

APPROACHES TO INDUSTRIAL EXPLOITATION OF MULBERRY (*Mulberry* sp.) FRUITS

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A B S T R A C T

Mulberry is grown worldwide. Its leaves are used to feed the silkworms which in turn produce silk fiber. Sericulture is mostly practiced in China, India and Japan. In the rest of the world, mulberry is generally used as forage in animal production, or for other purposes. Besides using the leaves, mulberry bears sweet fruit. The full-bodied flavor of this fruit is a good balance of sweetness and tartness with nutrient elements of vital importance for human metabolism. If these fruits are industrially exploited for various commercially valuable products, mulberry can become an important crop throughout the world. This paper presents a visualization of mulberry and the industrial exploitation of mulberry fruits for the global scenario. Mulberry can be used for making jam, jelly, pulp, fruit drink, fruit sauce, cake, fruit tea, fruit powder, fruit wine, food colorant, diabetes control agent and as ruminant livestock feed. It can also be used in the pharmaceutical industry. It opens a new vista for industrial exploitation of mulberry fruits worldwide. Such a use of the mulberry has been overlooked for the sake of using only mulberry leaf for the sericulture industry.

Key words: mulberry, sericulture, fruit, industrial exploitation

INTRODUCTION

Mulberry (*Morus* sp.) is grown around the world for sericulture, forage and other purposes and also for its fruits in a few Asian countries (Tab. 1). It is known by different names as morera or mora in Spanish, moreira in Portuguese, murier in French, tut in Urdu and sahtut in Hindi. In China, the world's leading sericultural country, there are over a thousand mulberry cultivars available for sericulture. They originated from four main species *i.e.* *M. alba*, *M. multicaulis*, *M. bombycis* and *M. atropurpurea* (Yongkang, 2000). The most popular species in the world are believed to be *M. alba* and *M. indica*. Intensive selections from open pollination, hybridization and mutation breeding have resulted in thousands of cultivars including many polyploids. In Brazil, about 90 genotypes of *M. alba* exist (De Almeida and Fonseca, 2000). Considering that the silk trade has been going on for a long time throughout the world, and, that this plant is also cultivated for its fruit and for landscaping, it is no wonder that mulberry germplasm has been taken to many countries. Now it has a very wide distribution range in Asia-Europe, Africa (North and East Africa) and in both Americas. Most of the mulberry cultivars are believed to have originated in the area of China-Japan and in the Himalayan foothills. In some Asian countries, mulberry leaves have been traditionally fed to farm animals. Intensive production of mulberry and its

utilization for animal production started in several countries in the late 1980's and early 1990's. The higher biomass yield, the palatability and the exceptionally high nutritive value of the leaves has generated a great interest in mulberry for animal feeding in recent years. In the former Soviet Union, the most common species are *M. multicaulis*, *M. alba*, *M. tartarica* and *M. nigra* (Datta, 2000). In Indonesia (West Java), the mulberry species grown are *M. alba*, *M. nigra*, *M. multicaulis*, *M. australis*, *M. cathyana* and *M. miorovra* (Katsumata, 1972). The majority of the mulberry species are available in Asia, especially in China (about 24 species) and the Japan (about 19), though America is also rich in *Morus* species. However, the genus is poorly represented in Africa, Europe and the Near East. In Vietnam, about 100 mulberry cultivars of the species *M. alba*, *M. nigra* and *M. laevigata* are available. In China, about 15 species exists, out of which, *M. alba*, *M. multicaulis*, *M. atropurpurea* and *M. mizuho* are cultivated for sericulture. The mulberry species *M. insignis*, *M. rubra* and *M. celtidifolia* exist in Latin America also. In India, generally *M. indica*, *M. alba*, *M. serrata* and *M. laevigata* are grown naturally in northern India (Ravindran et al., 1997). But, meanwhile, several cultivars of *M. multicaulis*, *M. nigra*, *M. sinensis* and *M. philippinensis* have also been introduced. However, most of the Indian cultivars belong to either *M. indica* or *M. alba*. In India, about 244 mulberry cultivars are maintained,

