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Phytochemical Contents and Antioxidant potentials of Eggplants from Kano State, Nigeria: A Review

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Abstract
Fruits and vegetables are considered as good source of functional foods due to their health benefits and nutritional content. Dietary constituents of fruits and vegetable are commonly available and has significant application in management of chronic diseases such as; coronary heart disease, stroke, cancer and diabetes, many medicinal purposes, control of excess weight and obesity due to high fiber content present. Many phenolic compounds had been identified in garden eggplant such as; catechin, rutin, naringin, naringenin, syringic acid, chlorogenic acid, caffeic acid, p-coumaric acid, sinapic acid and anthocyanin. Health-conscious consumers generally focus on the antioxidant capacity, and the phenolic content, vitamins, carotenoids and phytochemicals. All varieties of garden egg vary in polyphenol endowed with antioxidant activity. Polyphenolic compounds and antioxidant activity in eggplants which depend on the cultivar, maturity stage and parts of the fruit. Growing conditions are also reported to significantly affect the phenolic contents. This review discussed the polyphenolic contents and antioxidant activities of different eggplant cultivars. Priority was given to green, white and dark-purple cultivars which are commonly grown in Nigeria. White and green eggplants possess higher phenolic contents when compared with dark purple eggplant which possesses higher antioxidant capacity. They contain about 92% water, 5% protein, copper (0.62mg/100g), magnesium (81.69mg/100g), potassium (87.22mg/100g), sodium (32.51mg/100g), irons (31.41mg/100g), zinc (1.41mg/100g), carbohydrate (7.2 g/100g), fibers (2.0g/100g), calcium (28 mg/100g), iron (1.5 mg/100g) and considerable amount of beta carotene (0.35 mg/100g), ascorbic acid (8 mg/100g), riboflavin (0.06 mg/100g) and thiamin (0.07 mg/100g). The species of African eggplant have nutritional and therapeutic values and can be used in the development of functional foods and these bioactive compounds are responsible for high functions of eggplants and provide antibacterial, anti-inflammatory, anti-allergic, hepatoprotective, antithrombotic, antiviral, anti-carcinogenic and vasodilatory properties in humans.

Keywords: Antioxidant capacity, Eggplant, Garden egg, phenolic content

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INTRODUCTION

Eggplant was first discovered and named by a Botanist called Thomas Jefferson (Fraces, 2016; Mohammed and Asenay, 2019). Egg plants are non-climacteric fruit, non-tuberous cultivated herbs from a family *Solanum melongena* (Jett, 2011). The fruit is classified as a berry which contains numerous small and soft edible seeds, while some have a bitter taste because they contain nicotinoid alkaloids; this is unsurprising as it is closely related to tobacco in certain composition as reported by Bello and Sauban (2015). It has an economic impact in Africa, Europe, and Asia, where more than 90% of the total eggplants are produced. It is particularly important and celebrated plant in China and India with highest consumption (Martínez-Ispizua *et al*., 2021). The leading producers of eggplant are China (56% of world output), India (26% of world output), Egypt and Turkey (Barik *et al*., 2020). Eggplant variety are of different shapes and colors ranging from white, green, yellow, through grades of purple pigment to almost black color (Muhammad and Senay, 2019).

Nigeria had a vast quantity of fruits and vegetables which are not just consumed as food only but also used for medicinal purposes (Martínez-Ispizua *et al*., 2021). Eggplant is an inexpensive source of nutrients which includes; proteins, carbohydrate, minerals, vitamins and fibers (Kadiri and Jung *et al*., 2011; Olawoye 2015; Djouadi *et al*., 2016). Polyphenolic compound and antioxidant activities in eggplant seems to depend on their variety, stage of maturity and parts of the fruit used (Martínez-Ispizua *et al*., 2021).

