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A BRIEF REVIEW ON *ABELMOSCHUS ESCULENTUS* LINN. OKRA

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ABSTRACT: Okra is a cultigen (a plant that has been altered by humans through a process of selective breeding). The exact origin of okra is unknown, but it is thought to have come from Africa, where it has been grown as a crop for centuries. Evidence suggests it was grown in Egypt as long ago as 2,000 BC. Today it is widely cultivated for its edible green fruits, which are harvested when immature (after 3 - 5 days of development), and are infamous for their slimy mucilage. It plays a vital role to preserve our health. In recent times, the use of herbal products has increased tremendously in the western world as well as developed countries. India is one of the most medico-culturally diverse countries in the world where the medicinal plant sector is part of a time-honoured tradition that is respected even today. Medicinal plants are believed to be safer and proved elixir in the treatment of various ailments. *Abelmoschus esculentus* (Okra) is an important medicinal plant of tropical and subtropical India. Its medicinal usage has been reported in the traditional systems of medicine such as Ayurveda, Siddha and Unani.

INTRODUCTION: Okra (*Abelmoschus esculentus*) is the only vegetable crop of significance in the Malvaceae family and is very popular in the Indo-Pak subcontinent. In India, it ranks number one in its consumption but its original home is Ethiopia and Sudan, the north-eastern African countries. It is one of the oldest cultivated crops and presently grown in many countries and is widely distributed from Africa to Asia, southern Europe and America. It is a tropical to subtropical crop and is sensitive to frost; low temperature, water logging and drought conditions, and the cultivation from different countries have certain adapted distinguishing characteristics specific to the country to which they belong [1].

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It is an oligo purpose crop, but it is usually consumed for its green tender fruits as a vegetable in a variety of ways. These fruits are rich in Vitamins, calcium, potassium and other mineral matters. The mature okra seed is a good source of oil and protein has been known to have superior nutritional quality. Okra seed oil is rich in unsaturated fatty acids such as linoleic acid, which is essential for human nutrition. Its mature fruit and stems contain crude fibre, which is used in the paper industry [1].

Description:

Biological Name: *Hibiscus esculentus*, *Abelmoschus esculentus*.

Scientific Classification:

Kingdom : Plantae
Division : Magnoliophyta
Class : Magnoliopsida
(Unranked) : Rosids
Order : Malvales
Genus : Abelmoschus

Species : *A. Esculentus*
Binomial name : *Abelmoschus esculentus*

Other Names: Kacang Bendi, qiu kui, Okra, okura, Okro, Quiabos, Ochro, Quiabo, Gumbo, Quimgombo, Bamieh, Bamya, Quingumbo, Bamia, Ladies Fingers, Bendi, Bhindi, Kopi Arab [2].

FIG. 1: *ABELMOSCHUS ESCULENTUS* OKRA FRUIT

FIG. 2: *ABELMOSCHUS ESCULENTUS* OKRA FLOWER

Chemical Composition: Okra bast, a multicellular fiber was analyzed and the estimated average chemical compositions of OBF (*Abelmoschus esculentus* variety) are 67.5% a-cellulose, 15.4% hemicelluloses, 7.1% lignin, 3.4% pectic matter, 3.9% fatty and waxy matter and 2.7% aqueous extract. It is clear that the main constituents of OBF are a-cellulose, hemicelluloses and lignin and the rest are very minor in proportion, so render a little influence to the structure of OBF. Therefore, the structure of a-cellulose, hemicelluloses and lignin and the mode of combinations that exist in between themselves are dominating the structure of OBF.

TABLE 1: OKRA RAW NUTRITION VALUE PER 100g

Energy	33 kcal
Carbohydrates	7.45 g (140
Sugars	1.48 g
Dietary Fibers	3.2 g
Fat	0.19g
Protein	2g
Water	90.19g
Vitamin A	36µg (7%)
Thiamine(B1)	0.2 mg (17%)
Riboflavin(B2)	0.06mg (5%)
Niacin (B3)	1mg (7%)
Vitamin C	23mg (28%)
Vitamin E	0.27 mg (2%)
Vitamin K	31.3 µg (30%)
Calcium	82mg (8%)
Iron	0.62 mg (5%)
Magnesium	57 mg (16%)
Potassium	299mg (6%)
Zinc	0.58 mg (6%)

Percentages are related to US recommendations to for adults. (Source: USFDA database) Okra is a popular health food due to its high fiber, Vitamin C, and folate content. Okra is also known for being high in antioxidants. Okra is also a good source of calcium and potassium.

