Ethnobotanical and taxonomic screening of genus *Morus* for wild edible fruits used by the inhabitants of Lesser Himalayas-Pakistan

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Received 20 October, 2010; Accepted 26 October, 2010

The present study was focused on ethnobotanical and taxonomic screening of four wild edible fruit species of family Moraceae including *Morus alba* L., *Morus laevigata* Wall., *Morus nigra* L. and *Morus rubra* L. used by the local inhabitants of Lesser Himalayas-Pakistan. Questionnaires based on semi-structured interviews and observations were used to collect data about ethnobotanical importance of these plants. Morphological, including organoleptographical characters of leaves, flowers, fruits and leaf epidermal anatomy were investigated. Leaf epidermal anatomy was carried out under light microscope. All four species showed variations in fruit size, shape, color, in leaf lamina and base shape, floral characters, leaf epidermis cells shape, size and type of stomata. Such taxonomic variations are significant in correct identification of plant species.

**Key words:** Ethnobotanical, taxonomic screening, *Morus*, Lesser Himalayas.

**INTRODUCTION**

The Pakistani Himalaya is located south and east of the Indus River, which originates close to the holy mountain of Kailash in Western Tibet, marking the ranges true western frontier. The Himalaya is a totally separate range to the Karakoram which runs parallel to the north. The Himalaya in Pakistan is green and fertile as compared to the arid Karakoram and Hindukush. The Himalaya is spread across three Pakistan’s provinces. The Northern area encompasses the Nanga Parbat massif and her surrounding valleys, Azad Jammu and Kashmir and extreme South-east corner of the North West Frontier Province (Pakhtoonkhawa). The Lesser Himalaya is a prominent range 2,000 to 3,000 m high formed along the main boundary Thrust fault zone, with a steep southern face and gentler northern slopes. These Himalayas lie north of the Sub-Himalayan Range and south of the Great Himalayas. In Pakistan these mountains lie just North of Rawalpindi district, covering the districts of 

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of potassium chloride in a test tube for 2 to 3 min. These leaf pieces were then washed with distilled water twice. Epidermis was peeled off and kept in 60% potassium hydroxide solution for 1 to 2 h. Finally, thin sections of epidermis were suspended in lactic acid on glass slide for light microscopic (LM) study. Microphotographs were taken by using CCD digital camera (Model: DK 5000) fitted on Leica light microscope (Model: DM 1000).

RESULTS

Morus alba L.


A monoecious, deciduous, 8 to 15 m or rarely up to 20 m tall tree with a dense, compact leafy crown. Trunk is 1.5 to 2 m in circumference, with dark grey-brown, rough, vertically fissured bark, tender twigs airy to glabrescent. Leaves are green, sticky, herbaceous, 12.1 to 2.9 cm long and 12.5 to 1.6 cm wide, ovate, alternate, somewhat hairy, scabrous, insertion of leaf; ramal, petiolate, lamina narrow to broad, shallowly cordate base, upper surface glabrous, midrib and veins pubescent, margin; regularly serrate, Apex; obtuse, acute or shortly acuminate, stipule; brownish, lanceolate and hairy. Male catkins is 10 to 20 mm long including slender, hairy peduncle, 5.6 mm broad, with flowers. Male flowers: sepals free, broadly ovate, 2.5 mm long, cucullate, obtuse, glabrous to hairy; staminal filaments equal to sepals, with ovate, exserted anthers. Female catkins is ovoid, 5 to 10 mm long, without equally long or slightly longer peduncle. Female flowers: sepals sub orbicular, as long as or slightly larger than male flowers, glabrous or ciliate on margins; ovary with glabrous free styles (Plate # 1).

Organoleptography of fruits: Dark green (unripe), pale yellow to creamy (ripe), edible, sweet, axillary, simple succulent, fleshy, sorosis, drupelets, oval, up to 2.24 cm long, 2.18 cm wide and 3.29 cm circumference. Exocarp, mesocarp and endocarp are indistinct (Plate # 2).

