



Exploring Economic Opportunities and Health Benefits of Elderberry in Missouri

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Project Summary

American elderberry (*Sambucus canadensis*) is a rapidly emerging new perennial crop for Missouri. Missouri has been one of the leading producers for commercial-scale production of elderberries in the United States. The aim of this project is to explore the novel uses of the elderberry and its byproducts in the industries by systematically examining their health-promoting compounds. Tasks to be completed to address this research aim include:

- 1) conduct scientific research in characterizing the health-promoting compounds in the elderberry and its byproducts (juices, stem barks, leaves, fruits, and root extracts) through modern mass spectrometry, global metabolomic analysis and high-throughput screening bioassay protocol;
- 2) conduct a market research to identify potential uses and formulation of the identified health-promoting compounds from elderberry and byproducts for cosmetic, personal care products and pharmaceutical industries;
- 3) examine the niche market of the identified value-added products. A market guide will be compiled to provide information on health-promoting compounds from elderberry and byproducts, their potential uses in producing value-added products in the industries. The proposed study will increase the overall incomes of the chain production and benefit all the participants involved in the supply chain of the elderberry industry in Missouri.

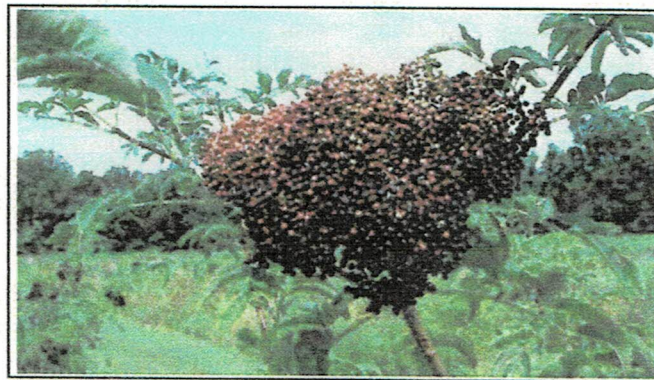


Figure 1: The fruit of the American elderberry

Project Description Rationale

American elderberry (*Sambucus canadensis*) is a rapidly emerging new perennial crop for Missouri. Missouri has been one of the leading producer for commercial-scale production of elderberries in the United States. Most of the elderberries grown in the Missouri are harvested for processing markets. At present, usage of fruit for wine, juice, jelly, syrup and dietary supplement products is on the rise. Several wineries produce elderberry wines from the fruit, while the panicles are used to flavor wines. Elderberry juice or fruit are used for jam and jelly. Elderberry juice and concentrates are marketed as nutraceuticals.

Elderberries have become popular in the U.S. as remedies for treating cold and flu symptoms, especially popular for its antiviral properties as it is recommended for the prophylaxis and treatment of influenza. It is marketed primarily through natural food stores alongside other popular herbal remedies used for treatment or prevention of upper respiratory tract infections and other symptoms associated with colds and flus. Antiviral, immunomodulating, antioxidant anti-inflammatory and insulin-stimulating properties of fruit extracts have also been described in scientific literature.

Stem barks, leaves, fruits, and root extracts are used to treat bronchitis, cough, upper respiratory infections, and fever. Up to date, more than 50 health-promoting bioactive polyphenols, such as bioflavonoids and anthocyanins, have been identified in elderberry and its byproducts. However, systematic characterization of the health-promoting compounds in elderberry fruits and its byproducts has never been explored or demonstrated. The lack of the critical scientific information in these aspects has significantly restricted the wider use of elderberry and its byproducts in many industries, such as cosmetic, personal care products, nutraceuticals and pharmaceutical industries.

Recent advancement in mass spectrometry, metabolomics algorithm, computation capacity and high-throughput screening bioassay screening protocol has made the global identification of bioactive compounds possible. With a growing global consumption of organic personal care products and diet supplements, through identifying the novel uses of the black walnut and its byproducts, this project will provide the opportunities to turn abundant, low-value, renewable materials from the walnut and its byproducts into profitable value-added products in Missouri. This project will contribute to the income growth of participants involved in the black walnut industry, organic products production and consumption, and sustainable rural communities in Missouri.

Objectives

This proposed one-year project aim to facilitate our ongoing efforts to health-promoting compounds in elderberry (juices, fruits, roots and leaves) and the byproducts (e.g., wine and juice) and explore their new uses (e.g., organic personal care products, dietary supplements) through the integration of global metabolomics approach with high-throughput screening bioassay protocol.

