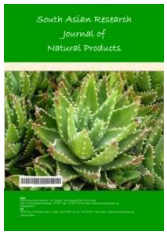

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Antioxidant Activity of Some Whole Fruit Cultivars of Raw and Processed (Boiled) Egg Plant (*Solanum melongena)*

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Eggplant (*Solanum melongena)* is one of the most common vegetables consumed all around the world. It is a very rich source of polyphenol compounds endowed with antioxidant activity. The current study evaluated the antioxidant potential of seven different varieties of eggplant carried out both in raw and processed form in terms of total phenolic content, total flavonoid content and DPPH radical scavenging assay. The phenolic and flavonoid content were quantified by aluminum chloride and Folin-Ciocalteu methods, respectively. Processed extract from yellow eggplant showed more antioxidant activity (52.35 ± 0.75%), while raw extract from purple stripe eggplant showed more antioxidant activity than the other samples (83.00 ± 0.20%). It was also observed that values for all samples carried out for total phenolic and total flavonoid content both raw and processed extract was low which ranges from (7.65 ± 0.02 µg/g to 7.89 ± 0.04 µg/g) for raw extract and (7.60 ± 0.08 µg/g to 7.82 ± 0.24 µg/g) for processed extract in total phenolics and (62.09 ± 0.08 µg/g to 62.43 ± 0.05 µg/g) for raw extract and (62.43 ± 0.05µg/g to 62.56 ± 0.05 µg/g) for processed extract in total flavonoid, compared to values for DPPH, which ranges from (25.07 ± 0.47% to 83.00 ± 0.20%) for raw extract and (36.60 ± 0.19% to 57.03 ± 0.50%) for processed extract.

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Keywords: Eggplant; antioxidant activity; total phenolic; total flavonoid.

1. INTRODUCTION

Garden egg also known as eggplant (*Solanum melongena)*, or aubergine is a species of nightshade plant, known for its edible fruit. Eggplant is the common name in North America, Australia and New Zealand, but British English uses the french or aubergine. It is known in South Asia and South Africa as brinjal [1].

Many different types of eggplant exist with different sizes and shapes ranging from huge to small due to cultivars differences, some are large, cylindrical, round, small green fruits, oval and long necked fruits like large Zucchini [2]. Some of the more popular of these varieties include the Thai yellow egg, Japanese white egg, Ping Tung long, African garden egg and the Chinese round mauve, while the most common eggplants in the U.S. are lying and purple. Eggplant (*Solanum melongena),* is widely used in cooking, as a member of the *genus Solanum*, it is related to tomatoes and potato because they both belong to the family of nightshade

Antioxidants are substances (nutrients) in foods which slow or prevent the oxidation of another chemical. It is one of the group of vitamins that act against the effects of free radicals. It possesses the ability to neutralize free radicals. They also help prevent and repair damage and worn out tissues.

Flavonoid and phenolic compounds in eggplants have the capacities to quench lipid peroxidation, prevent DNA oxidative damage and scavenging of reactive oxygen species, such as superoxide, hydrogen peroxide and hydroxyl radicals [3]. Phyto-chemicals have been a supply of natural antioxidants used for health promotion, food preservation, food flavoring and cosmetics as they are safer than synthetics.

2. LITERATURE REVIEW

All eggplants belong to the scientific family *solanaceae* or "nightshade" and a scientific order called polemoniales. Botanically, most eggplants are called "*Solanum melongena"* and they are one of the non-tuberous cultivated herbs [4]. Similarly, they are non-climatic fruits described as an agronomically important crop [5].