Leaf epidermal anatomy: Costal and inter costal zonation conspicuous. Epidermal cells on the abaxial and adaxial surfaces are variously shaped. The size of epidermal cells; adaxial 33.41 (27.5 to 37.75) × 18.58 (13.25 to 22.5) µm, abaxial 20.83 (12.5 to 27.5) × 10.08 (7.5 to 12.75) µm. Stomata are absent on adaxial surface while on abaxial surface anomocytic to desmocytic stomata are present. Size of stomatal complex is 17.5 (12.5 to 22.5) × 9.58 (6.25 to 12.5) µm while size of aperture is 9.08 (7.5 to 10) × 2 (0.25 to 3) µm. Peltate glands and hooked hairs were also present on adaxial surface. Non-glandular and unicellular trichomes are present on the adaxial surface. The size of trichome is 165 (20 to 250) µm while the base of trichome is rounded.
Figure 1. Leaf epidermal anatomy of *Morus alba* L.

Figure 2. Leaf epidermal anatomy of *Morus nigra* L.

having breadth of 22.66 (12.5 to 25.5) µm, while glandular and unicellular trichomes are present on abaxial surface. The size of trichome is 43.33 (37.5 to 47.5) × 7.58 (7.5 to 7.75) µm (Figure 1).

Ethnobotanical uses: Fruits are cool and laxative used to cure sore throat, dyspepsia and melancholia. Wood is used as fuel, in tool handles and construction. Fresh leaves are used as fodder for goats and sheep.

*Morus nigra* L.

English name: Black mulberry. Local name: Kala Toot. Distribution, Pakistan: cultivated and grows wild throughout the country. World: Westwards to Asia Minor, Central and South Europe, North Africa, Central Asia and U.S.A. Habitat: It grows commonly on the clay soil. Flowering period: February to March. Fruiting period: March to April. Morphology: A monoecious, dioecious, medium or small sized tree, up to 10 m tall, with a compact spreading wide crown. Trunk is 1 to 2 m in circumference with fissured rough bark, tender twigs which are reddish-brown, with densely hairy Leaves that are green, glucose, scabrous above, herbaceous, 11.7 to 4.5 cm long and 8.1 to 4.2 cm wide, insertion of leaf is ramal, petiolate, lamina broad ovate, deeply cordate base, somewhat hairy. Margin: crenate-dentate, Apex: acuminate to caudate, stipules; pale brown, lanceolate, hairy. Male catkins is 25 to 35 mm long, including dense hair, up to 10 mm long peduncle. Flowers: sepals free, broadly ovate, 2.5 to 3 mm long, 23 mm wide, deeply concave, lanate-hairy outside; stamens with broadly oval, exserted anther. Female catkins are oval, 15 to 28 mm long including 6 to 8 mm long, hairy peduncles. Female flowers: sepals broadly elliptic, 3 to 3.5 mm long, 2.5 to 3 mm broad, hairy outside; ovary with densely white hair and divergent styles (Plate 3).

Organoleptography of fruits: Dark green (unripe), black (ripe), edible, sweet, axillary, simple succulent, fleshy, berry, globular, up to 2.59 cm long, 2.29 cm wide and 3.57 cm circumference. Exocarp, mesocarp and endocarp are indistinct (Plate 4).

Leaf epidermal anatomy: Costal and intercostals zonation conspicuous. Epidermal cells on abaxial and adaxial surfaces are variously shaped. The size of epidermal cells; adaxial 25 (22.5 to 27.5) × 16.75 (12.75 to 20) µm, abaxial 21.75 (17.5 to 25.25) × 11.58 (10 to 12.5) µm. Peltate glands and hooked hair are also present on adaxial surface. Stomata are absent on adaxial surface while on abaxial surface anomocytic stomata are present. Size of stomatal complex is 18.41 (12.75 to 22.5) × 6 (5.25 to 7.5) µm while size of aperture is 10.16 (7.5 to 13) × 1.91 (0.25 to 2.75) µm. Glandular and unicellular trichomes having pointed heads are present on the adaxial surface. The size of trichome is 40.91 (40 to 42.5) µm while the base of trichome is rounded having breadth of 9.16 (7.5 to 12.5) µm, while unicellular glandular as well as non-glandular trichomes and hooked hairs are present on abaxial surface. The size of glandular trichome is 17.58 (12.25 to 27.5) and its base is rounded having breadth of 10.75 (7.5 to 12.5) µm. The size of non-glandular trichome on abaxial surface is 216.66 (87.5 to 250) µm, the base of trichome is also rounded having breadth of 52.5 (50 to 55) µm (Figure 2).

