

**THE EFFECT OF SUN AND OVEN DRYING METHODS ON THE
ANTINUTRIENT CONTENT OF *AMARANTUS HYBRIDUS*, *TALINUM
TRIANGULARE* AND *TEIFAIRIA OCCIDENTALIS*.**

Okafor, Ugonna Martin* & Agbam, Ella Francis**

Introduction

These three plants belong to a group of plants classified agriculturally as vegetables. Vegetables are described as parts of plants that are consumed by humans or other animals as food. It is often regarded collectively as edible plant matter, including flowers, fruits, stems, leaves, roots, and seeds. including the flowers, fruits, stems, leaves, roots, and seeds. A vegetable is usually herbaceous plant (such as the cabbage, bean, or potato)

There are many different types of vegetables and they are often classified based on their edible parts that are used for culinary purposes. However, some veggies can fall into several categories when various parts of the plant are edible. . Flower vegetables are plants that produce flowers that are commonly used for culinary purposes such as Cauliflower, broccoli.. Leafy vegetables also known as greens, salad greens, or vegetable greens, are a good source of valuable nutrients. They can be eaten raw or cooked and are mainly grown for their leafy parts. The best examples of leafy vegetables are spinach, cabbage, lettuce. Tuber vegetables are veggies that grow underground on the root of a plant. Tuberous vegetables are usually high in starch and are used as a staple food in many parts of the world. The most commonly consumed tuber vegetables are potato, cassava, sweet potato, and yam. Root vegetables are plants that generally grow underground and are sources of edible roots. These veggies are full of valuable nutrients and also contain carbs, starches, and sugar. Examples include Carrot, beet, , celery, turmeric. Bulb vegetables are plants that grow just below the ground and produce edible. They are intensely aromatic, bulbs usually have many layers, and depending on the type can be eaten raw or used to add flavor to cooked dishes. Some of the most commonly used bulbs are onion, shallot, garlic, leek, spring onion. Stem vegetables are plants that grow above ground and have edible stems fall under stem vegetables. There are also modified stems that can be found above and below ground, such as corms, rhizomes, and tubers. Asparagus, celery, and the most popular stem vegetables. Fruit vegetables are certain types of plants that are botanically classified as fruits but are used as vegetables for culinary purposes. Tomatoes, cucumbers, eggplants avocado, bitter melon and, pepper are also good examples of fruit vegetables. Pod and seed vegetables are popularly known as legumes are types of vegetables that contain seeds inside a pod. These vegetables are a good source of protein and fiber, and also contain valuable minerals. The most popular podded vegetables are peas, beans, lentils, okra, chickpea, peanut, soybean

Vegetables are high in nutrient content and loaded with vitamins and minerals that contribute to the growth and maintenance of good health. For instance, Vegetables are high in potassium which is essential for healthy blood pressure. Vegetables are rich in antioxidants which fight cellular damage and help prevent disease. Fiber is an important nutrient found only in plant foods. Fiber helps to scour bad cholesterol out of the arteries, thus lowering the risk of heart disease. It also helps the digestive system to run smoothly and control blood sugar levels. Vegetables are also a boon to dieters because they are low in fat and calories, large quantities can be eaten without gaining weight. The fibre in vegetables also help in managing body weight because diet rich in fibre makes one fuller for a longer period, which helps eat less and aid in weight loss and maintenance. They also serve as antioxidants and loads of vitamins such as A, C, and E. A diet laden with vegetables leads to a reduction in the terminal incidence of cancer, stroke, cardiovascular disease, and other chronic ailments. Consumption of vegetables also assists in the control of high cholesterol levels and blood pressure in the body. It aids to reduce inflammation and aid digestion. Leafy vegetables are an integral part of Nigerian cuisine. They are present in almost all soups, an accompaniment to carbohydrates and served as a side.

