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Nutritive Value and Mineral Content of Different Varieties of Citrus Fruits

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Abstract: The mineral and nutrient composition of five varieties of Citrus species: sweet orange (*Citrus sinensis*), tangerine (*Citrus reticulata*), lemon (*Citrus limonum*), lime (*Citrus aurantifolia*) and grape (*Citrus grandis*) were determined. The research showed that these citrus fruits contained crude protein (10.94-17.06%), crude fiber (5.84-7.10%), carbohydrate (70.86-77.10%), moisture (4.28-5.70%), crude lipid (0.64-1.24%), ash (4.40-7.80%) and food energy content was (347.04-363 g cal^{-1}) of fresh fruits. The most important minerals detected in the fruits include calcium (2.0-3.20%), phosphorus (0.24-0.41%), potassium (0.28-1.0%), magnesium (0.49-0.61%) and sodium (0.28-0.36%). These nutrients are indispensable for the good condition of our health. This study justifies the use of citrus fruits as food and drug in herbal medicine in Southeastern Nigeria.

Key words: Citrus fruits, proximate composition, nutritive value, energy value, medicinal properties

INTRODUCTION

In many parts of the world, citrus fruits have been part of the human diet for many years. In recent times, citrus fruits have assumed greater importance in diets of both urban and rural dwellers. The increased interest in the consumption of citrus fruits is not only due to their sweet refreshing properties but also as a result of their medicinal and nutritional values.

Citrus fruits and citrus juice have several beneficial health and nutritive properties (Okwu and Emenike, 2006). They are rich in ascorbic and folic acids as well as good source of dietary fiber.

Over the last decades, many other virtues and medicinal benefits of citrus fruits have been discovered besides the anti-scurvy property (Rapisararda *et al*., 1999). There is convincing epidemiological evidence that the consumption of Citrus fruits is beneficial to health and contributes to the prevention of degenerative process, particularly lowering incidence and mortality rate of cancer and cardio-and cerebro-vascular diseases (Rapisararda *et al*., 1999). The protection that citrus fruits provide against these diseases has been attributed to the various antioxidant phytonutrients contained in citrus spices (Okwu and Emenike, 2006; Rapisararda *et al*., 1999).

Citrus flavonoids are widely distributed group of polyphenolic compounds with health related properties, which are based in their antioxidant activity (Rio *et al*., 1997).

These properties have been found to include anti-carcinogenic, antiviral, anti-inflammatory activities, effects on capillary fragility and ability to inhibit human platelet aggregation (Rio *et al*., 1997).

In addition, some citrus flavonoids and their derivatives in the field of food technology are well known for their ability to provide a bitter or sweet taste and as bitterness inhibitor (Rio *et al*., 1997).

Apart from being rich in ascorbic and folic acids, citrus fruits are good sources of dietary fiber. They are fat free, low in sodium content and without cholesterol (Economos, 1999). Citrus fruits are also helpful to reduce the risk of pregnant women to have children with birth disease (Economos, 1999). Due to the hesperidin content as well as diosmine and other flavonoids, the citrus fruit reinforces the stability of the capillary vessels and improves venous blood flow (Rio *et al*., 1997; Economos, 1999; Roger, 2002). They are useful in cases of swollen legs, edema, varicose veins, hemorrhoids, thrombosis and emboli (Roger, 2002).

It is also recommended for people who suffer from higher blood pressure (Roger, 2002, 1999).

The citrus species are medium sized tree of the rutaceae family. They are evergreen trees that give fruits of different forms and sizes (from round to oblong) which are full of fragrance, flavor and juice. Citrus fruits have a rough, robust and bright colour (from green to yellow) skin or rind known as epicarp or flavedo which covers the fruits and protects from damages. The glands contain the essential oils that give the fruit its typical citrus fragrance.

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The endocarp is rich in soluble sugars and contains significant amounts of vitamin C, pectin, fibers, different organic acids and potassium salt which gives the fruit its characteristic citrus flavor (Roger, 2002). Citrus juice contains organic acids (citrus, malic, acetic and formic acids) (Roger, 2002).

In spite of the various uses of the citrus fruits in food and drug formulation in Nigeria, their constituents have not been fully documented, in respect of nutritional values and mineral composition. We have earlier (Okwu and Emenike, 2006) reported on the phytonutrient and vitamin composition of some citrus fruits.

