



Vegetable species

for multi-storey
cropping systems
and human nutrition

NutriHAF Africa

Diversifying agriculture for balanced nutrition
through fruits and vegetables in multi-storey
cropping systems

www.zef.de/project/NutriHAF-Africa

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1. Advantages and challenges of multi-storey cropping systems

In a multi-storey cropping system crops of **different heights** are grown together, for example pumpkin (ground cover), pigeon pea (shrub) and mango (tree) in a **homegarden**; or **coffee with vegetables** underneath.

The crops are grown at the same time on the same piece of land and hence using land, water, and space most efficiently and economically.

Advantages

- Introducing and intensifying vegetable production in multi-storey cropping systems can be a solution to improve human nutrition of smallholder families.
- Multi-storey cropping systems can also increase land-use efficiency in areas where additional land for agricultural expansion is not available.
- Additional land is especially difficult to obtain in biodiversity hotspots and in the neighbourhood of biosphere reserves.
- Multi-storey cropping systems can be highly productive. Yields on small plots can be maximised using a multi-storey cropping system including fruit trees and with vegetables in the lowest layer.
- Mixed cropping systems, in most cases, have lower pest infestations than monocultures.

Challenges

- In a multi-storey cropping system there can be competition for nutrients, sunlight and water which may affect productivity, especially when it comes to integrating vegetables into existing multi-storey cropping systems.
- In forest areas wild animals can potentially damage the crops and it is difficult to guard the vegetables as compared to fenced home gardens.
- In general, there has been some evidence of indigenous vegetable production in multi-storey systems in Africa, however this system is disappearing due to changes in farming systems and climatic conditions.



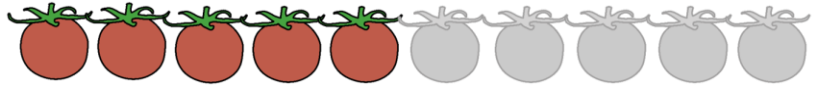
Vegetable crops grown under trees © Edossa Etissa

2. Why vegetables and fruits are required for the daily diet

Fruits and vegetables in the Ethiopian diet

The NutriHAF Africa project intends to integrate appropriate vegetables into multi-storey cropping systems to increase nutrition security and to diversify and intensify agriculture. In the framework of this study, 308 rural households in Yayu biosphere reserve, Ilu Ababora Zone, Oromia National Regional State, Ethiopia were interviewed. It was found, among others, that

- Only 52% of households consumed **vegetables** on the day prior to the interview.
- Only 27% of households consumed **fruits** on the day prior to the interview.
- Only 8% of all households consumed **dark green leafy vegetables** rich in vitamin A on the day prior to the interview.



Of course seasonal variations in vegetable and fruit consumption need to be considered. In addition, the amount of vegetables and fruits consumed is important. A similar picture as in the NutriHAF project was found by another study in Ethiopia (Ruel et al. 2005):

- In Ethiopia, 93% of households consume **vegetables**

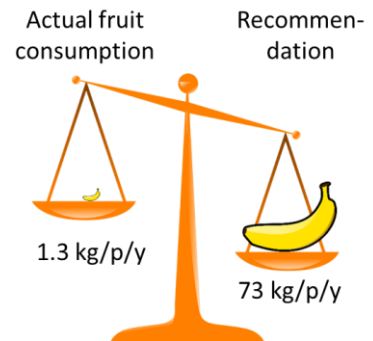
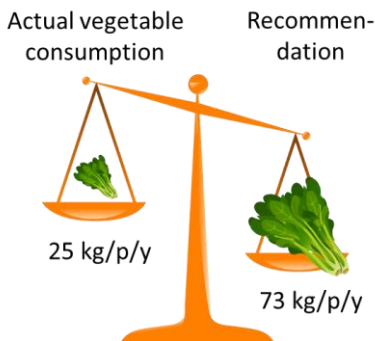


- Vegetables are consumed at an average amount of **25 kg/ person/ year**

- In Ethiopia, only 20% of households consume **fruits at all**



- Fruits are consumed at an average amount of **1.3 kg/ person/ year**



The World Health Organization of the United Nations (WHO) and the Food and Agriculture Organization of the United Nations (FAO) recommends the consumption of about **73 kg/ person/ year** of vegetables and **73 kg/person/ year** of fruits (in total about 146 kg/ person/ year).

The suggested amount of about **146 kg/person/year** of vegetables and fruits (WHO/FAO) is not reached in Ethiopia by far. Next to the availability of fruits and vegetables, also the knowledge about the importance of fruits and vegetables in the diet and about a balanced diet in general is essential.

What we need to eat to stay healthy

There are many different types of nutrients, and these different nutrients are found in different foods. We often group foods into separate categories based on the kinds of nutrients that they contain. There are **six main food groups**:

Carbohydrates and fats – energy-giving foods	
Staples	Grains such as rice, wheat, maize, sorghum, teff and products made from grains for example breads; roots and tubers; green bananas
Fats and oils	Butter, cooking oil, coconut oil, sesame oil, nuts such as groundnuts and nut oils, mustard oil, avocado
Micronutrients – protective foods	
Vegetables	Dark-green, leafy vegetables like kale, spinach, amaranth leaves, cowpea leaves, pumpkin leaves, Swiss chard; other vegetables like tomato, pumpkin, squash, sweet/ hot pepper, onion, carrot, beet root, fresh/ vegetable beans and peas, lettuce
Fruits	Dark-orange or yellow fruits such as mango and papaya; orange, lemon, banana, guava, passion fruit, peach
Proteins – body-building foods	
Legumes and nuts	All types of beans, chickpea, cowpea, nuts, seeds
Animal source foods	Eggs, beef, goat, sheep, chicken, fish, milk, cheese, whey, breastmilk



Plates containing a meal from all six food groups: different types of vegetables cooked with oil; lentils cooked with milk; rice and fruit, and chicken, respectively © G.B. Keding

A Nutritious Diet

Why do we have so much malnutrition?

Most of the foods that are locally available in Ethiopia are nutritious. The reasons why we have so much malnutrition are mainly due to the following conditions:

- People do not have access to or do not eat enough food from all six food groups.
- People do not eat regular meals spaced throughout the day.
- People do not combine foods properly to ensure a diverse diet needed for proper health, growth, and development.

What foods to eat?

There is no one single food that is complete and best. In fact, we need to eat from **every food group**, including a variety of foods throughout the week, in order to get all the types of nutrients that our bodies need.

Our food should be safe: free from all diseases or germs transferred from our hands to the food during harvesting or preparation; or through use of toxic water to irrigate vegetables or use of human feces to fertilize land.

A good meal should contain:

- A **staple** food
- Foods that may be made into a **sauce, stew or relish**. These should include:
 - a) **legumes** and/or foods from **animals**;
 - b) at least one **vegetable**;
 - c) some **fat or oil** (but not too much) to increase the energy and improve taste.
- **Fruits** eaten with a meal or as a snack
- Plenty of clean **water** during the day

Avoid drinking black tea or coffee until 1-2 hours after a meal (when food will have left the stomach) as these reduce the absorption of **iron** from food.



Fruits and vegetables in a market in Addis Ababa © S.K. Kriesemer

How to increase variety in the diet?