Amaranthus hybridus is a specie of annual or short-lived perennial herbaceous plants collectively called Amaranths which are cultivated as leafy vegetables. *A. hybridus* is commonly called green amaranth, slim amaranth, smooth amaranth, smooth pigweed, or red amaranth. Amaranth greens are simply called green in Nigeria, it is called *Efo Tete* in Yoruba and *Inine* in Igbo, *Alefo* in Ghana . *Amaranthus* is rich in protein. Protein is essential for maintaining muscle mass and blood supply in the body. *Amaranthus* is also an impressive source of Iron, Calcium, Vitamin C, Phosphorous, Manganese Selenium, Magnesium, Manganese plays a key role in more than 300 enzyme reactions in the body, including immune responses, hormone creation, and even blood and bone formation.(Manuel and Isabel, 2019).

Talinum triangulare is a leafy vegetable found in open waste places with rich top soil. Yoruba call it *gbure*, Igbo named it *mgbolodi* . Waterleaf, as the plant is commonly called, is popular as a pot herb in Nigeria. *Talinum triangulare* has an advantage of perennial survival because it can be propagated vegetatively and it sets viable seeds which germinate in five days. Apart from the use of *talinum* for vegetable, it is also used as fodder for snails and supplement for chickens and turkeys; the carotenes make the yolk of the eggs of these birds yellow. *Talinum* is rich in Vitamin C, Vitamin E, Omega-3 fatty acids, calcium, magnesium, soluble fibres (pectin), potassium, β -carotene, proteins and dietary fibre. Waterleaf is a rich source of crude

protein. All these vitamins and minerals contribute to the high antioxidant value of waterleaf. (Aja *et al* 2010; Ezekwe, *et al* 2013).

Ocimum gratissimum popularly known as scent leaf; *efinrin* in Yoruba, *nchanwu* in Igbo and *daidoya* in Hausa is native to Africa and belongs to the family of Lamiaceae. It is used particularly in Igboland as a culinary herb. It is a herbaceous plant with woody main stems branching into a sub-shrub which can attain a height close to two metres and a large canopy depending on the soil quality in its habitat. The seeds are fertile and they are copious. Most of the medicinal properties of *Ocimum gratissimum* is a function of its essential oil. The leaves can be boiled and the water taken as tea; they can be blended and cooked but they are mostly used as spice. The whole plant and the essential oil have many applications in traditional medicine especially in Africa. It is commonly used in folk medicine to treat different diseases like upper respiratory tract infections, diarrhoea, headache, ophthalmic, skin diseases, pneumonia, cough, fever and conjunctivitis. Preparations from the whole plant are used as stomachic and in treating sunstroke, headache and influenza. The seeds have laxative properties and are prescribed for gonorrhoea. The essential oil which has anti-inflammatory properties is an insect repellent; it is applied against fever, inflammations of the throat, ears or eyes, stomach pain, diarrhoea and skin diseases. It is being tested as an antibiotic. The plant is also cultivated as a hedge plant. The phytochemical screening of the of the fresh scent leaf revealed the presence of alkaloids, phenols, terpenoids, glycosides, flavonoids, steroids, saponins, and tannins. The saponins present in the scent leaf have been reported to have good antibacterial, anti-inflammatory and immune-boosting properties.(Olufunke, F. 2020).

Nutrients in plants are not always easily digested. This is because plants may contain antinutrients. Antinutrients are natural or synthetic compounds that interfere with the absorption of nutrients. (Cammack *et al.*, 2006). Such antinutrients include: Phytate (phytic acid) which are mainly found in seeds, grains and legumes, phytate reduces the absorption of minerals from a meal such as iron, zinc, magnesium and calcium. Tannins may impair the digestion of various nutrients. Lectins which are found in all food plants, especially in seeds, legumes and grains. Some lectins may be harmful in high amounts, and interfere with the absorption of nutrients. Protease inhibitors interfere with protein digestion by inhibiting digestive enzymes. Calcium oxalate when bound to oxalate is poorly absorbed. Protease inhibitors inhibit trypsin, pepsin, and other proteases in the gut, preventing digestion and absorption of proteins and amino acids. Lipase inhibitors interfere with enzymes, such as lipases, which catalyze hydrolysis of some lipids and fats. Amylase inhibitors prevent the action of enzymes that break the glycosidic bonds of starches and other complex carbohydrates, preventing the release of simple sugars and absorption by the body. Phytic

acid has a strong binding affinity for calcium, magnesium, iron, copper, and zinc, preventing their absorption. Oxalic acid and oxalates bind calcium to prevent its absorption. (Attii, 2017).

