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Nutrients and Antinutrients in Peanut Greens

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The use of young peanut leaves as a green vegetable will increase utilization of the plant and reduce production wastes that will have to be recycled in an enclosed environment such as the controlled ecological life support system (CELSS) of a space station. In CELSS, plant wastes have to be transformed into an edible or reusable form or into a compact and possibly lighter form for eventual return to earth. Young leaves from an improved Spanish variety and Georgia Red grown in greenhouse beds and from Georgia Red grown using a nutrient film technique were analyzed to determine the nutritional quality of the peanut greens, including protein, fat, ash, total dietary fiber, mineral (Ca, Fe, K, Mg, Na, and Zn), vitamin (ascorbic acid, carotene, and thiamine), oxalic and tannic acid, and trypsin and chymotrypsin inhibitor content. Although differences in the nutrient and antinutrient concentrations due to variety and production method were observed, the levels were similar to those of other leafy vegetables. Oxalic and tannic acid concentrations were reduced by blanching. Compared to those of collard greens, the sensory evaluation ratings of peanut greens for appearance, tenderness, and acceptability were lower, but they were similar for flavor.

INTRODUCTION

For long-term space missions, production of some crops in the controlled ecological life support system (CELSS) is planned by the National Aeronautics and Space Administration (Hoff *et al.*, 1982). CELSS is an engineered biological life support system where the ecology is strictly controlled to operate within a limited, enclosed environment and within certain environmental parameters (Wieland, 1994). Peanut (*Arachis hypogaea* L.) is a candidate leguminous plant for CELSS, and is being produced by Tuskegee University using a nutrient film technique (NFT) (Bonsi *et al.*, 1992; Morris *et al.*, 1989). The peanut seed is consumed by humans, and the foliage is generally plowed back into the field or used as animal feed. In Senegal, the leaves are sometimes used as a potherb mixed with couscous (Dalziel, 1948) and occasionally as a leafy vegetable (M. Egnin, personal communication). In a CELSS, potential use of all plant parts must be considered to maximize utilization and reduce production wastes. Also, wastes have to be transformed into an edible or reusable form, or into a compact and possibly lighter form for eventual return to earth. We are promoting the use of the young peanut leaves as a leafy vegetable or greens for humans especially for this environment.

This study was conducted to determine the nutrients and antinutrients in the peanut greens from plants grown by NFT or in greenhouse beds. Concentrations of protein,

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ash, fat, total dietary fiber, minerals (Ca, Fe, K, Mg, Na, and Zn), vitamins (carotene, ascorbic acid, and thiamine), oxalic and tannic acids, and chymotrypsin and trypsin inhibitors in the young leaves were obtained to determine the nutritional quality. The effects of variety and production method on the greens composition and of blanching methods on the reduction of oxalic and tannic acid concentrations were investigated. Consumer acceptance of the vegetable was determined by sensory evaluation.

MATERIALS AND METHODS

Sample Production, Collection, and Preparation

In 1994, improved Spanish and Georgia Red peanut cultivars were grown in greenhouse sand beds in the George Washington Carver Agricultural Experiment Station, Tuskegee University (Tuskegee, AL). The plants were watered thrice a week and foliar fertilized with a mixture of Peters professional soluble plant food (20-20-20 NPK, 3 g/liter H_2O) (Grace Sierra Horticultural Products Co., Milpitas, CA) and NH_4NO_3 (2 g/liter H_2O) once a week. Stems with the unopened and four youngest open leaves were harvested when flowers were starting to bloom. Approximately 500 g was collected randomly to form a composite sample.

Greens were also harvested from Georgia Red cultivar grown in a NFT system for sweetpotato modified by placing a 4-in. layer of Jiffy Mix (Jiffy Products of America, Inc., Batavia, IL) on the surface of the flat plate assembly during formation of the first floral buds and by using modified Hoagland solution (Morris *et al.*, 1989; Mortley *et al.*, 1991). The stems were collected during harvest of the plants at 90 days after transplanting the 30-day-old seedlings into the channels to avoid reduction of peanut seed production.

The leaflets were separated from the stems and petioles, and used as greens. These were washed and dried with paper towels before cutting into ca. 0.5-cm width. Samples were used fresh or after drying in the oven at 55°C overnight and grinding, depending on the requirement of the assay.

Blanching of Greens

A hot plate (conventional) or a microwave oven was used as the heat source for blanching the cut greens in boiling water (3 g/20 ml) (Proctor and Golblith, 1948; Lund, 1988). In the conventional method, water was initially boiled, poured into a beaker containing the leaves, boiled again for 2.5, 5.0, or 10.0 min, and drained immediately by filtration through Whatman filter paper. In the microwave method, water was boiled for 60 s, poured into a beaker containing the leaves, and boiled again for 30, 45, or 60 s. The blanched leaves were also recovered by filtration (Almazan, 1995).