Encourage families to use:

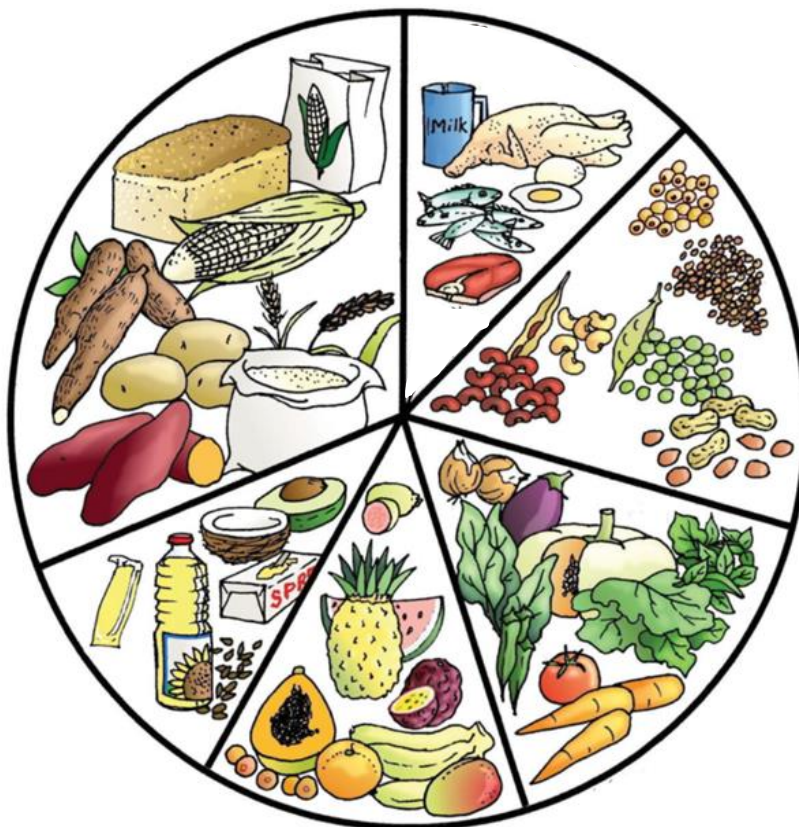
- **Several groups of foods** at each meal;
- **Different vegetables and fruits** at different meals because different vegetables and fruits contain varying amounts of the different micronutrients;
- Either legumes or – if possible – meat, poultry, offal or fish daily because these foods are the best sources of iron and zinc (which are often lacking in diets, especially the diets of young children and women).

The foods listed above can provide adequate amounts of all necessary nutrients if consumed based on individual size, age, conditions (pregnant, lactating, sick), and level of activity.

While the specific amount of food of these different groups needs to be adapted to each individual, it is important that **everyone, regardless of age, eat from all six food groups every day**: starchy staples; vegetables; fruits; legumes and nuts; animal source foods; fats and oils.

The **exception is infants 0-6 months** who receive all the nutrients and calories they need from exclusively breastfeeding (no other food or liquid by mouth).

SOURCE: ACDI/VOCA (2016) Nutrition-Sensitive Agriculture Farmer Training; FAO (2004) Family Nutrition Guide.



The Food Circle – note the different sizes of the slices which represent the **proportion** that each food group should have in the daily diet

Image: © FAO (2012). Promoting Improved Infant and Young Child Feeding: Key Messages Book.

Nutrition information on local vegetables and fruits

Which nutrients can be found in vegetables and fruits?

Vegetables and fruits are in general rich in so-called micronutrients, namely vitamins and some minerals.

- Orange coloured vegetables and fruits such as carrot, pumpkin, squash, mango and papaya contain beta-carotene (**vitamin A**) which prevents infection and keeps the immune system working properly; it keeps the skin, eyes and lining of the gut and lungs healthy and is needed to see in dim light.
- A good source of **vitamin C** that enhances immunity and prevents diseases is citrus fruits such as oranges and lemons but also kales and sweet pepper. Vitamin C aids the absorption of some forms of iron, destroys harmful molecules (free radicals) in the body and helps heal wounds.
- Green leafy vegetables are also a good source of **folic acid** which is important to make healthy red blood cells and to prevent abnormalities in the foetus.
- Dark green leafy vegetables contain **iron** which helps in blood formation, namely to make haemoglobin, the protein in red blood cells that carries oxygen to the tissues, to enable the muscles and brain to work properly.

How to retain nutrients in foods?

The way we store, prepare and cook our food affects the nutrients in it. For example, some vitamin C and folic acid are lost during cooking. Ways to reduce nutrient losses are:

- Buying or picking vegetables and fruits on the day you use them and storing them in a cool place.
- Cleaning and cutting vegetables and fresh starchy roots immediately before cooking.
- Cooking vegetables in little water or with a stew until just tender; other cooking methods for vegetables that preserve nutrients are stir frying (i.e. frying very quickly over high heat), or sautéing (i.e. cooking in fat or oil in a pan or on a griddle).
- Eating food soon after cooking.
- We absorb the vitamin A in plant foods better when the food is cooked (but not overcooked) and eaten with fat.
- When drying leafy vegetables this should be done under shade, e.g. in a solar drier. Through open sun-drying more carotenes (vitamin A) will be lost.

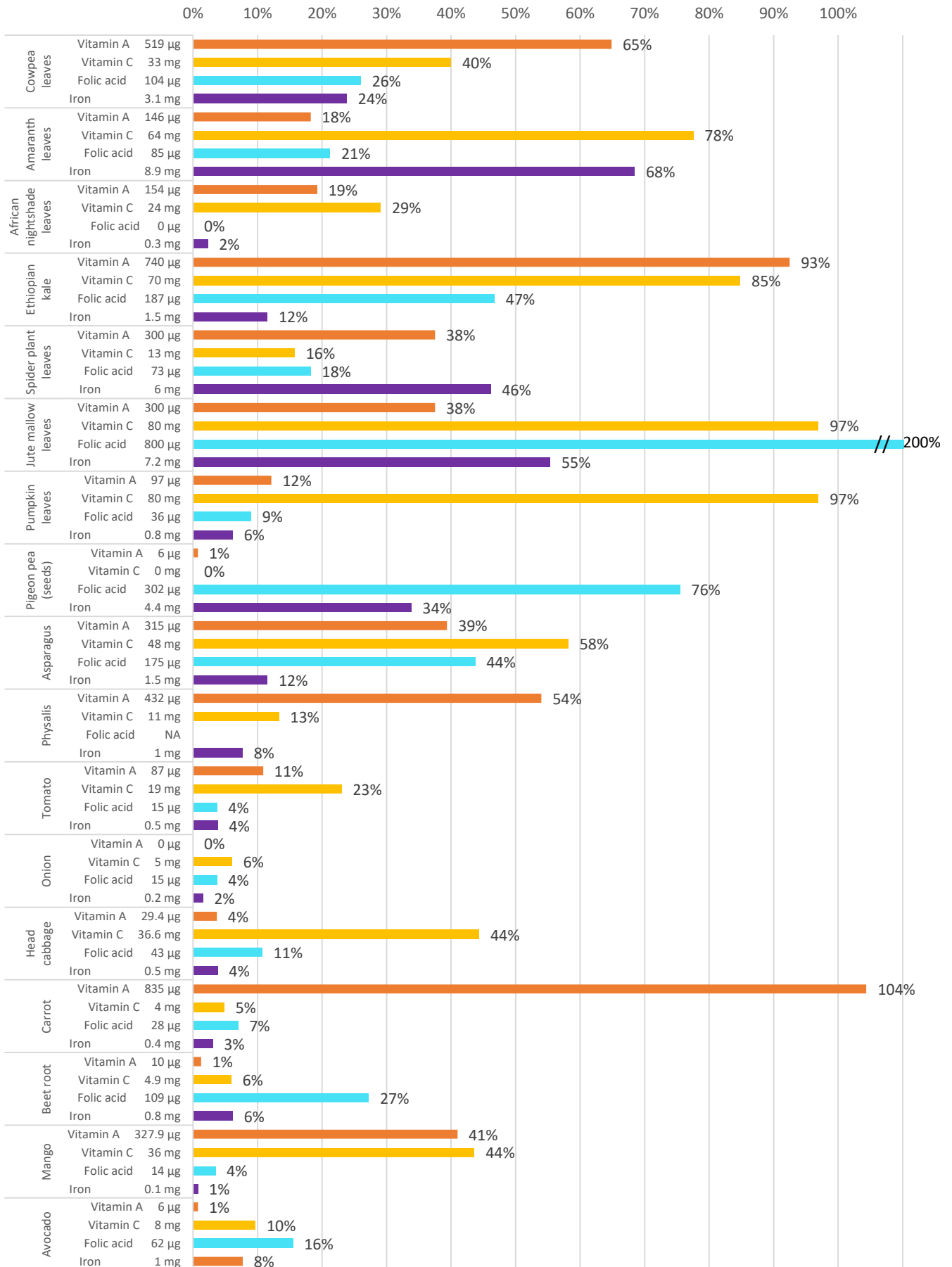


Cooking green leafy vegetables
© G.B. Keding

SOURCE: FAO (2004) Family Nutrition Guide

Nutritional characteristics of local vegetables and fruits

Nutrient content per 100g raw edible portion of vegetable/fruit and contribution in percentage to daily nutrient requirement (average for female and male adults 19-50 years)



