5

Ramie

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5.1 Introduction and history

5.1.1 Introduction

Ramie is the name given to the product of one or more species of the genus *Boehmeria*, a member of the order *Urticaceae* and closely allied to the stinging nettle genus (Urtica), from which, however, it differs in the absence of stinging hairs. Some confusion has arisen on the use of the various terms *Chinagrass, Ramie and Rhea*. Two plants are concerned. One, *Boehmeria nivea*, China-grass, has caused some confusion to arise on the use of the various terms *Chinagrass, Ramie and Rhea*, cultivated by the Chinese from very early times under the name Tschou-ma. This is known as white ramie. The other, probably a variety of the same species (*Boehmeria nivea, var. tenacissima*), though sometimes regarded as a distinct species (*B. Tenacissima*), is the Ramie (Malay zamf) of the Malaysian Islands and the Rhea of Assam. This is known as green ramie. Ramie is a member of the group referred to as the bast fibre crops.

There are at least two acceptable pronunciations for the word. Some authorities call it 'ray-mee' while others say 'rah-mee'. Traditionally ramie is used to make cloth, and is usually found in combination with cotton in knitted sweaters. It is also used to make tablecloths, napkins, and handkerchiefs. Ramie fibre is used in fine fabrics for clothing fabrics, upholstery, canvas, filter cloths, sewing threads, gas mantles, fishing nets and marine packaging. The main areas of application for naturally produced plants, including ramie, are

- textiles
  - – woven
  - – non-woven
  - – knitting
  - – technical
- pulp and paper
- composites
- agro-chemicals.

5.1.2 History

Ramie is a plant fibre that has been used since ancient times. It is one of the oldest vegetable fibres known and has been used for thousands of years. Ramie was well established as one of the principal fibres of the Far East. Long before the introduction of cotton it was used in mummy cloths in Egypt during the period 5000–3300 BC and has been grown in China for many centuries. In the Asia of those days the main areas of ramie cultivation were China, Indonesia and India.

In Africa the main areas of ramie's cultivation were the present territories of Algiers and Congo. *Boehmeria cylindrica* was used by Indians of the New World as twine to attach spear and arrow heads to shafts. Europe was introduced to ramie in 1733. The first cultivation trials were undertaken in Holland in 1808–09. However, according to Karpowiczowa[1] the first notification concerning the cultivation of ramie in Europe is dated 1786 in Bologna, Italy.

Ramie in China and the Orient is usually harvested by hand as the canes mature. The strands of ramie tend to be uneven, making harvesting difficult. Pounding and scraping is necessary to separate the fibres. After being separated from the woody matter and soft tissues, fibres remain in ribbon-like strips because they are held together by gums and pectin. The fibres must be degummed by boiling in lye or acid; this frequently weakens the fibre and it is very expensive. Machines are not yet capable of performing all the steps necessary which is why ramie is not widely used.

The first attempts in the mechanisation of ramie processing were undertaken by the government of India in 1869 and then by the French government leading towards the design of a hand-fed raspador decorticator patented in the United States in 1896. Floridians (USA) have found that hydrogen peroxide and lime can be used for degumming – these are much less harmful than the chlorine and sulphuric acid currently being used. In these regions ramie is locally spun and woven into coarse cloth, often without degumming, in China it is also used to make fine oriental textiles. Brazil began production in the late 1930s with production peaking in 1971 at about 30,000 t/yr. Since then, production has steadily declined as a result of competition from alternative crops, such as soybeans, and the importation of synthetic fibres. Production in the Philippines began in the early 1950s, peaking in the mid-1960s at 5,500 t/yr. Since then production has declined steadily.

Nowadays, the main producer counties are reported to be China, Brazil, Philippines, India, South Korea and Thailand. However, the available statistics are not reliable but the best available are those of the FAO (Table 5.1) and from these and for all practical purposes the only country of any consequence is China. Ramie usage in the US increased in the mid-1980s with the fashion emphasis of natural fibres and the fact that this fibre was not covered by the multifibre agreement (see below).

Table 5.1 World production of natural fibres (million tonnes, average 1998–2000)

	Fibre	Million tonnes
1.	Cotton	19.32
2.	Jute and similar fibres	3.52
3.	Wool and other fine animal hair	1.52
4.	Flax	0.6
5.	Sisal (agave and similar fibres)	0.386
6.	Kapok	0.195
7.	Ramie	0.17
8.	Abaca	0.095
9.	Silk, tussah and similar wild silks	0.1135
10.	Hemp	0.08
	Total natural fibres	26.0

The main importing countries are Japan, Germany, France and the United Kingdom. Only a small proportion of production enters international trade as most is used in the country of production. Under the MFA, ramie, and garments made of more than 50% ramie, could be imported into the United States without import quota limits. Legislation was passed in 1986 eliminating this quota-free status of ramie.

