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Environmental factors affecting the phytonutrient contents of indigenous vegetable panawil (*Leptosolena haenkei* C. Presl.) in the Cordillera Region, Northern Philippines

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Abstract

Plants are known to produce wide array of chemicals. Indigenous vegetables are rich sources of vitamins, minerals, and phytochemicals (phytonutrients). It has tremendous potential to address poverty alleviation, nutritional security and with great potential value for future utilization. Panawil (*Leptosolena haenkei* C. Presl.) belongs to the Family Zingiberaceae. This endemic plant to the Cordillera has flowers which was utilized locally as vegetable. *Panawil* grow in clusters thriving in its ecological habitat at an altitudinal range of 600-1200 meters above sea level in Benguet and Mountain Province. Measured temperature at the time of sampling ranges from 22-26^{o}C. Soil fertility was analyzed using the parameters soil pH, organic matter, phosphorus, and potassium content of the soil. Phytonutrient analyses revealed that indigenous vegetable *panawil* is a rich source of phytochemicals such as terpenoids, tannins, flavonoids, total phenolics, and antioxidants; minerals like phosphorus, potassium, iron, and zinc; and including vitamins A (β-carotene) and C (ascorbic acid). The study revealed that environmental factors influenced the phytonutrient contents of *panawil*. Total phenolic content of *panawil* varies with altitude, while flavonoid and leucoanthocyanin is influenced by soil pH. Similarly, variation in soil organic matter affects the plant potassium content.

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Introduction

The start of industrial age had changed the lifestyles of human beings dramatically. Physical pressures have led people into various fast-eating habit. People are contented with easy-to-cook food such as instant and tasty meals but lower nutritional value. As consequences, there is an alarming increase in diabetes, obesity, and heart diseases (LEISA, 2007). Plants are known to produce wide array of chemicals. Eusebio (2006) mentioned that indigenous vegetables (IV) have tremendous potential to address poverty alleviation and nutritional security. Affordable and readily available, easy to grow, and require minimum production inputs. It is also rich in vitamins, minerals, and phytochemicals with anti-oxidant properties. Indigenous vegetables are wild and weedy species gathered and used as leafy vegetables (Madesa & Tshamekang, 2006). AVRDC (1990), implied the necessity to identify plant species that do not contain toxic components and are rich sources of dietary nutrients and with great potential value for future utilization. The demand for production and consumption of food will increase as population growth and poverty continues (Engle & Altoveros, 2000; Chadha & Olouch, 2002).

Moreover, the presence and amount of phytochemicals and nutrients in plant depends not only on its genetic makeup but also to its environmental influences (Shepherd and Griffiths, 2006; Jones, 1991; Hamilton, 2001). Elevation often dictates plant composition that can thrive in a certain type of habitat (Salcedo, 2001). Marko (1994) added that the type and amount of a secondary metabolite depends on many factors including the individual plant, its resources, environment, and evolutionary constraints. Factors such as resource availability, soil quality, climate, and insect animal herbivory pressures are known to affect levels of nutrients in plants (Asami, 2003). One plant that is endemic to the Cordillera Region, Philippines is an herb locally known as p*anawil* growing in Benguet and Mountain Province. Co (2002) identified *panawil* as *Leptosolena haenkei* C. Presl belonging to the Family Zingiberaceae. The flowers of the indigenous vegetable *panawil* are locally utilized as vegetable. The flowers are gathered for consumption before it fully blooms. Folks acknowledged the flower to have a sweet smelling taste, delicious when combined with fish and meat dishes, and is very acceptable to local taste. The study assumes that this IV has rich phytonutrient contents and are being influenced by environmental factors.