The antinutrients could be reduced through the following methods: Soaking, Sprouting, Fermentation, Boiling and Drying. Antinutrient content of some plant species have been studied. (Nwokolo and Bragg, 1977; Ihekoronye and Ngoddy, 1985, Onwuka, 1992; Nwachukwu and obi, 2007). Studies on the effect of drying are few and in most cases limited to a single plant species or to a particular antinutrient content. In this study, the researchers investigated comparatively the effect of drying methods on the antinutrient content of three (3) leafy vegetables popularly used in culinary activities in Igboland, Nigeria.

Materials and Methods

Materials:

The three (3) vegetable samples were obtained from the farmland at Agulu, Anaocha L.G.A. of Anambra state. All the samples were identified by a taxonomist from Biology Education department of Federal College of Education (Technical), Umuze.

Processing of the samples:

The samples were sorted to select the good ones. Each sample was then shared into four (4) equal parts. The four (4) portions represent wet samples, sun drying samples, oven drying samples at 70°C and oven drying samples at 100°C respectively. The portion for wet analysis was ground with a mortar and pestle into a paste and used immediately for analysis. The portions for drying were dried to constant weight before grinding with blender. The powdered form was sieved using 1mm sieve. It was then stored at room temperature and used for all the analysis.

Determination of the Antinutrients:

Tannins were determined by the method of Desphandes et al. (1986). Phytic acid was determined by the method of Marfor et al. (1990). Oxalate was determined according to the method of Oke (1969). Alkaloids, Saponins and Cyanogenic glycoside were determined by the method of Cheeke (1989). Flavonoids were determined by the method of Ozo and Caygill (1986).

Results

Table 1: Antinutrient content of wet samples (mg/100g)

Samples	Tannins	Phytic acid	Antinutrient Factors		
			Oxalate	Alkaloids	Flavonoids
C.glycosides	Saponins				
A.hybridus	1.69±0.03	19.42±0.06	2.14±0.08	2.13±0.16	
	1.02±0.02	8.40±0.02			
T. triangulare	1.86± 0.03	20.85±0.06	3.40±0.01	2.40±0.06	
	1.05±0.12	6.55±0.12			
O.gravissimum	2.26±0.01	21.87±0.01	3.20±0.01	2.50±0.06	1.00±0.12
	1.25±0.32	6.67±0.12			

Table 1 shows the antinutrient content of the wet sample analysis. Tannins were found to be in the highest levels in *Ocimum gravissimum* and least in *Talinum triangulare*. Phytic acid was in the highest levels in *Ocimum gravissimum* and least *Amaranthus hybridus*. Oxalate was in the highest level in *Talinum triangulare* and least *Ocimum gravissimum*. Alkaloids were in the highest level in *Ocimum gravissimum* and least in *Amaranthus hybridus*. Flavonoids and cyanogens glycosides were found to be in low levels in the wet samples. Albeit, Flavonoids were in highest level in *Talinum triangulare* and least in *Ocimum gravissimum*. Cyanide glycosides were in highest level in *Talinum triangulare* and least in *Ocimum gravissimum*. Saponins were in the highest level in *Amaranthus hybridus* and least in *Talinum triangulare*.