Parts Used: fruit, leave seed and root [18].

Ethnomedicinal Uses: Plants for a future cannot take any responsibility for any adverse effects from the use of plants. Always seek advice from a professional before using a plant medicinally. Antispasmodic; Demulcent; Diaphoretic; Diuretic; Emollient; Stimulant; Vulnerary **Table 2**. The roots are very rich in mucilage, having a strongly demulcent action. They are said by some to be better than marsh mallow (*Althaea officinalis*). This mucilage can be used as a plasma replacement.

An infusion of the roots is used in the treatment of syphilis. The juice of the roots is used externally in Nepal to treat cuts, wounds and boils. The leaves furnish an emollient poultice. A decoction of the immature capsules is demulcent, diuretic and emollient. It is used in the treatment of catarrhal infections, dysuria and gonorrhoea. The seeds are antispasmodic, cordial and stimulant. An infusion of the roasted seeds has sudorific properties [17, 189].

Other Uses: Fibre; Paper; A fibre obtained from the stems is used as a substitute for jute. It is also used in making paper and textiles. The fibres are about 2.4 mm long.

When used for paper the stems are harvested in late summer or autumn after the edible seedpods have been harvested, the leaves are removed and the stems are steamed until the fibres can be stripped off. The fibres are cooked for 2 hours with lye and then put in a ball mill for 3 hours.

TABLE 2: OKRA IN ETHNOMEDICINE

Parts	Form	Name of the Medicinal system where it is used	Used for
	Infusion of the fruit mucilage	Indian ethnomedicine	For treating dysentery and diarrhoea in acute inflammation and irritation of the stomach, bowels, and kidneys catarrhal infections, ardour urinae, dysuria, diuretic, plasma replacement and gonorrhoea [22-26]
Fruit	Infusion of the fruit mucilage	Indian ethnomedicine	Antipyretic and plasma replacement
	A decoction of the immature fruit	Indian ethnomedicine	Demulcent and emollient poultice
	Extract of leaves and roots	Indian ethnomedicine	Demulcent, though less so than that of okra fruit
Leaves	Extract of leaves	Indian ethnomedicine	Extract of leaves mixed with egg albumin and applied on hair which makes black and silky hair [22, 27]
	Leaves	Latin America	Remedies for tumour
	Extract of roots	Indian ethnomedicine	Demulcent and emollient poultice
Root	The juice of the roots	Nepal	To treat cuts, wounds and boils [22, 23. 27-29]
	An infusion of the roots	Indian ethnomedicine, Malaya	Treatment of syphilis
	Infusion of the roots	Traditional medicine of Nicoragua's Atlantic Coast and Turkey	Used as stomachic, to treat diabetes, ulcer, used as laxative and treatment of jaundice
	Seeds	Indian ethnomedicine	Antispasmodic, cordial and stimulant
	Infusion of the roasted seeds	Indian ethnomedicine	Has sudorific properties
Seed	Okra seed	Indian ethnomedicine	Treatment of spermatorrhoea [23, 25, 30-34]
	Okra seed	Turkish folk medicine	In managing increased blood glucose concentration
	Seeds	Latin America	Remedies for tumour
	Infusion of roasted okra seeds	Turkey	Diabetes mellitus therapy
Flower	The decoction of the leaves and flowers	Indian ethnomedicine	Used for the treatment of bronchitis and pneumonia [23, 35]

Distribution:
Found In: Bangladesh, India, Myanmar.

Introduced Into: Alabama, Albania, Andaman Is., Angola, Bahamas, Benin, Borneo, Bulgaria, Burkina, Cambodia, Cape Verde, Cayman Is., Central African Repu, Chad, China South-Central, China Southeast, Congo, Cuba, Dominican Republic, Eritrea, Fiji, Gabon, Gambia, Greece, Guinea-Bissau, Gulf of Guinea Is., Hainan, Haiti, Illinois, Ivory Coast, Jamaica, Jawa, Krym, KwaZulu-Natal, Leeward Is., Malaya, Mali, Marianas, Mauritania, Mexico Southwest, Mozambique, Nicobar Is., Niger, Nigeria, Northern Provinces, Oman, Philippines, Puerto Rico, Romania, Senegal, Sierra Leone, South European Russi, Southwest Caribbean, Sudan, Tanzania, Togo, Uganda, Ukraine, Venezuela, Venezuelan Antilles, Windward Is., Zambia, Zaïre, Zimbabwe.

