



International Journal of Food and Nutrition Research (ISSN:2572-8784)



Nutrients, phytochemicals and antioxidant properties of two varieties of tropical almond (*terminalia catappa*) pulp

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ABSTRACT

Ripe fruits of tropical almond (*Terminalia catappa*) of red and yellow varieties were collected from National Root Crops Research Institute (NRCRI) Umudike environs. The pulp was analyzed as eaten. The nutrient compositions were determined using AOAC techniques. Minerals were determined using wet acid digestion method for multiple nutrient determinations as described by AOAC. Gravimetric and spectrophotometric methods were used for phytochemical determinations. The anti-oxidant activity of the extracts was measured in terms of hydrogen donating or radical-scavenging ability using the stable free radical 1.1-diphenyl-2-picrylhydrazyl (DPPH). Means and standard deviation were calculated and compared using student t-test. Tropical almond had moisture (82.74 – 83.68%), fiber (1.69 -1.74%), fat (0.06 – 0.07%) Protein (1.27 – 1.32%). predominate minerals were P(143.34 – 145.45mg/100g), K(234.77 -235.82mg/100g), and Ca(12.84 – 14.43mg/100g). B-carotene obtained was 5540 - 5830mcg/100g, vitamin C 17.44 - 18.83mg/100g. all phytochemicals analyzed were below 1%. Radical scavenging ability of red variety of tropical almond were 18.30, 23.70, 32.40, 35.40 and 48.50% at the corresponding concentrations of 2,4,6,8, and 10ppm while the scavenging ability of the yellow variety at 2, 4, 6, 8 and 10ppm were 16.70, 21.30, 29.40, 32.50 and 43.80 respectively. The results show that consumption of tropical almond will contribute significantly to intake and health benefits.

Keywords: Tropical almond, Nutrients, Anti-oxidants, phytochemicals, pulp

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How to cite this article:

Okudu et al., Nutrients, phytochemicals and antioxidant properties of two varieties of tropical almond (*terminalia catappa*) pulp. International Journal of Food and Nutrition Research, 2017; 1:6.

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Website: <http://escipub.com/>

Introduction

Fruits are rich source of various vitamins and micronutrient which are essential in optimizing health. For example, Vitamin A has been reported to have multiplier roles in the body including vision, cell differentiation, immunefunction, reproduction, and organ and bone formation and growth (Ross, 1999; Depee and West, 1996; Regan *et al.*, 2015), dietary fibre which is reported to improve laxation and plays role cardiovascular disease, weight management, immune function, and colonic health (Tucker *et al.*, 2009; Joanne, 2013), and phytochemicals which also have convincing research evidence of its protective effects against diseases including reducing the risk of cancer (Tsuda, 2012; Torronen 2009). Increased consumption of fruits and vegetables promotes good health and provides protection against degenerative diseases, such as cardiovascular disease (CVD), some cancers, and the onset of dementia (Joshipura, *et al.*, 2001; Knekt, *et al.*, 2002; Youdim and Joseph, 2001). This has led to the recommendation that individuals consume more than 400g (or 5 servings) of fruit and vegetables per day (Anon, 2003).

Tropical almond (*Terminalia catappa*) is one of the lesser known legumes found in the tropics and in Nigeria ecosystems. Tropical almond which belongs to the family *Combretaceae* is a large deciduous tree that thrives as an ornamental tree. The leaves are arranged in close spirals, the leaf blade is simple and broadly obovate with round and blunt top, gradually tapering to a narrowing substrate base. *T. catappa* tree produces fruits whose pulp is fibrous, sweet and edible when ripe. The fruit pulp is reported to contain protein, fat, sodium, calcium, magnesium, niacin, zinc, iron, thiamine, beta carotene, cyanidin-3-glucoside, brevifolin, carboxylic acid, ellagic acid and tannins (Manjunath, 1976; Soepadmo, 1998; Olatidoye and Sobowale, 2011) and is widely eaten by children as forage snack with the nuts and seeds often discarded. Tropical almond tree is slightly deciduous during dry season, and in some environments may lose their leaves twice in a year (Thamson and Evans, 2006). This work is therefore designed to evaluate the chemical composition of the pulp and seed of two varieties of tropical almond (*Terminalia catappa*). For a data to be useful it need to be complete and

detailed

Materials and method

Sources of raw material

Ripe fruits of tropical almond (*Terminalia catappa*) of red and yellow varieties were collected from National Root Crops Research Institute (NRCRI) Umudike environment. The samples collected were taken to the Department of Agronomy, Michael Okpara University of Agriculture, Umudike (MOUUAU), Abia State for proper botanical identification of varieties.