Ethnobotanical uses: The leaves are used for feeding silkworms. Leaves infusion is used to control sugar level and blood pressure. Fruits are edible and considered as refrigerant and laxative. Leaves are also used as fodder. Wood is used as fuel and in construction. Young soft and flexible branches are used in making baskets.
**Morus laevigata** Wall.

Local name: Shah Toot. English name: Long black mulberry. Distribution, Pakistan: Haripur, Abbottabad, Swat, Hazara, Peshwar, Rawalpindi. World: India, Nepal, West and South China and Indo-China. Habitat: It grows rarely on the clay soil. Flowering period: March to April. Fruiting period: May to June. Morphology: A small to large tree, up to 10 m tall with a dense crown. Trunk is 1.5 to 2 m in circumference, with grey smooth bark, young shoots long soft and hairy. Leaves: Dark green, herbaceous, 12.8 to 4.8 cm long and 8.9 to 3.4 cm wide, pubescent petiole, up to 2.5 to 4 cm long, lamina glaucous, ovate to rotundate, cordate base, sparsely pubescent to glabrous. Insertion of leaf: ramal. Margins: serrate, shortly acuminate, Apex: obtuse to acute, stipules: brownish, lanceolate and hairy. Male catkins are 5 to 10 cm long including a slender 1.5 cm long, pubescent peduncle, densely hairy. Male flowers: Sepals 4, imbricate on margins; staminal filaments as long as sepals. Female catkins are cylindrical, 5 to 12 cm long including 2 cm long peduncle, pendulous, lax-flowered and almost glabrous. Female flowers: sepals 4, imbricate, thin, with outer 2 concave-rotundate, inner ones are plane, floccose-ciliate on margins; ovary with elongated, bipartite style, with stigmas that are patent (Plate 5).

**Organoleptography of fruits:** Dark green (unripe), yellowish white (ripe), axillary, edible and somewhat sweet, multiple fruits and sorosis, flattened, up to 4.3 cm long, 1.2 cm wide and 2.2 cm circumference. Exocarp, mesocarp and endocarp are indistinct (Plate 6).

**Leaf epidermal anatomy:** Costal and intercostal zonation are conspicuous. Epidermal cells on the abaxial surface are undulating to irregular shaped while on the adaxial surfaces the cells are variously shaped. The size of epidermal cells; adaxial 36.66 (30 to 42.5) × 21.66 (17.5 to 25) μm, abaxial 41.25 (23.75 to 62.5) × 13.41 (10 to 17.5) μm. Peltate glands and hooked hairs are also present on adaxial surface. The stomata are absent on the adaxial surface while anomocytic to anomotetraecytic stomata are present on the abaxial surface. Size of stomatal complex is 20.75 (17.5 to 24.75) × 14.25 (10 to 17.5) μm while size of aperture is 12.5 (10 to 15) × 2.93 (2.75 to 3.25) μm. Glandular and unicellular trichomes are present on adaxial surface. The size of trichome is 45 (43.5 to 46.25) μm, while base of trichome is rounded having breadth of 3.125 (3 to 3.25) μm. On abaxial surface trichomes and glands are absent (Figure 3).

**Ethnobotanical uses:** Ripe fruits are edible, laxative and refrigerant. Leaves are excellent fodder for goats and sheep. Wood is used in making tool handles and in decoration pieces.

