Nutritional Quality and Health Benefits of Okra (Abelmoschus Esculentus): A Review

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Abstract

Okra (Abelmoschus esculentus) is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. This paper was aimed to review nutritional quality and potential health benefits of edible parts of Okra. Okra is a multipurpose crop due to its various uses of the fresh leaves, buds, flowers, pods, stems and seeds. Okra immature fruits, which are consumed as vegetables, can be used in salads, soups and stews, fresh or dried, fried or boiled. It offers mucilaginous consistency after cooking. Often the extract obtained from the fruit is added to different recipes like stews and sauces to increase the consistency. Okra mucilage has medicinal applications when used as a plasma replacement or blood volume expander. The mucilage of okra binds cholesterol and bile acid carrying toxins dumped into it by the liver. Okra seeds are a potential source of oil, with concentrations varying from 20

Index terms— okra, nutritional, quality, health, edible, oil.

1 Introduction

kra (Abelmoschus esculentus) is one of the most widely known and utilized species of the family Malvaceae (Naveed et al., 2009) and an economically important vegetable crop grown in tropical and sub-tropical parts of the world (Oyelade et al., 2003; **??**ndras et al., 2005;Saifullah & Rabbani, 2009). This crop is one of the most widely known and utilized species of the family Malvaceae (Naveed et al., 2009). Okra plant was previously included in the genus Hibiscus. Later, it was designated to Abelmoschus, which is distinguished from the genus Hibiscus (Aladele the little contact between Ethiopia and the rest of the world within historic times, it is not surprising that little is known about the early history and distribution of okra. The routes by which okra was taken from Ethiopia to North Africa, the eastern Mediterranean, Arabia, and India, and when, are by no means certain (Tindall, 1983).

Okra is known by many local names in different parts of the world. It is called lady's finger in England, gumbo in the United States of America, guino-gombo in Spanish, guibeiro in Portuguese and bhindiin India (Ndunguru & Rajabu, 2004;Sorapong Benchasr, 2012). In its origin of Ethiopia it is also called Kenkase (Berta), Andeha (Gumuz), Bamia (Oromica/Amharic). The name Okra probabily derives from one of Niger-Congo group of languages (the name for okra in the Twi language is nkuruma) (Benjawan et al., 2007). The term okra was in the use of English by the late 18th century (Arapitsas, 2008).

Okra is suitable for cultivation as a garden crop as well as on large commercial farms (Rubatzky & Yamaguchi, 1997). Okra plants are grown commercially in many countries such as India, Okra is a multipurpose crop due to its various uses of the fresh leaves, buds, flowers, pods, stems and seeds (Mihretu et al., 2014). Okra immature fruits (green seed pods), which are consumed as vegetables, can be used in salads, soups and stews, fresh or dried, fried or boiled (Ndunguru & Rajabu, 2004). It offers mucilaginous consistency after cooking. Often the extract obtained from the fruit is added to different recipes like soups, stews and sauces to increase the consistency.

Okra mucilage has medicinal applications when used as a plasma replacement or blood volume expander. The mucilage of okra binds cholesterol and bile acid carrying toxins dumped into it by the liver. The immature

pods are also used in making pickle. The entire plant is edible and is used to have several food (Madison, 2008;Maramag, 2013).

Okra seeds are source of oil and protein. Okra seeds have been used on a small scale for oil production. It can be also used as non-caffeinated substitute for coffee. Okra seeds may be roasted and ground to form a caffeine-free substitute for coffee (Calisir, & Yildiz, 2005). Okra also has industrial applications and is used in confectionary (Adetuyi et al., 2011). To promote the use of indigenous vegetables like Okra that have play significant role in mitigate food insecurity and alleviate malnutrition in the country. However, Okra has been considered a minor crop and no attention was paid to its improvement in the international research program in past (Sanjeet et al., 2010).

On the other hand, the demand for vegetable oils is rapidly increasing due to the growing human population and the expanding oil industry with health promoting oil components, the exploration of some underutilized and newer resources of vegetable oils is of much concern (Schalau, 2002). Okra, which is currently grown mainly as a vegetable crop, has potential for cultivation as an essential oilseed crop because okra seeds contain high amount of oil (20-40%) (Sorapong, 2012; MEF, 2013). However, there is also no comprehensive literature information regarding characteristics of the oils produced from Okra seeds. Therefore, this review was aimed to assess literature regarding the nutritional quality and potential health benefits of edible parts of Okra (Abelmoschus esculentus) vegetable. The oil compositions of okra seed was also discussed in order to provide further reliable information about health promoting oil components of Okra seeds.