This present research examines the nutritional potential and mineral contents of some citrus fruits and citrus juice as healthy foods.

MATERIALS AND METHODS

Sample collection: The experimental citrus fruits comprising sweet orange (*Citrus sinensis*), lime (*Citrus grandis)*, tangerine (*Citrus reticulata*) and lemon (*Citrus limonum)* were harvested from the National Roots Crops Research Institute (NRCRI) orchard Umudike, Ikwuano, Local Government Area of Abia State, Nigeria on 15th April 2005. The citrus species were identified by Dr. A. Nmeregini of Taxonomy Section, Forestry Department, Michael Okpara University of Agriculture Umudike, Nigeria.

Sample preparation: The epicarps of the five different citrus species were peeled out and disposed. The mesocarps and endocarps were cut into smaller particles with a sharp clean knife. This helps in reducing the surface area and thus enhances drying. They were air-dried for 6 days. The dried materials were pulverized into powdery form using a Thomas Wiley machine and stored in airtight bottles till required for analysis.

Also the juice from the 5 citrus fruit samples were pressed out from the fruits preserved and stored in airtight bottles in a refrigerator till required for analysis.

Chemical analysis: Total nitrogen content was determined by using Kjaldl apparatus (AOAC, 1984). The protein content was calculated as N×6.25, moisture, crude fat (ether extract), crude fiber and ash content were determined according to AOAC methods (1984) Total carbohydrate was estimated as the remainder after accounting for ash, crude fiber, protein and fats (Muller and Tobin, 1980).

The gross food energy was estimated according to the method of Osborne and Voogt (1978) using the equation:

$$FE = (\%\ CP\times 4) + (\%\ lipids\times 9) + (\%CHO\times 4)$$

Where:

FE = Food Energy (in gram calories)
CP = Crude Protein
CHO = Carbohydrate.

Mineral determination: The major elements comprising calcium, phosphorus, sodium, potassium and magnesium were determined according to the method of Shahidi *et al.* (1999).

The ground plant samples were sieved with a 2 mm rubber and 2 g of each of the plant samples were weighed and subjected to dry ashing in a well-cleaned porcelain crucible at 550°C in a muffle furnace. The resultant ash was dissolved in 5 mL of $HNO_3/HCl/H_2O$ (1:2:3) and heated gently on a hot plate until brown fumes disappeared. To the remaining material in each crucible, 5 mL of deionized water was added and heated until a colourless solution was obtained. The mineral solution in each crucible was transferred into a 100 mL volumetric flask by filtration through a Whatman No 42 filter paper and the volume was made up to the mark with deionized water. The solution was used for elemental analysis by atomic absorption spectrophotometer. A 10 cm-long cell was used and concentration of each element in the sample was calculated according to the percentage of dry matter.

Phosphorus content of the digest was determined colorimetrically according to the method described by Nahapetian and Bassiri (1995).

To 0.5 mL of the diluted digest 4 mL of demineralized water, 3 mL of 75 m H_2SO_4, 0.4 mL of 10% $(NH4)_6Mo_7O_{24}$ $4H_2O$ and 0.4 mL of 2% w/v ascorbic acid were added and mixed. The solution was allowed to stand for 20 min and absorbance readings were recorded at 660 nm. The content of phosphorus in the extract was determined.

RESULTS

The nutrient compositions of the citrus fruits are shown in Table 1. The moisture content of the citrus fruits ranged from 4.28% in *C. sinensis* to 6.24 obtained in *C. grandis*. The highest protein content was obtained from *C. Sinensis* (17.06%) followed by *C. limonum*, which contained 14.44% while *C. aurantifolia* contained the least protein (10.94%).

Similarly, the value for crude fiber was found to be highest in *C. grandis* (7.10%) followed by *C. limonum* (6.78%) while *C. reticulata* contained the least crude fiber (5.84%). The ash content ranged from 4.40% obtained in *C. reticulata* to 7.80% in *C. aurantifolia.* The results of fats and oil was low in *C. aurantifolia, C. limonum* and *C. reticulata* which contained 0.64, 0.68 and 0.84%, respectively while the highest value of fats and oil were obtained in *C. grandis* (1.24%).

