

Okra and its various applications in Drug Delivery, Food Technology , Health Care and Pharmacological Aspects - A Review

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Abstract:

Background: Medicinal plants are the nature's gift to human being to have disease-free healthy life. Okra is a one of the traditional plant scientifically known as *Abelmoschus esculentus* Linn belong to the family Mallow, having rich nutritional value and proved to have many therapeutic uses. Different parts of this plant used in the extensively in traditional medicine as antidiabetic, diuretic, and anticancer,. They are widely used in the pharmaceutical & food industries .Okra is rich in bioactive compounds, such as flavonoids, polysaccharides, polyphenols, caffeine, and pectin. The aim of present review is to highlight the beneficial effects of the Okra in human health, diverse pharmacological uses and its various applications in drug delivery system and food technology.

Method: This is a review article, which was obtained by a search in databases such as Pub Med and Google Scholar.

Results: The above indicated Okra containing vital nutrients which aids in proper functioning of the human biological system.. A powerhouse of valuable nutrients, okra is a miraculous medicinal vegetable to treat numerous diseases. Okra possess powerful antioxidant, antidiabetic ,antihyperlipidemic and antibacterial activities. In Drug Delivery system okra mucilage works wonder as a binding, emulsifying, suspending and film coating agent.

Conclusion.. The information presented here shows that the overall, okra is an important vegetable crop with a diverse array of nutritional quality and potential health benefits. Moreover the polysaccharide content in the fruit have been the subject of significant interest in the research field of food and pharmaceutical industries. Furthermore this vegetable can be used as an indispensable tool in prevention of various diseases and okra based various formulations can be done rather than being confined only to kitchen.

Keywords: *Abelmoschus esculentus*, edible, medicinal, Pharmacological, Drug Delivery, Ethno medicine.

1. INTRODUCTION:

Natural Plants play important role to preserve our health. Man has familiarized himself with plants and used them in a variety of ways from the very beginning of his existence.. Plants are finding use as pharmaceuticals, nutraceuticals, cosmetics and food supplements, even as traditional source of medicines and also play vital role for the sources of prescription drugs in allopathic medicines(1) In current time there is more demand of use of plant and natural product rather than synthetic ones.

Okra is a multipurpose crop due to the varied use of its leaves, buds, flowers, pods, stems and seeds The whole okra plant is edible and has various food, non-food and medical applications (Adelakun et alole)(1). the seed is the nutritionally richest part of the okra.(Adelakun, O. E., Oyelade, O. J., Ade-Omowaye, B. I., Adeyemi, I. A., Van de Venter, M., & Koekemoer, T. C. (2009). Influence of pre-treatment on yield chemical and antioxidant properties of a Nigerian okra seed (*Abelmoschus esculentus* Moench) flour.*Food and Chemical Toxicology*, 47 (3): 657-661.)

The plant contains in its fruit leaves and stem, a mucilaginous material that has several food and medicinal uses. The green stems of mature plants after the picking of fruit are generally used for preparation of crude mucilage extract. The okra mucilage is a glycoprotein comprising of about 10% protein and 80% polymeric carbohydrates. It has large water binding properties due to hydroxyl group of sugar. The okra mucilage helps to stabilize blood sugar by curbing the rate of which from the intestinal tract (Kalu et.al, 2006). The fruits are harvested when immature and eaten as a vegetable (kiran, 2002).).Okra is eaten as a food(4)

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 (2)

2.Biological Name : The Biological Name of Okra is known as *Abelmoschus esculentus*.

