Nutritional Content and Health Benefits of Bangladeshi Eggplant Cultivars

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Abstract — The investigation was conducted at the Olericulture Division, Bangladesh Agricultural Research Institute and the laboratory work was done at Vegetable Research Technology Section, Institute of Food Science and Technology, Bangladesh Council of Scientific and Industrial Research, Dhaka, Bangladesh during 2019-20 with ten types (Six- OP, four- Hybrid) of eggplant cultivar viz., BARI Begun-4, BARI Begun-6, BARI Begun- 8, BARI Begun-10, BARI Hybrid Begun-2, BARI Hybrid Begun-4, SM233, SM275, Hybrid 5x216 and Hybrid 21x11 to study the nutritional composition and its human health benefit. Eggplant is ranked amongst the most top ten vegetables that provide the healthiest food with low calories and also contain high phenolic contents that are helpful in radical absorbing capacity. Each vegetable contains a unique amount of various nutrients that are strongly linked with the protection of different health diseases. There were no significant differences among the six OP and four hybrid cultivars regarding yield. Fruit yield was more or less the same but the main differences were in fruit size and color as well as fruit shape. We got the moisture content (91.39-94.87%, crude fiber (1.01-2.48%), ash (0.37-0.62%), protein (0.85-1.54%), fat (0.02-0.4%), carbohydrate (4.27-6.63%), energy (19.59-32.1Kcal), sugar (0.48-1.38%), ascorbic acid (6.57-17.21 mg 100g⁻¹), anthocyanin (6.31-78.51 mg C3GE 100 g⁻¹). Significant amount of mineral were present in eggplant cultivars viz., K (122.38-162.27mg 100g⁻¹), Na (4.06-8.51 mg 100g⁻¹), Ca (26.62-48.33 mg 100g⁻¹), P (14.45-23.45 mg 100 g⁻¹), Mg (15.42-24.8 mg 100g⁻¹), Fe (0.91-5.0 mg 100g⁻¹), Zn (0.22-0.57 mg 100g⁻¹), Mn (0.25-0.41mg 100g⁻¹) and Cu (0.10-0.16 mg 10 0g⁻¹). These nutritional amounts will able to provide a significant amount of nutrition to the human body for the proper growth. These compounds were found helpful in the cure of various diseases like cancer, anti-inflammatory, anti-asthmatic, anti-platelet hypo-lipidemic, and hypotensive, etc. Today most modern scientific techniques are available to cure different various health problems but still majority of the population across the globe depends upon the vegetables sources nutritious food.

Index Terms — Nutritional content, Health benefits, Bangladesh, Eggplant cultivars, *Solanum melongena* L.).

I. INTRODUCTION

Eggplant (*Solanum melongena* L.) is a popular vegetable in Bangladesh as well as the sub-continent of South East Asia along with the Mediterranean area. It belongs to a family *Solanaceae* and is an economically important

vegetable crop. Fruit from eggplant is available in the market throughout the year as it is generally grown twice or thrice in a year. Eggplant is shown a variety of shapes (egg to long club-shaped) and colors occur from white, green, yellowish, different color s of purple, black color [60]. Eggplants fruit is very nutritious and uses for medicinal purposes due to its composition, which includes has very low calories with good minerals like potassium, calcium, magnesium, sodium, iron, and phytochemicals that contain phenolic components (caffeine and chlorogenic acid), flavonoids, mainly nasunin. [36], [49] as well as dietary fiber that is helpful for our health [51], [63]. Fruits and vegetables are the main dietary sources of phenolic compounds for humans, with phenolic acids and flavonoids being the most abundant [34], [52]. Eggplant has very low calories in its fruit with good mineral content that is helpful for our health. Eggplant is ranked amongst the most top ten vegetables that provide the healthiest food with low calories and also contain high phenolic contents that are helpful in radical absorbing capacity [7], [8].

A wide range of secondary metabolites along with primary metabolites is producing by plants that influence human nutrition and health as well [30]. Primary metabolites are proteins, vitamins, lipids, and carbohydrates, etc. which mainly involved in developmental and physiological developments of plants that are also vital in our diet [57]. Secondary metabolites are those phytochemicals that often play a crucial role against different stresses but are not important for the basic processes of the plant [57]. Moreover, these phytochemicals are a vital basis for various medicines and the pharmaceutical industry, even recent modern and traditional remedies mainly depend on these phytochemicals [58]. Vegetables are excellent sources of such compounds that constitute the main portion of our diet and consider as a major source of vitamins (A, B complex (B1, B6, B9) and E), dietary fiber, minerals, and phytochemicals [48], [66].