Plate 1: White big eggplant

Plate 2: White small eggplant

Plate 3: Yellow eggplant

Plate 4: Purple oblong eggplant

Plate 5: Purple stripe eggplant

Plate 6: Green big eggplant

Plate 7: Green small eggplant

Plate 1. Seven different cultivars of eggplant

Knowledge of eggplants cultivation began in the 3rd century in India, in China around the 4th and 5th century, then in Africa around the 9th century [2]. Eggplant is known as one of the 10 sources of the world's healthiest food which is also described as best species cultivated worldwide [6]. Anthocyanins, an important group of naturally occurring pigments of red or purple coloured fruits, are the main phenolic compounds in eggplant peel [7]. The whole eggplant fruit possesses antioxidant activity in terms of oxygen radical absorbance capacity [8]. There are also many reports on the health benefits of eggplant. Systematic examination of the phenolic acid content of the flesh fruit of several commercial eggplant cultivars were carried out [9]. The quality and quantity of phenols present in fruit may be influenced significantly by cultivar, environment, soil type, growing, storage conditions, and cooking and extraction procedures [10].

2.1 Nutrients Present In Eggplant

Eggplant contains numerous nutrients which are all needed in the body predominantly for growth, repair of worn out tissues and then for protection. They are made up of a host of vitamins and minerals, dietary fibre, proteins, antioxidants as well as phytochemicals that possess antioxidant activity [5]. The nutrients are mostly calculated both in the raw and cooked state.

Nutritionally, raw eggplant is low in fat, protein, dietary fibre and carbohydrates. Minor changes in nutrient composition occur with seasonal environment of cultivation and genotype.

2.2 Health Benefit of Eggplant

Eggplant is described clinically as a fruit because of the seeds presents in it, also used as a vegetable which is inexpensive so majority of consumers can afford. It also has copious medicinal qualities enumerated as beneficial to human health when it is highly patronized [2].

- It aids in the decrease of cardiovascular diseases (stroke, cardiac arrest, heart diseases) by cleaning up damaging free radicals
- It controls blood pressure
- It enables weight loss
- It keeps the brain healthy by safe guarding the brain cell and protecting it against the destruction of free radical cells, whilst the antioxidant has the ability to avoid brain turmoil [1].

2.3 Objectives of Research

This research study is aimed to evaluate the free radical scavenging activity of some cultivated eggplant varieties in Ekpoma environment, Edo State, Nigeria.

3. MATERIALS AND METHODS

3.1 Materials

Beakers (250 ml, 500 ml)
Laboratory blender (Philips blender)
Domestic knifes
Tissue paper
Domestic plastic sieve
Filter paper (whatman No.10)
UV- Spectrophotometer (Vinmax LDC, Model 721)
Methanol (JHD)
2% sodium carbonate (BDH)
2% aluminum trichloride (Kermel)
1,1- Diphenyl-2-picryl-hydrayl (DPPH) (Fisher scientific UK)
Folin-Ciocalteu (Fisher scientific UK)

Different cultivars of Brinjal with different skin colour; white (small), white (big), yellow, purple (oblong), purple (stripe), green (small) and green (big) were purchased from Ekpoma market, Edo State, Nigeria.

3.2 Sample Preparation

Preparation of extract was carried out with raw and processed (boiled) brinjal.

The processed brinjal was washed and boiled with water for 5 min and then set aside to cool. About, 50 g of fresh raw and boiled brinjal was sliced and blended with a laboratory blender (Philips blender) separately with 20mL of distilled water and filtered with a filter paper (whatman No.10) and a domestic plastic sieve in the laboratory. Each resulting extract was placed in a plastic container and stored in the refrigerator at 38°F until further analysis.