3. Other Names:

TABLE : 1

Scientific Name	ABELMOSCHUS ESCULENTUS (HIBISCUS ESCULENTUS)
Common Name	LADY FINGER.OKRA
Vernacular Name	, OKRA, GUMBO
Sanskrit Name	TINDISHA, PITALI, GANDHAMULA
Hindi Name	BHINDI
English Nam	OKRA, LADIES' FINGER, EDIBLE HIBISCUS, OCKRO
Middle East	In ARABIC FARSI,HEBREW,and TURKISH,it is called BAMIA and BAMVEH,BOSNIA
Italian	GOMBO
French	GOMBO
Swedish	OKRA

4. Scientific Classification:

TABLE : 2

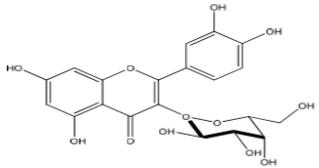
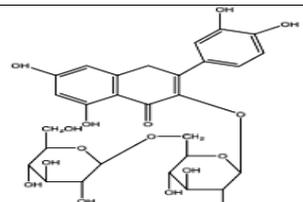
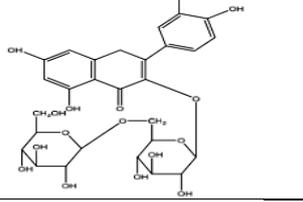
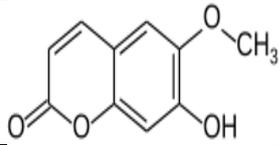
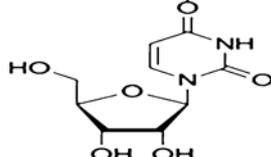
Plant Family	MALVACEAE (MALLOWS)
Kingdom	PLANTAE
Sub-Kingdom	VIRIDIPLANTAE
Infra Kingdom	STREPTOPHYTA (land plants)
Super Division	EMBRYOPHYTA
Division	TRACHEOPHYTA (TRACHEOPHYTES or Vascular Plants)
Sub Division	SPERMATOPHYTINA (SPERMATOPHYTES or Seed Plants)
Class	MAGNOLIOPSIDA
Super Order	ROSANAE
Order	MALVALES
Family	MALVACEAE (MALLOWS)
Genus	ABELMOSCHUS (OKRA)
Species	ABELMOSCHUS ESCULENTUS

5. Chemical constituents (www.mpbd.info)

Petals yield 13 flavanoid glycosides; gossypetin and hibiscetin glucosides. Fresh fruits are rich in pectin and mucilage; it contains oxalic acid, protein, fat, minerals (potassium, sodium, magnesium, sulphur, copper, manganese and iodine), carbohydrate, calcium and phosphorus. Fresh fruits also contain vitamin A, thiamine, riboflavin, ascorbic acid and niacin. d-Galactose, l-rhamnose and d-dalacturonic acid also isolated from the mucilage of the fruit. Flavonoid compound has been reported from fruits. Essential oil isolated from pods and seeds contain aliphatic alcohols, cyclohexanol, p-tolualdehyde (in fruits), a-terpenylacetate (in seeds) and citral; nonvolatile neutral part contains β -sitosterol & its 3 β -galactoside (in seeds). Leaves have got more or less same constituents. Ripe seeds contain 10-22% edible oil. (Anon, 1959; Asolkar et al., 1992).

6. Isolated chemical constituents (National academies press (2006) Lost crops of Africa vegetables, volume II: 287-301.)

TABLE :3

SL.no	Compound	Name	Plant sources	Structure
1	Hyperoside/ Hyperin	dihydroxyphenyl-3-[(3R,4S,5R,6R)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]oxy-4Hchromene-4,5,7-triol	Abelmoschus esculentus	 Hyperoside
2	Flavonoid glycoside	5,7,3',4'-tetrahydroxy-4''-O-methyl flavonol-3-O- β -D-glucopyranoside	Abelmoschus esculentus	
3	Flavonoid glycoside	5,7,3',4'-tetrahydroxy flavonol -3-O-[β -D-glucopyranosyl-(1 \rightarrow 6)]- β -Dglucopyranoside	Abelmoschus esculentus	
4	Coumarin scopoletin	7-hydroxy-6-methoxychromen-2-one	Abelmoschus esculentus	
5	Uridine	1-[(3R,4S,5R)-3,4-dihydroxy-5-(hydroxymethyl)oxolan-2-yl]pyrimidine-2,4-dione	Abelmoschus esculentus	

