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Actinidia arguta (Baby Kiwi) Waste: Preliminary Considerations on Seed Recovery

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Abstract: Fruit seed oils are of new interest due to their significant properties and can be a good opportunity to recover fruit waste. *Actinidia arguta* (baby kiwi) fruits are a novelty in the market and berries can be consumed with the peels. Due to their limited shelf life, fruits are very perishable and the waste management techniques used post-harvest are an important issue. Berry waste can be reused, for biological flows focused on food losses and waste reduction. Therefore, baby kiwi fruit samples were collected from the Ortofruititalia company orchards in Cuneo, Italy, and then processed and analysed for seed oil constituents using standard analytical methods. The results of this study indicate that unsaturated fatty acids were the most dominant fatty acids (92.6 g/100 g) in comparison with saturated (7.4 g/100 g). In addition, α-linoleic acid (82.7 g/100 g) was the most dominant unsaturated fatty acid. Additionally, γ-Tocopherol (0.023 g/100 g) was the most dominant tocopherol in this study. Extraction of seed oil from these berries could be proposed as an option for obtaining high-added-value oils for pharmaceutical cosmetics, among other uses.

Keywords: *Actinidia arguta*; baby kiwi; seed oil; phytochemicals; circular economy

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1. Introduction

The structural burden of agri-food waste along the entire supply chain in Europe constitutes approximately 31% and is globally one of the main negative externalities that significantly affect the environment, food safety, human health, and economic and social problems [1–3]. The fruit and vegetable (F&V) sector contributes 44% (36.9% energy and 50.1% protein) of its edible mass to this critical issue prior to human consumption, while approximately 38% of food waste is produced during food processing [1,4]. The complexity of the supply chain (harvesting, transportation, grading, storage, industrial processing, market distribution, and consumer handling) affects the rate and the ratio of this phenomenon. Consequently, new approaches, solutions and mitigating actions are also needed in the agri-food system to achieve the Sustainable Development Goals (SDGs), specifically Goal 2, which advocates for zero hunger by reducing food loss and waste, which must be achieved by 2030 by all members of the United Nations (UN). The translation of agri-food waste management into an innovative process could represent an opportunity to redirect the activities of all the food actors toward sustainable production processes. Specifically, this is also the driver of the EU Action Plan for the Circular Economy (CE) COM/2015/0614 "closing the loop". The rethink is one of the eight CE principles focused on the recovery of agri-food waste, based on considering agri-food waste flows for other roles/contexts of use (re-contextualisation). To fulfill this vision, the knowledge and characterisation of biological raw materials are required. In this case, the quality and quantity of the waste and by-products from the F&V chain vary according to the different origins (crop waste and residue, fruit and vegetable by-products such as peels, seeds, stones, residual pulp, and discarded pieces, sugar, starch, and confectionary industry by-products, oil industry by-products, cereal and legume by-products, distilleries and breweries) [5]. The high variability of discarded products also influences their reuse. F&V by-products are low in fat but rich in bioactive phytochemicals (phenolic compounds, vitamins, minerals, dietary fibres, antioxidants, carotenoids, etc.), and several studies have shown their application in preventing human diseases due to their antihypertensive, antiacne, antidiabetic, anti-inflammatory and hypolipidemic activities [6–12]. The introduction of innovative and sustainable strategies able to give new life to agri-food waste is an activity in line with functional services based on the bio-circular economy, with a pragmatic contribution to the transition scenario in Europe, saving approximately 20% of the estimated cost of materials by 2050. Waste and by-products from food processing are rich sources of potentially valuable bioactive compounds. Their use to produce value-added products could reduce environmental issues, improve economic growth, and promote human health benefits through foods enriched with bioactive compounds [13]. Among the different species of baby kiwis, *Actinidia arguta* [(Siebold and Zucc.) Planch. ex Miq.], can be considered an interesting source of bioactive compounds such as carotenoids (lutein and β-carotene) and phenols, vitamins C, E, K, and B9, fibre, potassium and several minerals (potassium, calcium and zinc). Such compounds are found not only in the fruit but also in the seeds, stems and leaves [14]; polyphenols are largely dependent on variety and storage conditions [15]. Recent studies have reported that these berries are a good source for purifying cysteine proteases, which would positively affect human protein digestion [16].