- Objective 1: perform an array of high-throughput screening bioassays (e.g., anti-viral, anti-inflammatory and antioxidant) to identify the bioactive compounds and their commercial applications.
- Objective 2: identify and characterize the bioactive phytochemicals, using targeted and untargeted global metabolomics approach (XCMS).
- Objective 3: identify potential uses and applications of extracted health-promoting compounds from elderberry and byproducts in cosmetic, personal care products, nutraceuticals and pharmaceutical industries.

- Objective 4: examine the niche market of the identified value-added elderberry products using organic personal care products as an example.

Expected Outcomes and Impacts

This project will help the producers in Missouri identify the new uses and markets for the elderberry and the byproducts. Having a better understanding of the new uses and health benefits will help develop a niche market, and therefore raise the demand for elderberry and byproducts. The raised demand will increase the overall incomes of the elderberry chain production. Market participants, including elderberry growers, harvesters, and processors will be able to diversify their income generation sources and get additional economic benefits.

Preliminary Findings

More than 173 health-promoting compounds have been identified in elderberry juice.

No.	Compound	Bioactivities
1	Narcissin	antioxidant, antitumor, antiprotozoa
2	Stellarin 2	anti-inflammatory, anti-bacteria
3	Vanilloloside	immunoregulatory activity, anti-cancer, neuroprotective effect, anti-inflammatory
4	Luteolin 3,7-diglucoside	anti-oxidant, anti-inflammatory
5	Rutin	anti-oxidant, anti-cancer, anti-microbial, anti-virus, anti-inflammatory, etc
6	Kaempferol-7-neohesperidoside	anti-tumor + anti-cancer
7	Citric acid monohydrate	anti-oxidant, anti-coagulant, calcium chelating agent
8	Dehydroascorbic acid	anti-virus, neuro-protective agent, anti-scorbutic
9	L-Asparagine	neuro-protective
10	Fumaric acid	antipsoriasis (anti-inflammatory), neuroprotective
11	Bilobalide	neuro-protective and anti-inflammatory
12	Lipoic acid, reduced	anti-inflammatory, antioxidant
13	Caryoptosidic acid	anti-inflammatory
14	Benzocaine	anesthetic, antihistamine
15	Tricaine	anesthetic
16	Pantothenic acid	antioxidant
17	Ginnalin B	antioxidant, skin anti-aging, anti cancer, anti-diabetic, anti-inflammatory
18	Isorhamnetin-3-glucoside	anti-oxidant
19	Vasicinol	anti-cancer
20	Idazoxan	anti-depressant
21	Nirvanol	anti-convulsant
22	L/D-glutamine	non-essential amino acid, anti-inflammatory, anti-analgesic
23	Loganin	neuro-protective agent, anti-inflammatory, etc
24	Chlorogenic acid methyl ester	anti-oxidant, anti-inflammatory
25	Aucubin	anti-inflammatory, antiproliferative, anti-tumor, anti-oxidant
26	Deutzioside	anti-inflammatory
27	Torcetrapib (CP-529414)	anti-cholesterol
28	2,2',3,3',4,4'-Hexahydroxy-1,1'-biphenyl-6,6'-dimethanol dimethyl ether	anti-apoptotic
29	Oxaloacetate	neuro-protective agent, anti-aging, anti-cancer
30	Aminocaproic acid	acute bleeding treatment

