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Nutritional and Sensory Evaluation of *Atriplex triangularis* Leaves

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ABSTRACT

Leaves of Atriplex triangularis *(AT), a highly salt-tolerant plant, were evaluated for nutritional and sensory characteristics. Samples of frozen AT, along with commercial brands of spinach and mustard green, were analyzed for proximate composition, ascorbic acid and vitamin A. Several minerals were determined on dried samples of AT and spinach. Sensory evaluations of these vegetables were conducted. On the basis of the nutritional analysis and the sensory evaluation, AT leaves have good potential for use as a green leafy vegetable.*

INTRODUCTION

The need for salt-tolerant crops around the world increases each year as a growing population seeks to feed itself on ever-decreasing soil resources and dwindling fresh water supplies. More than 45% of the total land area of the earth and more than 33% of all irrigated lands are salt-affected (Jefferies, 1981). Salinization of the soils in many parts of the world is reducing the acreage available for conventional agriculture. Salinity, desertification and aridity have led to several famines in Africa in recent years.

Two approaches have been taken to expand irrigation agriculture to arid and semi-arid regions of the world. One is to select conventional crops (such as rice, barley, wheat, tomato, etc.) and genetically manipulate them to be

more salt tolerant (Shannon, 1982). The other approach is to select plants that are already growing in saline environments (O'Leary, 1985). At the University of Delaware, Somers *et al.* (1979) have screened more than 350 selections from 60 species of halophytes for salt-tolerance, edible yield, characteristics of edible portion and quality. One of their selections, *Kosteletzkya virginica*, has been evaluated by Islam *et al.* (1982) and shown to have good potential for use as food or feed. *Atriplex triangularis* L. (AT), which grows into a bushy plant of about 1·5 m in height, is another halophyte selected by Somers *et al.* (1979). This plant, also known as seaside green, is widely distributed in both arid and coastal saline areas. It can tolerate salt concentrations up to 30 parts per thousand and produces medium size leaves of dark green color. The objective of this study was to assess the nutritional value and acceptance of AT leaves for their potential use as a green leafy vegetable.

MATERIALS AND METHODS

Sample preparation

The *Atriplex triangularis* leaves used for this study were grown at the experimental plots of the University of Delaware during the summer of 1983. About 12 kg leaves were harvested manually in August at about 3 months after planting. The harvested AT leaves were then brought to our laboratory in Newark, DE. After washing and removal of sand, etc., the leaves were separated into 2 kg lots and blanched in 5 litres of boiling water for 4 min. The green color of AT leaves intensified after blanching. They were then packaged in pint-size Kordite freezer bags (Mobil Chemical Co. Macedon, NY) containing about 300 g/bag and frozen at $-18°C$ in a still-air freezer. For comparison, commercial brands of frozen spinach and mustard green were purchased at the local supermarkets.

Nutrient analysis

Proximate composition

The frozen vegetable samples were thawed and blended, in triplicate, for about 2 min to make a uniform mixture for determining their proximate compositions. Moisture, protein ($N \times 6{\cdot}25$), fat and ash contents were determined by the methods outlined in AOAC (1980). Fiber was determined as acid detergent fiber by using sulfuric acid and cetyltrimethylammonium bromide (AOAC, 1980).

Minerals

For mineral analysis, AT leaves and spinach samples, in triplicate, were dried in an oven at 70°C and ground in a Wiley mill equipped with a 0·5 mm screen. The powdered material was redried at 70°C to constant weight and then sent to the A & L Agricultural Laboratory at Memphis, TN, for analysis. All the minerals except phosphorus were determined by flame photometry on a Varian Aerograph 175-A atomic absorption spectrophotometer. Two gram dry samples of the powdered vegetables, in duplicate, were ashed for 4 h at 600°C. After cooling, 10 ml of 1:1 HCl was added to the ash and allowed to react for 15 min. Two millilitres of the acidified solution were then diluted to 20 ml with distilled water and read on the atomic absorption spectrophotometer for Mg, K, Fe, Mn, Cu and Zn. An additional tenfold dilution was carried out for reading Na and Ca. Phosphorus was determined colorimetrically by the molybdenum method of the AOAC (1980).

Total ascorbic acid and beta carotene

Samples, in triplicate, were analyzed for total ascorbic acid and beta carotenes. A single slurry was made, for each of the triplicate analyses, in 100% ethanol for determining these two nutrients (Randall *et al.*, 1975; Islam & Lea, 1979). Two-hundred grams of blended samples of each vegetable were thoroughly mixed with 200 g of 100% ethanol. The slurries were stored in amber glass jars at −10°C until analyzed.

Total ascorbic acid was determined by the 2,4-dinitrophenylhydrazine method using norit (Fisher Scientific, Springfield, NJ) as the oxidizing agent (Freed, 1966). Beta carotene was determined colorimetrically, following separation by column chromatography according to the method of the Association of Vitamin Chemists. Vitamin A in international units (IU) was calculated from the beta content (0·6 mcg of beta carotene = 0·3 mcg of Vit. A = 1 IU).