The fruits are botanically classified as berries from the Actinidiaceae family but are different from the genus *Actinidia chinensis* (yellow kiwi) and *Actinidia deliciosa* (green kiwi). In fact, the berries are mostly consumed with the skin on, but they are very perishable with a shorter shelf life compared to other kiwis. Baby kiwis are typically harvested at commercial maturity, so they can be stored until the fruit reaches its physiological maturity. Once at that stage, its shelf life is approximately seven days [17]. Harvesting must take place at a precise time; otherwise, the quality will quickly deteriorate or fail to reach its optimal potential (Figure 1). Due to the physiological differences compared to traditional green kiwis, the same management procedures cannot be utilized for baby kiwis. The actual post-harvest management is extremely important to limit product loss, and the supply chain is similar to that of other berries such as blueberries. Indeed, after harvesting, baby kiwis can be stored under modified atmosphere conditions in a pallet bag solution [18] to achieve a maximum shelf life of 45 days. After this period, the fruit can be directly packaged into clamshells to be sold. Even if this technology is promising to store fruit, losses during the calibration procedure or cold storage are still critical issues for the economy of the baby kiwi supply chain. Various opportunities can be offered to valorise baby kiwis that are discarded from the fresh market, but limited reports are available on their reuse [19,20]. Recently, studies have placed great attention on fruit seed oils due to their positive role in the health industry [21,22]; however, studies on the quality and quantity of lipids in seed oil are few and infrequent. Kiwi seed oil has been reported to have strong anti-inflammatory effects and a positive role against obesity and hypercholesterolaemia [23,24], while soft berries (red raspberries, marionberry, boysenberry and blueberry) seed oils are promising in terms of a high content of carotenoids, tocopherols and linolenic acid [25]. According to the last Regulation of the European Parliament and the Council on novel foods, coriander seed oil, allanblackia seed oil, plum kernel oil from *Prunus domestica*, pomegranate seed oil and oilseed rape *Brassica napus* are listed for the human consumption. Therefore, the present study was conducted to report preliminary *Actinidia arguta* cv. Tahi (baby kiwi) oil constituents. The properties of the oil could be a useful tool for valorising the *Actinidia arguta* supply chain as a source of natural ingredients in the food, cosmetic and/or pharmaceutical sectors among others.

Figure 1. Baby kiwi quality appearance after successful or unsuccessful storage.

2. Materials and Methods

2.1. Raw Material and Sample Preparation

Berries at the ripening stage with a solid soluble content of 7° Brix and weighing between 10 and 15 g were harvested from the Ortofruititalia company (Cuneo, Italy) orchards [26]. Without pasteurization, the fruits were processed into a puree at the Department of Agricultural, Food and Forest Sciences (DISAFA) with a blender (Kitchenaid®, Benton Harbor, Milano, Italy) at an approximate speed of 3000 rpm. The skin and larger particles were removed from the puree using a 500 µm stainless steel sieve (Savatec, Torino, Italy). Pulp and seeds were separated by centrifuging the puree (7690 rpm, 15 min, 15 °C) (Rotofix 32A centrifuge; Savatec, Torino, Italy), and then frozen separately (−20 °C) until the oil was extracted. To obtain the oil, the seeds (200 g) were cleaned and air dried at 50 °C for 30 min. Oil extraction was carried out by cold pressing using a screw press rotation speed of 40 rpm (Täby Type 40a expeller press, Örebro, Sweden).

2.2. Baby Kiwi Seed Oil Analysis

Seed oil analysis was conducted at the Ortofruititalia company laboratory one month after extraction. The fatty acid compositions and phytosterols were respectively quantified using the AOCS Ce 1i-07 methods [27] and AOCS Official Method Ch 6-91 [28], while the tocopherols and terpenes were quantified using the ISO 9936 methods [29].

