



Review

The Potential of Introduction of Asian Vegetables in Europe

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Abstract: Increasing longevity, along with an aging population in Europe, has caused serious concerns about diet-related chronic diseases such as obesity, diabetes, cardiovascular diseases, and certain cancers. As recently noted during the coronavirus pandemic, regular exercise and a robust immune system complemented by adequate consumption of fruit and vegetables are recommended due to their known health benefits. Although the volume of fresh vegetable consumption in the EU is barely growing, demand for diversified, nutritious, and exotic vegetables has been increasing. Therefore, the European market for fresh Asian vegetables is expected to expand across the EU member states, and the introduction of new vegetables has enormous potential. We conducted this review to address the high number and wide range of Asian vegetable species with a commercial potential for introduction into the current European vegetable market. Many of them have not received any attention yet. Four Asian vegetables: (1) Korean ginseng sprout, (2) Korean cabbage, (3) Coastal hog fennel and (4) Japanese (Chinese or Korean) angelica tree, are further discussed. All of these vegetables possess several health benefits, are increasingly in demand, are easy to cultivate, and align with current trends of the European vegetable market, e.g., vegetables having a unique taste, higher value, are decorative and small. Introducing Asian vegetables will enhance the diversity of nutritious horticultural products in Europe, associated with all their respective consumption benefits. Future research on the Asian vegetable market within Europe is needed. In addition, experimental studies of Asian vegetables under practical conditions for their production in different European environments are required. Economic, social, and ecological aspects also ought to be considered.

Keywords: health; aging population; consumption of fruit and vegetables; diversification; market trend; Korean ginseng sprout; Ssamchoo; *Peucedanum japonicum*; *Aralia elata* (Miq.) Seem

1. Introduction

Health and well-being are important factors of a modern lifestyle. The health conditions of individuals and households have economic significance for both developing and developed countries, including the EU member states [1]. Additionally, an aging population is considered a significant challenge in the coming decades for the European Union [2]. Worldwide chronic diseases are increasing as leading causes of death every year, with scientific evidence linking these chronic diseases to diet [3]. These diet-related chronic diseases include obesity, diabetes, cardiovascular diseases (CVDs), and certain cancers [3–6].

Obesity is associated with various health problems including CVD, type 2 diabetes mellitus, musculoskeletal disorders such as osteoarthritis, work disability and respiratory disorders [7]. According to a 2016 report from the Organization for Economic Co-operation and Development/European Union (OECD/EU [8], 16% of adults in the EU member states were obese in 2004, an increase

from 11% in 2000. Moreover, overweight or obese children have a higher risk of poor health in adulthood [9].

Diabetes causes a higher risk of developing cardiovascular diseases such as heart attack and stroke [8]. Across EU countries, 7% of adults reported having diabetes in a self-reported interview survey in 2014. The rate of diabetes is associated with the level of education and age [8].

CVDs are the leading cause of mortality in nearly all EU countries [8]. CVDs caused almost 40% of all deaths in 2013 [8]. CVDs include a wide range of diseases, such as ischemic heart diseases (e.g., heart attack) and cerebrovascular diseases (e.g., stroke) [8].

Cancer is the second leading cause of mortality after cardiovascular diseases in EU countries [8]. 26% of all deaths were caused by cancer in 2013 [8]. Cancer mortality rates for men are higher than for women in all EU countries [8]. Considered risk factors for colorectal cancer are age, a diet high in fat, and genetic background [8].

According to WHO, the COVID-19 pandemic is caused by a novel coronavirus [10,11]. A study in China reported that approximately 50% of patients confirmed with COVID-19 had underlying chronic diseases such as CVDs (40%) and diabetes [12]. Another retrospective analysis in Wuhan showed that obesity was commonly observed in critical patients and death from COVID-19 [13]. According to this study, 88.24% of patients with a BMI (body mass index) over 25 kg/m² were in the non-survivor group [13]. Based on current evidence, COVID-19 is considered to be highly associated with a compromised immune system of individuals that are affected by age, gender and comorbidities (CVDs, diabetes, cancer) [14]. Understanding the significant correlation among diet, nutrition, infection, and immunity [15], a diversified, balanced, and healthy diet with macro-, micro- and phytonutrients, mainly found in vegetables, may promote healthy immune responses for prevention of chronic diseases [16].

European consumers are growing more interested in diversified, nutritious, and exotic vegetables. The cultivation and consumption of Asian vegetables are increasing in Europe. For instance, Chinese cabbage (*Brassica pekinensis*) [17–20] and pak choi (*Brassica chinensis*) [17,18,20,21], which were unknown some years ago, are the two most popular Asian vegetables in Europe. These leafy vegetables originating from China [22] are essential in northeastern Asia. However, as they started to be commercially cultivated in Europe, bolting was a significant concern for European growers [23]. Bolting is induced by vernalization which is a process of accelerated flowering by exposure to prolonged cold [24] that results in elongation of the flower stalk [25]. Vernalization lets the plants bloom and produce seeds instead of leafy heads [26], which then lead to low yield and quality loss of pak choi [27] and Chinese cabbage. As a result, many research studies of cultivation have shown how to control bolting and early flowering of Chinese cabbage and pak choi.

Mizuna [17,20], a cultivar of *Brassica rapa* var. *niposinica*, and water spinach (*Ipomoea aquatica*) [17,20,21] are other Asian vegetables introduced to Europe. They both are less well known than Chinese cabbage and pak choi in Europe. Mizuna is a Japanese vegetable [28] that is mostly cultivated in open fields but also inside greenhouses in Italy [29,30]. There is also a concern about bolting for commercial production of mizuna [28]. In contrast, to our knowledge, water spinach is consumed but is not commercially cultivated in Europe.

Currently, shiso (*Perilla frutescens* var. *crispa*), which is a Japanese herb, is cultivated in greenhouses in Germany [31]. Choy sum (*Brassica rapa* var. *parachinensis*), kai choi (*Brassica juncea*) [17–21], edamame (*Glycine hispida*), Japanese murasaki sweet potato (*Ipomoea batatas*), Okinawa sweet potato (*Ipomoea batatas* cv. 'Ayamurasaki') are produced in Portugal [32].

Carotenoids, anthocyanins, flavonoids, and other phenolic compounds in vegetables may prevent and counter many common diseases such as high blood pressure, diabetes, cancer, vision loss, heart disease, and several intestinal disorders. The link between fruit and vegetable consumption and a lower risk of mortality has been increasing [33–35]. Cardiovascular mortality may notably decrease with high consumption of fruit and vegetables [36]. It was also noticed that not only the elderly and chronic disease sufferers, but also smokers and alcohol drinkers were in the high-risk patient group

during the Covid-19 pandemic. Thus, eating vegetables is suggested together with sporting activities to boost the immune system [16,37].

To our best knowledge, no published literature to date provides a comprehensive review of Asian vegetables that have the potential to be introduced in Europe. The objective of this paper is to contribute to an increasing diversity of vegetable consumption in Europe.

2. Vegetable Consumption in Europe

According to Shahbaz et al. [38], vegetables provide a variety of health benefits. They are generally low in fat and calories yet rich in vitamins and dietary fibers. Moreover, they present a valuable source of mineral nutrients, essential amino acids, antioxidants and phytochemicals such as carotenoids, anthocyanins, flavonoids, and other phenolic compounds.

Besides the nutritional attributes, vegetables also provide a diverse range of taste, aroma, texture, and color, which significantly increase the variety in food and satisfy a myriad of personal preferences [39]. Although increased daily vegetable intake has been recommended for health benefits, and the EU has made efforts to advocate it, European vegetable consumption remains below the recommended level [40–42]

2.1. '5-A-day' Campaign of Daily Vegetable & Fruits Consumption

WHO recommended daily consumption of a minimum 400 g of fruits and vegetables to prevent chronic diseases in 1990 [43]. After that, the '5-a-day' fruit and vegetable campaign was launched in several European countries such as the UK, Germany, and France [43]. The '5-a-day' fruit and vegetable campaign recommended at least five portions of fruits and vegetables a day, excluding potatoes and other starchy tubers [44]. Indeed, evidence provided by a meta-analysis showed that consumption of vegetables and fruit—up to five servings a day—was associated with a lower risk of all causes of mortality, especially cardiovascular mortality [36]. In addition, the consumption of similar amounts of vegetables appears to be significantly healthier than that of fruits [43,45] because the fructose found in fruit can be a major factor of obesity [46–48].