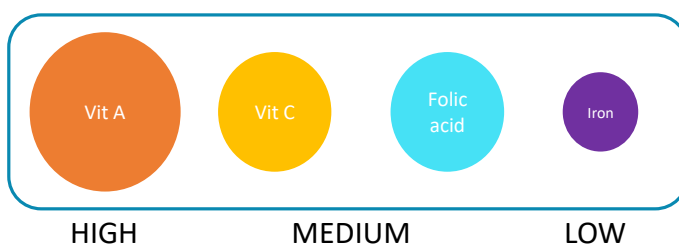
3. Priority vegetable species for multi-storey cropping systems and human nutrition

Introduction

- In chapters 3 and 4 information about cultivation and preparation of **eight different vegetable and one fruit species** is summarised.
- Those species were selected by the team members of the NutriHAF project in close cooperation with farmers and local stakeholders for the transition zone of the **Yayu biosphere, Ethiopia**, with a focus on their nutritional values and with a high potential to be cultivated under shade and thus in multi-storey cropping systems.
- The four vegetables in **chapter 3** were already tested in Yayu while information in **chapter 4** is only drawn from the literature.
- Recommendations for all crops are largely based on information from the World Vegetable Center, PROTA - Plant Resources of Tropical Africa and Useful Tropical Plants Database (see chapter 6 for references).
- Please note that most cropping recommendations are **for cultivation in the open field** and some adjustments are needed under shade, for example spacing usually needs to be wider.

How to use this guide?

- This guide can be used as a specialised dictionary to look up all information about the listed vegetable and fruit species – not only production under different conditions but also consumption issues, namely
 - Production: In which environment does the crop grow best? How is the crop cultivated? How is the crop propagated? How is the crop harvested?
 - Consumption: Which part of the crop can be eaten? What are typical nutritional characteristics of the crop? How to prepare and preserve the crop?
- Because vegetables and fruits are highly seasonal at the end of this guide a table gives an overview on seasonal availability and harvest of local vegetables and fruits so that you quickly get to know when and for how long you can harvest the vegetables and fruits.
- Nutritional characteristics: detailed information is given in the diagram on the previous page, however, to get a quick and rough idea of the nutritional characteristics of the key species, the content of vitamin A, vitamin C, folic acid and iron **in the leaves** (unless stated otherwise) is shown as circles of three different sizes depicting high, medium and low content for each crop.



- Because not only single nutrients play a role but it is in general important to eat a variety of foods including vegetables and fruits daily, please refer to chapter 2 for more information on why vegetables and fruits are important parts of the daily diet.

3.1 Amaranth leaves (*Amaranthus* spp.)

In which environment does amaranth grow best?

- Amaranth requires full sun or partial sun and high temperatures and will not perform well at temperatures below 15-18°C.
- The preferred soil type is well-drained sandy/ clayey loam or clay.
- It tolerates drought although during the dry season it needs irrigation about once a week. Without irrigation it starts flowering and stops leaf production.
- It is sensitive to frost, salinity and flooding.

How is amaranth cultivated?

- Grown throughout the year by either directly sowing in beds at a depth of 0.5-1.0 cm in rows 20-30 cm apart, or by broadcasting.
- Note that spacing **under shade** needs to be wider!
- Thinning is done after 3 weeks when plants have 3-4 true leaves, so that spacing is 20-30 cm between rows and 10-15 cm from plant-to-plant within rows.
- Note that all plants removed through thinning can already be used as a vegetable!



Amaranthus dubius © prota.org



Amaranthus cruentus © Scamperdale in tropical.theferns.info



Amaranthus cruentus flowering © Edossa Etissa

How is amaranth propagated?

- For seed production, the recommended spacing is 60 cm between rows and 25 cm between plants.
- Cut inflorescence before shattering. To determine if the seed is able to be harvested gently shake or rub the flower heads between your hands to see if the seeds fall readily.

How and when is amaranth harvested?

- Harvesting of leaves is usually done within 3-5 weeks of sowing, depending on the variety and crop management.
- Once-over: uproot or cut off at ground surface.
- Repeated: cut 50% of foliage and tender stem every 1-2 weeks at 15-20 cm above ground surface until flowering.

Which parts of amaranth can be eaten?

- The leaves and tender stems are eaten as a vegetable while the seeds can be used as cereal substitute.
- Leaves and young seedlings/ tender stems are served cooked, stir-fried or steamed as a relish, added to soups, or eaten raw.
- The seed is eaten raw or cooked; used as a cereal substitute, the seed is usually ground into a flour for use in porridges, bread etc.

What are typical nutritional characteristics of amaranth?

- The leaves are high in iron and vitamin C and medium rich in folic acid and beta-carotene (vitamin A).
- The seed contains 12-15% crude protein and 5-8% oil; seeds are rich in iron and calcium.

Vit A

Vit C

Folic acid

Iron

How to prepare and preserve amaranth leaves?

- Leaves may be preserved by drying or boiling and then drying to be used during the dry season.
- Leaves to be preserved for later use are generally plucked towards the end of the season.



Cooking green leafy vegetables © G.B. Keding

Recipe: Amaranth leaves with potato

Ingredients

- 3 bunches amaranth leaves
- 1 teaspoon black pepper
- 1 tablespoon mixed spices (mixed cumin, clove, cinnamon and cardamom)
- 1 kg potatoes
- 2 large onions
- 1/4 litre oil
- 2-3 tablespoons refined Ethiopian butter (optional)
- 2 cloves garlic
- 3 pieces green chilli
- 1 piece of ginger
- 2-3 tomatoes
- Drinking water
- Salt to taste

Procedure

- Wash your hands with soap and clean the preparation materials.
- Sort, wash and prepare the amaranth leaves.
- **Steam in very little water** until the amaranth leaves soften, stirring from time to time.
- Cook potatoes until they become soft.
- Clean and slice onions and green chillies.
- Clean and chop tomatoes.
- Prepare mixed spices (mixed cumin, clove, cinnamon and cardamom).
- Clean and peel the ginger and garlic, and crush together.
- Heat the oil in a pan/pot and cook sliced onion until it begins to brown and then add black pepper.
- Add cooked potatoes and about half a glass of water; **simmer for about 5 minutes**.
- Add cooked amaranth leaves and chopped tomatoes and stir well while adding about a glass of water and **cover the pan**.
- Add the crushed garlic and ginger and the mixed spices.
- Add 1/8 litres oil or refined Ethiopian butter and immediately close the pan to let vegetables absorb the aroma. Let it boil a few minutes, and then add a teaspoon of ground or sliced green chillies and some additional salt to adjust the taste.
- Serve with bread, injera or with your other favourite staple food.

3.2 Cowpea leaves (*Vigna unguiculata*)

In which environment does cowpea grow best?

- Cowpea is a warm-season drought tolerant annual crop that originated in Africa (optimal daytime temperature 25-30°C).
- It does not grow well in the cold season (<15°C).
- Determinate bushy types or indeterminate viny types are grown either intercropped or in relay with maize, cassava, groundnuts, sorghum, or pearl millet.



Cowpea (*Vigna unguiculata*) © ILRI

How is cowpea cultivated?

- Seeds are sown on ridges or flat beds at a depth of 4-5 cm.
- For spreading types, use rows 50-60 cm apart with 15 cm between plants within a row.
- For erect types, use 15-30 cm between plants within a row.
- When the crop is grown mainly for its leaves, sow on 1 m wide beds with 6 rows spaced at 15 cm apart and 10 cm between plants within a row to produce more good quality leaves.



Cowpea grown at forest margin © Edossa Etissa

How and when is cowpea harvested?

- Leaves are harvested 6-7 weeks after sowing.
- Continued harvest of leaves can take place up to 12 weeks.



Cowpea grown under coffee © Edossa Etissa

How is cowpea propagated?

