



Nutrition Integration Fact Sheet

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In recognition of the relationship between nutrition, agricultural science and market forces, the development community is moving toward increasingly integrated value chain development programming. Practitioners now must include nutritional considerations into core agricultural development work and measure nutritional impact. This fact sheet is produced as part of ACDI/VOCA's ongoing learning agenda. It is one in a series designed to be a practical and informative resource for staff on the nutritional value of crops and on leverage points within the value chains for maximizing nutritional impact.

Introduction

Many countries have prioritized market development of vegetable value chains based purely on their economic growth potential. Compared to staple crops, vegetables typically fetch higher prices in the market, provide a higher return on investment, are often grown and/or sold by women, and can successfully be produced on limited amounts of land. Because of

their high nutritional content, increased access to a variety of vegetables is also a critical element of the nutritional security, developmental growth and human productivity of a nation. However, research continues to show that increased vegetable production does not lead to increased household consumption. Hence it is important to pair vegetable value chain work with awareness-raising and behavior-change activities to ensure that producers themselves are able to reap the nutritional benefits of what they grow.

Most vegetables contain significant amounts of vitamins, minerals and antioxidants, and can improve diet diversity and a household's nutritional status when eaten in combination with staple foods. Improving micronutrient intake through increased vegetable consumption—whether the vegetables are grown on household farms or purchased in the market—is key to tackling Africa's dual burden of undernutrition and increasing rates of obesity.¹

This fact sheet provides information on the nutritional benefits of a number of commonly grown vegetables in sub-Saha-

ran Africa. The purpose of this overview is to assist practitioners in the selection of vegetables for value chain development and to inform rotation, intercropping and household utilization choices that may better address nutritional deficiencies among farming families. It closes with several general tips on how to avoid loss of vitamins and minerals during the production, harvesting, processing and cooking of vegetables.



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Vegetable Nutritional Profiles

Three classes of vegetables with high nutritional content are profiled below: dark-green leafy vegetables; orange, red and yellow vegetables; and podded vegetables. See Figure 1 for nutritional profiles.

Dark-Green Leafy Vegetables

The dark-green leaves of veg-

etables such as spinach, spider weed, pigweed, moringa, cassava and sweet potato indicate a high vitamin and mineral content—specifically, vitamin A, iron and zinc. These vitamins and minerals are often lacking in staple foods and are particularly important for the health and development of pregnant and lactating women and children. Dark-green leafy vegetables are great additions to meals that are based on ce-

reals and legumes, but they do not store well and need to be eaten soon after harvesting.

Orange, Red and Yellow Vegetables

These vegetables include some of fruit/flower vegetables as well as root/tube/bulb vegetables that are discussed in detail below. Vegetables and fruits of an orange color usually contain a greater amount of vitamin A

Figure 1: Nutritional Profile

Crop	Nutritional Profile
Dark-Green Leafy Vegetables	
Spinach	Spinach has a high nutritional value, especially when fresh, steamed or quickly boiled. Its iron content is twice that found in other green vegetables, and the available iron is higher when eaten raw. It is also a rich source of folate, vitamins A, C, E, and K, magnesium, and antioxidants.
Spider plant/weed	Spider weed, also known as spider plant or African cabbage, is high in vitamins and minerals, especially vitamin A, vitamin C and iron. Spider weed can be sold as fresh produce in markets, and it can be used to make medicinal products, insecticides and seed oils that are used in soaps, biofuels or other commercial products.
Amaranthus (Pigweed)²	Amaranth has nutritional leaves and seeds, and it contains high levels of micronutrients such as vitamin A, vitamin C, iron and calcium in leaves, and high protein content in seeds. The leaves are also rich in lysine, an essential amino acid that is low or absent in cereals and tubers. The protein found in young plants is important for people without access to meat or other sources of protein. The fat content in amaranth seed is high (7–8 percent), which is double that of common cereals.
Moringa	Moringa leaves contain high-level complete protein, vitamin A, B vitamins, vitamin C and minerals. Moringa is considered extremely valuable by people aware of its nutritional and pharmaceutical qualities. Moringa yields at least four different edibles—pods, leaves, seeds and roots—and has a potential role in reducing hunger, malnutrition, deforestation and rural poverty. In Africa, moringa leaves appear at the end of the dry season when there are few other sources of leafy green vegetables. Its leaves are developed into powder and food additives, its pods can be processed like peas, its trunks are raw material for making paper and the tree can thrive in wasteland. ³
Cassava leaves	Cassava leaves contain carbohydrates as well as proteins and vitamin A. They are suitable for children's diets but must be cooked properly to remove toxins (e.g., through blanching).
Sweet potato leaves	Sweet potato leaves provide a dietary source of protein, vitamins, minerals, antioxidants and dietary fiber. These leaves are affordable sources of nourishment.

