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Investigation on the potential of halophytes as a source of edible oil case study: *Suaeda aegyptiaca* and *Halostachys caspica*

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Key words: Alinity, Edible oil, *Suaeda aegyptiaca*, *Halostachys caspica* , saturated and unsaturated fatty acids.

Abstract

The aim of this study was to investigate the potential of two halophytes namely: *Suaeda aegyptiaca* and *Halostachys caspica* as a source of edible oil as well as quantitative and qualitative oil analysis. For this purpose, the seeds of two halophytes were collected from saline lands of Yazd province, Iran. The extraction of fatty acids was performed by Soxhlet method using a solvent. The analysis of fatty acids was performed by GC. The oil yield obtained from *S.aegyptiaca* and *H caspica* was calculated to be 32.99 and 11.97%, respectively. According to the results of oil analysis, Lauric acid (C12), Myristicacid (C14), Palmitic acid (C16) and Stearic acid (C18) were identified as saturated fatty acids in the seed oil of both studied halophytes. Unsaturated fatty acids included Oleic acid (C18: 1), Linoleic acid (C18: 2) and Linolenic acid (C18: 3) and related isomers. The results clearly indicate that the seeds of *S.aegyptiaca* could be used as a source of edible oil for human consumption. Although the oil yield obtained from *H.caspica* was almost half that of *S.aegyptiaca*, however, due to the percentage of saturated and unsaturated fatty acids identified in *H.caspica* further investigation is required to examine the real potential of this halophyte as a source of edible oil.

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Introduction

Arid regions occupy over one third of the earth's surface in which about 16 percent of world population is living. On the other hand, population growth in these areas especially in developing countries is so that arable lands and available freshwater do not meet the population growth. Reduction of freshwater resources has caused pressure on human civilization in increasing use of saline soil and water resources and most likely, the twenty-first century will be the century of halophytes and salt-tolerant species. According to FAO (2005), every year million hectares of fertile lands lose their fertility due to the salt accumulation so that the problem of soil salinity has become a serious problem worldwide. Various information and statistics show that every minute at least 3 hectares of arable lands in the world are degraded due to salinity (Anon, 2006).Halophyte and salt tolerant species may be appropriate and reasonable alternatives for many developing countries (Ayoub andSquires,1994). Iran, with an area of 1648000 square kilometers has extensive saline rangelands. According to some reports, the area of the lands affected by salinity in Iran has been estimated to be 25-27 million hectares equivalent to 15 to 17% of the whole country (Akhani,2006).

So far, more than 1,500 salt tolerant species have been identified worldwide, some of which are able to tolerate high concentrations of salt in the soils. Halophytes from different families can produce greater amount of biomass or seed under irrigation with seawater (Glenn *et al*.,1997). Totally, in Iran 365 halophytes and salt tolerant species from 151 genera and 44 families have been identified, of which 52% of the species belong to the chenopodiaceae family. Since solving the problem of soil salinity and amendment requires a long-term effort and enormous cost, therefore, what in particular is very important is trying to find and develop appropriate species, tolerant to salinity and water shortage with an acceptable yield (Arab,2007). Halophytes do not compete with conventional agricultural products for high quality soil and water and hence the resources needed for food production are preserved. Perennial halophytes have canopy cover for a long time, playing an important role in terms of the savings of annuals planting costs (Gomez *et al*.,2008). Therefore, perennial grasses and shrubs are a better choice for this purpose (Ohlrogge *et al.,* 2009).

In Iran, despite the large areas of arable lands and relatively large potential for oilseeds production, more than 90% of the oil needed is still imported from abroad. In response to an imbalance in supply and demand for food, import cannot be considered a sustainable policy due to fluctuations in foreign exchange income. Given the importance of food security in the 20-year long-term strategy, government officials are trying to implement development programs and supportive policies for the cultivation of oil seeds and developing the processing capacity to reach self-sufficiency in this respect. These programs are mainly in the field of cultivation of sunflower, rapeseed, soybean and olive and practically halophytes have received no attention as a source of edible oil (Mirmohhamadi *et al.,* 2002). The seeds of many halophytes contain significant amounts of edible oil (Glenn *et al*., 1991; Weber *et al*., 2001;). In recent years, some research has been done in countries such as America, China, and Pakistan to examine the potential of halophytes for the production of edible oils (Weber *et al*., 2001).

This research was aimed to investigate the potential of two mentioned halophytes in saline lands of Yazd province as a source of edible oil.

Materials and methods

Study sites

Saline habitats in Yazd province were selected as main sites in this research so that the habitats of *Suaeda aegyptiaca* and *Halostachys caspica* were selected in Ardakan and Abarghou, respectively. High production and ability to tolerate a wide range of environmental conditions especially salinity were among the criteria to select these species. Both selected species are native, perennial, high producing and halophyte, distributed widely in the study area as vegetation types.