Materials and methods

Site description

The study was conducted in Benguet (Bakun, Bokod, Itogon) and in Mountain Province (Tadian, Sagada, Bontoc). These three municipalities were selected as sampling stations. Benguet Province is in the roof of Northern Luzon. It straddles the Cordillera mountain ranges at the southernmost part of the Cordillera Administrative Region (Fig. 1). Pangasinan bounds on the south, Ifugao and Nueva Viscaya on the East, Mountain Province on the north, and on the west are provinces of La Union and Ilocos Sur. It has a total land area of 261,648 hectares and lies at an elevation of between 457 to 2926 meters above sea level (Benguet Profile, 2005). Mountain Province also has a mountainous, rugged, and rolling terrain with a total land area of 223,989 hectares. The topography is rough, with very steep to nearly level slopes and deep ravines. Towering peaks and sharp ridges are features of its central and western landscape, while gradually sloping and rolling foothills characterize its eastern towns. Elevation ranges from 500 meters to 2,710 meters (Mountain Province Profile, 2006).

Fig. 1. Map of Cordillera Region (NSO Map, 2010).

Collection and Sampling Stations
A Global Navigation Satellite Positioning System (GNSS) was used to determine the geographical location and elevation of the sampling sites. Two elevation ranges from 600-900 masl to 900-1200 masl were considered as the lower and upper altitude respectively. The temperatures were measured in the Celsius scale (°C) using a wet and dry bulb thermometer. The temperatures of the different sampling areas were taken between 6:00 to 9:00 in the morning and from 3:30 to 6:30 in the afternoon.

A Quadrat size of 4mX4m was established in the lower and upper altitude of Benguet and Mountain Province. Panawil plant species enclosed into the quadrats were collected. Leaf samples collected for analysis included those from the shoot to the first three sheaths (pseudostem) below the shoot. The leaf samples were sorted, washed, and air-dried at the Benguet State University-Semi-Temperate Vegetable Research and Development Center Laboratory prior to analyses. Similarly, a composite soil samples were collected from each quadrat where the *panawil* plant samples were gathered. The soil samples were stored in a plastic bag, labeled, and then brought to laboratory for air-drying.

Chemical Analyses
Soil analysis. Air-dried soil samples were pulverized using a mallet and then screened with a fine 2mm mesh sieve and was subjected to analysis. The soil chemical properties such as soil pH, organic matter, phosphorus, and potassium soil contents were analyzed at Baguio Soils Laboratory, Pacdal, Baguio City.

Phytochemical analysis
About 100 grams of air-dried leaves of p*anawil* were homogenized and ethyl alcohol was used to submerge the plant samples for 48 hours. The filtrate collected was concentrated using a rotary evaporator with the water bath. The *panawil* crude extracts was used for the phytochemical analysis. The standard protocol of Guevara (2005) was used to determine the presence of secondary metabolites in *panawil*. Then, the presence of secondary metabolites in *panawil* was confirmed using the Thin-Layer Chromatography (TLC) technique.

The procedure of Edeoga *et al.* (2005) was used to confirm the presence of terpenoids. The semi-quantitative level of the phytochemicals found in *panawil* was determined based on a scale that corresponds to the intensity of the colors and precipitate obtained from the tests. Phytochemical analysis was performed at the Chemistry Department, Benguet State University.

Mineral and vitamin analyses. About 1 kg of air-dried *panawil* leaves was brought for mineral and vitamin analyses. The analytical method, Ashing-acid Digestion/Atomic absorption spectrophotometry, was used for the analysis of the plant minerals; potassium, phosphorus, iron, and zinc, while High Performance Liquid Chromatography was used for determining the β-Carotene, ascorbic acid, total phenolic contents and antioxidant activities of the plant samples. Plant samples were brought to Institute of Food Science, University of the Philippines, Los Baños, Laguna.

Treatment of the Data
The data gathered were tabulated and analyzed statistically. T-test was used to compare the differences in the soil chemical properties and the phytonutrient contents of *panawil* plant found growing in the lower and upper altitudes of Benguet and Mountain Province. The Pearson Product Moment Correlation (PPMC) was used to determine the relationship between the phytonutrient contents of *panawil* and the environmental factors considered.