Preparation of samples

The ripe fruits collected were inspected and sorted. Fruits that were firm, mature and free from insect damage or mechanical injuries were selected and washed. After washing, the pulp was carefully scrapped off the hard core nut using a stainless steel knife, blended and then taken for immediate chemical analysis.

Chemical analyses

The proximate compositions of the sample were determined using standard AOAC (2006) methods. Moisture content of the blend was determined gravimetrically. The crude protein content was determined by micro-Kjeldahl method, using 6.25 as the nitrogen conversion factor. The crude fat content was determined by Soxhlet extraction method using petroleum ether. The ash content was determined by incinerating the samples at 600 °C in a muffle furnace. Carbohydrate was obtained by difference, while energy was calculated using the Atwater Conversion factors in KJ and Kcal (17KJ per 4Kcal, 17KJ per 4Kcal, and 37KJ per 9Kcal, for protein, carbohydrate and lipid respectively.

Mineral elements were determined using wet-acid digestion method for multiple nutrients determination as described by the method of AOAC. (2006). About 0.2g of the processed sample material was weighed into a 150ml Pyrex conical flask. Five (5.0) ml of the extracting mixture (H₂SO₄ – Sodium Salicylic acid) was added to the sample. The mixture was allowed to stand for 16 hours. The mixture was then placed on a hot plate set at 30 °C and allowed to heat for about 2hours. Five (5.0) ml of concentrated perchloric acid was introduced to the sample and heated vigorously until the sample was digested to a

clear solution. Twenty (20) milliliter of distilled H₂O was added and heated to mix thoroughly for about a minute. The digest was allowed to cool and was transferred into a 50ml volumetric flask and made up to the mark with distilled water. The digest was used for the determinations of calcium (Ca) and magnesium (Mg) by the ethylamine ditetra acetic acid (EDTA) Versanate compleximetric titration method. Potassium (K) and sodium (Na) were evaluated by flame photometry method and phosphorus (P) by the vanadomolybdate method using the spectrophotometer. The trace metals (zinc, iron, selenium) were determined using the atomic absorption spectrophotometer 969 instrument. The appropriate cathode lamp was fixed for each element. The sample was introduced to the atomizer and the value concentration of the element printed out as mgX per liter.

The β – carotene, riboflavin, niacin and thiamin of the products were determined spectrophotometrically as described by AOAC (2006), while ascorbic acid was determined as described by AOAC (2006) using titration method. Gravimetric method (Harborne, 1973) was used to determine alkaloids. Saponin was determined by gravimetric oven drying method as described by the method of AOAC (2006). Tannin content of the sample was determined spectrophotometrically as described by Kirk and Sawyer (1991). Phenol was determined by the folin-ciocatean spectrophotometry method (AOAC, 2006). Flavonoid was determined by gravimetric oven drying method as described by Harborne (1973).

Determination of 1,1-diphenyl-2-picrylhydrazyl free radical scavenging ability (DPPH)

The anti-oxidant activity of the extracts was measured in terms of hydrogen donating or radical-scavenging ability using the stable free radical 1,1-diphenyl-2-picrylhydrazyl (DPPH) was evaluated as described by Gyamfi *et al.* (1999). First, 50µl of sample or control (water) and 450 µl of 50mmol/l Tris-HCL buffer (pH 7.4) were pipetted into test tube and vortex. Then 1.0ml of 0.1mmol/l DPPH-methanol solution was added, the mixture was swirled and kept in a dark place for 30 minutes. After incubation period, absorbance was measured at 517nm with the mixture of water, buffer and methanol as blank solution, obtained values was converted into percentage inhibition using the equation'

$$\text{Inhibition \%} = \frac{(\text{C Absctrl} - \text{Abs Sample}) \times 100}{\text{Absctrl}} \quad 1$$

Where;

Absctrl is the absorbance of the control and Abs sample is the absorbance of a sample.

