MATCHING SHADES OF FOREST ENVIRONMENT TO SUSTAIN CRUDE FIBRE AND MINERAL CONTENTS IN DOMESTICATED SPECIES OF WILD VEGETABLES

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ABSTRACT

This study aimed at determining the most suitable types of shades under which domesticated wild Vegetables can be grown to sustain their mineral content values. Seeds from *Solana scabrum, Launaea cornuta, Bidens pilosa and Basella alba* – the most preferred wild Vegetables in the study area were collected, managed and then sown in nurseries and planted under different types of shades. Five different types of shades were employed as experimental treatments using the Randomized Complete Block Design (RCBD). The natural forest condition served as a control. Samples of the edible parts from the domesticated and wild Vegetables were harvested for laboratory analysis for calcium, zinc, iron and crude fibre using the Atomic Absorption Spectrophotometer method. It was found that different types of shades have different effects on the contents of calcium, zinc, iron and crude fibre of domesticated wild Vegetables.

Key words: *Atomic Absorption Spectrophotometer, domestication, minerals wild Vegetables*

INTRODUCTION

Wild Vegetables are an important source of carbohydrates, proteins, crude fibre, vitamins (such as vitamins A and C), minerals (such as zinc, iron, and calcium) and iodine (Ohiokpehai 2003). Protein is emphasized in diets of young children as its deficiency may cause protein-energy-malnutrion (PEM), which is very common in weaned children. The PEM can eventually cause brain underdevelopment in children. Active forms of vitamin A participate in 3 essential functions, namely, visual perception, cellular differentiation and immune response. Vitamin C in human nutrition plays the role of a biological reducing agent and may be linked to its prevention of degenerative diseases, such as cataracts, certain cancers and cardiovascular diseases (Bowman and Russel, 2001). Iron is essential for the formation of red blood cells (haemoglobin) that carries oxygen from the lungs to all cells of the body (Ohiokpehai 2003). Zinc is an essential element in human nutrition, and its importance to human health has received much recent attention. Zinc plays an important role in the proper functioning of the immune system, cell division, cell growth, and wound healing. It is also involved in the senses of taste and smell, as well as in the metabolism of carbohydrates (Bowman and Russel 2001). Calcium is an important mineral necessary for life whereby long-term calcium deficiency can lead to rickets and poor blood clotting. Crude fibre may be defined as the remnants of the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Crude fibre has physiological importance such as lowering plasma cholesterol levels, modifying the glycaemic response and improving bowel function (Rumm, *et al.* 1997).

Micronutrient deficiency is a universal problem, which presently affects over two billion people worldwide, resulting in poor health, low worker productivity, and high rates of mortality and morbidity (Flyman and Afolayan 2006). Deficiency in micronutrients has led to increased rates of chronic diseases and permanent impairment of cognitive abilities in infants born to micronutrient deficient mothers. Wild Vegetables have been the mainstay of human diets for centuries, providing millions of consumers with important micronutrients, such as vitamins and minerals needed to maintain health and promote immunity against infections (Humphry *et al*. 1993). Their promotion and integration into human diets could assist in their protracted use and consequent conservation (Flyman and Afolayan, 2006). Unfortunately, due to ever increasing deforestation rates and wild fires, some of these wild Vegetables are disappearing. Domestication in house gardens and farm lands of wild Vegetables provides an option for their sustainable availability (Ogoye-Ndegwa and Aagaard-Hansen 2003; Midmore *et al.* 1991). Through domestication practises, wild Vegetables' performance can be studied and managed just like the other crops. However, domestication of wild Vegetables subjects them to different environmental conditions in terms of soil type and composition, humidity and other factors which might change the plant physiology. Studies by Edmonds and James (1997) and Michele *et al.* (2008) indicated that domestication of wild Vegetables have resulted in altering their nutritive values. Similar findings were found by Kimambo *et al*. (unpublished) that domestication of wild Vegetables led to variation in their vitamin and protein contents when compared to their counterparts in their natural habitats. Therefore, this suggests that domestication efforts of wild vegetables should go hand in hand with those of determining the growing conditions in which domesticated wild Vegetables can maintain their nutritive values. Unlike unpublished study by Kimambo (2010) which investigated effects of shade type on protein and vitamins contents of domestication of wild Vegetables, this study looked at variation in mineral contents (zinc, iron, calcium) and crude fibre. It aimed at simulating the natural growing conditions of wild Vegetables by using different types of shades to determine the ones that can maintain their mineral values. The study tested the hypothesis that: "different shade types applied to domesticated wild Vegetables have different effect on the mineral contents of wild Vegetables".