2.2. EU Policy to Promote Vegetable & Fruits Consumption

The EU has made efforts to promote a well-balanced diet to prevent chronic diseases. One of the policy objectives of the EU is the promotion of fruit and vegetable consumption, especially in schools and workplaces [49]. The European School Fruit Scheme, which supplies fresh fruit and vegetables to children together with educational measures, was introduced in the schools of 24 EU countries in 2009–2010 [8]. Since then, the European School Fruit Scheme has been positively showing a significant increase in fruit and vegetable intake frequency by children [8]. Caton et al. [40], reported the importance of learning to eat vegetables at an early age. The European Commission is monitoring progress in the consumption of fruit and vegetables to maintain a balance against a worsening trend of poor diets [8,50]. The WHO European Food and Nutrition Action Plan 2015-20 was designed to reduce the burden of preventable diet-related NCDs (Noncommunicable diseases) and obesity [8].

2.3. Daily Vegetable (& Fruits) Consumption of Young (Girls & Boys) and Adults in the EU

According to OECD/EU [8], over one in three girls and one in four boys ate vegetables daily in EU countries in 2013–14. The average daily vegetable consumption of adults was 51% in 28 EU countries in 2014. More women eat vegetables daily than men and older adults eat more fruits and vegetables daily than younger people do. About 12% of adults in 28 EU countries have reported a daily consumption of at least five fruits and vegetables. People with higher education levels tend to eat fruits and vegetables more often than those with lower education levels.

2.4. Daily Vegetable Consumption of European Countries—A Systematic Comparison with Asian Countries

According to the Food and Agriculture Organization of the United Nations (FAO) (1999) [51], about 75 percent of the world's food is generated from only 12 plants and five animal species. A recent study by international scientists in collaboration with the FAO identified a total of 1097 vegetable species worldwide [52] of which 392 vegetable crops are cultivated and consumed [39]. However, even in the current globalization era, there are significant differences between countries. More than 200 species are known to be produced in Asian countries whereas the maximum number of vegetable species is only 60 coming from 16 plant families in Germany. Considering the fact that approximately 81% of the consumption/capita/year is concentrated on 23 vegetable species, it is clear that the diversity of vegetables in Germany is relatively weak [53]. This situation is reflected in the average rate of daily vegetable consumption.

Data sourced by OECD Health Statistics (2017) [54] showed that the average rate of daily vegetable consumption among adults in OECD 32 member countries is 59.8%. The data of European countries are all lower than of those other countries including Korea (99.1%), Australia (99.0%), New Zealand (95.3%) and the United States (92.4%) (unfortunately, no data for China were recorded) [54].

China was the world's largest fresh vegetable producer in 2017 [55] and was the world's biggest vegetable exporter in 2018 [56]. The FAO and World Bank reported in 2017 [57] that China was likely to consume the most vegetables per capita (1033 g/day). In other Asian countries, South Korea consumed 540.14 g, Vietnam 467.25 g, Japan 249.61 g, and Thailand 109.3 g per day [57].

Among the Mediterranean countries, Croatia consumed the most vegetables per capita (699.03 g/day), followed by Portugal (418.62 g/day), Greece (410.84 g/day), and Spain (401.52 g/day) [57]. In Northwestern Europe, Belgium consumed the most vegetables (379.46 g/day), followed by Denmark (276.44 g/day), France (264.85 g/day) and Germany (261.29 g/day) [57].

Despite the current recommendations and the apparent health benefits, vegetable consumption in European countries is below the recommended level [40–42]. For instance, in Germany, the consumption per capita has increased from 186.3 g to 261.38 g in the past 30 years [53,57]. However, consumption has stagnated at approximately 94–95 kg/capita/year for many years now. The recent numbers include the comprehensive campaigns that were previously mentioned, including the 5X a day campaigns, activities for pre- and school-children, as well as information targeting adults concerning health issues.

Therefore, one possible way to increase the consumption of vegetables in EU countries could be diversification. Consumers are looking for new products, especially in the winter with reduced varieties available, which could be an excellent opportunity for new vegetables coming from Asian countries.

3. The Potential for the Introduction of New Asian Vegetables in Europe and the Market Trends

The consumption of fresh vegetables in the EU is barely increasing, and the European vegetable market is highly competitive. However, the current demand for healthy, high-quality and attractive exotic vegetables is growing steadily. Therefore, the market for fresh Asian vegetables has the potential to expand across the EU member states. But, how can we define Asian vegetables?

The meaning of “Asian vegetables” varies and the term is often used ambiguously as “Oriental vegetables” in literature. Asian vegetables can be defined as vegetables that have originated, are cultivated or are commonly consumed in Northeast Asia (China, Korea, and Japan) or in Southeast Asia (Thailand, Indonesia, Vietnam, the Philippines, and Malaysia). In this study, we will use the term Asian vegetables to mean the vegetables from both regions.

A list of Asian vegetables is provided in Tables 1–6. In the list, some well-known vegetables that can be found in other countries are not included, such as onions (*Allium cepa*), potatoes (*Solanum tuberosum*), sweet potatoes (*Ipomoea batatas*), tomatoes (*Solanum lycopersicum*), and okra (*Abelmoschus esculentus*) even though they are commonly used in Asian cuisines. However, we still included these vegetables if they are unique from their western counterparts, such as Asian green onions (*Allium fistulosum*), Japanese pumpkin (*Cucurbita maxima*), and Korean zucchini (*Cucurbita moschata*). Native Asian vegetables such as soybeans and Chinese cabbage are also included.

Table 1. Sprout vegetables.

Vegetable	Scientific Names	Used Parts	Culinary Uses	Reference	Vegetable	Scientific Names	Used Parts	Culinary Uses	References
Mung bean sprouts/Mungo bean sprouts/Small bean sprouts	<i>Phaseolus aureus/Vigna radiata</i>	sprouts	eaten raw, blanched, stir-fried	[17,18,21]	Soybean sprouts	<i>Glycine hispida/G. max</i>	sprouts	blanched, boiled	[17,18,21]

Table 2. Tree vegetables.

Vegetable	Scientific Names	Used Parts	Culinary Uses	Reference	Vegetable	Scientific Names	Used Parts	Culinary Uses	References
Aralia sprout/Dureup/Fatsia sprout/Korean angelica tree	<i>Aralia elata</i> (Miq.) Seem./ <i>Aralia elata</i> var. <i>elata</i>	young shoots	blanched, pickled	[18,19,58]	Alangium/Trilobed-leaf alangium	<i>Alangium platanifolium</i> var. <i>trilobum</i> (Miq.) Ohwi	young leaves	eaten raw young leaves, blanched, pickled	[18,58]
Bamboo shoot	<i>Bambusa</i> spp./ <i>Bambusa</i> sp./ <i>Dendrocalamus</i> sp./ <i>Phyllostachys</i> sp.	young shoots	blanched, boiled, pickled, stir-fried	[17,18,21]	Ginkgo nut	<i>Ginkgo biloba</i>	seeds	cooked, grilled	[18]
Burning bush spindle tree	<i>Euonymus alatus</i> (Thunb.) Siebold	young shoots	blanched	[18]	Blue Japanese oak acorn/Ring-cup oak acorn	<i>Quercus glauca</i> Thunb.	acorns	its starch is cooked and made jelly	[18,58]
Chinese cedar	<i>Cedrela sinensis</i> Juss.	young shoots	blanched, pickled, deep fried	[18,19]	Konara oak acorn	<i>Quercus serrata</i> Murray	acorns	its starch is cooked and made jelly	[18,58]
Devil's bush/Siberian-ginseng	<i>Eleutherococcus senticosus</i>	young shoots	blanched	[18,58]	Sansho pepper/Sichuan pepper	<i>Zanthoxylum</i> sp.	husks of seeds	adding in stews, foods, oiled	[20]
Matrimony-vine	<i>Lycium chinense</i>	young shoots	blanched young leaf buds	[17,18]	East Asian arrow root/Kudzu	<i>Dolichos japonica/Pueraria hirsute/P. lobata</i> (Willd.) Ohwi/ <i>P. thunbergiana</i>	roots	eaten raw, made juice, dried and boiled tea, made jelly, powdered	[17,18,58]
Sayur manis/weet leaf bush	<i>Sauropus androgynus</i>	shoot tips, young leaves	steamed, grilled, cooked in soups, stir-fried	[21]					

Table 3. Leaf and Stem Vegetables.