3.3 Biomarker Assay

3.3.1 Determination of 1,1-diphenyl-2-picryl-hydrayl (DPPH) radical scavenging activities

The free radical scavenging activity of brinjal extract was measured by 1,1- Diphenyl-2-picryl-hydrayl DPPH [13]. 2 mL of DPPH solution was

Table 1. Nutritional value of raw and processed eggplant per 100 g

Food nutrients	Raw eggplant	% Value
Energy	100-104kj	1%
Carbonhydrate	4.70-5.88g	4%
Sugar	2.35-3.35g	
Dietary fiber	2.80-3.40g	9%
Fat	0.18-0.20g	
Protein	0.80-1.01g	2%
Retinol (A)	0.8mg	1%
Thiamine (B1)	0.039mg	3%
Riboflavin (B2)	0.037-0.11mg	3%
Niacin (B3)	0.649mg	4%
Pantothenic acid (B5)	0.281mg	6%
Vitamin B6	0.084-0.1mg	6%
Vitamin K	2.9-3.5mg	3%
Folate (B9)	18-22mg	6%
Vitamin C	1.8-2.2mg	3%
Vitamin E	0.2-0.3mg	2%
Calcium	07.4-9.0mg	1%
Iron	0.20-0.24mg	2%
Magnesium	13.5-14mg	4%
Manganese	0.20-0.25mg	11%
Phosphorus	22.5-25mg	3%
Potassium	129-130mg	5%
Zinc	0.10-0.16mg	2%
Selenium	0.2mg	
Sodium	1.6-2.0mg	
Copper	0.1-0.12mg	

Source: [11,12]

added to different volumes of brinjal extract and diluted with distilled water until volume reached 4 mL, the mixture was shaken vigorously and allowed to stand for 30 min in the dark at room temperature. The absorbance was measured at 517 nm against blank consisting of all reacting agent except extract, with the UV-VIS Spectrophotometer (Vinmax LDC, Model 721). Ascorbic acid (Foodchem) was used as standard.

The % of scavenging activity was calculated as;

Where Ao= absorbance of blank (2 mL of DPPH solution and 2mL of distilled water)

And A1= absorbance of the reaction mixture / standard

3.3.2 Determination of total flavonoid content

Total flavonoid content of brinjal extract was determined using Dowd method [14]. 2 mL of Brinjal extract was treated with 2mL of 2% aluminum trichloride in ethanol, the mixture was kept in darkness for 10min after which absorbance was measured at 415 nm with the UV-VIS Spectrophotometer (Vinmax LDC, Model 721) against blank consisting of all reacting agent except extract. Total flavonoid was calculated as microgram rutin equivalent by using an equation obtained from standard rutin graph as;

Absorbance= 0.0144 x total flavonoid (µg rutin) + 0.0556

3.3.3 Determination of total phenolic content

Total phenolic content of brinjal extract was determined colorimetrically with Folin-Ciocalteu reagent [15]. 1 mL of extract was diluted with 10 mL of ethanol. Subsequently, 1 mL of the diluted solution was dissolved in 40 mL of distilled water, 1 mL of Folin-Ciocalteu reagent was added before shaking the mixture vigorously. After 2 min, 3 mL of 2% sodium carbonate was added and incubated for 2h at room temperature in darkness with intermittent shaking. The absorbance was measured against blank at 760 nm from a UV-VIS Spectrophotometer (Vinmax LDC, Model 721). The concentration was calculated as microgram pyrocatechol equivalent

using an equation obtained from standard pyrocatechol graph as;

Absorbance= 0.021x total phenolic (µg pyrocatechol) – 0.0092

3.4 Statistical Analysis

All results were presented as mean ± standard deviations (S.D) of the triplicate determinations for total phenolic, total flavonoid and DPPH scavenging activity.

4. RESULTS AND DISCUSSION

4.1 Discussion

4.1.1 Total Phenolic Content (TPC)

Phenolic compounds are the large group of phytochemicals that are gaining acceptance as being responsible for the health benefit associated with fruits and vegetables. They can scavenge free radicals and inactive pro-oxidants and also interact with a number of biological [16]. Bringal extract was found to have varying levels of TPC, from 7.65 ± 0.02 µg/g to 7.89 ± 0.04 µg/g for raw extract and 7.60 ± 0.08 µg/g to 7.82 ± 0.24 µg/g for processed extract. For raw extract, the TPC value was marked higher in yellow eggplant 7.89 ± 0.04 µg/g followed by purple strip eggplant 7.83 ± 0.05 µg/g, green (small) eggplant had the lowest TPC 7.65 ±0.02 µg/g. For processed extract, TPC was markedly higher in white (big) eggplant 7.82 ± 0.24 µg/g, while green (big) eggplant had the lowest TPC 7.55 ± 0.02 µg/g.