Approaches to industrial exploitation of mulberry (*Mulberry* sp.) fruits

Table 1. Mulberry utilization in the world (Sanchez, 2002)

Country	Mulberry utilization				
	mulberry cultivation area (x 1000 ha)	Sericulture	fruit	forage/animal feeding	other uses
Egypt and Tunisia	n.a.	√	√		
Ethiopia	n.a.	√			
Kenya	n.a.	√		√	
Madagascar	n.a.	√			
Tanzania	n.a.			√	
Argentina and Bolivia	n.a.				√ ¹
Brazil	38	√		√	
Colombia	n.a.	√		√	
Costa Rica	n.a.			√	
Cuba	<1			√	
Dominican Rep.	<1			√	
El Salvador	<1			√	
Guatemala	n.a.			√	
Honduras and Panama	<1			√	
Mexico	<1	√	√	√	√ ¹
Panama	<1			√	
Peru	n.a.				√ ¹
Saint Vincent	<1			√	
United States	n.a.				√ ¹
Afghanistan	n.a.			√	
China	626	√			√ ²
India	280	√		√	√ ³
Indonesia	n.a.	√			
Japan	n.a.	√	√	√	√ ²
Korea	n.a.	√		√	
Kyrgyzstan	n.a.	√	√		
Malaysia	n.a.	√			
Pakistan	n.a.	√		√	
Philippines	n.a.	√			
Syrian Arab Republic and Turkey	n.a.		√		
Tajikistan	n.a.	√			
Turkmenistan	n.a.	√	√		
Viet Nam	n.a.	√		√	
Uzbekistan	n.a.	√			
Bulgaria	n.a.				√
France	n.a.			√	√ ¹
Greece	n.a.				√ ¹
Italy	n.a.				√ ¹
Poland	n.a.				√ ¹
Spain	n.a.				√ ²

Other uses: √¹ = Landscaping and gardening; √² = Medicinal and infusion; √³ = Handicrafts and cabinet work; n.a. = data not available

and most of the states have taken up sericulture as an important agro-industry with high economic returns. Though mulberry cultivation is practiced in various climates, the major sericulture zone is tropical India covering Karnataka, Andhra Pradesh and Tamil Nadu states. The sericulture zone in India contributes about a 90 percent share of the country's silk production by growing mulberry cultivars Kanva-2, S-34, S-36, S-54, DD, V-1 (all belong to *M. indica*), S-13 (*M. alba*) and MR-2 (*M. sinensis*). In the sub-tropical zone, West Bengal, Jammu and Kashmir, Uttaranchal, Uttar Pradesh and Himachal Pradesh are the major areas under mulberry cultivation with the cultivars S-1 (*M. alba*), S-799 (*M. latifolia*), S-1635 (*M. alba*), Tr-10 (*M. australis*), BC2-59 (*M. latifolia*) and S-146 (*M. alba*) being the most popular. The cultivars Gosheorami (*M. multicaulis*), English Black (*M. nigra*), Okinawa (*M. alba*) and Chinese white (*M. alba*) are cultivated in temperate climates.

Globally, mulberry is exploited for feeding leaf to silkworms in order to obtain silk fiber or for animal feedstock production. All other plant parts have not been given much importance as far as industrial use is concerned. Mulberry fruit can also provide enormous economic additions just like the leaf, which has been utilized for silkworm rearing. Mulberry fruits are syncarpous formed by the coalescence of a spike of flowers. Similar to the blackberry, it is an aggregate fruit composed of many smaller fruits called drupes, appearing

like swollen loganberry. When pollinated, the flowers and their fleshy bases begin to swell. Ultimately, they get completely altered in texture and colour and become succulent and full of juice. The shape and size of fruits vary from cultivar to cultivar. Usually they are ovoid or subglobose or ellipsoid to cylindrical. Mulberries have a stalk distinguishing it from blackberries and raspberries. The skin of the fruit is smooth and fragile, and its colour changes as it matures. Fruits of different genotypes are white, lavender and deep red to black. However, the colour of the fruit does not identify the species, as the genotypes of *M. alba* (white mulberry) can produce white, lavender or black fruits which are generally very sweet but often lack tartness. Red mulberry fruits are usually deep red, almost black, and its best clones have a flavour that almost equals that of the black mulberry. Black mulberry fruits are large and juicy with a good balance of sweetness and tartness that makes them the best flavoured species of mulberry. The ripe berries are delectably sweet like a cooling blend of the tastes of raspberry and strawberry while its refreshing tart taste is somewhat reminiscent of grapes. Mulberries ripen over an extended period of time unlike many other fruits which seem to come all at once. As a rule, the fast growing mulberry trees bear few berries in the first year. The fruit have the richness of sweet cherries. White and red mulberries and hybrid fruits generally are ready for harvest in spring. The fruits of black mulberries