Vegetable	Scientific Names	Used Parts	Culinary Uses	Reference	Vegetable	Scientific Names	Used Parts	Culinary Uses	References
Asian goldenrod	<i>Solidago virgaurea</i> subsp. <i>asiatica</i> Kitam. ex H. Hara	young shoots	blanched	[18,19,58]	Komatsuna	<i>Brassica rapa</i> var. <i>komatsuna</i> /var. <i>perviridis</i>	leaves, stalks	eaten raw, stir-fried, boiled, pickled, cooked in soups	[20]
Asian royal fern/Royal fern	<i>Osmunda japonica</i> Thunb.	young shoots	boiled, stir-fried	[18,19,58]	Korean cabbage/Ssamchoo	<i>Brassica lee</i> ssp. <i>namai</i> cv. <i>Ssamchoo</i>	leaves, stalks	eaten raw	[18]
Bracken/Eastern bracken/Tender fern fronds	<i>Pteridium aquilinum</i> var. <i>latiusculum</i> (Desv.) Underw. ex A.Heller	young shoots	boiled, stir-fried	[17,19,58]	Mibuna greens	<i>Brassica rapa</i> var. <i>japonica</i> /var. <i>nipposinica</i>	leaves, stalks	eaten raw	[20]
Edible aster/Rough aster	<i>Aster scaber</i> Thunberg	young shoots	eaten raw	[18,19,58]	Mizuna greens/Potherb-mustard cabbage	<i>Brassica rapa</i> var. <i>japonica</i> /var. <i>nipposinica</i>	leaves, stalks	eaten raw, stir-fried, cooked in soups	[17,20]
Fulvous daylily	<i>Hemerocallis fulva</i> L.	young shoots	blanched	[18,19]	Sweet potato	<i>Ipomoea batatas</i>	leaves, stalks	blanched	[18]
Japanese spikenard/Manchurian spikenard/Mountain asparagus/Udo	<i>Aralia cordata</i> var. <i>continentalis</i> (Kitag.) Y.C.Chu	young shoots	blanched, deep fried, cooked as pancakes	[18,20]	Turnip greens	<i>Brassica rapa</i>	leaves, stalks	boiled, stir-fried, salted	[17,18]
Pea shoots	<i>Pisum sativum</i>	young shoots	stir-fried	[20]	Chinese taro/Japanese taro/Taro	<i>Colocasia esculenta</i>	stalks	boiled, stir-fried	[17,18]

Table 3. Cont.

Vegetable	Scientific Names	Used Parts	Culinary Uses	Reference	Vegetable	Scientific Names	Used Parts	Culinary Uses	References
Tartarian aster/Tatarinow's aster	<i>Aster tataricus</i> L. f.	young shoots	blanched	[18,19,58]	Citronella grass/Lemon grass	<i>Cymbopogon citratus</i>	stalks	cooked in curries, soups	[20]
Water shield	<i>Brasenia schreberi</i> J.F.Gmelin	young shoots	eaten raw, cooked in soups, dried, grounded	[20,58]	Sweet potato	<i>Ipomoea batatas</i>	stalks	blanched, stir-fried, salted	[17]
Hot pepper	<i>Capsicum annuum</i>	young shoots, leaves	Blanched, cooked in soups and in pancakes	[18]	Amaranthus/Chinese spinach/Edible amaranth/Pig weed	<i>Amaranthus gangeticus/A. mangostanus</i> L./ <i>A. tricolor</i>	young leaves, stems	blanched, stir-fried, cooked in soups	[17–21,58]
Komarov's Russian thistle/Okahijiki	<i>Salsola komarovii</i> Iljin	young shoots, leaves	eaten raw, blanched, steamed	[20,58]	Ashitaba	<i>Angelica keiskei</i>	young leaves, stems	eaten raw, blanched, cooked in pancakes, pickled	[18,19]
Korean-mint	<i>Agastache rugosa</i>	young shoots, leaves	eaten raw young leaves, blanched, cooked in soups, as pancakes	[18]	Coastal hog fennel	<i>Peucedanum japonicum</i> Thunb.	young leaves, stems	eaten raw, pickled, blanched, deep fried	[18,19,58]
Okinawan spinach/Velvet plant	<i>Gynura bicolor</i>	young shoots, leaves	eaten raw, blanched, stir-fried, deep-fried, cooked in soups, stews	[20]	Curled mallow/Mallows	<i>Malva verticillata/M. verticillata</i> var. <i>crispa</i> L.	young leaves, stems	cooked in soups, stir-fried	[18–20]
Stringy stonecrop	<i>Sedum sarmentosum</i>	young shoots, leaves	eaten raw	[18,19]	East Asian hogweed	<i>Heracleum moellendorffii</i> Hance	young leaves, stems	eaten raw, blanched, pickled, stir-fried	[18,19,58]
Ceylon spinach/Malabar nightshade/Tsurumurasaki	<i>Basella alba/B. cordifolia</i> B. <i>rubra</i>	shoots, leaves	stir-fried, cooked in soups	[17,20,21]	Field aster	<i>Aster yomena</i> (Kitam.) Honda	young leaves, stems	blanched, stir-fried, cooked in soups, deep fried	[18,58]
Castor	<i>Ricinus communis</i> L.	young leaves	blanched	[18]	Gondre/Korean thistle	<i>Cirsium setidens</i> (Dunn) Nakai	young leaves, stems	cooked in soups, pickled, dried leaves are cooked as side dishes	[18,19,58]
Mugwort	<i>Artemisia</i> spp./ <i>A. princeps</i> Pampanini/ <i>A. vulgaris</i>	young leaves	cooked in soups, in rice cakes, pancakes	[17,20,21]	Green garlic	<i>Allium sativum</i>	young leaves, stems	eaten raw, blanched, steamed, pickled	[18]
Chinese chives/Flat chives/Garlic chives	<i>Allium senescens/A. senescens</i> var. <i>minor/A. thunbergii/A. tuberosum</i>	leaves	eaten raw, stir-fried, pickled, cooked in pancakes	[18–21]	Japanese angelica	<i>Ligusticum acutilobum</i>	young leaves, stems	eaten raw, blanched, pickled	[18]
Perilla	<i>Perilla frutescens</i>	leaves	eaten raw, pickled, stir-fried	[17,18,20]	Japanese atractylodes/Ovate-leaf atractylodes	<i>Atractylodes japonica/A. ovata</i> (Thunb.) DC.	young leaves, stems	eaten raw, blanched, cooked in pancakes	[18,58]
Soybean	<i>Glycine max</i> (L.) Merr.	leaves	blanched, pickled, salted	[18]	Lesser solomon's seal/Solomon's seal	<i>Polygonatum odoratum</i> var. <i>pluriflorum</i> (Miq.) Ohwi	young leaves, stems	pickled	[18,58]
Asian plantain	<i>Plantago asiatica</i> L.	young leaves, stalks	blanched, cooked in soups, stir-fried	[18,58]	Riverside wormwood/Selenge wormwood	<i>Artemisia selengensis</i> Turcz. ex Besser	young leaves, stems	blanched	[18,58]
Butterbur/Giant butterbur/Sweet coltsfoot/	<i>Petasites japonicus</i> (Siebold & Zucc.) Maxim.	young leaves, stalks	blanched, pickled	[17–20,58]	Swamp cabbage/Water convolvulus/Water spinach	<i>Ipomoea aquatica/I. reptans</i>	young leaves, stems	Eaten raw, blanched, boiled, stir-fried	[17,20,21]
Chamnamul/Short-fruit pimpinella	<i>Pimpinella brachycarpa</i> (Kom.) Nakai	young leaves, stalks	blanched	[18,19,58]	Three-leaf ladybell	<i>Adenophora triphylla</i> var. <i>japonica</i> (Regel) H. Hara	young leaves, stems	eaten raw, blanched	[18,58]
Deltoid synurus	<i>Synurus deltoides</i> (Aiton) Nakai	young leaves, stalks	blanched, cooked in rice cakes	[18,19,58]	Ulleungdo aster	<i>Aster glehnii</i> F.Schmidt	young leaves, stems	blanched, deep fried	[18,58]

Table 3. Cont.

