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NUTRIENT EVALUATION OF SEVERAL LEAFY GREEN VEGETABLES

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ABSTRACT

Nine different leafy green vegetables were analysed for their nutrient and mineral content. The vegetables included green bok choi, red bok choi, large green bok choi, green loose leaf lettuce (var. 'Butterscotch'), red loose leaf lettuce (var. 'Red Ruby'), green mustard greens, green curly leaf kale, large leaf kale and beet leaf greens (var. 'Dakota'). The bok choi, beet leaves and lettuce varieties had the highest moisture contents, in excess of 90%. The mustard greens had the highest protein content (2.2%). The lettuce and mustard greens were also determined to be rich sources of potassium. This study clearly demonstrated that the nine leafy green vegetables are a readily available source of nutrients.


Mustard Greens


Beet leaf greens

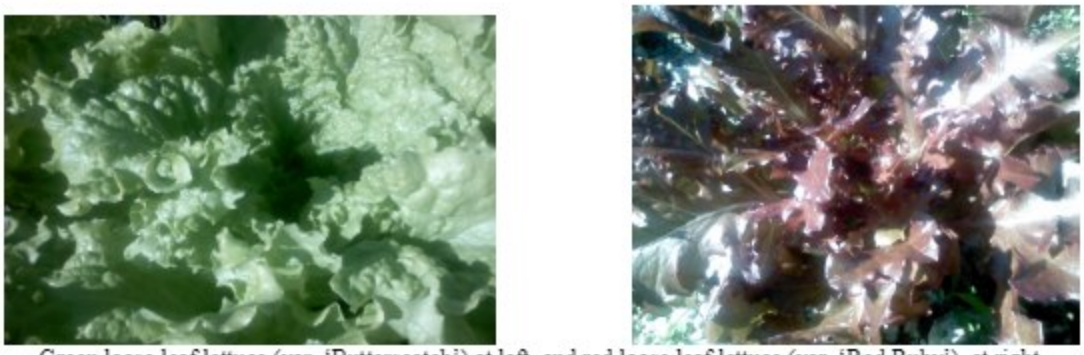

Kale


Leafy green vegetables in the field at the Gladstone Road Agricultural Centre.

Introduction:

Leafy green vegetables are very important components of the human diet and play a vital role in the improvement of health and the prevention of diseases. As such, they contain valuable food ingredients which can be utilised to build up and repair the body (Caunii, *et al*., 2010). They provide fibre, minerals and vitamins (Acikgoz, 2011; Emebu and Anyika, 2011; Gupta and Prakash, 2011; Sikora and Bodziarczyk, 2012), are low in calories and are a very good source of antioxidants (Velioglu, *et al*., 1998; Bunning and Kendall, 2007; Acikgoz, 2011; Gupta and Prakash, 2011). Leafy green vegetables are an inexpensive source of iron and can be utilised to combat iron deficiency anemia in growing children (Gupta and Prakash, 2011). They are also low in fats and sodium (Ayaz, *et al*., 2006; Emebu and Anyika, 2011).

Red bok choi at left and green bok choi at right.



Green loose leaf lettuce (var. 'Butterscotch') at left, and red loose leaf lettuce (var. 'Red Ruby'), at right.

Bok choi *(Brassica rapa* L. *var. chinensis)*, or chinese cabbage, is usually consumed as a cooked vegetable, but is also eaten raw. It is high in vitamin C and contains phytochemicals called indoles that may prevent cancer (Kahlon, *et al*., 2012). In The Bahamas, bok choi grows best during the cool season of October to March and responds well to nitrogen fertilisers (Vavrina, *et al*., 1993). Loose leaf lettuce (*Lactuca sativa*) is also a cool season vegetable crop that is used in fresh salads and sandwiches. It is a good source of minerals, including calcium, magnesium, phosphorus, iron and selenium, and an excellent source of vitamins (Caunii, *et al*., 2010). It also contains the antioxidant compound beta-carotene and anthocyanin, which accounts for the red colouration in some lettuce varieties. Mustard greens [*Brassica juncea* (L.) Czern.], also known as Chinese mustard, are rich in vitamins and minerals, such as calcium, iron and phosphorus. They grow well on a wide range of soils and can be harvested at a very early stage. Kale (*Brassica oleracea* var. *acephala*) is a member of the cabbage family. It is a cool season vegetable green, but is heat tolerant and can be grown during the summer months. Beet leaf greens (*Beta vulgaris*) have a very short growing season and are not demanding of soils. Beet leaves have a high protein

content, are good digestive aids and contain mineral compounds that help complete deficiencies of both micro and macro elements (Dzida, *et al*., 2011).