2 II.

3 Nutritional Composition of Okra

Okra is more a diet food than staple **??**National Research Council, 2006). Okra seeds have been used on a small scale for oil production. Lipid components greatly contribute to the nutritional and sensory value of almost all types of foods. Nature provides a large number of fats that differ in their chemical and functional properties. Four classes of lipids are habitually found in vegetable oils: triacylglycerols, diacylglycerols, polar lipids, and free fatty acids. The fatty acid composition determines the physical properties, stability, and nutritional value of lipids. The most naturally occurring storage lipids are triacylglycerols. Triacylglycerols are natural compounds that consist of saturated and unsaturated fatty acids that differ in the length of their acyl chains and the number and positions of double bonds: saturated, monoenoic, and polyunsaturated fatty acids that differ with respect to detailed fatty acid composition.

Monoenoic fatty acids and polyunsaturated fatty acids are structurally distinguished by the presence of repeating methylene units. These units produce an extremely flexible chain that rapidly reorients through conformational states and constitutes an influential group of molecules that promote health (Vermerris & Nicholson, 2006). Okra seeds from Greece are a potential source of oil, with concentrations varying from 20% to 40% (Sorapong, 2012; MEF, 2013), depending on the extraction method. The oil mainly consists of linoleic acid (up to 47.4%) **??**Andras et al., 2005) . Okra seed oil is a rich source of linoleic acid, a polyunsaturated fatty acid essential for human nutrition (Savello et al., 1980).

Proteins play a particularly important role in human nutrition. The amino acid contents, proportions, and their digestibility by humans characterize a protein's biological value (Ewa, 2011). Okra has been called "a perfect villager's vegetable" because of its robust nature, dietary fiber, and distinct seed protein balance of both lysine and tryptophan amino acids (unlike the proteins of cereals and pulses) (Holser & Bost, 2004; Sanjeet et al., 2010). The amino acid composition of okra seed protein is comparable to that of soybean and the PER is higher than that of soybean (Adetuyi et al., 2012) and the amino acid pattern of the protein renders it an adequate supplement to legume or cereal based diets (Ndangui et al., 2010). Okra seed is known to be rich in high quality protein especially with regards to its content of essential amino acids relative to other plant protein sources (Oyelade et al., 2003; **??**ational Academic Council, 2006). Hence, it plays a vital role in the human diet (Farinde et al., 2007).

Okra also contains carbohydrates and vitamins (Owolarafe & Shotonde 2004, Gopalan et al. 2007, Arapitsas, 2008, Dilruba et al., 2009), and plays a vital role in human diet (Kahlon et al., 2007, Saifullah & Rabbani, 2009). Consumption of young immature okra pods is important as fresh fruits, and it can be consumed in different forms (Ndunguru & Rajabu, 2004). Fruits can be boiled, fried or cooked **??**Akintoye et al., 2011). The composition of okra pods per 100 g edible portion (81% of the product as purchased, ends trimmed) is: water 88.6 g, energy 144.00 kJ (36 kcal), Volume XIV Issue V Version I Year ( ) K protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fibre 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, ?-carotene 185.00 ?g, riboflavin 0.08 mg, thiamin 0.04 mg, niacin 0.60 mg, ascorbic acid 47.00 mg.

The composition of okra leaves per 100 g edible portion is: water 81.50 g, energy 235.00 kJ (56.00 kcal), protein 4.40 g, fat 0.60 g, carbohydrate 11.30 g, fibre 2.10 g, Ca 532.00 mg, P 70.00 mg, Fe 0.70 mg, ascorbic acid 59.00 mg, ?-carotene 385.00 ?g, thiamin 0.25 mg, riboflavin 2.80 mg, niacin 0.20 mg (Gopalan et al., 2007, Varmudy, 2011). Carbohydrates are mainly present in the form of mucilage (Liu et al., 2005, Kumar et al., 2009). That of young fruits consists of long chain molecules with a molecular weight of about 170,000 made up of sugar units and amino acids. The main components are galactose (25%), rhamnose (22%), galacturonic acid (27%) and

amino acids (11%). The mucilage is highly soluble in water. Its solution in water has an intrinsic viscosity value of about 30%.