Vegetable	Scientific Names	Used Parts	Culinary Uses	Reference	Vegetable	Scientific Names	Used Parts	Culinary Uses	References
Fischer's ragwort/Gomchwi	<i>Ligularia fischeri</i> (Ledeb.) Turcz.	young leaves, stalks	eaten raw, cooked in soups, pickled, blanched	[18,19,58]	Water celery/Water dropwort/Water parsley	<i>Oenanthe javanica/O. stolonifera</i>	young leaves, stems	eaten raw, blanched, cooked in soups, as pancake	[17–20]
Honewort/Mitsuba	<i>Cryptotaenia canadensis</i>	young leaves, stalks	eaten raw, stir-fried, deep fired, cooked in soups	[17]	Chinese broccoli/Chinese kale	<i>Brassica oleracea</i> var. <i>alboglabra</i>	leaves, stems	boiled, steamed, stir-fried	[17,20,21]
Korean bellflower	<i>Campanula takesimana</i> Nakai	young leaves, stalks	blanched	[18,19,58]	Chrysanthemum/Chrsanthemum greens/Crown daisy/Garland chrysanthemum	<i>Chrysanthemum coronarium</i>	leaves, stems	eaten raw, cooked in stews, blanched	[17–21]
Narrow spiked Ligularia/Narrow-head ragwort	<i>Ligularia stenocephala</i> (Maxim.) Matsum. & Koidz.	young leaves, stalks	eaten raw, cooked in soups, pickled, blanched	[18,19,58]	Stem lettuce	<i>Lactuca sativa</i> var. <i>augustana</i> /var. <i>asparagina</i>	leaves, stems	blanched, stir-fried	[20]
Pumpkin	<i>Cucurbita moschata</i>	young leaves, stalks	steamed	[18]	Manchurian wild rice/Water bamboo/Wild rice	<i>Zizania latifolia</i> (Griseb.) Turcz. ex Stapf	swollen stem bases	eaten raw, stir-fried	[20,58]
Rape	<i>Brassica napus</i> L.	young leaves, stalks	blanched, cooked in soups	[18,19]	Green onion/Japanese bunching onions/Oriental bunching onion/Scallions/Shallots/Spring onion/Welsh onions	<i>Allium fistulosum</i>	leaves, bulbs	eaten raw, stir-fried, salted, cooked in soups, pancakes	[17–21]
Salt sandspurry	<i>Spergularia marina</i> (L.)	young leaves, stalks	eaten raw, blanched, cooked in pancakes	[18]	Korean wild chive Wild garlic	<i>Allium monanthum</i> Maxim.	leaves, bulbs	eaten raw cooked in soups, pickled	[18,19,58]
Bok choy/Chinese cabbage/Pak choi/White cabbage/White-mustard cabbage	<i>Brassica campestris</i> var. <i>chinensis</i> /B. <i>rapa</i> var. <i>chinensis</i>	leaves, stalks	eaten raw, blanched, stir-fried	[17,18,20,21]	Korean youngia	<i>Youngia sonchifolia</i>	young leaves, roots	salted	[18,19]
Chinese cabbage	<i>Brassica pekinensis</i> /B. <i>pe-tsai</i>	leaves, stalks	eaten raw, salted, cooked in soups, as pancakes, pickled, stir-fried	[17–20]	Shepherd's purse	<i>Capsella bursa-pastoris</i>	young leaves, roots	blanched, cooked in soups	[18–20]
Chinese celery	<i>Apium graveolens</i>	leaves, stalks	eaten raw, stir-fried, cooked in soups, steamed, pickled	[20,21]	Toothed ixeridium/Toothed ixeris	<i>Ixeridium dentatum</i> (Thunb.) Tzvelev	young leaves, roots	blanched, cooked as pancakes, salted	[18,19,58]
Chinese clover	<i>Medicago denticulate</i> /M. <i>hispida</i>	leaves, stalks	stir-fried	[20]	Young radish	<i>Raphanus sativus</i> L.	young leaves, roots	salted	[18,19]
Chinese mustard/Green mustard/Leaf-mustard cabbage/Mustard cabbage/Mustard greens	<i>Brassica juncea</i> /B. <i>juncea</i> var. <i>rugosa</i>	leaves, stalks	salted, pickled, stir-fried	[17–21]	Korean ginseng sprout	<i>Panax ginseng</i> Meyer	young leaves, stems, roots	eaten raw	[59]
East Asian wildparsley/Mitsuba/Honewort	<i>Cryptotaenia canadensis</i> /C. <i>japonica</i> Hassk.	leaves, stalks	eaten raw, blanched, stir-fried, deep fired, cooked in soups	[17–20,58]	Mioga ginger	<i>Zingiber mioga</i> (Thunb.) Roscoe	flower buds	blanched, cooked in soups, pickled	[18]
Horseradish/Japanese horseradish/Wasabi	<i>Eutrema japonica</i> /Wasabia <i>japonica</i>	leaves, stalks	eaten raw, cooked in soups, pickled, blanched	[18]	Banana bud	<i>Musa</i> spp.	flowers	eaten raw, blanched, stir-fried, steamed, cooked in soups, curries	[21]
Japanese radish greens/Korean radish greens	<i>Raphanus sativus</i>	leaves, stalks	dried leaves are cooked in soups, stir-fried	[18]					

Table 4. Fruit, pod and seed vegetables.