There is an increasing demand by the Bahamian consumer for fresh vegetable produce. With the rising cost of imported food items, consumers look for ways to reduce their household's food bill. With the initiation of the Department of Agriculture's 'Backyard Gardening' programme, the cultivation of these leafy vegetables is a means by which families can reduce their food bill and supplement their incomes. With proper cultivation practices, several harvests can be obtained from a single planting of leafy green vegetables.

Objectives:

The objective of this study was to evaluate the nutrient composition and mineral content of several leafy green vegetables.

Materials and Methods:

Nine leafy green vegetable crops were evaluated for their leaf yield and quality at the Gladstone Road Agricultural Centre during January of 2013. The leafy greens included green bok choi, red bok choi, large green bok choi, green loose leaf lettuce (var. 'Butterscotch'), loose leaf lettuce (var. 'Red Ruby'), green mustard greens, green curly leaf kale, large leaf kale and beet leaves (var. 'Dakota').

The seeds were set out in a seed bed during October and November of 2012. After about six weeks, when the plants achieved at least four mature leaves and a well developed root system, they were transplanted in double rows to raised beds of 100 ft length. Plant spacing was 8 in (20 cm) between plants within the rows. The rows were 5 ft (1.5 m) apart. The rows were irrigated using a drip irrigation system which supplied water throughout the short growing season. The leaves were sprayed weekly, using a combination of Xentari® and Bravo® with Nutrileaf® liquid fertiliser in a 20-20-20 formulation, as a preventative measure against insect pests and diseases. Weeds were controlled by hand weeding.

A non-destructive harvesting of single leaves of the leafy vegetable greens commenced about 50 days after planting, when the leaves were of a marketable size. Leaves were harvested over a two-week period, as they grew to size. A total of 32 leaves were weighed, for each type of leafy greens.

Two views of leafy green vegetables in the field at the Gladstone Road Agricultural Centre, January 2013.

This study examined the nutrient and mineral composition of the leafy greens. Randomly selected leaf samples were cleaned to remove dirt and submitted to the Food Safety and Technology Laboratories of the Department of Marine Resources for analyses. The leaves were processed, then analysed for nutrient and mineral composition and the values expressed on a dry matter basis. Quality characteristics measured included, moisture, dry matter, protein, crude fat, ash, sodium and potassium.

Methods Used in Analysis of leafy greens (Based on A.O.A.C., 1995):

Moisture/Dry Matter – leaves were wiped and chopped into small pieces. Triplicate 2g samples were accurately weighed into pre-labelled, pre-weighed dishes and were dried at 130°C to constant weight. Dried samples/dishes were weighed. Moisture content (%) was calculated. Dry matter (%) was calculated by 100 – Moisture content (%).

Other Analyses - Samples were wiped, chopped and dried in oven. The dried samples were subsequently powdered in a high-speed blender and used for the remainder of the tests.

Protein - Duplicate 1g dried and powdered samples were weighed and digested with H_2SO_4 and K_2SO_4/Se catalyst tablets, using the block digestion method in a Foss Tecator Auto Digestor. The resulting digest was steam distilled into boric acid using a Labconco Rapid Still II. Titration of the distillate with standard HCl was used to estimate crude protein. The method was based on the A.O.A.C. Official Method 2001.11.

Salt - Determination using the Volhard method where sample was treated with $AgNO_3$, wet ashed and the excess $AgNO_3$ back titrated with KSCN using $FeNH_4(SO_4)_2$ as indicator.

Sodium and Potassium - Aqueous solutions of ashed samples were aspirated directly into a Cole-Parmer Model 2655-00 flame analyzer. Intensity was compared against a prepared standard curve.

The mean daily maximum and minimum temperatures for the trial period were 27.8°C (82.1°F) and 20.9°C (69.7°F), respectively. The total rainfall for the period was 246.1 mm (9.69 in). Mean monthly sunshine duration for the period was 7.7 h. Weather information (Table 1) was obtained from the Meteorological Department of The Bahamas.

