

Article

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Article

The Number of Health-Promoting Substances that All Edible Vascular Plants Contain Compared to the Species-Specific Number of Health-Promoting Substances of Five Wild Edible Plants (WEPs)

Mauri K. Åhlberg

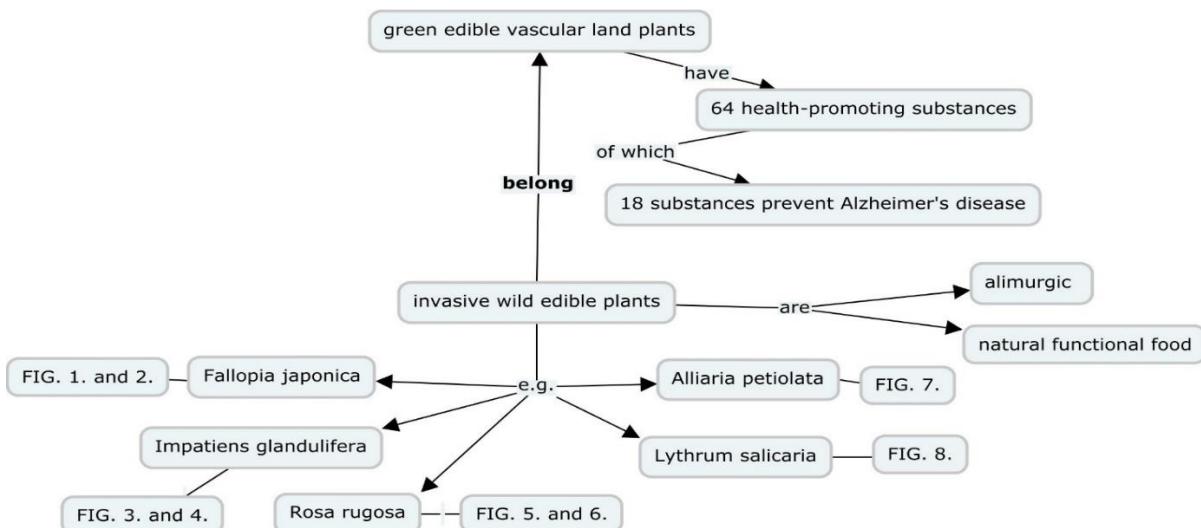
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Abstract: The Mediterranean diet, a widely studied and highly beneficial diet, underpins my research. Initially, the Mediterranean diet included Wild Edible Plants (WEPs). According to numerous research reports, this diet 1) promotes health and longevity and 2) prevents various modern diseases, including coronary and Alzheimer's disease. A vital component of this diet is consuming locally available green plants, which are rich in health-promoting substances. In Åhlberg (2021, 2022b), I presented evidence for 56 health-promoting substances that all green vascular WEPs contain. While reading research reports of these five species, I found eight more health-promoting substances that all green vascular wild edible plants have. This article adds eight new substances to the earlier 56, bringing the total to 64. This is a novel and groundbreaking finding for which I provide research evidence. Each WEP has 1) health-promoting substances that all green vascular plants share and 2) species-specific health-promoting substances. I present the latest research on five invasive wild edible plants (WEPs) species. Each contains at least 64 health-promoting substances and a varying number of species-specific health-promoting substances. I also present the experimental research results showing how many of these substances prevent Alzheimer's disease.

Keywords: wild edible plants (WEPs); wild food plants; Mediterranean diet; functional foods; good health; longevity; Alzheimer's disease; alimurgic plants; invasive species; sustainability

The graphical abstract



The graphical abstract

1. Introduction

Interest in the Mediterranean diet, foraging, and use of Wild Edible Plants (WEPs) is continually growing (De Cortes Sánchez-Mata et al. (2016), Jordan (2023), Kallas (2023), and Åhlberg (2019, 2020a, 2020b, and 2022a). The field is very fragmented. Since De Cortes Sánchez-Mata et al. (2016) and my books and articles Åhlberg (2019, 2020a, 2020b, 2021, 2022a, and 2022b), there has not been any research-based overview. As an example, a computer search by Google Scholar in 2024 using the keyword <wild edible plants> brings 7050 results (7.4.2024). Before Åhlberg (2021) there was very little interest in what health-promoting substances all green edible plants contain. In the present paper, I also highlight the importance of species-specific health-promoting substances.

Capurso (2024) wrote a historical analysis of the Mediterranean diet. He calls the earliest known version a “bread-olive oil-wine” triad integrated with legumes and cheeses produced with the milk of lean sheep and goat meat. Capurso (2024) does not mention Wild Edible Plants (WEPs) in his overview. He mentions, “... barbarian populations, between 400 and 800 AD, made the diet enriched with products from wild, uncultivated areas, meat from game and pigs, and vegetables”. Capurso (2024) could refer to wild vegetables in the quotation.

De Cortes Sánchez-Mata et al. (2016) and Åhlberg (2019, 2020a, 2020b, 2021, 2022a and 2022b) provide more accurate knowledge of wild edible plants (WEPs) in the Mediterranean diet. There is plenty of evidence that WEPs have been consumed since prehistoric times in Mediterranean countries.

Åhlberg (2019) compared ethnobotanical lists of WEPs foraged and consumed in different parts of the world. Many of the best WEPs are edible weeds spread nearly globally through agriculture, such as *Taraxacum officinale*, *Sonchus arvensis*, *Sonchus oleraceus*, and *Chenopodium album*.

Åhlberg (2020a and 2020b) searched for WEPs that have 1) a long history of use, 2) an extensive distribution, and 3) experimental research that shows that the species is not toxic and promotes health. The result was 94 species in the temperate and subtropical vegetation zones. In these books, I refer to many biochemical mechanisms of health-promoting substances when they are described in the latest research articles.

Åhlberg (2022a) selected 75 Finnish species of the earlier 94 species for a book dedicated to the Finnish audience. The book also includes the latest research results on health-promoting substances in English.

Sustainable global food chains require safeguarding the future of food sources and the environment. Applying Paura & Marzio (2022), Monari & al. (2021), and Marrelli & al. (2020), WEPs are examples of alimurgic plants. In times of famine caused by war, drought, plant diseases, pests, or any other cause, alimurgic plants provide food. When there is little else to eat, edible weeds and other WEPs, such as alimurgic plants, provide health-promoting raw materials for food. Top chefs use these plants to create tasty and healthy portions (e.g., Egebjerg & al. (2018), Tallberg & al., 2023). Since 2016, research has grown exponentially. Nowadays, we often know in detail the health-promoting chemical constituents of these plants. Research has also revealed many biochemical mechanisms on how these substances promote health. Christodoulou & al. (2023) and Åhlberg (2022) classify WEPs as natural functional foods.

Biodiversity decline, climate change, war, famine, overpopulation, hunger, obesity pandemic, and Alzheimer's disease are examples of current crises. In these crises, some people are worried about invasive alien species. European Union has developed a strategy to eradicate them. The latest EU document on this theme is the European Commission (2022a).

I present the latest research on three invasive alien WEPs in Europe and two in North America. The three invasive alien WEPs in Europe are Japanese knotweed (*Fallopia japonica*), Himalayan balsam (*Impatiens glandulifera*), and rugosa rose (*Rosa rugosa*). The two invasive alien WEPs in North America are garlic mustard (*Alliaria petiolata*) and purple loosestrife (*Lythrum salicaria*).

From the sustainability viewpoint, I forage mainly soft new aerial parts of these WEPs. I eat rose petals and hips raw. I never gather all plant material. I allow WEPs to grow new leaves, petals, and hips. As described in Åhlberg (2019, 2020 a, 2020b, and 2022), tender leaves of other foraged WEPs I usually boil first because 1) it kills possible bacteria and parasites, 2) it removes antinutrients such as

oxalic acid and extra nitrates, 3) it increases the availability of many health-promoting substances by breaking cell walls. Boiling is ordinary in Mediterranean countries (Arias-Rico & al. 2020; Seal & al. 2023; Sergio & al. 2020).

Finally, briefly mention the main aim of the work and highlight the principal conclusions.

My main aim of the work is to present research evidence that 1) there are at least 64 health-promoting substances in all green vascular plants, 2) these include substances that prevent Alzheimer's disease, 3) each plant species also has a varying number of species-specific health-promoting substances, and 4) these include substances that prevent Alzheimer's disease.

Principal conclusions: 1) Knowing these 64 health-promoting substances relieves many fears and opens new possibilities. For instance, the knowledge that all green vascular edible plants contain a) ascorbic acid relieves the fear that you do not get enough of it, b) melatonin relieves the fear of using it because it is in all edible vascular green plants, promotes health, and prevents Alzheimer's disease, and c) acetylcholine relieves the fear of avoiding it because every edible vascular green plants and the human body itself produces it. 2) The first time we know clearly that all green vascular edible plants have both shared health-promoting substances and species-specific health-promoting substances. This knowledge increases the willingness to consume a large variety of plants.

2. Materials and Methods

Knowledge from earlier research is necessary to create and test new knowledge. I used mainly information from online published papers, but when necessary, I used printed books and periodicals in libraries. Sometimes, I had to buy books and articles because they were not available from the library of The University of Helsinki. All research starts with research questions.

Research questions: (1) How did I find 64 health-promoting substances in all green vascular WEPs? (2) According to experimental research, how many of these substances prevent Alzheimer's disease? (3) How many species-specific health-promoting substances do five selected invasive WEPs contain? (4) How many Alzheimer's disease-preventing, species-specific health-promoting substances do these five selected plants have?

Everybody can check all claims of species and their health-promoting substances using the following research databases, which I have used in my research:

- 1) Europe PMC: <https://europepmc.org/>
- 2) Google Scholar: <https://scholar.google.com/>
- 3) PubMed: <https://pubmed.ncbi.nlm.nih.gov/>
- 4) PubChem: <https://pubchem.ncbi.nlm.nih.gov/>
- 5) HMDB: Human Metabolome Database: Searching HMDB
- 6) Science Direct: <https://www.sciencedirect.com/>
- 7) Web of Science Core Collection: <https://clarivate.com/products/scientific-and-academic-research/research-discovery-and-workflow-solutions/web-of-science/web-of-science-core-collection/>
- 8) Wiley Online Library: <https://www.onlinelibrary.wiley.com/>

I have used keywords: <the scientific name of plant species>, <chemical constituents>, <name of the specific substance>, <health>, and <Alzheimer's disease>.

KESKEN. TÄRKEÄÄ: 7.4.2024 all Figureures, tables and Vignettes sijoitetaan omille paikoilleen. Mitään ei säilytetä lopussa.

3. Results

3.1. Answers to Research Questions (1) How did I find 64 Health-Promoting Substances in all Green Vascular WEPs? (2) According to Experimental Research, How Many of These Substances Prevent Alzheimer's Disease?

From Åhlberg (2021 and 2022b), we know that all edible green vascular plants contain at least 56 health-promoting substances, according to experimental research. While reading research sources

for this new paper, I realized that all vascular green edible plants contain at least eight more health-promoting substances. There is experimental evidence that 1) galactolipids, 2) oxylipins, 3) phenylpropanoids, 4) phospholipids, 5) plant fats, 6) plant lipids, 7) salicylic acid, and 8) sphingolipids belong to the new list of 64 health-promoting substances that all green edible vascular plants contain. Of these 64 health-promoting substances, 18 prevent Alzheimer's disease, according to experimental research articles. I have written a paragraph about these eight new substances.

According to Haslam & Feussner (2022) and Suh & al. (2022), all land plants contain 1) sphingolipids. According to Dong & Lin (2021), all green vascular plants have 2) phenylpropanoids. According to Kim (2020) and Suh & al. (2022), all green vascular plants contain 3) oxylipins, 4) phospholipids, 5) plant fatty acids, 6) plant lipids, and 7) galactolipids. According to Ding & al. (2023), Jia & al. (2023), Mishra & Baek (2021), and Yang & al. (2023), both bacteria and plants, in particular land plants, produce 8) salicylic acid. Salicylic acid is one of the most essential plant hormones. According to the research databases, all eight substances promote human health. Plant lipids are the overarching concept covering plant fatty acids, galactolipids, and sphingolipids. Lipid synthesis involves several cell organelles. Fatty acids are synthesized in chloroplasts. Fatty acids are directly combined with glycerol to become a galactolipid, a significant component of the chloroplast membrane. Fatty acids are transferred to the cytoplasm to bind with glycerol in the endoplasmic reticulum to become phospholipids of the cell membrane. I present vignettes of these eight health-promoting substances that all (wild) edible vascular plants contain: 1) galactolipids, 2) oxylipins, 3) phenylpropanoids, 4) phospholipids, 5) plant fatty acids, 6) plant lipids, 7) salicylic acid, and 8) sphingolipids. The references inside the vignettes follow the style of my earlier vignettes in Åhlberg (2020a, 2020b, 2021, 2022a, and 2022b).

Vignettes 1 – 8. The eight new health-promoting substances that all edible green vascular plants contain and their functions in humans and plants.

galactolipids	<p>FOR HUMANS: According to Kuan & al. (2022), Cheng & al. (2016), and Winther & al. (2016), galactolipids have the following health-promoting properties:</p> <p>1) antioxidants, 2) reduce oxidative stress in cells, 3) anti-inflammatory, 3) improve skin wrinkles, moisture, and elasticity in healthy subjects, and 4) antitumor.</p> <p>IN PLANTS: According to Suh & al. (2022), Zhu & al. (2022), and Kim (2020), galactolipids: 1) are a component of the chloroplast membrane, 2) take part in photosynthesis, 3) prevent lack of phosphorus (P): "the plastid membranes mainly consist of glycolipids, while extraplastidic membranes mainly consist of phospholipids. Under P-deficiency conditions, phospholipids can be degraded to release the phosphate group; then the non-phosphorus galactolipids are compensatively synthesized to replace the phospholipid".</p> <p>Cheng, B. & al. 2016. The genus Rosa and arthritis: Overview on pharmacological perspectives. Pharmacological Research 114, 219-234.</p> <p>Kim, H. 2020. Lipid metabolism in plants. Plants 9, 871.</p> <p>Kuan, C. & al. 2022. Ameliorating effect of <i>Crassocephalum rabens</i> (Asteraceae) extract on skin aging: A randomized, parallel, double-blind, and placebo-controlled study. Nutrients 14, 2655.</p>
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	<p>Suh, MC. & al. 2022. Plant lipids: trends and beyond. <i>Journal of Experimental Botany</i> 73(9), 2715–2720.</p> <p>Winther K. & al. 2016. Bioactive ingredients of rose hips (<i>Rosa canina</i> L) with special reference to antioxidative and anti-inflammatory properties: in vitro studies. <i>Botanics: Targets and Therapy</i> 6, 11–23.</p> <p>Zhu, S. & al. 2022. Advances in plant lipid metabolism responses to phosphate scarcity. <i>Plants</i> 11, 2238.</p>
oxylipins	<p>FOR HUMANS: According to Shinto & al. (2022) and Caligiuri (2017), oxylipins have the following health-promoting properties: 1) antiaging, 2) prevent cardiovascular disease;3) prevent heart disease, 4) take part in immunity, 5) prevent inflammation, 6) prevent blood coagulation, and 7) take part in vascular tone regulation, 7) may prevent Alzheimer's disease.</p> <p>IN PLANTS: According to Sugimoto (2022), oxylipins 1) take part in plant growth, 2) take part in development, 3) take part in interactions with biotic and abiotic stressors, 4) take part in plant-environment interactions, 5) take part in plant-pathogen interactions, 6) take part in plant-plant interactions, 7) act as defense phytohormones, 8) take part in the activation of secondary metabolite accumulation, such as alkaloids and terpenoids, which act as toxic compounds to pathogens and pests.</p> <p>Caligiuri, S. 2017. Dietary modulation of oxylipins in cardiovascular disease and aging. <i>American Journal of Physiology-Heart and Circulatory Physiology</i> 313(5), H903–H918.</p> <p>Shinto L. & al. 2022. A Review of oxylipins in Alzheimer's disease and related dementias (ADRD): potential therapeutic targets for the modulation of vascular tone and inflammation. <i>Metabolites</i> 12, 826.</p> <p>Sugimoto K. & al. 2022. Editorial: Oxylipins: The front line of plant interactions. <i>Frontiers in Plant Science</i> 13, 878765.</p>
phenylpropanoids	<p>FOR HUMANS: According to Jaye & al. (2022), Navarre & al. (2022), Neelam & al. (2020), and Kolaj & al. (2018), phenylpropanoids have the following health-promoting properties:1) antioxidant, 2) anti-inflammatory, 3) antimicrobial, 4) antidiabetic, 5) anticancer, 6) renoprotective, 7) hepatoprotective, 8) cardioprotective, 8) protect mitochondria, 9) neuroprotective, and 10) may prevent Alzheimer's disease.</p>