Sensory evaluation

Samples of the three frozen vegetables were cooked for about 15 min and served warm on white plates to 18 untrained judges. About 1·25% (w/w) NaCl was added during cooking to the spinach and mustard greens. No salt was added to AT leaves, since adequate Na was already present. The plates were coded and served in a random manner. Panel members scored the vegetables for color, flavor, texture and general acceptance by marking on a 9 cm line, where 0 to 9 represented poor to excellent. The scores were then subjected to analysis of variance and Duncan's multiple range test (Larmond, 1970).

RESULTS AND DISCUSSION

Nutrient composition

The proximate compositions of *Atriplex triangularis* leaves, spinach, and mustard green are presented in Table 1. Average moisture contents of AT leaves, spinach and mustard green were 88·1%, 90·6% and 92·5%, respectively. Protein content of AT leaves was 2·9% compared to 3·1% of spinach and 2·1% of mustard green. Ash content of AT leaves was much higher than those of spinach and mustard green. This is obviously because of the high salt content (5·1% on a dry weight basis) of AT leaves.

Mineral contents of AT leaves and spinach are presented in Table 2. Compared to spinach, AT leaves are low in potassium, calcium, zinc and iron. However, AT leaves contained 17 times more Na than spinach (Table 2). *Atriplex* species are known to have salt glands in the leaves that collect salt from surrounding tissues (Rains, 1979). The preparation of many frozen vegetables usually includes the addition of 1·0% to 1·5% by weight of NaCl. The high sodium content of AT leaves would eliminate the need for adding

TABLE 1
Proximate Composition of *Atriplex triangularis* Leaves, Spinach, and Mustard

Vegetable	*% Fresh weight*[a]					
	Moisture	*Protein* ($N \times 6{\cdot}25$)	*Fat*	*Fiber*	*Ash*	*NFE*[b]
AT leaves	88·1 ± 1·5	2·9 ± 0·4	0·1 ± 0·02	1·0 ± 0·1	2·0 ± 0·3	5·9 ± 0·7
Spinach	90·6 ± 0·8	3·1 ± 0·3	0·2 ± 0·02	0·8 ± 0·1	1·6 ± 0·1	3·7 ± 0·3
Mustard	92·5 ± 0·8	2·1 ± 0·2	0·2 ± 0·03	0·7 ± 0·1	1·1 ± 0·1	3·3 ± 0·4

[a] Samples analyzed in triplicate.
[b] Nitrogen-free extract obtained by difference.

TABLE 2
Mineral Contents of *Atriplex triangularis* Leaves and Spinach[a]

Vegetable	*Concentration (% Dry weight)*					*Concentration (ppm)*			
	P	*K*	*Mg*	*Ca*	*Na*	*Zn*	*Mn*	*Fe*	*Cu*
AT leaves	0·3	1·4	0·9	0·4	5·1	40	85	109	15
Spinach	0·4	4·3	0·7	1·3	0·3	58	70	320	16

[a] Samples analyzed in duplicate.

TABLE 3
Total Ascorbic Acid and Vitamin A Content of *Atriplex triangularis* Leaves, Spinach and Mustard

Vegetable	*Total ascorbic acid (mg/100 g)*[a]	*Vitamin A (IU/100 g)*[a]
AT leaves	40·2 ± 4·4	2 690 ± 56
Spinach	28·0 ± 1·8	8 100 ± 488
Mustard	49·0 ± 4·1	5 800 ± 115

[a] Values represent means of triplicate samples ± SD.

salt for preparation of a frozen product. Keeping in mind that the recommended dietary allowance of sodium is only 1100–3300 mg/day (NRC, 1980) for adults, patients on a salt-restricted diet should avoid AT leaves.

Ascorbic acid level of AT leaves is comparable to that of mustard green and much higher than that of spinach (Table 3). Vitamin A content of AT leaves, however, is relatively low. A 100-g serving (1/2 cup) of AT leaves will provide about 67% of the RDA value for vitamin C and 27% for vitamin A.

Sensory evaluation

AT leaves rated similar to spinach in all the four quality attributes (Table 4). Mustard green was rated lower than both AT leaves and spinach for all sensory responses except texture. This implies that AT leaves were accepted or favored more than the mustard green which is already an established frozen leafy vegetable. Thus, AT leaves would be a viable candidate for introduction as a new leafy vegetable particularly in parts of the world where

TABLE 4
Mean Sensory Scores of *Atriplex triangularis* Leaves, Spinach and Mustard

Vegetable	*Sensory scores**			
	Color	*Flavor*	*Texture*	*Overall acceptability*
Spinach	6·9 ± 1·5*a*	7·0 ± 1·3*a*	5·2 ± 2·3*a*	6·6 ± 1·3*a*
AT leaves	4·5 ± 2·9*a*	5·1 ± 2·0*ab*	5·6 ± 1·8*a*	5·4 ± 1·8*a*
Mustard	2·9 ± 1·5*b*	3·7 ± 2·4*b*	3·8 ± 2·0*a*	3·5 ± 2·5*b*

* Means within columns followed by different letters are significantly different according to Duncan's multiple range test ($P < 0·01$).

high salinity and desertification are serious problems. AT can be grown as a food crop on lands which are not currently used for conventional agriculture. Even though *A. triangularis* leaves contain only moderate quantities of protein, ascorbic acid, and vitamin A, they have the potential of making a significant impact on the dietary intake of the population living on deserts and saline land.

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