- For seed production, spacing of 30 cm between rows and 15 cm between plants is recommended.
- Seeds are pre-soaked for 12 hours in warm water and sown 4-5 cm deep in the soil. The seed germinates best when the soil temperature is above 21°C.
- After harvest, seeds are dried for 4-6 days and stored in a cool dry place.

Which parts of cowpea can be eaten?

- The leaves and the immature seeds and pods of cowpea are eaten as vegetables.
- The tender seedless cowpea pods are sometimes used as a vegetable either fresh, steamed, cooked, stir-fried or sautéed.
- The mature seeds are used cooked in soups, stews or purees; they also can be ground into flour or fermented.
- The roots are sometimes eaten, e.g. in Ethiopia and Sudan.

What are typical nutritional characteristics of cowpea?

- The leaves are extremely high in beta-carotene (vitamin A), high in vitamin E, folic acid and calcium, and medium in vitamin C.
- The green pods are medium in beta-carotene (vitamin A), folic acid and vitamin C.
- The dry seeds are extremely high in folic acid and iron and contain 24% of protein.



How to prepare and preserve cowpea leaves?

- Cowpea leaves are served steamed, boiled or stir-fried and are usually eaten with a porridge.
- Immature, green and still soft seeds are cooked to a thick soup and used as relish.
- Cowpea flour made from mature seeds can be processed into crackers, composite flour and baby foods.
- Leaves may be preserved by drying or boiling and then drying to be used during the dry season.
- Leaves to be preserved for later use are generally plucked towards the end of the season. It is believed that leaves developed towards the end of the season are tastier as they tend to grow under conditions of stress.

Recipe: Cowpea leaves with groundnuts

Ingredients

- 1 bunch of cowpea leaves
- 1 onion
- 2 carrots
- ½ cup groundnuts
- 1 cup water
- 4 tablespoons cooking oil
- 1 cup milk
- Salt to taste

Procedure

- Wash your hands with soap and clean the preparation materials.
- Wash the cowpea leaves, chop finely.
- Wash and chop the onion.
- Wash, peel, and grate the carrots.
- Roast the groundnuts and grind finely.
- Boil little water, add salt and chopped cowpea leaves, and cover the pan for 10 minutes.
- Fry the chopped onion and carrots in oil until onions are light in colour.
- Add boiled cowpea leaves and stir thoroughly.
- Mix milk with groundnut flour, add to the vegetable, and stir well while simmering for 5 minutes with the lid on.
- Season to taste and serve while hot as a relish.



Cowpea © Edossa Etissa

3.3 Pumpkin leaves (*Cucurbita* spp.)

In which environment does pumpkin grow best?

- Pumpkin can be grown from the temperate zone to the tropics, as long as there is a warm growing season of at least 150 days.
- It requires a rich, well-drained moisture retentive soil and a very warm, sunny and sheltered position.
- Pumpkin can be grown at elevations up to 2,400 metres in the tropics.
- It grows best in areas where annual daytime temperatures are within the range 20-30°C, but can tolerate 10-40°C. It can be killed by temperatures of 0°C or lower.
- It prefers a mean annual rainfall in the range 600-1,600 mm, but tolerates 300-2,800 mm.

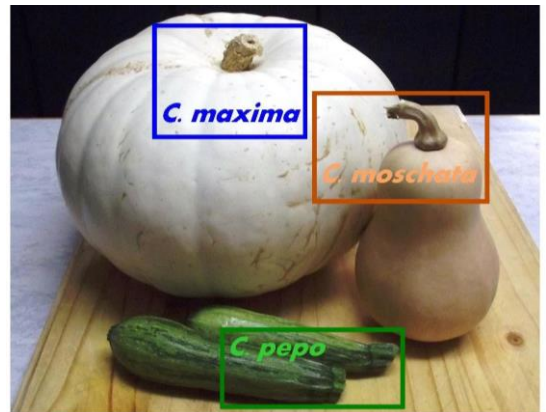
How is pumpkin cultivated?

- It can be grown as a monocrop or intercropped with maize and other field crops.
- Seeds are directly sown in 15 cm deep furrows, or sown in containers (about 5 cm deep) for transplanting.
- Space plants 60-120 cm apart in rows 90-120 cm apart.



Pumpkin leaves © Gedefa Daba and Matiws Bekele

- There are three major species in this genus that are cultivated for their fruits (*C. maxima*, *C. moschata* and *C. pepo*), and they are often not easy to distinguish.
- Distinction is easiest by observing differences of the fruit stalk, stems and leaves.



Three different *Cucurbita* species ©Roots 'n' Shoots <http://rsandss.blogspot.de/2012/11/fruits-of-month-squash-pumpkin.html>

How is pumpkin propagated?

- Seeds can be sown directly in the soil or in containers.
- Germination should take place within 2 weeks.
- When starting in containers, sow 2 or 3 seeds per pot and thin out to keep the best plant. Plant out when they are about 10 cm tall.
- If grown for seed production, isolation between fields of musk pumpkin and of other *Cucurbita* species is recommended, not only to maintain seed purity, but also to obtain maximum yields, since pollen of other species may cause reduced fruit set.

How and when is pumpkin harvested?

- Pumpkin fruits are picked about 4-6 weeks after flowering and can be harvested in several rounds until the crop stops producing, 90-120 days after planting.
- Young leaves can be harvested continuously while leaving sufficient leaves on the plant for long-standing growth.

Which parts of pumpkin can be eaten?

- The fruits are eaten cooked or baked. The flesh can be dried and ground into a powder then used in making breads etc.
- Leaves and young stems can be cooked and used as any other leafy vegetable, as a potherb or added to soups, stews etc.
- Seeds can be consumed raw or cooked and an edible oil is obtained from them.
- Also flowers can be eaten cooked.

What are typical nutritional characteristics of pumpkin?

- Fruits of *C. pepo* are especially high in beta-carotene (vitamin A), *C. moschata* and *C. maxima* are rich in calcium.
- Leaves are high in vitamin C, calcium and medium in beta-carotene (vitamin A).
- Seeds are a good source of iron and zinc and rich in oil with a pleasant nutty flavour.



How to prepare and preserve pumpkin leaves?

- The fruits of some varieties are used as soon as they are harvested, though others can be stored for several months (some up to 9 months) after their harvest.
- Leaves and young stems can be steamed, cooked or stir-fried
- Leaves may be preserved by drying or boiling and then drying to be used during the dry season.



Pumpkin tips © Gedefa Daba and Matiwos Bekele



Cooking green leafy vegetables © G.B. Keding

Recipe: Pumpkin soup

Ingredients

- ½ kg pumpkin fruit
- 2 carrots
- 2 tomatoes
- 2 potatoes
- 2 onions
- 2 litres drinking water
- 1 teaspoon black pepper powder
- 2 cups milk
- 2 tablespoons butter
- Salt and spices to taste

Procedure

- Wash your hands with soap and clean the preparation materials.
- Wash and peel the pumpkin, carrots, tomatoes, and potatoes; chop into cubes.
- Peel the onions and chop finely.
- Boil the vegetables with water and salt for about 15 minutes or until soft.
- Stir well, or blend the mixture.
- Add black pepper powder, milk, and butter. Bring to a boil; stir well for 5 minutes.
- Season to taste with salt and your favourite spices, serve while hot.
- Variation: Use any other fat or oil which is available instead of butter.

Pumpkin leaves can be prepared in the same way as any other leafy vegetables, e.g. like

- Amaranth (see 3.1 recipe for amaranth leaves with potato) or like
- African nightshade (see 4.1 recipe for nightshade relish)

3.4 Jute mallow (*Corchorus olitorius*)

In which environment does jute mallow grow best?

- An indigenous vegetable that grows in a range of soil types (except clay soils) and thrives in areas with prolonged moisture (flood-tolerant) and hot weather.
- It is usually grown as a rainfed crop under minimal management.

How is Jute mallow cultivated?