Results and discussion

Botanical description
Panawil (*Leptosolena haenkei* C. Presl.) is an endemic plant species in Northern Luzon, Philippines including Benguet, Cagayan, Ilocos Norte, La Union, Mountain Province, Nueva Viscaya and Zambales (*Funakoshi*, 2005). It was outstanding and most distinct among the Zingiberaceae Family because of its large flowers with extremely long and slender corolla tube extended from the calyx (Fig. 2). These flowers are gathered for consumption before it fully blooms and utilized locally as vegetable.

Fig. 2. The *panawil* plant in its natural habitat with inset flower stages.

Environmental Factors

The *panawil* plants collected from Benguet and Mountain Province were found to be growing in different altitudinal ranges. The lower altitude set at 600-900 masl while the upper altitude ranges from 900-1200 masl. The temperatures recorded ranges from 22^{o}C to 26^{o}C.

The lowest temperature was recorded in Sagada, Mountain Province while the highest was recorded in Bokod, Benguet and Bontoc, Mountain Province. Soil analysis was conducted to determine soil pH, organic matter, phosphorus, and potassium content of the soil from which *panawil* plant samples were collected. These chemical parameters determine fertility of the soil and probably type of plants that grow on the soil.

Phytonutrient Contents

Phytochemical content. A pre-test was done on the crude ethanol extracts of the air-dried *panawil* leaves using test tube reactions showed the presence of terpenoids, flavonoids and tannins. Thin-layer chromatography was performed to confirm the presence of the phytochemicals determined in the pre-test. Other analyses revealed the presence of total phenolics and antioxidants in the sample.

Polyphenols are the most abundant group of plant phenolic compounds known to provide much of the flavor, color, and taste to fruits, vegetables, and seeds. It includes the flavonoids, tannins, and terpenoids. Phenolic compounds are associated with plant pigments some of which are associated with the defense of plants against a range of attacks from browsing animals (Crozier, 1986). Flavonoids are polyphenolic compounds that are ubiquitous in nature and are categorized according to chemical structure into flavonols, flavones, flavanones, isoflavones, anthocyanidins, aurones, cathechins, and chalcones. The flavonoids have been reported to have anti-viral, anti-allergic, antiplatelet, anti-inflammatory, antitumor, and antioxidant activities (Buhler, *et al.*, 2000). Tannins are plant polyphenolics that possess the property of precipitating proteins from aqueous media, which can be classified into hydrolysable tannins and the condensed or pro-anthocyanidins (Guevara, 2005).

Mineral content. The presence of minerals such as phosphorus, potassium, iron, and zinc was revealed in Panawil. Potassium was the highest among the minerals determined in *panawil* content. This was observed in both altitudes of Benguet and Mountain Province. Iron and zinc content has minimal content compared to potassium. Plant derived minerals contribute to what the body need. Potassium helps regulate and stabilize blood pressure levels which may help in the prevention of strokes. For instance, Calpi (2001) stated that potassium is not only a component of the structural make up since it plays a vital role in the physiological and biological functions of the plant. It enhances disease resistance by strengthening the stalks and stems, activates various enzyme systems within the plants to prevent wilting, enhance fruit size, flavor, texture and development, and is involved in the production of amino acids, chlorophyll formation and sugar transport from the leaves to roots. Parker (2003) stated that iron is required for a number of vital functions, including growth, reproduction, healing and immune function. But plant derived minerals are 100% absorbable and is health beneficial.

Comparing the Recommended Dietary Intake (RDI) for minerals and vitamins which the body needs to the mineral contents of *panawil*, the amount which *panawil* can supply far exceeds what is required.