Other Botanical Information: *Abelmoschus esculentus* (usually 2n = 130) is probably an amphidiploids (allotetraploid), derived from *Abelmoschus tuberculatus* Pal and H. B. Singh (2n = 58), a wild species from India, and a species with 2n = 72 chromosomes (possibly *Abelmoschus ficulneus* (L.) Wight and Arn. ex Wight). Another edible okra species, *Abelmoschus caillei* (A. Chev.) Stevels occurs in the humid parts of West and Central Africa. There are strong indications that also *Abelmoschus caillei* is amphidiploids with *Abelmoschus esculentus* being one of the parental species. There are no apparent differences in use between the common and West African okra, which is why they are often lumped together.

Morphologically *Abelmoschus caillei* differs in several respects from *Abelmoschus esculentus*, but the epicalyx offers the best discriminating characteristic: the width of the epicalyx segments is 0.5 - 3 mm in *Abelmoschus esculentus* and 4 - 13 mm in *Abelmoschus caillei*. The two okra species can be quite reliably (but not with absolute certainty) recognized on the basis of fruit form. Fruits of *Abelmoschus esculentus* are cylindrical to pyramidal, whereas fruits of *Abelmoschus caillei* are ovoid. Literature references on common okra have to be interpreted with care because they may include information related to *Abelmoschus caillei*.

There are many cultivars of common okra. Some of the better known are 'Clemson Spineless', 'Indiana', 'Emerald' (United States) and 'Pusa Sawani' (India), which have been in use for about 30 years [3].

Diseases and Pests: The most serious fungal diseases of okra in Africa are damping-off (*Macrophomina phaseolina, Pythium aphanider-matum,* and *Rhizoctonia solani*), vascular wilt (*Fusarium oxysporum*), Cercospora blight (*Cercospora abelmoschus*, *Cercospora malayensis*) and powdery mildew (*Erysiphe cichoracearum, Oidium abelmoschi*). Okra mosaic virus (OkMV), transmitted by flea beetles (Podagrica), is widespread in Africa but damage is much less important than that caused by okra leaf curl disease (OLCV), transmitted by whitefly (*Bemisia tabaci*). Whitefly is also the vector of yellow vein mosaic virus (BYVMV), a major cause of crop failure in Asia. These viruses can only be controlled through control of the vectors.

Nematodes of the genus Meloidogyne constitute a major problem. Damage by nematodes is avoided by crop rotation (*e.g.* with cereals) and by large applications of organic manure. Important pests are fruit and stem borers (*Earias* spp. and *Heliothis* spp., *Pectinophora gossypiella*), flea beetles (*Podagrica* spp.) and jassids (*Empoasca* spp.). Chemical control is hazardous because crop harvesting is frequent. Common okra is in general more seriously affected by diseases and pests than West African okra [3, 15, 13, 14].

Yield: A vegetable yield of 10 t/ha can be considered a good harvest, but yields of over 40 t/ha can be realized under optimal conditions. Yields are usually low (2 - 4 t/ha) as a result of non-intensive growing methods. Seed yields are in the range of 500- 1000 kg/ha [3].

Validated Pharmacological Properties of the Okra:

Antioxidant Activity and Prevention of Cellular Damage Related Diseases: Reactive oxygen species (ROS) *i.e.* superoxide anion ($O_2^{-)}$, hydrogen peroxide (H_2O_2), and the hydroxyl radical (OH^-) and reactive nitrogen species (RNS) *i.e.* nitric oxide (NO), peroxynitrite ($ONOO^-$) when produced in excess, cause cell dysfunction and ultimately death. This happens due to alteration of metabolic pathway [36] and / or the structure of cellular membranes, DNA, or proteins [37, 38]. Many medicinal plants, fruits and their products, fermented food, etc are proved to have sufficient antioxidant to scavenge these free radicals and to prevent the ensuing damage [39 - 45]. With regard to Okra, several studies have been conducted on the antioxidant activity with different parts of the plant. Atawodi *et al*., (2009) [46] 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.