Intake of vegetables in our daily diet results with over-all good health impact, reduction in gastrointestinal problems, improvement in vision and also playing an important role to reduce danger for various systems of cardiovascular problems, cancer, diabetes, stroke, anemia, gastric ulcer and other long-lasting disorders [21]. Lower risk of cardiovascular diseases in humans strongly associated with a high intake of vegetable diet [37]. According to the World Health Report, each year 2.7 million death causes because of a diet poor in vegetable consumption and with a stumpy intake of dietary fiber, carbohydrates, and proteins [12]. A survey carried out regarding world vegetable cultivation showed that around 402 vegetables are cultivated across the globe, characterize 69 families, and 230 genera [29]. Leafy vegetables (both leaves or fresh leaves) are utilized were the most frequently consumed (53% of the total), trailed by

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vegetable with below ground edible portions covered 17% and then by vegetable fruits (15%) [28], [29].

Eggplant cultivars produce fruits with a wide diversity of shapes, sizes, and colors [26], [27]. Also shown a variety of shapes (egg to long club-shaped) and colors occurs from white, green, yellowish, through grades of purple pigment to almost black color [60]. Various forms, colors, and shapes of eggplant are found throughout Southeast Asia, suggesting that this area is an important center of variation and possibly of origin. [64] suggested that its center of origin was in the Indo-Burma region. It is extensively grown in Bangladesh, India, Pakistan, Nepal, China, Japan, and the Philippines. We think different types of eggplant will contain different nutritional quality as well the physiological characteristics. So it is necessary to study the individual eggplant cultivar for their nutrition status. This work aimed to study the morphological characteristics, nutritional composition, and compare the proximal composition, mineral content, and antioxidant bioactive compounds of the popular eggplant cultivar in Bangladesh.

II. MATERIALS AND METHODOLOGY

A. Experimental site

The investigation was conducted at the Olericulture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI), and the laboratory work was done at Vegetable Research Technology Section, Institute of Food Science and Technology, Bangladesh Council of Scientific and Industrial Research, Dhaka, Bangladesh during 2019-20. The experimental field was at 23.9920° N Latitude and 90.4125° E Longitudes having an elevation of 8.2 m from sea level under agro-ecological zone (AEZ) 28 [3]. The experimental site is situated in the sub-tropical climatic zone and characterized by scanty rainfall during the experimental time. The average minimum and maximum temperature were 18.37°C and 29.37°C.

B. Plant materials

Ten types of eggplant cultivar viz., BARI Begun-4, BARI Begun-6, BARI Begun- 8, BARI Begun-10, BARI Hybrid Begun-2, BARI Hybrid Begun-4, SM233, SM275, Hybrid 5x216 and Hybrid 21x11 were used in this study (Fig. 1).

C. Sample preparation

Eggplant fruits from the representative ten types of cultivar viz., BARI Begun-4, BARI Begun-6, BARI Begun-8, BARI Begun-10, BARI Hybrid Begun-2, BARI Hybrid Begun-4, SM233, SM275, Hybrid 5x216 and Hybrid 21x11 were used in this study (Fig. 1). Fruit samples of each eggplant cultivar were harvested at the commercial mature stage from the experimental farm of Olericulture Division, Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI) during 2019-20 (23.9920° N Latitude and 90.4125° E Longitudes), washed and sorted by color and size and divided into two groups. The first group was used fresh for proximate and mineral analysis, while the second group was freeze-dried and stored at -80 °C, for further evaluations of ascorbic acid and anthocyanin.

D. Estimation of nutrients

Moisture, ash, protein (N x 6.25), crude fiber, fat, and carbohydrates (by difference) contents were determined according to AOAC methods [4]. The mineral analysis was

also done based on AOAC methods [4]. Potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), copper (Cu) and manganese (Mn) were determined by atomic absorption spectroscopy using a Varian SpectraAA 220. Phosphorus (P) was determined colorimetrically at 650 nm in a Varian Cary E1 UV-Vis spectrophotometer.