Vegetable	Scientific Names	Used Parts	Culinary Uses	Reference	Vegetable	Scientific Names	Used Parts	Culinary Uses	References
Angled gourd/Dishcloth gourd/Vegetable gourd/Luffa/Sponge gourd	<i>Luffa acutangula</i>	fruits	cooked in soups, stir-fried	[17,20,21]	Spaghetti marrow	<i>Cucurbita pepo</i> var. <i>fastigata</i>	fruits	steamed, baked, stir-fried	[20]
Balsam-pear/Bitter gourd/Bitter melon	<i>Momordica charantia</i>	fruits	steamed, stir-fried, cooked in soups, in stews	[17,19–21]	Baby corn/Miniature corn	<i>Zea mays</i> var. <i>rugosa</i>	corns with cobs	eaten raw, stir-fried	[21]
Bottle gourd/Edible bottle gourd/White-flowered gourd	<i>Lagenaria leucantha/L. siceraria/L. vulgaris</i>	fruits	eaten raw, dried, stir-fried, cooked in soups	[17–21]	Asparagus bean/Cow pea/Long bean/Yard long bean/Yard-Long beans	<i>Dolichos sesquipedalis/Vigna sesquipedalis/Vigna sinensis</i> var. <i>sesquipedalis</i>	pods	eaten raw, stir-fried, cooked in stews	[17,20,21]
Chinese preserving melon/Wax gourd/Winter gourd	<i>Benincasa cerifera/B. hispida</i>	fruits	eaten raw, cooked in soups, in stews, pickled, steamed, stir-fried	[17,18,20,21]	Asparagus pea/Goa beans Winged bean	<i>Psophocarpus tetragonolobus</i>	pods	blanched, stir-fried	[17,21]
Eggplant	<i>Solanum melongena</i>	fruits	steamed, stir-fried, deep fried, pan fried, grilled, cooked in soups, in stews	[18,21]	Edible-podded peas	<i>Pisum sativum</i> var. <i>macrocarpon</i>	pods	stir-fried	[17]
Fiery little bird's-eye chili	<i>Capsicum frutescens</i>	fruits	eaten raw, cooked	[21]	Snow pea/Sugar pea	<i>Pisum sativum</i> var. <i>saccaratum</i>	pods	blanched, stir-fried	[21]
Finger-length chili	<i>Capsicum annuum</i> cv. group <i>longum</i>	fruits	eaten raw, cooked	[21]	Adzuki bean	<i>Phaseolus angularis/Vigna angularis</i>	beans	cooked gruel, sweet paste	[18,20]
Hairy melon/Jointed gourd	<i>Benincasa hispida</i> var. <i>chieh-gua</i>	fruits	eaten raw, steamed, cooked in soups, stir-fried	[20]	Borlotti bean/Red-streaked bean	<i>Phaseolus vulgaris</i> cv.	beans	simmered, cooked in soups, stews	[21]
Japanese pumpkin/Kabocha squash	<i>Cucurbita maxima/C. moschata</i> some hybrids between the two	fruits	Steamed, deep fried, cooked pancakes, porridge	[18,20]	Cowpeas	<i>Vigna sinensis/V. unguiculata</i> L. Walp.	beans	grounded, cooked gruel, pancakes, jelly	[17–19]
Korean zucchini/Young pumpkin	<i>Cucurbita moschata</i>	fruits	stir-fried, cooked in soups, pancakes	[18,19]	Jwinunikong	<i>Rhynchosia nulubilis</i>	beans	cooked, roasted, boiled tea	[18]
Long eggplant	<i>Solanum melongena</i> var. <i>serpentinum</i>	fruits	steamed, stir-fried	[17,19]	Mungbean	<i>Vigna radiata</i>	beans	grounded, cooked gruel and pancakes, jelly	[18,19]
Oriental cucumber	<i>Cucumis sativus</i>	fruits	eaten raw, salted, pickled	[20]	Soya bean/Soybeans	<i>Glycine hispida/G. max</i>	beans	grounded, cooked and made tofu, pastes, sauces, sweets, side dishes	[17–20]
Oriental pickling melon	<i>Cucumis melo</i> var. <i>conomon</i>	fruits	pickled	[18]	Sword bean	<i>Canavalia ensiformis</i>	beans	cooked, boiled, steamed, roasted and boiled tea	[18,19]
Oriental pickling melon/Pickling melon	<i>Cucumis melo</i> var. <i>conomon</i>	fruits	Eaten raw, pickled, baked, stir-fried, boiled, cooked in soups	[17,20]	Twisted cluster bean	<i>Parkia speciosa</i>	beans	stir-fried	[21]
Papaya	<i>Carica papaya</i>	fruits	eaten raw, simmered, cooked in soups	[21]	Perilla seed	<i>Perilla frutescens</i>	seeds	roasted and made oil, roasted or grounded and used as seasonings	[18]
Pea eggplant	<i>Solanum torvum</i>	fruits	eaten raw, cooked in curries	[21]	Sesame seeds	<i>Sesame indicum</i>	seeds	roasted and made oil, roasted or grounded and used as seasonings	[18,20]
Snake gourd	<i>Trichosanthes cucumerina</i> var. <i>anguina</i>	fruits	stir-fried, cooked in curries	[21]	Water caltrop/Water chestnut	<i>Trapa bicornis /T. bispinosa /T. natans</i>	seeds	boiled	[17,20,58]

Table 5. Root vegetables.

Vegetable	Scientific Names	Used Parts	Culinary Uses	Reference	Vegetable	Scientific Names	Used Parts	Culinary Uses	Reference
Arrowhead/Chinese potato/Swamp potato	<i>Sagittaria sagittifolia/S. sinensis</i>	tubers	boiled, fried, stir-fried, grilled	[17,20]	Gegeol radish	<i>Raphanus sativus</i>	roots, leaves	salted, pickled	[18]
Chinese artichoke	<i>Stachys affinis/S. Sieboldii/S. tubifera</i>	tubers	eaten raw, blanched, stir-fried, steamed, pickled	[20]	Japanese turnips	<i>Brassica rapa var. rapifera</i>	roots, leaves	eaten raw, boiled, stir-fried, cooked in soups	[20]
Chinese potato/Chinese yam/Cinnamon-vine/East Asian mountain yam/Yam	<i>Dioscorea batatas/D. japonica Thunb./D. opposita</i>	tubers	eaten raw, steamed, cooked gruel and pancakes	[17–20,58]	Korean radish	<i>Raphanus sativus</i>	roots, leaves	eaten raw, salted, cooked in soups, dried	[18,19]
Baker's garlic/Rakkyo	<i>Allium chinense</i>	bulbs	pickled	[20]	Small radish	<i>Raphanus sativus</i> L.	roots, leaves	salted	[18,19]
Chinese taro/Japanese taro/Taro/	<i>Colocasia esculenta</i>	corms	cooked in soups, stews, grilled, steamed, simmered	[17–21]	Balloon-flower	<i>Platycodon grandifloras</i> (Jacq.) A.DC.	roots	eaten raw, boiled as tea	[18,19,58]
Gonyak	<i>Amorphophallus konjac</i>	corms	Its starch is cooked and made jelly	[18]	Bonnet bellflower/Deodeok/Lance Asiabell	<i>Codonopsis lanceolate</i> (Siebold & Zucc.) Benth. & Hook.f. ex Trautv.	roots	eaten raw, grilled, salted	[18,19,58]
Water chestnut	<i>Eleocharis dulcis</i> (Burm.f.) Trin. ex Hensch./ <i>E. tuberosa</i>	corms	eaten raw, boiled, pickled, grilled	[20,21,58]	Burdock/Great burdock	<i>Arctium lappa/A. majus/Lappa major, L. edulis</i>	roots	blanched, pickled, stir-fried, deep fried, cooked in soups	[17,19,20]
Lotus roots	<i>Nelumbo nucifera</i>	rhizomes	eaten raw, steamed, stir-fried, pickled	[17–21]	Horseradish/Japanese horseradish/Wasabi/Wild wasabi	<i>Eutrema japonica</i> (Miq.) Koidz./ <i>Wasabia japonica</i>	roots	grated roots are used as seasoning 'Wasabi' for Sushi	[18–20,58]
Daikon	<i>Raphanus sativus longipinnatus</i>	roots, leaves	pickled, simmered, cooked in soups, dried	[17–19,21]					

Table 6. Mushrooms.

Vegetable	Scientific Names	Used Parts	Culinary Uses	Reference	Vegetable	Scientific Names	Used Parts	Culinary Uses	References
Juda's ear	<i>Auricularia auricula-judae</i>		stir-fried	[18]	Pine mushroom	<i>Tricholoma matsutake</i> Sing.		eaten raw, grilled	[18]
Lesser rock tripe/Plated rock tripe/Smooth rock tripe	<i>Manna lichen</i>		blanched, stir-fried	[18]	Straw Mushroom	<i>Volvariella volvacea</i>		stir-fried, cooked in soups	[21]
Oak Mushroom/Shiitake Mushroom	<i>Lentinus edodes</i>		stir-fried, cooked in stews, soups, pancakes	[18,21]	Winter mushroom	<i>Flammulina velutipes</i> Sing.		stir-fried, cooked in stews, soups	[18]

Due to the limited number of publications and information in Europe, we added some commonly consumed or unique Asian vegetables to the list. Interestingly, some vegetables that had been traditionally gathered in the wild have recently been cultivated to provide more choice for consumers looking for diversity and health benefits. These vegetables are becoming more available in both online and offline markets.

Since vegetables have various common English names in the literature, we use their scientific names to avoid confusion and for better accuracy. The Asian vegetables are categorized under six groups: (i) sprout vegetables (Table 1), (ii) tree vegetables (Table 2), (iii) leaf and stem vegetables (Table 3), (iv) fruit, pod and seed vegetables (Table 4), (v) root vegetables (Table 5), and (vi) mushrooms (Table 6).

For the list of Asian vegetables in Tables 1–6, we gathered information from three published sources in English which introduce Asian vegetables, mainly from China, Japan and Southeast Asia. We also referred to information from published literature in Korean from various South Korean government ministries for more specific data. Additionally, we searched for the popularity of each species on the Internet. If the vegetable name did not appear in offline or online markets or in recipes and comments of internet users, we did not include the vegetable name in the list. Furthermore, we discuss four Asian vegetables and their future potential in the European market.