3. Results and Discussion

The fatty acid (FA) compositions of *Actinidia arguta* cv. Tahi seed oil are shown in Table 1. Five main types of fatty acids were detected in the oil samples. The saturated, mono and polyunsaturated groups classify FA due to the number of chemical compounds that affect the stability of the oil to environmental factors such as light, temperature and exposure to oxygen. The scientific literature reports that fruit type (Table 2), cultivar, pre-harvest and post-harvest factors influence the main composition of the different FA fractions [30] and their content is fundamental for final use (human nutrition, cosmetic or pharmaceutical) of seeds and oils. The low content of saturated fatty acids and the high content of monounsaturated oleic acid as reported for the sour cherry (Table 2) could suggest a favourable role of the oil in the human diet. In baby kiwi, saturated fatty acids (SFA) are represented by 7.4%, with stearic acid (C18:0) and palmitic (C16:0) acid (1.9% and

5.5%, respectively). Their content is lower when compared to that of other oleaginous fruits such as avocado fruits (20.4 g/100 g of palmitic acid) [31], but it is in the range of fruits reported in Table 2. Due to the low melting point of unsaturated fatty acids, seeds with unsaturated fatty acids have the capacity to germinate earlier and grow more rapidly at low temperatures as a consequence of the faster availability of energy [32]. The unsaturated fatty acids consist of 92.6% oleic acid (C18:1) (0.6%), linoleic acid (C18:2ϖ6) (9.3%) and α-linolenic acid (C18:3ϖ3) (82.7%). Even if the high percentage of α-linolenic acid (82.7%) differentiates *Actinidia arguta* cv. Tahi oil from others such as Perilla oil and Linseed oil, whose content is in the range of (51–60%) [33], this value is too low to effect a significant change in the human diet considering the ϖ6:3 ratio. It is an essential fatty acid, which is not synthesized in the human body; consequently, its external supply is fundamental to regulating the main anti-inflammatory mechanisms for human health. In fact, the linoleic and α-linolenic acid content affects the ϖ6:3 ratio, which is very low (0.11), meaning that this oil has an extremely low nutritional status when compared to those with this ratio close to one [34], as reported for blueberries (Table 2). The mean daily intake of α-linolenic acid and linolenic acid is reported to be between 1–2 g and 15 g, respectively [35].

Table 1. Fatty acid contents in *Actinidia arguta* cv. Tahi seed oil.

Fatty Acid Content (g/100 g)	
Palmitic acid (C16:0)	5.5 ± 0.2
Stearic acid (C18:0)	1.9 ± 0.0
Oleic acid (C18:1)	0.6 ± 0.0
Linoleic acid (C18:2ϖ6)	9.3 ± 0.3
α-linolenic acid (C18:3ϖ3)	82.7 ± 0.2
Σ Saturated fatty acids	7.4 ± 0.2
Σ Unsaturated fatty acids	92.6 ± 0.5
ϖ6:3	0.1

All values reported are the mean value of three replicates.

Table 2. Seed oil fatty acid content in different fruit species.

Fatty Acid	Redcurrant (g/100 g) [36]	Blackberry (g/100 g) [37]	Blueberry (g/100 g) [38]	Raspberry (g/100 g) [38]	Grapeseed (g/100 g) [39]	Pomenagrate (g/100 g) [40]	Sour Cherry (g/100 g) [41]
Palmitic acid (C16:0)	4–5	3.71	4.98	2.73	7.40	3.90	5.30
Stearic acid (C18:0)	1–2	2.18	1.47	0.87	3.90	2.60	1.50
Oleic acid (C18:1)	14–16	14.72	18.00	11.76	15.60	6.60	63.90
Linoleic acid (C18:2ϖ6)	41–42	61.22	35.84	54.27	72.20	6.90	27.00
α-linolenic acid (C18:3ϖ3)	29–31	17.60	36.08	26.68	0.24	-	0.10
Σ Saturated fatty acids	6.00	5.89	6.45	3.30	11.30	6.50	6.80
Σ Unsaturated fatty acids	94.00	94.11	93.55	96.70	88.70	93.50	93.20
ϖ6:3	1.40	3.50	0.90	2.00	>100	-	>100