According to Khomsug, Thongjaroenbuangam, Pakdeenarong, Suttajit, and Chantiratikul (2010) [48], total phenolic content of pulped and seeds of okra extracts as 10.75 ± 0.02 mg GAE/100g extract and 142.48 ± 0.02 mg 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 seeds. In pulped seed catechin, procycanidin B2, 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 [48] whereas pre-treatment (soaking and blanching) increased the nutrient composition, but decreases antioxidant activity [49]. Ansari, Houlihan, Hussain, and Pieroni (2005) [50] reported Okra extract as in vitro non-enzymatic inhibitior of lipid peroxidation in liposomes. A. esculentus peel and seed powder contains significant *in vivo* antioxidant property in streptozotocin-induced diabetic rats.

Administration of different doses of peel and seed powder significantly increased liver, kidney and pancreas superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), reduced glutathione (GSH) levels and decreased thiobarbituric acid reactive substances (TBARS) ($P < 0.001$) levels in diabetic rats compared to diabetic control rats. Liao, Liu, and Yuan, (2012) [51] 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 total flavonoids were found [51]. 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 as Antidiabetic and Antihyperlipidemic and Related Disease Prevention: In traditional medicine Okra seeds are reported to have ability in managing increased blood glucose concentration. Modern research has correlated this traditional claim with Tomoda *et al*., (1989) [52] reported that okra polysaccharide possesses anticomplementary and hypoglycemic activity in normal mice. *A. esculentus* was found to have hypolipidemic activity in *in vivo* tested rat model (Trinh, Nguyen, Tran, and Nguyen 2008) [53] and in mice [54]. Okra polysaccharide lowers the cholesterol level in blood and may prevent cancer by its ability to bind bile acids [55]. Cholesterol levels decreased 56.45%, 55.65%, 41.13%, 40.50% and 53.63% respectively in mice groups orally administered with dichloromethane okra plant extract, methanol okra plant extract, dichloromethane okra fruit extract, methanol okra fruit extract and simvastatin as compared to the tyloxapol injected group [54].

The effects of crude extracts of *A. esculentus* on albumin and total bilirubin levels of diabetic albino rats were reported to have a significant ($P<0.05$) increase (82%) in total bilirubin levels in diabetic control group over the normal control [56]. Ramachandran, Sandeep, Srinivas, and Dhanaraju, 2010 [57] reported anti-diabetic activity of okra on alloxan - induced diabetic rats. Sabitha, Ramachandran, Naveen, and Panneerselvam Sabita *et al*., (2012, 2013) [58, 59] has reported antidiabetic and antihyperlipidemic potential of okra peel and seed powder in streptozotocin (STZ)-induced diabetic rats.

Administration of peel and seed powder at 100 and 200 mg/kg dose in diabetic rats showed significant ($P < 0.001$) reduction in blood glucose level and increase in body weight than diabetic control rats. Water-soluble fraction of the fruits of Okra was studied to check the absorption of oral glucose as well as metformin from the gastrointestinal tract in the Long Evans rats. It showed significant reduction in absorption of glucose as studied in the 24 hr fasting rats [60]. Thanakosai and Phuwapraisirisan, (2013) [61] has reported, the presence of two major flavonol glucosides named isoquercetin (2) and quercetin-3-O-beta-glucopyranosyl- (1"→6")-glucoside (3) in okra seeds which are α-glucosidase inhibitors. These two compounds selectively inhibited rat intestinal maltase and sucrase, in which isoquercetin (2) was 6 - 10 times more potent than its related diglucoside 3. Subrahmanyam *et al*., (2011) [62] has reported antidiabetic activity of okra fruit extract.

