha, P., Jesion, I., Park, Y.-S., Katrich, E., Barasch, D., Nemirovski, A., & Gorinstein, S. (2016). Bioactivity and nutritional.

Lindsey B. Cundra, Steve M. D'Souza M.D., Parth J. Parekh, David A Johnson (2020). *Gut Gastroenterol* Volume 3(1).

Lintas C., Adorisio S., Cappelloni M., Monastra F. (1991). Composition and nutritional evaluation of kiwifruit grown in Italy, New Zealand Journal of Crop and Horticultural Science, 19, 341-344.

Litz, R.E. (2005). Biotechnology of fruit and nut crops. Vol. 29, *CABI.*

Liu S., Manson J.E., Lee I.M., Cole S.R., Hennekens C.H., et al. (2000). Fruit and vegetable intake and risk of cardiovascular disease: The women's health study. *American J Cl Nutr* 72: 922-928.

Lopez-Sobaler, ´ A.M., Aparicio Vizuete, A., & Ortega Anta, R.M. (2016). Nutritional and health benefits

associated with kiwifruit consumption. Nutricion Hospitalaria, 33, 21–25.

Lucas J.S., Nieuwenhuizen N.J., Atkinson R.G., Cochrane S.A., Warner J.O., Hourihane J. (2007). Kiwifruit allergy: actinidin is not a major allergen in the *United Kingdom, Clinical and Experimental Allergy*, 37, 1340-1348.

Lucas, J.S.A., Lewis, S.A., Hourihane, J.O'B. (2003). Kiwi fruit allergy: a review. Pediatr. *Allergy Immunol*. 14, 420–428.

Lucas, J.S.A., Lewis, S.A., Hourihane, J.O'B. (2003). Kiwi fruit allergy: a review. Pediatr. *Allergy Immunol*. 14, 420–428.

Maddumage R., Nieuwenhuizen N., Bulley S.M., Cooney J.M., Green S.A., Atkinson R.G. (2013). Diversity and relative levels of actinidin, kiwellin and thaumatin-like allergens in 15 varieties of kiwifruit (*Actinidia*), Journal of Agricultural and Food Chemistry, 61, 728-739.

McGhie, T.K., Ainge, G.D., McGhie, T.K., and Ainge, G.D. (2002). Color in fruit of the genus actinidia: carotenoid and chlorophyll compositions. J. Agric. Food Chem. 50(1): 117–121. doi:10.1021/jf010677l. PMID:11754554.

Mishra S, Monro J. (2012). Kiwifruit remnants from digestion *in vitro* have functional attributes of potential importance to health. *Food Chem* 135:2188-2194.

Monzini A, Gorini F. (1986). Aspects and problems of preservation of *Actinidia*: Cultivation of Actinidia. *Italian Horticultural Society*, Verona, Italy. pp: 141-170.

Morais, R.M.S.C., Morais, A.M.M.B., Dammak, I., Bonilla, J., Sobral, P.J.A., Laguerre, J.-C.; Afonso, M.J. (2018). Ramalhosa, E.C.D. Functional Dehydrated Foods for Health Preservation. J. Food Qual, 3, 1–29.

Nardin C, Galliano A. (1988). Technologies for refrigerant preservation of the product. Proceedings on *Actinidia*. Saluzzo, 27-28 May. Pp. 135-150.

Nguyen H.V.H. (2012). Oxalate and antioxidant concentrations of locally grown and imported fruit in New Zealand. PhD Thesis, Lincoln University.

Nishiyama I., Yamashita Y., Yamanaka M., Shimohashi A., Kukuda T., Oota T. (2004). Varietal difference in vitamin C content in the fruit of kiwifruit and other *Actinidia* species, *Journal of Agricultural and Food Chemistry*, 52, 5472-5475.

Nishiyama I. (2007). Fruits of the Actinidia genus. *Adv. Food Nutr.* Res. 52: 293– 324. doi:10.1016/S1043-4526(06)52006-6. PMID:17425948.

Pastorello E., Conti A., Pravettoni V., Farioli L., Rivolta F., Ansaloni R., Ispano M., Incorvaia C., Giuffrida M.G., Ortolani C. (1998). Identification of actinidin as the major allergen of kiwifruit, *Journal of Allergy and Clinical Immunology*, 101, 4(1), 531-537.