7. Edible Uses:

Immature fruit - cooked on their own or added to soups etc. They can be used fresh or dried. Mucilaginous, they are commonly used as a thickening for soups, stews and sauces. The fruits are rich in pectin and are also a fair source of iron and calcium. The fresh fruits contain 740 iu vitamin A. Seed - cooked or ground into a meal and used in making bread or made into 'tofu' or 'tempeh'. The roasted seed is a coffee substitute. The seed contains up to 22% of an edible oil.(1)

8. Medicinal Uses

Antispasmodic: -This quality in the seeds is beneficial to the gastrointestinal tract

Demulcent : :This quality of the roots is very active due to the mucilage which can be used to replace plasmid. It is a quality that is present in the leaves, the skin and young pods.

Diuretic : The young pods act as a diuretic and emollient. Releases accumulation of water that leads to swelling/water retention.

Emollient: Soothes and softens the skin (<https://ajaytaobotanicalblog.wordpress.com/.../botanical-name-abelmoschus-esculentus>.)

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, 18

Okra in Ethno medicine:**TABLE :4**

Parts	Form	Name of the medicinal system Where it is used	Used for
FRUITS	Infusion of the Fruit mucilage	Indian ethno medicine	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
	Infusion of the Fruit mucilage	Indian ethno medicine	Antipyretic and plasma replacement
	A decoction of the immature fruit	Indian ethnomedicine	Demulcent and emollient poultice
	Extract of leaves and fruits	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 2
	Leaves	Latin America	Remedies for tumour
ROOT	Extract of roots	Indian ethnomedicine	Demulcent and emollient poultice
	The juice of the roots	Nepal	To treat cuts, wounds and boil
	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
SEED	Seeds	Indian ethnomedicine	Antispasmodic, cordial and stimulant
	Infusion of the roasted seeds	Indian ethnomedicine	Has sudorific properties
	Okra seed	Indian ethnomedicine	Treatment of spermatorrhoea ²
	Seeds nfusion of roasted okra see	Latin America	Remedies for tumour
FLOWER		Turkey	Diabetes mellitus therapy

11. Biochemical and Nutritional Potential of Okra:

Okra provides an important source of carbohydrates, proteins and minerals which are often lacking in the diet in developing countries⁴⁸. The composition of edible portion of okra is given in Table 2.

Okra Nutritional Benefits: The Nutritional Benefits of Okra are presented in Table 5 (ANNJANA-2017)

TABLE :5

COMPOUND S	QUANTIT Y	MINERAL S	QUANTIT Y
Calories	35.6gm	Sodium	6.9mg
Moisture	89.6 gm	Calcium	66.0mg
Carbohydrates	6.4gm	Iron	0.35mg
Proteins	1.9 gm	Potassium	103mg
Fats	0.2gm	Magnesium	53mg
Fibre	1.2gm	Copper	0.19mg
Minerals	0.7gm	Thiamine	0.7mg
Phosphorous	5.6 mg	Riboflavine	0.01mg
Sulphur	30.0mg	Nicotinic Acid	0.06mg

A powerhouse of valuable nutrients, okra is a miraculous medicinal vegetable to treat numerous diseases. **(menlify)**

1. Okra for Diabetes (www.curejoy.com)

Okra's peel and seed can lower blood glucose levels, making them useful in managing diabetes mellitus. They do so by inhibiting carb-breaking enzymes, increasing sensitivity to insulin, and ensuring there are sufficient insulin-producing cells in the pancreas. More insulin and less breakdown of carbs to glucose means lower blood sugar. Okra is beneficial and effective in stabilizing blood sugar due to its insulin-like property. Okra contains a type of dietary fiber, Eugenol. This helps in stabilizing blood sugar and slowing down the absorption of sugar in the intestinal tract.

