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Investigation on potential of *Suaeda fruticosa* as a source of edible oil

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Abstract

Given the extent of saline lands in Iran, cultivation and utilization of halophytes and salt tolerant species under the condition that both water and soil are saline could be a viable option in production and extraction of vegetable oils from halophytes and salt tolerant species.The aim of this study was to investigate the potential of a halophyte namely *Suaeda fruticosa* as a source of edible oil as well as qualitative and quantitative analysis of the oil. For this purpose, seeds of *Suaeda fruticosa* were collected from saline soils of Garmsar Desert Research Station. The extraction of fatty acids was performed by solvent in Soxhlet method, and GC was used to analyze the fatty acids.The quantity of oil present was 31.97%.According to the results of seed oil analysis by gas chromatography, the lipids in the seed were found to contain four saturated fatty acids (11.04%) and six unsaturated fatty acids (89.06%).Our data clearly indicate that the seeds of halophyte *Suaeda fruticosa* could be used as a source of oil for human consumption.

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Introduction

Oils, as the second largest energy source, after carbohydrates, play a central role in human nutrition and in order to maintain food security it should be accessible to the extent required in consumption pattern.Oilseeds or annual species including corn, cotton, peanuts, sunflower, canola, sesame, soya, as well as perennial crops such as palm oil, olive and coconut are the largest source of edible oils.Dietary studies support the concept that saturated fats are a greater risk for heart diseases thanpolyunsaturated fatty acids (Hu, 1997). Palm oil has 52%saturation whereas animal fats (lard) are 40%, and canola oil is 8% saturated (Declercq and Daun, 1998; Weber *et al.*, 2001).Due to increasing population and consumption of vegetable oils, domestic production cannot meet domestic needs, and in Iran, the demand for vegetable oils has increased exponentially, as in average, 95 percent of oilseeds is imported (Saeedi and Sedqi, 2008). Due to the economic sanctions imposed against Iran and also the oil embargo, Iran has great difficulty in importing oilseeds and vegetable oils. In other words, if the range of sanctions against Iran is expanded, it can cause serious damage to the country's macro economy. Therefore, vegetable oils are considered a strategic product. Studies and experiences of successful countries on cultivation of oilseeds show that our country due to the different climates and talented workforce can reduce and minimize the coefficient dependence on import of oilseeds and causes foreign exchange savings (Movahed and Qavami,2007). This requires special attention to the facts on which about 43 percent of Earth's land is arid and semi-arid and 98% of the water is saline (Jeon *et al.*, 2010).More than 800 million hectares of the world is affected by salinity (Szabolcs,1989).Of the current 230 million ha of irrigated land, 45 million ha are salt-affected soils and this threat is being transmitted to the arable lands.

In our country, the area of saline lands is estimated to be 27 million ha.With this view, encouraging residents of such areas to cultivation and utilization of halophytes can be a viable option in production and extraction of vegetable oils from halophytes.Halophytes thrive under varying soil salinity conditions and may be irrigated with brackish water or with a certain percent of seawater without any major ill effects on growth and reproduction (Parida and Das, 2005). Seeds of many of these halophytes may contain appreciable quantities of edible oil (Glenn *et al.*, 1991; Weber *et al.*, 2001), however, research on halophyte oilseeds appears scanty. Oil extracted from the seeds of *Salicornia bigelovii*, a highly salt tolerant stem succulent annual halophyte, was reported to be of good quality, whose level of unsaturation was comparable to oils extracted from conventional oil seeds (Glenn *et al.*, 1991). This was followed by a report of oils extracted from perennial halophytes distributed in the Great Basin desert of North America on total lipids and individual fatty acid fractions in five halophytic species indicating that the level of unsaturation ranged from 85% to 90%. The best quality oil was extracted from a highly salt tolerant perennial species *Suaeda moquinii* (Weber *et al.*, 2001). This report clearly suggests that the quality of extracted oil is approaching the quality of the best edible oils (Olive and Canola) reported (Declercq and Daun, 1998). This observation is further supported by reports on other halophytes such as *Crithmum maritimum*, *Zygophyllum album* (Zarrouk *et al.*, 2003), *Kosteletzkya virginica*, (He *et al.*, 2003), *Nitraia sibiria*, *Suaeda salsa*, *Chenopodium glaucum* and *Descurainaia sophia* from China (Yajun *et al.*, 2003), which indicate the presence of good quality oil. Yajun *et al.*, (2003) also reported that *D. sophia* collected from saline soil (0.4% NaCl) contained higher amounts (53.7%) of linolenic acid in their seeds in comparison to those plants growing in non-saline soil (< 0.1% salt), where about 36% linolenic acid was present. Linolenic acid is a precursor for producing prostaglandin in human body, which is helpful in dilating blood vessels, alleviating asthma, and in curing gastric ulcer (Anonymous, 1995).