31	Salicylic acid	anti-inflammatory and antibacterial
32	3,4-Dihydroxybenzaldehyde	anti-cancer
33	Lamiide	anti-inflammatory
34	Dihydromelilotoside	anti-malaria, anti-oxidant, anti-diabetic, anti-hyperlipidemic
35	Oleoside dimethyl ester	anti-oxidant
36	Caffeic acid	anti-oxidant, anti-inflammatory, anti-neoplastic, anti-cancer
37	L/D-Aspartic acid	testosterone booster, increase muscle mass n strength
38	Myricitrin	anti-oxidant, anti-nociceptive, anti-inflammatory, anti-fibrotic
39	Isoquercitrine	anti-histamine, anti-inflammatory, anti-oxidant
40	Hyperoside	anti-proliferation, anti-inflammatory, anti-oxidant
41	5-Acetoxypalisadin B	anti-microbial
42	Succinic acid	anti-oxidant, anti-ulcer, nutraceutical
43	Ferrichrome	anti-cancer
44	Zimelidine dihydrochloride	anti-depressant
45	m-Coumaric acid	anti-hemorrhagic, neurotrophic, tyrosinase inhibitor (skin whitening)
46	2-hydroxycinammic acid (o-coumaric acid)	anti-fungi (Candida), anti-microbial
47	p-Coumaric acid	anti-oxidant, anti-cancer, anti-microbial, anti-virus, anti-inflammatory, etc
48	Gardenoside	anti-cancer, anti-inflammatory (NF-kB)
49	Quercetin	anti-oxidant, anti-cancer, anti-microbial, anti-virus, anti-inflammatory, etc
50	Morin	anti-oxidant, anti-diabetic, anti-inflammatory, anti-tumor. et.
51	Delphinidin	anti-oxidant, anti-cancer, anti-tumor, skin anti-aging
52	Hieracin	anti-tumor, antibacterial
53	Isoetin	anti-depressant
54	Moschamindole	anti-oxidant & anti-bacterial
55	Tarennoside	anti-tumor
56	Sweroside	anti-inflammatory
57	Calabricoside B	anti-oxidant
58	Quercitrin	anti-oxidant, anti-leishmanial agent, tyrosinase inhibitor, anti-aging, anti-inflammatory
59	Kaempferol-7-O-glucoside	anti-oxidant, anti-viral
60	Astragalin	anti-inflammatory, anti-oxidant, neuroprotective, cardioprotective, etc
61	Phenylactic acid	anti-microbial, anti-fungal
62	Mandelic acid, methyl ester	key drug intermediate

63	Isopeonol	anti-inflammatory
64	o-Veratraldehyde	anti-fungal
65	Phloretic acid	anti-microbial
66	Remoxipride	anti-psychotic
67	Phloretin 3',5'-Di-C-glucoside	anti-inflammatory
68	Torsemide	anti-hypertension
69	Dimethylcaffeic acid	NRF2-inducer, anti-hemorrhagic
70	Lactobionic acid	anti-oxidant, skin moisturizer
71	Acexamic acid	anti-inflammatory
72	Cinnamic acid	anti-oxidant, anti-microbial, anti-cancer
73	Mytilin B	anti-microbial
74	Sesamol	anti-oxidant
75	Esculetin	anti-oxidant
76	Tuckolide; Decarestrictine D	anti-cholesterol
77	Daucic acid	anti-oxidant
78	Sambacin	anti-fungal
79	Gluconolactone	anti-inflammatory, anti-oxidant, skin moisturizing
80	Verbenalin	anti-prostatitis
81	Usambarine	anti-amoebic, anti-plasmodial
82	Norcantharidin	anti cancer
83	Phloracetophenone	cholesterol lowering effect
84	Vanillic acid	antioxidant, anti-inflammatory
85	Losartan potassium	anti-hypertension, anti-diabetic
86	Coformycin	anti-tumor, antibiotic
87	Temozolomide	anti-tumor
88	L-Noradrenaline bitartrate	anti-plasmodium, sympathomimetic drug
89	Remoxipride	anti-psychotic agent
90	Artemisinin	anti malaria, anti-cancer, anti-oxidant, anti-inflammatory, antimicrobial
91	Octyl gallate	anti-fungal, anti-oxidant, anti-diabetic
92	Luteolin	anti-inflammatory, anti-cancer, etc
93	Kaempferol	anti-inflammatory, anti-cancer, anti-oxidant, antibacterial, etc
94	Cyanidin	neuroprotective agent, antioxidant
95	Fisetin	anti-oxidant, anti-tumor, anti-inflammatory
96	Tricetinidin	anti-oxidant
97	Isobutrin	anti-inflammatory
98	Butrin	anti-inflammatory
99	Hygromycin A	anti-bacterial
100	Olanzapine	anti-psychotic
101	Aucubin	anti-inflammatory, anticancer
102	Ceftazidime	antibiotic drugs, antibacterial

