

Composition of Vegetable Oil From Seeds of Native Halophytes

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Abstract—Of the world's land area, about 7 percent is salt affected. Irrigated land is more susceptible to salinity and it is estimated that over 1/3 of the irrigated soils are becoming saline. Certain plants (halophytes) grow well on high saline soils. One approach would be to grow halophytes on high saline soils and harvest their seeds. The oil in the seeds would be extracted for cooking oil. The amount of unsaturated fatty acids is a measure of the quality of cooking oil. High-unsaturated fatty acid content is considered a factor in preventing heart diseases. Seeds of seven halophytic shrubs were extracted and the oil was analyzed for fatty acids using gas chromatography and mass spectrometry. The average unsaturation for the fatty acids in the seed oil was 84 percent, which is a favorable percent. The major saturated fatty acid was Hexadecanoic acid. There were several dominant unsaturated fatty acids namely: 9,12-Octadecadienoic acid, 13-Octadecenoic acid, 11-Eicosenoic acid, 9,12,15, Octadecatrienoic acid, and 9-Octadecenoic acid. It appears that these halophytes have potential for reclaiming and utilizing saline soil.

Introduction

Approximately 7 percent of the world's land area is salt affected (Dudal and Purnell 1986). The Great Basin area of the Western United States has no river that drains the water to the sea. The water drains into inland lakes such as Great Salt Lake or evaporates in the valleys. Many salt playa accumulate in the Great Basin area. The inland salt playas are harsh environments for living organisms (Goodin and others 1990). The high salt content of the soil limits the plant communities to mainly halophytic plants. This includes salt tolerant shrubs and annuals. The salinity of the soil ranges from 29 dS/m (2 percent NaCl) to 145 dS/m

(9 percent). The salinity of the soil in the bottom of the salt pans can be as high as 15 percent salt. At the same time desert conditions exist during the hot summer months. Precipitation is about 66 mm (2.6 inches) per year. The water table varies from 1 m to 3.3 m below the surface (Khan and Ungar 1995).

Dregne and others (1991) suggested that about 74 million hectares of land are salt affected due to human causes. For use in the agricultural area, salt tolerant agriculture plants have been selected to grow on the saline soils. There has been some success but the selected agriculture plants cannot tolerate very high saline conditions. Another approach to this problem is to grow plants that are adapted to saline soils such as halophytes and then find an economic value for the halophytes (Khan and others 1990). One possibility would be animal forage or fuel (presto logs). The economic return of these products is low. A more valuable economic product would be cooking oil. Cooking oil is a basic food need throughout the world. The seeds of halophytes contain oil that could potentially be extracted for human use.

The composition of cooking oils has an impact on health. Dietary studies (Hu 1997; Lang 1997) support the concept that diets that are high in saturated fats result in greater risk to heart diseases. In contrast, foods that are high in polyunsaturated fatty acids are considered much more healthy. Animal fats are high in saturated fatty acids whereas plant fats are normally high in unsaturated fatty acids. A saturated fatty acid such as stearic acid has no double bonds in the hydrocarbon chain. With unsaturated fatty acids such as oleic acid, there is one double bond in the hydrocarbon chain. Linoleic has two double bonds and alpha linolenic acid has three double bonds in the hydrocarbon chain.

The purpose of this investigation was to analyze the oil from several native halophytes to determine their fatty acid content and quality.

Methods

Seeds of native halophytes were collected from salt playa and salt marsh areas in Utah Valley and Rush Valley in north-central Utah. The seeds were separated from the vegetative plant parts and cleaned. The seeds were ground with a Wiley mill and extracted three times with methanol and chloroform (1:2 v/v). The percent oil in the seeds was determined by weight.

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The fatty acids in the oil extract were methylated with Alltech meth prep 1 ((trifluoromethylphenyl) trimethylammonium hydroxide). The methylated fatty acids were separated by gas chromatography and identified by GC mass spectrometry.

Results

The following salt tolerant plants were analyzed for total oil content in their seeds and the fatty acids in the seed oil.

Allenrolfea occidentalis (Wats) Kuntze

One of the most salt tolerant plants in the Great Basin area. It has a fleshy stem with reduced leaves. The oil content of the seeds was 14 percent. The fatty acid composition was: 88.33 percent unsaturated and 11.67 percent saturated.

Unsaturated fatty acids	Percent of fraction
7-Hexadecenoic acid, methyl ester	0.30
9-Hexadecenoic acid, methyl ester	0.29
9-Octadecenoic acid, methyl ester	24.69
11-Eicosenoic acid, methyl ester	11.89
13-Docosenoic acid, methyl ester	15.13
9,12-Octadecadienoic acid, methyl ester	16.78
10,13-Octadecadienoic acid, methyl ester	23.57
9,12,15, Octadecatrienoic acid, methyl ester	7.36
Saturated fatty acids	Percent of fraction
Hexadecanoic acid, methyl ester	45.79
Heptadecanoic acid, methyl ester	2.06
Octadecanoic acid, methyl ester	19.93
Eicosanoic acid, methyl ester	10.92
Docosanoic acid, methyl ester	9.98
Teracosanoic acid, methyl ester	9.56
Pentadecanoic acid, methyl ester	0.68
Oxiraneundecanoic acid, 3 pentyl methyl ester	0.99

Atriplex heterosperma Bunge

This is a two-seeded *Atriplex* that grows in saline areas. The oil content of the seeds was 15.8 percent. The fatty acid composition was: 84.73 percent unsaturated and 15.27 percent saturated.