4. Four Recommended Asian Vegetables

Several Asian vegetables that were traditionally gathered wild, harvested from fields or forests, are now sold in online and offline markets in South Korea as ‘Ssam’ or ‘Namul’ vegetables. Vegetable-consuming cultures can also be found in other Asian countries. Pickled vegetables are consumed in China as ‘Pao Cai’ and in Japan as ‘Tsukemono’ and ‘Asazuke’. Additionally, most Southeast Asian countries and China typically consume vegetables by using the stir-fried cooking method. The vegetables are consumed mostly in the forms of ‘Kimchi’, ‘Ssam’ and ‘Namul’ as we explain further below.

‘Kimchi’ consists of salted and fermented vegetables. It is served as a side dish in almost every meal and can be made with various kinds of vegetables such as Chinese cabbage, radish (*Raphanus sativus*), cucumber (*Cucumis sativus*), and spring onion (*Allium fistulosum*). Approximately 300 varieties of ‘Kimchi’ are estimated to exist in Korea [60]. ‘Ssam’ consists of wrapping fillings such as cooked meat, rice (*Oryza sativa*) with fresh leafy vegetables such as lettuce (*Lactuca sativa*) and perilla leaves (*Perilla frutescens*). Recently, various new leafy vegetables have been introduced for ‘Ssam’ and landed successfully in the vegetable market. ‘Namul’ are seasoned fresh vegetables prepared either blanched or raw as side dishes. Various vegetables, not only cultivated but also gathered wild, are used for ‘Namul’.

Below, we present four Asian vegetables. They possess health benefits and exhibit increasing demand in the vegetable market. Additionally, they are easy to cultivate and fit the current trends in the European vegetable market because of their unique taste, higher value, decorative ability and small size. We strongly believe that these crops have the potential to be introduced in the European market in the future.

4.1. Korean Ginseng Sprouts (*Panax Ginseng Meyer*)

Korean ginseng is a perennial plant in the *Araliaceae* family. Korean ginseng has been used as a medicinal plant in East Asia [61] for more than 2,000 years [62]. Ginsenoside (triterpene glycoside saponin) is the main bioactive ingredient in Korean ginseng and is known to have various pharmacological and physiological benefits [61] such as anti-cancer [63], anti-diabetic [64,65], immunomodulatory [63,66], neuroprotective [63], radioprotective [67], anti-amnestic [63], and anti-stress properties [68,69].

Korean ginseng sprout [59] is a new medicinal vegetable recently introduced in the South Korean vegetable market with demand increasing [59]. Korean ginseng is customarily used only for its roots

and should be grown for about 5–6 years before harvest [70]. Because of this length of time, it is a high-priced product for consumers (Figure 1). In contrast, Korean ginseng sprout uses all parts of the plant, not only roots, but especially the leaves due to their young tender texture. Leaves contain higher levels of certain types of ginsenosides (Rg1, Rg2+Rh1, Rd, and Rg3) than roots [71]. It can be grown in a hydroponic cultivation system either without soil [72,73] or with nursery soil [59,74] Therefore, ginseng sprouts can be produced all year round without using pesticides in appropriate conditions. It only needs to be grown for 2–8 weeks after transplanting of one-year-old-ginseng-seedlings [59,72].



Figure 1. Mountain-cultivated Korean ginseng (*Panax ginseng* Meyer).

These plants are found in mountainous regions (Gangwon-do, South Korea). Compared to intensive field-cultivated plants, mountain-cultivated ginseng is more expensive. Since wild mountain ginseng is rare and Eastern Asians strongly believe in its health benefits, its value is highly appreciated. Intensively cultivated ginseng needs 5–6 years until harvest, while wild mountain ginseng has a slow growth rate and requires a longer time. Mountain ginseng has a smaller size than intensively cultivated ginseng. Korean ginseng is not usually sold in supermarkets, but in particular markets only for Korean ginseng products or online markets (Source: Hong, personal communication)

Korean ginseng sprouts are a small sized vegetable with a mild, bitter flavor. Soil-less ginseng sprouts can provide health benefits and a pesticide-free alternative for consumers. It can be consumed in a variety of ways, including in salads, milkshakes, deep-fried, sushi, soups, and tea. Furthermore, Korean ginseng sprout can be used in health food supplements and cosmetics.

4.2. *Ssamchoo* (*Brassica lee* ssp. *Namai* cv. *Ssamchoo*) and *Red Ssamchoo* (*Brassica koreana* Lee var. *Redleaf*)

Ssamchoo [18] is a hybrid plant species. This handle-fan-shaped leafy vegetable was developed by aneuploidy crossing Chinese cabbage with regular cabbage as ‘*Ssam*’ leafy vegetables [75,76]. Therefore, *Ssamchoo* combines the advantages of Chinese cabbage and cabbage [76]. *Red Ssamchoo* (*Brassica koreana* Lee var. *redleaf*) is a variety of Green *Ssamchoo* [76].

According to a leafy vegetables-agricultural technology guide from the Rural Development Association (RDA) South Korea [76], *Ssamchoo* has all the benefits of Chinese cabbage and cabbage, and a very high fiber content making it easier to digest. Overall contents of calcium, iron, vitamin A and ascorbic acid in *Ssamchoo* are higher than Chinese cabbage, cabbage and lettuce [76].

Producers can grow *Ssamchoo* either in soil or hydroponic systems. The method of cultivation is similar to that of lettuce. *Ssamchoo* can be harvested one month after sowing [76]. However, this vegetable is intolerant to hot and humid weather [76].

Ssamchoo has a smaller leaf size (Figure 2) than those of Chinese cabbage and regular cabbage [76]. Red Ssamchoo draws attention due to its red leaf and stem color [76]. Ssamchoo brings together the slight bitterness from Chinese cabbage and nutty sweetness from regular cabbage [76]. This leafy vegetable is lightly aromatic, sweet, juicy, mini-sized, and can be used in salads and soups and may be deep-fried [76].



Figure 2. Ssamchoo (*Brassica lee* ssp. *namai* cv. Ssamchoo).

Leaves of Ssamchoo can be easily found in open showcases fitted with a cool-mist humidifier in supermarkets. This vegetable is displayed with other various types of fresh leafy vegetables in a ‘Ssam-leafy-vegetables-section’ of supermarkets. Ssamchoo can be purchased in offline or online stores. Some online stores deliver fresh Ssamchoo leaves within 24 h after placing an order, even in the early morning of the next day of purchase (Source: Hong, personal collection).

4.3. *Peucedanum Japonicum*

Peucedanum japonicum [18,19,58] is a perennial herb [77] that belongs to the *Umbelliferae* family and is used as a medicinal plant [78]. This herb is found in China, South Korea, Japan, Taiwan, and the Philippines [79]. Its leaves are consumed traditionally to treat coughs in the Okinawa islands in Japan [78]. *Peucedanum japonicum* is reported to possess pharmacological benefits such as anti-obesity [78,80,81], anti-oxidant [82], anti-bacterial [83], anti-diabetic [81], tyrosinase inhibition [84], and anti-platelet aggregation [77].

Peucedanum japonicum is traditionally had been foraged from the wild. However, the plant is now cultivated in South Korea for its health benefits (Figure 3). The leaves contain a fragrant aroma, a little bitter and sweet taste. This leafy vegetable can be eaten raw as a salad, blanched, pickled or deep-fried. *Peucedanum japonicum* can be cultivated in an open field, greenhouse or hydroponic cultivation system [85,86].



Figure 3. *Peucedanum japonicum*.

Young leaves with stems, packed in a plastic bag are sold in ‘Namul-leafy vegetable section’ of supermarkets. *Peucedanum japonicum* can be purchased in offline or online stores. Some online stores deliver this fresh leafy vegetable within 24 h after placing an order, even in the early morning of the day after purchase (Source: Hong, personal collection).

4.4. *Aralia Elata* (Miq.) Seem.