2. Lowers Bad Cholesterol:

Okra appears to help lower cholesterol levels. A study that was recently published in the Journal of the Federation of American Societies for Experimental Biology showed that supplementation with okra affected the absorption of cholesterol, thus lowering levels in the body in comparison to a control group. There is another type of fiber in which Okra has, it's pectin. This is beneficial in lowering the bad cholesterol. Okra promotes cholesterol degradation and inhibits the production of fat in the body. It, thus, decreases total cholesterol and triglyceride and enhances excretion of bile acids (made from cholesterol) in the feces.

The way it lowers the bad cholesterol is by altering the bile production in the intestines. This helps in eliminating the clots and deposited cholesterol.

3. Gut Bacteria Friendly

The probiotics in Okra is the gut bacteria's friend. The microbiome or the good community of bacteria in the intestinal tract loves Okra. It aids in the biosynthesis of

vitamin B complex. This serves a similar function as yogurt does to the small intestines.

4. Rich in Fiber

The abundance of dietary fibers presents in Okra not only beneficial to controlling blood glucose and clearing up cholesterol deposits. It also helps in clearing up wastes in the small intestines. This results in a better digestion and prevention of constipation.

5. Lowers Risk of Colon Cancer

Due to its rich insoluble fiber contents, Okra serves as an intestinal tract cleaner particularly in the colon, large intestines. This reduces the risk of colon cancer. Plus due to the antioxidants present in Okra, it boosts the immune system and prevents cell mutations.

6 Boosts The Immune System

Vitamin C is of Okra's potent nutrients. This alone is a potent antioxidant plus other antioxidants present in Okra makes up a good immune system booster. Other minerals present in Okra that are beneficial in fighting and eliminating free radicals include calcium, iron, manganese, and magnesium

7. Pregnancy Benefits

Okra's high levels of vitamin A, B vitamins (B1, B2, B6), and vitamin C, and traces of zinc and calcium, make it an ideal vegetable to eat during pregnancy. Okra also serves as a supplement for fiber and folic acid. Foliates also prevent miscarriages. It is also beneficial in the formation of the neural tube of the fetus and provides protection to these tubes preventing defects. This helps prevent birth defects like spina bifida and can even stop constipation during pregnancy.

8. Rich in Protein

The proteins are present in Okra seeds. It is one of the best sources of vegetable protein. The protein contain is rich in amino acids similar to those found in sulfur, cysteine, and tryptophan

9. Obesity Prevention :

Obesity is a metabolic disorder similar to diabetes. With the regular usage of okra, in either the raw or the cooked form, you can avoid obesity to a great extent. Obesity is not necessarily due to the consumption of fatty and calorific foods but also due to the lack of nutrients. Okra consumption along with healthy eating habits and lifestyle can help prevent weight gain, and eventually obesity. It has a minimal calorie content. Plus the high fiber content allows satiety without eating a lot.

10. Genital Disorder Solution

Not only that Okra is beneficial in boosting sexual health and fertility, it also beneficial in treating gonorrhoea, syphilis, excessive menstrual bleeding, leucorrhoea, and dysuria.

Hence, it is both beneficial for men and women

11. Liver Detoxification:

Okra helps to cleanse the liver: The slimy substance in okra contains substances that bind bile acid and cholesterol to detoxify the liver. Okra contains glutathione which is a protein molecule that is produced naturally in the body. Glutathione is a powerful antioxidant that helps the body fight against the harmful effects of germs and bacteria

12. Skin Cleansing:

Fibre aids toxic waste cleansing and Vitamin C aids in repairing body tissues, preventing skin pigmentation, reducing acne, psoriasis and other skin conditions

13. Makes Hair Healthy

Okra is not just for ingestion, but it also works fantastic as a hair conditioner. It is a good moisturizer for the scalp, itchy scalp prevention, eliminates lice and dandruff, and makes hair shiny.

14. Bone Health

Okra is among the many vegetables containing Vitamin K. Although not very popular as vitamin C, vitamin K is essential for blood-clotting process. It also helps restore bone density and prevention of osteoporosis.