Ascorbic acid extraction was done according to [42] with little bit modification as described by [40]. Ascorbic acid was quantified according to [13] using a Varian Pro Star 330 photodiode array detector HPLC system and a Varian Bondesil NH2 column (250 x 4.6 mm). Results were expressed in milligrams per 100 grams of eggplant on a fresh basis.

Total anthocyanin was determined using a spectrophotometric method adapted from [1]. Anthocyanin content was calculated as the concentration of total anthocyanin, expressed as mg of cyanidin-3-glucoside equivalents per 100 g of sample (mgC3GE 100g-1).

E. Statistical analysis

ANOVA was used to assess statistical differences among eggplant types with a 5% confidence level. When a significant difference was found, Tukey's multiple range tests were carried out to separate means using MSTAT-C. Data were expressed as means values of three samples.

III. DISCUSSION

A. Morphological characteristics of eggplant

In our morphological characteristics study, we evaluated ten eggplant cultivars of Bangladesh including six OP and four hybrid cultivars. We evaluated the horticultural characters [earliness (days to 1st harvest), fruit shape, fruit color, fruit length (cm), fruit diameter (cm), individual fruit weight (g) and fruit no/ plant, fruit yield]. Considering the mentioned traits, we got BARI Begun-6, BARI Begun-8, BARI Begun-10, SM275, BARI Hybrid Begun-4 and Hybrid 21x11 were superior compare to other cultivars (Table 1). There were no significant differences among the OP and hybrid cultivars regarding yield. Fruit yield was more or less same but main differences were in fruit size and color as well fruit shape.

B. Nutritional composition of eggplant

Eggplants fruit is very nutritious and uses for medicinal purposes due to its composition, which includes has very low calories with good minerals like potassium, calcium, magnesium, sodium, iron, and phytochemicals that contain phenolic components (caffeine and chlorogenic acid), flavonoids, mainly nasunin. [36], [49] as well as dietary fiber that is helpful for our health [51], [63].

Generally we familiar with eggplants that are large and dark purple or oval green. But the shape, size, and color can vary from small and oblong to long and thin and from shades of purple to white or green. So, this interpretation will focus on the nutritional benefits of the traditional purple and green colored long and oval-shaped eggplant.

Considering the above fact, we have some nutritional composition analysis of popular eggplant cultivars in Bangladesh. Due to laboratory limitations, we have done the following analysis and got the results as follows. Moisture content was 91.39-94.87% (Table 2), while [17, 35, 38] got the moisture content 91.8 to 94.2%, while Nino-

Medina *et al.*, 2014 reported little bit less with the value 90.10 to 92.70%.

Fig. 1. Morphological differences among eggplant cultivars in Bangladesh

TABLE 1. MORPHOLOGICAL CHARACTERISTICS OF POPULAR EGGPLANT CULTIVARS IN BANGLADESH

Test parameters	BARI Begun-4	BARI Begun-6	BARI Begun-8	BARI Begun-10	SM233	SM275	BARI Hybrid Begun-2	BARI Hybrid Begun-4	Hybrid 5x216	Hybrid 21x11
Earliness (Days to 1 st harvest)	Early 100-103	Medium 105-108	Medium 105-108	Medium 105-108	Early 100-103	Medium 105-108	Early 100-103	Early 100-103	Early 100-103	Early 100-103
Fruit shape	Medium long, cylindrical with round end	Oval	Long, cylindrical with round end	Long, cylindrical with flat end	Elongate with round end	Oval	Oblong with round end	Oblong with round end	Oblong with round end	Oblong with round end
Fruit color	Glossy uniform black purple	Light green	Uniform purple	Shiny dark purple	Uniform black purple	Green with white stripe at bottom	Uniform light purple	Light green	Uniform purple	Green with white stripe at bottom
Fruit length (cm)	17-18	10-12	26-28	28-30	17-18	10-12	14-15	10-12	12-14	12-13
Fruit diameter (cm)	3.7-4.2	8-9 c	3.7-4.2	4.0-4.5	3.7-4.2	8-9	5.0-5.5	5.0-5.5	6.0-6.5	5.0-5.5
Individual Fruit weight (g)	100-110	230-250	130-140	140-150	100-110	230-250	130-140	100-110	130-140	100-110
Fruit no/ plant	45-50	17-20	25-30	22-25	50-55	15-18	22-25	45-50	33-35	40-45
Yield/ plant (kg)	4.5-5.0	4.0-4.2	3.8-4.0	4.0-4.2	4.5-5.0	4.0-4.2	4.0-4.2	4.0-4.2	4.0-4.2	4.0-4.2