Unsaturated fatty acids	Percent of fraction
9-Hexadecenoic acid, methyl ester	0.61
11-Eicosenoic acid, methyl ester	7.01
13-Docosenoic acid, methyl ester	15.13
13-Octadecenoic acid, methyl ester	75.06
15-Tetracosenoic acid, methyl ester	1.02
6,9-Octadecadienoic acid, methyl ester	0.28
9,12,15, Octadecatrienoic acid, methyl ester	0.89
Saturated fatty acids	Percent of fraction
Nonanedioic acid dimethyl ester	2.87
Hexadecanoic acid, methyl ester	69.95
Octadecanoic acid, methyl ester	14.65
Eicosanoic acid, methyl ester	11.32
Teracosanoic acid, methyl ester	1.21

Atriplex rosea L.

This *Atriplex* grows in disturbed areas and is wide spread in the world. The oil content of the seeds was 12.9 percent. The fatty acid composition was: 82.79 percent unsaturated and 17.21 percent saturated.

Unsaturated fatty acids	Percent of fraction
9-Hexadecenoic acid, methyl ester	0.31
9-Octadecenoic acid, methyl ester	5.58
13-Octadecenoic acid, methyl ester	40.50
11-Eicosenoic acid, methyl ester	12.36
13-Docosenoic acid, methyl ester	13.89
15-Tetracosenoic acid, methyl ester	0.35
6,9-Octadecadienoic acid, methyl ester	0.15
7,10-Octadecadienoic acid, methyl ester	0.13
8,11-Octadecadienoic acid, methyl ester	1.21
9,12-Octadecadienoic acid, methyl ester	0.37
9,12,15, Octadecatrienoic acid, methyl ester	25.15
Saturated fatty acids	Percent of fraction
Hexadecanoic acid, methyl ester	51.47
Hexadecanoic acid, 14-methyl ester	1.31
Heneicosanoic acid, methyl ester	1.14
Octadecanoic acid, methyl ester	3.93
Nonanedioic acid, methyl ester	2.11
Octadecanoic acid, methyl ester	11.54
Eicosanoic acid, methyl ester	10.21
Docosanoic acid, methyl ester	3.85
Teracosanoic acid, methyl ester	3.14
15-Teracosanoic acid, methyl ester	5.46
Tricosanoic acid, methyl ester	0.83
Pentadecanoic acid, methyl ester	0.60
Oxiraneundecanoic acid, 3 pentyl methyl ester	1.65
Oxiraneundecanoic acid, 3 octyl methyl ester	2.76

Halogeton glomeratus (Bieb.) C. A. Mey

This plant is a native of Asia and grows well on alkaline soil. It contains oxalates that can be toxic to livestock if eaten in excess. The oil content of the seeds was 24.7 percent. The fatty acid composition was: 84.38 percent unsaturated and 15.62 percent saturated.

Unsaturated fatty acids	Percent of fraction
9-Hexadecenoic acid, methyl ester	0.48
Hexadecenoic acid, 14-methyl ester	0.16
13-Octadecenoic acid, methyl ester	66.54
11-Eicosenoic acid, methyl ester	2.44
13-Docosenoic acid, methyl ester	1.27
15-Tetracosenoic acid, methyl ester	0.32
6,9-Octadecadienoic acid, methyl ester	0.15
9,10-Octadecadienoic acid, methyl ester	0.24
7,10-Octadecadienoic acid, methyl ester	0.67
9,11-Octadecadienoic acid, methyl ester	0.28
9,12-Octadecadienoic acid, methyl ester	20.04
9,12,15, Octadecatrienoic acid, methyl ester	7.41
Saturated fatty acids	Percent of fraction
Hexadecanoic acid, methyl ester	77.10
Hexacosanoic acid, methyl ester	1.01
Octadecanoic acid, methyl ester	11.56
Eicosanoic acid, methyl ester	4.55

Docosanoic acid, methyl ester	3.01
Teracosanoic acid, methyl ester	2.51
Tricosanoic acid, methyl ester	0.26

Kochia scoparia (L.) Schrader

An annual plant that grows on saline soils and can be grazed by livestock. The oil content of the seeds was 9.7 percent. The fatty acid composition was: 80.79 percent unsaturated and 19.21 percent saturated.

Unsaturated fatty acids	Percent of fraction
9-Hexadecenoic acid, methyl ester	4.43
11-Eicosenoic acid, methyl ester	2.30
13-Docosenoic acid, methyl ester	2.59
15-Tetracosenoic acid, methyl ester	0.83
2,4-Hexadienecarboxylic acid, methyl ester	0.33
9,12-Octadecadienoic acid, methyl ester	89.52

Saturated fatty acids	Percent of fraction
Hexadecanoic acid, methyl ester	68.00
Heptadecanoic acid, methyl ester	0.61
Hexacosanoic acid, methyl ester	0.88
Octadecanoic acid, methyl ester	16.68
Eicosanoic acid, methyl ester	4.61
Docosanoic acid, methyl ester	3.64
Teracosanoic acid, methyl ester	5.58

Sarcobatus vermiculatus (Hook.) Torr.