	<p>IN PLANTS: According to Ramaroson & al. (2022), Dong & Lin (2020, and Deng & Lu (2017), phenylpropanoids: 1) are a large class of plant secondary metabolites derived from aromatic amino acids, mostly phenylalanine; 2) mainly include flavonoids, lignin, lignans, monolignols, hydroxycinnamic acid, phenolic acids, stilbenes, and coumarins; 3) are widely distributed in the plant kingdom; 4) take part in plant development; 5) are essential components of cell walls; 6) take part in plant defense against biotic or abiotic stresses; 7) protect against high light and UV radiation; 8) phytoalexins against herbivores and pathogens, and 9) act as floral pigments to mediate plant-pollinator interactions.</p> <p><i>Deng, Y. & Lu, S. 2017. Biosynthesis and regulation of phenylpropanoids in plants. Critical Reviews in Plant Sciences 36(4), 257-290.</i></p> <p><i>Dong, N. & Lin, G. 2020. Contribution of phenylpropanoid metabolism to plant development and plant-environment interactions. Journal of Integrative Plant Biology 63(1), 180–209.</i></p> <p><i>Epifano, F. & al. 2023. Protection of mitochondrial potential and activity by oxyprenylated phenylpropanoids. Antioxidants 12(2), 259.</i></p> <p><i>Jaye, K. & al. 2022. The role of crucial gut microbial metabolites in the development and treatment of cancer. Gut Microbes 14(1), e2038865, 1-29.</i></p> <p><i>Kolaj, I. & al. 2018. Phenylpropanoids and Alzheimer's disease: A potential therapeutic platform. Neurochemistry International 120, 99-111.</i></p> <p><i>Navarre, D. & al. 2022. Plant antioxidants affect human and gut health, and their biosynthesis is influenced by environment and reactive oxygen species. Oxygen 2(3), 348-370.</i></p> <p><i>Neelam, A. & al. 2020. Phenylpropanoids and their derivatives: biological activities and its role in food, pharmaceutical and cosmetic industries. Critical Reviews in Food Science and Nutrition 60(16), 2655-2675</i></p> <p><i>Ramaroson, M. & al. 2022. Role of phenylpropanoids and flavonoids in plant resistance to pests and diseases. Molecules 27(23), 8371.</i></p>
phospholipids	<p><u>FOR HUMANS</u>: According to Chang & al. (2022) and Küllenberg & al. (2012), phospholipids promote health in the following ways: 1) anti-inflammatory, 2) anticancer, 3) prevent coronary heart disease, 4) reduce cholesterol levels, 5) prevent platelet aggregation, 6) prevent hypertension, 7) reduce risk of arteriosclerosis, 8) promote the intestinal absorption of</p>

	<p>cholesterol and other lipids, 9) promote brain health by carrying essential polyunsaturated fats to the brain, 10) improve memory, 11) improve cognition, 12) improve immunological functions, and 13) prevent liver diseases.</p> <p><u>IN PLANTS:</u> According to Khosa (2022), Shu & al. (2022), and Wang & al. (2022), phospholipids: 1) are components of cell membranes, 2) phospholipids take part in the coordination of fundamental life processes at the cellular level, 3) take part in cell signaling, and 4) regulate flowering.</p> <p><i>Chang, W. & al. 2022. Phospholipids in small extracellular vesicles: emerging regulators of neurodegenerative diseases and cancer. Cytotherapy 24(2), 93-100</i></p> <p><i>Khosa, J. 2022. Phospholipids and flowering regulation. Trends in Plant Science 27(7), 621-623.</i></p> <p><i>Küllenberg, D. & al. 2012. Health effects of dietary phospholipids. Lipids in Health and Disease 11, 3, 1 -16.</i></p> <p><i>Suh, MC. & al. 2022. Plant lipids: trends and beyond. Journal of Experimental Botany 73(9), 2715–2720.</i></p> <p><i>Wang, P & al. 2022. Keep in contact: multiple roles of endoplasmic reticulum-membrane contact sites and the organelle interaction network in plants. New Phytologist. Accepted author manuscript.</i></p>
plant fatty acids	<p><u>FOR HUMANS:</u> 1) According to Cai & al. (2022), Casillas-Vargas & al. (2021), Trautwein & McKay (2020), and Marsiñach & Cuenca (2019), <u>plant fatty acids</u> have the following health-promoting properties: 1) take part in several metabolic and structural functions, 2) are components of the cell membranes, 3) take part in the transport of vitamins, 4) regulate the concentration of lipids in plasma; 5) produce precursors of eicosanoids, decosanoids, steroid hormones, and biliary acid, which are fundamental for the adequate functioning of the metabolism; 6) the most crucial energetic nutrient. Researchers recommend that at least 20% of the total energy intake should derive from lipids; 7) reduce the risk of cancers; 8) positively influence dyslipidemia; 9) lower the risk of cardiovascular diseases; and 10) antibacterial.</p> <p><u>IN PLANTS:</u> According to Kalinger & al. (2020): 1) Plants use fatty acids to synthesize acyl lipids for many different cellular, physiological, and defensive roles, such as 2) the synthesis of the essential membrane, 3) storage, 4) surface lipids, 5) the production of various fatty acid-derived metabolites used for signaling, and 6) the production of various fatty acid-derived metabolites used for defense.</p>

	<p><i>Cai, H. & al. 2022. Low-carbohydrate diet and risk of cancer incidence: The Japan Public Health Center-based prospective study. Cancer Science 113, 744–755.</i></p> <p><i>Casillas-Vargas, G. & al. 2021. Antibacterial fatty acids: An update of possible mechanisms of action and implications in developing the next generation of antibacterial agents. Progress in Lipid Research 82, 101093.</i></p> <p><i>Kalinger, R. & al. 2020. Fatty acyl synthetases and thioesterases in plant lipid metabolism: diverse functions and biotechnological applications. Lipids 55(5), 435-455.</i></p> <p><i>Marsiñach, M. & Cuenca, A. 2019. The impact of sea buckthorn oil fatty acids on human health. Lipids in Health and Disease 18:145.</i></p> <p><i>Trautwein, E. & McKay, S. 2020. The role of specific components of a plant-based diet in the management of dyslipidemia and the impact on cardiovascular risk. Nutrients 12, 2671; doi:10.3390/nu12092671</i></p>
plant lipids	<p><u>FOR HUMANS</u>: According to Amadi & al. (2022), Lim & al. (2022), and Yin (2022), <u>lipids</u>: 1) are crucial to several functional processes in the body, 2) are crucial to the storage of energy, 3) are crucial to the regulation of hormones, 4) are crucial to the transportation of nutrients, and 5) regulate adaptive immunity (T cells), 6) a moderate amount of unsatisfied omega-3 fatty acids prevent inflammations, 7) The brain has the highest lipids content after the adipose tissue. A part of its unsatisfied fatty acids usually comes from plants.</p> <p><u>IN PLANTS</u>: According to Suh & al. (2022), Kim (2020), and Macabuhay & al. (2022), <u>lipids</u>: 1) are one of the primary biological molecules in plants, 2) have a wide variety of functions in plant cells, both as structural components and as bioactive substances, 4) are essential for the integrity of cells and organelles by acting as a hydrophobic barrier for the membrane, 5) are involved in cell signaling, 6) are component of the chloroplast membrane, take part in photosynthesis, 8) store energy for seed germination, 9) contribute to defense against diseases, 10) contribute to defense against pests, and 11) take part plant root-microbe interactions.</p> <p>Amadi, P. & al. 2022. Lipid metabolism and human diseases. Frontiers in Physiology 13, 1072903.</p> <p>Kim, H. 2020. Lipid metabolism in plants. Plants 9, 871.</p> <p>Lim, S. & al. 2022. Lipid metabolism in T cell signaling and function. Nature Chemical Biology 18, 470–481.</p>

	<p><i>Macabuhay, A. & al. 2022. Modulators or facilitators? Roles of lipids in plant root–microbe interactions. Trends in Plant Science 27(2), 180 – 190.</i></p> <p><i>Suh, M. & al. 2022. Plant lipids: trends and beyond. Journal of Experimental Botany 73(9), 2715–2720.</i></p> <p><i>Yin, F. 2022. Lipid metabolism and Alzheimer's disease: clinical evidence, mechanistic link and therapeutic promise. The FEBS Journal, the online version before press: 07 January 2022.</i></p>
salicylic acid	<p>FOR HUMANS: According to Ding & al. (2023), Thrash-Williams & al. (2016), Randjelovic & al. (2015), and Baxter & al. (2001), salicylic acid has the following health-promoting properties: 1) antioxidant, 2) anti-inflammatory, 3) cardioprotective, 4) antidiabetic and 5) neuroprotective.</p> <p>IN PLANTS: According to Ding & al. (2023), Jia & al. (2023), Mishra & Baek (2021), and Yang & al. (2023), both bacteria and land plants produce salicylic acid. One of the most essential phytohormones is salicylic acid. Plants use salicylic acid: 1) signaling in heat production (thermogenesis), 2) as a signaling molecule during pathogen infection; 3) The increased levels of salicylic acid are associated with the induction of defense genes and systemic acquired resistance (plant immunity); 4) Salicylic acid is the critical signal molecule in regulating the activation of local and systemic defense responses against infections by pathogens; 5) Salicylic acid has a regulatory role in abiotic stresses, like heat stress and drought, and biotic stresses, such as the systemic acquired resistance-mediated defense response against pathogen infection; 6) Salicylic acid regulates plant growth and development processes, such as photosynthesis, respiration, vegetative growth, seed germination, flowering, senescence, etc.</p> <p><i>Baxter, G. & al. 2001. Salicylic acid in soups prepared from organically and non-organically grown vegetables. European Journal of Nutrition 40, 289–292 (2001). https://doi.org/10.1007/s394-001-8358-x</i></p> <p><i>Ding, Y. & al. 2023. Shared and related molecular targets and actions of salicylic acid in plants and humans. Cells 12(2), 219. https://doi.org/10.3390/cells12020219</i></p> <p><i>Jia, X. & al. 2023. The origin and evolution of salicylic acid signaling and biosynthesis in plants. Molecular Plant 16(1), 245–259. https://doi.org/10.1016/j.molp.2022.12.002</i></p> <p><i>Mishra, A.K. & Baek, K. 2021. Salicylic acid biosynthesis and metabolism: A divergent pathway for plants and bacteria. Biomolecules 11, 705. https://doi.org/10.3390/biom11050705</i></p>

	<p><i>Randjelovic, P. & al. 2015. The beneficial biological properties of salicylic acid. Acta Facultatis Medicae Naissensis 32(4):259-265.</i></p> <p><i>Thrash-Williams, B. & al. 2016. Methamphetamine-induced dopaminergic toxicity is prevented owing to the neuroprotective effects of salicylic acid. Life Sciences 154, 24-29. https://www.sciencedirect.com/science/article/pii/S0024320516301229</i></p> <p><i>Vizzari, G. & al. 2019. Circulating salicylic acid and metabolic profile after 1-year nutritional-behavioral intervention in children with obesity. Nutrients 11, 1091. doi:10.3390/nu11051091</i></p> <p><i>Yang, W. & al. 2023. Emerging roles of salicylic acid in plant saline stress tolerance. International Journal of Molecular Sciences 24(4), 3388. https://doi.org/10.3390/ijms24043388</i></p>
	<p><u>FOR HUMANS</u>: According to Sugawara (2022), Yamashita & al. (2021), and Norris & Blesso (2017), <u>sphingolipids</u> have the following health-promoting properties:</p> <p>1) anti-inflammatory, 2) prevent dyslipidemia, 3) prevent nonalcoholic fatty liver disease, 4) improve skin barrier function, 5) prevent diseases, 6) prevent cancer, 7) prevent metabolic syndrome, 8) improve lipid absorption, 9) improve metabolism,</p> <p><u>IN PLANTS</u>: According to Haslam & Feussner (2022), Suh & al. (2022), and Zeng & Yao (2022), Sphingolipids are essential metabolites found in all plant species. <u>Sphingolipids</u>: 1) take part in maintaining plasma membrane integrity. They are components of cell membranes; 2) take part in responses to biotic and abiotic stresses; 3) participate in intracellular signaling; 4) are essential for controlling cellular homeostasis; and 5) regulate plant immunity.</p> <p><i>Haslam, T & Feussner, T. 2022. Diversity in sphingolipid metabolism across land plants. Journal of Experimental Botany 73(9), 2785–2798, https://doi.org/10.1093/jxb/erab558</i></p> <p><i>Norris, G. & Blesso, C. 2017. Dietary sphingolipids: potential for management of dyslipidemia and nonalcoholic fatty liver disease. Nutrition Reviews 75(4), 274–285. https://doi.org/10.1093/nutrit/nux004</i></p> <p><i>Sugawara, T. 2022. Sphingolipids as functional food components: benefits in skin improvement and disease prevention. Journal of Agricultural and Food Chemistry 70(31), 9597–9609.</i></p>

	<i>Suh, M. & al. 2022. Plant lipids: trends and beyond. Journal of Experimental Botany</i> 73(9), 2715–2720. https://doi.org/10.1093/jxb/erac125
	<i>Yamashita, S. & al. 2021. Dietary sphingolipids contribute to health via intestinal maintenance. /International Journal of Molecular Sciences</i> 22, 7052, 1-18. https://doi.org/10.3390/ijms22137052
	<i>Zeng, H. & Yao, N. 2022. Sphingolipids in plant immunity. Phytopathology Research</i> 4,20, 1-19.

According to Åhlberg (2021, 2022b and the evidence presented above), the list of 64 health-promoting substances that all green vascular (wild) edible plants contain, is as follows: 1) acetylcholine, 2)alpha-linolenic acid, 3) antheraxanthin, 4) ascorbic acid, 5) beta-carotene, 6) betasitosterol, 7) biotin, 8) caffeic acid, 9) calcium, 10) carotenoids, 11) chlorophylls, 12) chloride, 13) choline, 14) citric acid, 15) copper, 16) dietary fibers, 17) fatty acids, 18) flavonoids, 19) folic acid, 20) galactolipids, 21) glutathione, 22) iron, 23) lignins, 24) linoleic acid, 25) lutein, 26) manganese, 27) magnesium, 28) melatonin, 29) molybdenum, 30) neoxanthin, 31) niacin, 32) nickel, 33) nitrates, 34) oleic acid, 35) oxylipins, 36) pantothenate, 37) phenolic acids, 38) phenolic compounds, 39) phenylpropanoids, 40) phospholipids, 41) phosphorus, 42) phylloquinone, 43) phytic acid, 44) phytosterols, 45) plant lipids, 46) plant proteins, 47) polyphenols, 48) polysaccharides, 49) potassium, 50) pyridoxine, 51) riboflavin, 52) salicylic acid, 53) selenium, 54) silicon, 55) sodium, 56) sphingolipids, 57) sulfur, 58) terpenoids, 59) thiamin, 60) tocopherols, 61) violaxanthin, 62) xanthophylls, 63) zeaxanthin, 64) zinc.

After reviewing experimental research of these 64 substances, I have concluded that all edible green vascular plants include the following 18 substances that prevent Alzheimer's disease: 1) alpha-linolenic acid, 2) ascorbic acid, 3) caffeic acid, 4) carotenoids, 5) choline, 6) dietary fibers, 7) flavonoids, 8) lutein, 9) melatonin, 10) phenolic acids, 11) phenolic compounds, 12) phenylpropanoids, 13) phytic acid, 14) polyphenols, 15) polysaccharides, 16) silicon, 17) terpenoids, and 18) tocopherols.

3.2. Answers to Research Questions: (3) How many Species-Specific Health-Promoting Substances do Five Selected Invasive WEPs Contain? (4) How many Alzheimer's Disease-Preventing, Species-Specific Health-Promoting Substances do these Five selected Plants Have?

My second subtheme concerns five wild edible plants that some researchers and environmental administrators regard as "invasive alien species" that should be eradicated. Foragers and WEP researchers disagree strongly. These five invasive species provide ecosystem services such as health-promoting foods. For this paper, I checked the latest research on what health-promoting substances these five plants contain.

In the following alien-invasive WEP presentations, I use expressions like "141 (64+77) health-promoting substances...". In parentheses, Figure 64 is the number of health-promoting substances common to all wild edible vascular plants according to Åhlberg (2021, 2022b, and the evidence presented in this article). The second Figure 64 of the sum is the species-specific substances that promote health, according to the evidence presented in this article. The example of 77 species-specific substances is from the aerial parts of Japanese knotweed (*Fallopia japonica*).