Crude fiber is an important item for the human body and we got it within 1.01-2.48%, whereas, [40] got 0.65 to 1.54%, which is similar to our study. In the case of ash, the range was 0.37-0.62% whereas [17, 35, 38] got similar ash content in a different cultivar with 0.3% to 0.7%.

Protein is a vital nutrient for any living organism, which was 0.85-1.54% in this study, while [17, 35, 38] got the protein content 0.11 to 1.2%. In this study it was estimated that the range of fat was 0.02-0.4%, which was a little bit similar to that of other researchers i.e. [40] analyzed the fat content in different eggplant types reporting values ranging from 0.03 to 0.04 %.

Now a day, consumers are so much concern about the low carbohydrates, while in general carbohydrate in eggplant is 5.96 to 7.92%, which was analyzed by [40]. In this study, it was estimated at 4.27-6.63%.

According to USDA reported by [18], the suggested energy from eggplant is 25.0 kcal, whereas it was 19.59-32.1 kcal in this study. [65] got the energy amount was 33.6 kcal in eggplant.

Sugar is another body concern item for the human. In general, everybody is interested to take a low amount of sugar, while eggplant assures that low amount. [18] mentioned 3.53%, while [65] mentioned 3.04%. In our study, it was 0.48-1.38, which was much lower.

In case of mineral content range of popular eggplant cultivars in Bangladesh was K (122.38-162.27 mg 100g⁻¹), Na (4.06-8.51 mg 100g⁻¹), Ca (26.62-48.33 mg 100g⁻¹), P (14.45-23.45 mg 100g⁻¹), Mg (15.42-24.8 mg 100g⁻¹), Fe (0.91-5.0 mg 100g⁻¹), Zn (0.22-0.57 mg 100g⁻¹), Mn (0.25-0.41 mg 100g⁻¹), Cu (0.10-0.16 mg 100g⁻¹) (Table 3). These findings are more or less similar with the findings of [15, 36, 40].

TABLE 2. NUTRITIONAL COMPOSITION OF 10 POPULAR EGGPLANT CULTIVARS IN BANGLADESH

Test parameters	BARI Begun-4	BARI Begun-6	BARI Begun- 8	BARI Begun-10	SM233	SM275	BARI Hybrid Begun-2	BARI Hybrid Begun-4	Hybrid 5x216	Hybrid 21x11	Range
Moisture content (%)	94.87	92.15	93.27	91.39	92.17	93.49	93.86	92.81	94.31	92.51	91.39-94.87
Crude fiber (%)	1.92	1.01	2.48	1.89	1.53	1.33	1.50	1.72	1.19	1.74	1.01-2.48
Ash (%)	0.47	0.37	0.62	0.61	0.42	0.50	0.42	0.50	0.38	0.50	0.37-0.62
Protein (%)	1.05	1.04	1.54	1.38	1.02	1.12	0.85	1.42	0.95	1.38	0.85-1.54
Fat (%)	0.19	0.03	0.05	0.02	0.04	0.07	0.40	0.17	0.13	0.19	0.02-0.4
Carbohydrate (%)	4.73	6.63	4.27	4.94	6.05	5.72	5.20	4.61	6.27	4.91	4.27-6.63
Energy (Kcal)	19.59	30.07	24.69	32.1	29.84	24.39	24.88	27.61	21.89	28.91	19.59-32.1
Sugar (%)	0.83	1.38	0.51	0.87	0.72	0.63	0.48	1.06	0.66	0.66	0.48-1.38