4.1.2 Total Flavonoid Content (TFC)

Flavonoid and phenolic compounds in eggplants have the capacities to quench lipid peroxidation, prevent DNA oxidative damage and scavenging of reactive oxygen species, such as superoxide, hydrogen peroxide and hydroxyl radicals [3]. The total flavonoid content of bringal extract ranges from 62.43 ± 0.05 to 62.09 ± 0.08 in raw extract and 6.56 ± 0.05 to 62.43 ± 0.05 in processed extract. TFC is higher in white (big) eggplant 62.43 ± 0.05, while yellow eggplant 62.09 ± 0.08 has lower TFC values for raw extract. For processed extract TFC value is higher in yellow eggplant 62.56 ± 0.05 and lower in green (big) eggplant 62.43 ± 0.05. It was observed that in both total phenolic content and total flavonoid content of green (big) has lower values of antioxidant activities for processed eggplant.

4.1.3 DPPH radical scavenging activity

The DPPH radical scavenging assays used as substrate to evaluate the free radical scavenging ability of various samples [17]. The degree of discolouration is an indication of the scavenging capacity of the extract. The extracts were able to reduce the stable violet DPPH radicals to yellow DPPH over a range of concentrations. DPPH radical scavenging ability is widely used as an index to evaluate the antioxidant potentials of medicinal plants. Usually, higher total phenolics and total flavonoid contents leads to more DPPH radical scavenging activity [15], but in this present study it varies. DPPH radical scavenging activity for processed extract is higher in yellow eggplant 52.35 ± 0.75 and lower in purple (stripe)

Table 2. Mean (±SD) content of total phenols and flavonoids and antioxidant capacity of seven different varies of eggplant

S/N	Varieties	Total phenolic content (µg/g)	Total flavonoid content (µg/g)	DPPH assay (%)
1	White small (raw)	7.81 ± 0.04	62.25 ± 0.07	25.07 ± 0.47
	White small (processed)	7.60 ± 0.08	62.45 ± 0.10	46.40 ± 0.10
2	White big (raw)	7.82 ± 0.05	62.43 ± 0.05	47.90 ± 0.50
	White big (processed)	7.82 ± 0.24	62.47 ± 0.04	45.30 ± 0.72
3	Yellow (raw)	7.89 ± 0.04	62.09 ± 0.08	45.47 ± 0.49
	Yellow (processed)	7.75 ± 0.02	62.56 ± 0.05	52.35 ± 0.75
4	Purple oblong (raw)	7.84 ± 0.06	62.37 ± 0.04	51.53 ± 0.42
	Purple oblong (processed)	7.73 ± 0.06	62.52 ± 0.08	49.70 ± 0.07
5	Purple stripe (raw)	7.83 ± 0.05	62.30 ± 0.05	83.00 ± 0.20
	Purple stripe (processed)	7.76 ± 0.04	62.49 ± 0.11	36.60 ± 0.19
6	Green small (raw)	7.65 ± 0.02	62.36 ± 0.01	41.53 ± 0.45
	Green small (processed)	7.72 ± 0.07	62.50 ± 0.14	57.03 ± 0.50
7	Green big (raw)	7.82 ± 0.07	62.37 ± 0.05	52.13 ± 0.70
	Green big (processed)	7.55 ± 0.02	62.43 ± 0.05	50.23 ± 0.25