- Seeds can be directly sown in the field or sown in nursery and transplanted.
- Direct sowing is mainly applied for once-over harvest by uprooting or low cutting at soil level.
- Otherwise thin when seedlings are 7-10 cm high, leaving 1-2 plants/hole spaced 25 cm apart.
- In the field, seeds can be sown on raised ridges or flat beds at 25 cm within rows and 30-50 cm between rows.
- For the more common harvesting by repeated cuttings, 10-20 g seed per 10 m² is sown in a nursery in well-loosened soil. When the seedlings are 5-10 cm tall, they are transplanted at a spacing of 15-20 cm in the row and 30-50 cm between the rows.
- Dig cattle or chicken manure or compost into the soil either before sowing or during the growing season for best results.



How is Jute mallow propagated?

- Pre-soak the seed for 24 hours in warm water and then sow in the soil.
- Keep a few plants for harvesting seeds in the garden or field until fruit maturity.
- For a good seed yield of 25 g per plant and more, a spacing of 50 cm between and within the row is recommended.
- The seed is ripe when all the leaves have dropped, depending on the variety.
- For own on-farm seed production, the stems with fruits are harvested, and after drying in the sun they are kept until the next season.
- Well-dried seed keeps a high germination capacity for several years.

How and when is Jute mallow harvested?

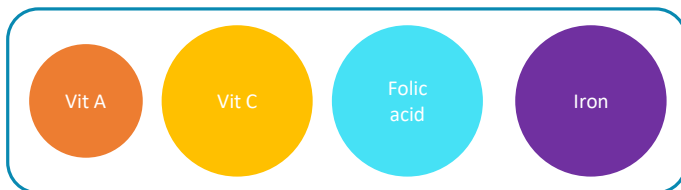
- Direct sown crop: the first harvest consists of thinned plants with their roots.
- The next harvest will be tops picked at about 15 cm above ground, repeated 3-4 times.
- For a once-over harvest from a direct sown crop, the plants are uprooted or cut at ground level when they are 30-40 cm tall, 3-5 weeks after emergence and before development of fruits.
- Transplanted crop: The first harvest by cutting shoots 20-30 cm long may take place 4-6 weeks after transplanting at a height of 10-20 cm above the ground. This cutting stimulates the development of side shoots.
- Subsequently every 2-3 weeks a cutting may take place, in total 2-8 cuttings.

Which parts of Jute mallow can be eaten?

- Jute mallow is used as a leafy vegetable.
- Leaves can be eaten raw or cooked: young leaves are added to salads whilst older leaves are cooked as a pot-herb.
- The dried leaves can be used as a thickener in soups or an infusion can be made from them.
- Young shoots are consumed together with the leaves depending on the harvesting method.
- Immature fruits are added to salads or used as a potherb.

What are typical nutritional characteristics of Jute mallow?

- The leaves are high in vitamin C, iron and folic acid and medium rich in beta-carotene (vitamin A).



How to prepare and preserve Jute mallow?

- The cooked leaves form a mucilaginous sauce, comparable to okra.
- A powder prepared from dried leaves is used to prepare this sauce during the dry season.
- The immature fruits, called bush okra, are also dried and ground to a powder for the preparation of this slimy sauce.
- In East Africa several recipes exist, e.g. Jute mallow may be cooked with cowpeas, pumpkin, cocoyam leaves, sweet potato, milk and butter, meat, and flavoured with peppers and lemon.



Cooked Jute mallow leaves with beans kik
© Adamassu Tesso

Recipe: Jute mallow with beans kik

Ingredients

- 4 bunches Jute mallow leaves
- 600 g beans kik
- 2 large onions
- 3 pieces green chilli
- 2-3 tomatoes
- 1 tablespoon mixed spices (cumin, clove, cinnamon and cardamom)
- 1 teaspoon black pepper
- 2 cloves garlic
- 1/4 litre oil
- 2-3 tablespoons refined Ethiopian butter (optional)
- 1 piece of ginger
- Drinking water
- Salt to taste

Procedure

- Wash your hands with soap and clean the preparation materials.
- Sort, wash and chop the Jute mallow leaves.
- Cook until the jute mallow leaves soften, stirring from time to time. Remove from the fire, drain in a sieve and rinse with cool water. Squeeze out the water and shape the leaves into balls then cut into small pieces.
- Cook beans kik until it becomes soft.
- Clean and slice onions and green chillies.
- Clean and chop tomatoes.
- Prepare mixed species (cumin, clove, cinnamon and cardamom) and black pepper.
- Clean and peel the garlic and crush.
- Heat half of the oil in a pan/pot and cook sliced onion until it begins to brown and then add black pepper.
- Add cooked beans kik and about half a glass of water; **simmer for about 5 minutes.**
- Add cooked Jute mallow leaves and chopped tomatoes and stir well while adding about a glass of water and **cover the pan.**
- Add the crushed garlic and the mixed species.
- Add 1/8 litres oil or refined Ethiopian butter and immediately close the pan to let vegetables absorb the aroma. Let it boil a few minutes, and then add a teaspoon of ground or sliced green chillies and some additional salt to adjust the taste.
- Serve with bread, injera or with your other favourite staple food.

4. Potential future vegetable and fruit species for multi-storey cropping systems and human nutrition

4.1 Pigeon pea (*Cajanus cajan*)

In which environment does pigeon pea grow best?

- Pigeon pea is a perennial crop that can be grown in marginal soils.
- It is drought-resistant and can be grown in areas with less than 650 mm annual rainfall.

How is pigeon pea cultivated?

- Planting arrangements vary widely, and seeds may be broadcast or sown in rows with plant spacings of 40-200 cm × 20-180 cm.
- Seedlings are difficult to transplant.
- It fits well in intercropping and multi-storey cropping systems because its slow initial growth reduces competition with the associated crop and its late maturity spreads labour requirements at harvest time.
- After harvest of the intercrop, long-duration pigeon pea continues to grow and to produce seed and thus to protect the soil.
- Pigeon pea performs well when grown in single rows alternating with 2 rows of cereals (e.g. sorghum, millets, maize), cotton, groundnut or cassava.

How is pigeon pea propagated?

- Propagation is done by seed: sow in the soil during the wet season, placing the seed 2-3 cm deep in the soil.
 - Two seeds are often planted per station, thinning to the best plant.
- Note that all plants removed through thinning can already be used as a vegetable!
- The seeds germinate at temperatures of 19-43°C, but most rapidly at 20-30°C.
 - Emergence is complete 2-3 weeks after sowing.
 - Vegetative development starts slowly, but after 2-3 months growth accelerates.

How and when is pigeon pea harvested?

- Immature pigeon pea pods are picked over a long period of time in home gardens or hedge crops.
- Under shade, young leaves can be harvested like the immature pods.
- For ripe seeds the crop is usually cut near the ground when most pods are mature; many leaves are still green at that stage.
- Alternatively, the ripe pods are picked from the standing crop, sometimes in several rounds as the crop often matures unevenly.



Leaves and flowers of pigeon pea © ILRI



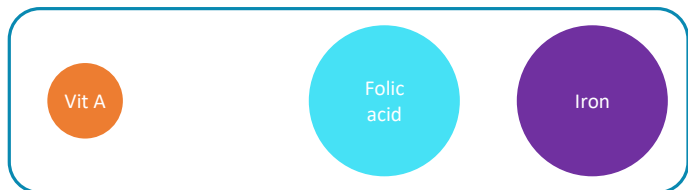
Pods of pigeon pea © cdn.croptrust.org

Which parts of pigeon pea can be eaten?

- Leaves and young shoots can be eaten as a vegetable. They have a strong, spicy odour, with a flavour that is not agreeable to everyone. The leaves quickly become fibrous.
- Very young seeds can be eaten like peas.
- Mature seeds can be used in a dried form.
- The unripe seedpods are also consumed cooked. The pods can be harvested as soon as the seeds become apparent.

What are typical nutritional characteristics of pigeon pea?

- The seeds are a good source of protein and are high in folic acid, iron (as shown below) and zinc.
- The leaves contain 15-24% crude protein.



How to prepare and preserve pigeon pea?

- Leaves and young shoots are cooked and used as a vegetable.
- Very young seeds can be cooked like peas, going well in rice dishes.
- The seed may be used instead of soya bean to make tempeh or tofu, and can also be sprouted and eaten when about 25 mm long.
- The unripe seedpods are eaten in curries or other mixed dishes.
- Mature seeds are dried to keep them for some time; they can be added to soups and stews.