The five species presented in this article are attached with the list of substances that prevent Alzheimer's disease. I show the number of substances in the following form: 60 (18 + 42). This example is from Japanese knotweed (*Fallopia japonica*). In parentheses, the first Figure 64 is 18. All green vascular wild edible plants contain 18 substances that prevent Alzheimer's disease, according to Åhlberg (2021, 2022a, 2022b, and the evidence presented in this article). The second Figure 64 (42) after the plus operator is the number of species-specific substances that prevent Alzheimer's disease, according to experimental research.

3.2.1. Three Invasive Alien WEPs in Europe

Japanese Knotweed (*Fallopia japonica*)

HEALTH-PROMOTING PROPERTIES: I checked experimental studies and found that Japanese knotweed leaves (*Fallopia japonica*) have at least 141 (64+77) health-promoting substances that promote health. I take resveratrol as an example because all tissues of Japanese knotweed contain it. Resveratrol promotes health in the following ways: 1) antioxidant, 2) anti-inflammatory, 3) anticancer, 4) antiviral, 5) antidiabetic, 6) anti-obesity, 7) anti-metabolic syndrome, 8) cardiovascular protective, 9) antiplatelet, 10) anti-hypertension, 11) antiaging, 12) protects against neurodegenerative diseases, such as Alzheimer's disease, 13) anti-stroke, 14) nephroprotective, 15) hepatoprotective, 16) delays the progression of osteoarthritis, and 17) maintains genome stability, promoting a longer and healthier life. (Leaves of Japanese knotweed (*Fallopia japonica*) contain 57 (18 + 39) substances that prevent Alzheimer's disease. I list them at the end of the species description.)

WARNINGS: Japanese knotweed (*Fallopia japonica*) contains oxalic acid. It is wise to use it with calcium (Ca) and magnesium (Mg) sources, such as cheese or yogurt.

SUGGESTIONS FOR USE: A wise option is to use leaves and shoots of Japanese knotweed (*Fallopia japonica*) in the Mediterranean-style boiled mixtures of wild edible plants.

According to Ke & al. (2023), the Chinese have used thousands of years of rhizomes of Japanese knotweed (*Fallopia japonica*, synonyms *Polygonum cuspidatum*, and *Reynoutria japonica*) as medicine. They need to learn research on aerial parts of Japanese knotweed (*Fallopia japonica*) for food. In the conclusion of Ke & al. (2023) article, they express the need: "... aerial parts should receive more attention." Åhlberg (2020a, 2020b, and 2022) has focused on research on aerial parts. I present the results below.

Milanović & al. (2020) and Cucu (2021) regard Japanese knotweed (*Fallopia japonica*) as a harmful invasive alien species. But this species also provides ecosystem services, which I'll present evidence of. Milanović & al. (2020) present a general framework for discussion but do not understand the importance of foraging this species for food. According to Shimoda & Yamasaki (2016), in the homeland of this species, it is valued as a wild edible plant. It was recorded in the oldest history book in Japan in 720 AD.

According to Cucu (2021), a particular ecological service of Japanese knotweed (*Fallopia japonica*) is that bees create healthy honey from the nectar of the female flowers. Female flowers of Japanese knotweed (*Fallopia japonica*) are a great source of nectar, which is rich in fructose and glucose. Therefore, pollinating insects, such as bees, visit the flowers.

According to Shimoda & Yamasaki (2016, 449), from 927, there were written instructions on gathering Japanese knotweed (*Fallopia japonica*) spring shoots for the emperor. According to these over thousand-year-old guidelines, subjects conserve shoots in salt for later cooking. According to Shimoda & Yamasaki (2016, 453), the Japanese still use spring shoots of Japanese knotweed (*Fallopia japonica*) for cooking. In Japan, it is a trendy wild edible plant in spring. According to Nyman (2018, 6), Japanese knotweed (*Fallopia japonica*) was brought to Great Britain in the 19th century as an ornamental plant and as a food and medicinal plant. In Europe, its use for food has remained insignificant. I hope this will change because of the new experimental research on health-promoting substances of Japanese knotweed (*Fallopia japonica*).

Kallas (2023, 199 – 230) discusses Japanese knotweed (*Fallopia japonica*) as a WEP. According to Kallas (2023, 225): "I have found no historical or scientific records of people eating the leaves of our knotweeds, so I assume that they are not edible." Åhlberg (2020a and 2022a) has found research evidence of the edibility of Japanese knotweed (*Fallopia japonica*) leaves.

According to Lachowicz & Oszmiański (2019), Japanese knotweed leaves and stems (*Fallopia japonica*) contain health-promoting substances suitable as raw materials for functional food. According to Lachowicz & al. (2019, 700), leaves of Japanese knotweed (*Fallopia japonica*) are an excellent source of resveratrol and piceid. According to Chen & al. (2015), piceid is polydatin. Polydatin (piceid) and resveratrol may change each other in the living organism. Basholli-Salihu & al. (2016) describes in detail how this happens. According to Chen & al. (2015), polydatin protects the

nervous system. Japanese researchers Kurita & al. (2016, 31) recommend using young leaves of Japanese knotweed (*Fallopia japonica*) for food, as they do in Japan. They published their research in the Italian Journal of Food Science.

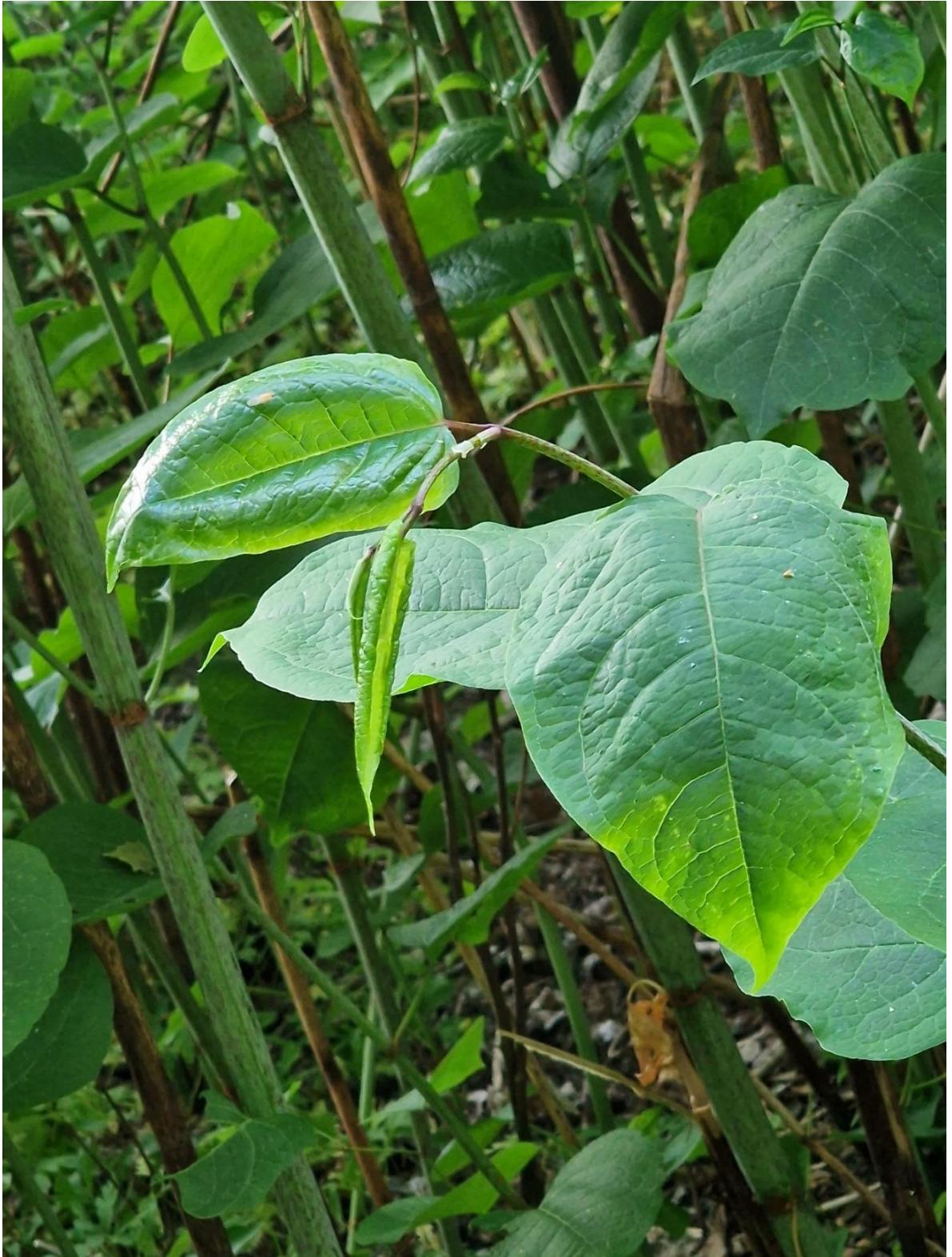


Figure 1. Foragers can use the soft new leaves of Japanese knotweed (*Fallopia japonica*) in Mediterranean-style boiled mixtures of wild edible plants. These leaves are non-toxic and contain many health-promoting substances, including resveratrol. Photo Mauri K. Åhlberg.



Figure 2. The Japanese boil or fry spring shoots of *Fallopia japonica*. They contain oxalates. Japanese knotweed spring shoots are used with food containing calcium and magnesium ions, such as cheese, whole-grain bread, or both. Photo Mauri K. Åhlberg.

Kurita & al. (2016) found plenty of neochlorogenic acid in the leaves of Japanese knotweed (*Fallopia japonica*). Leaf extract of Japanese knotweed (*Fallopia japonica*) is a potent antioxidant. Kurita & al. (2016, 31) recommend using young leaves of Japanese knotweed (*Fallopia japonica*) for food, as they do in Japan. They published their research in the Italian Journal of Food Science.

According to Lachowicz & al. (2019, 700), leaves of Japanese knotweed (*Fallopia japonica*) are an excellent source of resveratrol and piceid. According to Chen & al. (2015), piceid is polydatin. Resveratrol may change to polydatin (piceid), and polydatin may change to resveratrol in the living organism. Basholli-Salihu & al. (2016) describes in detail how this happens. According to Chen & al. (2015), polydatin protects the nervous system. According to Girardi & al. (2022, 923), “emodin and resveratrol were detected in all plant tissues” of *Fallopia japonica*.

Japanese knotweed (*Fallopia japonica*) contains 141 (64+77) health-promoting substances. I have listed the 77 species-specific health-promoting substances at the end of this species description.

Resveratrol is an excellent example of the 141 health-promoting substances of Japanese knotweed (*Fallopia japonica*). I present resveratrol in more detail in the following vignette.

Vignette 9. A synthesis of how resveratrol promotes health.

According to Alesci & al. (2022), Wu & al. (2022), Zhu & al. (2022), Alauddin & al. (2021), Grinan-Ferre & al. (2021), Xiong & al. (2021), Kumar & al. (2020), Matsuno & al. (2020), Martínez & al. (2019) and Singh, A. & al (2019a) **resveratrol** has following health-promoting properties: 1) antioxidant, 2) anti-inflammatory, 3) anticancer, 4) antiviral, 5) antidiabetic, 6) anti-obesity, 7) anti-metabolic syndrome, 8) cardiovascular protective, 9) antiplatelet, 10) anti-hypertension, 11) antiaging, 12) protects against neurodegenerative diseases, such as Alzheimer's disease, 13) anti-stroke, 14) nephroprotective, 15) hepatoprotective, 16) delays the progression of osteoarthritis, and 17) maintains genome stability, promoting a longer and healthier life. According to Zhua & al. (2019), resveratrol has protective effects on stress-induced depression and anxiety. They present a molecular biological mechanism for it. According to Grinan-Ferre & al. (2021), resveratrol is a powerful antioxidant and "possesses pleiotropic actions, exerting its activity through various molecular pathways." Kumar & al. (2020) state that resveratrol can cross the blood-brain barrier. Neuroinflammation is a part of Alzheimer's disease. Resveratrol prevents neuroinflammation.

Alauddin, M. & al. 2021. Potential of nutraceutical in preventing the risk of cancer and metabolic syndrome: from the perspective of nutritional genomics. Cancer Plus 3(2) 1 - 18.

Alesci, A. & al. 2022. Resveratrol and immune cells: A link to improve human health. Molecules 2022 27(2), 424. <https://doi.org/10.3390/molecules27020424>

Grinan-Ferre, A. & al. 2021. The pleiotropic neuroprotective effects of resveratrol in cognitive decline and Alzheimer's disease pathology: From antioxidant to epigenetic therapy. Aging Research Reviews, volume 67, article 101271, 1 – 24.

Kumar, S. & al. 2020. Resveratrol, a molecule with anti-inflammatory and anticancer activities: natural product to chemical synthesis. Current Medicinal Chemistry 27, 1 – 14.

Matsuno, Y. & al. 2020. Resveratrol and its related polyphenols contribute to the maintenance of genome stability. Scientific Reports, volume 10, article 5388, 1 – 10.

Wu, S. & al. 2022. Effects and mechanisms of resveratrol for prevention and management of cancers: An updated review. Critical Reviews in Food Science and Nutrition, DOI: 10.1080/10408398.2022.2101428

Xiong, G. & al. 2021. Effect of resveratrol on abnormal bone remodeling and angiogenesis of subchondral bone in osteoarthritis. International Journal of Clinical and Experimental Pathology 14(4) 417 – 425.

Zhu, H. & al. 2022. Resveratrol protects against chronic alcohol-induced liver disease in a rat model. STEMedicine 3(3), e133. <https://doi.org/10.37175/stemedicine.v3i3.133>

In this paper, I have presented evidence that all vascular green plants contain 64 health-promoting substances. In addition to these, Cucu & al. (2021), Lachowicz & al. (2019), Lachowicz & Oszmiański (2019), Mikulic-Petkovsek & al. (2022), and Åhlberg (2020a) found from published research the following 77 health-promoting, species-specific substances in aerial parts of Japanese knotweed (*Fallopia japonica*): 1) 3-feruloylquinic acid, 2) 3-p-coumaroylquinic acid, 3) 4-caffeooylquinic acid, 4) 5-caffeooylquinic acid, 5) 5-p-coumaroylquinic acid, 6) anthraquinones, 7) apigenin, 8) astringin, 9) betulinic acid, 10) caffeooylquinic acids, 11) caftaric acid, 12) catechin gallate, 13) chlorogenic acid, 14) cis-resveratrololoside, 15) coumarins, 16) dicaffeoylquinic acid, 17) emodin, 18) epicatechin, 19) ferulic acid, 20) flavanols, 21) flavones, 22) flavonols, 23) gallic acid, 24)

galloylhexoside, 25) isorhamnetin hexoside, 26) kaempferol, 27) kaempferol hexoside, 28) kaempferol-3-rhamnoside, 29) kaempferol-3-rutinoside, 30) lignans, 31) luteolin, 32) luteoxanthin, 33) myricetin-3-rhamnoside, 34) neochlorogenic acid, 35) neochrome, 36) neoxanthin, 37) oleanolic acid, 38) p-coumaric acid, 39) piceatannol hexoside, 40) piceid, 41) polydatin, 42) proanthocyanidins, 43) procyanidin B2, 44) procyanidin dimer 1, 45) procyanidin dimer 2, 46) procyanidin dimer 3, 47) procyanidin tetramer 1, 48) procyanidin tetramer 2, 49) procyanidin tetramer 3, 50) procyanidin tetramer 4, 51) procyanidin trimer 1, 52) procyanidin trimer 2, 53) procyanidin trimer 3, 54) procyanidin trimer 4, 55) procyanidin trimer 5, 56) procyanidin trimer 6, 57) procyanidin trimer 7, 58) quercetin, 59) quercetin acetyl hexoside, 60) quercetin dihexoside, 61) quercetin-3-arabinofuranoside, 62) quercetin-3-arabinopyranoside, 63) quercetin-3-galactoside, 64) quercetin-3-glucoside (isoquercitrin), 65) quercetin-3-rhamnoside (quercitrin), 66) quercetin-3-xyloside, 67) quinones, 68) resveratrol, 69) rutin (quercetin-3-rutinoside), 70) stilbenes, 71) syringic acid, 72) t-cinnamic acid, 73) trans-coutaric acid, 74) trans-piceid 1, 75) trans-piceid 2, 76) trans-resveratrololoside, and 77) ursolic acid.

Answer to the research sub-question: How many Alzheimer's disease-preventing, species-specific health-promoting substances do the aerial parts of Japanese knotweed (*Fallopia japonica*) contain?

