An Updated Overview on *Abelmoschus moschatus*

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Abstract: *Abelmoschus moschatus* (L.) Medik (Family: Malvaceae) is an annual or biennial, erect, hispid herb or undershrub (commonly known as ambrette), yields ambrette oil (essential oil) from outer layer of seed coat which finds application both in flavour and fragrance formulations not withstanding its profound significance in therapeutic as well as ethnobotanical uses. The species is also examined as a non-traditional edible oil crop. Although the plant species possesses immense commercial potentiality but lack of sustainable cultivation seems to be affecting ambrette seed production and subsequently trade. An updated overview on *A. moschatus* is reported involving nearly all essential aspects to provide the available information and to generate interest among researchers for its effective cultivation and utilization for human benefit.

Key words: *Abelmoschus moschatus*, an overview, ambrette seed oil

INTRODUCTION

Abelmoschus moschatus (L.) Medik (=Hibiscus abelmoschus) (Family: Malvaceae) is an annual or biennial, erect, hispid herb, undershrub (Widodo 1999, Sharma and Shahzad 2008, Ramu et al. 2010) or shrub (Nautiyal and Tiwari 2011) yielding ambrette oil (Orwa et al. 2009, Ramu et al. 2010, Nautiyal and Tiwari 2011) of commerce (essential oil) which finds application both in flavour and fragrance formulations (Arctander 1960, Rout et al. 2002) apart from its potential use in traditional medicine (Widodo 1999). Herbal drugs containing ambrette are introduced by Indian drug manufacturers for medicinal uses (Duke 1985, Lawrence 1996). The ambrette oil obtained from seeds (possessing a characteristic musk like odour) is localized in the outer layers of the seed coat (Nee et al. 1986). The bark of the species is processed into fibre and root mucilage used for sizing paper (Orwa et al. 2009). Sahoo et al. (2003) examined edibility of oil seeds. An updated overview on *A. moschatus* is presented with an objective to provide references as well as impetus to researchers looking to improve the species for human welfare.

COMMON NAMES - Arabic: hhabb el misk, anbar bul; **Chinese:** ye you ma, shan you ma, huang ku, huang kai; **English:** ornamental okra, musky-seeded hibiscus, musk okra, musk mallow, annual hibiscus, fautia, yorka okra; **French:** Ambrette, graine de musc, ketmie mosque, gombo mosque, **German:** bisamstrauch, bisameibisch; **Italian:** abelmosco, fior muschiato, ibisco muschiato, ambretta; **Thai:** chamot ton, som chaba; **Malay:** kapas hutan; **Vietnamese:** cay bong vang, bup vang – (Source: Agroforestry Database 4.0, Orwa et al. 2009); **India: Hindi** – mushkdana, kasture bhendi, Assamese – gukhia korai, **Telugu** – kasturi bhenda, **Malayalam** – kattukasturi, **Tamil** – varttilai kasturi, **Sanskrit** – lalkasturika (Krishnamurty 1993); **Bengali** – lata kasturi, mushakdana.

ORIGIN OF THE NAME - The generic name *Abelmoschus* is derived from Arabic 'abu-l-mosk' (father of musk) in allusion to the smell of the seeds; specific epithet means 'musk smelling' (Orwa et al. 2009).

DISTRIBUTION - The species is native to India, Tropical Asia, Southern and some parts of Pacific Island, China, Cook Island, Fiji and Samoa (Du et al. 2008, Orwa et al. 2009). Widodo (1999) reported that the species is cultivated commercially in Java, India (mainly in the Deccan and Carnatic), Madagascar and in parts of Central and South America and to a small scale throughout the tropics and in warm temperate areas. Dubey et al. (2011) successfully cultivated the species in West Bengal Plains (Experimental Field Plots of University of Kalyani - 22°99′ N, 88°45′ E, elevation 48 feet above sea level, sandy loamy soil, organic carbon 0.76%, soil pH 6.85) with an objective to provide wider base for its commercial utilization. However, Velayudhan et al. (2007) considered that the species is found rarely as a cultivated plant but occurs wild in India specifically all over the hilly regions.