Recipe: Pigeon pea pods with butter

Ingredients

- About ½ kg pigeon pea pods
- 2-3 tablespoons butter or vegetable oil
- 1 cup water
- Salt and pepper to taste

Procedure

- Wash your hands with soap and clean the preparation materials.
- Sort and clean the pigeon pea pods and wash.
- Heat a pan, add the butter or oil and shortly afterwards the pigeon pea pods.
- Add salt and pepper and little water and stir-fry the pigeon pea pods for a few minutes until the water has gone.
- Serve while hot as a side dish.



Pigeon pea grown next to coffee © Edossa Etissa

4.2 African nightshade (*Solanum* spp.)

In which environment does African nightshade grow best?

- Nightshade can be grown throughout the year if water is available but it is sensitive to drought. Yet, it requires less water than fruity vegetables like tomato and sweet pepper.
- It requires full or partial sun and high temperatures and is sensitive to frost.
- Preferable soil types are sandy loams to friable clays.
- Several species are grown for their nutritious leaves, including *Solanum americanum*, *S. scabrum* and *S. villosum*.

How is African nightshade cultivated?

- Seeds are sown directly at the beginning of the rainy season.
- Mix seeds with sand, ash, soil, or dry poultry manure at 1:3 to make them easier to sow at about 1 cm apart in rows 15-20 cm apart.
- A few (3-10) seeds are used per hole when sown among other crops in an intercropping system. The strongest plants are kept and the others removed as the first harvest or for transplanting.
- After 4-6 weeks, seedlings with 4-6 true leaves are transplanted using 20 x 20 cm spacing for continuous picking in home gardens.
- Note that spacing **under shade** needs to be wider!
- A wider spacing is also used when the crop is to be kept for a long period, encouraging stronger branches and an extended harvest period for which additional fertilizing is needed.
- Branching is stronger at a wider spacing, making up for the lower number of plants. Close planting is mainly used when the growing season is expected to be short or with once-over harvesting.
- Adequate water is needed just before and immediately after transplanting since roots are sensitive to drought.
- Direct sowing during the wet season results in taller plants and, when there is adequate room, in more and larger leaves and branches and higher dry matter content than with transplanting.

How is African nightshade propagated?

- Propagation of *Solanum scabrum* is by seed and, less commonly, by cuttings.
- Transplant seedlings are spaced 50 x 50 cm for seed production considering that plants may reach 1 m in height (if not trimmed).
- Seed production takes about 4-6 months after thinning and transplanting.
- Ripe fruits are fermented for 24 hours in water, and then the seed is washed, dried, packed and stored in a cool dry place.
- When propagation by cuttings is practised, cuttings of 20-30 cm length are taken from the main stem and are trimmed before they are inserted into the soil.
- The advantage of this propagation method (by cuttings) is that the first harvest can start early (3-4 weeks after planting). However, the total yield is lower than from transplanted seedlings or from plants sown directly.

How and when is African nightshade harvested?

- The first harvest is about 5 weeks after transplanting and continues for 9 months.
- To maximize leaf yield, the side and main stem should be cut about 5-10 cm from the tip to allow side shoots to develop, which will allow 3-4 pickings per plant at 7-14 days intervals.



African nightshade © Bioversity international/
T.Borelli

Which parts of African nightshade can be eaten?

- Only the yellow to orange coloured fruits of *S. villosum* are edible while those from other species are poisonous.
- However, several species are grown for their nutritious leaves, including *Solanum americanum*, *S. scabrum* and *S. villosum*.

What are typical nutritional characteristics of African nightshade?

- African nightshade leaves are medium rich in beta-carotene (vitamin A), calcium and vitamin C.
- Information about nutrient content of the yellow to orange coloured fruit of *S. villosum* is not available.
- The green fruits contain comparatively high amounts of the poisonous glycoalkaloid solanine and the less poisonous solanidine.

Vit A

Vit C

Iron

How to prepare and preserve African nightshade leaves?

- Leaves and fresh shoots of *Solanum scabrum* are widely used as a cooked vegetable. It can be very bitter in taste but this is appreciated by elderly people who may add them to their soup.
- Bitterness is reduced by discarding the cooking water and replacing it with fresh water. Some people add milk or salt to further reduce the bitterness.
- The leaf may be preserved by drying or boiling and then drying to be used during the dry season.

Recipe: Nightshade relish

Ingredients

- 1 bunch of nightshade leaves
- 1 onion
- 2 carrots
- 4 tablespoons cooking oil
- 1 cup drinking water
- 1 cup milk
- 1 cup groundnut flour
- Salt to taste

Procedure

- Wash your hands with soap and clean the preparation materials.
- Sort the nightshade leaves, wash and chop.
- Wash and chop the onion.
- Wash, peel, and grate the carrots.
- Fry the onions and carrots in oil until soft.
- Add the chopped nightshade leaves with water and salt. Stir well and simmer for 10 minutes.
- Mix milk with groundnut flour. Add to the pan and stir for 5 minutes.
- Season to taste. Serve while hot as a relish.



African nightshade (*Solanum scabrum*) © Lin et al (2009)

4.3 Spiderplant (*Cleome gynandra*)

In which environment does spiderplant grow best?

- A traditional vegetable that prefers warm sunny conditions and a range of soils including sandy loams.
- It does not cope well with waterlogging, very cold weather or shade.

How is spiderplant cultivated?

- Grown as a monocrop or intercropped with nightshade or amaranth.
- Spider plant benefits from the addition of manure or compost at 2 kg/m².
- The seeds are very small and therefore mixed with dry sand at a ratio of 1:10.
- Seeds can be sown by broadcasting or in rows 30-50 cm apart.
- Deep sowing should be avoided because it hampers germination.
- Thin plants at 15-20 cm between plants in rows or about 5 cm between plants if broadcast.
- The thinned plants are usually consumed.

How is spiderplant propagated?

- Propagation is done by seeds: use surface sowing or only lightly cover the seed and keep moist.
- The seed usually germinates in 5-14 days at 25°C.
- When large enough to handle, prick the seedlings out into individual pots and plant them out when large enough.
- Day time temperatures below 20°C depress germination but a night time fall to 20°C is necessary.
- Transplanting is only possible at the very early stage because young seedlings have a taproot with few lateral roots.

How and when is spiderplant harvested?

- To harvest, uproot whole young plants 5-6 weeks after sowing.
- Re-sowing can be done straight away.
- Young leaves and stems also can be regularly harvested as the plant grows so that new leaves are produced for up to 4 months.
- Plants older than 4 months can be cut at the base (ratooning), which allows young shoots to sprout; shoots can be harvested for 4 months.



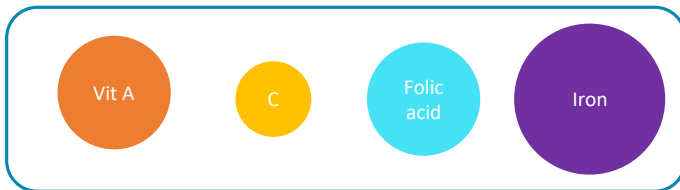
Spiderplant © Pau Pámies Gràcia, wikimedia.org

Which parts of spiderplant can be eaten?

- The tender leaves are used raw or cooked as a potherb.
- The leaves provide a piquant taste, or a sourness, to the meal.
- Also the young shoots and occasionally flowers are eaten boiled as potherb, relish, stew or side dish.
- The seeds may be used as a substitute for mustard.

What are typical nutritional characteristics of spiderplant?

- Spiderplant leaves are high in iron.
- They are medium rich in beta-carotene (vitamin A) and folic acid.



How to prepare and preserve spiderplant?

- The bitter leaves are used as a vegetable after cooking, soaking or fermentation in order to reduce the bitterness.
- Bitterness can be also reduced through cooking with milk and/or with other leafy vegetables such as cowpea leaves, amaranth, or African nightshade.
- Because of the bitter taste groundnut paste or roasted and grounded groundnuts can be added to improve the flavour (see also recipe).
- The leaves are also added to soups and stews, pickled, or used as a flavouring in sauces.
- The leaves may be blanched, made into small balls and solar- or air-dried. These balls or leaf powder can be stored up to a year and are soaked in water before being used in cooking.