Potassium, Sodium, Magnesium and Calcium are the principal elements in pods, which contain about 17% seeds. Presence of Iron, Zink, Manganese and Nickel also has been reported (Moyin-Jesu, 2007)38. Fresh pods are low in calories (20 per 100 g), practically no fat, high in fiber, and have several valuable nutrients, including about 30% of the recommended levels of vitamin C (16 to 29 mg), 10 to 20% of folate (46 to 88 mg) and about 5% of vitamin A (14 to 20 RAE). Both pod skin (mesocarp) and seeds are excellent source of zinc (80 mg/g) (Cook et al., 2000).

Okra seed is mainly composed of oligomeric catechins (2.5 mg/g of seeds) and flavonol derivatives (3.4 mg/g of seeds), while the mesocarp is mainly composed of hydroxycinnamic and quercetin derivatives (0.2 and 0.3 mg/g of skins). Pods and seeds are rich in phenolic compounds with important biological properties like quartering derivatives, catechin oligomers and hydroxycinnamic derivatives (Arapitsas, 2008). These properties, along with the high content of carbohydrates, proteins, glycol-protein, and other dietary elements enhance the importance of this foodstuff in the human diet (Manach et al., 2005; Arapitsas, 2008).

Dried okra sauce (pods mixed with other ingredients and regularly consumed in West Africa) does not provide any beta carotene (vitamin A) or retinol (Avallone et al., 2008). However, fresh okra pods are the most important vegetable source of viscous fiber, an important dietary component to lower cholesterol (Kendall & Jenkins, 2004 Arapitsas, (2008) and Kumar et al., (2010). The okra pods were reported to have viscous fiber and lower cholesterol content (Kumar et al., 2010;Kendall & Jenkins, 2004). Okra seeds were determined to have appreciable protein content according to Akingbala et al., (2003).

The variations in polysaccharides found in the mucilage are higher in okra pods according to Hirose et al., (2004) and Sengkhamparn et al., (2009).

Green vegetables contain valuable chlorophyll (Ebermann et al., 2006). Chlorophyllin as an important component of chlorophyll was reported for enormous health benefits. The physiological and biochemical activities of phenolic compounds as antioxidant, anti-inflammatory and anti-microbial were also reported by Ali and Deokule, (2008); Manach et al., (2005) and Middleton, (2000). Marinova et al., (2005) proved the higher values of phenolic and flavonoid values, ratios and distributions in some Bulgarian vegetables and fruits. Generally, fruits and vegetables have shown the basic useful properties especially in providing an excellent health and nutritional qualities in the area of prevention and delay in the onset of chronic diseases and the provision of vitamins and enzymes necessary for proper body function (Aman et al., 2005).

IV.

4 Mucilage and its Potential

Okra mucilage refers to the thick and slimy substance found in fresh as well as dried pods. Mucilaginous substances are usually concentrated in the pod walls and are chemically acidic polysaccharides associated with proteins and minerals (Woolfe et al., 1977). Although nature of the polysaccharides varies greatly, neutral sugars rhamnose, galactose and galacturonic acid have been reported often (Hirose et al., 2004;. The okra mucilage can be extracted as a viscous gum using various procedures. Such diversity in the extraction procedures seems to contribute to the observed variability in the mucilage chemical composition (Ndjouenkeu et al., 1996). Okra mucilage is a renewable and inexpensive source of biodegradable material. Its physical and chemical properties include high water solubility, plasticity, elasticity and viscosity **??**Be Miller et al., 1993).

Most physical and chemical properties are influenced by factors such as temperature, pH, sugar and salt contents, and storage time (Woolfe et al., 1977; **??**aht & Tharanathan, 1987). Okra mucilage has potential for use as food, non-food products, and medicine. Food applications include use as a whipping agent for reconstituted egg whites, as an additive in the formulation of flour-based adhesives, and as an additive in India for clarifying sugarcane juice. Non-food applications include brightening agents in electro deposition of metals, as a deflocculant in paper and fabric production, and as a protectant to reduce friction in pipe-flow (Be Miller V.