5.2 Classification and description

Boehmeria nivea is a shrubby plant with the growth of the common nettle but without stinging hairs, sending up each season a number of straight shoots from a perennial underground rootstock. The long-stalked leaves recall those of the nettle in their shape and serrated margin, but their backs are clothed with a downy substance and have a silvery appearance. The minute greenish flowers are closely arranged along a slender axis.

The variety *tenacissima* differs in its more robust habit and larger leaves, which are pale green on the face and a very much paler green on the back. They

Table 5.2 Classification of ramie[2]

Division:	Magnoliophyta
Class:	Magnoliopsida
Subclass:	Hamameliade
Order:	Urticales
Suborder:	
Family:	Urticaceae
Sub-species family:	
Species:	Boehmerieae
Sub-species:	

are not downy, however, and this affords a ready means of distinction from true China-grass. *Boehmeria nivea* is sometimes found wild in India, Malaya, China and Japan, and is probably a native of India and Malaya. China-grass and ramie are widely cultivated not only in China, Formosa and Japan, but also in Brazil, Mexico and the southern states of North America, and also in Southern Europe.

Ramie is a member of the *Urticaceae* or nettle family and is a hardy perennial which produces a large number of unbranched stems from underground rhizomes. The true ramie or *China grass* is also known as *white ramie* and is the Chinese cultivated plant. It has large heart shaped, crenate leaves covered on the underside with white hairs that give it a silvery appearance. A second type, *Boehmeria nivea* var. *tenacissima*, is known as *green ramie* or *rhea* and is believed to have originated in the Malay Peninsula. This type has smaller leaves which are green on the underside and it appears to be better suited to tropical conditions.

Boehmeria nivea is an erect, usually non-branching, tall fast-growing herbaceous perennial, one to two metres high. The leaves are green on the topside with a felty-white underside, the whole being covered with inconspicuous hairs. As the plant matures, the leaves defoliate naturally from the lower part of the stem. The small seeds are dark brown in colour, ovate and produced in very large quantity. Ramie stems are slender, sometimes striated and range in diameter from 8 to 16 mm at the base. They may attain a height of two to two and a half metres in 45 to 60 days under ideal growing conditions. They are usually hollow at maturity, being filled with dried pith and may be readily crushed between the fingers.

Ramie differs from the other bast fibre crops in several important characteristics. The principal difference is that ramie is a hardy perennial which under suitable conditions can be harvested up to six times a year. Also the useful crop life ranges from 6 to 20 years. *Boehmeria nivea* is a dicot and angiosperm, it is adapted to moist tropical climates and deep soils, is a perennial plant, occupies the land year round and when cultivated, is without branches (apical dominance, apical buds pinched off).

5.3 Properties of the ramie fibre

Ramie is classified chemically as a cellulosic fibre, as are cotton, linen, rayon and others. Leading producers of ramie are China, Taiwan, Korea, the Philippines and Brazil. Until recently ramie has been unknown in the ready-to-wear apparel market, but its use in this market is now increasing. It is often blended with cotton and available in woven and knitted fabrics that resemble fine linen to coarse canvas. Ramie usage increased in the mid-1980s with fashion, the emphasis on natural fibres and a loophole in the textile import regulations of the Multi Fibre Agreement (MFA).

Ramie's fibres are found in the bark of the stalk. The process of transforming ramie fibre into fabric is similar to producing linen from flax. The fibre is very

fine and silk-like, naturally white in colour and has a high lustre. Ramie is a term that is appearing with increased frequency in the labelling of sweaters and some linen-look textiles.

5.3.1 Physical and chemical characteristics of ramie compared to other cellulosic fibres

Because ramie is a bast fibre the technology of its extraction from the plant is different from that of cotton, where the fibres have to be separated from the seeds. It is therefore difficult to establish a direct comparison of the properties of ramie with those of other fibres but Table 5.3 gives some of the chemical and physical characteristics of ramie, flax, hemp and cotton. These figures illustrate some of the advantages of ramie over other fibres and in particular the lengths of its ultimate fibres and their tensile strength. Other tables comparing Ramie's characteristics with those of other fibres can be found in the appendix to Chapter 1. The ultimate fibres are the longest known in the plant realm[3] with one report claiming the fibres range up to 580 mm, averaging about 125 mm. Another report describes the ultimate fibre as ranging between 48 and 290 mm in length. Also reported is the range of bark fibre lengths as 5 to 36 mm and the fibre width as 41.8 microns.