Sampling

In the key area of both vegetation types (*S. aegyptiaca* and *H. caspica*), 10 species with three replications (totally 30) were marked separately. After seed maturity stage, the seeds were collected to determine the quantity and quality of seed oil. The collected seeds from both halophytes were cleaned and transferred to the laboratory of Maybod Branch, Islamic Azad University.

Laboratory analyses

In the laboratory, 50 gr of seeds of each species were powdered with an electric mill and passed through the sieve. The oil was extracted three times with methanol and chloroform (1:2 v/v) by Soxhlet extraction method. The percentage oil in seeds was determined by weight. Fatty acids in oil extracts were methylated with Altech methyl prep. [(trifluromethyl phenyl) trimethyl ammonium 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.

Statistical analysis

All obtained data were analyzed by SAS software (Ver 9.00). Mean comparisons were performed by Duncan's Multiple Range Test at 1% level of significance.

Results and discussion

According to the results of analysis of variance, significant differences were found between two studied species in oil content, oil composition (fatty acids), iodine and saponification numbers (P<0.01) and oil acidity (P<0.05).

Table 1. Analysis of variance for oil percentage and oil composition in *Suaeda aegyptiaca* and *Halostachys caspica*.

		MS													
S.O.V	df	oil%	Stearic acid	*Lauricacid*	*Myristic acid*	*Palmitic acid*	*Oleic acid*	*isomer trans-oleic acid*	*Linoleic acid*	*isomer trans-Linoleic acid*	*α- linolenic acid*	*isomer trans-α- linolenic acid*	Saponificationvalue	iodine value	pH
Replication	2	3 .47^{NS}	0.018^{NS}	0.00^{Ns}	0.00^{NS}	0.029**	0.7^{NS}	0.00^{NS}	0.09^{Ns}	0.00^{Ns}	0.005^{Ns}	0.00^{NS}	0.11^{NS}	0.63^{Ns}	0.007^{Ns}
Species	1	323.95**	0 .39**	0.012**	0.002*	2.28**	28.32**	0.003**	265.29**	0.008**	6.04**	0.39**	732.12**	193.22**	0.27*
Error	3	2.72	0 .004	0 .00	0.00	0.00	0.38	0.00	0.36	0.00	0.006	0.00	0.12	0.18	

Results of mean comparisons of oil content and oil compositions showed that the oil content of *Suaeda aegyptiaca* and *Halostachys caspica* was recorded to be 32.99% and 11.97%, respectively.

The identified saturated and unsaturated fatty acids, iodine and saponification numbers and oil acidity of both halophytes are presented in Table 3.

The comparison of oils extracted from the two studied species showed that the oil content in *Suaeda aegyptiaca* was twice as high in *Halostachys caspica* .However, an oil plant cannot be recommended for cultivation only based upon having high oil content.In other words, other attributes such as oil quality, the percentage of saturated and unsaturated fatty acids, oil retention, iodine number, saponification number, agronomic characteristics of plants and above all seed yield and economic performance of a plant and its cost should be taken into consideration (Khraisha, 2000). The results clearly indicated that the oil content in *H.caspica* was lower as compared to other oilseeds while the oil content of *S.aegyptiaca* was comparable with other species**.**

Table 2. Mean comparisons of oil percentage and oil compositions in *Suaeda aegyptiaca* and *Halostachys caspica***.**

Treatment Species	oil%	Stearic acid	Lauricacid	Myristic acid	Palmitic acid	Oleic acid	isomer trans- oleicacid	Linoleic acid	isomer trans- Linoleic acid	α- linolenic acid	isomer trans- α- linolenic acid	Saponification Value	iodine value	pH
Halostachys caspica	11.97^B	1.43^B	0.15^B	0.11^B	9.21^B	18.28^B	0 .00^B	64.67^B	0.00^B	2.92^B	0.00^B	165.27^B	123.37^B	1.23^B
Suaedaaeg yptiaca	32.99^A	2.35^A	0 .07^C	0 .08^C	7.44^C	14/49^C	0.08^A	73.14^A	0.08^A	0.69^C	0/34^A	188.9^A	138.27^A	1.67^A
Mean	22.48	1.89	0.11	0.09	8.32	16.38	0.04	68.90	0.04	1.80	0.17	177.08	130.82	1.45

Means within each column followed by the same letters are not significantly different.

Elsebaie *et al.* (2013) investigated the physical and chemical properties of oil extracted from *Salicornia fruticosa* and the amount of extracted oil was reported to be 28.57%.