ripen in summer to late summer depending upon the locality and the climate. The mulberry fruits are often harvested by spreading a sheet on the ground and shaking the branches. In some of the genotypes, the fruits are so ripe that just picking them breaks the fragile skin of the fruit and stains the fingers purple with juice.

Promising mulberry cultivars for fruit yield

Most of the mulberries are white mulberry (*Morus alba*), black mulberry (*M. nigra*), Indian mulberry (*M. indica*) or the red mulberry (*M. rubra*). Korean mulberry (*Morus australis*), Himalayan mulberry (*M. laevigata*) and many hybrid forms also exist between *Morus alba* and *M. rubra* and others. Generally mulberries were native to Asia but have spread to the temperate areas of northwest and central Asia, Europe and North America, through the tropics of Asia, Africa and Latin America, and to the southern hemisphere (southern Africa and South America). There are mulberry cultivars for many environments, from sea level to altitudes of 4,000 m, and from the humid tropics to semi-arid lands. In the Near East with 250 mm of annual rainfall and southwest USA, mulberry is also cultivated under irrigated conditions. Based on their origin, the following mulberry cultivars are highly promising for fruit yield.

United States of America

- Wellington (*M. nigra*): Originated in Geneva, USA, takes several

weeks for fruits to ripen. Medium sized fruits are of 2.5-3.0 cm in length with good flavoured sweet juice.

- Hicks Everbearing (*M. rubra*): It originated in Kentucky. It is much like Downing in size and colour.
- Johnson (*M. rubra*): It is a popular shade-tree of San Antonio, Texas and in Ohio. The leaves of this cultivar are very large. Fruits are fleshy and juicy.
- Illinois (*M. alba* x *M. rubra*): The cultivar originated in White County, Illinois. It bears very long, black coloured fruits containing highly flavoured sweet juice.
- Tehama (*M. alba*): It originated in Tehama county, California. White coloured succulent fruits are very large; about 7.0 cm in length, containing very sweet juice.
- Shangri La (*M. alba*): The cultivar originated in Naples, Florida. It has large black fruits.
- Collier (*M. alba* x *M. rubra*): Originated in America, it is an everbearing fruit cultivar. It has a long ripening period. The purple to black coloured fruits are 2.0 -2.5 cm in length containing sweet flavoured juice with a little trace of tartness.
- Kaester (*M. nigra*): It originated in Los Angeles, California. It bears deep purple to black coloured fruits; about 1.5-2.5 cm in length. Highly flavoured juice with a good balance of sweetness and tartness.
- Riviera (*M. nigra*): The cultivar originated in Vista, California. Elongated deep purple to black

coloured fruits are 2.5 - 3.75 cm in length containing very sweet juice.

- Stubbs (*M. rubra*): Fruits are very large; about 5.0 cm in length with a diameter of about 1.7 cm. It is valuable cultivar in the South which does well under irrigation in southwest Texas.

North America

- Thorburn and Trowbridge (*M. alba*): It is found in N. America and is considered as one of the best cultivars for producing good quality fruits in northern latitudes.
- New American (*M. alba*): The cultivar is hardier in Ohio and in the Southeast and South, but is not as hardy in the West. It was selected N. America and is considered to be the best genotype for producing good quality fruits in northern latitudes. Black coloured fruits are quite big and juicy.