Ramie fibre is very durable. It is reported to have a tensile strength eight times that of cotton and seven times greater than silk. However, other reports claim that the tensile strengths of cotton, flax, hemp and ramie are similar. These discrepancies can be partly attributed to the effects of sources of supply,

Table 5.3 Some physical and chemical characteristics of ramie compared to other cellulosic fibres

Characteristics	Ramie	Flax	Hemp	Cotton
Ultimate fibre length in mm				
minimum	5	1	5	9
average	120–150	13–14	15–25	20–30
maximum	620	130	55	63
Ultimate fibre diameter in microns				
minimum	13	5	10	12
average	40–60	17–20	15–30	14–16
maaximum	126	40	50	20
Tensile strength in kg/mm^2	95	78	83	45
Moisture regain in %	12	12	12	8
Chemical composition in %				
cellulose	72–97*	64–86	67–78	88–96
lignin	1–0	5–1	6–4	0
hemicellulose, pectin and others	27–3	31–14	27–18	12–4

* Minimum and maximum cellulose contents refer to decorticated and degummed ramie respectively.

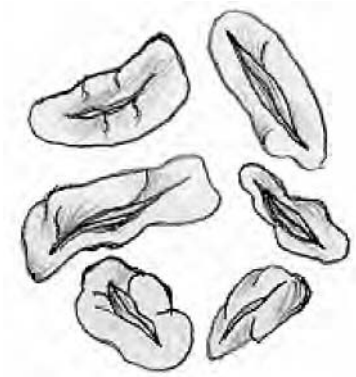

Figure 5.1 Cross-section through ramie fibres with lumen (cavity in fibre). Source: Gesamtverband der Deutschen Versicherungswirtschaft. Courtesy: www.tis-gdv.de.

methods of processing, the test conditions, and the influence of temperature and humidity on the fibre. Ramie's tenacity increased by 25% on wetting. It is the least affected by moisture. Ramie fibre, after extraction and primary processing is strong and durable, ranking first amongst all vegetable fibres in this respect. It also has the particular advantage of resisting rot when exposed to weather conditions or immersed in water. The fibre is exceptionally white, comparable to bleached cotton, and also has a high lustre, exceeding linen in this respect.

The long, fine ramie fibres are naturally white and lustrous with an almost silky appearance. The inner structure of ramie differs from that of other plant fibres in that the physical form of the cellulose is rigid and crystalline, like linen, but has a more porous sieve-like form providing it with even better absorbency than other cellulose fibres. The unevenness of the fibres has a strong resemblance to the thick and thin appearance of linen but at a reduced cost. In addition, ramie is softer and has better dyeability. Ramie's fibres are found in the bark of the stalk. The process of transforming ramie fibre into fabric is similar to producing linen from flax. The fibre is very fine and silk-like, naturally white in colour and has a high lustre. Ramie is a term that is appearing with increased frequency in the labelling of sweaters and some linen-look textiles.

Like linen and cotton, ramie has poor resiliency and wrinkles easily. Application of wrinkle-resistant finishes or blending with synthetic fibres can reduce the problem in woven fabrics. Because of its high absorbency, ramie is comfortable to wear, especially during warm weather. Other properties include resistance to alkalis, rotting, light and mildew. Resistance to insects is good unless the fabric is heavily starched. Ramie is not harmed by mild acids but can be damaged by concentrated acids. The fibre has some natural stain-resisting ability with ease of stain/soil removal similar to that of linen, which is better

than cotton. Dyes appear to have good wet-fastness in laundering but there can be a tendency for crocking in dark or saturated colours. Precautions such as wearing dress shields can reduce crocking problems. Dark colours may lose their vibrancy over repeated launderings.

5.4 Cultivation and harvesting

5.4.1 Cultivation

Ramie is easy to cultivate and thrives in almost any soil but grows best on open type, and rich warm sandy soils that are very well drained. Also suitable are soils of volcanic origin, including pumaceous types and friable sandy loams. It can be propagated by seeds, cuttings or layers, or by root separation. Ramie is intolerant of wet soils. It does best in areas with high temperatures and high humidity plus a rainfall of 1100 cm evenly distributed throughout the year. Sudden changes of weather result in irregularities of growth and these have a tendency to produce plants that vary in strength. It tolerates a pH in the range 4.3 to 7.3 but prefers slightly acid soil conditions. Calcareous soils are totally unsuitable despite the high demand of ramie for calcium. This is a very greedy plant and can soon impoverish a soil. All plant remains, after the fibre has been removed, should be returned to the soil or organic or inorganic fertilisers should be added. The plant can be grown from seed or layers but it is generally propagated vegetatively, using rhizome or stem cuttings. Production begins to decline once roots become overcrowded. Roots suffering overcrowding require thinning out or the area must be replanted.

The following characteristics of the ramie crop would influence its suitability in farming systems:

- it is a perennial crop with a life of 6 to 20 years.
- it is capable of producing high yields of biomass and if the harvesting system involves total removal of this biomass, there would be a rapid decline in soil fertility.
- Ramie is subject to a number of pests and diseases, including nematodes.