5 Health Benefits of Okra

In recent years, increasing attention has been paid to the role of diet in human health (Ohr, 2004). The high intake of plant products is associated with a reduced risk of a number of chronic diseases, such as atherosclerosis and cancer (Gosslau & Chen, 2004). These beneficial effects have been partly attributed to the compounds which possess antioxidant activity. The major antioxidants of vegetables are vitamins C and E, carotenoids, and phenolic compounds, especially flavonoids. These antioxidants scavenge radicals and inhibit the chain initiation or break the chain propagation (the second defense line). Vitamin E and carotenoids also contribute to the first defense line against oxidative stress, because they quench singlet oxygen (Krinsky, 2001). Flavonoids as well as vitamin C showed a protective activity to ?-atocopherol in human LDL, and they can also regenerate vitamin E, from the ?chromanoxy radical (Davey et al., 2000).

Nutrient antioxidants may act together to reduce reactive oxygen spieces level more effectively than single dietary antioxidants, because they can function as synergists (Rossetto et al., 2002). In addition, a mixture containing both water-soluble and lipid-soluble antioxidants is capable of quenching free radicals in both aqueous and lipid phases (Trombino et al., 2004).

For example, with the liposome oxidation method, the activity of combination of quercetin or catechins plus ?tocopherol was significantly higher than the sum of the individual activities. Combinations of ?-tocopherol or vitamin C plus phenolic compounds also provided synergistic effects in human erythrocyte membrane ghosts and phosphatidylcholine liposome systems (Liao & Yin, 2000).

Okra seed is rich in protein and unsaturated fatty acids such as linoleic acid (Oyelade et al., 2003). In some countries, okra also is used in folk medicine as antiulcerogenic, gastroprotective, diuretic agents (Gurbuz, 2003). However, little information on antioxidant capabilities of major phenolic compounds from okra seed is available. Okra is also a popular health food due to its high fiber, vitamin C, and folate content. Okra is also a good source of calcium and potassium. Okra pod contains thick slimy polysaccharides, which are used to thicken soups and stews, as an egg white substitute, and as a fat substitute in chocolate bar cookies and in chocolate frozen dairy dessert Administration of different doses of peel and seed powder significantly increased liver, kidney and pancreas superoxide dismutase, catalase, glutathione peroxidase, reduced glutathione levels and decreased thiobarbituric acid reactive substances (TBARS) ($P < 0.001$) levels in diabetic rats compared to diabetic control rats. Liao et al., (2012) has done a comparative analysis of total phenolics and total flavonoids and antioxidant ability of different organs (flower, fruit, leaf, and seed) and different enrichment fractions of water extracts of the A. esculentus plant. They confirmed fruitful presence of total phenolics and total flavonoids related to antioxidant ability in all the extracts of the plant organs although percentage varied. In flower of okra highest amount of total phenolics and totalflavonoids were found (Liao et al., 2012). This data suggests Okra as a good contributor to the antioxidant status and promising chemopreventive agent as described in several traditional medicines for human race. Okra is abundant with several vitamins, minerals, and nutrients that handles the health advantages the plant provides.

Here are a few of okra's health advantages Okr contain high fiber, which "helps to stabilize blood sugar by regulating the rate at which sugar is absorbed from the intestinal tract". Because of fiber along with other nutrition, okra shows useful for minimizing blood sugar levels within the body, assisting along with diabetes. The fiber likewise helps support blood sugar levels level simply by slowing down sugar assimilation through the intestines (Ngoc et al., 2008).

The frequent usage of okra might help avoid kidney disease. Within the research, "those who consumed okra every day decreased clinical indications of kidney damage a lot more than the ones that simply consumed a diabetic diet." This ties along with diabetes, as almost 50% of kidney disease cases are generated by diabetes (Lengsfeld et al., 2004).

Okra is used to to treat digestive issues. The polysaccharides present in immature okra pods possessed considerable antiadhesive properties (i.e. they help remove the adhesive between bacteria and stomach tissue, preventing the cultures from spreading). Okra's polysaccharides were particularly effective at inhibiting the adhesion of Helicobacter pylori, a bacterium that dwells in the stomach and can cause gastritis and gastric ulcers if left unchecked. Therefore, eating more okra can keep our stomach clean and create an environment that prevents destructive cultures from flourishing (Messing et al., 2014). Okra is used to supports colon health. It smoothly sails down our colon, absorbing all toxins and excess water in its path. Okra is filled with dietary fiber,that is required for colon health and digestive health all together. The fiber Okra offers helps to cleanse the intestinal system, letting the colon to operate at higher amounts of effectiveness. In addition, the vitamin A plays a role in wholesome mucous membranes, assisting the digestive system to function adequately (Georgiadisa et al., 2011).