103	Catalpol	anti-diabetic, antiinflammatory, neuro protective agent
104	Brusatol	anti-aging
105	L-tyrosine	neuro-cognitive effects (anti-depressant)
106	Indoleacrylic acid	anti-inflammatory
107	L-Valine	anti-fungal, anti-bacteria, anti-inflammatory,
108	Betaine	anti-inflammatory, ergogenic effect
109	lucenin 2	anti-inflammatory, anti-hepatotoxic
110	3-hydroxycoumarin	anti-inflammatory, anti-oxidant, photoprotective effect (UV B)
111	4-hydroxycoumarin	anti-inflammatory, anti-tumor
112	umbelliferone	anti-oxidant, anti-inflammation, anti cancer
113	isorhamnetin	anti-cancer, anti-aging, anti-acetylcholinesterase, anti-coagulant,
114	tamarixetin	anti-inflammatory
115	Aminopterin	anti-leukemic, anti-bacterial, anti-cancer
116	4-hydroxybenzaldehyde	anti-inflammatory
117	salicylaldehyde	nematicidal activity, anti-microbial
118	tropolone	anti-fungal, anti-bacterial, tyrosinase inhibitor, anticancer, anti tumor
119	coumarin	anti-inflammatory, anti-coagulant, anti-bacterial, anti-fungal, anti-viral, anti-cancer, etc.
120	chromone	anti-cancer, hepatoprotective effect
121	niacin	anti-cholesterol, anti-ageing
122	picolinic acid	neuro-protective effect
123	hymechrome	anti-tumor
124	herniarin	anti-fungal, antigenotoxic
125	dimethadione	anti-convulsant
126	spermine	anti-oxidant
127	Ethyl p-coumarate	anti-fungal
128	Myristicin	anxiolytic activity
129	Dehydrozingerone	anti-microbial, anti-oxidant
130	Naphthalene-1,2-diol	anti-cancer
131	Kuwanon L	HIV-1 Integrase inhibitor
132	Allamandin	anti-inflammatory, anti-tumor
133	Burseran	anti-neoplastic
134	Mephenesin	neuroprotective effect
135	Ilomastat	anti-inflammatory, anti-bacterial, anti-neoplastic
136	Kinetin riboside	anti-tumor
137	YO-01027	anti-tumor, anti-cancer, anti-microbial
138	Cinnamaldehyde	anti-diabetic, anti-inflammatory, anti-bacterial, anthelmintic

139	Triacetin	anti-fungal
140	LP44	analgesic
141	GW441756	anti-cancer
142	Trifusal	anti-thrombotic
143	Aurentiacin	anti-inflammatory, anti-microbial
144	Sulfamethizole	anti-bacterial
145	Pyroglutamic acid	anti-malarial
146	Moroctic acid	anti-bacterial, anti-microbial, anti-diabetic
147	a-parinaric acid	anti-cancer
148	Ro 08-2750	anti-cancer
149	Castanospermine	anti-inflammatory, anti-dengue virus, anti-HIV-1
150	Salicin	anti-pyretic, analgesic, anti-inflammatory
151	Gastrodin	anti-oxidant, anti-inflammatory
152	Niacinamide	anti-aging, anti-inflammatory, anti-pruritic, anti-microbial, anti-oxidant
153	Epiafzelechin trimethyl ether	anti-microbial
154	Anethole	anti-inflammatory, anti-cancer, anti-diabetic, neuro-protective agent
155	Cuminaldehyde	neuro-protective agent, anti-microbial, melanin inhibition
156	Estragole	anti-microbial
157	Gallic acid	anti-oxidant, anti-apoptotic, anti-microbial
158	7,8-Dihydroxycoumarin	neuro-protective, anti-cancer, anti bacterial, anti-viral,
159	5,7-Dihydroxychromone	neuro-protective, anti-microbial
160	JW55	anti-cancer
161	Salidroside	neuro-protective, anti-aging, anti-depressant, hepatoprotective
162	(+)-Nutlin-3	anti-tumor
163	Cearoin	anti-cancer, anti-inflammatory
164	p-cymene	anti-oxidant, anti-inflammatory, anti-tumor, anti-microbial
165	o-cymene	anti-microbial
166	Eudesmic acid	anti-bacterial
167	Cotinine	neuro-protective agent
168	Monocerin	anti-malarial, anti-oxidant, anti-fungal
169	Ferulic acid	anti-oxidant, anti-microbial, anti-cancer, hepatoprotective, skin anti-aging, etc
170	Vitisin C	anti-oxidant, anti-spasmodic, neuro-protective effect
171	Isohopeaphenol	anti-inflammatory, anti-hyperlipidemic, anti-fungal
172	r-Viniferin	anti-cancer, anti-fungal
173	Palmitoyl glycine	antinociceptive, anti-inflammatory, anti-cancer