Out of the total 141 (64+77) health-promoting substances that Japanese knotweed (*Fallopia japonica*) has, the aerial parts of Japanese knotweed (*Fallopia japonica*) contain the following 57 (18 + 39) substances that prevent Alzheimer's disease: 1) alpha-linolenic acid, 2) ascorbic acid, 3) caffeic acid, 4) carotenoids, 5) choline, 6) dietary fibers, 7) flavonoids, 8) lutein, 9) melatonin, 10) phenolic acids, 11) phenolic compounds, 12) phenylpropanoids, 13) phytic acid, 14) polyphenols, 15) polysaccharides, 16) silicon, 17) terpenoids, 18) tocopherols, 19) 4-caffeoylequinic acid, 20) 5-caffeoylequinic acid, 21) anthraquinones, 22) apigenin, 23) betulinic acid, 24) caffeoylequinic acids, 25) catechin, 26) chlorogenic acid, 27) coumarins, 28) dicaffeoylquinic acid, 29) emodin, 30) epicatechin, 31) essential oils, 32) ferulic acid, 33) flavanols, 34) flavones, 35) flavonols, 36) gallic acid, 37) isoquercitrin, 38) kaempferol, 39) lignans, 40) luteolin, 41) luteoxanthin, 42) neochlorogenic acid, 43) neoxanthin, 44) oleanolic acid, 45) p-coumaric acid, 46) piceid, 47) polydatin, 48) proanthocyanidins, 49) procyanidin B2, 50) quercetin, 51) quercitrin, 52) quinones, 53) resveratrol, 54) rutin, 55) stilbenes, 56) syringic acid, and 57) ursolic acid.

CONCLUSION: Chemical research has shown that Japanese knotweed (*Fallopia japonica*) contains at least 141 valuable health-promoting substances, including resveratrol, emodin, and polydatin. Tender aerial parts can be used as ingredients for healthy food. I use the young leaves in boiled mixtures of wild edible plants.

Himalayan Balsam (*Impatiens glandulifera*)

GENERAL HEALTH-PROMOTING PROPERTIES: From published research, I have found 136 (64 + 72) substances in aerial parts of Himalayan balsam (*Impatiens glandulifera*) that promote health according to experimental research in the following ways: 1) antioxidant, 2) anti-inflammatory, 3) antimicrobial, 4) antifungal, 5) antiviral, 6) antitumor, 7) anticancer, 8) cardioprotective, 9) anti-obesity, 10) arthritis-protective, 11) pulmonary and asthma-protective, 12) ovary-protective, 13) UV-protective, 14) antidepressant, 15) neuroprotective. 16) Aerial parts of Himalayan balsam (*Impatiens glandulifera*) contain 46 substances that prevent Alzheimer's disease, according to experimental research.

WARNINGS: Himalayan balsam (*Impatiens glandulifera*) has sharp needle-shaped oxalate crystals in almost all tissues. They are called raphids of calcium oxalate, which can irritate the intestine's mucous membrane. That is why it is not wise to eat leaves or stems. They can be vomiting (emetic). (The seeds may be an exception because many researchers have reported that children eat seeds of Himalayan balsam (*Impatiens glandulifera*).) Himalayan balsam (*Impatiens glandulifera*) is a toxic cadmium (Cd) hyperaccumulator. Researchers have found cadmium (Cd) in all researched parts of Himalayan balsam (*Impatiens glandulifera*). Accordingly, in clean, healthy environments, it is wise to only forage leaves, flowers, and seeds of Himalayan balsam (*Impatiens glandulifera*).

SUGGESTIONS FOR USE: Use boiling water to make water-infusion (water decoction) of Himalayan balsam (*Impatiens glandulifera*) fresh or dried leaves, shoots, and flowers. This herbal water extract is health-promoting. Start with small doses. Taste a flower, whether you can eat it fresh. It is worth trying because flowers contain many health-promoting substances. Seeds, both raw and mature, are tasty and healthy. Seeds have more unsaturated omega-3 fatty acids than unsaturated omega-6 fatty acids. This proportion promotes health.

Himalayan balsam (*Impatiens glandulifera*) is an invasive alien species with an extensive distribution (Figure 3).

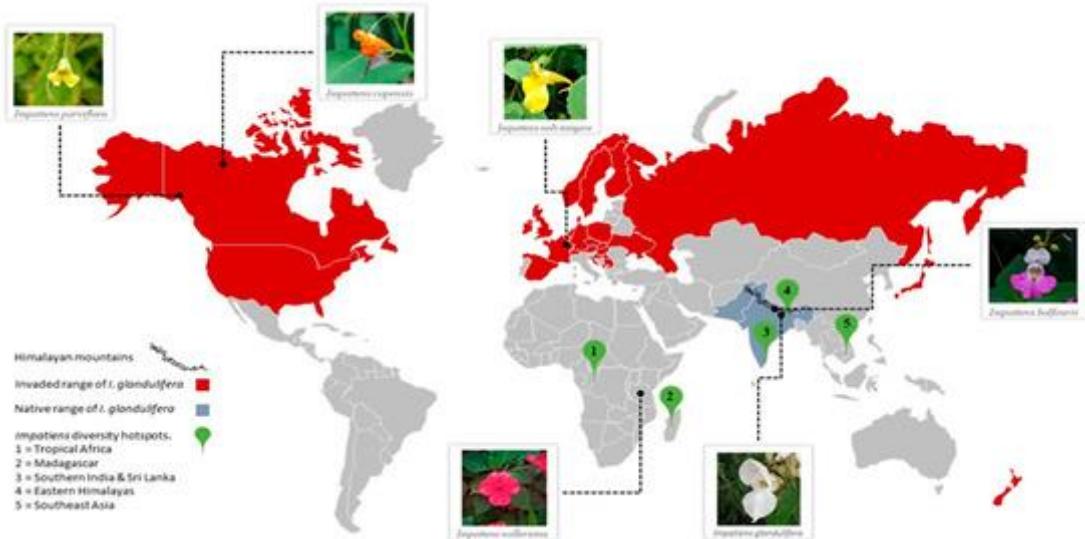


Figure 3. Extensive distribution of *Impatiens glandulifera*. The native range and the invaded range. This map is from Coakley & Petti (2021), an open-access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. <https://doi.org/10.3390/biology10070619>.

Milanović & al. (2020) regard Himalayan balsam (*Impatiens glandulifera*) mainly as a harmful invasive alien species. But this species also provides ecosystem services, which I'll present evidence of. Milanović & al. (2020) present a general framework for discussion but do not understand the importance of foraging this species for food.

Himalayan balsam has large inflorescences. It blooms in late summer. Prdun & al. (2022) state that Himalayan balsam (*Impatiens glandulifera*) is a significant nectar source for bees in late summer. It produces plenty of nectar with pollen and sugars. It attracts plenty of bees.

Leaves and flowers of Himalayan balsam (*Impatiens glandulifera*) are best in boiled-water extracts. Almost all parts of this plant have raphids (needle-like sharp calcium oxalate crystals). I have not found any research on raphids in flowers or seeds. Children eat seeds without any harm, as I have done. Raphids do not enter drinks, which are tonic, refreshing, and full of health-promoting substances. Juice (water extract) of flowers of Himalayan balsam (*Impatiens glandulifera*) is cooling and tonic. (Tonic means medicine for invigorating: increasing physical or mental strength.) Drink only in moderate doses.

According to Kayani & al. (2015, 192), Pakistanis make decoction out of flowers and leaves of Himalayan balsam (*Impatiens glandulifera*). According to Kayani & al. (2015, 192), Pakistanis make a powder after drying the Himalayan balsam (*Impatiens glandulifera*) flowers and leaves. They use this powder to make juice with health-promoting properties: 1) it provides a cooling effect, 2) improves sleep, and 3) it heals depression.

According to Balogh (2008, 133): "The nut flavored seeds and cooked young leaves, and shoots said (sic!) to be edible." Balogh (2008, 133) presents no research references. According to Kraehmer & Bauer (2013, 378 and 382), leaves and shoots contain raphids of calcium oxalate (oxalate crystals, which have a sharp needle-like shape), because of which may irritate the mucous membrane of the intestine. According to Hoover & Wijesinha (1945), intestinal calcium oxalate is insoluble. In their

ethnobotanical research, Qureshi & al. (2007, 2278) found that infusions of Himalayan balsam (*Impatiens glandulifera*) flowers are cooling and tonic. Ch & al. (2013, 247 – 248) found that locals use flower juice as a cooling agent and tonic in their ethnobotanical research.

Without any sources, Singh & Arora (1978, 82) claim that the seeds of Himalayan balsam (*Impatiens glandulifera*) are "the seeds which taste like nuts are eaten raw." Srivastava (1988, 205) made an ethnobotanical study on which Himalayan balsam (*Impatiens glandulifera*) seeds are eaten raw in India. According to Nasim & Shabbir (2012, 63), Himalayan balsam (*Impatiens glandulifera*) seeds are eaten raw in Pakistan. According to Nasim & Shabbir (2012, 63), "... its flavor is famous in young ones."

According to ethnobotanical research by Thakur & al. (2017, 3), locals in the Himalayan mountains eat Himalayan balsam (*Impatiens glandulifera*) fruits. According to Nasim & Shabbir (2012, 63), Pakistanis boil young shoots and leaves of Himalayan balsam (*Impatiens glandulifera*) into expectorant. Kumar & al. (2009, 1254) conducted ethnobotanical research on medicinal plants in India. People they interviewed allocated Himalayan balsam (*Impatiens glandulifera*) into the same category as common dandelion (*Taraxacum officinale*) and pomegranate (*Punica granatum*), which are used as 1) tonic, 2) appetizer, and 3) cooling agents. According to Gairola & al. (2014, 634 and 655), Indian people use Himalayan balsam as a tonic and aphrodisiac. Tonic means medicine for invigorating: increasing physical or mental tone and strength.

According to Orzelska-Górka & al. (2019, 206 -207), extracts made of Himalayan balsam (*Impatiens glandulifera*) have the following health-promoting properties: (1) antioxidant, (2) antimicrobial, (3) cytostatic, (4) anti-anxiety, and 5) antidepressant. According to Szewczyk & al. (2018b, 11), extracts made of aerial parts of Himalayan balsam (*Impatiens glandulifera*) are (6) anti-inflammatory.

Himalayan balsam (*Impatiens glandulifera*) has oxalate crystals in its tissues that have a sharp needle-like shape. They are called raphids of calcium oxalate, which can irritate the intestine's mucous membrane. According to Kraehmer & Bauer (2013, 378 and 382), researchers have found calcium oxalate raphids in almost all Himalayan balsam tissues (*Impatiens glandulifera*). They present only one photograph of raphids of calcium oxalate. In the photo, there are plenty of sharp raphids between cells. According to Ch & al (2013, 248), leaves of Himalayan balsam (*Impatiens glandulifera*), when eaten fresh (raw), are emetic. In medicine, emetic means that a substance is vomiting. The cause for emitting is probably raphids of calcium oxalate, which are in almost all tissues of Himalayan balsam (*Impatiens glandulifera*).

According to Kumar & al. (2009, 1254), (Nasim & Shabbir 2012, 63), and (Kayani & al. 2015, 192), foragers can cook shoots and leaves of Himalayan balsam (*Impatiens glandulifera*) for 1) tonic, 2) cooling the body, 3) expectorant, 4) sleep-promoting drink, and 5) to heal depressions. The sharp raphides of calcium oxalate probably remain in plant tissues if only the liquid is drunk. According to Guil & al. (1997, 102), most of the insoluble oxalates in other high-oxalate plants like spinach (*Spinacia oleracea*) and rhubarb (*Rheum rhabonticum*) do not solve into water. According to Coakley & al. (2019), Himalayan balsam (*Impatiens glandulifera*) is a hyperaccumulator of toxic cadmium (Cd). All researched parts of Himalayan balsam (*Impatiens glandulifera*) accumulate cadmium (Cd). Accordingly, in clean and healthy environments, it is wise to only forage leaves, flowers, and seeds of Himalayan balsam (*Impatiens glandulifera*).

I have selected phenolic acids to represent health-promoting substances in Himalayan balsam (*Impatiens glandulifera*). According to Szewczyk & Olech (2017), Himalayan balsam (*Impatiens glandulifera*) contains significant phenolic acids. According to Åhlberg (2022a), all main edible parts of Himalayan balsam (*Impatiens glandulifera*) contain phenolic acids: leaves, flowers, and seeds.

Vignette 10. A synthesis of how phenolic acids promote health and their functions in plants.

phenolic acids	For humans: According to Caruso al.& (2022), Rashmi & Negi (2020), Kumar & Goel (2019, Călinoiut & Vodnar (2018), and Szwaigier & al. (2018, phenolic acids have the following health-promoting properties: 1) antioxidants, 2) anti-inflammatory, 3)
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	<p>antimicrobial, 4) anticancer, 5) anti-allergic, 6) antidiabetic, 7) immunoregulatory, 8) anti-thrombotic, 9) anti-atherogenic, 10) cardioprotective, 11) neuroprotective, and 12) prevent Alzheimer's disease.</p> <p>In plants: According to Marchiosi & al. (2020) and Kumar & Goel (2019), phenolic acids are among plants' most widely distributed phenolic compounds. They are ubiquitous in both wild and cultured edible plants. Phenolic acids have critical biological roles. Many participate in the biosynthesis of structural components of the cell wall. Others are crucial for defence responses to pathogens and herbivores.</p> <p>Marchiosi & al. (2020, 893) divides simple phenolic acids into three groups: Group 1: benzoic acid and benzoic acid derivates, e.g., 1.1) benzoic acid, 1.2) gallic acid, 1.3) protocatechuic acid, 1.4) p-hydroxybenzoic acid, 1.5) salicylic acid, Group 2: cinnamic acid and cinnamic acid derivatives, e.g., 2.1) cinnamic acid, 2.2) p-coumaric acid, 2.3) caffeic acid, 2.4) ferulic acid and 2.5) sinapic acid, and Group 3: others, e.g., 3.1) catechol, 3.2) pyrogallol, and 3.3) chlorogenic acid.</p> <p><i>Caruso, G. & al. 2022. Phenolic acids and prevention of cognitive decline: polyphenols with a neuroprotective role in cognitive disorders and Alzheimer's disease. Nutrients 14, 819.</i> https://doi.org/10.3390/nu14040819</p> <p><i>Kumar, N. & Goel, N. 2019. Phenolic acids: Natural, versatile molecules with promising therapeutic applications. Biotechnology Reports, volume 24, article e00370, 1 – 10.</i></p> <p><i>Marchiosi, R. & al. 2020. Biosynthesis and metabolic actions of simple phenolic acids in plants. Phytochemistry Reviews 19, 865 – 890.</i></p> <p><i>Rashmi, H. & Negi, P. 2020. Phenolic acids from vegetables: A review on processing stability and health benefits. Food Research International, volume 136, article 109298, 1 – 14.</i></p> <p><i>Szwajgier, D. & al. 2018. Phenolic acids exert anticholinesterase and cognition-improving effects. Current Alzheimer Research 15(6) 531 – 543.</i></p>
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Figure 4. Flowering Himalayan balsam (*Impatiens glandulifera*). Using only water decoctions or infusions of shoots is wise because all tissues have sharp needle-like oxalate crystals. Photo Mauri K. Åhlberg.



Figure 5. Seeds of Himalayan balsam (*Impatiens glandulifera*). On the left are green raw seeds, half-mature seeds in the middle, and mature dark seeds on the right. Photo Mauri K. Åhlberg.

Seeds of Himalayan balsam (*Impatiens glandulifera*) contain over three times more omega-3-unsaturated fatty acids than omega-6-unsaturated fatty. This ratio promotes health. Seeds also contain oleic acid, the primary health-promoting fatty acid in extra-virgin olive oil.

According to Granado-Casa & Didac (2019), oleic acid is the primary monounsaturated fatty acid in olive oil and nuts, two essential foods in the Mediterranean diet. According to Gavahiana & al. (2019, 222), extra virgin olive oil contains oleic acid. It promotes healthy bacterial diversity in the gut. Wild edible plants often contain oleic acid. According to Granado-Casa & Didac (2019) and Sales-Campo & al. (2013), oleic acid has the following health-promoting properties: 1) prevents metabolic syndrome, 2) prevents high blood pressure, 3) prevents overweight (obesity), 4) prevents hyperglycemia, 5) prevents atherogenic lipid profile, 6) prevents insulin resistance, 7) prevents inflammation, 8) prevents prothrombotic alterations, 9) bactericidal, 10) fungicidal, 11) anticancer, and 12) attenuation of the effects of autoimmune diseases.