There is a remarkable diversity among eggplant cultivars in the market varying in shape, size and color, eggplant fruit is ranked among the top ten vegetables in terms of antioxidant capacity and oxygen radical absorbance due to their phenolic content (Jung.*et al*., 2011; Djouadi *et al*., 2016; Martínez-Ispizua *et al*., 2021). It is one of the most important vegetable crops in West Africa particularly Nigeria where it is consumed on a daily bases and remain source of income for many rural people (Chioma *et al*., 2011; Nwanna *et al*., 2013). The eggplant is eaten raw, boiled, or fried and also as an ingredient of stew, soup and vegetable sauces (Eletta *et al*, 2017).

Botany of Garden Eggs

The eggplant (*Solanum melongena* L.) is an annual plant of the *Solanaceae* family known as nightshade (Aziz, 2010). The fruits are pear- round or long- shaped and cylindrical depending on the variety (Jung *et al*., 2011). They are perennial crops but cultivated as an annual crops grown for their commercially purposes. There are about 25 species of eggplants in Nigeria. The prominent among these are; the *Solanum aethiopicum* (Ethiopian eggplant) and s*carlet* eggplant known as bitter eggplant, they are the species of *Gilo*. *Solanum macrocarpon L.* (*Gboma* eggplant) known as African eggplant and *Solanum melongena* (Eletta *et al*., 2017).

Nutritional Content of Eggplant

Fruits and vegetables have been considered as functional foods due to their health benefits besides nutritional content (Yunusa *et al*., 2018). In relation to nutritional concerns, the eggplant has become a highly consumed crop (Martínez-Ispizua *et al*., 2021). The consumption of the fruits and vegetables has grown high due to the abundance health-promoting compounds found in it (Yahia *et al*., 2018; Martínez-Ispizua *et al*., 2021). The eggplant contains 92 percent water, vitamins (vitamins A, B and C especially Riboflavin), minerals (magnesium, calcium, potassium and iron), beta – carotene and starch (Grusak, 2017; Barik *et al*., 2020; Sedlar *et al*., and 2021; Quamruzzaman *et al*., 2021). Some varieties contain up to 5 % protein with significant amount of methionine which is one of the essential amino acids most difficult to find in plant-based foods (Norman *et al*.,2006; Sedlar *et al*., 2021), dietary fiber and antioxidants (Karasawa and Mohan, 2018). The eggplant contains minerals such as; calcium

(256.60mg/100g), copper (0.62mg/100g), while manganese is absent or relatively low. Other minerals present include; magnesium (81.69mg/100g), potassium (87.22mg/100g), sodium (32.51mg/100g), irons (31.41mg/100g), and zinc (1.41mg/100g) as reported by Usunobun and Igwe (2016). African eggplant fruits have relatively higher carbohydrate of (7.2 g/100g), fibers (2.0g/100g) and considerable amount of beta carotene (0.35 mg/100g), ascorbic acid (8 mg/100g), riboflavin (0.06 mg/100g) and thiamin (0.07 mg/100g) (Majubwa, *et al.,* 2015; Theodosy, *et al.,* 2014).

Uses of Eggplant

Fruits

In Africa, eggplants are chopped, cooked and mixed into a variety of vegetables, meat, or fish sauce and sausages. Although bitter taste is a major characteristic of many African eggplants or bland, especially in the immature stage in which they are eaten, peeling is unnecessary because the skin becomes tender enough to be consumed. They are among the few vegetables that reach full flavor only after being cooked beyond the crisp stage (Norman *et al.,* 2006).

Leaves

Bello and Sauban (2015) reported that Africans eat the leaves of certain types of eggplants species as vegetables, although these leaves are high in *solanine* (a toxic substance which is normally destroyed through cooking or apparently renders them harmless). The leaves are excellent source of vitamins A and B, calcium, phosphorus, and iron (Oyeyemi *et al.,* 2015). *Solanum macrocarpon* leaves showed maximum antioxidant activities. Barik *et al.,* (2021) reported that the fruit or leafy part of eggplant is used for the treatment of constipation, ulcers, toothache, skin disease, cough, piles, inflammation, infections, sores throat, stomach problems, or as snake bite remedy when applied to the infected area (Usunobu and Igwe 2016; Barik *et al*.,(2021)

Root

The root of eggplant is used traditionally as medicine in treatment of bronchitis, asthma, wounds, abdominal worms, and diabetes and stomach disorders. (Omovbude, 2020). They are used as carminative and cough expectorant, nasal ulcers, worm expeller, nervous disorder and fever (Oyeyemi *et al*., 2015).