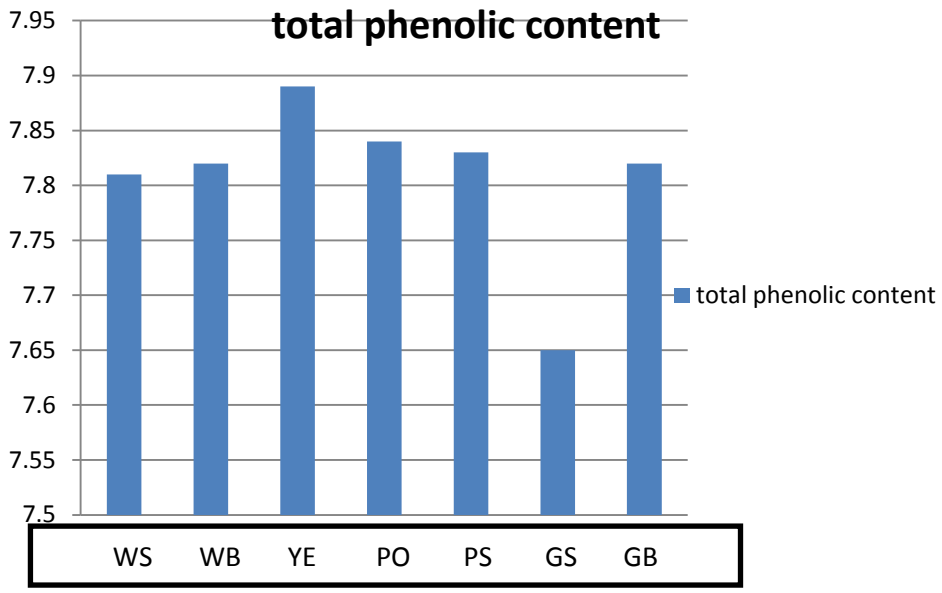

Fig. 1. Total phenolic content of raw samples

(WS = white small, WB = white big, YE = yellow, PO = purple oblong, PS = purple stripe, GS = green small, GB = green big)