One study³ says;

Several mechanisms are suggested by which vitamin K can modulate bone metabolism. Besides the gamma-carboxylation of osteocalcin, a protein believed to be involved in bone mineralization, there is increasing evidence that vitamin K also positively affects calcium balance, a key mineral in bone metabolism.

15. Alternative Flue and Cold Treatment

The leaves and flowers of Okra are just as healthful. Harness their health benefits by boiling it. It's a good alternative and natural treatment for pneumonia and bronchitis. The slimy stuff or mucilaginous is the secret to treating and soothing for common colds and flu.

16. Beneficial For People with Asthma

One of the okra health benefits is for asthma prevention. Okra contains potent antioxidants like vitamin C and anti-inflammatory properties that are helpful in preventing the occurrence of asthma. The antioxidant and anti-inflammatory properties of Okra, and rich vitamin C content, curtail the development of asthma symptoms and prevent fatal attacks.

17. Anemia Prevention

Due to its Vitamin K, iron and folate contents, it is one of the natural means of preventing anemia. These nutritional contents help in the formation of hemoglobin and production of red blood cells. They also aid in blood coagulation. All these functions and benefits combined, Okra is helpful in providing a good protection against anemia.

18. Ulcer Treatment

The mucilaginous, which is the slimy stuff in Okra is alkaline. This helps in neutralizing the acid. Additionally, it provides protective coating within the digestive tract, which speeds up the healing process of peptic ulcers.

19. Relieves and Prevents Constipation

The slimy mucilaginous stuff present in Okra aids on appropriate water absorption along the digestive tract. This helps bulk up the stool making it neither too soft nor too hard to pass.

Okra's mucilaginous content along with fiber bind to toxins and lubricates the large intestines. This ensures effortless and normal bowel movement due to its natural laxative property

20) Protection Against Sun Strokes:

Some studies show that Okra is beneficial in avoiding sunstrokes. This is a possibility because Okra is a natural cooling agent.

21) Maintain Healthy Blood Vessels

Okra contains flavonoids. There are studies that shown consuming flavonoids and vitamin C from fruits and vegetables are beneficial to blood capillaries. The good news is Okra has both. Hence, it is a good idea to consider including Okra as part of typical daily diet.

22) Maintain Good Eyesight

The vitamin A along with antioxidant contents such as lutein, xanthin, and carotenes are beneficial for maintaining good vision. Okra contains beta-carotenes (precursor of vitamin A), xanthin and lutein, all antioxidant properties, preventing eye problems like cataract and glaucoma.

23) Okra to perform better in studies(okra properties-w.botanical,online.com)

A scientific study in the University of Maharakham(Thailand) has shown that okra protects neuronal function, improves learning and memory due to its content in flavonoids(quercetin) and rutin which have a neuroprotective effect. By these findings, it appears that okra is a food indicated in the diet to increase memory.

12. Pharmacological Properties of the Okra:**a)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.

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 procyanidin B2 as predominant phenolic compound followed by

procyanidin B1 and rutin in seeds. In pulped seed catechin, procyanidin B2, epicatechin and rutin are reported to be present.

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 43ml

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

b) 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) (9) 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) (10) and in mice . Okra polysaccharide lowers the cholesterol level in blood and may prevent cancer by its ability to bind bile acids (11) . 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 (10)

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 (12) . Thanakosai and Phuwapraisirisan, (2013) (13)has reported, the presence of two major flavonol glucosides named isoquercetin (2) and quercetin-3-O-beta-D-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) (14)has reported antidiabetic activity of okra fruit extract.