HABITAT - *A. moschatus* grows in variable places namely, roadsides, brushwood, fallow land and on the rice fields and occurs up to 1650 m altitude in

Indonesia, and in India it is cultivated up to 1000 m (Widodo 1999).

BOTANICAL DESCRIPTION - Plants (Figs. 1-2) herb or undershrub attaining height of 109.2 cm to 155.0 cm at maturity; stem solid, woody, hispid hairy; leaves alternate, palmately 3 to 5 lobed, serrate margin, petiolate; flowers bisexual, actinomorphic, hypogynous, bracteolate, solitary in cymose inflorescence without peduncle and bracts; stamens numerous, monadelphous; carpels 5, syncarpous, ovary 5 chambered, many ovules in axile placentation; fruits capsular, oblong conical to ovoid spindle shaped, ribbed, hispid hairy throughout; seeds with verrucose interrupted lines, colour Congo brown (BS3-038) to Mahogany brown (RAL 8016; colour laid down from RAL CLASSIC COLOUR CHART, UK).

VARIETIES AND SUBSPECIES - Masters (1874) reported 2 varieties namely, *multiformis and betulifolius* in *A. moschatus*; while, Hochreutiner (1900) added 2 more to the species (*genuinus and rugosus*). Brossom-Walkers (1966) reported 3 subspecies, viz., subsp. *moschatus,* subsp. *biakensis* (Hochr.) Bross. and subsp. *tuberosus* (Span.) Bross. of which only subsp. *moschatus* reported from India and it was corroborated by Sivaranjan and Pradeep (1996) from their taxonomical studies on Malvaceae. Dubey et al. (2011) reported 2 cultivars in *A. moschatus* based on morphological, anatomical, cytological, physiological (stomatal parameters) and palynological characteristics. Cultivar I was recommended as tall, branched whereas cultivar II as dwarf, unbranched types.

THERAPEUTIC USES

The aromatic seeds are valued medicinally as they are used as tonic and considered as aphrodisiac, ophthalmic, cardiotonic, digestive, pectoral, stomachic, constipating, carminative, diuretic and deodorant apart from possessing antiseptic, antipasmodic, and antivomiting properties (Cravo et al. 1992, Orwa et al. 2009, Ramu et al. 2010, Nautiyal and Tiwari 2011). The seeds are effective against *kapha* and *vata*, intestinal complaints and diseases of the heart (Orwa et al. 2009). The seed extract is useful in nervous disability and hysteria (Sharma and Shahzad 2008). According to Unani system of medicine seeds allay dyspepsia, urinary discharge, leucoderma and itch (Ramu et al. 2010). Further, Ramu et al. (2010) reported seed starch (16.0% w/w) of *A. moschatus* as disintegrant to paracetamol tablets at concentrations of 2.5 to 10.0% w/w. In the Philippines a decoction of the roots and leaves is taken as an emollient remedy for gonorrhoea and rheumatism (Agharkar 1991). In traditional Vietnamese medicine the plant is used as antivenom against venomous reptiles (Lindley 1985). In Indonesia pulverized seeds mixed with powder provide comfort against prickly heat. Liu et al. (2005) showed that myricetin (purified from aerial part of A. moschatus) enhance glucose utilization (effective dose 1.0 mg/kg in STZ – diabetic rats) to lower plasma glucose in diabetic rats lacking insulin. Liu et al. (2006) reported that plasma glucose lowering action of myricetin in insulin-deficient animals is mediated by activation of opioid mu-receptors of peripheral tissue in response to increased beta-endorphin secretion. Experimental studies on rats indicated that *A. moschatus* is potentially useful for adjuvant therapy for patient with insulin resistance and/or wishing to increase insulin sensitivity (Liu et al. 2010). Maheshwari and Kumar (2009) reported that hexane, ethyl acetate, methanol and aqueous extracts from the leaves of *A. moschatus* showed antibacterial activity against *Staphylococcus aureus, Bacillus megaterium, Shigella flexneri, Proteus mirabilis* and *Corynebacterium diphtheria.*