5.4.2 Harvesting

Two to four harvests per year are possible depending upon the climate but under good growing conditions ramie can be harvested up to six times per year. It is harvested as the stems turn brown. Harvesting is done just before or soon after the onset of flowering, since there is a decline in plant growth at this stage and maximum fibre content is achieved. The timing of the harvest of a particular stem is important as fibre yields are reduced if it is immature. Also there are difficulties in removing the fibre from the stem if it is over-mature. According to Buchanan, it is best harvested as the female flowers open.[5] The outer bark is

Figure 5.2 Mechanical harvester for bast fibres developed by the Institute of Natural Fibres, Poznan, Poland.

removed and then the fibrous inner bark is taken off and boiled before being woven into thread.[6]

Stems are harvested by cutting just above the lateral roots or the stem can be bent, to enable the core to be broken and the cortex can then be stripped from the plant *in situ*. Mechanical harvesters have been developed but are not used commercially (Fig. 5.2). After harvesting, stems are decorticated whilst the plants are fresh as the bark gets harder to remove as the plant dries out. The bark ribbons are dried as quickly as possible to prevent attack by bacteria or fungi.

5.4.3 Crop and fibre yields

The dry weight of harvested stem from both tropical and temperate crops ranges from about 3.4 to 4.5 t/ha/year; a 4.5 tonne crop yields about 1,600 kg/ha/year of dry un-degummed fibre. The weight loss during degumming can be up to 25% giving a yield of degummed fibre of about 1,200 kg/ha/year.

5.5 Primary processing

Ramie's fibres are found in the bark of the stalk. The process of transforming ramie fibre into fabric is similar to producing linen from flax. The fibre is very fine and silk-like, naturally white in colour and has a high lustre. Ramie is a term that is appearing with increased frequency in the labelling of sweaters and some linen-look textiles. After soaking the stems in water for a few hours, the inner fibre is stripped away from the skin using a blunt knife or something similar. Having dried the fibre in the shade, it is then split into narrow strips with the

fingernails, whilst occasionally wetting the fingers. According to some authors the extraction process of the fibre bundles is carried out in two stages: firstly, the cortex, comprising the bast and outer bark, is removed from the stem; this is sometimes called decortication and can be done by hand or machine. Secondly, this cortex is scraped to remove most of outer bark, the parenchyma in the bast and some of the gums and pectins. Extraction of the bundles is followed by washing, drying and degumming before the ultimate, spinnable, fibres are obtained.

5.5.1 Stripping

Stripping consists of removing all the phloem (including the fibres), some parenchyma and some outer bark (epidermis in young plants, periderm in mature plants). The resulting strips are often referred to as *China grass*. Hand stripping is always carried out on fresh stems and is said to yield better quality fibre than that produced by decorticating dry stems.[7,8] Some authors affirm that hand stripping gives higher yields of fibre than mechanical ribboning; hand stripping is a slow, laborious process and is economic only where cheap labour is plentiful. According to Dempsey[9] stems are cut before stripping, in the Chinese method[10,11] uncut stems are stripped.

The harvester removes the cortex containing the fibre from the fresh stems as a strip by gripping the growing stem and bending it over to the right; its woody core fractures about 23 cm above ground level. Then, whilst still pressing the stem downwards, he moves it over to the left, fracturing the woody core again. He then inserts his finger into one side of the stem between the core and bast, and runs it upwards, separating the top half of the bast from the stem and breaking off the small branches in the process; he then run his finger down to the butt (root) end where the strip is easily broken off. The process is repeated on the other half of the stem, thus two green strips are removed from each stem.

Bark and parenchyma are removed from the strips by pulling them between a scraper and a bed plate held in the same hand. The bed plate is a strip of bamboo about 13 mm thick, 16 mm wide and 60 mm long; it is held by the thumb through a metal ring, which is securely anchored to the bamboo. The bamboo lies between the thumb and forefinger with its long axis along the thumb. The scraper has blunt edges and is similar in shape to a shoe horn; the narrow end is held between the forefinger and middle fingers with the concave side towards the harvester and the long axis lying along the long axis of the bamboo. The harvester holds a strip in his other hand, by its butt end, and places it under the scraper as close as possible to the butt. In one swift movement, which is usually sufficient to scrape the strip from within 15 cm of the butt to the tip, he pulls the strip under the scraper. The strip is then reversed and the butt end is scraped. The process is quick and it is rarely necessary to give more than two scrapes in either direction.[12]

5.5.2 Ribboning

Ribboning consists of removing the outer bark/epidermis and the bast from the woody core of the stem; in fact the entire cortex is removed. Ribbons thus contain more of the outer parts of the stem than strips. To remove the ribbons, the stems are usually fed between longitudinally fluted rollers which crush the woody core and knock any wood fragments out of the bast. However, ribbons may also be obtained by using a modified decorticator in which the core is removed from the stem by the action of a moving drum; but it is still essential first to pass the stems through crushing rollers.[13] A simple ribboning machine with only one set of rubber rollers which crush the stem is also effective. Possibly the rollers distort and envelop the stem, and thus subject its circumference to differences in the peripheral speeds of the rollers over the area of the distortion; this could cause the bast and outer bark to be detached from the stem.[14]