Vitamin content. β-Carotene and ascorbic acid are present in the indigenous vegetable *panawil*. Vitamin A was determined as β-carotene, the precursor of vitamin A. On the other hand, vitamin C was determined as ascorbic acid. These vitamins are considered dietary antioxidants hence they probably contribute to the antioxidant activity of *panawil*. Both from Benguet and Mountain Province, panawil contains high vitamin A, while vitamin C in Mountain Province is lower than in Benguet. The results mean that *panawil* as a food source can contribute to the vitamin requirement of the body. Vitamin A plays an important role in vision, essential for the integrity of epithelial tissues, bone development, reproduction and healthy skin (Bolayo, 2006). According to Kohlmeir (2003), vitamin C is important for gum, arteries and other soft tissues, brain function and act as antioxidants defense against free radicals.

Relationships of Environmental Factors to the Phytonutrient Contents of Panawil

Temperature and phytonutrient contents. The relationships between the environmental temperatures at the time of sampling to the phytonutrient contents of *panawil* found in Benguet and Mountain Province were analyzed. The very low values of r and the p-values which are higher than the 0.05 level of significance indicate that there is no significant correlation. This means that temperature does not affect the phytonutrient contents of *panawil,* hence the plant can be harvested anytime. The study of Wahid *et al.* (1997) revealed that vegetative tissues under high temperature stress show an accumulation of anthocyanins in rose and sugarcane leaves. Findings of the study showed that elevated temperatures greatly modulate or even decrease the concentration of phenolic compounds in buds and fruits. Low temperature also increases the production of phenolic compounds like the flavonoids and phenylpropanoids.

Altitude and phytonutrient contents. Results shows that altitude is significantly correlated to the total phenolic compounds of *panawil*. This means total phenolic contents will vary at different altitudes. There are no significant correlations between altitudes to the mineral and vitamin contents of *panawil*, which is in contrast to the results reported by Pugnaire and Lugue (2001) that different elevation sites show different values in the mineral and vitamin contents in plants. Harborne (1972) also reported that concentrations of plant constituents are determined not only by genetic factors but also by environmental factors such as climate, temperature, light, altitude and latitude and edaphic factors are responsible for such differences.

Soil chemical properties and the phytonutrient contents. Each of the soil chemical properties analyzed was correlated to the phytonutrient contents of *panawil* from Benguet and Mountain province. Ethering (1975) stated that soil pH show strong correlations with soil type and formation, vegetation type, and profile horizon. Furthermore, that patterns of climatic and altitudinal species distributions are determined by these interactions. In addition, Marschner (1986) stated that soil chemical factors such as pH, salinity and nutrient availability determine the distribution of the natural ecosystem.

a. *Soil pH.* The relationship of soil pH to the phytonutrient contents of *panawil* (Fig. 3). Only flavonoid (flav. 2, leucoanthocyanin) gave a linear correlation (R^2 = 0.805) to the soil pH while the rest are not. Statistical analysis using the Pearson Product Moment Correlation Coefficient (r), reveals that this relationship is highly significant.

The calculated r-value of 0.65 and the p-value of 0.01 indicate a highly significant correlation. What this means is that the flavonoid content is affected by the soil pH. Bell and Charlwood (1980) found that the level of phytochemicals in individual fruits and vegetables is affected by many factors including variety, soil, climatic conditions, physiological stress under which plants are grown and degree of ripeness, storage conditions and length of storage before consumption. This is supported by Humphrey *et al.*, (1989) that levels of terpenoids can vary widely with plant variety and growth conditions.

The findings of the study corroborates the study of Mitchell (2006) that flavonoids and isoflavonoids are produced in higher amounts in soil low in nitrogen. He further mentioned that plants produce high levels of alkaloids when grown in soil poor in nitrogen.

b. Soil organic matter. Soil organic matter is linearly correlated with the potassium content of *panawil* (Fig. 4). The degree of linearity is measured in terms of $R^2 = 0.372$. The coefficient of correlation, r, is 0.56 with a p-value equal to 0.05. This means that there is a significant correlation between the soil organic matter and the potassium content of *panawil.* The result suggests that soil organic matter does influence the presence of phytonutrients in *panawil,* in particular the potassium mineral.