Statistical Analysis

All determinations were done in duplicates. The data generated were entered into the computer and analyzed using Statistical Package for Social Sciences (SPSS version 20) Means and standard deviation obtained from the chemical analysis were calculated. Level of significance was accepted at $p < 0.05$. Analysis of variance (ANOVA) was used to compare the values obtained for sensory evaluation.

Results

Energy and proximate composition of the yellow and red varieties of tropical almond fruits

The results of energy and proximate composition of two varieties is shown on Table1. Moisture (83.68%), fiber (1.74%), and protein content of the yellow variety were significantly higher than those of red variety (82.74, 1.69 and 1.27% respectively), while the carbohydrate (12.84%) and energy (57kcal) were significantly higher in the red variety. the amount ash (1.39 and 1.44%), fat (0.06 and 0.07) obtained in the two varieties were not significantly ($p > 0.05$) different from each other.

Mineral composition of the yellow and red varieties of tropical almond fruits

The mineral composition of tropical almond (*Terminalia calappa*) is presented on Table 2. Calcium (14.43mg/100g), phosphorus (145.45mg/100g) and potassium (236,86mg/100g) obtained for yellow variety were significantly higher the values obtained for the red variety (13.84, 143.34 and 234mg/100g respectively). Magnesium, sodium, iron, and zinc contents (8.90, 8.33, 1.7 and 0.85mg/100g respectively) of the yellow variety were not significantly ($p > 0.05$) higher than those of the red variety (8.72, 8.51, 1.78 and 0.08mg/100g respectively).

Table 1: Energy and Proximate Composition of Tropical Almond Fruit (*Terminalia catappa*) (as eaten)

Sample	% MC	%Ash	%Fibre	%Fat	%Protein	%CHO	Energy (Kcal/ KJ)
Red variety	82.74 ^b ±0.95	1.39 ^a ±0.03	1.69 ^b ±0.03	0.06 ^a ±0.00	1.27 ^a ±0.03	12.84 ^b ±0.55	56.98/242.09 ^a
Yellow variety	83.68 ^a ±0.95	1.44 ^a ±0.03	1.74 ^a ±0.03	0.07 ^a ±0.00	1.32 ^a ±0.03	11.74 ^a ±0.55	52.84/224.61 ^b

Values are means ± standard deviation of duplicate samples

^{a-b} means with different superscript using the same column are significantly different at p<0.05

Table 2: Mineral Content of Almond Fruit (*Terminalia catappa*) (mg/100g)

Sample	Mg	Ca	P	K	Na	Fe	Zn
Red variety	8.72 ^a ±0.09	13.84 ^b ±0.31	143.34 ^b ±1.10	234.77 ^b ±1.0	8.51 ^a ±0.09	1.78 ^a ±0.02	0.85 ^a ±0.02
Yellow variety	8.90 ^a ±0.09	14.43 ^a ±0.30	145.45 ^a ±1.10	236.82 ^a ±1.0	8.33 ^a ±0.09	1.75 ^a ±0.01	0.82 ^a ±0.02

Values are means ± standard deviation of duplicate samples

^{a-b} means with different superscript along the same column are significantly different at p<0.05

Table 3: Vitamin Content of Tropical Almond Fruit (*Terminalia catappa*) (mg/100g)

Sample	Vit B ₁	Vit B ₂	Vit B ₃	Vit C	β-carotene (mcg/100g)
Red variety	0.78 ^a ±0.03	0.34 ^a ±0.00	1.64 ^a ±0.03	18.83 ^a ±0.69	5540 ^a ±0.08
Yellow variety	0.83 ^a ±0.02	0.33 ^a ±0.00	1.57 ^a ±0.04	17.44 ^b ±0.70	5830 ^a ±0.08

Values are means ± standard deviation of duplicate samples

^{a-b} means with different superscript along the same column are significantly different at p<0.05

Vitamin composition of the yellow and red varieties of tropical almond fruits

The vitamin composition of tropical almond presented on Table 3 shows that most of the vitamins analysed with the exception of β -carotene and vitamin C for the two varieties of tropical almond were not significantly ($p>0.05$) different from each other. B-carotene obtained for yellow variety (5830mcg/100g) was significantly higher than that of the red variety (5540mcg/100g), while the vitamin C content of the red variety (18.83mg/100g) was significantly higher than (17.44mg/100g). Vitamins B₁, B₂ and B₃ values (0.78, 0.34, 1.64mg/100g) of the yellow variety were not significantly different from values obtained those of the red variety (0.83, 0.33, and 1.57mg/100g respectively).