5.5.3 Decortication

Decorticated fibre consists of bundles of phloem fibres still bonded together and parenchymatous cells. Recently, the most promising way of decorticating ramie is mechanical. This is carried out on either fresh green stems or dry stems. Dry decortication is said to be quicker and need not be confined to the harvesting season, thus reducing the number of decorticators needed. However, decortication of fresh stems is said to produce a better quality fibre.[15,16] Although various mechanical decorticators are available they are usually built on the principle of subjecting the stem to a succession of blows to break up the woody core. The stem is held against a rotating drum fitted with blunt blades, which pass over a fixed plate leaving only a restricted clearance. The edge of the

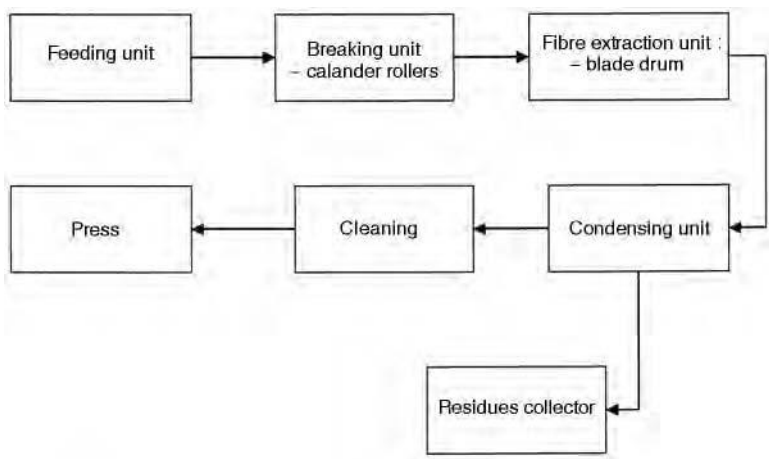

Figure 5.3 Schematic diagram of decortication line.

plate supports the stems with their long axis lying along the radial axis of the drum. The stems are fed into the drum where the high velocity blades disintegrate them, causing the fibre to separate, fan out and bend down into the restricted space between the blades and fixed plate. The blades then scrape away the epidermal, parenchymatous and woody tissues from the fibre; much of this is removed between the blades and fixed plate, but the fibre tends to travel around the drum where the licking action of the blades cleans it further.

Decorticators developed for ramie include small mobile types suitable for use in the field and larger machines designed for central operation. Use of decorticators in the field saves the cost of transporting unwanted plant material to a central decorticator and allows the plant waste to be quickly returned to the soil. Decorticators vary in complexity. The simplest and cheapest is the raspador; this consists of a covered drum on a stand.[17] Some decorticators are fitted with a conveyor system for the stems, and the most complex and most expensive are the large cross-feed machines.

5.5.4 Washing and drying

Washing of fibre from fresh stems during or immediately after decortication has been shown to remove water-soluble gums which reduces the dry weight of the fibre by 8%.[18] This reduces transport costs to the degumming site. The extracted fibrous material, after washing, should be immediately dried or degummed to prevent the development of mildew. Degumming of fresh ribbons prevents loss in fibre value caused by mildew which develops in slowly or incompletely dried fibre. Kundu[19] has shown that immediate drying is advisable since dried fibre is 10–15% stronger than undried fibre and also it is unlikely that, in the producing countries, the wet fibre could be delivered to the degumming plant before it begins to deteriorate.

5.5.5 Degumming

Raw ramie fibre produced either by hand scraping or decortication contains a fairly large percentage of gums and non-fibrous cells, or parenchyma (30–35%). These gums and cells are, for the most part, insoluble in water and must be removed before the fibre can be mechanically spun to fine count yarns. These gums are composed principally of arabans and xylans which are readily soluble in alkaline solutions. Many chemical degumming processes have been developed for ramie over the years. These all follow a similar pattern, consisting of the following basic steps:

- boiling of the fibre one or more times in an aqueous alkaline solution with or without pressure and agitation, and with or without penetrants or reducing agents

- washing with water and neutralizing
- bleaching with dilute hypochlorites or hydrogen peroxide
- washing with water and neutralizing
- oiling with a sulphonated hydrocarbon.

These steps may be carried out on the undried or dried fibre although Hoefer's[20] findings indicate the latter is preferable. Most of the processes involve a treatment with caustic soda to dissolve the residual pectins and gums. (A detailed recipe and description of a degumming process is set out in Appendix A.)