Table 1: Proximate composition (%) and food energy (g cal^{-1}) values of citrus species

Citrus species	Moisture	CP	CF	Ash	Lipid	CHO	FE
C. reticulata	5.70±0.10	11.81±0.01	5.84±0.10	4.40±0.20	0.84±0.10	77.10±0.10	363.20
C. curantifolia	5.80±0.20	10.94 v 0.20	6.24 v 0.20	7.80 v 0.10	0.64±0.10	74.38±0.10	347.04
C. limonum	6.14±0.11	14.44±0.20	6.78±0.11	5.80±0.20	0.68±0.11	72.30±0.20	353.08
C. grandis	6.24±0.10	13.13±0.10	7.10±0.20	5.10±0.11	1.24±0.10	73.42±0.10	357.36
C. sinensis	4.28±0.10	17.06±0.10	5.88±0.11	5.10±0.20	1.10±0.10	70.86±0.11	361.58

Data are means of triplicate determination±standard deviation, DM = Dry Matter, CP = Crude Protein, CF = Crude Fiber, CHO = Carbohydrates; FE = Food Energy

Table 2: Mineral composition (g 100 g^{-1} DM) of the citrus species

Citrus species	P	K	Mg	Na	Ca
C. reticulata	0.25±0.10	0.47±0.20	0.49±0.11	0.33±0.20	2.41±0.22
C. aurantifolia	0.29±0.11	1.00±0.10	0.61±0.20	0.36±0.11	2.81±0.10
C. limonum	0.38±0.20	0.37±0.11	0.49±0.10	0.33±0.02	2.00±0.10
C. grandis	0.24±0.10	0.28±0.02	0.49±0.10	0.28±0.10	3.20±0.11
C. sinensis	0.41±0.22	0.82±0.10	0.49±0.20	0.33±0.30	2.00±0.10

Data are means of triplicate determination±standard deviations, DM = Dry Matter

All the citrus fruits contained carbohydrate ranging from 70.86% obtained from *C. sinensis* to 77.10% found in *C. reticulata*. The energy values ranged from 347 cal g^{-1} in *C. aurantifolia* to 363.20 cal g^{-1} in *C. reticulata.*

The mineral contents of these citrus fruits are shown in Table 2. Calcium was the most abundant macro element present ranging from 2% in *C. sinensis* to 3.20% in *C. grandis*. This is followed closely by potassium, which was present from 0.28% in *C. grandis* to 1.0% obtained in *C. aurantifolia*. The value for sodium was low in all the citrus fruits.

DISCUSSION

Results on the proximate and mineral values of the citrus fruits investigated clearly indicated the citrus fruits as source of quality food. They are not only sufficiently rich in calories but also contain adequate quantities of other essential nutrients such as proteins, vitamins, phyto -nutrients and minerals (Okwu and Emenike, 2006).

Citrus fruits generally have low fat content. Thus making an ideal fruit for people suffering from cancer of the colon, coronary diseases or thrombosis. More importantly is that citrus fruits are usually recommended as part of weight reducing diets (Roger, 1999). The fat content is low and mainly devoid of saturated fatty acids. Citrus fruits are good examples of healthy foods since they contain little fat (Akobundu, 1999). They provide dietary fiber, softer stools and enhance frequent waste elimination, including bile acids, sterols and fat (Akobundu, 1999). Citrus fiber acts as an authentic broom in the intestine; absorbing toxins and carrying out harmful substances such as biliary acids, the precursors of cholesterol (Roger, 1999). Citrus fiber when taken swells with water, this however increases in volume many times. This consequently gives consistency to the feces and facilitates its transit through the colon until it is expelled through the rectum. When the diet contains little fiber, the feces are hard, dry and concentrated. This eventually causes the intestine to make effort to eliminate them. This causes or worsens several problems such as intestinal diverticulum, hemorrhoids and even cancer of the colon (Roger, 2002, 1999).

Even though citrus fiber does not provide energy, nor passes to the blood directly, it is an indispensable component of a healthy and balanced diet. This is because it is devoid of intestinal constipation. Fiber has a physiological effect on the gastrointestinal function of promoting the reduction of tracolonic pressure, which is beneficial in diverticular disease such as cancer of the colon and hemorrhoids (Roger, 1999; Akobundu, 1999).