OTHER USES

Ambrette seed oil is used in perfumery, cosmetic products and as an additive in the preparation of chewing tobacco, baked products, sweets, alcoholic and non-alcoholic drinks (Arctander 1960). The seeds are also used to flavour coffee in Arabia. In Malaya people uses leaves of *A. moschatus* to wrap parcels. The mucilage from the roots is used in China for sizing paper. Seeds are used to protect clothes against insects. The stem bark yields a good quality fibre rich in cellulose (78%) content (Sharma and Shahzad 2008). The flowers in the species are in demand for making zarda. Further, tender leaves, shoots and pods are edible.

CULTIVATION

Climatic factors: Ambrette is cultivated as pre-kharif crop in India (Widodo 1999, Orwa et al. 2009) and is sown in March-April, fruits ripen from November-January and harvested when fully matured (Oudhia 2001); however, Dubey et al. (2011) cultivated the species as rain fed kharif crop (sown – 1st weak of July; harvested - late November to early December; temperature 25.5°C to 39°C max., 18.4°C to 24.2°C min., relative humidity 82.2% to 95.2% max., 48.8% to 76.7% min., rainfall 1.08 mm to 15.2 mm) in West Bengal Plains. Heavy and continuous rain affects crop growth negatively and the optimum temperature for vegetative growth is about 20-28°C but it can tolerate 45°C, although frost is not tolerated (Widodo 1999). During flowering and fruiting dry weather is preferred. *A. moschatus* is photosensitive and short days promote early flowering (Oudhia 2001).

Propagation: *A. moschatus* is propagated by seeds

and the seed rates of 4lg/kg are optimum (Orwa et al. 2009). Widodo (1999) reported that about 5kg/ha of seed are used for sowing in rows spaced 75-90 cm apart. Soaking of seeds in water overnight accelerates germination and germination rate of good commercial seed is about 85%.

Soil types: Thrives best in fertile loamy or sand-loamy soil but clayey/sandy/saline/strongly alkaline soils are not preferable for growth of *A. moschatus*. Water logging is not tolerated.

Management: Weeding (2-3 times) is necessary during early growth period. Further, pruning (50 to 60 days from transplantation of the plants from seed bed) increases seed yield by about 40% (Widodo 1999). Application of dried Neem leaves (500kg/ha) at last ploughing increases oil content and quality (Orwa et al. 2009). Application of fertilizers improves growth of plant and seed yields (0.5 to 1.2 t/ha, 120kg N/ha; 1.5 t/ha, 120kg N/ha + 35kg P/ha – Widodo 1999) but chemical inputs result in negative impact on oil content and quality (Krishnamurty 1993).

Yield: Average seed yield in India 0.8 to 1.0 t/ha (Source: http://proseanet.org/prosea/e-prosea_detail.php?frt=&id=76).

Market value: The main producers of ambrette seeds are India, Colombia, Ecuador and Martinique and the seed oil is rarely traded. The world market price is about US$5000/kg (Source: http://proseanet.org/prosea/e-prosea_detail.php?frt=&id=76).