Phytochemical composition of the yellow and red varieties of tropical almond fruits

The phytochemical of the fruit is shown on Table 4. Flavonoid (1.29mg/100g), phenols (0.18mg/100g) and saponin (0.52mg/100g) contents of the yellow variety were not significantly different from the flavonoid (1.24mg/100g), phenol (0.17mg/100g) and saponin (0.56mg/100g) obtained for the red variety. Also tannins, alkaloids and saponins (0.61, 1.38 and 0.50mg/100g) obtained for yellow variety were not significantly different from the values obtained (0.55, 1.45 and 0.56mg/100g) for the red variety. phytate obtained for each variety was 0.28mg/100g.

Radical scavenging abilities of the yellow and red varieties of tropical almond fruit

The radical scavenging ability of the yellow and red varieties of tropical almond is shown on Table 5. The result shows that the radical scavenging ability of red variety of tropical almond were 18.30, 23.70, 32.40, 35.40 and 48.50% at the corresponding concentrations of 2,4,6,8, and 10ppm while the scavenging ability of the yellow variety at 2, 4, 6, 8 and 10ppm were 16.70, 21.30, 29.40, 32.50 and 43.80 respectively.

Discussion

The values of moisture obtained in this study were similar to the ones reported for the red (81.90%) and yellow variety (83.37%) of tropical almond in a similar study (Oduro *et al.*, 2009).

When compared to other studies the moisture values found in tropical almond were higher those of most fruits (Chowbury *et al.*, 2008; Ekpete *et al.*, 2013), but comparable with values given for guava, pineapple and mango (Stadimayr *et al.*, 2012). Moisture is an index of the shelf-life of fruits. The high moisture content of tropical almond explains why the fruit decays once harvested. Protein, fat, fiber carbohydrate and energy values of tropical almond fell within values reported for tropical almond in a similar work (Oduro *et al.*, 2009); although the proximate components (fiber, protein and fat) were relatively low these values were however higher than those of most consumed fruits like pawpaw, pineapple and water melon (Stadimayr *et al.*, 2012). The low energy, high moisture, low fat and low protein makes tropical almond suitable for patients with some physiological conditions.

Predominate minerals found in tropical almond were phosphorus and potassium. Calcium, zinc and iron were found in relatively high amounts. Most of the mineral analysed in the two varieties (with the exception of calcium and potassium) were not significantly different from each other. When compared with other findings the calcium and magnesium content of tropical almond were comparable to those of some commonly consumed fruits (Stadimayr *et al.*, 2012). Calcium is an essential mineral required for diverse physiological and biochemical functions in human body (Nour *et al.*, 2010). High potassium and low sodium values found in tropical almond is an indication that the consumption of the fruit will support normal fluid and electrolyte balance in the body. Iron and zinc obtained in this study were several folds higher than the ones reported for (). Iron and zinc are important element for the function of normal body physiology. The role of iron is a vehicle for the transport of oxygen. Zinc is necessary for numerous reactions and the absorption of vitamin B-complex (ATSDR, 1999).

The two varieties of tropical almond were good sources of vitamin C and β -carotene. Red variety was better sources of vitamin C while the yellow varieties richer in β -carotene. Vitamins act as antioxidants in the body (Whitney and Rolfes, 2004), also β -carotene is a precursor of vitamin A and vitamin C enhances the absorption of plant iron in the body.

Table 4: Phytochemical Content of Tropical Almond (*Terminalia catappa*) (mg/100g)

Sample	Tannins	Flavonoids	Phenols	Alkaloids	Saponins	Phytates
Red variety	0.55 ^a ±0.03	1.24 ^a ±0.02	0.17 ^a ±0.00	1.45 ^a ±0.03	0.56 ^a ±0.02	0.28 ^a ±0.00
Yellow variety	0.61 ^a ±0.03	1.29 ^a ±0.02	0.18 ^a ±0.00	1.38 ^a ±0.03	0.52 ^a ±0.02	0.28 ^a ±0.00

Values are means ± standard deviation of duplicate samples.