Okra is used to promotes healthy skin and blood. One hundred grams of okra also contain approximately 27 percent of our RDI of vitamin C and 50 percent of our RDI of vitamin K. Vitamin C is, of course, an essential antioxidant that aids in the growth and repair of bodily tissues. For this reason, eating more okra can rejuvenate our skin and hair, and also shield us from degenerative diseases associated with long-term free radical damage. Vitamin K, on the other hand, plays an important role in blood clot formation. If you suffer from regular nosebleeds, bleeding gums, heavy menstrual bleeding, or easy bruising, your blood might be too thin. Consider adding more vitamin K-rich foods like okra to your diet to improve your blood's ability to coagulate (Bakre & Jaiyeoba, 2009).

Okra is used to promotes a healthy of the pregnancy. An incredibly essential B vitamin for creating and maintaining new cells, foliate is a vital substance for optimum pregnancy. The vitamin aids in preventing birth defects just like spina bifida and enables the baby to develop completely. Vitamin C is additionally required for baby development. Okra is full of both foliate and vitamin C. The high quantity of foliate included in the okra is helpful for the fetus while pregnant. Foliate is a vital nutrient that increases the growth and development of the fetus' brain. The high quantity of folic acid within okra performs a huge role within the neural tube formation of the fetus through the fourth to the 12th week of pregnancy (Zaharuddin et al., 2014).

Okra is used to improves heart health. The soluble fiber within okra helps you to reduce serum cholesterol and therefore decreases the chance of cardiovascular disease. Consuming okra is an efficient method to manage the body's cholesterol level. Okra is additionally loaded with pectin that can help in reducing high blood cholesterol simply by modifying the creation of bile within the intestines (Ngoc et al., 2008). Okra is also used to improves good eyesight. The okra pods are fantastic options for Vitamin A and also beta carotene that are both important nourishment for sustaining an excellent eye-sight along with healthy skin. Additionally, these types of important nourishment also assist inhibits skin. Okra is better ingested when joined along with other healthy veggies.

Consuming okra has truly numerous advantages, simply bear in mind to eat natural veggies as opposed to processed veggies (Messing et al., 2014).

Okra is used to controls the body's cholesterol level. There are numerous significant illnesses related to high cholesterol level of the entire body. Managing the body's cholesterol level is nearly difficult because it's hard to avoid foods loaded with cholesterol content. One of the better health advantages of consuming okra is definitely the powerful management of the human body's high cholesterol level. This healthy vegetable is beneficial in slimming down and also decreasing cholesterol therefore keeps a healthy and also low cholesterol body. Okra have been taken advantage by diet advisors due to these qualities (Zaharuddin et al., 2014).

Generally, okra is used to stabilize blood sugar by regulating the rate at which sugar is absorbed from the intestinal tract. It is a good vegetable for those feeling weak, exhausted, and suffering from depression and it is also used in ulcers, lung inflammation, sore throat as well as irritable bowel. Okra is good for asthma patients and it also normalizes blood sugar and cholesterol levels . Previous studies reported that okra polysaccharide possesses anticomplementary and hypoglycemic activity in normal mice (Tomoda et al., 1989) Also, okra polysaccharide lowers cholesterol level in blood and may prevent cancer by its ability to bind bile acids . Additionally, Okra seed possess blood glucose normalization and lipid profiles lowering action in diabetic condition (Sabitha et al., 2011).

VI.

6 Conclusion

The information presented here shows the potential nutritional importance of Okra and its role in improved nutrition and health. It is an affordable source of protein, carbohydrates, minerals and vitamins, dietary fibre and health promoting fatty acids. Scientific studies provide some evidence to support the potential beneficial effects of Okra components in lowering the risk for various chronic diseases, although information pertaining to the role of edible plant parts of Okra in disease prevention and the mechanisms of action are limited to date. This is due to the complex nature of disease etiology and various factors impacting their occurrence.