China

- Russian (*M. tartarica*): The cultivar was introduced to Europe from China. It bears reddish black coloured good quality sweet fruits.
- Pendulum (*M. alba*): The cultivar grown at Kew bears with very tasty juicy fruits.
- Nana (*M. alba*): It is a dwarf shrub cultivar.
- Hunza seedless (*M. alba*): The medium-sized fruits are pure white and seedless. They are usually dried and stored by the people of Hunza, who use fruits as a staple part of their diet.

- Black Persian (*M. nigra*): The Persian mulberry is widely admired and reportedly grown extensively in Russia on collective farms for eating the fresh fruit and for canning. It is extensively grown in California, Arizona and Texas. In California, the cultivar fruits from May to the October. It bears large black fruits of about 2.5 cm in length and breadth with rich flavoured juice. Black mulberry trees of the Persian cultivar can grow up to 20 feet high, and the berries can be harvested by shaking the trees and collecting the mulberries on sheets which have been placed beneath.
- Downing (*M. alba*): It is cultivated in USA and the fruits are black with excellent flavour.
- English Black (*M. nigra*): It is cultivated in South America. Fruits are 2.5 to 4.0 cm in length with a diameter of about 1.25 cm.
- Beautiful Day (*M. alba*): It is a medium sized highly productive tree requiring little care. It produces medium to large white coloured fleshy sweet fruits.

Pakistan

- Pakistan (*M. alba*): It originated in Islamabad, Pakistan and bears very long, deep red fruits of about 6.00-8.50 cm. in length. Fruits are of excellent quality with a sweet taste.

Black, red and white mulberries are widespread in Northern India, Azerbaijan, Syria, Armenia, Pakistan, Iran and Afghanistan, where trees and

fruits are known by the Persian-derived names i.e. toot (mulberry) or shahtoot (King's or "superior" mulberry). Jam and syrup are often made from fruits in these regions.

Promising mulberry fruit yielding genotypes in Japan

Most of the mulberry cultivars in Japan belongs to *M. bombycis* Koidz, *M. alba* and *M. latifolia* Poiret. Cultivars belonging to *M. bombycis* are primarily cultivated in cold regions, such as the Tohoku district. *M. latifolia* cultivars are mainly cultivated in warmer places, such as the Kyushu district. However, cultivars of *M. alba* are cultivated in a wider area, from Kyushu to Tohoku district, since they have intermediate traits of these two species. Besides these, *M. acidosa* Griff. grows naturally and is cultivated in the southwest islands, including the Okinawa islands. *M. kagayamae* Koidz and *M. boninensis* Koidz are indigenous to the remote islands of Hachijoujima and Ogasawara, respectively. For the production of fruits, the genotypes Kataneo and Okaraguwa have been identified as very promising among 260 mulberry genotypes screened by Machii et al. (1999). In Okaraguwa, every fruit is of about 7.15 g. Iijima and Oshigane (1991) screened a large number of genotypes for making jam. Tanaka and Tachibanada (1988) analyzed mulberry fruit sugar and organic acid content for mulberry wine.

Promising mulberry genotypes for fruits in China

Although there are many species of *Morus*, the one grown in China is

the white mulberry (alba = white). One of the primary uses of the plant is for rearing silkworms. China has been producing silk since ancient times and remains one of the world's leading countries for silk production. The Chinese term for the mulberry plant is sang, and the fruits are known in China as sanshenzi or sangshen.

Mulberry in Azerbaijan

There are three main species of mulberries i.e. white, red and black cultivated throughout Azerbaijan. The white mulberry, in particular, grows in the forests stretched along the Kur, Araz and Samur rivers. But in Baku, the capital city of Azerbaijan, mulberry trees can be found in parks and along streets and boulevards. It is one of the favorite fruits. Mulberry trees are not just grown for their fruit, but, in the summer, village residents around Baku sit and drink tea or play cards in the cool shade of mulberry trees (www.itmonline.org, 2009). A song has even been written about the mulberry tree. Today, mulberry trees (most frequently those bearing black fruit) line the streets of Baku and lend shade to courtyards. In the countryside, mulberry trees are often found in orchards and courtyards, along with a cultivar of other fruit trees like cherry, fig, pomegranate, apricot, apple and pear. Originally, male (fruitless) mulberry trees were planted along the streets and in the parks of Baku in order to provide shade and decoration. But somehow it happened that some female trees got planted as well. When their fruit becomes ripened, it tends to drop to the ground and stain the sidewalks.