MATERIALS AND METHODS

Study Area Description

The study was conducted in two villages namely; Kweminyasa and Mahange which surround the Balangai Forest Reserve in Lushoto district, Tanga region in Tanzania. In this area, annual temperatures vary with altitude, where at 500 meters above sea level, temperatures range from 25^0C to 27^0C while between altitude 1500 to 1800 above sea level, temperatures range from 16 ^{0}C to 18 ^{0}C. The area has bimodal rainfall pattern which ranges between 600 to 1200mm (Msangi 1990 cited by Shemdoe 2003). The dominating soil type is latosols, however in the lower wetter areas soils are humic ferralic whereas in the drier area soils are humic ferrisol (URT 2002 cited by Shemdoe 2004).

Data collection

Data collection was done at four different levels, i.e. at village, forest, home gardens and laboratory. At the village level, selection of two villages was done among the five which surround the Balangai Forest Reserve that were to be involved in the study. These villages were those believed to be highly involved in the domestication practices. The selection was done with the assistance of the village extension officers. Household interviews to identify types of wild Vegetables which are most preferred and commonly consumed by people in the study community were conducted using a self administered questionnaire. Preference was assessed by respondents/households (represented by one family member) giving scores to each of the listed wild Vegetables. The most preferred wild Vegetables scored 4, followed by 3, 2, 1 and 0. In that order, the least preferred scored 1 and those not preferred at all scored 0.

Also, types of shades under which domestication of wild Vegetables is done were identified. The sample size of households to be interviewed was determined using the following expression by Kothari (2004):

$$n = \frac{Z^2 pq}{e^2}$$

Where,

n = desired sample size;

z = the value of the standard variate at 95 per cent confidence level

p= sample proportion of the target population (users of wild Vegetables), q = 1 – p.

e = the acceptable error.

p= was determined through a pilot survey and

e = was determined iteratively on site.

At the forest level, dry seeds from most preferred Vegetables were harvested, pooled and stored in paper bags. Before sowing, seed beds were prepared by simple ploughing, just as it is done by farmers in the area. No fertilizer was added. Where vines were used, vines of about 15 to 20 cm in length were cut and planted directly without storage.

At home garden level, seeds were planted directly after one week storage at room temperature in a dry room. Seeds and vines were sown within the habitats of communities at Kweminyasa and Mahange villages. A Randomized Complete Block Design (RCBD) experimental design was used in this study. Plots under different shades (blocks), namely, garden under banana plantations, garden under improvised shade, garden in open field, and garden under tree cover received four treatments (Vegetable species) and were replicated three times. The natural forest condition served as a control. The plants were provided with supplementary irrigation using watering cans, which is a common practice in the area. Encroaching plants such as weeds were hand-picked to remain with clear stands of intended plants in each respective plot.

Samples of leaves (for both domesticated and wild Vegetables) for laboratory analysis were harvested when plants were one and half months old before the onset of fruiting. The edible portion, which included leaves and young petioles were cut as practiced by the Balangai communities when they harvest wild Vegetables. Care was taken to only pick plant's parts and not any other material that would affect laboratory results e.g. insects, twigs or other plant materials. The picked parts were briefly air swilled (shaken) to remove dust and soil particles. Collection of leaves from wild Vegetables in natural environment was done at around half a kilometre to two kilometres into the forest to avoid boarder effects on the Vegetables. After harvest samples were packed in air tight bags. Care was taken not to further expose the samples to sunlight after harvesting by undertaking these last steps in the shade and immediately storing them in cool boxes with ice packs to maintain a temperature of + 4 to 8^{o}C. On the way to Sokoine University of Agriculture laboratories, the cool boxes were replenished with fresh ice every 12 hours.

Each species provided a laboratory sample that was analyzed separately and the results compared between natural versus domesticated wild Vegetables. At laboratory level, determination of minerals contents (iron, zinc and calcium) was done using the Atomic Absorption Spectrophotometer (AAS) method (model 919, Cambridge, UK) according to AOAC (2000). A total of 0.5 g of dried and powdered sample was weighed into a digestion tube. Then 5 ml of 68% nitric acid was added and left overnight. The digestion tube was placed in the digestion block and temperature set at 1250ºC and digested for one hour. It was then removed and the tube cooled. A total of 5 ml of 30% hydrogen peroxide (H_2O_2) was added and heated to about 700ºC. After cooling, 5 ml of 30% H_2O_2 was again added and heated once more to 700ºC. The treatment was repeated until the digest was colourless. Temperature was increased to 1800ºC and continued digesting to almost dryness, and was left to cool. A total of 10 ml of 10% nitric acid was added and the dissolved digest transferred quantitatively to a 50 ml volumetric flask. The flask was filled to mark with distilled water and mixed. The solution was then used to determine iron, zinc and calcium contents by the AAS employing the standard technique.