Table 1. Weather data on rainfall, hours of sunshine and mean maximum and minimum temperatures for New Providence for the period of October 2012 to January 2013, courtesy of the Meteorological Department of The Bahamas.

Month	Total rainfall (mm/inches)	Mean monthly radiation (h)	Mean maximum temperature (°C/°F)	Mean minimum temperature (°C/°F)
October 2012	**155.4**/6.12	**7.4**	**30.2**/86.3	**23.8**/74.9
November 2012	**24.9**/0.98	**8.1**	**26.9**/80.5	**19.8**/67.7
December 2012	**58.9**/2.32	**7.6**	**26.9**/80.5	**19.8**/67.7
January 2013	**6.86**/0.27	**7.6**	**27.2**/81.0	**20.2**/68.4

Note: Monthly mean values have been rounded up to the nearest tenth.

Results:

The analysis of variance (ANOVA) of the total leaf weights per plant among nine leafy green vegetables are summarised in Table 2. The table showed a statistical significance for leaf weights at a 5.0% level of confidence, among the nine leafy greens.

Table 2. Analysis of variance (ANOVA) for individual leaf weights (g) of nine different leafy green vegetables. Standard error is for each treatment mean. Error mean square has 287 df. *, ** and *** denote statistical significance at 5, 1 and 0.1% level of confidence, respectively. NS indicates differences between means not significant.

		----------Significance levels----------
Source	df	**Single leaf weights (g)**
Leafy green	8	*
Error	279	
Std. Err		11.5

Table 3 presents a summary of measurements for the proximate analyses of the leaves of the nine leafy green vegetables evaluated. Because of a lack of sufficient material to conduct all of the analyses, some determinations for the nutrient and mineral compositions were incomplete. These results showed high moisture contents for all the leafy greens, which ranged from 86.9% in the mustard greens to 94.6% in the 'Butterscotch' lettuce variety. The mean values for sodium (Na^+) and potassium (K^+) were high/low.

Table 3. Proximate analyses of the fresh leafy green vegetables.

LEAFY GREENS	MOISTURE %	DRY MATTER %	PROTEIN %	FAT (CRUDE) %	SODIUM (MG/100G)	POTASSIUM (MG/100G)
Green bok choi	93.3	6.7	1.2	I/S	I/S	I/S
Red bok choi	93.8	6.2	1.4	I/S	I/S	I/S
Large green bok choi	91.8	8.2	0.9	0.1	I/S	I/S
Green loose leaf lettuce 'Butterscotch'	94.6	5.4	0.6	0.1	25.7	334.5
Red loose leaf lettuce 'Red Ruby'	93.2	6.8	0.7	0.1	37.3	368.4
Green mustard greens	86.9	13.1	2.2	0.2	17.3	406.1
Green curly leaf kale	89.2	10.8	1.9	0.3	I/S	I/S
Large leaf kale	88.7	11.3	1.9	0.3	I/S	I/S
Beet leaves 'Dakota'	90.2	9.8	1.7	0.2	I/S	I/S

I/S: Insufficient Sample

Discussion:

The moisture contents of the nine leafy greens examined were generally very high, in particular the bok choi and lettuce varieties. Foods with high moisture contents are highly perishable, as they are susceptible to microorganisms that thrive under such moist conditions (Emebu and Anyika, 2011).

The leafy green vegetables exhibited appreciable amounts of crude protein with low fat contents. In select samples the potassium content was in abundance. The results indicate that these leafy greens can contribute to meeting the requirements for normal growth and adequate protection against diseases, if consumed in sufficient quantities.

This report gives only a partial assessment of the nutritional composition of the leafy green vegetables evaluated. Additional studies on the fibre and protein contents, and a complete analysis of the fatty acid and mineral compositions will assist in the selection of leafy green vegetable varieties with improved nutritional values.

This study demonstrates that the leafy green vegetables can become viable horticultural crops for local production. These varieties can be recommended to farmers for inclusion in their winter vegetable cropping systems. More studies need to be done however, to determine whether the cultivation of these, or similar leafy greens, could be extended into the warmer months of the year.

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