Table 2: The Effect of Sun drying on the Antinutrient content of wet samples (mg/100g)

Samples	Tannins	Phytic acid	Antinutrient Factors		
			Oxalate	Alkaloids	Flavonoids
C.glycosides	Saponins				
A.hybridus	3.90±0.02	26.45±0.28	14.18±0.13	1.75±0.02	0.62±0.06
	1.67±0.16	4.00±0.17			
T. triangulare	3.35±0.02	24.23±0.05	6.45±0.05	1.86±0.03	0.61±0.02
	1.74±0.02	8.14±0.22			
O.gravissimum	3.55±0.13	25.68±0.05	0.34±0.05	0.69±0.02	0.51±0.07
	1.02±0.06	8.01±0.11			

In table 2, the result shows that there is a general increase in the levels of antinutrients in the samples. However, flavonoid levels and cyanogens glycoside levels decreased respectively.

Table 3: The Effect of oven drying at 70°C on the Antinutrient content of wet samples (mg/100g)

Samples	Tannins	Phytic acid	Antinutrient Factors		
			Oxalate	Alkaloids	Flavonoids
C.glycosides	Saponins				
A.hybridus	3.60±0.17	25.39±0.19	6.17±0.06	1.02±0.06	0.67±0.01
	2.43±0.15	8.34±0.19			
T. triangulare	1.98±0.06	22.70±0.10	17.58±0.16	1.31±0.18	0.64±0.01
	1.68±0.01	7.43±0.11			
O.gravissimum	4.54±0.04	25.25±0.22	6.17±0.02	2.88±0.01	0.77±0.01
	2.30±0.11	10.34±20.23			

In table 3, oven drying at 70°C and 100°C increased the concentration levels of phytic acid, oxalate, cyanogens glycosides and saponins as compared with the result obtained from the wet analysis of the samples.

Table 4: The Effect of oven drying at 100°C on the Antinutrient content of the samples (mg/100g)

Samples	Antinutrient Factors				
	Tannins	Phytic acid	Oxalate	Alkaloids	Flavonoids
C.glycosides	Saponins				
A.hybridus	3.78±0.47	34.39±0.19	8.15±0.06	1.03±0.06	0.67±0.01
2.63±0.16	8.30±0.19				
T. triangulare	3.46±0.08	26.50±0.22	15.51±0.12	1.32±0.01	0.55±0.01
1.68±0.12	10.82±0.21				
O.gravissimum	3.88±0.04	24.54±0.22	8.16±0.22	2.88±0.01	0.85±0.01
2.25±0.11	11.54±0.25				

In table 4, oven drying at 70°C and 100°C increased the levels of phytic acid, oxalate, flavonoids, cyanogens glycosides and saponins as compared with the result obtained In the wet sample analysis.

Discussion

Both the sun drying and oven drying (at 70°C and 100°C) impacted on the tannin concentration by increasing its levels as compared to the result obtained from wet analysis. A similar observation was made by Okoh *et al* (1982) when they carried such during experiment on varieties of sweet potatoes. Tannins are phenolic compounds that precipitate proteins. They are found in many plant foods. They are responsible for the decrease in protein digestibility. Tannins are not easily destroyed by heat due to their high molecular weight. (Osagie *et al*, 1006). Nwachukwu and Obi (2007) in a similar experiment observed that drying increased the tannin levels in some leafy vegetables. They attributed the factor to the conversion of hydrolytic tannins to condensed ones.

Phytic acid concentration levels increased after sun drying and oven drying (at 70oC and 100oC) respectively. This increase in the levels may be due to the concentration effect of the phytic acid after the loss of moisture. Phytic acid, or phytate, is found in plant seeds. It serves as the main form of storage for phosphorus in the seeds. Then, when seeds sprout, phytate is broken down and the phosphorus is released. Nwachukwu and Obi (2007) opined that in drying methods applied to plant parts, the protein component may have been denatured by heat leading to further concentrastion of pure phytic acid. Phytic acid impairs the body's absorption of iron, zinc, and calcium. It may contribute to mineral deficiencies over time, but this is rarely a concern for those following well-balanced diets. Phytic acid may have several positive health effects, such as protection against oxidative damage and insulin resistance.(Alli, 2022).