**Morus rubra** L.

English name: Black mulberry. Local name: Shah Toot Kala. Distribution, Pakistan: Swat, Hazara, northern areas, Murree, Ghora gali. World: Southern New Mexico and Eastern North America. Habitat: It grows rarely on the clay soil. Flowering period: February to March. Fruiting period: April to June. Morphology: A tree up to 12 m tall. Bark is gray-brown with orange tint, furrows shallow, ridges flat, broad. Branchlets are red-brown to light greenish brown, glabrous or with a few trichomes; lenticels are light colored, elliptic, prominent. Buds are ovoid, slightly compressed, 3 to 7 mm, apex acute; outer scales are dark brown, often pubescent and minutely ciliate; leaf scars are oval to irregularly circular, bundle scars are numerous, in circle. Leaves: green, herbaceous, 5.8 to 8.1 cm long and 3.6 to 5.2 cm wide, glaucous, oblong-ovate, insertion of leaf: ramal, petiole up to 2 to 3.3 cm long. Margin: serrate to dentate, Apex: abruptly acuminate, leaf base: broadly ovate. Catkins: peduncle pubescent; staminate catkins 3 to 5 cm; pistillate catkins 8 to 12 × 5 to 7 mm. Flowers: staminate and pistillate on different plants. Staminate flowers: sepals connate at base, green tinged with red, 2 to 2.5 mm, pubescent outside, ciliate toward tip; stamens 4; filaments 3 to 3.5 mm. Pistillate flowers: calyx tightly surrounding ovary; ovary green, broadly ellipsoid or obovoid, slightly compressed, 1.5 to 2 mm, glabrous; style branches divergent, whitish, sessile, 1.5 mm; stigma papillose (Plate 7).

**Organoleptography of fruits:** Dark green (unripe), red or black (ripe), axillary, edible, sweet, multiple fruit and sorosis, flattened, up to 6 cm long, 1.6 cm wide and 2.6 cm circumference. Exocarp, mesocarp and endocarp are
Leaf epidermal anatomy: Zonal and interzonal cells are conspicuous. Epidermal cells on abaxial and adaxial surfaces are variously shaped. The size of epidermal cells; adaxial 33.33 (30 to 37.5) × 21.75 (20.25 to 22.5) µm, abaxial 30 (27.5 to 32.5) × 14.25 (12.5 to 15.25) µm. Peltate glands and hooked hairs are also present on adaxial surface. The stomata are absent on the adaxial surface while actinocytic and anomocytic stomata are present on the abaxial surface. Size of stomatal complex is 19.88 (19.75 to 20) × 18.16 (17 to 20) µm while size of aperture is 12.33 (12 to 12.5) × 4.91 (4.75 to 5) µm. Unicellular glandular as well as non-glandular trichomes are present on both surfaces. The size of unicellular glandular trichome: Adaxial, 127.91 (112.5 to 157.5) × 26.58 (24.75 to 30) µm, abaxial, 29.91 (27.5 to 32.25) × 13.66 (12.25 to 16.25) µm, while the size of unicellular non-glandular trichomes is: Adaxial, 27.83 (27.25 to 29.75) × 14.16 (10 to 20) µm. The base of trichome is rounded and stomata on abaxial surface (20×). D: Non-glandular and Glandular trichomes and stomata on abaxial surface (20×) (Figure 4).
Plate 2. *Morus nigra*. A: Peltate glands on adaxial surface (20×), B: Non-glandular trichomes, hooked hairs on adaxial surface (10×), C: Glandular and unicellular trichomes on abaxial surface (10×), D: Glandular trichomes and hooked hair on abaxial surface (20×).

Plate 3. *Morus laevigata*. A: ordinary epidermal cells adaxial surface (40×), B: Peltate glands on adaxial surface, C: Stomata on abaxial surface (40×), Glandular trichomes and stomata on abaxial surface (20×).
Plate 4. *Morus rubra*. A: Peltate glands and hooked hairs on adaxial surface (20x), B: Hook Ethnobotanical uses: Fruits are laxative and purgative. Root infusion is useful in weakness and urinary problems. Tree sap rubbed directly on the skin as treatment for ringworm. Also used as fodder and in construction.