Analyses

Dry matter content was determined by drying overnight at 100 ± 2°C. Total nitrogen was determined by digestion of the ground sample in a Tecator digestion system, followed by distillation and titration in a Kjeltec Auto 1030 analyzer (Tecator AB, Hogans, Sweden). Crude protein was calculated by multiplying Kjeldahl nitrogen by 6.25. Ash was gravimetrically obtained by combustion of the dried material at 600°C (AOAC, 1990; AOAC 942.05). Concentrations of Ca, Fe, K, Mg, Na, and Zn in the ash were determined by flame atomic absorption spectrophotometry (AOAC, 1990; AOAC 975.03). Fat was extracted with hexane using the Soxhlet method (AOAC, 1990; AOAC 963.15). Hexane was substituted for petroleum ether because it is less flammable. Also, hexane is the main component of petroleum ether and has been used to extract fat from cereals (Zecchinelli and Fossati, 1983; Zayas and Lin, 1989; Kapoor and Kapoor, 1990) and oil seeds (Shah *et al.*, 1983; Vijjan and Bedi, 1984; Garcia *et al.*, 1987). Total dietary fiber was obtained using an enzymatic gravimetric method (AOAC, 1990; AOAC 985.29). Carotene was extracted from the fresh materials and determined spectrophotometrically after separation from other pigments by column chromatography (AOAC, 1990; AOAC 941.15). The rapid fluorometric method was used to assay thiamine (AOAC, 1990; AOAC 953.17). Ascorbic acid in the extract was titrated with 2,6-dichloroindophenol (AOAC, 1990; AOAC 967.21). Tannins were extracted by homogenizing the leaves with water (2.5 g/50 ml), placing the homogenate in boiling water bath for 15 min, and filtering. Aliquots (0.10–0.20 ml) were assayed by a spectrophotometric method modified by reducing reagent volumes to 1/10th the original values (AOAC, 1990; AOAC 952.03).

Oxalic acid was extracted by homogenizing the sample with 0.6 *N* HCl (2.5 g fresh sample/100 ml), placing the homogenate in boiling water bath for 15 min, and filtering. The extracts were refiltered through 0.45-μm plastic disk filters before injection into a Bio-Rad high pressure liquid chromatograph with a UV monitor set at 210 nm (Bio-Rad Laboratories, Inc., Hercules, CA). The acid was eluted through a Bio-Rad Aminex HPX-87H column (300 $\times$ 7.8 mm) maintained at 30°C and attached to a microguard column (Bio-Rad cation H cartridge) with 0.015 *M* H_2SO_4 at a flow rate of 0.6 ml/min (Almazan, 1995).

Chymotrypsin and trypsin inhibitors were extracted (2.0 g/15 ml buffer) and assayed by inhibition of the enzyme action on the synthetic substrates *p*-tosyl-L-arginine methyl ester and *N*-benzoyl-L-tyrosine ethyl ester, respectively (Bradbury *et al.*, 1984, 1985). The Tris buffer pH for the trypsin inhibitor assay was changed from 8.1 to 7.6 to increase $\Delta A/\Delta t$.

There were two composite samples with different numbers of replicates depending on the component being analyzed. Means and standard errors of means for each of the components were obtained. The means were compared by analysis of variance (ANOVA) and tested by Fisher's protected least significant difference (PLSD) procedure using Statview 4.01 (Abacus Concepts, Inc., Berkeley, CA).

Sensory Evaluation

An untrained panel of 31 students, staff, and faculty at the School of Agriculture and Home Economics evaluated the sensory qualities of improved Spanish variety peanut greens. Collard greens were used for comparison because this is a common vegetable in the area. The former were collected from greenhouse sand beds while the latter were bought from a food store at Tuskegee. Whole peanut green leaflets were either steamed or boiled. Steamed peanut greens were prepared by simmering ca. 300 g leaflets with ca. 250 ml water and two chicken bouillon cubes (ca. 1.5-cm cubes) for flavor in a covered cooking pan to almost dryness. During the 30 min cooking time, the leaves were stirred occasionally and water was added to avoid drying. Boiled peanut greens was prepared by boiling approximately 300 g leaflets in ca. 750 ml water and three chicken bouillon cubes for 25 min.

