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Okra Plant: A Multi-purpose Underutilized Vegetable Crop: A Review

Pavan Gupta, Shamayita Patra

Shri Vaishnav Institute of Textile Technology, Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore-453 111, Madhya Pradesh, India.

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ABSTRACT

The plant kingdom has various species that are underutilised. Proper scientific approached help them to utilised for multiple end applications. Okra is one of such underutilized multi-purpose vegetable crop. Green immature okra fruits are consumed as a vegetable worldwide. Okra seed is a good source of oil and protein. Okra seeds are also used as a substitute for coffee. Okra roots are used for clarification of sugarcane juice. It has medicinal value as well as useful in wastewater treatment. Okra is also a potential source of natural fibers suitable for textile, paper and other engineering applications. The present paper reviewed the okra plant, its cultivation and applications in various form such as food, medicine, textile fiber, paper pulp, biomass, *etc*. for its introduction as a multi-purpose vegetable crop.

Key words: Agricultural waste, *Kharif* crop, Okra fiber, Okra plant.

The phrase "Food, clothing and shelter" shows the importance of food in human life. The major portion of global food demand is catered by agricultural products such as food grains (cereals and legumes), pulses, oilseeds, fruits and vegetables. Agricultural crops are mostly used for food production. The plant kingdom has various species which can be used for multiple purposes as well (Santulli *et al.* 2014). Few of such purposes are textiles, medical science, paper pulp, biofuel, *etc*. (Dungani *et al.* 2016; Reddy and Yang, 2005; Sen *et al*. 1987). A few of them are Okra, Banana, Pineapple, Coconut, Cornhusk, Jute, Flax, Maize, *etc.* (Dungani *et al.* 2016; Kambli *et al*. 2019; Rai *et al*. 2011; Reddy and Yang, 2005; Sen *et al.* 1987).

Okra is one of the underutilized multi-purpose crops in India. India ranks first in the world with 5,849 thousand ton Okra production (Ministry of Agriculture and Farmers Welfare 2017; Ministry of Environment and Forest 2011). It is a vegetable crop. It grows once (Summer) in the hills, twice or thrice (summer, *Kharif* and Late *Kharif*) in the eastern, western and northern Indian plains and almost the year in south India (Ministry of Environment and Forest 2011). Okra is valued for its green immature edible seed pods. Okra fruits are generally consumed as a vegetable in India. It can also be used for coffee, oil and protein as a part of food. Other than food application okra plant can be used for medical, textile, paper pulp and fuel purposes. The present paper reviews the okra plant, its cultivation and applications (food grade and non-food grade) for its introduction as a multi-purpose *Kharif* crop. Also, it advocates farmers for growing okra plant for additional income generation, while preventing production of greenhouse gases during burning (commonly practiced).

Okra plant

Okra (*Abelmoschus esculentus*) is the only vegetable crop which belongs to family Malvaceae. It is one of the oldest cultivated crops (Chanchal *et al*. 2018; Fathima and Balasubramanian, 2006; Martin 1982; Ministry of Environment and Forest 2011; Osawaru *et al.* 2014; Sathish and Eswar, 2013; Ullah *et al*. 2018; Varmudy 2011). It is grown in tropical and sub-tropical regions of the world (Chanchal *et al*. 2018; Jain *et al*. 2012; Makhadmeh and Ereifej, 2004; Martin 1982; Ministry of Environment and Forest 2011; Sen *et al.* 1987). It is an important vegetable crop especially in India, West Africa and Brazil (Joh *et al.* 2015). It is quite popular especially in India due to easy cultivation, drought resistance, dependable yield and adaptability to varying moisture conditions (Kocak *et al*. 2018; Ministry of Environment and Forest 2011; Sathish and Eswar, 2013).

Eight *Abelmoschus* species have been found in India. Out of these *A. esculentus* is the only known cultivated species. *A. moschatus,* a wild species, is also cultivated for its aromatic seeds. Okra is mainly propagated by seeds. It matures within 90-180 days. It is generally a perennial plant with a robust erected stem with variable branches. Okra plant's height can vary from 0.5 to 4.0 m (Agrawal *et al.* 2004; Ministry of Environment and Forest 2011; Moosavi *et al.* 2018; Sarasini and Fiore, 2018).