In another study published in Iranian Journal of medical Sciences” The Effect of *Abelmoschus Esculentus* on Blood Levels of Glucose in Diabetes Mellitus suggests that *Abelmoschus esculentus* (AE)/Okra extract has a hypoglycemic effect that helps decrease blood glucose level. Its properties can be a useful remedy to manage diabetes mellitus. In addition, it leads to inhibition of cholesterol absorption and subsequently decreases the level of lipid and fat in the blood. The results of an investigation on diabetic mice by using this material has shown the same effect and confirmed this conclusion

c) For Treating Dysentery and Diarrhoea in Acute Inflammation and Irritation of the Stomach, Bowel

In Asia and African traditional medicine, okra fruits are served as mucilaginous food as a dietary meal in the treatment of gastric irritations and inflammatory diseases. Scientific explanation of such use came in recent years. Lengsfeld, Titgemeyer, Faller, and Hensel (2004) (15)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

The anti-adhesive qualities of okra were assumed to be due to a combination of glycoproteins and highly acidic sugar compounds making up a mucilage 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 (16) , it supported the previous claims and showed that the effectiveness in treating gastric irritations and inflammatory diseases is due to polysaccharides that inhibit the adhesion of *H. pylori* to stomach tissue

d) Antibacterial Activity Of Okra

In a study entitled “Glycosylated compounds from okra inhibit adhesion of *Helicobacter pylori* to human gastric mucosa”, the crude polysaccharide isolated from the fresh juice by ethanolic precipitation showed strong inhibitory effects. Okra fresh juice preparation inhibited the bacterial adhesion almost completely in the 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 okra fruit

13. Applications In Drug Delivery.

a) A study published in the *Pharmaceutics* (ISSN 1999-4923; CODEN: HARK5) The use of *Hibiscus esculentus* (Okra) gum in sustaining the release of propranolol hydrochloride in a solid oral dosage form.’

Evaluation of the adhesion ability of okra gum, was performed which is gaining popularity as a tablet binder. For this purpose, gum was extracted from okra pods, and the binding strength of different concentrations (1%, 3%, and 5%) was determined quantitatively. Tablets

prepared with okra gum have better physical properties compared to formulations prepared with pre-gelatinized starch, including lower friability and greater hardness. Similar results have also been reported in the literature] where okra gum in lower concentrations (1–5%) have produced tablets with acceptable properties of friability, hardness, and disintegration time, as compared with higher concentrations of PVP (22%) and cornstarch (12.5%). This might indicate a better binding strength of okra, as compared with starch in the same concentrations, as discussed before.

It was concluded from this study that okra gum has a higher binding/adhesion strength as compared to pre-gelatinized starch. It employs that okra gum may be a better binder than pre-gelatinized starch and can be used as a binder in the future.

b)) A study published in the Journal of advanced Pharmaceutical Technology and Research

“Novel Extraction and application of Okra gum as a film coating agent using theophylline as a model drug” suggests that a natural polymer obtained from the pods of okra plant (*Abelmoschus esculentus*) has been used as a hydrophilic polymer matrix suspending, and bioadhesive agents. The potential of okra gum, obtained by traditional extraction, as a film coating agent was reported. The use was limited to 0.62% w/v in a laboratory coating equipment due to high viscosity when the gum was extracted using the traditional method

g) Mucilage Of Okra As Potential Pharmaceutical Adjuvant

A study published in “International Journal of PharmTech Research 2009” Entitled “Evaluation of *Abelmoschus esculentus* Mucilage as Suspending Agent in Paracetamol Suspension” suggests that the extracted mucilage of *Abelmoschus esculentus* is non toxic and has the potential as a suspending agent even at lower concentration (4%w/v) and can be used as a pharmaceutical adjuvant. In view of these properties, mucilage of *Abelmoschus esculentus* can be employed as stabilizer and thickener of choice when high viscosity’s desired especially in cosmetic, pharmaceutical and food industries.

h) Indigenous Ethiopian okra (*Abelmoschus esculentus*) mucilage: A novel ingredient with functional and antioxidant properties:

A study published in Wiley Food science and nutrition revealed that pods of okra accessions contain a desirable amount of mucilage contents and are potential sources of natural antioxidants. The study also revealed that the mucilage of the pods of okra accessions was found to exhibit good functional properties and can offer a great potential in various food systems. Particularly, mucilage of the pods had desirable water and oil absorption capacities, whereas mucilage of accession had high emulsifying and foaming properties.