It is imperative the scientific community continues to unravel the mechanisms involved in disease prevention and determine how food bio-actives from such foods as Okra can influence human health. Further research, needs to be performed to provide compelling evidence for the direct health benefits of Okra consumption. Therefore, promoting the consumption of traditional vegetables such as Okra could provide cheap sources of macro and micronutrients and mineral elements that can improve the nutritional status of resource-poor subsistence farmers in the area in particular and in Ethiopia in general. Furthermore, this vegetable can also be used as an indispensable tool when it comes to reducing the prevalence of malnutrition, especially among resourceconstrained urban households in addition to rural household. Consumption of Okra by both low-income and high-income groups can also used as a means of dietary diversification approach. [1] [2]

[1] © 2014 Global Journals Inc. (US)

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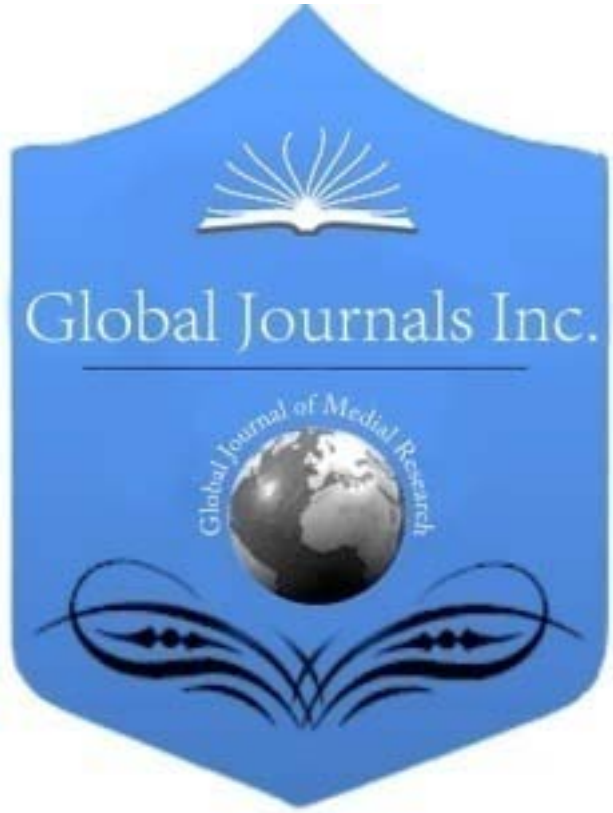

Figure 1:

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Figure 2:

III. Seed as Potential Edible Oil and Flour Source

Okra seed oil yield is comparable to most oil seed crops except oil palm and soybean (Sanjeet et al., 2010). Moreover, okra seed oil has potential

The enormous nutritional and other biological activities in the pods and seeds were reported by Agbo et al., (2008),

[Note:). Sevendays-old fresh okra pods have the highest concentration of nutrients (Agbo et al., 2008). hypocholesterolemic effect. The potential for wide cultivation of okra for edible oil as well as for cake is very high (Sanjeet et al., 2010). Okra seed flour could also be used to fortify cereal flour (Adelakun et al., 2008). For example, supplementing maize ogi with okra meal increases protein, ash, oil and fiber content (Akingbala et al., 2003). Okra seed flour has been used to supplement corn flour for a very long time in countries like Egypt to make better quality dough. However, long-term rodent/animal feeding trials would be pertinent before making final recommendations for wider consumption of okra seed flour (Sanjeet et al., 2010).]

Figure 3:

epicatechin and rutin are reported to be present. It is quite important to the see that roasting (1600°C for 10-60 minutes) increased the nutrient composition and antioxidant activity of the seeds whereas pre-treatment (soaking and blanching) increased the nutrient composition, but decreases antioxidant activity (Adelakun et al., 2010). Ansari, (2005) reported Okra extract as in vitronon-enzymatic inhibitior of lipid peroxidation in liposomes. A. esculentus peel and seed powder contains significant in vivo antioxidant property in streptozotocin-induced diabetic rats.

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Okra is also known for beir

antioxidants activity with different parts of the plant (Shui & Peng, 2004). Atawodi et al., (2009) has reported in vitro antioxidant assay of methanol extract of okra fruits. They have done antioxidant/radical scavenging activities by xanthine oxidase and 2-deoxyguanosine methods and reported 50% inhibitory concentration values of 25 and 43 ml. In addition, Arapitsas, (2008) reported that Okra seed is rich in Phenolic compounds, mainly composed of flavonol derivatives and oligomeric catechins. According to Khomsug et al., (2010), total phenolic content of pulped and seeds of okra extracts as 10.75±0.02mg GAE/100g 142.48±0.02mg GAE/100g extract which corresponds with scavenging activities. Besides they have also found procycanidin B2 as predominant phenolic compound followed by procycanidin B1 and rutin in

Figure 4:

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