Okra requires a long, warm and humid cultivation period. It grows easily in hot humid climate. However, it is sensitive to frost and extreme low temperatures. The preferred temperature for its growth and development is 24-28°C. Adaptability with climatic factors helps them to grow once (summer) in the hilly areas, twice or thrice (summer, *Kharif* and late *Kharif*) in the eastern, western and northern Indian

*Corresponding author's E-mail: shamayitapatra@rediffmail.com

plains and almost throughout the year in south India. It has well-developed tap root system. Therefore, it can grow in a wide variety of soil type *i.e*. sandy to clay soils. Loose, friable, well-manured loam soil is suitable for its cultivation. The soil with a pH range of 6.0–6.8 is desirable for okra plant (Ministry of Environment and Forest 2011; Moosavi *et al.* 2018; Sharma and Prasad, 2010). In India, the major okra producing states are West Bengal, Bihar, Orissa Andhra Pradesh, Gujarat, Jharkhand, Chhattisgarh, Maharashtra and Madhya Pradesh.

Applications of Okra Plant

Okra as food source

Okra is mainly cultivated for its green non-fibrous immature fruit. Young fruits are harvested before full seed development and mostly consumed as a vegetable in a variety of ways or as alone (Joh *et al*. 2015; Martin 1982; Ministry of Environment and Forest 2011). The mature okra seed has superior nutritional quality. Okra is a rich source of vitamin A, vitamin B, vitamin C, folic acid, amino acids, calcium, zinc, iron, potassium and dietary fibers (Table 1). Protein (30%) and oil (15-19%) contained in the seeds of okra serve as the source of first-rate vegetable protein. The yield of protein and oil from okra is comparable to the yield of the same from soybean (Camciuc *et al*. 1998; Chanchal *et al*. 2018; Joh *et al.* 2015; Martin 1982; Moosavi *et al*. 2018; Sathish and Eswar, 2013). Its ripe seeds are roasted, ground and used as a substitute for coffee in some countries that has a good aroma while lacks the stimulating effect of caffeine. The tender leaves of okra plant are often used as a vegetable in areas where a wide variety of leaves are used in the food (West Africa, Southeast Asia). Its seeds are used in place of legumes in soups. In West Africa the okra fruits are sliced, sun-dried and stored for future use (Martin 1982).

Table 1: Raw okra nutrition value per 100g (Chanchal *et al.*).

Energy	33 kcal
Carbohydrates	7.45 g
Sugars	1.48 g
Dietary Fibers	3.2 g
Fat	0.19 g
Protein	1.93-2 g
Water	90.19 g
Vitamin A	36ìg (7%)
Thiamine (B1)	0.2 mg (17%)
Riboflavin (B2)	0.06 mg (5%)
Niacin (B3)	1mg (7%)
Vitamin C	23mg (28%)
Vitamin E	0.27 mg (2%)
Vitamin K	31.3 mg (30%)
Calcium	82 mg (8%)
Iron	0.62 mg (5%)
Magnesium	57 mg (16%)
Potassium	299mg (6%)
Zinc	0.58 mg (6%)

Okra for medicine

Fruits, leaves, root, seed and flower of okra are used in Indian ethnomedicine for treating dysentery, diarrhoea, kidneys catarrhal infections, hair treatment, *etc*. (Chanchal *et al*. 2018). Its medicinal value has also been reported in curing ulcers and relief of hemorrhoids (Chanchal *et al*. 2018; Joh *et al.* 2015; Ministry of Environment and Forest 2011; Roy *et al.* 2014; Sathish and Eswar, 2013). The mucilage and dietary fibers present in okra helps in adjusting blood sugar (Joh *et al.* 2015). Young leaves of okra have shown wound healing properties (Camciuc *et al*. 1998, Chanchal *et al*. 2018). Okra fruit mucilage has shown its suitability as potential alternative for blood plasma and stabilizer for foams and suspensions (Camciuc *et al*. 1998, Chanchal *et al*. 2018). Okra is also known for being identified with high level of antioxidants (Chanchal *et al*. 2018).