TABLE 1

PROXIMATE COMPOSITION AND ANTINUTRIENTS PER 100 G DRY PEANUT GREENS

	Spanish variety	Georgia Red	
Component	GH Bed*	GH Bed	NFT**
Dry matter, g (fresh wt.)	19.7±0.10[a]	17.8±0.13[b]	18.1±0.23[b]
Ash, g	7.0±0.20[c]	10.0±0.22[b]	12.3±0.44[a]
Protein, g	27.8±0.60[a]	29.1±0.58[a]	22.9±1.42[b]
Fat, g	3.9±0.14[a]	2.0±0.15[b]	1.4±0.10[c]
Total dietary fiber, g	30.9±2.04[b]	36.0±4.34[ab]	41.7±2.31[a]
Oxalic acid, mg	900±38[a]	560±11[c]	660±9[b]
Tannic acid, mg	2250±62[a]	1420±20[b]	2130±46[a]

Note. Means ± SE. Number of composite samples is 2 with three replicates each for DM, ash, and protein; two replicates each for fat; four replicates each for TDF; six replicates each for oxalic and tannic acids. Means for each row with different letters are different at $P < 0.05$.

* Plants grown in greenhouse beds.

** Plants grown in nutrient film technique system.

The collard leaf lamina was cut lengthwise into two or four pieces depending on the size, then crosswise into ca. 1-cm widths. The cut greens were steamed or boiled in the same manner as the peanut greens except that cooking time was increased 5 min more. Before serving, the four cooked greens were placed separately without the soup in a sectioned styrofoam plate, covered with stretchable clear plastic wrap or film, and microwaved at high setting for 20 s. The appearance, flavor, tenderness, and acceptability of the cooked greens were rated on a hedonic scale of 9 with 9 = like extremely and 1 = dislike extremely. The means of 31 ratings for each attribute of each cooked vegetable were compared using ANOVA and tested using Fisher's PLSD.

RESULTS AND DISCUSSION

Nutrients

There were variations in the nutrient content of peanut greens due to varietal differences and production method (Tables 1 and 2). In the discussion, improved Spanish variety greens from plants grown in greenhouse beds will be referred to as Spanish greens. Similarly, Georgia Red greens from greenhouse bed plants and from plants grown by NFT will be called bed GAR greens and NFT GAR greens, respectively.

Dry matter in the peanut greens ranged from 17.8 to 19.7%. NFT GAR greens had the highest ash content probably due to high mineral absorption by the plants

TABLE 2

MINERALS AND VITAMINS PER 100 G DRY PEANUT GREENS

	Spanish variety	Georgia Red	
Component	GH Bed*	GH Bed	NFT**
Minerals (mg)			
Ca	1040±32[b]	1170±60[b]	1500±59[a]
Fe	17±0.4[a]	14±1.1[b]	17±0.8[a]
K	930±114[b]	2360±148[a]	2100±28[a]
Mg	340±17[c]	490±44[b]	1200±40[a]
Na	90±8[b]	140±11[ab]	210±50[a]
Zn	8±0.2[a]	6±0.2[b]	2±0.1[c]
Vitamins			
Ascorbic acid,mg	340±28[a]	220±20[b]	320±12[a]
Carotene, mg	100±5[b]	100±13[b]	140±9[a]
Thiamine, μg	60±11[a]	40±6[a]	50±8[a]

Note. Means ± SE for two composite samples with three replicates each. Means for each row with different letters are different at $P < 0.05$.

* Plants grown in greenhouse beds.

** Plants grown in nutrient film technique system.

from the nutrient solution. Similar to most fresh leafy vegetables (Duke and Atchley, 1986), Spanish and bed GAR greens had ash contents of less than 2% on fresh weight basis. Crude protein concentration was higher when plants were grown in greenhouse beds. Compared to the values for sweetpotato tips, collard, mustard, red beet, and turnip greens (2.7–3.6%, fresh weight basis) (Duke and Atchley, 1966; Luh and Moomaw, 1979; Pennington and Church, 1985), protein content in peanut greens (4.1–5.5% fresh weight basis) was higher. Although percentage of crude fat of Spanish greens was slightly higher than those of GAR greens, the values for all samples (0.3–0.8% fresh weight basis) were still less than 1% on fresh weight basis, the range obtained for other leafy vegetables. Total dietary fiber levels were not different in the three samples and were similar to those of sweetpotato greens but higher than the values for collard, mustard, and sugar beet greens (Almazan and Zhou, 1995).