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Figure 1: Continued

Crop	Nutritional Profile
Orange, Red and Yellow Vegetables: Fruit and Flower Vegetables	
Tomato	Tomato is botanically a fruit and rich in vitamin C, vitamin A, vitamin K, B vitamins and iron. It is also a good source of the antioxidant lycopene, which is found in the pigment that makes tomatoes red. The vitamin C content increases as the tomato ripens; this continues even after harvest, but for optimal results, tomatoes should be vine ripened. Tomatoes can be preserved, although some of the nutrients are destroyed during drying, canning or processing into a variety of products such as tomato paste, tomato ketchup, tomato juice and sundried tomatoes. ⁴
Pepper⁵	All peppers are a good source of vitamin A and C, although nutritional values vary depending on the variety and stage of maturity. Bell peppers are usually picked before they reach maturity, however if they are left to ripen on the plant they are sweeter and higher in vitamin content. Other peppers (such as chili) are usually harvested at full maturity. In general, peppers have a short storage life of only one to two weeks.
Orange, Red and Yellow Vegetables: Root, Tube and Bulb Vegetables	
Onion and shallot⁶	Onions and shallots contains a significant amount of vitamin C, antioxidants and dietary fiber. Farmers can extend the shelf life of onions by placing them in a warm, well-ventilated area until the necks and outer skins are thoroughly dry and brittle.
Carrots	Carrots are an excellent source of vitamin A and contain a large amount of dietary fiber and antioxidants. Under proper storage conditions (e.g., buried in light moist sand in an underground cellar or stored in the garden in a pit insulated with straw), carrots keep up to 4 to 6 months.
Potato⁷	Potatoes are a starchy vegetable and do not contain many vitamins or minerals. However, like staple foods such as rice and maize they do provide a significant amount of calories due to their high carbohydrate content. Potatoes need to be stored in a cool, dark and well-ventilated place and kept in perforated plastic bags or paper bags to keep them dry and to prevent sprouting.
Sweet potato	The orange-flesh sweet potato is richer in vitamin A compared to other varieties, such as purple- or white-flesh sweet potatoes. Vitamin A biofortified orange-flesh potatoes have been developed and used in countries such as Uganda, Mozambique and Haiti. Sweet potatoes must be handled as little as possible to avoid scuffing and bruising. The storage life of many varieties can be greatly increased by proper curing and/or storing in underground pits.
Cassava^{8,9}	Cassava is a major source of calories for more than 250 million people in sub-Saharan Africa. However, a typical diet based on cassava provides less than 30 percent of the minimum daily requirement for protein and only 10–20 percent of the required amounts of iron, zinc, vitamin A and vitamin E. Moreover, because it carries low levels of a naturally occurring cyanide, cassava can be toxic if is not prepared properly. Cassava needs to be supplemented by other nutritious foods such as legumes and vegetables. Fresh cassava roots can be washed well, peeled, dried and ground into cassava flour, which has a long storage life and multiple uses. ¹⁰
Podded Vegetables	
Okra^{11,12}	Okra is a good source of vitamin B6 and folic acid and is rich in dietary fiber. Fresh okra has a short storage life and needs to be kept dry. It should be loosely wrapped in perforated bags to prevent bruises. Okra can be dried and stored in baskets, clay pots or bags. Okra seed can also be dried, and the dried seed is a nutritious material that can be used to prepare vegetable curds, or roasted and ground to be used as a coffee additive or substitute. Okra is considered to have diverse medical properties and and can be used to make items such as rope and paper.
Legumes	Please refer to the legume fact sheet



than other colored vegetables. Vitamin A is a critical nutrient for vision, immune function, promotion of growth and skin health. Vitamin A deficiency is prevalent in pregnant women and young children in many sub-Saharan African and South Asian countries.

Root vegetables are plant roots used as vegetables. The word “root” means any underground part of a plant.