Okra as textile fiber

Okra fiber is extracted from the plant waste by retting process. It is a multicellular lignocellulosic fiber like jute. (Alam and Khan, 2007; Chanchal *et al*. 2018; Sen *et al.* 1987; Sen *et al*. 1988). It contains 60-70% α-cellulose, 15-30% hemicellulose, 5-14% lignin, which resembles to other traditional bast fibers (Alam and Khan, 2007). Its physical characteristics are quite comparable with jute fiber (Sen *et al.* 1987).

Okra fiber can be white, light cream or yellow in color. It has good mechanical strength (Fathima and Balasubramanian, 2006). It has immense potential for textile applications in the form of fiber, yarn and fabric such as rope, twine, fishing net, sacking and decorative fabric, carpets, mats, handicraft, paper laminates and fibre reinforced composites (Agrawal *et al.* 2004; Fortunati *et al*. 2013; Isa *et al*. 2014; Khan *et al*. 2009; Khan *et al*. 2014; Potluri *et al.* 2017; Sen *et al*. 1988; Sule *et al*. 2014). Utilization of okra fiber is three decades old, but major research work has started after 2007 (Khan *et al.* 2017; Srinivasababu 2015). In India, the scope for okra fiber is enormous due to high amount of cultivation and availability of huge harvest waste plant is a potential fiber source.

Application of okra fiber in apparels is a challenging area due to its coarseness. It is three times coarser than jute (Rai *et al.* 2012). Coarse yarns can be produced from these fibers when processed in jute machinery along with jute (Sen *et al.* 1988). Studies have shown that okra fiber has good mechanical strength and can be a promising reinforcement material for polymer composites in commercial applications (Fortunati *et al*. 2013; Isa *et al*. 2014; Kalia *et al.* 2011; Khan *et al*. 2014; Moniruzzaman *et al.* 2009; Rosa *et al*. 2010; Srinivasababu *et al.* 2009; Srinivasababu *et al.* 2009; Sule *et al*. 2014). Cellulose nanocrystals (CNC) were extracted from okra fibers. The results have shown some potential for okra fibers for their application in the form of CNC in nanocomposite systems also (Fortunati *et al*. 2013). Diversified products can be made using okra fiber such as cleaning brush, shoe brush, painting

brush and rope (Gogoi *et al.* 2017; Reddy and Reddy, 2016). Nonwovens obtained from okra fiber showed good mechanical properties and thermal conductivity values similar to the traditional fibers (both natural and synthetic) used in industry (Duman *et al*. 2017).

Okra for the paper pulp

1st report about the use of okra fiber in the paper industry was in 1982 (Fathima and Balasubramanian, 2006; Martin 1982; Sen *et al*. 1988). It was used for commercial paper in the Southern USA (Camciuc *et al*. 1998). The 'Mobile Register Journal' was printed on okra paper in 1870 (Camciuc *et al*. 1998). Okra fibers were also used for making handmade papers (Gogoi *et al.* 2017). Okra fiber was also used in paper fiber composites (Agrawal *et al.* 2004). The paper laminates prepared from okra fiber showed better tearing and bending resistance than the laminates made from pure paper sheets. The developed paper fiber laminates can be a potential candidate for the use as a low-cost alternative to high-grade corrugated paper laminates in packaging industry (Agrawal *et al.* 2004).

Okra for purification

The roots and stems of okra are used for clarification of sugarcane juice from which gur or brown sugar is prepared (Ministry of Environment and Forest 2011). The seed powder has been used as a substitute for aluminum salts in water purification (Camciuc *et al*. 1998; Ministry of Environment and Forest 2011). Okra mucilage was found as good coagulant for industrial wastewater treatment (Freitas *et al*. 2015).

Biomass and fuel

At the end of okra plant life cycle, when all the okra fruits are removed from the plant, the remaining green plant can still be cut and the stem can be used as biomass in a power station for the generation of electricity. The thoroughly dried okra stems are also burned as an inexpensive cooking fuel (Martin 1982).

CONCLUSION

Okra is an underutilized multiple-purpose crop. Other than vegetable it is used as coffee substitute, oil and protein source, biomass, fuel, paper pulp production, water purification, medicinal and textile fiber usage. Production of okra can contribute to the sustainable development in the agricultural field which in turn create dual benefit from single crop while preventing production of greenhouse gases during burning (commonly practiced). India is the highest producer of Okra in the world.

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