Peschel W., Sanchez-Rabaneda F., Diekmann W., Plescher A., Gartzia I, et al. (2006). An industrial approach in the search of natural antioxidants from vegetable and fruit wastes. Food Chem 97: 137-150

Pinto T., Vilela A. (2018). Kiwifruit, a botany, chemical and sensory approach a review. *Adv Plants Agric Res*., 8(6): 383–390.

Popovic M., Grozdanovic M., Gavrovic-Jankulovic M. (2013). Kiwifruit as a food allergen source, Journal of the Serbian Chemical Society, 78(3), 333-352

Puri D.K., Manjula S.N. (2018). Nutritional Content and Therapeutic Potential of Kiwifruit. *World Journal of Pharmacy and Pharmaceutical Sciences*.;7(6):536–565.

Reddy D.K., Samala P., Singh J.K. (2015). Formulation and evaluation of preserved products using an under-exploited fruit [kiwi fruit (*Actinidia deliciosa*)]. *International Journal of Basic and Applied Biology*, 2 (4): 205-209.

Samadi-Maybodi A., Shariat M. R. (2003). Characterization of elemental composition in kiwifruit grown in Northern Iran. *J Agric Food Chem* 51:3108–3110.

Sanz V., Lopez-Hortas´ L., M.D. Torres, H. Domínguez. (2020). Trends in kiwifruit and byproducts valorization. *Trends in Food Science & Technology*. https://doi.org/10.1016/j.tifs.2020.11.010

Schakel, S., Pettit, J., and Himes, H. (2001). Dietary fiber values for common foods. In *The CRC handbook of dietary fiber in human nutrition*. 3rd ed. Edited by G. Spiller. CRC Press, London, UK.

Sivakumaran S, Huffman L, Sivakumaran S, Drummond L. (2016). The nutritional composition of Zespri SunGold® kiwifruit and Zespri sweet green® kiwifruit. *Food Chem* 238:195-202. https://doi.org/10.1016/j.foodchem.2016.08.118

Skinner M.A., Bentley-Hewitt K., Rosendale D., Naoko S. (2013). Pernthaner A., Effects of kiwifruit innate and adaptive immunity and symptoms of upper respiratory tract infection. In Advances in Food and Nutrition Research, *Burlington Academic Press*, 68, pp.301-320.

Souflerosa E.H., Pissab I., Petridisb D., Lygerakisb M., Mermelasb K., Boukouvalasb G., Tsimitakisb E., (2001). Instrumental analysis of volatile and other compounds of Greek kiwi wine; sensory evaluation and optimisation of its composition. *Food Chemistry* 75: 487–500.

Sozzi A., Testoni A., Youssef J., Deluisa A., Nardin C. (1980) Preservation of Actinidia in controlled atmosphere. Annali *Experimental Institute for the Technological Valorization of Agricultural Products, Italy* 11: 271-288.

Stănică, F. (2009). Kiwifruit, the fruit of XXth Century. Lucrări ştiinţifice USAMVB, Seria B, 53, 15–28.

Stănică, F., & Cepoiu, N. (1996). Actinidia - o nouă specie pomicolă pentru ţara noastră. (Actinidia – new fruit specie for our country). Rev. Horticultura, Bucureşti, 8, 22-25.

Stănică, F., & Zuccherelli, G. (2007). New selections of *Actinidia arguta* from the Romanian breeding program. *Acta Hortic*., 753, 263–267. DOI: 10.17660/ActaHortic.2007.753.32. 43.

Stănică, F., & Zuccherelli, G. (2009). Nuove selezioni di *Actinidia arguta* dal programma di miglioramento genetico italo-romeno. Societa Orticola Italiana, *Italus Hortus Journal*, 16, 262-265.

Stonehouse W., Gammon C., Beck K., Conlon C., von Hurst P., Kruger R. (2013). Kiwifruit: our daily

prescription for health, *Canadian Journal of Physiology and Pharmacology*, 91, 442-447.

Tarascou, I., Souquet, J.M., Mazauric, J.P., Carrillo, S., Coq, S., Canon, F., et al. (2010). The hidden face of food phenolic composition. *Arch. Biochem. Biophys.* 501(1): 16–22. doi:10.1016/j.abb.2010.03.018. PMID:20363210.