Root vegetables are generally storage organs, enlarged to store energy in the form of carbohydrates. They differ in the concentration and the balance between sugars, starches, and other types of vegetables. Of particular economic importance are those with a high carbohydrate concentration in the form of starch. Starchy root vegetables are important staple foods, particularly in tropical regions, overshadowing cereals throughout much of West Africa, Central Africa, and Oceania. Examples include cassava, yams and sweet potatoes.

Podded Vegetables Podded vegetables such as beans and peas tend to be cool-season crops. Podded vegetables are seeds that are found inside two-sided pods. They are a rich source of proteins, potassium, folic acid, complex carbohydrates, magnesium, iron, fiber and zinc.

Vegetable Rotation and Intercropping¹³

It is widely considered good agricultural practice to rotate and intercrop certain complementary crops in order to replenish soil nutrients from one season to the next and to control pests. For example beans are often planted after tomatoes to fix nitrogen back into the soil. By understanding the nutritional elements and agronomic properties of vegetable crops, agriculture programs can recommend beneficial rotation and intercropping choices. This can increase food availability, diversity and accessibility for households.

In a rotation, vegetables are often arranged according to families so that individual vegetables from the same family do not follow each other. To keep a rotation sequence in proper order, it is best to intercrop members of the same family whenever possible. Intercropping involves the simultaneous culture of two or more crops in the same garden within the same growing season.

Techniques for Reducing Nutrient Loss

The quality and nutritional value of fresh produce is affected by harvest methods, post-harvest handling and storage conditions, processing and packaging. Poor preservation results in waste during the in-

season, whereas during the off-season there is limited supply accompanied by high prices. Appropriate preservation and storage methods are needed to prolong the consumption of nutrient-rich foods year round. The following considerations play an important role in maximizing nutrient retention:

Harvest: Picking too early or too late may have an impact on the nutrient content of some vegetables.¹⁴

For example, crops such as tomatoes and avocados are climacteric, that is, they are capable of generating the ripening hormone ethylene after being detached from the mother plant. Climacteric produce may reach full ripe color even when harvested early, yet they will not reach the full nutritional quality that they would have had if they had ripened on the plant. Total vitamin C content of tomatoes, apricots, peaches and papayas is higher when these crops are picked ripe from the plant. Other crops are non-climacteric, such as asparagus, peppers, lettuce, cucumber, eggplant, pumpkin and beets, which will reach commercial maturity on the plant only.

If destined for distant markets, climacteric crops are often harvested as early as possible after they reach their physiological maturity; this helps them withstand mechanical harvesting and long-distance transport without damage. For household consumption from home gar-

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dens, it is best to pick produce ripe, right before consumption, to ensure higher vitamin C and other nutrient content.

Harvesting should take place at cooler times of the day, such as the early morning, to minimize nutrient loss and increase the work efficiency of pickers.

Bruising and damaging as a result of poor post-harvest handling, exposure to temperatures and humidity, and transportation can accelerate nutrient loss.

Processing and packaging¹⁵:

Processing, such as cutting, slicing, chopping and peeling, can injure the plant tissues and initiate deterioration (by enzymatic reactions) and water losses. This increases susceptibility to spoilage due to bacteria or fungus growth and thus compromises food safety. It also alters chemical make-up and increases nutrient loss. Preservation methods include drying and/or packaging in a timely manner; blanching before storage, packaging or freezing; irradiation; chemical preservation (using ascorbic acid or citric acid); or pickling with sugar or salt. The following are some useful techniques:

- » **Cooling** slows physiological processes such as bacteria and fungus growth and spoilage. Lower storage temperatures increase storage life; blocking sunshine and allowing good air flow in storage spaces can help

reduce temperature.

- » **Blanching** is the heating of fruits or vegetables for a short time with either steam or water, and is an essential step before canning, drying or freezing of food. Blanching inactivates certain substances that would otherwise adversely affect nutrient content, color, flavor or texture during subsequent processing and storage. Blanching is useful for green beans, broccoli, asparagus and some other vegetables and fruits.
- » **Canning**, using either glass jars or tin cans, is one of the most effective ways to preserve vegetables. To avoid botulism, special caution should be taken when canning low-acid foods such as vegetables at home or on a small-scale.
- » **Protective packaging** such as liners, cushioning and individual wraps can reduce damage and vents in carton boxes can minimize heat buildup.