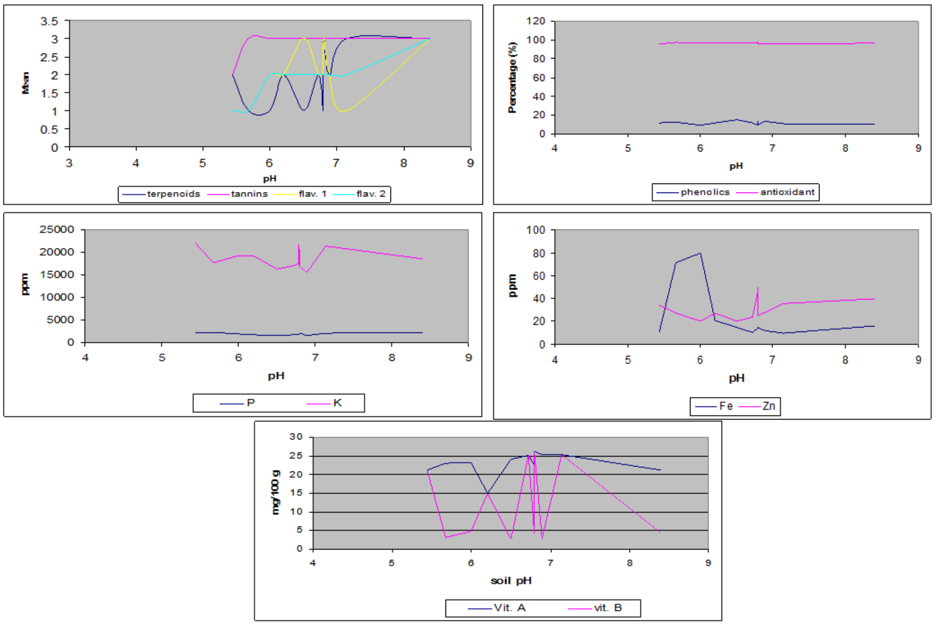

Fig. 3. Relationship of soil pH to the phytonutrient contents of *panawil.*

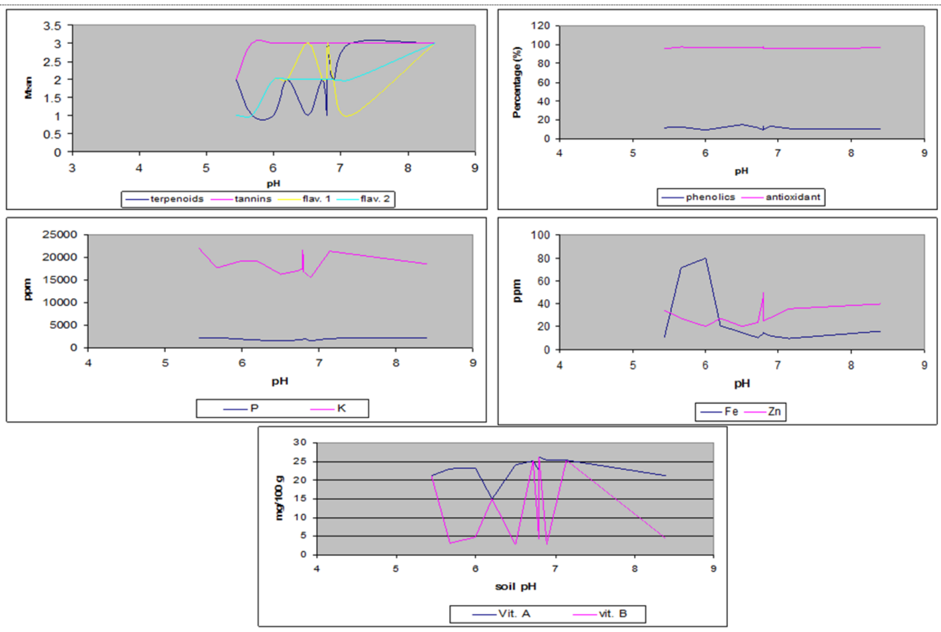

Fig. 4. Relationship of soil organic matter to the phytonutrient contents of *panawil.*

c. Soil phosphorus. No linear correlation between soil phosphorus and any of the phytonutrients (Fig. 5). The calculated r values (coefficient of correlation) calculated supports this observation. The soil phosphorus is not significantly correlated to any of the phytonutrients present in *panawil*. The amounts of phosphorus absorbed by plants are affected by the pH of the medium surrounding the roots. The pH of the soil samples from which *panawil* were gathered is slightly acidic and alkaline. Phosphorus do not form part of polyphenols.

