Helianthus porteri as a Potential Source for Enhancing Linoleic Acid Concentration in Sunflower Oil

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Abstract

Confederate Daisy, or Porter's Golden-Eye, *Helianthus porteri*, formerly known as *Viguiera porteri*, is an annual sunflower that was recently transferred to the genus *Helianthus*. It occurs in and around granite outcroppings in the Piedmont regions of North and South Carolina, Alabama, and Georgia. Wild sunflower species offer the potential to improve the quality of sunflower oil, a key issue in sunflower breeding. High levels of linoleic fatty acid (>720 g/kg) in sunflower oil make it desirable for use in the production of margarines. The objective of the study was to evaluate achene oil of *H. porteri* populations for composition of four major fatty acids: palmitic (16:0), stearic (18:0), oleic (18:1), and linoleic (18:2). Achenes from eight populations collected in Georgia and North Carolina were analyzed. Fatty acid composition was determined using a gas chromatograph on oil extracted from two 10-achene samples for each population converted to methyl esters using an organic catalyzed transesterification method. Oleic acid concentration averaged 65.2 g/kg, which is low compared to normal sunflower oil. This resulted from a high linoleic acid concentration. The 815 g/kg average linoleic concentration in *H. porteri* was the highest observed in any wild sunflower species, with one population having a concentration of 834 g/kg. The higher linoleic acid concentrations (>700 g/kg) are generally observed at northern latitudes, while lower values are observed at southern latitudes. Linoleic acid concentration was higher than expected for populations grown in southern latitudes. The high linoleic acid concentration observed in *H. porteri* has the potential to improve the linoleic concentration in commercial sunflower oil. Further research will be needed to determine the inheritance of the linoleic fatty acid. Other agronomic traits will need to be maintained during the introgression of these traits into cultivated sunflower.

Introduction

Sunflower (*Helianthus annuus* L.) oil has the potential to be improved for industrial and nutritional purposes through selection and breeding. The narrow genetic base of cultivated sunflower has been broadened by the infusion of genes from wild species resulting in a continuous improvement of agronomic and economic traits in cultivated sunflower (Jan and Seiler, 2007). The genus *Helianthus* consists of 51 species and 19 subspecies with 14 annual and 37 perennial species (Schilling, 2006). While a few populations of some wild sunflower species have been collected and evaluated for oil concentration and fatty acid composition, many remain to be evaluated to fully characterize the available genetic diversity. There is an urgent need to collect species that are endemic to limited geographic areas that may be at risk of being eliminated by the activities of man. One of these species is the Confederate Daisy, or Porter's Golden-Eye, *Helianthus porteri* (A. Gray) J. F. Pruski (formerly known as *Viguiera porteri*), an annual sunflower that was recently transferred to the genus *Helianthus* (Pruski, 1998). Where it occurs, it produces a conspicuous massive floral display when in bloom, with quite small achenes, averaging 1.5 mg/seed, compared to 2.5 to 3.4 mg/seed for most other wild sunflower species. It occurs in and around granite outcroppings in the Piedmont regions of North Carolina, Alabama, and Georgia. Recent emphasis on the fatty acid composition of sunflower achenes has increased interest in using wild species in breeding programs to enhance oleic or linoleic acid, or to reduce saturated fatty acids, especially palmitic and stearic acids, but information about oil concentration and fatty acid composition is lacking for a number of rare and threatened species. The objective of the study was to evaluate achene oil of *H. porteri* populations for composition of four major fatty acids: palmitic (16:0), stearic (18:0), oleic (18:1), and linoleic (18:2).

Materials and Methods

Plant materials

Populations of wild sunflowers were collected between 17 and 28 October, 2003. The expedition covered a distance of 3,000 km in three states: Alabama, Georgia, and North Carolina. Details of this exploration can be found in Gulya et al. (2007). Heads of wild sunflowers were collected from 50 to 250 plants within each population and bulked into a single sample. Each sample represented an isolated, open-pollinated segregating population. Specific site information obtained from local botanists, generalized distribution maps, and federal and state agencies was used to locate populations. Population size (number and extent), habitat, soil type, soil sample, seed set per head, and the presence of diseases, insects, and other wild sunflower species were recorded for each population. Achene samples were sent to the USDA-ARS North Central Regional Plant Introduction Station, Ames, Iowa, where they are maintained and distributed. All populations were collected from the broad distributional range of the species.

Fatty acids analysis

Achenes were stored at 5°C and low humidity (<20%) until analyzed for fatty acid composition (expressed as g/kg on a dry weight basis). Fatty acid composition was determined using a gas chromatograph on oil extracted from a 10-achene sample. The extracted oil was converted to methyl esters using an organic-catalyzed transesterification method. Fatty acids analyzed included the following acids: palmitic (16:0), stearic (18:0), oleic (18:1), and linoleic (18:2). Fatty acid composition was determined from two samples per population.

Results and Discussion

Eight populations of *H. porteri*, seven in Georgia, and one population in North Carolina were collected (Table 1 and Figure 1). The general phenotype of *H. porteri* is shown in Figures 2-4. The average oleic acid concentration was 65.2 g/kg in *H. porteri* (Table 2). This was accompanied by a high linoleic acid concentration. The 815 g/kg average linoleic concentration in *H. porteri* was the highest observed in any wild species, with one population having a concentration of 834 g/kg. The fact that all populations had linoleic concentrations > 720 g/kg indicates that this trait should have a genetic basis because it is relatively stable in the different populations over a wide range of environments. High linoleic sunflower oil with > 700 g/kg is preferred for the production of soft margarine (DeHaro and Fernandez-Martinez, 1991).