Soil salinity in Iran, like any other country of arid and semi-arid regions, is on the increase, supplies of good quality irrigation water are limited and underground water is largely brackish (FAO, 2005). Most of the conventional crops do not survive moderate salinity stress. Alternate approaches to growing crops have to be found to meet the other requirements (edible oil being an important one) of the human population.Therefore, it is economical to use halophytes as a source of vegetable oil since halophytes do not compete with conventional crops on high quality soil and water. If the selected species are perennial, they will have canopy cover for a longer time, playing an important role in savings in the cost of planting annual crops (Gomez *et al.*,2008).Therefore, perennial grasses and trees are a better choice for this purpose (Ohlrogge *et al.,*2009).These plants are found in abundance in nature. Since they are out of the human food chain and require low maintenance conditions, their growth is economical. Although many related aspects are required to research, knowledge on the potential of some halophytes paves the way to the possibility of selecting other candidates for oilseeds. Halophytes have several unique features which make them potentially interesting biological resources for the production of vegetable oils. The importance of the issue is noteworthy especially from the following aspects: firstly, the cultivation and production of the halophytes in salt-affected regions in which there is no possibility for crop cultivation could provide good job opportunities for people in addition to soil conservation and preventing the exacerbation of desertification. People in these areas may be encouraged to cultivate halophytes and seed collection.Secondly, lots of the need for oilseed to provide edible oils will be removed by cultivation of halophytes, resulting in reduction of oilseeds imports and outflow of foreign currency. Also, halophytes are not in competition with other crops such as corn, soybean and sunflower. They can also be grown with brackish water or sea water and their cultivation would not be a threat to any species.This research was aimed to investigate the potential use of halophyte *Suaeda fruticosa* as a source of edible oil in saline lands.This paper seeks to answer the question whether halophyte and salt tolerant species can be regarded as the potential for production of edible oil?

This paper tests the hypothesis that seeds of a perennial halophyte (*Suaeda fruticosa*) produce seeds containing oil acceptable for human consumption.In this regard, several studies have been conducted on the possibility of the use of halophytes for the production of edible oils in countries such as America, China, Pakistan, and so forth(Weber *et al.*,2001).Glenn *et al.*,(1991) reported that halophytes such as *Suaeda* and *Salicornia* were one of the potential sources to produce edible oils.Weber *et al.*, (2007) compared the vegetable oil from seeds of native halophytic shrubs and showed that in *Suaeda moquinii,* unsaturated fatty acid ranged between 85 and 90%. This report clearly showed that the quality of extracted oil was very close to the quality of olive oil and canola oil. Assadi *et al.*, (2013) determined the oil and fatty acids concentration in seeds of coastal halophytic *Suaeda aegyptica* and showed that the ratio of unsaturated fatty acids was higher than that of saturated ones. Linoleic and Palmitic acids were identified as the major unsaturated and saturated fatty acids of *Suaeda aegyptica*, respectively. Wang *et al.*, (2011) studied the seed oil content and fatty acid composition of annual halophyte *Suaeda acuminata* and reported that the seed oil content of this species ranged from 14.3 to 15.5% by dry weight. In this research, quantitative and qualitative characteristics of the seed oil obtained from *Suaeda fruticosa* were investigated at Research Institute of Forests and Rangelands, Iran.