According to Szewczyk & al. (2016), Szewczyk & Olech (2017), Szewczyk & al. (2018), Szewczyk & al. (2019a), Szewczyk & al. (2019b), Orzelska-Górka & al. (2019), Vieira & al. (2016), and Åhlberg (2020a and 2022): Aerial parts (leaves, shoots, flowers) of Himalayan balsam (*Impatiens glandulifera*) contain 136 (64+72) health-promoting substances: 1) (E)-ligustilide, 2) (Z)-ligustilide, 3) 4-

ethylguaiacol, 4) 4-hydroxybenzoic acid, 5) alpha-copaene, 6) alpha-phellandrene, 7) alpha-selinene, 8) alpha-terpineol, 9) alpha-terpinyl acetate, 10) astragalin, 11) beta-elemene, 12) beta-ionone epoxide, 13) beta-phellandrene, 14) borneol, 15) bornyl acetate, 16) butylphthalide, 17) campesterol, 18) carvacrol, 19) carvone, 20) chondrillasterol, 21) coumarins, 22) delta-cadinene, 23) eriodictyol, 24) essential oils, 25) gallic acid, 26) gamma-cadinene, 27) gamma-elemene, 28) gamma-muurolene, 29) gamma-terpinene, 30) gentisic acid, 31) geranyl acetate, 32) glanduliferin A, 33) glanduliferin B, 34) guaiacol, 35) heptacosane, 36) heptanal, 37) hexahydrofarnesyl, 38) hyperoside, 39) isoquercitrin, 40) kaempferol, 41) limonene, 42) linalool, 43) methyl palmitate, 44) monoterpane hydrocarbons, 45) myricetin, 46) myristic acid, 47) naphthoquinones, 48) oxygenated monoterpenes, 49) oxygenated sesquiterpenes, 50) palmitic acid, 51) p-coumaric acid, 52) p-cymene, 53) phellandral, 54) phytol, 55) piperitone, 56) p-isopropylbenzaldehyde, 57) protocatechuic acid, 58) quercetin, 59) saponins, 60) sitostanols, 61) sitosterols, 62) spinasterol, 63) syringic acid, 64) terpinen-4-ol, 65) terpinen-7-al, 66) terpinolene, 67) T-muurolol, 68) trans-carveol, 69) trans-ferulic acid, 70) trans-piperitol, 71) tricosane, and 72) vanillic acid.

The answer to the research sub-question: How many Alzheimer's disease-preventing, species-specific health-promoting substances do the aerial parts of Himalayan balsam (*Impatiens glandulifera*) contain? The species-specific compounds are highlighted.

These 136 health-promoting substances of Himalayan balsam (*Impatiens glandulifera*) include 46 (18+28) chemicals that prevent Alzheimer's disease according to experimental research: 1) alpha-linolenic acid, 2) ascorbic acid, 3) caffeic acid, 4) carotenoids, 5) choline, 6) dietary fibers, 7) flavonoids, 8) lutein, 9) melatonin, 10) phenolic acids, 11) phenolic compounds, 12) phenylpropanoids, 13) phytic acid, 14) polyphenols, 15) polysaccharides, 16) silicon, 17) terpenoids, 18) tocopherols, 19) (E)-ligustilide, 20) (Z)-ligustilide, 21) 4-ethylguaiacol, 22) alpha-selinene, 23) alpha-terpineol, 24) alpha-terpinyl acetate, 25) astragalin, 26) borneol, 27) butylphthalide, 28) carvacrol, 29) carvone, 30) coumarins, 31) eriodictyol, 32) essential oils, 33) gamma-terpinene, 34) guaiacol, 35) hydroxycinnamic acids, 36) hyperoside, 37) isoquercitrin, 38) kaempferol, 39) limonene, 40) linalool, 41) myricetin, 42) naphthoquinones, 43) p-cymene, 44) protocatechuic acid, 45) quercetin, and 46) saponins.

FLOWERS: Applying Åhlberg (2020a, 2022a, and 2023), Pires & al. (2021), Szewczyk & Olech (2017), and Vieira & al. (2016, 119), flowers of Himalayan balsam (*Impatiens glandulifera*) contain 81 (64 + 17) health-promoting substances. The 18 substances that are specific for the flowers of Himalayan balsam (*Impatiens glandulifera*) are 1) 4-hydroxybenzoic acid, 2) astragalin, 2) coumarins, 3) eriodictyol, 4) essential oils, 5) gallic acid, 6) gentisic acid, 7) hyperoside, 8) isoquercitrin, 9) kaempferol, 10) myricetin, 11) naphthoquinones, 12) p-coumaric acid, 13) protocatechuic acid, 14) quercetin, 15) syringic acid, 16) trans-ferulic acid, and 17) vanillic acid.

The 81 health-promoting substances of the flowers of Himalayan balsam (*Impatiens glandulifera*) include the next 26 (18 + 8) substances that prevent Alzheimer's disease: 1) alpha-linolenic acid, 2) ascorbic acid, 3) caffeic acid, 4) carotenoids, 5) choline, 6) dietary fibers, 7) flavonoids, 8) lutein, 9) melatonin, 10) phenolic acids, 11) phenolic compounds, 12) phenylpropanoids, 13) phytic acid, 14) polyphenols, 15) polysaccharides, 16) silicon, 17) terpenoids, 18) tocopherols, 19) coumarins, 20) essential oils, 21) gallic acid, 22) kaempferol, 23) myricetin, 24) protocatechuic acid, 25) quercetin, and 26) vanillic acid.

SEEDS: According to Åhlberg (2020a, 2022b, 2023) and Szewczyk & al. (2018), seeds of Himalayan balsam (*Impatiens glandulifera*) contain 79 (64+15) health-promoting substances. The specific health-promoting 15 compounds in seeds are 1) 9,19-cyclolanostan-3-ol, 24-methylene-acetate, (3beta), 2) arachidonic acid, 3) azelaic acid, 4) beta-amyrin acetate, 5) campesterol, 6) caprylic acid, 7) chondrillasterol, 8) ergosta-7,22-dien-3-ol, 9) gamma-linolenic acid, 10) oleic acid, 11) palmitic acid, 12) sitostanol, 13) spinasterol, 14) stigmasterol, and 15) triterpenes.

The seeds of Himalayan balsam contain 18 (18 + 0) substances that prevent Alzheimer's disease: 1) alpha-linolenic acid, 2) ascorbic acid, 3) caffeic acid, 4) carotenoids, 5) choline, 6) dietary fibers, 7) flavonoids, 8) lutein, 9) melatonin, 10) phenolic acids, 11) phenolic compounds, 12)

phenylpropanoids, 13) phytic acid, 14) polyphenols, 15) polysaccharides, 16) silicon, 17) terpenoids, and 18) tocopherols.

Conclusion: I cook leaves of Himalayan balsam (*Impatiens glandulifera*) and drink the infusion. I eat raw flowers of Himalayan balsam (*Impatiens glandulifera*) and seeds in all development stages. Based on research results, I regard this wise practice to promote my health and longevity.

Rugosa Rose (*Rosa rugosa*)

According to Kelager & al. (2013), *Rosa rugosa* is (1) native to East Asia, (2) one of the most troublesome invasive plant species in natural or semi-natural habitats of northern Europe, and (3) very difficult to control.

According to Dobreva & Nedeltcheva-Antonova (2023, 1), *Rosa rugosa* has been cultivated in East Asia for thousands of years.

Rosa rugosa provides many ecosystem services for humans, including 1) petals and 2) rose hips for food. It is an important ornamental and economical plant. Its essential oil is expensive and has high economic value. According to Katekar & al. (2022), "... the production of rose essential oil and rose water is a lucrative source of revenue for rural communities."

Rosa rugosa may have both flowers (petals) and fruits (hips) simultaneously. According to Xie & al. (2022), *Rosa rugosa* purple lines flowers from spring to autumn. Medveckienė & al. (2023) call *Rosa rugosa* purple line a genotype 'Rubra.' Usually, foragers and growers gather rose petals and hips for different purposes. Rarely have both petals and rose hips been used in the same dish. Strangely, two recent research articles (Razgonova & al. 2022 and Wangg & al. 2022) combined the chemical constituents of rose petals and rose hips. In these two papers, all found phytochemicals are listed, regardless of research results, whether they promote health. I have searched separately for the kinds of health-promoting substances *Rosa rugosa* petals and rose hips contain.

According to Cendrowski & al. (2017): "The main polyphenol fraction in *Rosa rugosa* petals was ellagitannins constituting from 69 to 74% of the total petals' polyphenols."

Petals

According to (Cendrowski & al. (2017), Dobreva & Nedeltcheva-Antonova (2023), Dobson & al. (1990), Feng & al. (2014), Katekar & al. (2022), Lu & Wang (2018), Maciąg & Kalembera (2015), Manjiro & al. (2008), Nowak & al. (2014), Olech & al. (2019), Sulborska & al. (2012), and Zhang & al. (2019), the petals of rugosa rose (*Rosa rugosa*) contain the following 130 health-promoting substances in addition of the 64 health-promoting substances that all green vascular plants contain: 1) (+)-catechin (cianidanol), 2) aliphatic alcohols, 3) alpha-cadinol, 4) alpha-curcumene, 5) alpha-glucans, 6) alpha-phellandrene, 7) alpha-pinene, 8) alpha-terpineol, 9) anthocyanins, 10) apigenin, 11) apigenin 7-O-glucoside, 12) astragalin, 13) avicularin, 14) beta-caryophyllene, 15) beta-caryophyllene oxide, 16) beta-citronellol, 17) beta-glucans, 18) beta-pinene, 19) borneol, 20) bornyl acetate, 21) cadalene, 22) camphene, 23) caprylic acid, 24) catechin, 25) cis-linalool oxide, 26) cyanidins, 27) docosanal, 28) docosanol, 29) dodecanol, 30) eicosane, 31) ellagic acid, 32) ellagitannins, 33) essential oils, 34) eugenol, 35) euscaphic acid, 36) flavan-3-ols, 37) flavones, 38) flavonoid glycosides, 39) flavonols, 40) gallic acid, 41) gamma-muurolene, 42) gentisic acid, 43) geranial, 44) geranic acid, 45) geraniol, 46) geranyl acetate, 47) geranyl formate, 48) glycosides, 49) hemiterpenes, 50) heneicosane, 51) heptanal, 52) hexacosane, 53) hydrolyzable tannins, 54) hyperoside, 55) isocaryophyllene, 56) isoquercitrin, 57) isorhamnetin 3-O-glucoside, 58) kaempferol, 59) kaempferol 3,4-di-O-glucoside, 60) kaempferol derivatives, 61) kaempferol-3-O-rutinoside, 62) lauric acid, 63) limonene, 64) linalool, 65) linalyl acetate, 66) methyl eugenol, 67) methyl jasmonate, 68) monoterpenes acids, 69) monoterpenes esters, 70) monoterpenes hydrocarbons, 71) monoterpenes oxygenated, 72) monoterpenes, 73) myrcene, 74) myricetin 3,5-di-O-glucoside, 75) nonadecene, 76) nerol, 77) neryl acetate, 78) neryl acetone, 79) octyl butyrate, 80) oleic acid, 81) p-coumaric acid, 82) p-cymen-8-ol, 83) p-cymen-9-ol, 84) pelargonidins, 85) pentacosane, 86) pentadecan-2-one, 87) peonidin 3,5-di-O-glucoside, 88) peonidin 3,5-di-O-glucoside, 89) peonidin 3-O-glucoside, 90) peonidin 3-osophoroside, 91) peonidins, 92) phenylacetaldehyde, 93) phenylethyl salicylate, 94) proanthocyanidins, 95) procyanidins, 96)

protocatechuic acid, 97) quercetin, 98) quercetin 3,4-di-O-glucoside, 99) quercetin 3,4-O-diglucoside, 100) quercetin 3-O-glucosyl-xyloside, 101) quercetin 3-O-rhamnoside, 102) quercetin derivatives, 103) quercitrin, 104) quinine, 105) rosamultin, 106) rose oxides, 107) rugosin D, 108) rutin, 109) sabinene, 110) salicylic acid, 111) sanguin, 112) sanguin H-2, 113) sesquiterpene, 114) sesquiterpene hydrocarbons, 115) sesquiterpene oxygenated, 116) sinapic acid, 117) stearic acid, 118) tannins, 119) tellimagradin II, 120) terpenoid alcohols, 121) terpenoids, 122) terpinen-4-ol, 123) tetracosane, 124) thymol, 125) tiliroside, 126) T-muurolol, 127) tormentic acid, 128) tricosane, 129) triterpenoids, and 130) undecanal.

Hips

According to Singh & Gairola (2023), edible wild rose hips have great potential for food security.

According to Zhou & al. (2023), people are becoming more health-conscious about the nutritional and health benefits of rose hips. "The rosehip is an underutilized and sustainably produced fruit with great potential to generate value-added products."

According to Olech & al. (2017), *Rosa rugosa* provides one of the most enormous hips for food products. They are tasty.

According to Olech & al. (2019), *Rosa rugosa* hips are the most abundant source of health-promoting polysaccharides such as alpha-glucan and beta-glucan.

According to Skrypnik & al. (2019): "This study showed the high nutritional value of rose hips, especially of the species *Rosa rugosa* Thunb."

Stuper-Szablewska & al. (2023) state that *Rosa rugosa* hips have antifungal and antiviral properties.

Åhlberg (2020a and 2022a), Al-Yafeai & al. (2018), Cunja & al. (2016), Dashbaldan & al. (2021), Medveckienė & al. (2023), Milala & al. (2021), Nijat & al. (2021), Nowak, R. (2005), Nowak (2006), Olech & al. (2017), Olech & al. (2019), Olech & al. (2023), Stuper-Szablewska & al. (2023), Xie & al. (2022), the hips of rugosa rose (*Rosa rugosa*) contain the following 100 health-promoting substances in addition of the 64 health-promoting substances that all green vascular plants contain: 1) 2-hexenoic acid methyl ester, 2) 2-octenal, 3) 3-feruloylquinic acid, 4) 24-methylenecycloartanol, 5) afzelin, 6) alpha-amyrenone, 7) alpha-amyrin, 8) alpha-cryptoxanthin, 9) alpha-farnesene, 10) alpha-glucans, 11) alpha-pinene, 12) apigenin, 13) astragalin, 14) avicularin, 15) beta-amyrin, 16) beta-cryptoxanthin, 17) beta-glucans, 18) beta-ionone, 19) beta-myrcene, 20) betulinic acid, 21) butyric acid, 22) campesterol, 23) caprylic acid methyl ester, 24) catechin, 25) cholesta-3,5-dien-7-one, 26) cis-3-hexenal, 27) corosolic acid, 28) cyanidin-3-glucoside, 29) decanal, 30) decanoic acid, 31) docosane, 32) dodecanoic acid, 33) edulan, 34) ellagic acid, 35) ellagic tannins, 36) erythrodiol, 37) essential oils, 38) farnesyl acetone, 39) flavanols, 40) flavanols, 41) fumaric acid, 42) gallic acid, 43) gamma-terpinene, 44) geranal, 45) geraniol, 46) guaiacol, 47) heneicosane, 48) hexadecanoic acid, 49) hexahydrofarnesyl acetone, 50) isofucosterol, 51) juglanin, 52) kaempferol, 53) lauric acid methyl ester, 54) limonene, 55) linalool, 56) linolenic acid methyl ester, 57) lupeol, 58) luteolin, 59) lycopene, 60) maslinic acid, 61) methyl caprate, 62) myristic acid, 63) naringenin, 64) nerol, 65) nonanal, 66) obtusifoliol, 67) octanal, 68) oleanolic acid, 69) oleanolic aldehyde, 70) palmitic acid methyl ester, 71) p-cymene, 72) pentacosane, 73) phloridzin, 74) phytoene, 75) pomolic acid, 76) procyanidins, 77) quercetin, 78) quercetin-3-O-sophoroside, 79) quercitrin, 80) quinic acid, 81) rutin, 82) safranol, 83) scutellarin, 84) sitostenone, 85) steroids, 86) stigma sta-3,5-dien-7-one, 87) stigmasterol, 88) stilbenoids, 89) tannins, 90) terpinolene, 91) tetracosane, 92) trans-geranyl-acetone, 93) tricosane, 94) triterpenoid acids, 95) triterpenoids, 96) ursolic acid, 97) ursolic aldehyde, 98) uvaol, 99) vitexin, and 100) Z-nerolidol.

HIPS: I found that the hips of rugosa rose (*Rosa rugosa*) have at least 164 (64+100) health-promoting substances.

HEALTH-PROMOTING PROPERTIES of petals and hips of rugosa rose (*Rose rugosa*), according to health-promoting properties of ellagitannins: 1) antioxidant, 2) anti-inflammatory, 3) antimicrobial, 4) antiglycative, 4) hepato-protective, 5) beneficial effects on kidney diseases, 4) anti-virus, 5) cardioprotective, 6) neuroprotective, 7) prebiotic, 8) chronic disease prevention, 7)

anticancer, 8) antidiabetic, 9) beneficial effects on chronic tissue inflammation, 10) beneficial effects on metabolic syndrome) 11) beneficial effects on obesity-mediated metabolic complications, 12) beneficial effects on gastrointestinal diseases, 13) beneficial effects on eye diseases, 14) beneficial effects on depression, 15) muscle mass protective effects, and 16) beneficial effects on Alzheimer's disease and other neurodegenerative diseases

WARNINGS: I used to warn about salicylic acid before I learned while writing this paper that all green vascular plants contain salicylic acid. According to experimental research, plant salicylic acid promotes health.