d. Soil potassium. Statistical analysis shows that soil potassium is not significantly correlated to the phytonutrient contents of *panawil*. The coefficient of correlation calculated have p-values which are higher than 0.05. In Fig. 6, no linearity was observed in any of the relationships.

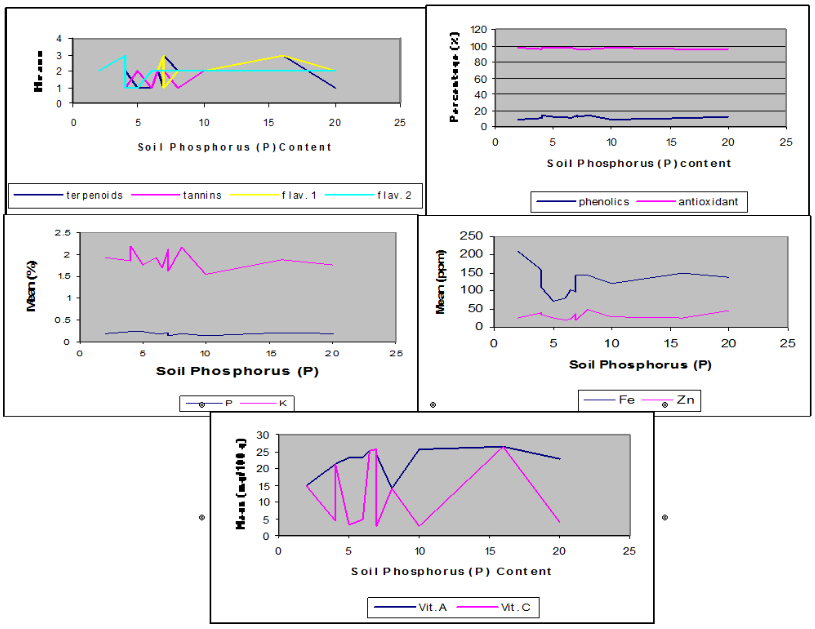

Fig. 5. Relationship of soil phosphorus content to the phytonutrient content of *panawil.*