According to the obtained results, it can be concluded that the two studied species, especially *S. aegyptiaca*, have the ability to produce edible oil but further investigation is required. The most important indicator of edible oil is fatty acid content and fatty acid variation in oil (Good *et al.*,2011).Given that the oil was extracted with solvent in this experiment, the iodine and saponification numbers were found to be in good amount for both species. In addition, oil acidity of 1.67% and 1.23% in *S.aegyptiaca* and *H.caspica* is considered as a good result. In the oil extracted from the seeds of both studied species, 10 fatty acids were detected so that palmitic acid and linoleic acid were identified as dominant saturated and unsaturated fatty acids, respectively. The results are in agreement with the findings reported by(Glenn *et al.*,1997;Wang *et al.*,2011;Weber *et al.*, 2007;Zuo*et al.*,2010).Assadi *et al.*(2013) studied the seed oil of *S. aegyptica* and according to the results, palmitic acid (11.02%) and linoleic acid (956.9%) were reported to be dominant saturated and unsaturated fatty acids, respectively. The results are close to what was reported in above mentioned study. SabzAlian*et al.* (2007) investigated physicochemical properties of the seed oil of *acanthus* and reported an iodine number of 166 mg per gram of oil and 9.8% palmitic acid as dominant saturated fatty acid. High levels of unsaturated fatty acids of oleic acid (29.59%) and linolenic acid (54.59%) were also reported, which confirms our findings. According to Zuo*et al.* (2010), the oil content of *Suaeda cornicolar* was reported to be 25.34%.Linoleic acid (80.03%) and palmitic acid (5.71%) were introduced as the dominant unsaturated and saturated fatty acids, respectively, confirming the results. Wang*et al.*, (2011) investigated the seed oil of

Suaeda acuminatea, and according to the obtained results, dominant saturated and unsaturated fatty acids were reported to be palmitic acid (7.51%) and linoleic acid (65%), respectively, consistent with our findings. The differences between our results and those reported by other researchers in terms of oil content and fatty acids can be attributed to the variability of climate, soil and differences in seed collection as well as methods of analysis. The consumption of oils such as olive oil with 75% mono unsaturated fatty acid (oleic acid) and grape seed oil due to having oleic acid could be useful in health of heart and blood vessels. The oils containing oleic acid is also used in the cosmetics industry.

Table 3. Saturated /un-saturated fatty acid fractions (%) in the oil of halophytes.

Fatty acids	*(%)Halostachys caspica*	(%)*Suaeda aegyptiaca*
saturated fatty acids		
Lauricacid(C12 :0)	0.15	0.07
Myristic acid (C14 : 0)	0.11	0.08
Palmitic acid(C16:0)	9.21	7.44
Stearic acid(C18 : 0)	1.43	2.35
un-saturated fatty acid		
Oleic acid(C18 : 1)	18.28	14.49
isomer trans- Linoleic acid(C18: 2)	0.00	0.08
Linoleic acid(C18 :2)	64.67	73.14
α- linolenic acid (ALA) (C18:3)	2.92	0.69
Saponification Value	165.27	188.9
Iodine value	123.37	138.27
pH	1.23	1.67

Existing oils in the oilseeds of studied halophytes are the most appropriate types of oil for human consumption because it contains a high percentage of unsaturated fatty acid. The oils existing in these plants have compositions similar to those of the oils on the market. The oil of *S. aegyptiaca* contains linoleic acid (w6) (73.14%), identified as the most important unsaturated fatty acid in terms of amount. Alpha-linolenic acid (w3) and linoleic acid (w6), not made in the body, are of fatty acids having a crucial role in maintaining human health and are called as essential fatty acids (EFAs).These types of fatty acids should be provided to the body due to the body's inability to synthesize them. Due to the low levels of saturated fatty acids, the seed oil of halophytes is competitive with other oils such as olive and rapeseed oils. Consequently, the seed oil of *S. aegyptiaca* could be considered as one of the best edible oils for human consumption in competition with olive and rapeseed oil due to the high levels of unsaturated fatty acids including (w6), having the ability to be extracted at a wide level. Halophytes are able to grow in saline lands irrigated with saline water or seawater (Dudal *et al.*,1985).

The cultivation and utilization of halophytes in saline lands where there is no possibility for the cultivation of agricultural crops, not only conserve the soil and prevent the exacerbation of desertification but also could be considered as a suitable option in terms of employment, production and extraction of vegetable oils from halophytes.

Conclusion

Considering the oil yield (32.99%) and the percentage of saturated and unsaturated fatty acids identified in *S. aegyptiaca*, the results clearly indicate that the seeds of this halophyte could be used as a source of edible oil for human consumption. Although the oil yield obtained from *H. caspica* was almost half that of

S. aegyptiaca, however, due to the percentage of saturated and unsaturated fatty acids identified in *H. caspica*, further investigation is required to examine the real potential of this halophyte as a source of edible oil.

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