Fiber also has a biochemical effect on the absorption and reabsorption of cholesterol and bile acids, respectively. Citrus fiber aids the excretion of bile acids and prevents the reabsorption of bile acids and consequently the absorption of dietary fat cholesterol. This in turn lowers the cholesterol pool and prevents the formation of plaque whose components are cholesterol, some fat and protein (Akobundu, 1999).

Citrus fruits have high calorific value. This may be due to the carbohydrate content which supplies the energies in calories. The carbohydrate content also acts as mild natural laxative for human being. They also add to the bulk of the diet.

The carbohydrate content of citrus fruits comprises mainly of dietary fiber, sucrose, glucose and fructose. With the exception of dietary fiber, all other carbohydrates (glucose, fructose and sucrose) are water soluble and sweet-tasting sugars. People with diabetes must always use sugars in moderation, remembering that the same amount of sugars is better tolerated when taken in its natural form in fruits containing vitamins, organic acids and phytochemicals (Roger, 2002).

In addition to the elements found in carbohydrates, fats and proteins the body needs many other elements to maintain good health. These additional elements required by the body for healthy living comprises phosphorous, calcium, magnesium and trace elements such as iron and iodine. A lack of calcium or phosphorus in the diet causes a disease known as rickets (Fliedner and Teichman, 1965) and osteoporosis (Hunt *et al.*, 1980) disease normally results due to lack of calcium. In osteoporosis condition, the bone mass is so decreased that adequate mechanical support can no longer be provided and sustained, spontaneous fractures often results (Hunt *et al.*, 1980). It occurs more on the adults' humans, particularly women. Improvement of nutritional status as mode of combating osteoporosis has revolved around increased intake of calcium and fluorine (Hunt *et al.*, 1980). This can be derived through citrus consumption.

However, the sodium content in citrus fruits is low. This is an added advantage due to the direct relationship of sodium intake with hypertension in human (Dahl, 1972).

The outcome of this investigation has greatly elucidated the nutritive composition of the citrus fruits as quality food with good medicinal properties.

REFERENCES

Akobundu, E.N.T., 1999. Healthy foods in human nutrition. J. Sustain Agric. Environ., 1: 1-7.

AOAC, 1984. Official Methods of Analysis. 14th Edn., Association of Official Analytical Chemists Washington DC.

Dahl, 1972. Salt and Hypertension. Am. J. Clin. Nutr., 25: 231-238.

Del-Rio, B.G. Obdulio, J. Castillo, F.R. Marin and A. Ortuns, 1997. Uses and properties of citrus flavonoids. J. Agric. Food Chem., 46: 4505-4514.

Economos, C., 1999. Nutrition and Agriculture FAO Publication.

Fliedner, L.J. and L. Teichman, 1965. Chemistry man's servant. Allya and Bacon, Inc., Boston, pp: 493.

Hunt, S.M., J.L. Groff and J.M. Holbrook, 1980. Nutrition; principles and clinical practice. John Wiley and Sons New York, pp: 451-452.

Muller, H.G. and G. Tobin, 1980. Nutrition and Food processing. Croom Helm Ltd., London.

Nahapetian, A. and A. Bassiri, 1995. Changes in concentration and interrelationships of phytate, P, Mg, Cu, Zn, in wheat during maturation. J. Agric. Food Chem., 23: 1179-1182.

Okwu, D.E. and I.N. Emenike, 2006. Evaluation of the phytonutrients and Vitamins content of citrus fruits. Int. J. Mol. Med. Adv. Sci., 2: 1-6.

Osborne, D.R. and P. Voogt, 1978. Calculation of calorific value. In: Analysis of Nutrients in roots. Academic Press New York, pp: 239-240.

Rapisararda, P., T. Antonio, L.C. Rossella, B. Prancesco, O.P. Anna and S. Antonella, 1999. Antioxidant effectiveness as influenced by phenolic content of fresh orange juice. J. Agric. Food Chem., 47: 4718-4723.

Roger, G.D.P., 1999. New Life style, enjoy it, editorial safeliz S.L. Spaim, pp: 75-76.

Roger, G.D.P., 2002. Encyclopedia of medicinal plants. Education and health library editorial safeliz S.L. Spalm, 1: 153-154; 265-267.

Shahial, F., U.D. Charah, A. Bal and D.B. Makenzie, 1999. Chemical composition of beach pea (*Lathyrus maritimus* L.). Plants Food Chem., 64: 39-44.