Varieties of Eggplant

***Solanum aethiopicum* (Greenish red species)**

The *S. aethiopicum L.* (Ethiopian eggplant) and *Scarlet* eggplant known as bitter eggplant, they are the species of *Gilo,* commonly referred to as bitter garden-egg and locally called *Gautan Daacii* Nigeria and *Gauta* in Hausa language (Eletta *et al*., 2017). Some varieties are sweet while others are bitter and this is what makes garden eggplant in many parts of Africans unique and most preferred. They are highly valued constituents of the Nigerian foods and indigenous medicines that are either eaten raw or cooked, very popular in mixed and rich dishes such as stews and soups (Norman *et al,* 2006; Agoreyo *et al.,* 2012).


Plate 1: *Solanum aethiopicum* fruits


Plate 2: *Solanum aethiopicum* fruits (*scarlet species)*

Note: use a single fruit rather than a whole basket.

***Solanum melongena* fruit (purple species)**

The varieties of *Solanum melongena L.* showed a wide range of fruit shapes and colors, ranging from oval long club-shaped or egg-shaped to slender type in a dark purple skin through degrees of purple pigmentation to almost black coloration. It is an economically important crop in Asia, Africa and the sub-tropics (India, Central America) (Muhammad *et al*., 2010; Jung *et al.,* 2011). The fruits are used as vegetables and cooked in combination with Tomato and Potato, (Bello and Sauban, 2015).


Plate 3: *Solanum melongena* (purple fruits)

Solanum macrocarpon (Gboma Eggplant)

Solanum macrocarpon are known as ''Gboma Eggplant'' one of the most cultivated and most utilized in Nigeria. The fruit grows nearly in all the 36 states of Nigeria, locally called by different names according to the ethnic group. For instance, in the eastern part, the Igbo's call it *Anara*, in the western states, the Yoruba's call it '*Igbagba*' while in the northern states, and it is known as "*Yalo* and "*Yalon bello*" by the Hausa's (Omovbude and Ikenwa. 2020).


Plate 4: *Solanum macrocarpon* fruits


Plate 5: *Solanum macrocarpon*

The Antioxidant compound in eggplant

The natural antioxidant compound particularly in fruits and vegetables have gained interest among consumers, several studies revealed that frequent consumption of natural antioxidants

is associated with a lower risk of cardiovascular diseases (Oviasogie *et al.,* 2009). Antioxidants are naturally occurring or synthetic chemicals in food that help to counter the detrimental effects of reaction oxygen species (ROS) and free radicals scavenging activities which causes degenerative human diseases such as cancer, heart diseases and cerebrovascular diseases (Martínez-Ispizua *et al.,* 2021). Recently, natural food and derived antioxidant compounds such as vitamins and phytochemicals have received growing attention. (Martínez-Ispizua *et al.,* 2021).

Ascorbic acid

Ascorbic acid is one of the most important antioxidant compound present in fruits and vegetables, beside its vitamin functions, disease prevention associated with its capacity to neutralize free radicals. Although, ascorbic acid is well-known antioxidant which plays important role in collagen synthesis and iron absorption in the body (Edet *et al.,* 2020).

Carotenoids

The fruits and vegetables are the main source of carotenoids due to the presence of conjugated double bonds present in their antioxidant properties (Martínez-Ispizua *et al.,* 2021). Lycopene and β-carotene are the most studied carotenoids source and protect against some digestive disorders (Tan *et al.,* 2010), reducing chronic illnesses such as; coronary heart disease and a certain type of cancers (Asanda, 2017).