Recipe: Spiderplant and groundnuts

Ingredients

- 1 bunch of spider plant leaves
- 1 onion
- 2 carrots
- ½ cup groundnuts
- 1 cup drinking water
- 4 tablespoons cooking oil
- 1 cup milk
- Salt to taste

Procedure

- Wash your hands with soap and clean the preparation materials.
- Wash the spider plant leaves, chop finely.
- Wash and chop the onion.
- Wash, peel, and grate the carrots.
- Roast the groundnuts. Grind finely.
- Boil water, add salt and chopped spider plant, and cover the pan for 10 minutes.
- Fry the chopped onion and carrots in oil until onions are light in colour.
- Add boiled spider plant leaves and stir thoroughly.
- Mix milk with groundnut flour, add to the vegetable, and stir well while simmering for 5 minutes.
- Season to taste and serve while hot as a relish.



Spiderplant © G.B. Keding

4.4 Asparagus (*Asparagus officinalis*)

In which environment does asparagus grow best?

- In tropical Africa, asparagus is primarily grown in high elevation areas in East and southern Africa.
- However, the crop can be successfully produced at low altitudes even in the tropics, though yield and spear quality are not as high as at higher altitudes.
- Deep well-drained sandy loams or volcanic soils are preferable.
- The optimum temperature for dry matter accumulation is 25-30°C, but the optimum temperature for the accumulation of food reserves in the roots may be slightly lower.
- A high relative humidity is a distinct disadvantage due to foliage diseases.

How is asparagus cultivated?

- In the tropics transplanting is done after about 8 months.
- Plant spacing in the field is normally 1.5 × 0.3 m for green asparagus production.
- Planting is in 15-20 cm deep furrows, the crown buds pointing up and the roots spread out.

How is asparagus propagated?

- Propagation is primarily by seed.
- The import of one-year old rhizomes (crowns) increases the risk of the introduction of new pests and diseases and is not economical.
- Seed is sometimes sown directly in the final growing site, but more commonly in a field nursery.
- In the nursery, seeds are sown at distances of 15 cm in the row and 35 cm between rows.
- A nursery of about 100 m² needs 0.8-1.0 kg seed, to produce 15,000-25,000 suitable seedlings (crowns) for transplanting.

How and when is asparagus harvested?

- The shoots are harvested after emergence when 18-25 cm tall as green asparagus.
- Because the spears from rhizome buds comprise the marketable yield, it is necessary to establish a large pool of stored food reserves in the swollen roots before the start of harvesting.
- It is therefore general practice not to harvest until two years after planting, and to slowly increase the harvest period from 3-4 weeks to 10-12 weeks per year from the third to the fifth year.
- Senescence of asparagus in the tropics starts earlier than in temperate areas due to the absence of dormancy.
- In the tropics the crop starts to decline fast and becomes uneconomic after 6-8 years, and in lowland areas already after 3-4 years.
- Once the old asparagus plants have been removed, the same field cannot be used for new asparagus plantings for tens of years, probably because the remaining tough old roots contain phytotoxic compounds and are infected with *Fusarium*.



Green asparagus © sydneyweeds.org.au

Which parts of asparagus can be eaten?

- The major product of asparagus is the tender young expanded shoots (spears).

What are typical nutritional characteristics of asparagus?

- The green shoots are medium rich in folic acid, vitamin C and beta-carotene (vitamin A).
- The green shoots are in general higher in micronutrients such as iron and vitamin C than the white shoots.

Vit A

Vit C

Folic
Acid

Iron

How to prepare and preserve asparagus?

- The shoots are eaten lightly cooked.
- The spears are also processed either by canning (or bottling) in brine.
- The green spears are normally eaten unpeeled while the white asparagus type is peeled prior to cooking.



Green asparagus © modernfarmer.com



Green asparagus with garlic and butter
© easynaturalfood.com

Recipe: Green asparagus with butter Ingredients

- 1 bunch fresh green asparagus
- 3 tablespoons butter
- 3 cloves garlic
- Salt to taste

Procedure

- Wash your hands with soap and clean the preparation materials.
- Wash the asparagus spears.
- Peel and finely chop the garlic.
- Melt the butter in a large pan over medium-high heat.
- Add the garlic and asparagus spears.
- Cover and cook for 10 minutes, stirring occasionally, or until asparagus is tender.
- If you like your asparagus well done, reduce heat and cook an additional 10 minutes.
- Add salt to taste and serve with your favourite starchy staple food.

4.5 Physalis (*Physalis peruviana*)

In which environment does physalis grow best?

- Physalis or Cape gooseberry is a plant of moderate to higher elevations in the tropics.
- In the tropics, elevations above 800 metres produce better yields.
- The plant grows best in areas where the mean annual temperatures are within the range 16-25°C, though it can tolerate 10-32°C.
- It prefers a mean annual rainfall in the range 1,500-2,300, tolerating 800-4,300. Plants are tolerant of light frosts.
- Succeeds in a sheltered position in any well-drained soil in full sun or light shade.

How is physalis cultivated?

- Physalis prefers a humus-rich loam but tolerates poor soils and dislikes clay soils. If the soil is too rich it encourages leaf production at the expense of fruiting.
- Temperature fluctuations during the day assist germination.
- Plant out into permanent positions when about 8-10 cm tall.

How is physalis propagated?

- Division is best done without digging up the plant. Remove young shoots that are growing out from the side of the clump, making sure that some of the below ground shoot is also removed.
- It is best if this has some roots on, but the shoot should form new roots fairly quickly if it is potted up and kept for a few weeks in a shady but humid area.
- If seeds are used for propagation, the seeds are sown in a seedbed or containers.

How and when is physalis harvested?

- A first harvest of fruits can be obtained about 3 months after sowing the seed
- Harvesting can continue for at least 3 years.
- The plant can flower and fruit all year-round when growing in frost-free areas.



Physalis fruit and flower © zimbabweflora.co.zw



Physalis fruits © pepinogold.cz

Which parts of physalis can be eaten?

- The fruits of physalis are eaten either raw or cooked
- The dried fruit is said to be a substitute for yeast.
- The plant conveniently wraps up each fruit in its own 'paper bag' to protect it from pests and the elements. This cover is toxic and should not be eaten.

What are typical nutritional characteristics of physalis?

- The fruit is high in beta-carotene (vitamin A) and in some vitamins of the B complex (thiamine, niacin and B12) and medium rich in vitamin C (no data for folic acid).
- The protein and phosphorus levels are exceptionally high for a fruit.

Vit A

Vit C

Iron

How to prepare and preserve physalis?

- The fruit is eaten raw or in pies, cakes, jellies, compotes, jams and other cooked forms.
- It has a delicious bitter-sweet flavour; it has smaller but sweeter fruits than *Physalis edulis*.
- The dried fruit can be used as a raisin substitute, though it is not so sweet.
- If picked carefully with the calyx intact, the fruit can be stored for 3 months or more.

Recipe: Physalis compote

Ingredients

- About 400g physalis fruits
- 200g sugar
- 2 lemons
- Drinking water

Procedure

- Wash your hands with soap and clean the preparation materials.
- Remove the cover ('paper bag'), wash the physalis fruits and cut in half.
- Mix water and sugar in a pot and bring to boil.
- Add the juice of the lemons and the physalis fruits and boil until fruits get soft.
- Fill into clean screw-top glasses and turn upside down for about 5 minutes.
- Please note: If no screw-top glasses are available, the compote keeps well only for a few days.



Physalis fruits © 3268zauber in tropical.theferns.info

5. When to harvest local vegetables and fruits

When and for how long can I harvest the vegetables and fruits?

Because the onset of the rain and consequently the beginning of the cropping season might vary from year to year a seasonal calendar with months is not provided. However, the time of harvest after sowing and the harvest period is known and it is shown below for all vegetables and physalis at a glance.