Plate 5. Organoleptography of fruits of *Morus alba* L.

Plate 6. Organoleptography of fruits of *Morus laevigata*. 
Ethnobotanical uses: Ripe fruits are edible, laxative and refrigerant. Leaves are excellent fodder for goats and sheep.

DISCUSSION

Pakistan is one of the developing countries having great potential of wild flora especially with reference to edible fruit bearing plants. Due to varied edaphic and climatic conditions, about 6000 flowering plant species have been reported from Pakistan. Majority of these plant species have ethnobotanical importance. During present work, preference was given to four edible species of genus Morus grown widely throughout lesser Himalayas. These plants species not only are sources of edible fruits but they are also used as medicinal plants, fuel wood, fodder, in construction, furniture, tool handles etc. Because of more ethnobotanical importance, these species are under high anthropogenic pressure, which demands their urgent conservation.

The comparative study of plant structure as morphology and anatomy has always been the backbone of the plant systematic, which endeavors to elucidate plant diversity, morphology and evolution. During the present investigation, four species of family Moraceae as Morus alba, M. nigra, M. leavigata and M. rubra were examined taxonomically which showed diversity in their morphological and anatomical features. Although these four species show some similarities in their characters like catkin inflorescence and sorosis type of fruits, there are remarkable differences in their shape of lamina; as ovate (M. alba), broadly ovate (M. nigra), ovate to rotundate (M. leavigata) and oblong-ovate (M. rubra). Lamina base; cordate (M. alba and M. leavigata), deeply cordate (M. nigra) and broadly ovate in M. rubra. Similarly, there is great diversity in leaf margin, apex and inflorescence of these species.

Organoleptographic characters indicates that fruit color in four species is different as pale yellow (M. alba), Black (M. nigra), yellow to white (M. leavigata) and reddish to black (M. rubra). Fruits length also varies as long fruits (4.3 to 6.5 cm) are present in M. leavigata and M. rubra while small but wide fruits are found in M. alba and M. nigra.

The leaf epidermal anatomy is one the most significant taxonomic characters studied in number of families based on leaf epidermis anatomy (Bhatia, 1984; Jones, 1986). According to Scotland et al. (2003), rigorous critical anatomical studies of morphological features in the content of molecular phylogenies are fruitful to integrate the strength of morphological data. Leaf epidermis anatomy also shows variation in anatomical features of these species (Table 1). Although there were similarities in epidermal cells in all four species of Morus but variation in shapes of epidermis cells can be observed (Figures 1 to 4). Variations can also be observed in the length and width measurement of these epidermis cells (Table 2). Hooked hairs and trichomes have been recorded on both adaxial and abaxial surface of these species except M. nigra where unicellular trichomes with pointed ends can be observed (Figure 3). There is also variation in the type and presence of stomata. Mostly, different types of stomata like anomocytic-desmocytic (M. alba); anomocytic (M. nigra); anomocytic-anomotetracytic (M. laevigata) and cyclocytic-anomocytic (M. rubra) were observed on abaxial surface (Figures 1 to 4). Presence of different stomata on same leaf indicates the systematic value of this character but its potential value, if properly interpreted and used with other characters, is substantial (Raju and Rao, 1977; Isawumi, 1989).
Table 1. Qualitative analysis of foliar epidermal cells characteristics.

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Leaf epidermis (Ad/Ab) Shape</th>
<th>Margin/Well morphology (Ad/Ab)</th>
<th>Stomata P/A Type</th>
<th>Trichomes P/A Type</th>
<th>Glands (Glandular/Non glandular)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morus alba</td>
<td>Variously shaped</td>
<td>Variously shaped</td>
<td>Ab</td>
<td>Anomocytic to DESemocytic</td>
<td>Both Peltate glands</td>
</tr>
<tr>
<td>Morus nigra</td>
<td>Variously shaped</td>
<td>Variously shaped</td>
<td>Ab</td>
<td>Anomocytic</td>
<td>Both Peltate glands</td>
</tr>
<tr>
<td>Morus leavigata</td>
<td>Variously shaped</td>
<td>Variously shaped</td>
<td>Ab</td>
<td>Anomocytic and Anomocytic</td>
<td>Both Glandular Peltate glands</td>
</tr>
<tr>
<td>Morus rubra</td>
<td>Undulating to irregular</td>
<td>Straight on ab and wavy on ad</td>
<td>Ab</td>
<td>Actinocytic and Anomocytic</td>
<td>Both Peltate glands</td>
</tr>
</tbody>
</table>

Ad: Adaxial; Ab: Abaxial; P: present; A: Absent.