TABLE 3. MINERAL CONTENT OF 10 POPULAR EGGPLANT CULTIVARS IN BANGLADESH

Test parameters	BARI Begun-4	BARI Begun-6	BARI Begun- 8	BARI Begun-10	SM233	SM275	BARI Hybrid Begun-2	BARI Hybrid Begun-4	Hybrid 5x216	Hybrid 21x11	Range
K (mg 100g ⁻¹)	131.20	142.55	152.75	154.91	142.63	134.53	143.73	162.27	122.38	155.44	122.38-162.27
Na (mg 100g ⁻¹)	4.14	4.79	6.54	7.23	7.32	8.51	4.89	5.32	4.90	4.06	4.06-8.51
Ca (mg 100g ⁻¹)	30.27	48.33	31.78	33.93	45.93	33.94	35.74	30.28	47.59	26.62	26.62-48.33
P (mg 100g ⁻¹)	14.45	20.67	21.09	23.45	18.26	19.37	21.94	15.91	18.46	20.62	14.45-23.45
Mg (mg 100g ⁻¹)	19.30	18.21	15.42	21.40	20.69	24.80	17.67	21.40	21.61	19.30	15.42-24.8
Fe (mg 100g ⁻¹)	1.44	1.35	1.50	1.86	1.60	1.17	1.40	1.65	5.00	0.91	0.91-5.0
Zn (mg 100g ⁻¹)	0.22	0.45	0.56	0.57	0.36	0.42	0.47	0.49	0.36	0.52	0.22-0.57
Mn (mg 100g ⁻¹)	0.37	0.36	0.40	0.25	0.33	0.41	0.30	0.29	0.26	0.32	0.25-0.41
Cu (mg 100g ⁻¹)	0.15	0.14	0.12	0.14	0.14	0.13	0.16	0.14	0.10	0.14	0.10-0.16

Ascorbic acid (mg 100g⁻¹) (Fig 2) and anthocyanin (mgC3GE 100g⁻¹) (Fig 3) ranges was 6.57-17.21 and 6.31-78.51, respectively. In the case of ascorbic acid content the range was higher than that of the findings of [14], [16], [45]. While the anthocyanin content in other researcher's

findings was 55 and 64 mg 100g⁻¹ by [43], [50], respectively.

Fig 2. Ascorbic acid (mg 100g⁻¹) content of 10 popular eggplant cultivars in Bangladesh

Fig 3. Anthocyanin (mgC3GE 100g⁻¹) content of 10 popular eggplant cultivars in Bangladesh

C. Health benefits of different nutrients contain in eggplant

Eggplants are a rich source of nutrients and their contents (Table 4) which all desirable mainly for body growth and

development, to the refurbishment of worn-out materials and also provide a shield. Eggplant is the complete set of minerals, vitamins, nutritional fiber, protein, anti-oxidants, along with some phytochemicals that having scavenging

activities [41], [67]. The eggplant has superb medicinal effects on different disorders like burns, warts, inflammatory infections, gastritis, stomatitis, and arthritis [24].

TABLE 4. NUTRIENTS AVAILABLE FROM 1 CUP OF EGGPLANT AND DAILY REQUIREMENTS [65]

Nutrients	Amount in 1 cup of eggplant cubes	Daily requirements for adults
Energy (kilocalories)	33.6	1,000–3,000
Carbohydrate (g)	8.29, of which 3.04 are sugar	130
Fiber (g)	2.4	22.4–33.6
Magnesium (mg)	10.6	310–420
Phosphorus (mg)	14.4	700–1,250
Potassium (mg)	117	4,700
Folate	13.4	400
Choline (mg)	8.93	400–550
Beta carotene (mcg)	21.1	No data

It has been known that anthocyanin has a significant role against diabetes, neuronal problems, cardiovascular disorders, and cancer as well. Eggplants are the rich source of anthocyanin compounds, besides their coloring functions. Purple eggplant has a high amount of nasunin compound in their flesh that consumption of such purple eggplant helps against lipid peroxidation and ROS accumulation which occur due to a high level of iron in cells [9]. Anthocyanins present in the skin of eggplant rise serum antioxidant volume and support against heart illness by decreasing LDL (low-density lipoprotein) oxidation. Anthocyanin in peels of brinjal seems a vital part in stopping overweightness by plummeting serum triglyceride and cholesterol and increasing high-density lipoprotein (HDL) cholesterol and decreasing serum triglyceride level [53]. Moreover, they are also helpful in ulcer treatment and vision [20], [68].