Although ramie fibres are usually degummed chemically, there have been promising developments in microbial degumming (retting). Additionally, some researchers report that the use of ultrasonic vibrations speeds up the degumming process. The undegummed fibre can be used as a jute substitute.[21] None of the methods used for the removal of the gum are entirely satisfactory because none achieve complete uniform degumming and most are covered by patents. Infrequent attempts have been made from time to time to devise microbial methods for degumming but it does not appear that micro-organisms are in common use for this purpose. The feasibility of a combination of microbial and chemical processes has also been investigated. Enzymatic treatment also seems to be promising.

5.5.6 Microbial degumming (retting)

This degumming method appears to be still at the experimental stage since no reports were found in the literature of it being used on a commercial scale. This method consists in the utilisation of several mixed bacterial cultures isolated from different sources. Each culture, containing several species of bacteria, is grown in association with others. The experiments with four of these cultures show promising results (see Table 5.4).[22] These researches indicate that attempts to separate individual organisms for isolation and identification failed, since they do not grow separately, probably owing to their dependence on the metabolic products of other organisms in the mixed culture for nutrition and growth.

Microbial degumming with mixed bacterial cultures is thus a good alternative to chemical degumming, as this process involves several treatments to obtain good-quality fibres. The mixed degumming method is simple and economical in that less alkali is required, the treatment is less drastic, and such fibre properties

Table 5.4 Bacterial cultures for degumming

Mixed-bacterial culture	Isolated from rhizosphere of
R_{IV}	Ramie (*Boehmeria nivea Gaud*)
SW1	Sunn fibre (*Crotalaria juncea Linn*)
Di and DII	Dhaincha (*Sesbania aculeata Pers*)

as softness, feel, and lustre are also much improved. The combined microbial and chemical method is also simpler and more economical. We must remember that the development of a commercial degumming process will require considerable development work since the temperature of the process and the quantities and concentration of chemicals in the liquor govern the fibre yield and strength, and also because the requirements for degumming fibre of different origins vary.

5.5.7 Chemical degumming

In the process of chemical degumming, hot alkali is used to dissolve the pectic substances which bind the ultimate fibres into bundles. Details of the degumming processes tend to be regarded as confidential information by the ramie mills concerned. According to some authors commercial degumming with sodium hydroxide, sometimes mixed with sodium carbonate is preferred on economic grounds. The main factors which affect the efficiency and economics of chemical degumming are:

- the concentration
- pH
- ratio of mass of liquor to mass of fibre
- the duration of degumming
- the freedom with which the alkaline liquor circulates through the fibre.

Degumming can be carried out both below ('low temperature') and above ('high temperature') atmospheric pressure; during the latter the yield of degummed fibre tends to be low (about 75% on washed decorticated fibre). This is because at temperatures above boiling point not only the pectic substances and adhering epidermal tissues are removed, but also hemicelluloses and sometimes some of the true cellulose.[23]

Two further aspects require consideration if chemically degummed fibre is to be suitable for spinning. Firstly, care must be taken to avoid tangling of the fibre during degumming and subsequent washing, especially if much mechanical agitation is used. Secondly, thorough washing after degumming is very important. Most of the published chemical degumming methods use water as either the sole or the final washing agent.

5.5.8 Further processing

Bleaching

After degumming process the degummed fibre, or filasse, is fairly white; if pure white fibres are required the filasse must be bleached. In the past the fibre was bleached before being made into yarn or cloth but nowadays it may be possible

to bleach cloth. Bleaching results in a small loss of weight and of fibre strength[24] and it should therefore be carried out only when absolutely necessary.

Softening

Since degummed fibres may be stiff, harsh and dry, and not completely separated, they need to be softened before spinning by the application of a suitable agent, for example, glycerine, oil, fat, soap, paraffin, wax or tallow, and left for some time to condition. The fibres can be further softened and separated by passing them through a series of paired fluted rollers and then through a pair of smooth rollers; if necessary, they can be passed through these several times.[25]

5.5.9 Fibre classification

According to J. B. Pears[26] the oldest qualification criterion has been established in China. It consists of eight grades:

1. *Piao-chuang* – best quality fibre of length up to 150 cm
2. *Tsu-piao* – same length as above but less delicate
3. *Tow-chuang* (Tow-tze) – first class, length up to 135 cm
4. *Er-chuang* (Er-tze) – second class, length 120 cm
5. *San-chuang* (san-tze) – third class, fibre length 105 cm
6. *Pai-chuang* – fibre length 60 cm
7. *Tsuo chuang* – same length as above but lower quality
8. *Chiao-chuang* – fibre length 45 cm.

Since 1954 in China a new qualification criterion is in force. This is shown in Table 5.5.

5.6 Spinning

Ramie is spun both by hand and on industrial equipment

5.6.1 Hand spinning

This is done on spinning wheels. It takes a great deal of patience and experience to be able to produce a yarn of an even thickness and consequently most of the people doing this arduous work are women in their eighties.