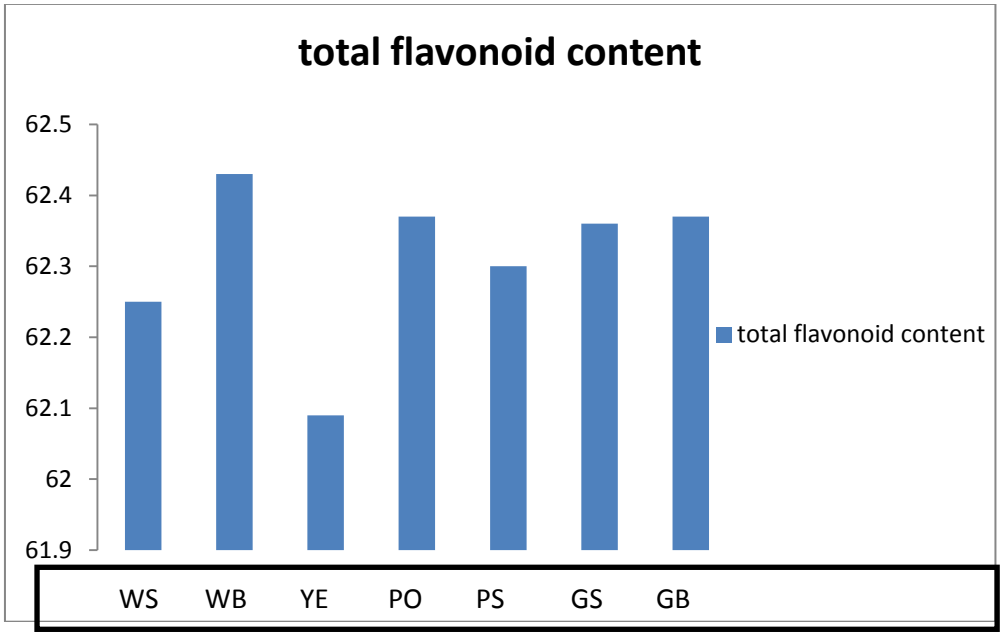

Fig. 2. Total flavonoid content of raw sample

eggplant 36.60 ± 0.17. While for raw extract, DPPH radical scavenging activity is higher in purple (stripe) eggplant 83.00 ± 0.20 and lower in white (small) eggplant 25.07 ± 0.47. DPPH radical scavenging activity for raw extract ranges from 83.00 ± 0.20 to 25.35 ± 0.47, while for processed extract, ranges from 52.35 ± 0.75 to 36.60 ± 0.17. The reason for the vary results in total phenolics, total flavonoids and DPPH scavenging activity is due to the presence of other components in the mixture i.e. temperature difference, light and concentration, which influences the results.

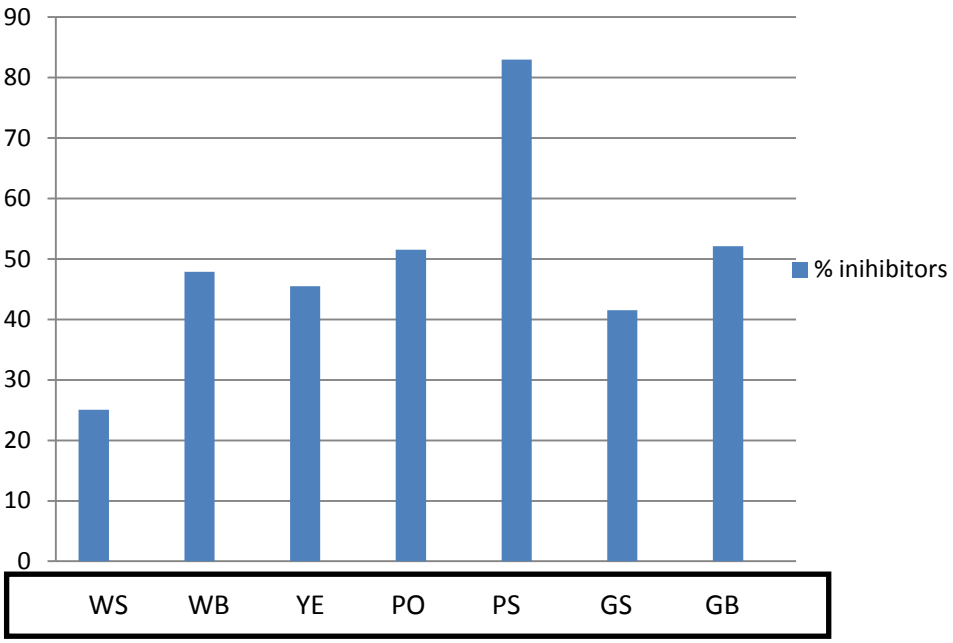

Fig. 3. DPPH radical scavenging activity of raw sample

5. CONCLUSION

The present study evaluated shows the antioxidant activities of seven different varieties of eggplant in raw and processed form, in terms of total phenolic, total flavonoid and DPPH. Result from the present study showed that extract for raw sample of eggplant could effectively scavenge reactive oxygen species compared to extract from processed (boiled) samples of eggplant. Values for both raw and processed eggplant has high antioxidant activity and high total flavonoid content, but raw brinjal possesses more scavenging activity than processed brinjal. Yellow and purple (stripe) eggplant showed higher DPPH scavenging activity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

The results were all generated statistically by repeating each parameter analysis three (3) times, i.e. n = 3 Using, for the following

X				**i**	**X**	**i**		**–**	**X**			
2	5	.	4	0	0	.	1		0	0	.	0	1
2	5	.	3	0	0	.	2		0	0	.	0	4
2	5	.	9	0	0	.	3		0	0	.	0	9

= = 25.5

S.D = S.D = , S.D = 0.3

The mean ± standard deviation = 25.5 ± 0.3

This procedure was repeated for other values obtained for the physic-chemical analysis of the results as shown in table.

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