The linoleic fatty acid concentration observed in the *H. porteri* populations was unusually high for southern latitudes. High temperatures during flowering, achene filling, and maturation favor a low linoleic acid concentration and a high oleic acid concentration (Seiler, 1986). Generally, the cooler northern latitudes have higher concentrations of linoleic acid in the oil than the warmer southern latitudes (DeHaro and Fernandez-Martinez, 1991). A lower concentration of 540 g/kg of linoleic acid is more typical of the concentration expected in warmer southern latitudes.

The concentration of palmitic and stearic acids in *H. porteri* averaged 55.3 g/kg and 32.1 g/kg, respectively. This is a reduction of 25% compared to these fatty acids in commercial sunflower oil. The lower saturated fatty acid profile of *H. porteri* has the potential to reduce saturated fatty acids in commercial sunflower oil.

Table 1. Location of *H. porteri* populations collected in Georgia and North Carolina.

Site no.	Species	Collection Date	GPS – N	GPS- W	Alt (ft.)	State	County
2401	*H. porteri*	10/21/03	35.96370	81.11849	1335	NC	Alexander
2417	*H. porteri*	10/24/03	33.75155	83.83260	900	GA	Walton
2418	*H. porteri*	10/24/03	33.70145	83.97935	750	GA	Rockdale
2419	*H. porteri*	10/24/03	33.70852	84.09322	960	GA	DeKalb
2420	*H. porteri*	10/25/03	33.70852	84.09322	730	GA	Butts
2421	*H. porteri*	10/25/03	33.14737	84.46487	880	GA	Pike
2422	*H. porteri*	10/25/03	32.98743	84.65955	880	GA	Meriwether
2423	*H. porteri*	10/25/03	33.41266	84.98012	990	GA	Coweta

Figure 1. Collection sites for *Helianthus porteri* in Georgia and North Carolina

Figure 2. Developmental stages of *Helianthus porteri* (Confederate Daisy): lower left—flowering; upper left—flower; lower right– leaves; and upper right—fruiting heads.

Figure 3. Gerald Seiler (left) and Tom Gulya (right) behind a population of *H. porteri* on top of Rocky Face Mountain, site #2401, Alexander County, North Carolina.

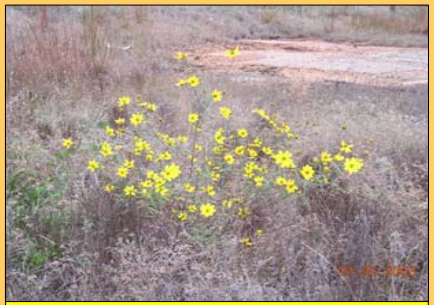

Figure 4. *Helianthus porteri* site #2420 in full bloom in right-of-way on a granite outcrop in Butts County, Georgia.

Table 2. Fatty acid composition of eight *Helianthus porteri* populations collected from the southeastern USA.

Population (Location)	Fatty acid composition			
	Palmitic (16:0)	Stearic (18:0)	Oleic (18:1)	Linoleic (18:2)
	g/kg			
2401 (NC)	47.6±0.3f* -	23.5±0.2g **	68.20.3c **	834.2±2.2a **
2417 (GA)	57.5±0.2b -	34.4±0.4c **	78.5±0.3a **	797.1±3.3e **
2418 (GA)	55.3±0.2d -	35.4±0.0.4b **	69.4±0.4b **	814.1±2.9d **
2419 (GA)	56.4±0.8c -	29.6±3.6f **	61.2±17.6e **	825.3±48.7bc **
2420 (GA)	57.0±0.2bc -	36.6±0.1a **	57.4±0.3f **	820.4±3.5cd **
2421 (GA)	61.1±0.4a -	36.4±0.4a **	45.1±0.4g **	828.1±2.6ab **
2422 (GA)	56.8±0.3abc -	30.7±0.5e **	78.4±0.4a **	799.8±3.9e **
2423 (GA)	52.7±0.3e -	31.6±0.5d **	65.4±0.4d **	817.5±2.8d **
Mean	55.3±0.2	32.1±0.4	65.2±0.4	814.9±3.5

Means followed by the same letter in a column are not significantly different at the P<0.05 and P<0.01** level according to the Duncan's New Multiple Range Test.

Conclusions

The high average linoleic acid concentration in *H. porteri* of 815 g/kg is the highest concentration reported for a wild sunflower species. Linoleic acid concentration was higher than expected for populations grown in southern latitudes. The concentration of palmitic and stearic acids in *H. porteri* averaged 55.3 g/kg and 32.1 g/kg, respectively, which is a reduction of 25% compared to commercial sunflower oil. The lower saturated fatty acid profile has the potential to reduce saturated fatty acids in commercial sunflower oil. High linoleic concentrations will provide a source for increasing this fatty acid in sunflower oil. Further research will be needed to determine the inheritance of the fatty acid composition.

References

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