5.6.2 Industrial spinning

This is a multi-stage process which consists of the usual three basic steps of carding, drawing, and spinning. Ramie may be combed and spun by several methods. The finest yarns are produced on the spun silk system developed by the

Table 5.5 China: new classification of ramie fibres

Grade	Fibre length in cm	Fibre colour		Fibre softness	Fibre purification after decortication	Fibre faults
		Green non-bleached fibre	White bleached fibre			
Extra	Over 150	Green or green with white shade of high gloss	White or white with light yellow shade of high gloss	Soft with high resilience	Good	Insignificant
I	Over 120	Green or green with white or yellow shade of high gloss	White or white with yellow shade of high gloss	Soft with high resilience	Good	Very small
II	Over 90	Green or green with white or tanned shade of gloss	White or white with yellow shade of gloss	Soft with medium resilience	Acceptable	Small
III	Over 60	Green or green with white or tanned shade of small gloss	Wgite or white with yellow or tanned shade of small gloss	Medium soft with lower resilience	Unacceptable	Little
IV	Over 40	Green or green with white or tanned shade of indistinctly gloss	White or white with yellow or tanned shade of indistinctly gloss	Low softness and resilience	Insufficient	Visible

Japanese, but this system is labour intensive. In Europe, Brazil and the Philippines, some modifications are made. This produces coarser count yarn but much less labour is required. Ramie may also be spun on the worsted and long draft cotton systems, but in the latter case stapled noils are used and usually blended with cotton or synthetic fibres. Since ramie fibre is relatively coarse in comparison with cotton, it is never spun into fine count yarns on the cotton system. It is apparent that the main difficulty in spinning ramie results from the combination of high tensile strength with the long fibre length; the breaker cards cannot break the fibre into staple lengths suitable for subsequent spinning. Therefore it is usually necessary to pass the fibre through a stapling machine. This breaks rather than cuts the fibre into the staple lengths required. The advantages claimed for this method of stapling include reduced fibre loss, easier spinning resulting from the more uniform length within a given staple, and smoother yarn resulting from feathered as opposed to blunt ends.

5.7 Weaving and finishing

The weaving of ramie yarn does not pose any problem and all kinds of linen and cotton looms are used for this purpose. Ramie can be top, yarn or piece dyed and its dyeing properties are similar to those of linen and cotton. Very rich in cellulose, ramie remains snow white after exposure to the sun. Textiles woven from ramie yarn show excellent wearing properties and cover a vast range, from very fine shirtings to heavy uniform suitings.

5.8 Applications of ramie

5.8.1 Strengths

Ramie is recognised in the clothing industry as a premium, high quality product.

5.8.2 Weaknesses

- Ramie fibre is subject to strong competition from cotton and synthetic fibres.
- The fibre is high cost which reduces its competitiveness against other textile fibres.
- The lack of ready supplies of satisfactory quality fibre has discouraged the industrial sector from promoting the crop.
- There is a traditionally high labour requirement for production, harvesting and decortication.
- There is a need to degum the fibre prior to processing.
- The high demand for nutrients and the consequent decline in soil fertility would require special attention to crop rotation.
- Many alternative crops can be expected to be more profitable.

Opportunities

There appears to be a small niche market for the textile fibre and improved cultivars are available from China, Argentina and India. Planting and harvesting can be mechanised and would greatly reduce labour requirements and the cost of production and processing. Improved processing procedures are available to further improve the economics of fibre production.

5.8.3 Textile applications

Blends are more common than pure ramie with the most typical being 55% ramie/45% cotton. The uneven linen-like texture is generally apparent in the blend, but the lustre is lost. Blends are readily available in woven and sweater knit form. When polyester and other man-made materials are included in the blend, wrinkle resistance is improved and help provide easy care and shrinkage control. When used in mixtures with wool, shrinkage is reported to be greatly reduced when compared with pure wool.

Advantages and disadvantages of ramie as a fabric

- Advantages: resistant to bacteria, mildew, and insect attack. Extremely absorbent. Dyes fairly easily. Increases in strength when wet. Withstands high water temperatures during laundering. Smooth lustrous appearance improves with washing. Keeps its shape and does not shrink. Can be bleached.
- Disadvantages: low in elasticity, lacks resiliency, low abrasion resistance, wrinkles easily, stiff and brittle.

5.9 Conclusion

Ramie fibre is acknowledged as a high quality fibre but its production mainly in developing countries is labour intensive and unlikely to be economic under current conditions. The need for biochemical, chemical or enzymatic treatment to extract the fibre has also been seen as a serious disadvantage. Also the fact that most of the well-equipped research centres in Europe and North America do not include ramie in their fields of interest, with the exception of Italy,[9] is another major disadvantage. However, experience with many other newly introduced crops has shown that all aspects of production and processing can now be mechanised and improved, and that could make growing this fibre competitive with production from traditional growing areas.