Extracts from brinjal have an extra toxic result on cancer cells than on normal cells [2]. Fiber of eggplant helps in digestion by removing toxins and harmful materials from our stomach thus reducing stomach and colon cancer [18]. Chlorogenic acid also shows anticarcinogenic functions by making apoptosis in many human cancer cells, such as leukemia and lung cancer cells [62]. A major phenolic compound chlorogenic acid, found in fruit skin [46] which works as an anti-obesity, anti-inflammatory, anti-diabetic agent and also have cardio-protective functions [44].

As carotenoids cannot be synthesized by our bodies, they should be taken into our diet. Carotenoid-rich foods consumptions are strongly related to reducing the hazard of some types of cancer [32]. Carotenoid-rich eggplant diet can reduce this problem in such countries [25].

Glycoalkaloids present in eggplant own anti-cancer actions. Naturally happening aglycone compound (solasodine) decreases human lung cancer cells *in vitro* [59]. They also have anti-inflammatory functions and also beneficial to lower blood cholesterol [19]. The phytonutrients maintain brain health via protecting its cell contrary to the obliteration of free radical cells. Compounds present in the eggplant have also the ability to avoid the brain tumor.

The Fe in eggplant has the ability to pact with premenstrual syndrome, amenorrhea, and antenatal anemia. [6], [10], [11], [31]. Eggplant is also known as a Fe chelator that is suggested particularly for pregnant females, lactating mothers, and teenagers females specifically. The researcher pointed out those patients with Fe deficiency in their body

must include eggplant, especially Turkey berry, Thai eggplant, and cherry eggplant for good results [5], [47]. It is also found out that dry eggplants are beneficial in the treatment of stomach bloating, gas, and treat piles, while the fresh fruits consumption strength bones, controls diabetes, prevents paralysis, and helpful in teeth related problems [10], [31]. Eggplants are a rich source of magnesium, manganese, potassium, and copper that are important for healthy bones.

Moreover, the matured fruits of eggplant are employed against stomach troubles, compress for swellings, and splintered nipples [39], [61]. The fruits are important in the treatment of various disorders like asthma, dysuria, dysentery, high blood pressure, and also to cure osteoporosis, arthritis, diabetes and bronchitis, heart diseases and strokes [54], [55]. Juice extracted from roots and leaves of brinjal are used to cure skin diseases, cough, otitis, anorexia, toothache, burns, general stimulant, piles, inflammation, intestinal foot pain, throat and stomach difficulties [33], [39], [54].

D. Nutrients available from 1 cup (100 g) of eggplant and daily requirements

A serving of eggplant can provide at least 5% of a person's daily requirement of fiber, copper, manganese, B-6, and thiamine. It also contains other vitamins and minerals. Besides, eggplants are a source of phenolic compounds that act as antioxidants. Antioxidants are molecules that help the body eliminate free radicals - unstable molecules that can damage cells if they accumulate in large amounts. Foods that contain antioxidants may help prevent a range of diseases. Among the antioxidants in eggplants are anthocyanins, including nasunin, lutein, and zeaxanthin. The following table shows the nutrients in 1 cup, or about 96 g, of cooked eggplant cubes. It also shows how much of each nutrient a person needs each day. However, people's requirements vary, depending on age and sex.

IV. CONCLUSION AND RECOMMENDATION

Eggplant is an economically important vegetable of the Solanaceae family with a significant foundation source of numerous quantities of therapeutic, pharmaceuticals, and nutraceuticals compounds. It is a rich source of abundant nutrients and their contents which all desirable mainly for body growth and development, to the refurbishment of worn-out materials and also provides a shield. In Bangladesh, there are several types of eggplants are available, amongst them ten eggplant cultivars were evaluated for morphologically and nutritionally and got the information regarding the nutritional composition which is very much useful for human body growth and development. A restricted sum of research was performed to explored health maintain compounds present in eggplant besides antioxidant and ascorbic acid. Additionally, primary metabolites, like amino acids and phenolic compounds, mainly overlooked. Needless to say, eggplant is a rich source of various valuable bioactive components that must be recognized and more research would be carried out to recognize the nutritive and pharmacological worth of eggplant in real words. So we can say eggplant is one of the world's healthiest foods.

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