Phenolic Compound

Phenolic compounds contribute to fruit physiological functions including pigmentation, antimicrobial, antioxidants, antimutagenic, antitumor activities, astringency and impart bitter taste in some products (Djouadi *et al.,* 2016; Martínez-Ispizua *et al*., 2021). Many phenolic compounds have been identified in garden eggplant such as; catechin, rutin, naringin, naringenin, syringic acid, chlorogenic acid, caffeic acid, p-coumaric acid and *sinapic* acid (Konic-Ristic *et al*., 2011; Juliana, 2020). Polyphenols are widely distributed in plants, contributed to fruit organoleptic and nutritive quality in terms of color, taste, aroma, and flavor and the composition varies with the cultivar types (Patricia *et al.,* 2010). Several studies had shown that phenolic compounds contribute to plant resistance to fungal infections, insect wounds or mechanical damage (Asanda *et al.,* 2017).

Anthocyanin

Anthocyanin is an important group of naturally occurring pigments found in plants of red and/or purple colored fruits. Eggplant is an example of good source of anthocyanin and it is concentrated in the peel, while chlorogenic acid also predominates in the pulp, surrounding the seeds (Eletta *et al.,* 2017; Koley *et al.,* 2019).

Flavonoid

Flavonoids are found present in garden eggplant as glycosides, which are more soluble (Ariel *et al*., 2016). Flavonoids are free radical scavengers, super antioxidants and potent water soluble which prevent oxidative cell damage and have strong anticancer activity (Usunobun and Igwe, 2017). The flavonoids include trace quantities of flavonols, namely quercetin-3-glucoside, quercetin-3-rhamnoside, and myricetin-3-galactoside as found in the pulp of eggplant, (Charanjti *et al.,* 2014). Total Phenolic Content and Antioxidant Capacity of Egg Plant (mg ascorbic acid/g of dry extract)

Table 1.0: Phenolic content (mg) and Antioxidant capacity (mg)

Varieties	cultivars	Phenolic content (mg)	Antioxidant capacity (mg)
Darks purple eggplant	Whole fruit	20.14	10.91
	pulp	24.13	11.8
	peel	548.77	324.34
White eggplant	Whole fruit	30.51	5.40
	pulp	25.29	-
	peel	87.82	89.52

Source: Djouadi *et al*., (2016).

The results on the table above reported by Djouadi *et al*. (2016) demonstrated the potential benefits of *Solanum macrocarpon* as an important dietary source of phenolic and antioxidant compounds for human health. Purple eggplant could be promising for human consumption, mainly for its antioxidant properties (Djouadi *et al*., 2016).

Importance of Phenols or phenolic compounds

The phenols are small molecules containing one antioxidant activity and play an important role in the protection of plant against ultraviolet radiation, pathogens and predators and contribute to the antioxidant properties and anti-cancer activities of garden eggplant as an active compound (Djouadi *et al*., 2016). The eggplant fruit ranked among top ten vegetables to scavenge oxygen radical species because of the presence of phenols and a good reservoir for polyphenolic compounds such as chlorogenic acid (Ankita, 2014). Phenolics or polyphenols have received considerable attention because of their physiological functions, including antioxidants, antimutagenic and antitumor. Phenolics have been reported to be a potential candidate to combat free radicals which are harmful to our body and foods systems (Oviasogie, 2009).

CONCLUSION

Eggplant is a plant food with high content of phenolic and polyphenolic compounds and antioxidant capacity. The phenolic content tends to be higher in white cultivar than in dark purple cultivars, while the antioxidant capacity is higher in white eggplant than in dark purple eggplant. Generally, peel tissue of eggplant contains higher amounts of phenolics such as; anthocyanin, and flavonoids than the pulp tissues. The bitterness of eggplants is due to the presence of alkaloids, mainly *glycol-alkaloids* and degree of bitterness determines to great extent of their edibility or otherwise. This review therefore showed the significant relations between the level of total phenolic compound and antioxidants capacity in garden eggplant, since the phytochemical analysis of eggplant showed that it is a good source of various essential compounds that are present in fruits and leaves.

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