The potential for production of ramie and the likely demand for this high-quality fibre would appear to warrant a more detailed assessment of the opportunities. This assessment would need to establish the level and value of

current imports of fibre and fabric and seek to establish likely future demand. It would also be important to identify the potential growing areas and assess the likely profitability of ramie production relative to current crops. Such assessments would need to examine the prospects and costs of mechanising all aspects of production and processing.

There is also, bearing in mind new research targets especially concerned with influences on the physiological states of the human body, an opportunity to bring to light new properties of ramie. This may help to find new applications in the apparel sector of the textile industry. Also, the growing interest in the use of natural fibres as reinforcement in composite materials may also provide a new application for ramie.

5.10 Appendices

Appendix A: Degumming, recipe and process

1. Treat the decorticated ribbons for one hour under 6 kg/square cm. pressure at 160 ºC with a liquor to dry fibre weight ratio of 6 : 1. Composition of liquor:
   - 6% sodium hydroxide
   - 3% sodium sulphite
   - 3% sodium tripolyphosphate
   - 3% organo-phosphate wetting agent.
2. Wash with water.
3. Repeat 1. above with a fresh supply of liquor.
4. Wash with water.
5. If required, bleach for one hour with hydrogen peroxide 1% at 83 ºC, pH9.
6. Rinse in a dilute solution of acetic acid in water.
7. Apply an oil emulsion such as sulphonated hydrocarbon, between 3% and 4% on dry fibre weight.
8. Remove excess emulsion (by calendering).

(Source: M. Petruszka. FAO Rome May 1977 ref w/K6485.)

Appendix B: Non-textile uses of ramie

The fibre is also used for making paper.[27] The leaves are removed from the stems, the stems are steamed and the fibres stripped off. The fibres are cooked for two hours with lye, fresh material might require longer cooking, and they are then beaten in a Hollander beater before being made into paper. Short fibres from processing wastes are used for the production of high quality papers, such as banknotes and cigarette papers. Pulping trials conducted in the USA rated ramie as among the best of the potential pulp sources.

Medicinal uses: antiphlogistic, astringent, demulcent, diuretic, febrifuge, haemostatic, resolvent, vulnerary and women's complaints. Used to prevent miscarriages and promote the drainage of pus.[28,29] The leaves are astringent and resolvent,[30,31] They are used in the treatment of fluxes and wounds. The root is antiabortifacient, cooling, demulcent, diuretic, resolvent and uterosedative.

Other uses: the ramie plant, grown mainly as a fibre crop, is also a source of nutritious green feed. The leaves and tops, unlike the stems, have low fibre content and are rich in protein, minerals, lysine and carotene. The nutritive value of ramie has been described as similar to that of lucerne, which it can, however, greatly outyield. When ramie is grown for fodder up to fourteen cuttings a year can be taken from established crops, yielding as much as 300 t of fresh material (42 t dry matter) per hectare per year.

The foliage is palatable and has proved to be of value not only to stock but also to pigs and poultry. Ramie can be grazed, used for silage, ensiled together with molasses or artificially dried for leaf meal. Ramie is palatable to all classes of domestic livestock and is an excellent feed for cattle. As long as satisfactory mineral levels are achieved, ramie can be fed to pigs of all ages and acceptable production obtained. Ramie meal has proved valuable to poultry as a source of carotenoids and riboflavin. The only problem associated with feeding ramie is its high mineral uptake, especially molybdenum on soils rich in this element; this can be corrected by adding appropriate levels of copper sulphate to the diet. When root-peeled and boiled it has a pleasant and sweet taste.[32] One can detect very little flavour, but the root has a very strange mucilaginous texture that does not appeal to most people who have tried it.[33] Once in the mouth it takes a lot of chewing before it is ready to be swallowed. Ramie takes up phosphorus, so it is potentially useful for use in cleaning up the Everglades, as this region suffers from a nutrient overload from the sugar industry.

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5.13 Glossary of terms

Boehmeria nivea Latin name for ramie. *See* China-grass.

China-grass White ramie – *Boehmeria nivea*, of Chinese origin as opposed to ramie, or green ramie – *Boehmeria nivea, var tenaccissima*, of Malay origin.

Crocking Dye rubbing off a fabric, usually due to inadequate dyeing.

Decortification Removing non-fibrous material from retted stalks or from ribbons or strips of bast or leaf fibres.

Green ramie *See* China-grass.

Noil The shorter fibres separated from the longer fibres in combing during the preparatory process before spinning.

Ribbonning Separating the outer bark/epidermis from the rest of the stalk.

Stripping Removing strips of bast fibres from the stalks of the plants.

White ramie *See China-grass.*