Aralia elata (Miq.) Seem. [18,19,59] is a shrub that is found across Northeastern China, Korea, Japan [87,88] and eastern Russia [89]. In Chinese traditional medicine, its root cortex has been used as a tonic, anti-arthritic and anti-diabetic agent [90]. In the leaves and root cortex, many saponins are isolated and reported to possess an anti-diabetic [90] and a cytoprotective effect [91]. Additionally, a study found specific anti-tumor activity in the extract of the shoots [92].

The young shoots of *Aralia elata* (Miq.) Seem. have been generally foraged from the wild, but it is cultivated in Japan and South Korea for its expected health benefits (Figure 4). This young shoot has a mildly bitter and sweet taste, fragrant aroma, and a crunchy texture. This shoot vegetable is enough to be an ornament itself in dishes, and thus this young shoot is used as a garnish in Japanese cuisine [93]. In South Korea, the shoots are simply blanched and consumed with a spicy-sour sauce. This aromatic vegetable can also be pickled and deep-fried.



Figure 4. *Aralia elata* (Miq.) Seem.

Young shoots of *Aralia*, packed in clear transparent disposable plastic containers can be found in the leafy vegetable section of supermarkets. The shoots are still attached to a small part of woody stems to keep the shoots fresh. Consumers should carefully remove woody stems covered with sharp thorns. Young shoots can be purchased in offline or online stores. Some online stores deliver this fresh young shoots within 24 h after placing an order, even in the early morning of the day after purchase (Source: Hong, personal collection).

Young shoots of *Aralia elata* (Miq.) Seem. can be harvested (April–May) in open field cultivation from a whole tree [94,95]. If the shoots are harvested in the greenhouse (February–April), stem cuttings must be prepared [95]. Shoots will develop naturally from the stem cuttings given appropriate humidity [95]. Producers following forcing culture practices need a simple cultivation system such as a double-layer plastic greenhouse, heater, and white greenhouse felt for insulation [95]. Stem cuttings can sprout in immersion cultivation, in which shoots can be harvested after 15 days (30–35 days long) [94]. This method results in harvest at least two weeks earlier than from forcing cultivation [94].

5. The European Market for Asian Vegetables

Fresh fruit and vegetable consumption in Europe started to recover slightly in 2014 after suffering declines since 2000 [96]. Daily consumption in the EU-28 stood at 353 g of fresh fruit and vegetables

per capita in 2014 [96]. This was split, on average, between 192 g of fruits and 161 g of vegetables consumed each day [96]. The consumption of fruits and vegetables in the EU market is expected to increase in the coming decades until 2030 [97]. The main reasons for this phenomenon are increasing interests in a healthy diet and the easier access to fruits and vegetables at new marketplaces, including petrol stations and snack bars [97].

According to Florkowski [98], the market of Asian fruit and vegetables is still small in Europe. However, it is expected to expand across the EU member states, due to increasing consumer interests in diverse, balanced and healthy foods, exchange with Asian people, and contact with the Asian food culture.

When people migrate from one country to another, they have to change their consumption patterns because some vegetables are not available, i.e., the people moving from the Mediterranean region to northern Europe. However, the migrants asking for the vegetables that they were used to eating in their home country find that they cannot be found easily in the new country. In this way, they stimulated the introduction of new vegetables into Europe. An analogous mechanism can be seen during holidays abroad. In foreign countries, people are acquainted with new vegetables. After returning from holiday, they then desire to buy these products in their home country. The introduction of eggplant (*Solanum melongena*) and zucchini (*Cucurbita pepo* subsp. *pepo* convar. *giromontiina*) to the Dutch [99] and German markets are examples of this.

The small market share of Asian fruits and vegetables in Europe could be further increased through consumer education and safety assurances, as well as marketing campaigns focused on their unique taste, health benefits, ease of preparation, and reasonable price [98]. On the other hand, we believe that the total European fresh vegetable market size will increase over the long term due to strong trends, such as vegetarianism, health and well-being. There is also rising demand from consumers for organic, local, seasonal, fresh, sustainable and new vegetable species and varieties, quality labels, and specific nutrients of vegetables [100]. Thus, increasing demand for locally grown and organic vegetables can lead to the cultivation of Asian vegetables in Europe as a promising business opportunity, especially when these products possess new and additional quality attributes.

Due to stricter European import regulations concerning organic and safety standards of fruits and vegetables, locally-based producers may have comparative advantages in meeting the requirements for supplying fresh Asian vegetables to the European market. For instance, southeastern Asian countries including Malaysia, Thailand and Vietnam which export exotic fruits and vegetables to Europe will need to invest in cultivation practices and laboratory testing for certifications ensuring the hygiene standards of their products [101]. Since most southeastern Asian fruit and vegetable producers are small and live under relatively lower socio-economic conditions, the stricter European regulations are very challenging to meet [102,103].

5.1. Import from Developing and Asian Countries

The import of exotic products from developing countries into Europe is continuously increasing [104]. According to a statistical overview from Eurostat on the fruit and vegetable sector in the EU [105], the value of imported fruit and vegetables from developing countries into the EU was approximately 20.1 billion euros in 2017, while the value of exports from the EU to non-Member States was 4.6 billion euros [105]. Fruit imports accounted for 84.7%, while vegetable imports made up 15.3% of the total value [105]. The reason for this large difference is the relatively higher self-production of vegetables than fruits in Europe [106].

Among Asian countries, China is the leading exporter of vegetables and fruit to the EU. According to data sourced from Eurostat Comext, of total agri-food imports to the EU from China in 2017, fresh, chilled and dried vegetables accounted for 12% (623 million euros) and prepared vegetables, fruit or nuts accounted for 8% (416 million euros) [107]. The EU also imports vegetables from South Korea and Japan [108]. Although the European market for fresh fruit and vegetables is highly competitive, this market is large, mature, and has a relatively stable demand [106].

5.2. Exotic and Higher-Value Products

European consumers have become more interested in exotic and higher-value fruits and vegetables, with the market for these exclusive niche products growing [104]. Niche products and new varieties are expected to continuously emerge, particularly within the high-end market, due to their unique taste and consumer demands [104].

The fruit and vegetable market in Europe focused on unique produces with specific nutritional value is expected to continuously grow. For example, products with specific health benefits such as blueberries, avocados, and pomegranates known commercially as ‘superfoods’ have become more popular, especially in northwestern Europe [104].

According to CBI research [106], the past five years (2014–2018) have seen the highest growth rates and values from the import of certain fruits from developing countries. For instance, blueberries at 249% (449 million euro in 2018), avocados at 180% (1115 million euro) and mangoes at 51% (778 million euro) [106]. Compared to these exotic fruits, specific vegetables imported from non-EU suppliers are considered to be niche products due to the smaller market in Europe. However, these vegetables showed continuous growth in the European market from 2014 to 2018 with items as chili pepper (*Capsicum annuum*) at 33% (48,000 tons in 2018), asparagus (*Asparagus officinalis*) at 12% (42,000 tons), tamarinds (*Tamarindus indica*) at 14% (41,000 tons), sugar snaps (*Pisum sativum* var. *macrocarpon*), snow peas (*Pisum sativum* var. *saccharatum*) and other peas (*Pisum sativum*) at 12% (30,000 tons) [106].

5.3. Taste and Emotional Connection

According to Rabobank [109], the evolving tastes and preferences in developed countries drive the growing value in global trade of fresh fruits and vegetables. The top three drivers are related to the level of customer satisfaction with the quality, fresh appearance, taste, and the size and shape of the products [110]. Taste has recently become a deciding factor for purchase [110]. Additionally, taste preferences are the factors that essentially prevent the consumption of vegetables, especially for younger adults and women in Europe [111]. However, by appealing to the senses - seeing, touching, feeling and smelling - trust and loyalty can be established with customers. Building the emotional connection between consumers and vegetables plays an important role in encouraging customers to make repeated purchases [110]. Even the current Dutch Nationaal Actieplan Groenten en Fruit (National Action-Plan for Vegetables and Fruits) is designed to focus more on emotions and health issues (<https://nagf.nl>). Besides, sensory appeals of food products, such as taste, texture, quality, smell and appearance, influence consumers to choose an item [112], even if the taste of vegetables does not match the high market price [100,113]. Therefore, in-store demonstrations or cooking classes with simple and delicious recipes can provide excellent opportunities for new and unfamiliar Asian vegetables for a successful launch in the European market. With various consumer marketing strategies, the unique tastes and qualities of Asian vegetables can be efficiently introduced to future consumers.