	Vegetable/ fruit	First harvest	Harvest period
3.1	Amaranth leaves	<ul style="list-style-type: none"> 3-5 weeks after sowing 	<ul style="list-style-type: none"> Every 1-2 weeks until flowering
3.2	Cowpea leaves	<ul style="list-style-type: none"> 6-7 weeks after sowing 	<ul style="list-style-type: none"> Continued harvest of leaves can take place up to 12 weeks
3.3	Pumpkin	<ul style="list-style-type: none"> Pumpkin fruits 4-6 weeks after flowering 	<ul style="list-style-type: none"> Young leaves can be harvested continuously while leaving sufficient leaves on the plant for long-standing growth
3.4	Jute mallow	<ul style="list-style-type: none"> Few weeks after sowing: thinned plants with their roots 3-5 weeks after emergence for a once-over harvest 4-6 weeks after transplanting 	<ul style="list-style-type: none"> Sown crop: tops picked at about 15 cm above ground, repeated 3-4 times Transplanted crop: every 2-3 weeks a cutting may take place, in total 2-8 cuttings
4.1	Pigeon pea	<ul style="list-style-type: none"> Pods: starting 5 months after sowing, depending on variety Young leaves can be harvested earlier 	<ul style="list-style-type: none"> Immature pigeon pea pods and young leaves (also under shade) are picked over a long period of time in home gardens or hedge crops
4.2	African nightshade	<ul style="list-style-type: none"> 4-6 weeks after sowing the strongest plants are kept and the others removed as the first harvest About 5 weeks after transplanting 	<ul style="list-style-type: none"> Continued harvest for up to 9 months 3-4 pickings per plant at 7-14 days intervals
4.3	Spiderplant	<ul style="list-style-type: none"> Uproot whole young plants 5-6 weeks after sowing 	<ul style="list-style-type: none"> Regular harvest of young leaves and stems for up to 4 months Plants older than 4 months can be cut at the base (ratooning), which allows young shoots to sprout; shoots can be harvested for 4 months
4.4	Asparagus	<ul style="list-style-type: none"> Do not harvest until two years after planting The shoots are harvested after emergence when 18-25 cm tall as green asparagus 	<ul style="list-style-type: none"> Slowly increase the harvest period from 3-4 weeks to 10-12 weeks per year from the third to the fifth year
4.5	Physalis	<ul style="list-style-type: none"> About 3 months after sowing the seed 	<ul style="list-style-type: none"> Harvesting can continue for at least 3 years. The plant can flower and fruit all year-round when growing in frost-free areas

6. References – further reading

- AVRDC – The World Vegetable Center: Healthy Diet Gardening Kit <https://avrdc.org/>
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Cowpea grown under coffee © Edossa Etissa



Amaranth © Edossa Etissa

Production requirements for African Indigenous Vegetables in Ethiopia

Characteristics and requirements		Cowpea	Amaranth	Ethiopian kale	Jute mallow	Pigeon pea	Pumpkin
Local name (A = Amharic, O = Oromiffa)		Yelaam Ater (A), Gaafee (O)	Amaasiloo (O)	Gomen/ Birango/ Yabesha gomen	Molokiya	Yewof ater	Buuqqee (O), Duba (A)
Botanical name		<i>Vigna unguiculata</i>	<i>Amaranthus</i> spp.	<i>Brassica carinata</i>	<i>Corchorus olitorius</i>	<i>Cajanus cajan</i>	<i>Cucurbita</i> spp.
Useable part	Leaves	✓	✓	✓	✓	✓	✓
	Tender shoots	✓	✓	✓	✓	✓	✓
	Tender pods, seeds, fruits	✓	-	-	-	✓	✓
	Dried seeds	✓	✓	✓ (mainly oil)	-	✓	✓ (also oil)
	Animal feed (forage)	✓	✓	✓	✓	✓	✓
Typical nutritional characteristics	Leaves	Beta-carotene (vitamin A), folic acid	Iron, vitamin C	Vitamin C, folic acid	Vitamin C, iron, folic acid	Protein	Beta-carotene (vitamin A), vitamin C, calcium
	Seeds/ fruits	Seeds: Folic acid, iron, protein	Seeds: Iron, calcium, protein	-	-	Seeds: folic acid, iron, zinc, protein	Seeds: iron, zinc Fruits: beta-carotene (vitamin A), calcium
Optimum temperature (°C)		8.5 - 30	18 - 28	15 - 20	>16 (25 - 32)	18 - 30	>18.5 (20 - 32)
Optimum Rainfall (mm)		400 - 700	sensitive to waterlogging	600 - 1200	600 - 2000	600 - 1000	600 – 1600 Likes constantly moist soil
Drought tolerance		✓	✓	✓	✓	✓	Less
Optimum soil pH (water)		5.6 – 6.0	4.7 - 6.4	5.5 – 8.0	4.5 - 8.2	4.5 - 8.4 (best 5.5 – 6.5)	5.5 - 7.5 Tolerating 4.5 - 8.3
Annual/ perennial		Annual	Annual	Both	Annual	Perennial	Annual
Growth in full sun		✓	✓ (C4 Plant)	✓	✓	✓	✓
Growth under shade		✓	Requires further research	Requires further research	Requires further research	Requires further research	✓ For leafy vegetable production only (no fruit)
Registered variety in Ethiopia		✓	In process	✓	No	No	No
Presence of diversity in Ethiopia		✓	✓	✓	✓	No	✓
Planting materials		Seed	Seed	Seed/ cuttings	Seed	Seed	Seed
Direct sowing		On ridges or flat beds at 5 cm depth	0.5 to 1 cm depth	0.5 to 1 cm depth	On ridges or flat beds	Place at 2-3 cm depth	In 15 cm deep furrows

✓ = yes/ possible

Production guidelines for African Indigenous Vegetables in Ethiopia



Characteristics and requirements	Cowpea	Amaranth	Ethiopian Kale	Jute mallow	Pigeon pea	Pumpkin
Nursery/ transplanting	Mostly direct sowing	Mostly direct sowing	15-20 cm between rows, 1 cm within row; thinning to 1-2 cm within row; transplanting at 4-5 leaves	Only direct sowing	Seedlings are difficult to transplant	Sown in containers for transplanting
Planting date (rainfed)	Starting at beginning of rainy season and throughout rainy season	Starting at beginning of rainy season and throughout rainy season	At beginning of and throughout rainy season. To avoid pest/disease attacks, sow 5-6 weeks before rains and transplant at onset of rains	Starting at beginning of rainy season and throughout rainy season	Starting at beginning of rainy season and throughout rainy season	Starting at beginning of rainy season and throughout rainy season
Field spacing	For leaf production: sow on 1 m wide beds, 6 rows at 15 cm apart and 10 cm between plants within a row	Rows 20 - 30 cm apart, thinning at 3-4 true leaves, after 3 weeks: 20-30 cm between rows and 10 - 15 cm between plants within row (different spacing when grown for seeds)	Transplanted at 30 cm x 50 cm About 35-40 cm within and 50-60 cm between rows	Can be sown on raised ridges or flat beds at 30-50 cm between rows and 25 cm between plants within rows	Broadcast or sown in rows with plant spacing of 40-200 cm between rows and 20-180 cm between plants within a row	For leaf production: approx. 30 x 30 cm. For fruit production: 90-120 cm between rows and 60-120 cm between plants within rows
Growth period /ready for leaf harvest	Leaf harvesting 6-7 weeks after sowing and continue up to 12 weeks	Leaf harvesting after 3-5 weeks depending on variety	Variable	First harvest can be thinned plants, next harvest consists of tops picked 15 cm above ground, repeated 3-4 times	120-430 days	Variable
Fit for intercropping	✓ Intercropped or in relay with maize, cassava, groundnuts, sorghum, or pearl millet	✓	✓	No	✓ Often grown in intercropping systems, usually with cereals, also with cassava and cotton	✓ With maize or other field crops (also back yard crop)

✓ = yes/ possible

Information compiled from:

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- PROTA – Plant Resources of Tropical Africa www.prota4u.org
- Department of Agriculture, Forestry and Fisheries, Republic of South Africa, Broshures and production guidelines, www.daff.gov.za

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