^{a-b} means with different superscript along the same column are significantly different at p<0.05

Table 5: % DPPH Radical Scavenging Ability at Different Concentrations of the Pulp of Red and Yellow of Tropical Almond (*Terminalia catappa*)

Concentration (in PPM)	DPPH radical scavenging ability (in %)	
	Red	Yellow
2.00 ± 4.00	18.30 ^a ± 13.30	16.70 ^b ±12.04
4.00 ± 2.00	23.70 ^a ± 7.96	21.30 ^b ±7.44
6.00 ± 0.00	32.40 ^a ± 0.74	29.40 ^b ± 0.66
8.00 ± 2.00	35.40 ^a ±3.74	32.50 ^b ± 3.76
10.00 ± 4.00	48.50 ^a ±16.84	43.80 ^b ±15.06

Means with the different superscript along the same row are significantly different at p<0.05

Tropical almond is a poor source of phytochemical. Phytochemical are plant chemical that protects plants; some of them have some health benefits. Tannins and phytate obtained in this study were lower than 0.17 – 0.18mg/100g and 4.67mg/100g reported by Justina *et al.* (2015) in a similar study. Tannins is associated with lowering of nutritive value of protein (Akwaowo *et al.*, 2000) while phytate makes calcium, zinc and iron bio-unavailable (FAO, 1990).

The radical scavenging ability of tropical almond shows that the scavenging capacity of two varieties of tropical almond increase with concentration but the scavenging capacity of the red variety was significantly higher than those of the yellow variety. this findings is in line with the statement made by Dragland *et al.* (2003), that the antioxidant concentration of plant vary in different plant species and also in different varieties of the same plant. The high scavenging ability of tropical almond, particularly that of the red variety shows that its consumption will boost or augment the effect of endogenous antioxidant defense mechanisms in the body to prevent free radical mediated oxidative stress.

Conclusion

The result shows that the yellow variety of tropical almond had significantly higher fiber, phosphorus, calcium, potassium and β -carotene. The red variety had higher carbohydrate and vitamin C. the red variety also had a higher scavenging ability than the yellow variety. The phytochemical obtained were less than 1%.

References

Agency for Toxic Substances and Diseases Registry (ATSDR) (1999). Toxicological profile for cadmium and nickel, ATSDR, US Department of Health and Human Services, public health service contact no., 205 – 93 – 0606.

Akwaowo, E. U., Udon, B. A., and Etuk, E. U. (2000). Food Chemistry, 2000, 70: 235 – 240

Anon, M. (2003). Diet, Nutrition and the prevention of chronic diseases. In: Consultation RaoJWFE (Ed), Technical Report Series, No. 916 World Health Organization, 159Pp.

Association of Official Analytical Chemist (AOAC) (2006). Official methods of analysis, association of official analytical chemistry, Washington, D. C.

Chowdhury, M.G.F., Islam, M.N., Islam, M.S. and Hassain, M.S. (2008). Study on preparation and shelflife of mixed juice based on wood apple and papaya. J. soil

Nature. 2: 50-60.

Depee, S. and West, C. E. (1996). Dietary Carotenoids and their role in combating vitamin A deficiency: A review of the Literature. European Journal of Clinical Nutrition 50 suppl 3: 538 – 53 {Pub Med Abstract}.

Dragland, S., Senoo, H., Wake, K., Holte, K. and Blomhoff, R. (2003). Several Culinary and Medicinal Herbs are Important Sources of Dietary Antioxidants. J. Nutr. 133:

1286-1290.

Ekpete, O.H, Ederi, O.S. and Fubara, E.P. (2013). Proximate and mineral composition of some Nigeria fruit. Bri. J. Appl. Sci. and Technol. 3:1447-1454.

Food and Agriculture Organisation (FAO) (1990). Root, tuber, plantains and bananas in human nutrition. FAO corporate document repository Rome <http://www.fao.org/docrep/to207e/TO207EO8.html#7>

Gyamfi, M. A., Yonamine, M. and Aniya. Y. (1999). Free-radical scavenging action of medicinal herbs from Ghana: *Thonningiasanguinea* on experimentally-induced liver injuries. General Pharma. 32: 661–667.

Harbourne, J. B. (1973). Phytochemical methods. A guide to modern technique of plants analysis. Chapman and hall. London Pp. 60-64.