Cooking: Cooking methods have an impact on nutrient loss and nutrient distribution. Water-soluble micronutrients, such as vitamin C, B vitamins and most natural forms of minerals, leak into the cooking water. Reusing or drinking the cooking water in which leafy vegetables are boiled can put these nutrients to good use. Likewise, fat-soluble nutrients, such as vitamin A, D, E, K and

most antioxidants, may dissolve into the fat portion of the dish (e.g., oil). For example, deep-fried sweet potatoes contain much less vitamin A because vitamin A dissolves into the oil and is destroyed by the high temperature of frying. Baking or steaming sweet potatoes will preserve more of their Vitamin A.

Key Messages

- » Vegetable value chain activities must be combined with awareness-raising and behavior-change activities to ensure that producers themselves are able to reap the nutritional benefits of what they grow.
- » The color of dark-green leafy vegetables indicates a high vitamin and mineral content—specifically, vitamin A, iron and zinc. These vitamins and minerals are often lacking in staple foods like rice and maize.
- » Orange, red, and yellow vegetables and fruits contain a large amount of beta-carotene (a plant-source vitamin A), which is critical for healthy vision, strong immune function, proper growth and healthy skin.
- » Cassava and potatoes lack the vitamins and nutrients found in more colorful vegetables. They most often take the place of other staple foods and should

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- be eaten with legumes and other vegetables to maximize nutritional benefit.
- » In general, vegetables do not have a long useful life after they have been picked, but their usefulness can be extended by curing, drying, or using appropriate storage methods.
 - » To maximize soil health, vegetables from the same family should be inter-cropped together, and vegetables from a different family should follow during the next crop rotation.
 - » Most fruits and vegetables have greater vitamin content if they are picked ripe from the plant, rather than being picked before they have fully ripened.
 - » Cooking methods have an impact on how much of a vegetable's nutrients can actually be consumed.
 - » Vitamin C, B vitamins and most natural forms of minerals will leak into the cooking water. Reusing or drinking the cooking water in which leafy vegetables are boiled can prevent the loss of these nutrients.
 - » Vitamins A, D, E, K and most antioxidants may dissolve into cooking oil. For example, deep-fried sweet potatoes contain much less vitamin A because vitamin A dissolves into the oil and is destroyed by the high temperature of frying.
 - » Producer and consumer education is key to increased consumption of nutritious foods. Using proper incentive strategies, other market actors (e.g., input suppliers, retailers, etc.) can also play an important role in education and behavior change.

¹ See the *Nutrition Primer*, part of this series, for additional information on macro and micronutrients and their affect on health and nutrition.

² Pigweed <http://www.botanicalsociety.org.za/ProjectsAndActivities/Useful%20Plants/Forms/DispForm.aspx?ID=4>

³ Lost crops for Africa—vegetables. http://www.nap.edu/catalog.php?record_id=11763

⁴ Determinants of post harvest losses in tomato production: a case study of Imeko – Afon local government area of Ogun state

⁵ Pepper Fact Sheet. Ohio State University Extension.

⁶ Onions: post-harvest operations. FAO. http://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compendium_-_Onion.pdf

⁷ Potato Nutrition Handbook. http://www.potatogoodness.com/Content/pdf/PPNHandbook_Final.pdf

⁸ Biocassava Plus http://www.danforthcenter.org/science/programs/INTERNATIONAL_PROGRAMS/BCP/default.asp

⁹ Impact of Cassava development on Food Security and Nutrition of the Rural Poor http://km.fao.org/fileadmin/user_upload/fsn/docs/SUMMARY_ImpactOfCassavaDevelopmentOnFSNofRuralPoor.pdf

¹⁰ Food storage and processing for household food security <http://www.fao.org/docrep/w0078e/w0078e07.htm>

¹¹ Okra. <http://urbanext.illinois.edu/veggies/okra.cfm>

¹² An overview of Production, Processing, Marketing and Utilisation of Okra in Egbedore Local Government Area of Osun State, Nigeria. <http://www.cigrjournal.org/index.php/Ejournal/article/viewFile/959/1119>

¹³ Vegetable Rotations, Successions and Intercropping <http://lubbock.tamu.edu/horticulture/docs/vegrote.html>

¹⁴ Healthy and Sustainable Food <http://chge.med.harvard.edu/programs/food/nutrition.html>

¹⁵ Processing of horticultural products. <http://www.fao.org/docrep/009/ae075e/ae075e22.htm>

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