Teresa Pinto (November 2018). Kiwifruit, a botany, chemical and sensory approach a review. *Advances in Plants & Agriculture Research*.

Torreggiani D., Forni E., Pelliccioni L. (1994). Modification of glass transition temperature by osmotic dehydration and kiwi color frozen stability. Research and innovation in the food industry, Pinerolo, 621–630.

Tyagi, S., Nanher, A. H., Sahay, S., Kumar, V., & Bhamini, K. (2017). Fruits for health and nutritional security. Fruit Crops & Horticulture.

Tylewic U., Nowacka M., Rybak K, Drozdzal K, Dalla Rosa M. and Mozzon M. (2020). Design of Healthy Snack Based on Kiwifruit. Molecule, 25, 3309; doi:10.3390/molecules25143309.

US Department of Agriculture. (2019). Kiwifruit, Green, Raw (SR Legacy, 168153). US Department of Agriculture (USDA), Agricultural Research Service (ARS), FoodData Central, Data Type: SR Legacy, *Food Category*:Fruits and Fruit Juices, FDC ID: 168153 NDB Number:9148. https://fdc.nal.usda.gov/fdc-app.html#/food-details/168153/nutrients

USDA (2010). USDA oxygen radical absorbance capacity (ORAC) of selected foods. Release 2. Available from http://www.ars.usda.gov.

USDA (2011). USDA national nutrient database for standard reference. Release 24. Available from http://www.ars.usda.gov.

Vasile Scăeţeanu G., Madjar R.M., Stănică F. and Peticilă A.G. (2019). An overview on chemical composition and health importance of kiwifruit. *The Publishing House of the Romanian Academy*, Proc. Rom. Acad., Series B, 21(1): 73–81.

Vissers, M.C.M., Bozonet, S.M., Pearson, J.F., and Braithwaite, L.J. (2011). Dietary ascorbate intake affects steady state tissue concentrations in vitamin C-deficient mice: tissue deficiency after suboptimal intake and superior bioavailability from a food source (kiwifruit). Am. *J. Clin. Nutr*. 93(2): 292–301. doi:10.3945/ajcn.110.004853. PMID:21123463

Wan X., Woods A.T., K.H. Seoul, Butcher N., Spence C. (2014). When the shape of the glass influences the flavour associated with a coloured beverage: Evidence from consumers in three countries. *Food Quality and Preference*, 39: 109–116. DOI: http://dx.doi.org/10.1016/j.foodqual.2014.07.004.

Warrington I. J. (1990). Areas and trends of kiwifruit production in New Zealand and around the world. In I. J. Warrington & G. C. Weston (Eds.), Kiwifruit: Science and management (pp. 511–525). Auckland: Ray Richards in Association with the *New Zealand Society of Horticultural Science*.

Watanabe K., Takahashi B. (1998). Determination of soluble and insoluble oxalate contents in kiwifruit (*Actinidia deliciosa*) and related species. *Journal of the Japanese Society of Horticultural Sciences*, 67(3), 299-305.

Stonehouse W., Cheryl S. Gammon, Kathryn L. Beck, Cathryn A. Conlon, Pamela R. von Hurst, and Rozanne Kruger. (2012). Kiwifruit: our daily prescription for health. *NRC Research Press*. dx.doi.org/10.1139/cjpp-2012-0303.

Wojdyło A., Nowicka P., Oszmiański J., Golis T. (2017). Phytochemical compounds and biological effects of *Actinidia* fruits. *J Funct Foods* 30:194–202

Wong J.M.W., Jenkins D.J.A. (2007). Carbohydrate Digestibility and Metabolic Effects. *J Nutr* 137:2539S-2546S.

Xiao X-G. (1999). Progress of Actinidia selection and breeding in China. *Acta Hortic* 498:25–35.

Yerex D., Haines W. (1983). The Kiwifruit Story. Master ton: *Agricultural Publishing Associates*.

Young H., Stec M., Paterson V. J., McMath K., Ball R., (1995). Volatile compounds affecting kiwifruit flavor. http://pubs.acs.org, 2016, DOI: 10.1021/bk-1995-0596.ch006.


EX·TERRA·AVRVM

VITICULTURE AND OENOLOGY


EX·TERRA·AVRVM