SUGGESTIONS FOR USE: The flowers and fruits (rose hips) of the rugosa rose (*Rosa rugosa*) are widely used in salads or the traditional Mediterranean-style boiled mixtures of wild edible plants. Foragers can use petals for healthy dish decoration.

Milanovića & al. (2020, 3) present rugosa rose (*Rosa rugosa*) as a harmful invasive alien species. However, they understand that this species also provides many ecosystem services (seven listed) and disservices (two listed). Foragers have found that rugosa rose (*Rosa rugosa*) provides food for humans and other ecosystem services, of which I'll present evidence. Milanovića & al. (2020) present a general framework for discussion but do not fully understand the importance of foraging this species for food. According to Zhang & al. (2019, 938) and Olech & al. (2019, 2), in different cultures, petals and rosehips of rugosa rose (*Rosa rugosa*) have been used for a long time as a health-promoting food. Petals of rugosa roses (*Rosa rugosa*) are more significant than many other roses, and they smell and taste good. Often, there are plenty of them. Also, the hips of the rugosa rose (*Rosa rugosa*) are the biggest I have seen in roses.

According to Ng & al (2005), *Rosa rugosa*-flower extract increases the activities of antioxidant enzymes and their gene expression and reduces lipid peroxidation. According to Aisa & al. (2019), the edible and medicinal properties of rugosa rose (*Rosa rugosa*) are widely applied in the world: rose oil, rose sauce, rose cake, rose wine, rose tea, rose herbs, and other applications. According to Cendrowski & al. (2017), "the petals of *Rosa rugosa* are a valuable source of bioactive compounds and can be considered a healthy, valuable resource." According to Nowak & al. (2013, 1), their utilization could be much higher despite the wide availability of raw materials from *Rosa rugosa*. This situation is likely to result from poor knowledge about the nutritional and medicinal properties of the species and a lack of comprehensive information on its chemical composition.

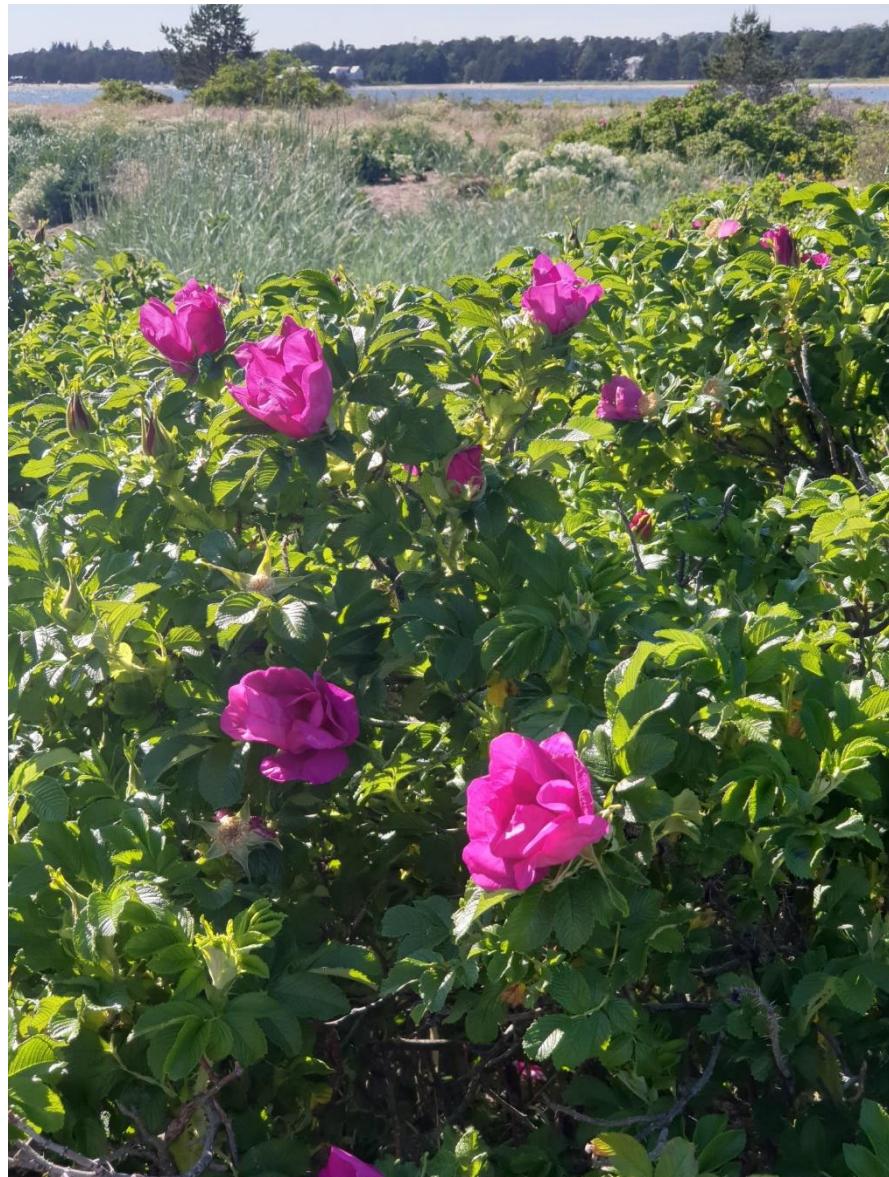


Figure 6. The rugosa rose (*Rosa rugosa*) is also known as the “beach rose” in English because it thrives on sandy beaches. Its petals and hips promote health and longevity and are an essential ecosystem service. Photo Mauri K. Åhlberg.



Figure 7. Rugosa rose (*Rosa rugosa*, purple line) has flowers and rosehips from early summer to late autumn in a good environment. It provides plenty of beautiful flowers and hips, which contain more health-promoting substances than other wild edible plants. Photo Mauri K. Åhlberg.

Cendrowski & al. (2017): “Due to the high content of bioactive compounds, especially polyphenolic compounds, including anthocyanins, flavonols, and ellagitannins, *Rosa rugosa* petals can be a valuable raw material for the production of health preparations.”

Cendrowski & al. (2017): “. Fresh petals of *Rosa rugosa* were collected from the industrial-scale plantation of the company “Polska Roza” located in Kotlina Kłodzka (Poland) in June 2011, June 2012, and June 2013.”

Both petals and hips of rugosa rose (*Rosa rugosa*) contain ellagitannins. I have selected ellagitannins as an example of over 164 (hips)-194 (petals) health-promoting substances that this invasive plant (*Rosa rugosa*) provides for humans as a free ecosystem service. I present them in more detail in the following vignette.

Vignette 11. A synthesis of how ellagitannins promote health.

ellagitannins	According to Chen & al. (2022), García-Villalba & al. (2022), Gopalsamy & al. (2022), Al-Harbi & al. (2021), D'Amico & al. (2021), Hoseinynejad & al. (2021), Milošević & al. (2021), Yüksel & al. (2021), Dreger & al. (2020), Li & al. (2020),
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Luca (2019, 17), Yoshida & al. (2018), Muthukumaran & al. (2017, 240 - 241), and Sangiovanni & al. (2013), ellagitannins have the following health-promoting properties: 1) antioxidant, 2) anti-inflammatory, 3) antimicrobial, 4) antglycative, 4) hepato-protective, 5) beneficial effects on kidney diseases, 4) anti-virus, 5) cardioprotective, 6) neuroprotective, 7) prebiotic, 8) chronic disease prevention, 7) anticancer, 8) antidiabetic, 9) beneficial effects on chronic tissue inflammation, 10) beneficial effects on metabolic syndrome) 11) beneficial effects on obesity-mediated metabolic complications, 12) beneficial effects on gastrointestinal diseases, 13) beneficial effects on eye diseases, 14) beneficial effects on depression, 15) muscle mass protective effects, and 16) beneficial effects on Alzheimer's disease and other neurodegenerative diseases. Schink & al. (2018) describe how ellagitannins prevent inflammations using molecular biology.

Al-Harbi, S. & al. 2021. Urolithins: The gut-based polyphenol metabolites of ellagitannins in cancer prevention, a review. Frontiers in Nutrition, Volume 8, article 647582, 1 – 15.

Chen P. & al. 2022. Recent advances and perspectives on the health benefits of urolithin b, a bioactive natural product derived from ellagitannins. Frontiers in Pharmacology 13:917266

D'Amico, D. & al. 2021. Impact of the Natural Compound Urolithin A on Health, Disease, and Aging. Trends in Molecular Medicine 27(7), 687 – 699.

*Dreger, M. & al. 2020. Pharmacological properties of fireweed (*Epilobium angustifolium* L.) and bioavailability of ellagitannins. A review. Herba Polonica 66(1), 52 – 64.*

García-Villalba, R. & al. 2022. Ellagitannins, urolithins, and neuroprotection: Human evidence and the possible link to the gut microbiota. Molecular Aspects of Medicine. Available online 5 August 2022, 101109. In Press, Corrected Proof. <https://doi.org/10.1016/j.mam.2022.101109>

Gopalsamy, R. & al. 2022. Health functions and related molecular mechanisms of ellagitannin-derived urolithins, Critical Reviews in Food Science and Nutrition. <https://doi.org/10.1080/10408398.2022.2106179>

Li, Q. & al. 2020. Anti-renal fibrosis and anti-inflammation effect of urolithin B, ellagitannin-gut microbial-derived metabolites in unilateral ureteral obstruction rats. Journal of Functional Foods, Volume 65, article 103748, 1 – 13.

Milošević M. & al. 2021. Memorable food: Figureting age-related neurodegeneration by precision nutrition. Frontiers in Nutrition, Volume 8, article 688086, 1 – 13.

Sangiovanni, E. & al. 2013. Ellagitannins from Rubus berries for the control of gastric inflammation: in vitro and in vivo studies. PLoS ONE, Volume 8(8), article e71762, 1 – 12.

*Yüksel, A. & al. 2021. Phytochemical, phenolic profile, antioxidant, anticholinergic, and antibacterial properties of *Epilobium angustifolium* (Onagraceae). Journal of Food Measurement and Characterization. Published*

	<p><i>online 12. 7. 2021, 1 – 10.</i></p> <p><i>Yoshida, T & al. 2018. The chemical and biological significance of oenothein B and related ellagitannin oligomers with macrocyclic structure. Molecules, Volume 23, article 552, 1–21.</i></p>
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How many Alzheimer's disease-preventing, species-specific health-promoting substances do the petals and hips of Rosa rugosa have? **The species-specific compounds are highlighted:**

PETALS: Petals of rugosa rose (Rosa rugosa) contain 194 health-promoting substances. They include the next 35 (18 + 17) compounds that prevent Alzheimer's disease according to experimental research: 1) alpha-linolenic acid, 2) ascorbic acid, 3) caffeic acid, 4) carotenoids, 5) choline, 6) dietary fibers, 7) flavonoids, 8) lutein, 9) melatonin, 10) phenolic acids, 11) phenolic compounds, 12) phenylpropanoids, 13) phytic acid, 14) polyphenols, 15) polysaccharides, 16) silicon, 17) terpenoids, 18) tocopherol, 19) anthocyanins, 20) apigenin, 21) catechin, 22) ellagic acid, 23) ellagitannins, 24) essential oils, 25) flavonols, 26) gallotannins, 27) isorhamnetin, 28) kaempferol, 29) limonene, 30) linalool, 31) myricetin, 32) procyanidins, 33) quercetin, 34) rutin, and 35) sinapic acid.

HIPS: Fruits (rosehips) of rugosa rose (Rosa rugosa) contain over 164 health-promoting compounds and ions; they include the following 39 (18+ 21) compounds that prevent Alzheimer's disease according to experimental research: 1) alpha-linolenic acid, 2) ascorbic acid, 3) caffeic acid, 4) carotenoids, 5) choline, 6) dietary fibers, 7) flavonoids, 8) lutein, 9) melatonin, 10) phenolic acids, 11) phenolic compounds, 12) phenylpropanoids, 13) phytic acid, 14) polyphenols, 15) polysaccharides, 16) silicon, 17) terpenoids, 18) tocopherol, 19) anthocyanins, 20) apigenin, 21) beta-caryophyllene, 22) catechin, 23) chlorogenic acid, 24) ellagitannins, 25) essential oils, 26) hespiridin, 27) hydroxycinnamic acids, 28) isorhamnetin, 29) kaempferol, 30) kaempferol-3-o-glucoside, 31) linalool, 32) luteolin, 33) lycopene, 34) myricetin (raw fruits), 35) naringin, 36) nobletin, 37) quercetin, 38) rutin, and 39) taxifolin.

Conclusion: The total number of health-promoting substances in rose petals is at least 194 (64 + 130). The total number of health-promoting substances in rose hips is at least 164 (64+100). I eat hips directly from rose bushes. I eat petals directly from flowers. I get plenty of health-promoting substances, prevent Alzheimer's disease, and get beneficial microbes (probiotics) everywhere on surfaces of edible plants. I use petals and rose hips to decorate my food.

3.2.2. Invasive Alien Species in North America

Garlic Mustard (*Alliaria petiolata*)

DISTRIBUTION: According to GBIF (2023), garlic mustard (*Alliaria petiolata*) is widely distributed globally.

HEALTH-PROMOTING PREVENTIVE PROPERTIES: Garlic mustard (*Alliaria petiolata*) has 100 health-promoting substances. One of them is apigenin, which promotes health in the following ways: 1) antioxidant, 2) anti-inflammatory, 3) antidiabetic, 4) beneficial role in amnesia and Alzheimer's disease, neuroprotective agent against Alzheimer's and Parkinson's diseases, 5) beneficial effects in depression and insomnia, 6) anticancer, protects from cancer in many ways, 7) mitigates rheumatoid arthritis, 8) alleviates autoimmune disorders, and 9) in elderly males increases androgen production for health; improves testosterone production, contributing to normal spermatogenesis and preventing age-related degenerative diseases associated with testosterone deficiency. Garlic mustard (*Alliaria petiolata*) has 24 substances that prevent Alzheimer's disease.

WARNINGS: Earlier, researchers warned about erucic acid. Nowadays, experimental research shows that it promotes health.

SUGGESTIONS FOR USE: The leaves of garlic mustard (*Alliaria petiolata*) smell like garlic. As with all wild edible weeds, it is wise to use only reasonable amounts in boiled mixtures of wild edible plants, preferably in the Mediterranean way.

According to Garcia-Herrera & Sanches-Mata (2016, 148), garlic mustard (*Alliaria petiolata*) belongs to traditional Mediterranean wild edible plants. When the leaves are crushed, new leaves of

garlic mustard (*Alliaria petiolata*) have a garlic odor. According to Fleischhauer & al. (2016, 126–127), Central Europeans use garlic mustard (*Alliaria petiolata*) in salads, soups, and other dishes. According to Lucchetti & al. (2019, 4), Italians use flowers and leaves of garlic mustard (*Alliaria petiolata*) in salads and to decorate dishes. According to Motti & al. (2022), Italians use garlic mustard as a vegetable.

According to Egebjerg & al. (2018, 134), leaves of garlic mustard (*Alliaria petiolata*) contain erucic acid, 31 percent of all lipids, and 0,5 % dry weight. According to Mira & al. (2019, 5), seeds of garlic mustard (*Alliaria petiolata*) contain erucic acid 28%, over 40 % of the total lipid content. According to EU CONTAM (2017, 1), the safe use of erucic acid is 7 mg per kg body weight. According to experimental research by Takahashi & al. (2021), erucic acid ameliorates obesity-induced metabolic disorders.

According to Altinoz & Ozpinar (2019), Dawkins & al. (2023), Galanty & al. (2023), Goya & al. (2023), Kim & al. (2016), Repsold & al. (2018), and Takahashi & al. (2021), (1) erucic acid is a health-promoting compound, and (2) erucic acid prevents Alzheimer' disease.

According to Sajna (2017), (1) in Europe, garlic mustard (*Alliaria petiolata*) is a “native humble understorey species.” Its habitats are forest understorey, forest edge, and ruderal site. (2) In North America, it is an invasive species.

In Europe, garlic mustard (*Alliaria petiolata*) has a patchy distribution. People spread it in Europe because it is an excellent wild edible plant. In North America, people regard it as a harmful invasive plant. Arrington (2020) suggests people could forage it and cook food in big cities like New York. Arrington (2020) understands that edible invasive plants provide ecosystem services.

According to Cavers & al. (1979, 221), garlic mustard (*Alliaria petiolata*) came to Canada probably with the first immigrants, who valued it as a culinary and medicinal plant. According to Rahman & al. (2018), Australians use garlic mustard (*Alliaria petiolata*) in salads.