Among the bioactive compounds, the content of tocopherols, sterols and squalene are shown in Table 3. The total content of tocopherols (0.027 g/100 g) is in the range of the total amount found in other Actinidia species [35]. Compared with other fruit species, as reported in Table 4, it is possible to show how the total content and the γ-tocopherol are similar to those of sweet cherry (0.020 g/100 g). They are associated with vitamin E whose antioxidant capacity depends on tocopherols and tocotrienols contents (decreasing passing from α to γ [41]. Additionally, γ-tocopherol could be more effective against certain types of cancer and myocardial disease [41]. α-tocopherol and γ-tocopherol are the most detected: 0.004 and 0.023 g/100 g, respectively. Considering the other active ingredients, squalene (19.3 mg/g) should play a positive role in the anticarcinogenic properties of the skin and it is the only terpene detected. The content of β-sitosterol (2.0 mg/g), which is chemically similar to the cholesterol molecule, can potentially interfere with its absorption and contribute to reducing its content in the human body.

Table 3. The weight content of tocopherols, squalene, and sterols in *Actinidia arguta* cv. Tahi seed oil.

Tocopherol Amount (g/100 g)		Squalene (mg/g)	Sterols (mg/g)
Total amount	0.027	19.3 ± 0.3	2.0 ± 0.0
α-tocopherol	0.004		(β-sitosterol)
β-tocopherol	Tr		
γ-tocopherol	0.023		
δ-tocopherol	Tr		

Tr = traces lower than 0.1 mg/100 g. All values reported are the mean value of three replicates.

Table 4. Tocopherol contents in seed oils from different fruit species.

Tocopherol	Redcurrant (mg/Kg) [39]	Blackberry (mg/Kg) [37]	Blueberry (mg/100 g) [38]	Raspberry (mg/100 g) [38]	Grapeseed (mg/100 g) [39]	Pomenagrate (mg/Kg) [42]	Sour Cherry (mg/Kg) [41]
Total amount	1043	1388.7			32–52	1281.4–1833.8	240.2
α-tocopherol	320	25.4	0.11	27.7	26–39	122.5–48.2	4.7
β-tocopherol	8	-	0.06	0.65	2–14	-	0.4
γ-tocopherol	-	1311.7	0.96	58.2	10–34	1176.3–1732.5	197.2
γ-tocotrienol	-	20.0	6.16	-	15–34	-	21.5
δ-tocopherol	-	31.7	0.27	-	Tr	7.8–35.6	15.1

4. Conclusions

Baby kiwi has in recent years gained popularity due to its nutraceutical superiority/advantages over the well-accepted green kiwi and its ease of consumption—when ripe, baby kiwi is suitable for direct consumption without peeling. The most prominent limitations of the mature baby kiwi are its limited shelf life and the fast quality deterioration that consequently affects fruit marketing. Due to its novelty on the market, specific practices optimal for the management of these berries are still limited. Baby kiwi losses and waste are representative. Waste valorisation plays an important role in the supply chain, allowing circular economic growth. Kiwifruit waste, for example, through applied microorganisms can be used to produce laccase enzyme or polyphenols, flavonoids, caffeic, and protocatechuic acid when the peel is processed. Today, the seed oil industry is increasing due to eco-friendly extraction methods and new by-product uses, and baby kiwi oil could contribute to it. Preliminary data collected from this work has revealed that *Actinidia arguta* cv. Tahi seed oil has significant properties. The physical and chemical properties of the cv. Tahi oil need to be analysed to complete the knowledge for its potential use. Furthermore, it is necessary to consider the limited shelf life due to the cold-pressed extraction that makes the oil thermally unstable due to the high content of unsaturated fatty acids. Therefore, the extraction and detection methods can largely affect the chemical differences of the *Actinidia arguta* cv. Tahi oil constituents and the maturity stage of fruits is also an important factor. In short, the elevated quantity of unsaturated fatty acids, the potentially rich antioxidant properties, and the high percentage of squalene could valorise this oil and make it an excellent candidate for the food, cosmetic, and pharmaceutical industries, among many more.

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