A perennial shrub that grows well on saline or alkaline flood plains. It is moderately poisonous to livestock if eaten in large amounts. The oil content of the seeds was 17.5 percent. The fatty acid composition was: 78.86 percent unsaturated and 21.14 percent saturated.

Unsaturated fatty acids	Percent of fraction
9-Hexadecenoic acid, methyl ester	0.45
11-Eicosenoic acid, methyl ester	1.22
13-Docosenoic acid, methyl ester	1.26
15-Tetracosenoic acid, methyl ester	0.28
7,10-Octadecadienoic acid, methyl ester	0.34
9,12-Octadecadienoic acid, methyl ester	96.16
Octadecatrienoic acid, methyl ester	0.29

Saturated fatty acids	Percent of fraction
Hexadecanoic acid, methyl ester	64.30
Heptadecanoic acid, methyl ester	1.79
Hexacosanoic acid, methyl ester	1.54
Heneicosanoic acid, methyl ester	2.07
Octadecanoic acid, methyl ester	5.82
Tetradecanoic acid, methyl ester	13.15
Eicosanoic acid, methyl ester	4.96
Docosanoic acid, methyl ester	3.56
Tetracosanoic acid, methyl ester	1.23
Tricosanoic acid, methyl ester	1.49

Suaeda torreyana Wats

A shrubby plant that is commonly associated with salt desert shrub communities. It produces black and brown seeds that have different properties towards salinity. The oil content of the seeds was 25.25 percent.

The fatty acid composition was: 89.58 percent unsaturated and 10.42 percent saturated.

Unsaturated fatty acids	Percent of fraction
9-Hexadecenoic acid, methyl ester	0.39
Hexadecenoic acid, 14-methyl ester	6.94
7-Hexadecenoic acid, 14-methyl ester	0.38
Nonanedioic acid, methyl ester	0.51
11-Eicosenoic acid, methyl ester	1.12
13-Docosenoic acid, methyl ester	2.40
15-Tetracosenoic acid, methyl ester	0.17
7,10-Octadecadienoic acid, methyl ester	0.95
9,12-Octadecadienoic acid, methyl ester	86.21
9,12,15, Octadecatrienoic acid, methyl ester	0.93

Saturated fatty acids	Percent of fraction
Hexadecanoic acid, methyl ester	58.27
Hexacosanoic acid, methyl ester	0.73
Heneicosanoic acid, methyl ester	1.86
Octadecanoic acid, methyl ester	19.70
Tetradecanoic acid, methyl ester	0.95
Eicosanoic acid, methyl ester	6.11
Docosanoic acid, methyl ester	6.24
Tetracosanoic acid, methyl ester	6.14

The percent unsaturation for the oil from the seeds of the halophytes ranges from 78.8 percent to 89.5 percent with an average of 84.2 percent.

Certain fatty acids tended to represent the major concentration. In the saturated fatty acids fraction of the halophytic seed oil, hexadecanoic acid was the major fatty acid in all cases. The average percent of the fraction was 62 percent.

In the unsaturated fatty acids, there was more diversity with 9,12-Octadecadienoic acid being the most common, followed by 13-Octadecenoic acid, 11-Eicosenoic acid, 9,12,15, Octadecatrienoic acid, and 9-Octadecenoic acid. The total number of fatty acids detected for *Allenrolfea occidentalis* was 31 even though the concentration of most of the individual fatty acids were very low.

Discussion

The seeds of the halophytes analyzed had an oil content ranging from 9.7 percent in *Kochia* to 25.5 percent in *Suaeda*. The actual yield per hectare for these halophytes has not been determined. In the case of the *Salicornia europaea*, field studies in Mexico, Egypt, and United Arab Emirates indicated a production of 20 tons of plant material per hectare (Goodin and others 1990). The oilseed yield was 2 ton per hectare. Based on 15 percent oil content, the oil yield would be 600 lbs of cooking oil per hectare (Goodin and others 1990).

The quality of the cooking oil is of importance and is related to the percent unsaturation. High unsaturation is considered more healthy. Animal fat (lard) is 59 percent unsaturated and butter is 32 percent unsaturated. Plant fats are higher in unsaturated fatty acids such as soybean (84.6 percent), olive oil (85.8 percent), safflower oil (91.1 percent) and canola oil (92.8 percent) (USDA handbook 8-4). The percent unsaturated from the seed oil of the halophytes

was favorable with the average being 84 percent. The seed oil of *Sueada torreyana* had an unsaturation of 89.6 percent, which is very close to canola oil. These results would suggest that the oil from the halophyte seeds is of high quality.

Future questions that need to be answered include conditions for establishment of stands of halophytes, level of production, and yield of seeds.

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