According to Fleischhauer & al. (2016, 126 - 127), Central Europeans use garlic mustard (*Alliaria petiolata*), like other wild vegetables, in various dishes, including salads and soups. According to Ivanova & al. (2023), Bulgarians eat garlic mustard in salads and dishes of boiled wild edible plants. According to Lucchetti & al. (2019, 4), Italians use leaves and flowers of garlic mustard (*Alliaria petiolata*) to flavor salads and other dishes. In various dishes, Europeans use garlic mustard (*Alliaria petiolata*) as an edible green and aromatic spice.

According to Rahman & al. (2018), garlic mustard (*Alliaria petiolata*) is an invasive species in Australia. Australians use leaves of garlic mustard (*Alliaria petiolata*) in salads.

According to Grieve (1959, 221), “*Alliaria petiolata* was probably introduced from Europe by the early colonists who valued it as a medicinal and salad plant.”

According to Rodgers & al. (2022, 521), “As a western Eurasian plant, garlic mustard was likely introduced to North America by early colonists as a medicinal plant and garlic substitute (Grieve 1959). … Garlic mustard was first formally identified in North America in the 1860s in Long Island, New York, and has since invaded a range of forest understorey and edge communities across the continent …”

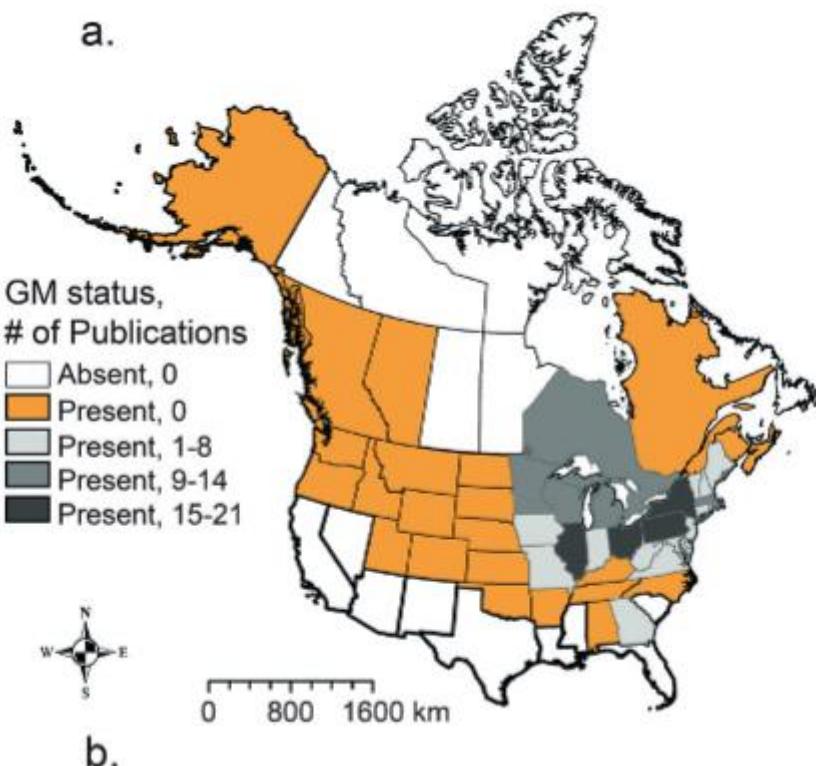


Figure 8. Distribution of garlic mustard (*Alliaria petiolata*) in North America. Source: Rodgers & al. (2022, 522). This open-access article is distributed under the terms of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted reuse, distribution, and reproduction in any medium provided the original work is properly cited. <https://doi.org/10.1093/biosci/biac012>.

According to Harris & al. (2022), garlic mustard (*Alliaria petiolata*) produces the secondary compound sinigrin, a type of glucosinolate that defends against herbivores and pathogens and is toxic to North American plants and butterflies.

According to Cavers & al (1979, 218): "Beneficial – Potentially, the greatest use of *Alliaria petiolata* may be as a green vegetable. The leaves and top just before flowering have a higher value of vitamin C, on a weight basis than oranges (Zennie and Ogzewalla 1977). Zennie and Ogzewalla also reported that the leaves at all times of the year have a higher value of vitamin A than spinach (which has the highest level of all the widely marketed garden vegetables). Fernald [Fernando] & al. (1958) suggested that *A. petiolata* may be used as a salad green or in sandwiches and may be substituted for garlic in cooking. Grieve (1959) reported that country people used the plant in sauces and salads. They called it "sauce alone."

According to Haribal & Renwick (2001), leaves of garlic mustard (*Alliaria petiolata*) contain apigenin. According to Dourado & al. (2020), Martin & Touaibia (2020), Kim & al. (2019), Salehi & al. (2019), Nabavi & al. (2018), Madunić & al. (2018) and Ali & al. (2017a), apigenin has the following astounding health-promoting properties: 1) antioxidant, 2) anti-inflammatory, 3) antidiabetic, 4) beneficial role in amnesia and Alzheimer's disease, neuroprotective agent against Alzheimer's and Parkinson's diseases, 5) beneficial effects in depression and insomnia, 6) anticancer, protects from cancer in many ways, 7) mitigates rheumatoid arthritis, 8) alleviates autoimmune disorders, and 9) in elderly males increases androgen production for health; improves testosterone production, contributing to normal spermatogenesis and preventing age-related degenerative diseases associated with testosterone deficiency. Apigenin is safe, even at high doses, and researchers have found no toxicity. Salehi & al. (2019) present molecular biological mechanisms for these properties. According to DeRango-Adem & Blay (2021), in natural sources, apigenin is commonly found as an apigenin-glucoside, such as 7-O-glucoside, 6-C-glucoside, or 8-C-glucoside. After ingesting the plant material,

these apigenin-glucosides are enzymatically metabolized in vivo into free apigenin (i.e., the aglycone form) and subsequently absorbed.

According to Blazevic & Mastelic (2008), garlic mustard contains more health-promoting isothiocyanates than other volatile substances. Applying Wu (2009): isothiocyanates are small molecules formed from glucosinolate precursors of cruciferous vegetables, such as garlic mustard (*Alliaria petiolata*).

Vignette 12. A synthesis of how isothiocyanates promote health.

isothiocyanates	<p>According to Ahmad & al. (2022), Kamal & al. (2022), Li & al. (2022), Kim (2021), Favela-González & al. (2020), Amron & Konsue (2018, 69), Giacoppo & al. (2015), and Agneta & al. (2013, 1935 - 1939), isothiocyanates have the following health-promoting properties: 1) antioxidants, 2) antimicrobial, 3) antifungal, 4) antiviral, 5) anticancer, anticarcinogenic, 6) anti-obesity, and 7) protect against neurodegenerative diseases, such as Alzheimer's disease. According to Martelli & al. (2020, 110), isothiocyanates emerge from the enzymatic hydrolysis of glucosinolates. This enzymatic reaction happens when these plants are crunched or cut. It means that their cell walls break. The enzyme myrosinase and glucosinolates are usually in separated plant cells. After the cell walls break, myrosinase and glucosinolates come into contact. Their reaction leads to the rapid formation of isothiocyanates.</p> <p><i>Agneta, R. & al. 2013. Horseradish (<i>Armoracia rusticana</i>), a neglected medical and condiment species with a relevant glucosinolate profile: a review. <i>Genetic Resources and Crop Evolution</i> 60(7), 1923 – 1943.</i></p> <p><i>Ahmad, H. & al. 2022. Derived Isothiocyanates on cardiovascular and neurodegenerative diseases. <i>Molecules</i> 27, 624. https://doi.org/10.3390/molecules27030624</i></p> <p><i>Amron, N. & Konsue, N. 2018. Antioxidant capacity and nitrosation inhibition of cruciferous vegetable extracts. <i>International Food Research Journal</i> 25(1), 65 – 73.</i></p> <p><i>Favela-González, K. & al. 2020. The value of bioactive compounds of cruciferous vegetables (<i>Brassica</i>) as antimicrobials and antioxidants: A review. <i>Journal of Food Biochemistry</i> 44, e13414. https://doi.org/10.1111/jfbc.13414</i></p> <p><i>Giacoppo, S. & al. 2015. An overview of neuroprotective effects of isothiocyanates for the treatment of neurodegenerative diseases. <i>Fitoterapia</i> 106, 12-21.</i></p> <p><i>Kamal, R. & al. 2022. Beneficial health effects of glucosinolates-derived isothiocyanates on cardiovascular and neurodegenerative diseases. <i>Molecules</i> 27(3), 624; https://doi.org/10.3390/molecules27030624</i></p> <p><i>Kim, J. 2021. Pre-Clinical Neuroprotective Evidences and Plausible Mechanisms of Sulforaphane in Alzheimer's Disease. <i>International Journal of Molecular Sciences</i> 22, 2929. https://doi.org/10.3390/ijms22062929</i></p> <p><i>Li, X. & al. 2022. The structure basis of phytochemicals as metabolic signals for combating obesity. <i>Frontiers in Nutrition</i> 9, 913883.</i></p> <p><i>Martelli, A. & al. 2020. Organic isothiocyanates as hydrogen sulfide donors. <i>Antioxidants&Redox Signaling</i> 32(2), 110 – 144.</i></p>
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According to Egebjerg & al. (2018, 134), (1) leaves of garlic mustard (*Alliaria petiolata*) contain erucic acid, 31 % of the total fats, and 0.5 % of dry weight. According to EU CONTAM (2017, 1), a tolerable daily intake of erucic acid is below 7 mg/kg body weight/day. When foragers eat garlic

mustard (*Alliaria petiolata*) as a flavoring substance, spice, or ingredient in mixed vegetables, erucic acid intake is clearly below this limit.

According to Egebjerg & al. (2018, 134), leaves of garlic mustard (*Alliaria petiolata*) contain sinigrin, a cyanogenic compound. The same is true with many other wild edible plants. The amounts that healthy adults get are so small that there are no problems. A couple of fresh leaves can be eaten raw without any health risks. According to Åhlberg (2019, 23, and 34), wild edible plants are used mainly in boiled mixtures of wild edible plants in Mediterranean countries. According to Encyclopaedia Britannica (2018), the boiling point of hydrogen cyanide is 26 °C. In cooking, hydrogen cyanide evaporates out of food into the air.

According to Guil-Guerrero et al. (2007, 288 and 292), garlic mustard (*Alliaria petiolata*) contains oxalic acid, but it also includes plenty of calcium (Ca) and magnesium (Mg). Calcium and magnesium oxalates are insoluble. They do not pass through the body outside the intestine; they pass through the body inside the intestine, so they cannot harm health.

According to Åhlberg (2020a, 2022a), Egebjerg & al. (2018, 134), Cámaras & al. (2016, 190), Cipollini & Cipollini (2016), de Cortes Sánchez-Mata & al. (2016, 122), Manchali & al. (2012, 97), Björkman & al. (2011, 540), Dinică. & al. (2010), Lupoae & al. (2010), Blaevi & Masteli (2008), Blazevic & Mastelic (2008), Haribal & Renwick (2001), and Guil-Guerrero & al. (1999) aerial parts of garlic mustard (*Alliaria petiolata*) contain 36 species-specific health-promoting substances of garlic mustard (*Alliaria petiolata*) are: 1) 2-phenylethyl alcohol, 2) 2-vinyl-4H-1,3-dithiin, 3) allyl isothiocyanate, 4) allyl thiocyanate, 5) alpha-ionone, 6) apigenin, 7) benzyl isothiocyanate, 8) benzyl thiocyanate, 9) capric acid, 10) caprylic acid, 11) diallyl disulphide, 12) diallyl sulphide, 13) erucic acid, 14) flavone 6-C-glycosides, 15) glucosinolate, 16) isoorientin, 17) isothiocyanates, 18) isovitexin-6-O"β-D-glucoside, 19) lauric acid, 20) methyl palmitate, 21) minerals, 22) myristic acid, 23) nonanal, 24) omega-3 polyunsaturated fatty acids, 25) omega-6 polyunsaturated fatty acids, 26) oxazolidinethiones, 27) palmitic acid, 28) pentadecanoic acid, 29) phytol, 30) polyunsaturated fatty acids, 31) quercetin, 32) sinigrin, 33) swertiajaponin, 34) swertisin, 35) undecanoic acid, and 36) vitamin A.

The answer to the research sub-question is: How many Alzheimer's disease-preventing, species-specific health-promoting substances do aerial parts of garlic mustard (*Alliaria petiolata*) have? The species-specific compounds are highlighted:

The 100 (64+36) health-promoting substances of garlic mustard (*Alliaria petiolata*) include the following 24 (18 + 6) substances that prevent Alzheimer's disease: 1) alpha-linolenic acid, 2) ascorbic acid, 3) caffeic acid, 4) carotenoids, 5) choline, 6) dietary fibers, 7) flavonoids, 8) lutein, 9) melatonin, 10) phenolic acids, 11) phenolic compounds, 12) phenylpropanoids, 13) phytic acid, 14) polyphenols, 15) polysaccharides, 16) silicon, 17) terpenoids, 18) tocopherols, 19) apigenin, 20) erucic acid, 21) essential oils, 22) isothiocyanates, 23) kaempferol, and 24) quercetin.

*** Insert Figure 9. here ***

Conclusion: Garlic mustard (*Alliaria petiolata*), consumed in the Mediterranean way of boiled mixtures of wild edible plants, makes food tasty and promotes health, well-being, and longevity.

Purple Loosestrife (*Lythrum salicaria*)

DISTRIBUTION: According to GBIF (2023), purple loosestrife (*Lythrum salicaria*) is widely distributed globally.

HEALTH-PROMOTING PROPERTIES: I found that the aerial parts of purple loosestrife (*Lythrum salicaria*) have at least 161 (64+97) health-promoting substances that promote health, according to experimental studies, in the following ways:

Aerial parts of purple loosestrife (*Lythrum salicaria*) have the following health-promoting properties: 1) antioxidant, 2) anti-inflammatory, 3) antimicrobial, 4) anticancer, 5) painkiller (analgesic), 6) antitussive and bronchodilatory, 7) antidiarrheal, 8) painkiller (antinociceptive), 9) anticoagulant and 10) externally used extracts of purple loosestrife (*Lythrum salicaria*) to promote skin health.

WARNINGS: None.

SUGGESTIONS FOR USE: Using the leaves and flowers of purple loosestrife (*Lythrum salicaria*) in Mediterranean-style boiled mixtures of wild edible plants is wise. Foragers use fresh flowers to decorate dishes. I use young shoots, leaves, and flowers of purple loosestrife (*Lythrum salicaria*) in Mediterranean-style boiled mixtures of wild edible plants and fresh in salads. Foragers may use flowers to decorate dishes and drinks.

According to Fleischhauer & al. (2016, 195), Central Europeans eat flowers, young, soft shoots, and leaves of purple loosestrife (*Lythrum salicaria*). Red flowers of purple loosestrife (*Lythrum salicaria*) have a pleasant aroma. Foragers use fresh flowers to decorate dishes. Central Europeans use young, soft shoots and leaves of purple loosestrife (*Lythrum salicaria*) in salads and young, tender shoots and leaves in boiled mixtures of wild edible plants. According to Couplan (2017, 187), humans have consumed purple loosestrife (*Lythrum salicaria*) in salads from ancient Greek and Roman times. Couplan (2017, 187) has traveled broadly, and according to him, Asians use purple loosestrife (*Lythrum salicaria*) as a vegetable in soups. According to Korean researchers Kim. & al. (2022), "The aerial part of *L. salicaria* L. would be the most appropriate for food development."

According to WFO (2023), purple loosestrife (*Lythrum salicaria*) belongs to the same family, Lythraceae, as a grenade (*Punica granatum*). Both species have many health-promoting substances.

According to Šutovská & al. (2012), flowering parts of purple loosestrife (*Lythrum salicaria*) contain polysaccharide-polyphenolic conjugates. According to Šutovská & al. (2012), these polysaccharide-polyphenolic conjugates have antitussive activity and bronchodilatory effect.

According to toxicological tests by Iancu & al. (2021), aerial parts of purple loosestrife (*Lythrum salicaria*) are not toxic. They contain many health-promoting substances, such as tannins and polyphenols, including anthocyanins. Spectrophotometric determinations of total polyphenols, tannins, and anthocyanins content revealed quantitative values of 16.39% in polyphenols, 10.53% in tannins, and 0.36% in anthocyanins.



Figure 10. Flowering purple loosestrife (*Lythrum salicaria*). The aerial parts are edible. The plant contains 161 health-promoting substances, including 41 chemicals that prevent Alzheimer's disease. Photo Mauri K. Åhlberg.