On the other hand, Crude fibre was determined by using dilute acid and alkali hydrolysis as described by AOCA (1995), method 920.86. Two gram sample was weighed and separated into 500 ml beakers. Then, 200 ml of 0.128M H2SO4 were added and the mixture boiled for 30 minutes. The mixture was then filtered under suction through a nylon cloth and the residue washed with hot water until the acid disappeared. Then 150 ml of 0.223M NaOH were added and the mixture boiled again for 30 minutes. The mixture was then filtered under suction through nylon and the residue washed in water until the alkali disappeared. The sample residue was scrapped into a crucible and placed in the oven at 105°C for 12 hrs, cooled in a desiccator and weighed (WI). The dry sample was then ashed at 55°C in a muffle furnace for four hours, cooled and weighed (W2). The percentage crude fibre was calculated from the following relationship.

$$\text{Crude fiber \%} = \frac{W1(g) - W2(g)}{W(g)} * 100$$

Where,
W- Weight of the sample

Data Analysis
Data were analysed using GLM procedures of SAS (2001) with shades (control, improvised, trees, banana shade and open field) and species (independent variables) against minerals concentration (iron, zinc, calcium) and crude fibre. Residues were considered as random effects and that means were separated by the Least Squares Means separation test using the PDIFF option when the respective F-test was significant ($P<0.005$).

RESULTS AND DISCUSSION

A total of 30 households' representatives participated in this study. They indicated that the most preferred wild Vegetables were *Launaea cornuta, Bidens pilosa, Basella alba* and *Solanum scabrum.* And that, when these Vegetables are domesticated they are commonly grown under shades of trees, bananas, improvised (not natural shade) and in the open.

Effect of the type of shade on the calcium content
Table 1 presents the results of calcium contents in leaves of four domesticated wild Vegetables in different experimental treatments (i.e. the natural environment or control and domesticated ones under different types of shades). In their natural environment, *Basella alba* and *Solanum scabrum* have the highest calcium contents. However, when domesticated under different types of shades, their calcium contents differ significantly.

Table 1: Effect of shade type on calcium content (mg/100g) for four domesticated species of wild Vegetables

Vegetable species	Treatments					Significance
	Control (Forest)	Improvised	Tree	Banana	Open Space	
Launaea cornuta	283.8^{c}	342.3^{a}	197.5^{d}	58.6^{e}	324.3^{b}	***
Bidens pilosa	342.7^{b}	158.7^{e}	228.0^{d}	575.7^{a}	313.7^{c}	***
Basella alba	448.2^{a}	111.7^{b}	106.5^{b}	106.6^{b}	70.8^{c}	***
Solanum scabrum	448.2^{a}	351.8^{b}	221.5^{d}	206.2^{e}	281.4^{c}	***
Significance	***	***	***	***	***	

Key:
Within rows: least squares means with common superscript are not significantly different (P>0.05).
Significance: *, $P<0.05$; **, $P<0.01$;***, $P<0.001$

For all tested Vegetables, none of the applied type of shades sustained the calcium content equivalent to that of the control. In *L. Cornuta*, open and improvised shades increased the calcium content while tree and banana shades decreased it. For *B. pilosa,* there is a hefty gain of about 70% in calcium content when it is grown under banana shades. When grown under improvised, tree shade and in the open the calcium contents in this Vegetable tend to decrease.

Domestication of *B.alba* under the common practise (shade types) in the area has all failed in terms of calcium contents whereby all types of experimental shades have significantly decreased the calcium contents in the Vegetable. Similarly, all types of shades studied significantly decreased the calcium contents in domesticated *Solanum scabrum.* In such a situation, the forest environment should be the best place for these Vegetables, if we are to continue to benefit from their natural levels of calcium.

Effect of the type of shade on the zinc content

Table 2 presents the results of zinc contents in leaves of four domesticated wild Vegetables in the different experimental conditions. In their natural environment, *Launaea cornuta* has the highest zinc content. However, *Basella alba* and *Bidens pilosa* have the highest zinc contents when grown in the open. Weinberger and Msuya (2004) reported zinc content in *Solanum scabrum* to be 0.88mg/100g while Kinabo *et al.,* (2004) reported 0.57 mg/100g. These findings are similar though not exact to what has been noted in this study. The variation in contents could be attributed to difference in study locations.