Joanne, S. (2013). Review Fiber and Prebiotics: Mechanisms and Health Benefits Nutrients, 5, 1417-1435; doi:10.3390/nu5041417

Joshipura K. J., Hu F. B., and Manson J. E. (2001). The effect of fruit and vegetable intake on risk for coronary heart disease. Annual International of Medicine. 134: 1106 – 14

Justina, I., Udotong, R., Michael, I. and Basse, B. (2015). Evaluation of the chemical composition, nutritive value and antinutrients of Terminaliacatappa L. fruit (Tropical Almond). International Journal of Engineering and Technical Research (IJETR). Vol. 3, P. 2454-4698.

Knekt, P., Jarvivaara, R., Seppanen, R., Maatela J. and Reunanen, A., (2002). Dietary flavonoids and the risk of lung, cancer and other malignant neoplasms. American Journal of Epidemiol 146: 223 – 30.

Kirk, R. and Sawyer, R.(1998). Pearson's composition and analysis of foods. Church Hill

Livingstone, Edinburgh. Accessed January 19th, 2019 from www.amazon.co.uk.

Manjunath, B. L. (1976). The wealth of India raw materials publications and information directorate, CSIR, New Delhi, Vol. 10, 168.

Nour, V., Trandafir, I. and Ionica, M. M. (2010). Compositional characteristic of several apple (*Malus domestica* Borkh) cultivars. *Not. Bot. Hort Agrobot Cluj* 38(3): 228 – 233.

Oduro, I., Larbie, C., Amoako, T. N. E. and Antwi-Boasiako, A. F. (2009). Proximate composition and basic phytochemical assessment of two varieties of Indian Almond (*Terminalia catappa*). *Journal of Science and Technology* vol. 29, No. 2, pp. 3 – 4

Olatidoye, O. P. and Sobowale, S. S. (2011). Chemical composition and physicochemical characteristics of tropical almond nuts (*Terminalia catappa* L.) cultivated in South West Nigeria, *Journal of Medical and Applied Biosciences*, Vol. 2.

Regan, L., Bailey, B., Keith, P., West, Jr. and Robert, E. B. (2015). The Epidemiology of Global Micronutrient Deficiencies. *Annual Nutrition and Metabolism* 2015;66(suppl 2):22–33 DOI: 10.1159/000371618.

Ross, A. C .(1999). Vitamin A and retinoids. In: Shils ME, Olson J, Shike M, Ross AC (eds.) *Modern Nutrition in Health and Disease*. 9th

Ross, R. N. (1999). Atherosclerosis – anti-inflammatory disease. *England Journal of Medicine* 17; 340(24).

Soepadmo, E. (1998). *The Encyclopaedia of Malaysian Plants*, Editions Didier Millet Jakarta, 16.

Stadimayr, B., Charrondiere, U.R., Enujiugha, V.N., Bayyili, R.G., Romric, G.B., Etel, G., Fagbohoun Samb, B., Addy, P., Barikmo, I. B., Ouattara, F., Oshaug, A., Akinyele, I., Annor, G.A., Bomfeh, K., Ene-Obong, H.N., Smith, I.F., Thiam, I., Burlingame, B. 2012. *West Africa Food Composition Table/ Table de composition des aliments d'Afrique de IOuest*. Food Agriculture Organization of the United Nations. Rome Italy.

Thomson, L. A. J. and Evans, B. (2006). *Terminalia catappa* (Tropical almond). In: Elevitch, C. R. (ed). *Spices profiles for pacific Island Agroforestry*. Permanent Agriculture Resources (PAR), Holoualua, Hawaii. <http://www.traditionaltree.org>.

Torronen, L. (2009). Ellagitannis, Ellagic acid and vascular health. In: *Molecular Aspects of Medicine*. *Molecular Nutrition Food Resources* 31(6):513-39.

Tsuda, T. (2012). Dietary anthocyanin-rich plants: Biochemical basis and recent progress in health benefits. *Molecular Nutrition Food Resources*, 56:159-170.

Tucker, L.A. and Thomas, K.S. (2009). Increasing total fiber intake reduces risk of weight and fat gains in women. *J. Nutr.* 2009, 139, 576–581.

Youdim, K. A. and Joseph, J. A. (2001). A possible emerging role of phytochemicals in improving age-related neurological dysfunctions. Multiplicity of effects. *Free Radical Biology and Medicine* 30, 583-594.

Whitney, E. and Rolfes, S. R. (2014). *Understanding nutrition*. Thomson learning Inc. United States of America. Pp. 119 - 447