DISEASES AND PESTS - Srivastava et al. (1986) reported that *A. moschatus* was free of serious diseases except for occasional infection by Hibiscus Mosaic Virus (control- infected plants should be uprooted and destroyed). Brown et al. (1989) reported leaf spot and blight of ambrette caused by a pathovar of *Pseudomonas syringae*. A fluorescent bacterium that closely resembled *P. syringae* pv. *hibisci* in morphological, biochemical, and physiological tests was consistently isolated from *A. moschatus* with a leaf spot and blight (Brown and McCarter 1991). The bacterium was seed borne, recovered from seed stored at 10°C and favoured disease development at low temperature (20°C-25°C). Widodo (1999) reported anthracnose caused by *Colletotrichum hibisci* affecting all parts starting in the seedling stage. Seed treatment and spraying with fungicides (like Bordeaux mixture) can control the disease. Alternaria leaf spot and Phytophthora leaf blight can also cause damage to the plant species, the latter especially under humid conditions. In India pests like spotted bollworm (*Earias insulana*), infect both vegetative and reproductive stages of growth; infected shoots turn brown, bend down and die; control: (spraying thiodan at 10-15 days intervals from seedling stage till harvest), pink bollworm (*Pectinophora gossipialla*; damages pod and seed in Northern India) and cotton semilooper (*Anomis flava*; rainy season, intensity decreases at lower temperatures, disappear in mid November) are reported (Widodo 1999, Orwa et al. 2009).

REPRODUCTIVE BIOLOGY - Bud initiation in *A. moschatus* in leaf axil takes about 45 to 60 days from germination in field and these buds bloom within 15 to 20 days. Flowering in the species continues over a period of more than 60 days. Anthesis occurs between 9 a.m and 11 a.m; however, crossing experiments between cultivars may be inducted in the early hours of morning (6:30 a.m to 7:00 a.m). The stigma is receptive on the day of anthesis. About 20 to 25 days required for fruit maturity.

CYTOLOGY - The chromosome number in *A. moschatus* is reported to be n = 36 (Hamon and Sloten 1989). Dubey et al. (2011) also observed 2n = 72 in the meiocytes regularly with predominance of bivalents at metaphase I (35.81 II + 0.39 I mean/cell) and normal disjunction (36/36) at anaphase I. Pollen fertility (based on 2% propinocarmine solution) in the species ranged between 21.7% to 50.0%.

POLLEN MORPHOLOGY - Pollen grains were larger in size (121.2 ± 1.99 × 121.9 ± 1.94 μm^2 to 153.7 ± 2.95 × 147.6 ± 2.06 μm2), prolate spheroidal, pantoporate and isopolar in nature (Dubey et al. 2011). Pores (25 to > 30/grains) large, rounded to oval. Exine thick, tectum echinate, spines many (50 to 60).

INDUCED MUTAGENESIS - Mishra et al. (2000) induced mutation following gamma irradiations (10-20 kR doses at 10 kR intervals – doses given from ^{60}Co source) to dry seeds of *A. moschatus* and the mutants screened were wide in terms of qualitative and quantitative traits in both positive and negative directions. One light yellow corolla mutant with a light purple eye at the base of the flower was detected at 20 kR and the mutant showed variation in some of the oil constituents and morphometric traits.

BIOCHEMICAL CONSTITUENTS

Reports of seed analysis suggested the presence of 11.1% moisture, 31.5% crude fibre, 14.5% lipids, 13.4% starch, 2.3% protein, 0.2 to 0.6% volatile oil, calcium and resin (Srivastava 1995). The species also contains 13 to 15 g (per 100 g seeds) of fatty oil (palmitic acid- 20.0%, oleic acid- 20.0 to 25.0 %, linoleic acid- 50.0 to 70.0%, stearic acid- 2.5 to 4.0% and trace amount of myristic acid and palmitoleic acid – (Widodo 1999).