Table 2. Quantitative analysis of Foliar Epidermal cells characteristics.

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Surface</th>
<th>Leaf epidermis (µm) Length × Width</th>
<th>Stomatal complex (µm) Length × Width</th>
<th>Trichomes (µm) Length × width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morus alba</td>
<td>Ab</td>
<td>20.83(12.5 - 27.5)×10.08(7.5 - 12.75)</td>
<td>17.5(12.5 - 22.5)×9.58(6.25 - 12.5)</td>
<td>43.33(37.5 - 47.5)×7.58(7.5 - 7.75)</td>
</tr>
<tr>
<td></td>
<td>Ad</td>
<td>33.41(27.5 - 37.75)×18.58(13.25 - 22.5)</td>
<td>Absent</td>
<td>165(20 - 250)×22.66(12.5 - 25.5)</td>
</tr>
<tr>
<td>Morus nigra</td>
<td>Ab</td>
<td>21.75(17.5 - 25.25)×11.58(10 - 12.5)</td>
<td>18.41(12.75 - 22.5)×6(5.25 - 7.5)</td>
<td>17.58(12.25 - 27.5)×10.75(7.5 - 12.5)</td>
</tr>
<tr>
<td></td>
<td>Ad</td>
<td>25(22.5 - 27.5)×16.75(12.75 - 20)</td>
<td>Absent</td>
<td>40.91(40 - 42.5)×9.16(7.5 - 12.5)</td>
</tr>
<tr>
<td>Morus leavigata</td>
<td>Ab</td>
<td>41.25(23.75 - 62.5)×13.41(10 - 17.5)</td>
<td>20.75(17.5 - 24.75)×14.25(10 - 17.5)</td>
<td>Absent</td>
</tr>
<tr>
<td></td>
<td>Ad</td>
<td>36.66(30 - 42.5)×21.66(17.5 - 25)</td>
<td>Absent</td>
<td>45(43.5 - 46.25)×3.125(3 - 3.25)</td>
</tr>
<tr>
<td>Morus rubra</td>
<td>Ab</td>
<td>30(27.5 - 32.5)×14.25(12.5 - 15.25)</td>
<td>19.88(19.75 - 20)×18.16(17 - 20)</td>
<td>29.91(27.5 - 32.25)×13.66(12.25 - 16.25)</td>
</tr>
<tr>
<td></td>
<td>Ad</td>
<td>33.33(30 - 37.5)×21.75(20.25 - 22.5)</td>
<td>Absent</td>
<td>127.91(112.5 - 157.5)×26.58(24.75 - 30)</td>
</tr>
</tbody>
</table>

Ad: Adaxial; Ab: Abaxial.

Conclusion

The present study was focused on ethnobotanical and taxonomic screening of four species of genus Morus. Fruit's organoleptography and leaf epidermal anatomy was studied first time with reference to Pakistan. Variations were observed in morphological and anatomical features of these species. All the taxonomic characters like leaves shape, size, width, types and size of branches, type of stem, floral characters, fruits morphology, leaf epidermis cells and stomata are important tools which play key role in the identification of plant species. Genetic diversity and DNA sequencing may also be helpful in this regard. Ethnobotanical investigation revealed that these plant species not only yield valuable edible and medicinal fruits but also an important source of
fuel, fodder and construction. There is an urgent need for conservation of this nature gift.

ACKNOWLEDGEMENT

We are very thankful to Higher Education Commission-Pakistan (HEC) for financial assistance.

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