According to The Local Food-Nutraceuticals Consortium (2005, 358-359), Spaniards eat the aerial parts of purple loosestrife (*Lytrum salicaria*). It contains more polyphenols than 127 studied Mediterranean wild edible plants and fungi.

According to Pirvu & al. (2014), "*Lytrum salicaria* L. (Fam. *Lythraceae*), or purple loosestrife, is described with high amounts of polyphenols compounds (up to 18%)." According to Bencsik. & al. (2011), in purple loosestrife (*Lytrum salicaria*): (1) the highest flavonoid content was measured in the leaves, and (2) total polyphenol contents were higher in the flowering branch tips than in the other organs.

According to the research evidence in this paper, purple loosestrife (*Lytrum salicaria*) contains 161 health-promoting substances. As an example of these, I present an overview of polyphenols.

Vignette 13. A synthesis of how polyphenols promote health.

polyphenols	<p>According to Gasmi & al. (2022), Mitra&al. (2022), Rajha & al. (2022), Cassidy & al. (2020), Redd & al. (2020), Reed & de Frietas (2020), Srećković & al. (2020), Durazzo, & al. (2019) Gorzynik-Debicka & al. (2018) Qu&al. (2018) and Ignat & al. (2010) polyphenols have the following health-promoting properties: 1) antioxidant, 2) anti-inflammatory, 3) neuroprotective, 4) prevent Alzheimer's disease, 5) anticancer, 6) protect the cardiovascular system, prevention of cardiovascular diseases, 7) reduce the risk of diabetes, 8) lower hypertension, 9) prevent metabolic abnormalities that may include hypertension, central obesity, insulin resistance, hypertension, and imbalance of lipids in the blood, 10) reduce weight in overweight and obese individuals, 11) antitumor, via anti-initiating, anti-promoting, anti-progression, and anti-angiogenesis actions, as well as by 12) modulating the immune system, participate in the immunological defense, 13) protect against oxidative damage on DNA, 14) antiallergic, 15) antimicrobial, and 16) antiviral. The biological activity of polyphenols is strongly related to their antioxidant properties. They tend to reduce the pool of reactive oxygen species (ROS) and neutralize these potentially carcinogenic metabolites. Leri (2020) describes the biomolecular mechanisms of how polyphenols promote health. Mitra & al. (2022) present experimental evidence on how polyphenols synergistically promote health.</p>
	<p><u>According to Coman & Vodnar (2020, 483), over 8000 plant polyphenols are known in plants.</u> According to Šamec & al. (2021), Singhet & al. (2021), and Marranzano & al. (2018), all higher land plants have polyphenols 1) against abiotic stressors, extreme temperatures, drought, flood, light, UV radiation, salt, and heavy metals. Some polyphenols protect plants against biotic stressors, e.g., 2) against herbivores (plant-eating insects and other animals. 3) against micro-organisms.</p> <p>Polyphenolic compounds against abiotic and biotic stressors include phenolic acids, flavonoids, stilbenoids, and lignans. Some polyphenols participate in 4) plant growth and 5) plant development. According to Åhlberg (2021), all wild edible plants have polyphenols.</p> <p><i>Cassidy, L. & al. 2020. Oxidative stress in Alzheimer's disease: a review on emergent natural polyphenolic therapeutics. Complementary Therapies in Medicine, volume 49, article 102294, 1 – 11.</i></p>

	<p><i>Gasmi, A. & al. 2022. Polyphenols in metabolic diseases. Molecules 27(19), 6280; https://doi.org/10.3390/molecules27196280</i></p> <p><i>Leri, M. 2020. Beneficial effects of plant polyphenols: molecular mechanisms. International Journal of Molecular Sciences, volume 21, article 1250, 1 – 40.</i></p> <p><i>Marranzano, M. & al. 2018. Polyphenols: plant sources and food industry applications. Current Pharmaceutical Design 24, 4125 – 4130.</i></p> <p><i>Mitra, S. & al. 2022. Polyphenols: A first evidence in the synergism and bioactivities. Food Reviews International. Published online: 24 Jan 2022. DOI: 10.1080/87559129.2022.2026376</i></p> <p><i>Redd, P. & al. 2020. Polyphenols are present in Alzheimer's disease and the gut-brain axis. Microorganisms 8, 19.</i></p> <p><i>Reed, J. & de Freitas, V. 2020. Polyphenol chemistry: implications for nutrition, health, and the environment. Journal of Agricultural and Food Chemistry 68(10), 2833–2835.</i></p> <p><i>Rajha, H. & al. 2022. Recent advances in research on polyphenols: effects on microbiota, metabolism, and health. Molecular Nutrition & Food Research 66, 210067.</i></p> <p><i>Šamec, D. & al. 2021. The role of polyphenols in abiotic stress response: The influence of molecular structure. Plants, volume 10, article 118, 1 - 24.</i></p> <p><i>Singh, S. & al. 2021. The multifunctional roles of polyphenols in plant-herbivore interactions. International Journal of Molecular Sciences, volume 22, article 1442, 1 – 20.</i></p> <p><i>Srećković, N. & al. 2020. <i>Lythrum salicaria</i> L. (Lythraceae) as a promising source of phenolic compounds in the modulation of oxidative stress: Comparison between aerial parts and root extracts. Industrial Crops and Products 155, 112781.</i></p>
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In this paper, I have presented evidence that all vascular green plants contain 64 health-promoting substances, and purple loosestrife (*Lythrum salicaria*) has 97.

According to Al-Snafi (2019), Becker & al. (2015), Iancu & al. (2021), Jiang & al. (2015), Manayi & al. (2013), Manayi & al. (2014), Pirvu & al. (2014), Piwowarski & al. (2015), Rauha & al. (2001), Srećković & al. (2020), Šutovská & al. (2012), Tong & al. (2019) and Tunalier & al. (2007), purple loosestrife (*Lythrum salicaria*) contains the following 97 health-promoting substances: 1) 1,6-di-O-galloylglucose, 2) 1H-pyrrole-2,5-dione, 3) 1-octen-3-ol, 4) 3,3',4'-tri-O-methylellagic acid, 5) 3,3',4'-tri-O-methylellagic acid-4-O-β-D-glucopyranoside, 6) alkaloids, 7) alpha-terpineol, 8) anthocyanins, 9) apigenin, 10) arabinogalactan, 11) apiiin, 12) arabinose, 13) aurantiamide, 14) benzoic acid, 15) betanone, 16) betulinic acid, 17) betulinic acid methyl ester, 18) buntansin, 19) castalagin, 20) catechin, 21) cinnamic acid, 22) chlorogenic acid, 23) corosolic acid, 24) coumarins, 25) cyanidin-3-galactoside, 26) cyanidin-3-O-glucoside, 27) daucosterol, 28) decanoic acid, 29) eicosane, 30) ellagic acid, 31) ellagitannins, 32) erythrodiol, 33) esculetin, 34) essential oils, 35) eugenol, 36) ferulic acid, 37) flavan-3-ols, 38) flavone-C-glycosides, 39) galactose, 40) galacturonan, 41) gallic acid, 42) gallotannins, 43) galloyl-bis-HHDP-glucose, 44) galloyl-HHDP-glucose, 45) heneicosane, 46) heptanoic acid, 47) hyperoside, 48) isochlorogenic acid, 49) isoorientin, 50) isovitexin, 51) lactones, 52) limonene, 53) linalool 54) loliolide, 55) luteolin, 56) lythrine, 57) malvidin, 58) methyl gallate, 59) monoterpenes, 60) muramine, 61) myristic acid, 62) n-hexadecanoic acid, 63) nonadecane, 64) nonanoic acid, 65) o-cresol, 66) octadecane, 67) octanoic acid, 68) oleanolic acid, 69) orientin, 70) p-coumaric acid 71) p-cresol, 72) pentadecane, 73) pedunculagin, 74) pentacosane, 75) peucedanin, 76) phytol, 77) polysaccharide-polyphenolic conjugate, 78) quercitrin, 79) rhamnogalacturonan, 80) rosmarinic acid,

81) rutin, 82) salicairine, 83) salicarinin A, 84) sesquiterpenes, 85) rosmarinic acid, 86) steroids (plant), 87) syringic acid, 88) tannins, 89) tricosane, 90) triterpenes, 91) triterpenoids, 92) umbeliferone-6-carboxylic acid, 93) uronic acids, 94) ursolic acid, 95) vanillic acid, 96) vescalagin, and 97) vitexin.

The answer to the research sub-question is: How many Alzheimer's disease-preventing, species-specific health-promoting substances do aerial parts of purple loosestrife (*Lythrum salicaria*) have? The species-specific compounds are highlighted:

The 161 health-promoting substances of purple loosestrife (*Lythrum salicaria*) include the next 41 (18 + 23) compounds that prevent Alzheimer's disease: 1) alpha-linolenic acid, 2) ascorbic acid, 3) caffeic acid, 4) carotenoids, 5) choline, 6) dietary fibers, 7) flavonoids, 8) lutein, 9) melatonin, 10) phenolic acids, 11) phenolic compounds, 12) phenylpropanoids, 13) phytic acid, 14) polyphenols, 15) polysaccharides, 16) silicon, 17) terpenoids, 18) tocopherols, 19) alpha-terpineol, 20) anthocyanins, 21) apigenin, 22) aurantiamide, 23) catechin, 24) chlorogenic acid, 25) coumarins, 26) ellagic acid, 27) ellagitannins, 28) essential oils, 29) gallotannins, 30) hyperoside, 31) isovitexin, 32) kaempferol, 33) linalool, 34) luteolin, 35) myricetin, 36) myristic acid, 37) oleanolic acid, 38) p-coumaric acid, 39) rutin, 40) vanillic acid, and 41) vitexin.

Conclusion: The aerial parts of purple loosestrife (*Lythrum salicaria*) contain 161 (64+97) health-promoting substances. I use them in salads and boiled WEP mixtures.

4. Discussion

In the first part of this paper, I presented 64 health-promoting substances that all edible green vascular plants have. At least 18 of these substances prevent Alzheimer's disease. This is valuable knowledge for all interested in their health and longevity.

In the second part of this paper, I discussed three invasive wild edible species in Europe: *Fallopia japonica*, *Impatiens glandulifera*, and *Rosa rugosa*, and two invasive wild edible species in North America: garlic mustard (*Alliaria petiolata*) and purple loosestrife (*Lythrum salicaria*). All these species contain also species-specific health-promoting substances, including those that prevent Alzheimer's disease. Applying Milanović & al. (2020), I have presented evidence that these species provide ecosystem services.

In Table 1, I compare these five invasive WEP species regarding the number of health-promoting substances they contain. This is a coarse measure of their effectiveness in sustaining and promoting health and longevity. All are good WEPs, but there are apparent differences in health-promoting potential.

Table 1. Five invasive WEP species in order of their health-promoting substances.

WEP species, aerial parts	Total number of health-promoting substances
<i>Rosa rugosa</i> petals	194
<i>Rosa rugosa</i> hips	164
<i>Lythrum salicaria</i>	161
<i>Fallopia japonica</i>	141
<i>Impatiens glandulifera</i>	136
<i>Alliaria petiolata</i>	100

In Table 2, I compare these five WEPs regarding the number of substances they have that prevent Alzheimer's disease, according to experimental research. All WEP species have many substances that prevent Alzheimer's disease. The order of the best species is surprising. The clear winner is Japanese knotweed (*Fallopia japonica*). The second species is also a surprise. It is Himalayan balsam (*Impatiens glandulifera*).

Table 2. Five invasive WEP species, in order of their number of substances, are preventing Alzheimer's disease.

WEP species	the number of substances in the aerial parts preventing Alzheimer's disease
<i>Fallopia japonica</i>	57
<i>Impatiens glandulifera</i>	46
<i>Lythrum salicaria</i>	41
<i>Rosa rugosa</i> hips	39
<i>Rosa rugosa</i> petals	35
<i>Alliaria petiolata</i>	24

According to Kanmaz & al. (2023), Himalayan balsam (*Impatiens glandulifera*) is an invasive species in Europe and North America. Kanmaz & al. (2023) are realists: "Preventive measures and monitoring are needed to keep the current distribution under control and prevent further spread to habitats that are already under the impact of global environmental change." It is easier to eradicate in the early phases of its spreading than later when it has conquered large areas. If people value its beauty and other ecosystem services, they may restrict this species to strictly controlled areas.

According to Åhlberg (2020a, 2020b, and 2022a), *Alliaria petiolata* and *Lythrum salicaria* are excellent wild edible plants in Europe. Arrington (2021) has a rational approach to these species: Ecosystem services like foraging for food must be balanced for invasive species management, which may be needed occasionally.

Many of these invasive species provide great possibilities as raw materials for food and other uses. For example, according to Wens & Geuens (2022), Japanese knotweed (*Fallopia japonica*) produces antifungal material against phytopathogenic fungi. The researchers compared extracts of aerial parts from nine plant species. The extract of Japanese knotweed (*Fallopia japonica*) was the most efficient. In the experiments of Anžlovar & al. (2020), the extracts of Japanese knotweed (*Fallopia japonica*) were efficient again against some phytopathogenic fungi species.

According to Kunkel & Chen (2021): "The invasive species *Alliaria petiolata* threatens forest understories as it alters soil nutrients and microbial composition, thereby changing the local plant community." Blossey & al. (2001) discuss differences in distributions of garlic mustard (*Alliaria petiolata*) in Europe and the USA. In Europe, garlic mustard (*Alliaria petiolata*) usually grows in separate small patches, but this plant may cover hectares of woodland in the USA.

Rogers & al. (2022) call purple loosestrife (*Lythrum salicaria*) a "purple menace." This strong expression is because, in the USA, purple loosestrife (*Lythrum salicaria*) forms large monocultures. In Europe, this species usually grows in separate small patches.

Wu & Colautti (2022, 3) present a map of thousands of observations of purple loosestrife (*Lythrum salicaria*) in North America over 150 years. Most specimens collected are in the Eastern states. The Mid-West also has plenty of observations. The western states have the least specimens collected. The authors do not allow copying of their excellent map. They use the most restrictive license: Creative Commons Attribution-Noncommercial-No Derivatives License 4.0 (CC BY-NC-ND).

For commercial use, enormous monocultures are beneficial. Only rugosa rose (*Rosa rugosa*) has been grown and utilized commercially. The other four plants offer great possibilities for humankind, but in my mind, mainly administrative regulations prevent their large-scale use in the food industry. It is best to forage wild edible plants for food from separate patches.

Applying Åhlberg (2019 – 2022a), the reason is that the healthiest way to consume wild edible plants is in mixtures of wild edible plants. They are first boiled, then frozen, and when needed, used in small portions in different dishes. Boiling and freezing break cell walls and, in this way, release more of the health-promoting substances that are necessary for human metabolism.

Salo & al. (2023) discuss global and local wild species harvest. Salo & al. (2023) state that wild species are “important resources for people worldwide, and their harvest is a major driver of ecosystem change.” In Åhlberg (2020a), I found that many wild edible plants have an almost global distribution and are used locally. In Western countries, wild species harvest is a nationally neglected opportunity. Salo & al. (2023) and Åhlberg (2019, 2020a, 2020b, 2021, 2022a, 2022b, and this article) try to increase the sustainable use of wild edible plants locally and globally.

According to Marrelli & al. (2020): “The alimurgic flora represents a strategic resource to which it is possible to associate many positive agri-food, ecological, and sociocultural values: food source, organic crops, low environmental impact, enhancement of local resources, conservation of biodiversity, conservation of traditional knowledge, income support to medium-sized companies, and introduction into the diet of new species with medicinal and nutraceutical potential.”

5. Conclusions

We need more research on both cultivated and wild edible plants. Researchers must also select which plants they focus their research efforts on. I have selected WEPs because they are part of the original Mediterranean diet. Since 1950-60, the Mediterranean diet has been repeatedly researched, and it is practically always one of the best diets. There is also a Mediterranean lifestyle, which involves plenty of time outdoors and with good friends.

When I compared health-promoting substances in over 94 WEPs, I realized that they share many more overlapping groups of health-promoting substances than the 64 that I have presented in this article. WEPs in the temperate vegetation zone are partly different from those in the subtropical Mediterranean area. However, there are many health-promoting substances in WEPs outside the Mediterranean. The same kind of healthy, tasty salads and boiled WEP mixtures with extra virgin olive oil and citrus juice can be enjoyed everywhere. Similar healthy, savory pastries, pies, and soups can be cooked.

We need more research on 1) WEPs and how they are best prepared and cooked for healthy and delicious meals; 2) which substances WEPs and cultivated plants best prevent Alzheimer's disease. Too many people get nowadays Alzheimer's disease. I have seen my own sister dying because of it. It is a terrible fate that I try to avoid. I trust the Mediterranean diet and way of life. This is the reason why I worked so hard to write this article, which is for the benefit of humanity.

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