The high ash content of NFT GAR greens was reflected in its mineral composition (Table 2). In Spanish greens, Ca concentration was higher than those of K and Mg. In GAR greens, K level was highest, followed by those of Ca and Mg. Leafy vegetable mineral contents generally have K as the element in highest concentration (Pennington

TABLE 3

REDUCTION OF OXALIC AND TANNIC ACIDS IN SPANISH VARIETY PEANUT GREENS BY BLANCHING (MG/100 G AS IS BASIS)

Treatment	Oxalic acid	Tannic acid
Fresh	180 ± 8^{a}	440 ± 12^{a}
Blanched, conventional		
2.5 min	110 ± 4^{d}	280 ± 3^{d}
5.0 min	130 ± 4^{c}	290 ± 8^{d}
10.0 min	150 ± 11^{bc}	260 ± 8^{d}
Blanched, microwave		
30 s	130 ± 5^{bc}	360 ± 4^{c}
45 s	110 ± 7^{de}	390 ± 16^{b}
60 s	120 ± 3^{cde}	400 ± 17^{b}

Note. Means ± SE for two composite samples with three replicates each. Means in the same column with different letters are different at $P < 0.05$.

and Church, 1985; Duke and Atchley, 1986). Among the minerals analyzed, Zn content was lowest.

NFT GAR greens had higher ascorbic acid and carotene contents than bed GAR greens (Table 2). Thiamine concentrations were similar in all samples. Compared with the values for vitamins in other leafy vegetables, peanut greens had higher carotene, similar ascorbic acid, and lower thiamine levels (Luh and Moomaw, 1979; Pennington and Church, 1985; Duke and Atchley, 1986).

Antinutritional Factors and Reduction by Blanching

Spanish greens had the highest oxalic and tannic acid concentrations while bed GAR greens had the lowest levels (Table 1). These values were lower than those for sweetpotato greens and spinach (Villareal *et al.*, 1979; Souci *et al.*, 1989; Almazan, 1995). Similar to the sweetpotato greens, both chymotrypsin and trypsin inhibitors were not detected in the peanut greens.

The reduction of oxalic and tannic acids in Spanish greens by blanching is shown in Table 3. Contrary to expectations, the residual oxalic acid amounts after conventional blanching (63–85%) increased with time probably due to better extraction as the leaves became more tender. This was not observed when the greens were microwave blanched. Also, increasing microwave blanching time did not increase the oxalic acid concentration that leached into the water. Both methods had the same efficiency in reducing oxalic acid concentrations. Conventional blanching was more effective in the reduction of tannic acid in the greens (34–40%) but reduction was not affected

TABLE 4

SENSORY EVALUATION OF STEAMED OR BOILED PEANUT AND COLLARD GREENS

Sample	Appearance	Flavor	Tenderness	Acceptability
Peanut greens				
Boiled	5.6 ± 0.36^{b}	5.5 ± 0.41^{c}	3.8 ± 0.38^{b}	4.6 ± 0.41^{b}
Steamed	6.2 ± 0.34^{b}	6.3 ± 0.35^{abc}	4.1 ± 0.40^{b}	5.2 ± 0.40^{b}
Collard greens				
Boiled	7.5 ± 0.22^{a}	6.7 ± 0.37^{a}	7.2 ± 0.28^{a}	6.9 ± 0.27^{a}
Steamed	7.7 ± 0.27^{a}	6.7 ± 0.38^{ab}	7.4 ± 0.30^{a}	7.1 ± 0.35^{a}

Note. Means ± SE of 31 ratings on a 9-point hedonic scale where 9 = like extremely and 1 = dislike extremely. Values in the same column with different letters are different at $P < 0.05$.

by blanching period. Apparently, only 9–19% of the acid was removed by microwave blanching, the increased amount observed with time probably also due to increasing leaf tenderness.

Sensory Evaluation

Boiled or steamed peanut greens had lower ratings for appearance, tenderness, and acceptability than boiled or steamed collard greens (Table 4). The largest difference was observed in the tenderness rating and may mainly account for the low acceptance of the vegetable. The low tenderness rating may be partly due to the higher total dietary fiber and dry matter contents in the fresh peanut greens than in the fresh collard greens (4.27 and 13.62%) (Almazan, 1995). The flavor of steamed peanut greens had the same rating as those of collard greens. Some panel members suggested cutting the leaflets to small pieces to improve appearance and tenderness, and to cook the greens longer.

Variations in the concentrations of the different nutrients and antinutrients in the peanut greens were observed due to variety and method of production. The values, however, were generally in the same ranges as for other leafy vegetables, suggesting that peanut greens have similar nutritional quality. Oxalic and tannic acids in the greens can be reduced by blanching. Improved preparation of cooked peanut greens and acquisition of a taste for its unique qualities can improve the consumer acceptance of the vegetable.

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