Open air drying and oven drying at 70°C and 100°C respectively also increased the concentration levels of oxalates as compared to the result of wet sample analysis. Nwachukwu and Obi (2007) suggest that this could be due to the crystal form of oxalate in plants which is not easily destroyed by heat. (Nwachukwu and Obi, 2007). Oxalates are natural compounds found in vegetables, fruits, nuts, and grains. Some examples of foods that are highest in oxalates include green leafy vegetables, soy, almonds, potatoes, tea, rhubarb, cereal grains and beets. Oxalates are also naturally created in the human body as a waste product. Oxalates can bind to calcium—and to a lesser extent—other minerals in the stomach and intestines. This binding can reduce absorption of these minerals inhibiting their ability to be used. For this reason, oxalates have been labeled an “anti-nutrient”. There are several factors that affect the level of oxalates in foods, including the growing season, weather conditions, and the plant variety. Cooking significantly reduces oxalate content in food. Although certain foods may contain residual amounts of oxalates after cooking, the health benefits of eating these foods will likely outweigh any potential negative nutritional effects. Oxalates can bind to minerals like calcium in the kidneys and form calcium oxalate kidney stones – the most common type of kidney stone. For most people, these compounds are usually removed in the urine. However, accumulation of these compounds may occur in some people potentially leading to kidney stones. (Eadon, 2022).

The alkaloid concentration levels were generally reduced during open and oven drying at 70°C and 100°C respectively as compared with the result obtained by the wet analysis of the samples. Alkaloids are a class of basic, naturally occurring organic compounds that contain at least one nitrogen atom. Alkaloids are produced by a large variety of organisms including bacteria, fungi, plants, and animals. Alkaloids have a wide range of pharmacological activities including antimalarial (e.g. quinine), antiasthma (e.g. ephedrine), anticancer (e.g. homoharringtonine), vasodilatory (e.g. vincamine), analgesic (e.g. morphine), antibacterial (e.g. chelerythrine. Other alkaloids possess psychotropic (e.g. psilocin) and stimulant activities (e.g. cocaine, caffeine, nicotine, theobromine), and have been used as recreational drugs. Alkaloids can be toxic too (e.g. atropine, tubocurarine).

Flavonoids were generally reduced in both the sun drying and oven drying at 70°C and 100°C respectively. This observation went in tandem with observations of MacWilliams (1979) when he noted that flavonoids are destroyed by increasing drying temperatures. However, flavonoids like antocyanidins are important for the strengthening of the blood capillaries and other connective tissues. Also, quercetin, another flavonoid has been implicated in the

relief of diabetic complications. (Alais and Guy, 1991). As such, flavonoids are now being considered as essential nutrients rather than antinutrients.

Slightly low levels of cyanogens glycosides were recorded in the samples. Cyanogens glycosides are precursors of hydrogen cyanide, a well-known natural toxicant in foods. Cyanide is one of the most potent, rapidly acting, poisons known. Cyanides inhibit the oxidative processes of cells causing them to die very quickly. The fact that drying further decreased the low levels of this antinutrient as found in wet samples suggest that there is no hazard associated with their presence in these vegetables.

Saponin levels generally increased after drying in the sun and in the oven respectively. Saponins are known for their hemolytic activity on human erythrocytes, which depends on the type of aglycone and sugar chains. Saponins are diverse and complex in structure and have shown effective anticancer potential in various cancer cell lines by inhibiting cell growth and by inducing apoptosis. Saponins have been reported to lower blood glucose level via rejuvenation of insulin action, increased plasma insulin level and released insulin from the pancreas. Saponins inhibit cholesterol absorption and reduce plasma cholesterol levels in experimental animals and are therefore of potential pharmacologic utility in the treatment of hypercholesterolemia.

Okafor, Ugonna Martin*

Department of Biology Education

School of Science

Federal College of Education (Tech), Umuze. Anambra State.

Agbam, Ella Francis**

Department of Biology Education

School of Science

Federal College of Education (Tech), Umuze. Anambra State.

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