Elite exotic and indigenous mulberry accessions for fruit yield in India

264 exotic and 836 indigenous mulberry accessions are being conserved at the field gene bank of Central Sericulture Germplasm Research Centre, Hosur, India (Kumaresan et al., 2008). The elite mulberry accessions found are MI-0118, MI-0171, MI-0249, MI-0300, MI-0497, MI-0512, MI-0059, MI-0506, MI-0380, MI-0572, ME-0004 and ME-0042, with variations in fruit yield per plant (Tab. 2). Besides, some of the genotypes of *M. laevigata*, namely MI-0365, MI-428, MI-0531 and MI-0340 bear long sweet fruits. Likewise, some of the accessions, namely, MI-442, MI-511, MI-0469 of *M. alba* bear highly sweet, white fruits. These being low leaf yielding accessions, have tremendous scope for fruit utilization.

In the Tamil Nadu state of tropical India, the mulberry cultivar MR-2 has been reported to yield about 40-50 g. of fruit per plant. The estimated production is 200-250 kg of fruit in one season, for an acre of irrigated bush plantation which has 90 x 90 cm spacing. Out of two fruiting seasons, higher fruit production has been reported during spring than summer (Masilamani et al., 2008). In the spring season, 50-60% juice content has been reported whereas only 30-40% has been reported for the summer season.

In Indian sub tropics, the mulberry cultivars Tr-10, Chinese white, MS-9404, S-146 and Mandalaya get lots of fleshy purple to black coloured sweet fruits from March to April. The highest fruit yield of 11.021 kg per

tree is found in the cultivar MS-9404 (Tab. 3). As much as 8.820 liters of fruit juice per tree has also been extracted. Juice is very sweet to a little sour in taste. But, in the field, the cultivar S-146 is more common for sericulture activities, where one tree provides about 1.847 liters of thick purple black coloured flavoured juice of sweet to sour taste. The juice is found suitable for industrial exploitation in the horticulture industry and for preparation of fruit jam, pulp and other horticulture products and uses (Singhal et al., 2009b).

In the temperate region of India, the amount of fruits from *M. multicaulis* and English Black is very high per tree compared to the few fruits of the cultivars Tr-8 and Okinawa (Tab. 4) (Khan and Singhal, 2006). Fruits are available during the spring season of Kashmir, India (the fourth week of March to the first week of June).

Mulberry fruit exploitation

Well ripened mulberry fruits are very sweet and are offered in the Indian market as a fruit dish for the dining table. In the United States, mulberry is not grown commercially because the fruits are so fragile and perishable. This factor makes them very rare and sought after, especially in California. Restaurant chefs have been known to line up for hours at outdoor markets to buy these fashionable berries at 10 \$ to 15 \$ for a pound of fruit. In the Los Angeles area, some Iranian immigrants have even resorted to planting their own mulberry orchards, so that, they will have easy access to their favorite

Approaches to industrial exploitation of mulberry (*Mulberry* sp.) fruits

Table 2. Elite exotic and indigenous mulberry accessions for fruit yield in India (Kumaresan et al., 2008)

Mulberry accession	Fruit colour	Range of fruit length [cm]	Range of fruit yield per plant [kg]
MI-0118	pink	2.22-2.50	1.50-2.00
MI-0171	black	2.50-3.20	2.00-2.50
MI-0249	white	1.50-2.00	2.00-2.50
MI-0300	white	1.50-2.00	2.00-2.50
MI-0497	black	1.60-2.00	2.00-2.50
MI-0512	white	1.50-2.00	1.50-2.00
MI-0059	pink	1.60-2.00	1.60-2.00
MI-0506	black	2.00-2.50	2.00-2.50
MI-0380	pink	6.00-7.00	1.50-2.00
MI-0572	black	6.00-7.00	1.50-2.00
ME-0004	black	2.50-2.70	2.00-2.50
ME-0042	pink	1.50-2.00	1.50-2.00