The characteristics musk like odour is due to mainly

lactone ambrettolide (Z-hexadec-7-en-16-olide, $C_{16}H_{28}O_2$) and ambrettolic acid (16-hydroxy-7-hexadecenoic acid, $C_{26}H_{30}O_2$) apart from possessing farnesol and farnesyl esters and other acyclic aliphatic esters and terpenes as identified following chromatography and spectroscopic studies (Rout et al. 2002). Nautiyal and Tiwari (2011) reported 2 novel compounds as constituents of ambrette seed oil: 1-(acetoxyethyl)-1-hexylcyclopropane and 1-(4-acetobutyl)-2-hexacyclopropane. Sriniwas (1986) identified cis-jasmone, trans-jasmone and farnesol isomers as important constituents of ambrette seed oil. Du et al. (2008) isolated a total of 58 nitrogen-containing compounds from the basic fraction of a CO_2 extract of ambrette seeds following GC-MS and NMR and among them were 27 pyrazine derivatives and 12 pyridines, including the tentative identification of 4 new natural compounds namely, 1-(6-ethyl-3-hydroxypyridin-2-yl)ethanone, 1-(3-hydroxy-5,6-dimethylpyridin-2-yl) ethanone, 1-(3-hydroxy-6-methylpyridin-2-yl)ethanone and 1-(3-hydroxy-5-methylpyridin-2-yl)ethanone.

Compounds like myricetin-3-glucoside and glycoside of cyanidin (in flowers); beta-sotisteral and beta-D-glucoside (seeds); myricetin and its glucoside (leaves and petals) and beta-sitosterol (dry fruit husk) were important constituents of volatile oil (Rastogi and Mehrotra 1991a,b).

IN VITRO STUDIES

Sharma and Shahzad (2008) induced multiple shoots in in vitro culture using different explants (cotyledonary node gave the best result) in MS medium supplemented with different hormonal combinations (0.01 mg/L thidiazuran proved to be the best followed by 0.25 mg/L N6 benzladenine + 0.5 mg/L kinetin). MS half strength supplemented with 0.5 mg/L indole-3-butyric acid was reported as most suitable medium for root induction in excised micro-shoots. The regenerated plants acclimatized in green house condition at a survival rate of 70%.

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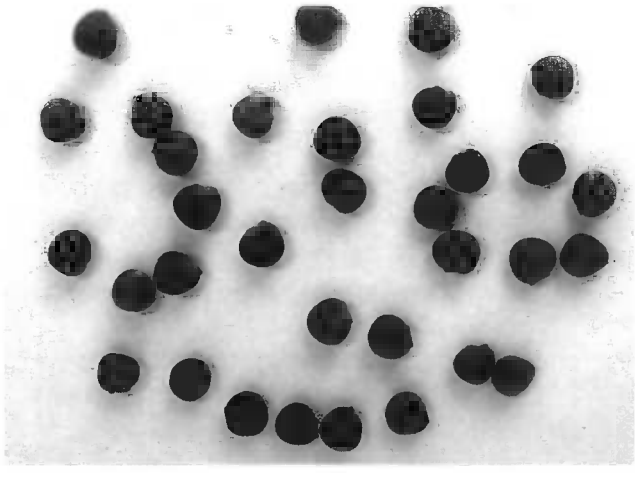
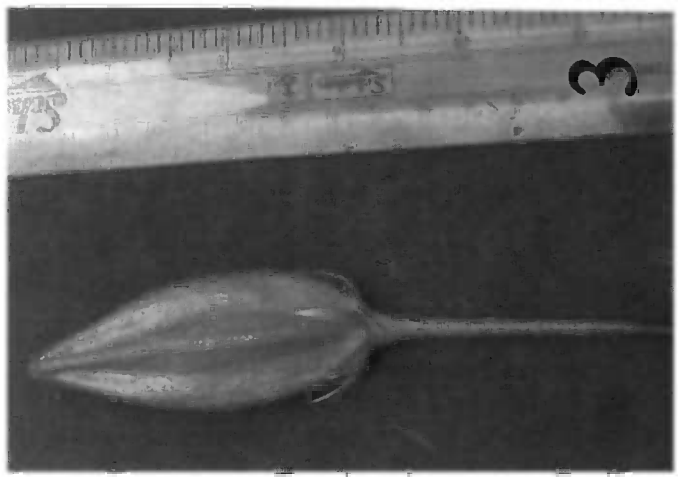


Seeds



Fruit

FIGURE LEGENDS

Figs. 1-2. *Abelmoschus moschatus*. 1. Plants in the experimental plot; flower