i) Emulsifying properties of extracted Okra (*Abelmoschus esculentus* L.) mucilage of different maturity index and its application in coconut milk

In a study published at International Food Research Journal 22(2): 782-787 (2015) revealed that the emulsifying properties of extracted okra (*Abelmoschus esculentus* L.) mucilage at different maturity indices (1, 2 and 3) were studied. The okra mucilage was prepared using water extraction method and was determined their viscosity at different temperature (10, 30, 50 and 70°C), water holding capacity (WHC), oil holding capacity (OHC), as well as their emulsion capacity (EC) and emulsion stability (ES). Results found that okra with maturity index 2 produced the highest percentage yield of mucilage (1.46%) and followed by index 1 (1.10%) and index 3 (0.31%) The viscosity of okra mucilage with maturity index 3 was the lowest, and it decreased as temperature was increased in the reaction. The WHC of okra mucilage with maturity index 3 obtained the highest capacity (4.84%), while the OHC of okra mucilage with maturity index 2 obtained the highest capacity (8.54%) Based on these findings, okra mucilage index 2 was selected to be added into oil-in-water (O/W) emulsion system of coconut milk at different percentage of 0.25%, 0.50% and 1.0%. Results revealed that okra mucilage (maturity index 2) at 1.0% percentage in coconut milk obtained the highest value in emulsion capacity (EC) and emulsion stability (ES). Thus this study concluded that okra plant have potential to be used as emulsifying agent in food emulsion system.

j) Development of *Abelmoschus esculentus* (Okra)-Based Mucoadhesive Gel for Nasal Delivery of Rizatriptan

Tropical Journal of Pharmaceutical Research April 2013; 12 (2): 149-153

The gel prepared from okra exhibited viscosity which was similar to those prepared with synthetic polymers indicating that the natural mucilage is suitable for nasal gel formulations. Similarly, the mucoadhesive strength of the okra nasal gel was comparable to that of the synthetic polymers tested. Viscosity and mucoadhesive strength of the formulation affect the retention ability of the nasal cavity. Mucoadhesive strength increased proportionately with increasing contact time of the gel. This may be because by increasing contact time, more free chains of the mucoadhesive polymer becomes available which penetrate into the mucosa and exhibit higher rate of adhesion. The data obtained demonstrate that this natural polymeric material possess good mucoadhesion and permeation characteristics. Its biodegradable nature as well as likely low toxicity (since plant fruit is widely consumed as food) further supports its use as a suitable alternative to synthetic mucoadhesive polymers for nasal delivery

k) Investigating Fresh and Dried Okra (*Hibiscus Esculentus*) for their Physico-Chemical and Antioxidant Properties: A Comparative Study

A study published in the International Journal for Research in Applied Science & Engineering Technology (IJRASET) revealed that the antioxidant assays indicate that okra fruit and seed is a good source of phytochemicals. Okra possesses high amounts of total flavonoids as well as moderate amounts of total phenolics, making it a good source of natural antioxidants. Thus based on the antioxidant activity, both okra pod and seed extracts should be considered as an additive to other products for the oxidative protection. All the antioxidant assays in methanol indicated that both fresh and dried okra seeds showed higher DPPH, reducing power, total phenolic content and FRAP activity compared to the pods. The results of the functional properties shows that okra gum is an acceptable replacement for fat and good water absorbing additive in different food products

l) In the research article --Film coating potential of okra gum using paracetamol tablets as a model drug :-

The potential of okra gum as a film-coating agent was investigated using paracetamol tablets as model drug. The tablets were evaluated for some physicochemical properties such as uniformity of weight, friability, disintegration time, and dissolution profiles. There changes in the friability, hardness, and disintegration time of coated were compared to the core. Generally, tablets that were coated with HPMC had better physicochemical properties than those containing okra, which in turn was better than the core tablets. Overall, the observed differences in physicochemical properties in the formulations did not lead to differences in the dissolution profiles of the three formulations, making it convenient to use either okra or HPMC at this concentration as a film former when taste and odor masking are the major considerations.