Table 3. Fruit characteristics of different mulberry cultivars under sub tropical conditions of India (Singhal et al., 2009b)

Fruit characteristics	Mulberry cultivars				
	S-146	Tr-10	Chinese White	MS-9404	Mandalaya
Fruit length [cm]	1.41	1.52	1.57	2.15	1.41
Fruit breadth [cm]	0.96	1.02	0.94	1.24	0.95
Length of fruit stalk [cm]	0.46	0.61	1.16	1.24	1.02
Average weight per fruit [g]	1.01	1.28	1.05	1.891	0.954
Total number of fruits per tree	3303	5763	2615	5902	2172
Fruit yield per tree [kg]	3.294	7.352	2.705	11.021	1.983
Juice content per tree [liter]	1.847	4.267	2.602	8.820	1.473
Taste	highly sweet to a little sour	moderately sweet to a little sour	moderately sweet to a little sour	highly sweet	moderately sweet to a little sour
Colour	purple black	purple black	purple black	pinkish red	purple

Table 4. Fruit yield of elite mulberry cultivars in Indian temperatures (Khan and Singhal, 2006)

Mulberry cultivar	Average fruit yield per tree [kg]
<i>Morus multicaulis</i>	10.85
English black	8.35
S-1531	2.71
S-1301	2.63
Okinawa	1.75
Tr-8	0.36

fruit. To pick mulberries, a person climbs up the tree and shakes the branches, causing the fruit to drop onto a cloth or plastic sheet below. The berries are very delicate and therefore need to be handled carefully so that they don't break open, because the stain does not wash out easily. In Azerbaijan, during the off season, mulberry fruits are enjoyed in the form of mulberry syrup concentrates known as doshab and bakmaz. Besides its sweet taste, fruits are also used as a medicine to protect against diseases of the liver, gall bladder and heart (Alakbarov and Aliyev, 2000).

Chemical composition of mulberry fruit

A well ripened fruit has a mouth watering sweet taste with a pleasant flavour. Its chemical composition has been depicted in Table 5. Due to very high nutritional value, mulberry fruits are used for the health benefits of human beings (Singhal et al., 2003, 2005ab). Moreover, fruit contains nutrient elements of vital importance in human metabolism (Akbulut and

Musazcan, 2009). In black mulberry (*M. nigra*) fruits, Koyuncu (2004) there is malic acid in the range of 35.4-198.5 mg/g followed by citric acid (5.5-23.4 mg/g). Tartaric acid, oxalic acid and fumaric acid were at a level of 4.16, 0.62 and 0.019 mg/g, respectively.

Anti-obesity mulberry fruit drink

A new UK fruit juice company "Fairjuice" has launched a super fruit drink prepared from pure fresh pressed mulberry fruits which is full of antioxidants. It is also a source of resveratrol which is considered to be beneficial for heart health. It also suppresses the appetite, which is why it has been reported as a useful drink against obesity (Fairjuice, 2008).

Horticulture products

In recent years, with considerable work on cultivating mulberry plants under various conditions, mulberry fruit juice has been commercially produced as a health beverage, and it has become very popular in China, Japan and Korea. Without adding

Table 5. Chemical composition of mulberry fruit (Singhal et al., 2009b)

Chemical constituents	Quantity
Carbohydrates	7.8–9.0%
Protein	0.5–1.4%
Fatty acids (linoleic, stearic and oleic acids in seeds)	0.3–0.5%
Free acid (mainly malic acid)	1.1–1.8%
Fiber	0.9–1.3%
Ash	0.8–1.0%
Moisture	85–88%
Calcium	0.17–0.39%
Potassium	1.00–1.49%
Magnesium	0.09–0.10%
Sodium	0.01–0.02%
Phosphorus	0.18–0.21%
Sulphur	0.05–0.06%
Iron	0.17–0.19%
Carotene	0.16–0.17%
Ascorbic acid	11.0–12.5 mg/100 g
Nicotinic acid	0.7–0.8 mg/100 g
Thiamine	7.0–9.0 µg/100 g
Riboflavin	165–179 µg/100 g

preservatives, the original juice of mulberry fruit remains fresh under cold storage for 3 months, while the bottled beverage remains fresh at room temperature for about 12 months (Dharmananda, 2008). From one acre of mulberry tree cultivation; which has a spacing of 8 x 9' between tree to tree and row to row, about 1993 kg of fruit jam and 2794 liters of fruit pulp can be prepared in sub tropical India. The market survey revealed an income of 1063.72 US \$ and 1161.70 US \$ from the sale of

jam and pulp, respectively in Indian markets (Singhal et al., 2009b).