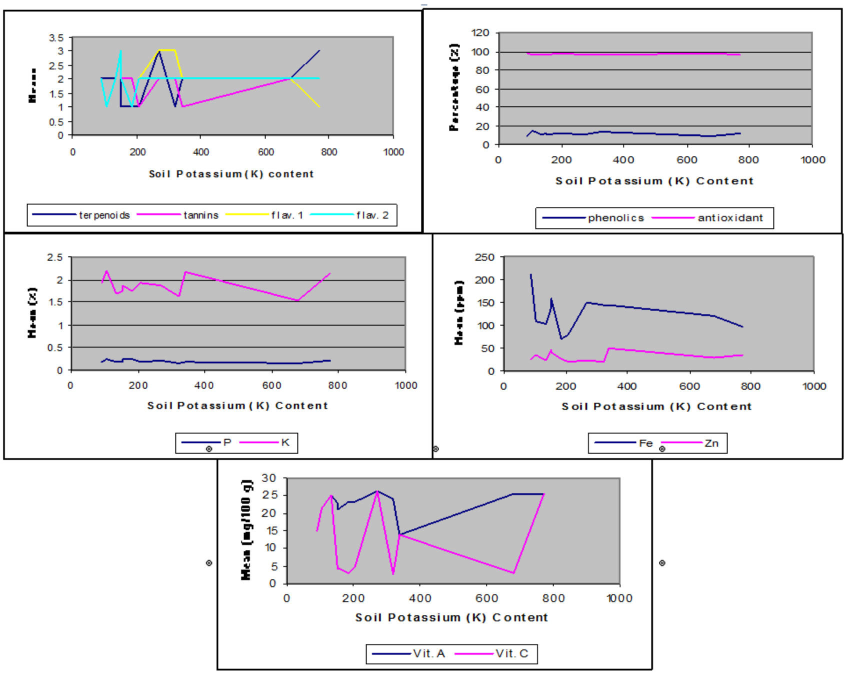

Fig. 6. Relationship of soil potassium to the phytonutrient contents of *panawil.*

Conclusion

The indigenous vegetable *panawil* has potential food value that can alleviate poverty. Rich source of phytonutrients for the local people that has to be protected and conserved. It can be a prospective source of drug studies and thus influenced by environmental factors. Finally, similar studies should be done on the ethnobotanical and phytonutrient studies on other endemic and indigenous vegetables utilized as food.

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References

Asami DK, Hong YJ, Barrett DM. 2003. Comparison of Total Phenolic and Ascorbic Acid Content of Freeze-Dried and Air-dried Marion berry, Strawberry, and Corn Grown Using Conventional, Organic and Sustainable Agricultural Practices. Agric. Food Chem 2003, **51(5),** pp 1237-1241.
www.pubs. acs.org/doi/abs/10.1021/jf020635c. J.

AVRDC. 1990. "Vegetable Research and Development in SADCC Countries". In: AVRDC Proceedings of a Workshop in Arusha, Tanzania (eds. Opena, R.T. & A.R. based_vegetable_gardens_and_other_strategies_to_overcome_micronutrient_malut

Benguet Province Profile. 2005. Municipal Planning and Development Office, La Trinidad, Benguet **15.**

Bolayo YD. 2006. Phytonutrient Analysis of the Shoots of Passion (*Passiflora edulis*, Sims). Master's Thesis. Benguet State University, La Trinidad, Benguet 34-42.

Buhler*† DR, Miranda† CL, Stevens JF, Ivanov V, McCall M, Frei F, Deinzer ML. 2000. Antioxidant and Prooxidant Actions of Prenylated and Nonprenylated Chalcones and Flavanones in Vitro. Journal of Agricultural and Food Chemistry 2000 **48(9),**

Calpi MT. 2001. Effect of Sul-Po-Mag on the Growth and Yield of Cabbage and on Some Chemical Properties of the Soil. Undergraduate Thesis. Benguet State University, La Trinidad, Benguet 9-11.

Chadha ML, Olouch MO. 2002. Home-based vegetable gardens and other strategies to overcome micronutrient malnutrition in developing countries. AVRDC.

Crozier AM, Ashihara H. 2006. Plant Secondary Metabolites: Occurrence Structure and Role in the Human Diet. New York: John Willey and Sons, Inc p. 285-320.

Engle, L.M., Faustino, F.C. 2007. Conserving The Indigenous Vegetable Germplasm Of Southeast Asia. Acta Hortic. **752,** 55-60
DOI: 10.17660/ActaHortic.2007.752.5
https://doi.org/ 10.17660/ActaHortic. 2007.752.5

Ethering JR. 1975. Environment and Plant Ecology. London: John Wiley and Sons, Inc p. 82-95.

Eusebio JE. 2006. Promoting Utilization of Indigenous Vegetables for Improved Nutrition in the Philippines. Paper Presented during the 1st International Conference on Indigenous Vegetables and Legumes held in ICRISAT, Hyderabad, India, Dec. 12-15, 2006.