5.4. Communication with Consumers

In order to increase the consumption of newly introduced Asian vegetables in the European market, potential European consumers need to be aware of these unfamiliar vegetables. For instance, consumers need to know how to select, store, prepare or cook these vegetables. In other words, a successful entry of new Asian vegetables into the European market requires various ways of communication with consumers. Communication channels need to be developed based on the lifestyle and culture of targeted consumers [98]. Websites with easy recipes, such as salads or stir fry, information about health benefits or the use of vegetables can inspire consumers. In addition, social media such as Instagram where people can take, edit, and share photos and videos [114] might contribute to increased demand for new vegetables. For instance, avocado was globally one of the 20 most hash-tagged vegetables on Instagram in 2018 [115]. Avocados had been imported into the European market with the highest growth rate of 180% for 5 years (2014–2018) and in value in 2018 [106].

6. Asian Vegetables from the Perspective of Climate Change and Cultivation Method

Trending vegetables in the European market are convenient, healthy, colorful, decorative, organic, local, seasonal [100], mini-sized, and have exceptional nutritional value. Therefore, for a successful entry in the European vegetable market, the introduced Asian vegetables must be tasty, not too exotic, functional, and easy to prepare [98]. For European growers, the new Asian vegetables must be easy to cultivate and should promise a good harvest with high yield. Moreover, these vegetables must be nutritious, clean, fresh, and high-quality to fulfill consumer demands [100,116].

To ensure a holistically sustainable development trajectory, the transformation towards vegetable-rich production and food systems should support climate change adaptation and protection of human and environmental health [117]. Production and the quality of vegetables are being threatened by exposure to an extreme environment, primarily due to climate change—summer heat-waves, heavy rains, drought, possible increasing infestation of weeds, pests, diseases and changes of CO₂ concentrations in the air [116–119]. Although traditional outdoor cultivation is cheaper in regards to energy and technology [120], innovative greenhouse cultivation technologies with evaporative cooling, shading, adequate water supply, and drainage systems can secure better vegetable quality [116,121,122].

7. Difficulties in the Introduction of New Vegetables and Other Ideas of Diversification

Promoting diverse vegetable supply should be accompanied by different measures—a selection of the best cultivar-genotypes to be grown in the new region, the development of cultivation techniques, avoidance of post-harvest facilities and providing consumers with information about the new ingredients and advice for cooking and preparation. However, the way of introducing new vegetables in the market is not always based on the same pattern. Introduction of kiwi and broccoli in the European market are examples. Even though kiwifruit is originally from China, it was introduced through New Zealand, where the fruit was named after the national “kiwi” bird, to Europe. Broccoli, a native European vegetable with origins in primitive cultivars grown in the Roman Empire, gained its reputation in the European market only after being re-introduced from the USA in the last century.

In many areas of the world, increased consumption of vegetables has been not only because of a growing understanding of the health benefits but also because of increasing availability of various vegetables [39]. Consumers want a continuous supply of vegetables, as well as diversity and novelty, which have become important selling points in modern markets—people are always looking for something new [123]. Introducing new Asian vegetables is just one of the ways to increase the consumption of vegetables in Europe. Introducing colorful vegetables, mini-vegetables, sprout-vegetables, and microgreens are other ways to increase consumption. The new vegetables that have been introduced to the European market include cherry and pear-shaped tomatoes (*Solanum lycopersicum*), baby-carrots (*Daucus carota* subsp. *sativus*), mini-cauliflowers (*Brassica oleracea* var. *botrytis*), mini-broccoli (*Brassica oleracea* var. *italica*), artichoke hearts (*Cynara scolymus*), fresh baby leaf curly kale (*Brassica oleracea* var. *sabellica*), pickling cucumbers (*Cucumis sativus*), beans sprouts (*Vigna radiata*), and different microgreens. The demand for lightly processed, ready-to-eat vegetables is also increasing [39].

Another way to increase vegetable consumption is the time of availability of the products. Year-round vegetable production is possible by using protected cultivation methods. Thus, colorful vegetables could be marketed in the winter period, especially in regions where the vegetable assortment is poor. Even well-known plants in the Mediterranean region, such as eggplant and sweet pepper (*Capsicum annuum* var. *grossum*), have been only recently available thanks to greenhouses. Besides, soil-less culture is popularly used because of its advantage in optimizing the root system and efficient control of pathogens without soil fumigation. Therefore, producers can achieve high-quality products as well as higher yields at a reasonable production cost using minimal pesticides [124–126]. Different cultivation methods with porous growing media and water culture systems (floating system, nutrient film technique, and aeroponics) are practiced in commercial greenhouse production [124].

In Asia, the indoor production of high-priced and high-quality vegetables is a well-known tradition. Farms use so-called plant factories as highly controlled environments. Figure 5 presents different cultivation steps and plant development stages for Korean ginseng sprouts from a farm in Korea. The vegetable growers of tomatoes, leafy greens, cucumbers, peppers, and others in Europe are progressively using hydroponics primarily because of the high-profit margins and ten times higher yields than traditional cultivation [127]. By using all-environment controlling technologies, producers in Europe can cultivate new Asian vegetables easily and efficiently, meeting food safety standards, only if they are rightly informed about the optimal cultivation conditions of these vegetables. New light processing and packaging technologies will enable fresh vegetables to be presented in a convenient form, e.g., with increased shelf life of pre-cut vegetables while maintaining nutritional value, safety, and freshness [39].



(a)



(b)



(c)



(d)

Figure 5. *Cont.*



(e)

Figure 5. Plant development stages of Korean ginseng sprouts (*Panax ginseng* Meyer). Korean ginseng sprouts in a modern plant factory using aquaponics. (a) one-year-old-ginseng-seedlings, freshly transplanted in holes of sponge-hydroponic-floating-rafts; (b) roots of one-year-old-ginseng; (c) roots of about ten-day old cultivated ginseng; (d) at about 21–27 days cultivating ginseng; (e) at about 21–27 days cultivating ginseng seedlings under LED lights. Lighting time: 1–15 days (10 h exposure/day), after 15 days (13 h exposure/day). Lighting lamps: LED blending ratio (blue:red = 2:1). The distance between leaves and LED lights about 10 cm (Source: kindly provided by K. Farm Factory).

8. Conclusions

Although the volume of fresh vegetable consumption in the EU is barely increasing, the outlook for the fresh vegetable market is positive. Some of the current trends in the market are the increasing demand for diverse, healthy, and exotic vegetables. In this regard, certain Asian vegetables may have good potential to be introduced and land successfully in the European vegetable market. Here, we discussed the potential of different Asian vegetables for introduction in the European market in the future and shared practical information for the cultivation of four species.

Asian vegetables can be introduced to European consumers not only as fresh vegetables but also as processed products with new and modern ideas, for instance, as Asian vegetable salad bags, as healthy juices, or as cosmetics. In the expanding European health product market, Asian vegetables may play an essential role due to their health benefits and pharmacological properties.

The cultivation of new Asian vegetables within Europe can provide a good opportunity for European vegetable growers to open a new premium niche market with safe, local/seasonal and organic products. For a successful introduction of new Asian vegetables into the European market, appropriate marketing strategies are essential.

Although interest in Asian vegetables is increasing in the European vegetable market, there have been very few studies conducted on Asian vegetables in Europe. From a marketing point of view, the consumer needs and preferences are the key factors leading the production. In complex markets and especially in export-markets, information about consumer needs and wishes does not reach producers all by itself. Thus producers must conduct market research in order to track consumer preferences and to monitor their changes continuously [99]. Further research is required on the Asian vegetable market within Europe and also on the cultivation of potential Asian vegetables under European climatic conditions. Economic, social, and ecological aspects also have to be considered. Further research will provide the basis for all those aspects.

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