Table 2: Effect of shade type on zinc content (mg/100g) for four domesticated species of wild Vegetables

Wild Vegetable species	Treatments					Significance
	Forest (control)	Improvised	Tree	Banana	Open Space	
Launaea cornuta	1.9^{a}	0.5^{d}	1.9^{a}	1.3^{b}	0.8^{c}	***
Bidens pilosa	1.0^{c}	0.4^{d}	1.9^{b}	0.7^{c}	9.7^{a}	***
Basella alba	0.7^{b}	0.3^{c}	0.5^{b}	0.3^{c}	9.1^{a}	***
Solanum scabrum	0.7^{d}	4.1^{b}	1.1^{d}	9.1^{a}	1.9^{c}	***
Significance	***	***	***	***	***	

Key:
Within rows: least squares means with common superscript are not significantly different (P>0.05).
Significance: *, $P<0.05$; **, $P<0.01$;***, $P<0.001$

All the four wild Vegetable species found a matching condition when domesticated in terms of zinc contents. When grown under tree shades, *Launaea cornuta, Basella alba* and *Solanum scabrum* maintain their natural levels of zinc contents. On the other hand, *Bidens pilosa* has to be grown under banana tree shade to maintain similar level of zinc as found in the natural condition (forest).

Effect of type of shade on iron content

Table 3 presents results of iron contents in leaves of wild Vegetables in different experimental treatments. When grown under banana tree shades, iron contents in *Bidens pilosa* shoot up from 32.7 mg/100g (in natural environment) to 52.4 mg/100g. Similar shooting up of iron contents when grown under banana tree shades are also noted for *L. cornuta* and *B. alba*. In order for *Launaea cornuta, Solanum scabrum* and *Basella alba* to maintain their iron contents, as in the natural environment, they can be grown, respectively, under shades of improvised, banana tree and in the open.

Table 3: Effect of type of shade on iron content (mg/100g) for four domesticated species of wild Vegetables

Vegetable species	Treatments					Significance
	Forest (control)	Improvised	Tree	Banana	Open Space	
Launaea cornuta	3.6^{b}	4.2^{b}	1.3^{c}	13.5^{a}	0.8^{d}	***
Bidens pilosa	32.7^{b}	25.1^{c}	20.6^{d}	52.4^{a}	10.1^{e}	***
Basella alba	1.0^{d}	4.4^{c}	5.6^{b}	12.2^{a}	1.4^{d}	***
Solanum scabrum	1.0^{d}	29.4^{a}	8.5^{b}	1.4^{d}	5.8^{c}	***
Significance	***	***	***	***	***	

Key:
Within rows: least squares means with common superscript are not significantly different (P>0.05).
Significance: *, *P* <0.05; **, *P* <0.01;***, *P* <0.001

Effect of shade type on crude fibre content

Table 4 presents the results of crude fibre contents in leaves of wild Vegetables under the five experimental treatments. In their natural environment, *Solanum scabrum* is the richest among the four Vegetables in terms of content of crude fibre. However, upon domestication of these species, *Basella alba* specifically when grown in the open takes the lead. On the other hand, except for *Bidens pilosa,* all other species found a matching shade. *Launaea cornuta* and *Basella alba* require a light improvised shade while *Solanum scabrum* apart from a light improvised shade, it also retains its crude fibre contents when grown under tree shades.

Table 4: Effect of type of shade on crude fibre content (mg/100g) for four species of wild Vegetables

Vegetable species	Treatments					Significance
	Forest (control)	Improvised	Tree	Banana	Open Space	
Launaea cornuta	0.7^{c}	0.6^{c}	0.9^{b}	1.5^{a}	0.5^{d}	***
Bidens pilosa	0.6^{c}	1.3^{b}	1.3^{b}	1.5^{a}	1.6^{a}	***
Basella alba	0.6^{d}	0.6^{d}	1.1^{b}	0.9^{c}	1.8^{a}	***
Solanum scabrum	1.5^{b}	1.4^{b}	1.3^{b}	1.7^{a}	0.7^{c}	***
Significance	***	***	***	***	**	

Key:
Within rows: least squares means with common superscript are not significantly different (P>0.05).
Significance: *, *P* <0.05; **, *P* <0.01;***, *P* <0.001

CONCLUSION AND RECOMMENDATION

Conclusion

Different types of shades under which domesticated wild Vegetables are grown influence their minerals contents differently. For calcium, none of the shades matched the calcium levels found in these Vegetables in their natural environment. However, matching levels of zinc contents were found for every species. To sustain zinc levels found in *Launaea curnuta, Basella alba* and *Solanum scabrum* in their natural environment, they should be grown under tree shades while *Bidens pilosa* must be grown under shades of banana trees.

With regard to iron contents, domesticated *Launaea curnuta, Basella alba* and *Solanum scabrum* maintain their iron levels when grown under improvised shade, open space and banana tree shades, respectively. None of the shades matched the iron levels in the natural environment for *B.pilosa.*

Crude fibre contents of domesticated *Launaea curnuta, Solanum scabrum and Basella alba* are maintained when grown under improvised shades, whereas all the type of shades produced higher levels than in the natural environment for *Bidens pilosa.*

Recommendation

The findings from this study make a good reference material when planning to plant and manage wild Vegetables for specific mineral requirements.

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