Fruit sauce and cakes

Many desserts are made from the Persian mulberries along with sauces, pie-making, cakes and jelly (www.tytyga.com, 2009).

Mulberry fruit tea

In Chinese markets, mulberry is often provided in the form of a paste called sangshengao. The paste is

mixed in hot water to make a tea to improve the liver and kidney and sharpen the hearing and brighten the eyes. For this application, it is combined with the traditional formula Yiqi Congming Tang, which is used for deficiencies in hearing and vision (www.itmonline.com, 2009). In Iran, dried mulberries are used as a sweetener in black tea. After a sip of tea, dried mulberry fruits are eaten to sweeten the mouth (www.recipezaar.com, 2007; www.rawepicurean.net, 2009).

Mulberry fruit powder

Mulberry fruits can be dried and stored as a powder. About 10 g of dried fruits provides about 100 mg of anthocyanins. As it contains resveratrol, fruit powder works as an anti-mutagen which can inhibit the mutation of healthy normal cells into cancerous cells (Hou, 2003). It is believed to prevent heart disease, cancer and other diseases associated with chronic inflammation. The fruit powder has an anti-aging effect on cells because it combats free radical damage. Fruit powder promotes healthy cholesterol and controls carbohydrate digestion in the human body (www.znaturalfoods.com, 2009; www.yourhealthyourherbs.com, 2009; Liu et al., 2009).

Mulberry fruit wine

Over-ripened and sour fruits can be converted into mulberry wine (Ehow, 2009). The wine has a sweet and sour taste. A glass of mulberry wine a day helps get rid of impurities

and coprostitis (faecal residue in the intestines) in the body which can help make the body slim. The wine made by immersing the mulberry in rice wine or grape wine works as medicine for weakness after diseases that can also be used to tonify masculine vitality and benefit overall vitality. In Azerbaijan, Georgia and Armenia, a potent liqueur “Tut araghi” made from mulberry fruit juice is very popular. It is one of the national Azerbaijani versions of vodka. It is believed that small dose of the drink protects against stomach and heart diseases (Alakbarov and Aliyev, 2000). In Greece, mulberry fruits are used for the production of the traditional aromatic mouro distillate. Soufleros et al. (2004) standardized the production process of mouro distillate for its safe use as an alcoholic beverage. Mulberry fruit wine is very popular as a ladies drink in Europe.

Food colorant

Mulberry fruits are rich in anthocyanins and deserve to be exploited for the industrial production of natural colour to be used in the food industry. In particular, it is known to contain cyanin, which contributes the red pigment that gives the fruit a red to purple colour. The major anthocyanins found are cyaniding-3-glucoside and cyaniding-3-rutinoside. These pigments hold potential for use as dietary modulators, of mechanisms for various diseases, and as natural food colorant (Wrolstad, 2001). As synthetic pigments are unsafe, there is a demand for natural food colorants

in the food industry. Since these are water-soluble, they are easily extractable and incorporated into the aqueous food systems. A cheap and industrially feasible method to purify anthocyanins from mulberry fruit has already been established (Liu et al., 2004), which could be used as a fabric tanning agent or food colorant of high color value. It is found that out of 31 Chinese mulberry cultivars tested, the total anthocyanin content varies from 148 mg to 2725 mg per liter of fruit juice. Total sugars, total acids and vitamins remain intact in the residual juice which can be used for pulp and wine preparation. However, anthocyanin content depends upon the climate of the area of cultivation. Anthocyanin content is particularly high in dry regions. Tropical sericulture countries could make quite a good profit with the industrial production of anthocyanin from mulberry fruits.