Materials and methods

Halophytic species *Suaeda fruticosa*, which are found in abundance in Garmsar and vicinity, were selected for the seed oil analysis. *Suaeda fruticosa* (L.) Forssk. (Chenopodiaceae) is a leaf succulent perennial halophytic shrub which is highly salt tolerant and is widely distributed in inland and coastal salt marshes as well as in deserts of center and south of Iran. Random sampling method was used for seed collection of *Suaeda fruticosa* from Garmsar Desert Research Station, located between 35° 15' 57" N and 52° 19' 48" E. This area is located at an altitude of 782 meters above sea level. The mean annual precipitation is about 100 mm. The seeds were separated from the vegetative plant parts, cleaned, ground with a Wiley Mill and extracted three times with methanol and chloroform (1:2 v/v). The percent oil in seeds was determined by weight. Fatty acids in oil extracts were methylated with Altech methyl prep. [(triflurometHyl phenyl) trimethylammonium hydroxide]. The methylated fatty acids were separated by capillary gas chromatography (Hp GC 6890) and identified by GC mass spectrometry (Hp MS 5973). The fatty acids were identified by matching the major fragments pattern with reference mass spectra of methyl ester fatty acids in the database.

Results

The seed oil content in the halophyte under study (*Suaeda fruticosa*) was obtained 32% (Figure 1). The amount of unsaturated fatty acids (USFA) was (89/06%) of the total fatty acids. Seed oil from *Suaeda fruticosa* (89.06% USFA) appeared to be the best from a health point of view. Analysis of seed oil showed the presence of ten fatty acids of which four were saturated and six were unsaturated fatty acids (Table 1). Palmitic (C16:0) was the dominant fatty acid in the seed oil of *Suaeda fruticosa*. The unsaturated fraction composition of oil from *Suaeda fruticosa* seeds showed that linoleic acid was the major fatty acid component (Table 1).

Table 1. Saturated /un-saturated fatty acid fractions (%) in the oil of *Suaeda fruticosa*.

Fatty acids	(%)
saturated fatty acids	
Lauricacid (C12 :0)	0.08
Myristic acid (C14 : 0)	0.08
Palmitic acid (C16:0)	7.54
Stearic acid (C18 : 0)	2.33
Total	11.04
un-saturated fatty acid	
isomer trans- oleic acid (C18:1)	0.09
Oleic acid (C18: 1)	14.88
isomer trans- Linoleic acid(C18: 2)	0.07
Linoleic acid (C18 :2)	73.06
isomer trans- α- linolenic acid (C18 :3)	0.34
α- linolenic acid (ALA) (C18:3)	0.62
Total	89.06

Discussion

The data presented here clearly indicate the potential to extract high-quality edible oil from *Suaeda fruticosa* seeds. This species in the present study contained 32 % oil which compares well with ca. 30% oil reported in *Suaeda bigelovii* (Glenn *et al.*, 1991; Bashan *et al.*, 2000). Weber *et al.* (2001) reported oil recovery from a low of 10% in *Kochia scoparia* to 26% in *Suaeda torreyana* and He *et al.*, (2003) reported 11% oil recovery from seed of *K. virginica*. Yajun *et al.*, (2003) found oil recovery ranging from 9% to 35% in four halophytes of their study.

Data for the best conventional oil seeds crop indicate that canola produces the best oil for human consumption. The oil recovery from canola seed is

40% with over 90% unsaturated fatty acid contents (Declercq and Daun, 1998). Halophytes such as *Cakile edentula* (O'Leary *et al.*, 1985) and *Crambe abysinnica* (Mandal *et al.*, 2002) have been reported to contain 50% and 60% oil, respectively. *Cakile maritima* is another halophyte from Tunisia studied in some details (Ghars *et al.*, 2005), where different accessions have been reported to contain 25.4–38.8% oil but because of the presence of 25–35% erucic acid, the oil was appropriate only for industrial application and unfit for human consumption.

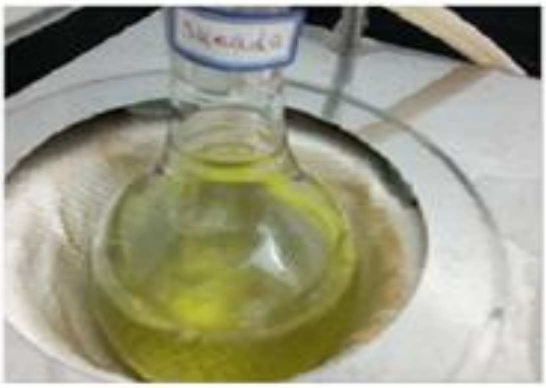

Fig. 1. Mixture of chloroform and fatty acids of Suaeda fruticosa in Soxhlet apparatus to prepare methyl ester.