The effects of *A. esculentus* fruits on alkaline phosphatase (ALP), aspartate aminotransferase (AST) and alanine aminotransferase (ALT) activities on diabetic albino rats were also investigated. Serum glucose levels and activities of enzymes *viz.* ALP, AST and ALT decreased significantly after administration of the extracts [56]. Hypoglycemic effect of ethanolic and aqueous extract of *A. esculentus* fruit was studied. Results revealed that aqueous extract of powdered drug had maximum effect (Saha, Jain, and Jain, 2011). Recent study reported that the extract of okra lowers blood glucose and serum lipids in high-fat diet-induced obese C57BL/6 mice. Ethanol extract of okra (EO) and its major flavonoids isoquercitrin and quercetin 3-O-gentiobioside reduced blood glucose and serum insulin levels and improved glucose tolerance in obese mice [63].

For Treating Dysentery and Diarrhoea in Acute Inflammation and Irritation of the Stomach, Bowels: In Asia and African traditional medicine, okra fruits are served as mucilaginous food as a dietary meal in the treatment of gastric irritations and inflammative diseases. Scientific explanation of such use came in recent years. Lengsfeld, Titgemeyer, Faller, and Hensel (2004) [64] pre-treated Helicobacter pylori with a fresh juice of okra that completely inhibited adhesion in an in situ adhesion model on sections of human gastric mucosa.

The anti-adhesive qualities of okra were assumed to be due to a combination of glycoproteins and highly acidic sugar compounds making up a

complex three-dimensional structure that is fully developed only in the fresh juice of the fruit. That is due to the blocking capacity of specific Helicobacter surface receptors that coordinate the interaction between host and bacterium. According to Messing *et al.*, 2014 [65], it supported the previous claims and showed that the effectiveness in treating gastric irritations and inflammative diseases is due to polysaccharides that inhibit the adhesion of *H. pylori* to stomach tissue.

Recent trends and future prospect Okra extract is used as a key ingredient in several commercially important products of food and medicine. The rheological behaviour [66], properties of forming oil water emulsion and ability to stabilize acidic emulsion [67] of okra can potentially be used as future value addition applications like composite materials [68] and food foam productions [69].

In last decade, extensive efforts have been given in developing of several nanoscale-carriers in to improve the drug delivery systems [42, 43, 701]. Okra may play a leading role in improved drug delivery system. Several reports came using okra polysaccharide as drug release agent. Okra gum as a mini-matrix for furosemide and diclofenac sodium tablets showed prolonged release of furosemide and diclofenac sodium from the compressed tablets [71]. Besides it is now used as a medium for several other drug deliveries. Bakre and Jaiyeoba (2009) [72] used it as metronidazole tablet formulation. Sharma, Kulkarni, and Sharma, (2013a) [73] used it in the development mucoadhesive gel for nasal delivery of rizatriptan benzoate. Recently this same research group (Sharma, Kulkarni, Sharma, Bhatnagar, and Kumar, 2013b) [74] have prepared and evaluated of mucoadhesive microspheres, using okra polysaccharide as a novel carrier for safe and effective delivery of rizatriptan benzoate into nasal cavity.

It is also used to study the sustaining release of drug [75]. Besides colon specific drug delivery studies also been carried out [76]. If drug release is the present hunk of okra research, the future might come as a medium of probiotic, nutraceutical delivery. Several new formulation might come like edible coating, preservative carrier *etc*. So more application oriented research might be carried out to get the full utilization of this novel natural gift.

CONCLUSION: The okra fiber posses an excellent quantity of cellulose. Hence it can be used as cellulosic raw materials in cellulose based industries. It also contains low percentage of lignin, which is responsible for yellowing and photochemical degradation. It is a high molecular weight compounds. So it has some developed properties like colour fastness, tensile strength etc. in Philippines OBF is used as textile fiber. It is also having excellent anti oxidant activity and memory enhancement activity. If we collect and properly use the okra bast by isolating fiber from it then a good prospect must be await for our country. And also we can use this extract as a good medicine for alzhemeirs disease.

The strong scientific evidence of *in vitro* and *in vivo* biological activity confirms the doubt of its traditional use. Detailed investigations for its myriad beneficial effects may enlighten the future of medicinal exploitation. However further research should be focused to find out the mechanism of action of the pharmacological activities at the molecular level. This can solve several unanswered questions of origin, development and cure of diseases. Besides, being nontoxic in nature, this fruit can be easily tried for human trials rather than animal models. Okra based anti-diabetic food, antioxidant rich food formulation can be thus easily be tried avoiding complicated medical trials. It would get go for better value addition and commercialization in near future not being confined only in kitchen.

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