Diabetes control syndrome

Mulberry fruits are reported as antidiabetic with antioxidative properties (Kim et al., 1996, 1998). Hong et al. (2004) found that mulberry fruit strengthens the antioxidative defence system and reduces damaging oxidative substances in the erythrocytes of diabetes induced rats. The accumulation of thiobarbituric acid reactive substance (TBARS) is checked

Mulberry fruit as feed supplements to ruminant livestock

Habib (2004) has reported that a multinutrient feed block prepared

from mulberry fruits has increased milk production from 30% to 50% in livestock with low disease incidence. It is found that a farmer can earn about US \$ 17-26 per month during the mulberry season from commercial preparation of mulberry fruit blocks. It is mentioned that the technology of utilizing mulberry fruits as feed blocks for animals can be exploited as an income-generating micro enterprise.

Mulberry fruits in pharmaceutical industry

The sole use of mulberries in modern medicine is for the preparation of syrup; to add flavors and natural colour in medicines (Singhal et al., 2001, 2003). The mulberry fruit is used for many medical purposes such as for balancing internal secretions and enhancing immunity (Kim and Bonchokak, 1991, Venkatesh Kumar and Chauhan, 2008). It is used to treat urinary incontinence, tinnitus, dizziness, constipation, sore throat, depression and fever. The fruits of *M. alba* have a cooling and laxative property and are used in throat infection, dyspepsia and melancholia (Jain and De Filippis, 1991). The juice which is refrigerant is used as a drink in febrile diseases. It checks thirst and cools the blood. The fruit juice is commonly used for reducing high fever as febrifuge. This is the first treatment normally given to any patient with symptoms of fever during endemic malaria (Shivakumar et al., 1995). It is mentioned by Singh (1997) that syrups and recipes prepared from fruits of *M. alba* are

used against hyperlipemia, constipation and insomnia, antiaging, premonitory and apoplexy. It is further mentioned, that, decoctions prepared from fruits are used against cerebral arteriosclerosis, chronic nephritis, kidney asthenia, central retinitis and nasopharyngeal cancer. Ripened fruit works as a good appetizer and are carminative. Fruits are also used for loss of appetite, flatulence and for controlling intestinal parasites like tapeworm. Fruits can nourish and promote the production of body fluid. As juice has a faint scent and sweet taste, it is suitable for people of all ages.

CONCLUSION

Mulberry (*Morus sp.*) is generally utilized for feeding leaf to silkworms to obtain silk. But the fruits of this genus also have tremendous potential for providing various valuable industrial products of very high economic value for human beings.

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MOŻLIWOŚCI PRZEMYSŁOWEGO WYKORZYSTANIA OWOCÓW MORWY (*Mulberry* sp.)

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S T R E S Z C Z E N I E

Morwa jest uprawiana w całym świecie. Jej liście są wykorzystywane do karmienia gąsienic jedwabnika, które z kolei wytwarzają włókno jedwabne. Uprawa morwy jako paszy dla jedwabników jest praktykowana głównie w Chinach, Indiach i Japonii. W innych częściach świata morwa jest zazwyczaj stosowana jako pasza dla bydła. Ponadto morwa rodzi owoce, które są przydatne do spożycia w stanie świeżym lub przetworzonym. Pełny, słodko-cierpki smak tego owocu pozostaje w równowadze z zawartością substancji odżywczych o ogromnym znaczeniu dla metabolizmu ludzkiego. Gdyby owoce morwy wykorzystać do produkcji różnych rynkowych produktów, stałaby się ona ważną rośliną uprawną na świecie. W tej publikacji przedstawiono obecne warunki uprawy morwy i możliwości przemysłowego wykorzystania jej owoców, które mogą być użyte do produkcji soku, dżemów, galaretek, przecieru, napoi owocowych, sosów owocowych, herbaty owocowej, wina, barwników do żywności, suplementów diety stosowanej w cukrzycy oraz jako pasza dla przeżuwaczy. Owoce morwy mogą także znaleźć zastosowanie w przemyśle farmaceutycznym. Otwiera to nowe, poza przemysłem jedwabniczym, możliwości wykorzystania morwy.

Słowa kluczowe: morwa, przemysł jedwabniczy, owoce, zastosowanie w przemyśle