m)In the Journal of Pharmaceutics Volume 2014 (2014), Article ID 204849, 'Recently Investigated Natural Gums and Mucilages as Pharmaceutical Excipients:'

A study suggests that Mucilage from the pods of *Abelmoschus esculentus* is evaluated for its safety and suitability as suspending agent. Mucilage extracted was found to be nontoxic and was used for formulation of paracetamol suspension. The mucilage was found to be superior suspending agent than tragacanth and its suspending efficiency was similar to sodium CMC (6). Mucilage was also evaluated for its disintegrating property. Various concentrations of the mucilage were used and batches of tablets were formulated and evaluated for dissolution, wetting time, and disintegration time. The study revealed that *Abelmoschus esculentus* mucilage powder was effective as disintegrant in low concentrations (4%).(7) Gum of *Abelmoschus esculentus* is used as a polymer for the development of a gastric floating dosage form. In this study tablet batches were prepared using *Abelmoschus esculentus* mucilage and HPMC E15 in

different combinations. It was seen that formulation containing *Abelmoschus esculentus* mucilage had poor floating capacity but showed sustained release, whereas formulation containing HPMC had better floating capacity but showed poor sustained release of the drug, so in all it was seen that formulation containing okra mucilage with HPMC gave better floating property as well as better sustained release of the drug

n) A study revealed in ' Evaluation of biological activities of *Abelmoschus esculentus* (Malvaceae)' that the crude methanolic extract and different fractions were subjected to evaluate different biological properties by standard protocol. Among all the fractions, highest free radical scavenging activity was found in aqueous soluble fraction with IC50 value (26.87±0.451) µg/ml followed by n-hexane soluble fraction with IC50 value (29.37±0.236) µg/ml respectively with respect to BHT having IC50 value (23.41±0.354) µg/ml. The crude methanolic extract revealed highest phenolic content (16.9 mg of GAE / gm of extractives), zone of inhibition ranging from 10.2-18.8 mm in case of bacteria whereas 10.1-14.7 mm to fungi at a concentration of 400 µg/disc and reduced blood sugar level about 41.25%, 43.15% and 46.50% after first, second and third hour at a dose 200 mg/kg body wt with respect to standard drug Glibenclamide (10 mg/kg body weight). It was also found that crude methanolic extract (1.0 mg/mL) inhibited 30.26% haemolysis of RBC (in hypotonic solution induced condition) compared to acetyl salicylic acid (71.9 %) and about 14.6% haemolysis of RBC (in heat induced condition). So it could be concluded that *A. esculentus* possesses medicinally important secondary metabolites and need further investigation to purify and isolate those chemical compounds.

Safety: There are no reports concerning this plant's side effects .It's completely safe and applied on a large scale.

Applications In Food Industry:(Some Applications Of Okra In The Food Industries

1 Okra powder has been used success fully as an emulsifying agent in mayonnaise and salad dressing where it acts as a protective colloid to preserve emulsion integrity.)

2) As a stabilizer, okra prevents the undesirable formation of ice crystals in ice cream and sherbets.

3) In cheese spreads okra gum acts as an emulsifier, which makes' it possible to add water to make a creamy, smooth spread.

4) In confectionery, okra is used in the formulation of fondants, frostings, sauces, etc.

A team of researchers at the University of Huddersfield, UK, has investigated the potential of okra for emulsification of certain food products using size-exclusion chromatography . Okra pectins differ quite substantially from those extracted from apple, citrus, and beet in terms of protein and acetyl contents, indicating their greater hydrophobicity and suggesting that pectin derived from okra can be used as an effective emulsifying(Nov 07, 2014By Kate Mosford-benefits of okra)

CONCLUSION:

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. Okra (*Abelmoschus esculentus* (L.) Moench) is one of the important vegetable crops having better dietary value with medicinal and industrial importance.

Moreover now-a-days natural polymers play a very important role almost in all kind of formulations. The pharmaceutical scientists have achieved a great success in developing the most therapeutic systems with suitable natural polymers.

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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