The actual yield (and the yield potential) of halophytes remain largely unknown because of absence of their domestication. They grow in areas of variable salinity and regimes. One thing appears certain that these plants will tolerate extremely harsh conditions. Isolated field studies with *Salicornia europaea* in Mexico, Egypt, and United Arab Emirates reported a production of 20 tons of total biomass per hectare, with a yield of two tons of seeds (Goodin*, et al.*, 1990). Glenn *et al.*, (1991) also reported similar yields with *S. bigelovii*. While such reports are encouraging, actual yield in a commercial set up would probably be much lower and would require considerable energy input. From a new use point of view, the production would involve perennial plants that use brackish water. An important aspect is the oil quality, which is related to its degree of unsaturation. Oil with high unsaturation is considered healthier (USDA, 1990; Lang, 1997). Unsaturation in the seeds of various halophytes e.g. species of *Suaeda*, *Atriplex*, *Halogeton*, *Kochia*, *Allenrolfea*, and *Sarcobatus* have been reported to range from 78% to 89% (Weber *et al.*, 2001). He *et al.* (2003) also reported that seeds of *Kosteletzkya virginica* were composed largely of unsaturated fatty acids, high potassium, and low sodium. The above data compare well with 89.06% unsaturated fatty acids present in the oil of *S. fruticosa*. While assessing the quality of edible oil, individual lipid fractions have also to be taken into consideration before making any recommendations. High level of erucic acid (C22:1) exceeding 25% for instance, is not considered fit for animal or human consumption (Cherif *et al.*, 1992). The oil from the seeds of *S. fruticosa* studied was free from any such undesirable component and could safely be recommended for human consumption. Oil from *S. fruticosa* in this study was almost similar in composition (not necessarily the quantities) with respect to individual fatty acids of commercial oils. While canola (Declercq and Daun, 1998) and olive oil (Zarrouk *et al.*, 1996) have very low palmitic acid (C16:0) and are dominated by monounsaturated oleic acid (C18:1), the fatty acid fractions present in *S. fruticosa* i.e. high linoleic acid (C18:2) is generally comparable with oil crops like sunflower (Karleskind, 1996) or cotton (Smaoui and Cherif, 1992) Preliminary studies of oilseed of local halophytic species validate the hypothesis that their oil quality is comparable with conventional edible oils such as those from sunflower and canola. These crops could be grown with brackish water.

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References

Anonymous. 1995. The Cyclopedia of Chinese Medicine-Basic Medicine. Science and Technology PublishingCompany, Shanghai, China 393–395 p.

Assadi T, Bargah A, Mohebbi Gh, barmak AR, Nabipour I, Mohajeri Borazjani S, Kholdebarin B. 2013. Determination of oil and fatty acids concentration in seeds of coastal halophytic Sueada aegyptica. Iranian South Medical Journal **16(1),** 9-16.

Bashan Y, Moreno M, Troyo E. 2000. Growth promotion of the seawater irrigated oilseed halophyte *Salicornia bigelovii* inoculated with mangrove rhizosphere bacteria and halotolerant Azospirillium spp. Biological Fertle Soils **32,** 265–272.

Cherif A, Ben Miled D, Marzouk B, Smaoui A, Zarrouk M. 1992. Metabolism, Structure and Utilization of Plant Lipids. CNP, Tunis. 341–343 p.

Declercq DR, Daun JK. 1998. Quality of 1997 Ontario Canola.Final Report. Grain Research Laboratory, Winnipeg, Manitoba, Canada: Canadian Grain Commission.

FAO. 2005. Global Network on Integrated Soil Management for Sustainable Use of Salt-affected Soils.

Ghars MA, Debez A, Smaoui A, Zarrouk M, Grignon C, Abdelly C. 2005. Variability of fruit and seed oil characteristics in Tunisian accessions of the halophyte *Cakile maritima* (Brassicaceae). Ecophysiology of High Salinity Tolerant Plants. Springer, The Netherlands 55–67 p.

Goodin JR, Epstein E, McKell CM, O'Leary JW. 1990. Saline Agriculture, Salt Tolerant Plants for Developing Countries. National Academy Press, Washington, DC, 143 p.