Funakoshi H. Kress WJ, Skornlckova J, Liu A, Inoue K. 2005. Return from the Lost: Rediscovery of the Presumed Extinct *Leptosolena* (Zingiberaceae) in the Philippines and its Phylogenetic Placement in Gingers. Acta Phytotaxonomica et Geobotanica **56(2005)** 1 p. 41-53 https://doi.org/10.18942/apg.KJ00004622912

Guevara QB. 2005. A Guidebook to Plant Analysis: Phytochemical and Biological. University of Santo Tomas Publishing House, UST, España, Manila p. 51-87.

Hamilton JG, Zangerl AR, De Lucia EH, Berenbaum MR. 2001. Ecology: The Carbon Nutrient Balance Hypothesis its Rise and Fall. Retrieved July **20,** 2006
www.life.uiv.edu/ delucia/CNB%paperpdf

Harborne JB. 1973. Phytochemical Methods: A Modern Guide Techniques of Plant Analysis. New York: Halsted Press p. 22-61.

Jones BJ, Wolf B, Mills HA. 1991. Plant Analysis Handbook: A Practical Sampling Preparation, Analysis and Interpretation Guide p. 17.

Kohlmeier M. 2003. Nutrient Metabolism. London: Academic Press p. 115-182. Kyomo). Tanzania, Africa. www.cabdirect.org/cabdirect/abstract/19920.

Low External Input and Sustainable Agriculture (LEISA). 2007. Healthier Farmers, better Products. Vol. 23. No. 3. Amersfoort, the Netherlands.

Madesa ME, Tsamekang ME. 2006. Conservation and Utilization of Indigenous Vegetables in Botswana. Proceedings of the IPGRI International Workshop on Genetic Resources of Traditional Vegetables in Africa: Conservation and Use 29-31 August 1995, ICRAF-HQ, Nairobi, Kenya. Retrieved July **20,** 2006 www.ipgri.cgiar.org/publications/HTMLPublications /500/begin.htm#Contents**.**

Marko M. 1994. Autotoxicity in Plants. Retrieved June **8,** 2006 www.colostate.edu/depts/ entomology/cources/en570/papers1994/marko.html

Marschner H. 1986. Mineral Nutrition of Higher Plants. London: Academia Press, Inc p. 230-275.

Miller HE, Rigelhof F, Marquart L, Prakash A, Kanter M. 2013. Antioxidant Content of Whole Grain Breakfast Cereals, Fruits and Vegetables, Journal of the American College of Nutrition **19,** sup 3, 312S-319S DOI: 10.1080/07315724.2000.10718966

Mitchell A. 2006. A Comparison of the Nutrient and Phytochemical Content of Organic and Conventional Tomatoes and Peppers. Retrieved February **14,** 2008. http://mitchell-davis.edu/OSA2006_Mitchell2.pdf

Mountain Province Profile. 2007. Municipal Planning and Development Office, Sagada, Mountain Province.

Parker R. 2003. Introduction to Food Science. Delmar Thompson Learning, Inc. Australia p. 212-253.

Philippine Council for Agriculture and Resources Research. 1980. Standard Methods of Analysis for Soil, Plant, Tissue, Water and Fertilizer. Farm resources and Systems Research Division, Los Baños, Laguna p. 25-58.

Pugnaire FI, Luque MT. 2001. Changes in Plant Interactions Along a Gradient of Environmental Stress. Retrieved June **9,** 2006 from OIKOS Journal. www.OIKOS% (2093) 42-49.

Salcedo PG. 2001. Floral Inventory and Assessment of Mount Amuyao Mossy Forest (Luzon, Philippines) for Biodiversity Resources Conservation and Management. Master's Thesis. University of the Philippines Los Baños, Laguna 39-44.

Shepherd S, Griffiths D. 2006. Tansley Review: The effects of Stress on Plant Cuticular Waxes. Retrieved May **20,** 2007.

Wahid A, Gelani S, Masraf M, Foolad M. 1997. Heat Tolerance in Plants: An overview. Environmental and Experimental Botany. Accessed on November **15,** 2007 www.plantstress.com/Articles/up_heat_files/Heat% 20Tolerance%pdf