Gomez LD, SteeleKing CG, McQueenMason SJ. 2008. Sustainable liquid biofuels from biomass: the writing's on the walls. New Phytol **178,** 47 3e 85.

Glenn EP, O'Leary JW, Watson MC, Thompson TL, Kuehl RO. 1991. *Salicornia bigelovii* Torr: an oilseed halophytes for sea water irrigation. Science **251,** 1065–1067.

He Z, Ruana C, Qin P, Seliskar DM, GallagherJL. 2003. *Kosteletzkya virginica*, a halophytic species with potential for agroecotechnology in Jiangsu Province, China. Ecological Engineering **21,** 271–276.

Hu F. 1997. Dietary fat intake and the risk of coronary heart diseases in women. New England Journal Medicine **337,** 1491–1499.

Jeon YJ, **Xun Z, Rogers PL**. 2010 .Comparative evaluations of cellulosic raw materials for second generation bioethanol production. Lett Appl Microbiol **51,** 518e24.

Karleskind, A .1996. Oils and Fats Manual, a Comprehensive Treatise, vol. I. Lavoisier Publishing, 806p.

Mattson FH, Grundy SM. 1985. Comparison of effects of dietary saturated, monounsaturated, and polyunsaturated fatty acids on plasma lipids and lipoproteins in man. J. Lipid Res **26,** 194.

Mandal S, Yadav S, Singh R, Begum G, Suneja P, Singh M. 2002. Correlation studies on oil content and fatty acid profile of some Cruciferous species. General Research of Crop Evolution **49,** 551–556.

Movahed S, Ghavami M. 2007. Determination and Comparison of fatty acid seed oil Iranian and imported grape composition. Research and development on natural resources **(75).**

Ohlrogge J, Allen D, Berguson B, Dellapena D, Hill YS, Styme S. 2009. Energy. Driving on biomass. Science **324,** 1019e20.

O'Leary JW, Glenn EP, Watson MC. 1985. Agricultural production of halophytes irrigated with seawater.Plant and Soil **89,** 311–321.

Parida AK, Das AB. 2005. Salt tolerance and salinity effects on plants: a review. Ecotxicological Environment Safety **60,** 324–349.

Saeedi G, Sedqi V. 2008. Influence of macronutrients and microelements on the yield of oilseed crops Conference, University of Isfahan**.**

Smaoui A, Cherif A. 1992. Glycerolipids in salt stressed cotton seeds. In: Ungar, I.A. (Ed.), Ecophysiology of Vascular Halophytes. CRC Press, Boca Raton, FL.

Szabolcs I. 1989. Salt-affected soils. Boca Raton, FL: CRC Press.

USDA. 1990. Composition of foods: fats and oils—raw, processed, prepared. Agriculture Hand Book 8-4, Beltsville, MD, USA..

Wang L, Zhang K, Huang W. 2011. Seed Oil Content and Fatty Acid Composition of Annual Halophyte *Suaeda cuminate*: A comparative study on dimorphic seeds. Afr J Biotechno.

Weber DJ, Gul B, Khan M, Williams T, Wayman P, Warner S. 2001. Comparison of vegetable oil from seeds of native halophytic shrubs. In: Mc Arthur ED, Fairbanks DJ. (Eds.), Proceeding of Shrubland Ecosystem Genetics and Biodiversity. RMRS-P-21. USDA Forest Service, Ogden, UT, Rocky Mountain Research Station, USA, 287–290 p.

Weber DJ, Ansari R, Gul B, Ajmal Khan M. 2007 .Potential of halophytes as source of edible oil. J Arid Environ **68,** 315-21.

Yajun B, Xiaojing L, Weiqiang L. 2003. Primary analysis of four salt tolerant plants growing in Hai-He plain,China. In: LeithH, Mochtchenko M. (Eds.), Cash Crop Halophytes: Recent Studies. Kluwar Academic Publishers, London, Great Britain, 135–138 p.

Zarrouk M, El Almi H, Ben Youssef N, Sleimi N,Smaoui A, Ben Miled D, Abdelly C. 2003. Lipid composition of seeds of local halophytes: *Cakilemaritima*, *Zygophyllum album* and *Crithmum maritimum*. In: LeithH, Mochtchenko M. (Eds.), Cash Crop Halophytes: Recent Studies. Kluwer Academic Publishers, London, Great Britian. p. 121–124.