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Hemp

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[*Editor's note*: Unlike the chapters in this book on the other fibres, this chapter is divided into two parts. The first is a detailed study of traditional hemp production in Hungary, one of the few countries in Europe that is still growing hemp and manufacturing it into textile products, and the second is a general account of the present situation of the fibre and of current developments which, if they are successful, may lead to a marked improvement of the present prospects of the fibre.]

PART 1

4.1 Introduction: hemp in Hungary

Hemp was first mentioned in chronicles of the 12th century, after the Hungarian settlement of the Carpathian Basin. In 1198 the customs tariff of Esztergom enumerates numerous plants including hemp and flax. Another record mentions that the owner of a cart carrying hemp or flax had to pay four bundles of hemp or flax as duty and according to other records dated 1309 a 42 acre hemp field was required for every 57 acres of land held in villeinage.

In the Middle Ages hemp processing, spinning and weaving were quite common and this work was an intrinsic part of the villeins' feudal obligations. According to a document dated 1324, of the 17 industries listed in Hungary, spinning and weaving seem to have been the most important.

It is evident that in the life of the Hungarian people hemp has a history of a thousand years, and knowledge of the growing and processing of hemp was already well established when they settled in the Carpathian Basin. According to established practice flax was used to make finer, thinner fabrics whilst hemp was used to make harder-wearing fabrics. Hemp served other requirements as well and rope, twine, bags, tarpaulins, etc., were produced for agricultural and other purposes.

On small farms and later on large estates hemp was essential. On the estates the first machines that were operated by mobile steam engines replaced manual tools and these engines were fuelled by hemp hurds. In this way hemp process waste was used to generate energy for the machines. Gradually the demand for hemp products grew and production increased to satisfy these wider markets. Hemp followed the economic and social changes of this lengthy period; it was part of the industrialisation of the country and it formed the basis of its textile industry.

The city of Szeged played an important role in the development of the Hungarian hemp industry. With the help of its natural waterway, the Tisza, Szeged – an extensive stockbreeding centre – became one of the biggest collecting and distributive markets in the southern part of the country. According to medieval sources, agricultural products, livestock and industrial products from distant regions were sold in large and busy fairs. The city was not only a trading centre but also an important staging post for traffic to Italy, the Balkans and the East and the traveller of the time could find a relatively well-developed guild life within its walls. In 1522 the tithe register of the Diocese of Bács lists 291 independent tradesmen, two of them being ropemakers. After gradually expelling the Turks from the country the fight for freedom against the Habsburgs prevented the economy from developing and this situation improved only in the middle of the 18th century. The prosperity of the economy was greatly helped by settled German craftsmanship and the guilds of the city flourished. The development of shipping on the river Tisza (especially transporting wheat and other agricultural products) stimulated the shipbuilding industry, heavy canvas and rope manufacture. The rope manufacturers of Szeged received their first charter of incorporation from Maria Theresa on 20 May 1743.

The processing of hemp and manufacturing was done in small guilds that could be found especially in the southern cities of the country. At this time 'factory size' hemp processing did not exist and only in the last two decades of the 18th century do we find three 'factory sized rope-walks'. All three were situated on the coast at Fume, in present Croatia.

The raw material for the numerous little guilds was mainly supplied from abroad as the limited production of hemp from the small farms was not sufficient to satisfy the 'hungry' industry's requirements. The local authorities in the country became aware of this situation and took important steps to develop hemp processing; in other words, it became essential that hemp processing develop into a manufacturing industry. A survey was made in order to establish which areas were most suitable for the cultivation of hemp and flax and 20 tonnes of high fibre yield seed was bought from Italy. Peasants from Bologna, who had several decades of experience in the growing and processing of hemp, were settled in the southern part of the country. In 1865 Count Rezso Chotek founded the first hemp factory in Hungary in Futak-Ojvidik (today Novi-Sad, in present Yugoslavia). This plant included scutching and other primary processing of the hemp. Following the establishment of this factory others (spinning, weaving, ropewalks, etc.) sprang up like mushrooms.

This industrial processing of hemp was the consequence of the modernisation of the more than 100 years old rope-laying guilds and of the expansion of the range of products and the mechanisation of production that was of revolutionary importance at this time. Examples of these developments were the predecessor of Elso Magyar Kenderfonó Rt. in Szeged, the rope making factory of Nandor Bakay in 1877 and in 1888, also in Szeged, Elso Szegedi Kenderkikeszito Gyor Rt., (this company is now well known as Heavytex Újszegedi Szövo Rt.).

By 1878, 93,500 ha of hemp were cultivated. Production increased and by the beginning of the 20th century Hungary was an important producer. Production continued to increase until 1940 and from booklets advising on the cultivation of hemp we learn that several hundred factories of various sizes processed the enormous hemp crop of Bácska (formerly part of Southern Hungary) at the beginning of the 1940s, where annual production reached between 40,000 and 50,000 tonnes. After the Second World War hemp processing mills and 34 smaller fibre processing plants were taken into public ownership; at that time 31,000 farms were growing hemp.

Hemp, as an agricultural crop in the Hungarian economy, has stood the test of time and as the basis of an industry has been an important factor in the industrialisation of the country. Bast fibres (hemp and flax) were, apart from local wool, the only textile raw materials which did not need to be imported. They were a major source of industrial raw materials which were not imported and which never received any state subsidy. Hemp provided a living for nearly 20,000 people in agriculture and the bast fibre industry.

Today the situation is different. Hemp has lost its former competitiveness in the economic growth of the country and in the world. Its environmentally friendly characteristics, excellent agricultural potential, the present under-exploitation of arable land, together with a new policy of restoration and subsidy and more vigorous lobbying, might improve hemp's role in the national economy. There are only a few countries in Europe that can provide 100% of their raw material for a sector of industry from within their own borders.

4.2 Hemp varieties and their cultivation

Hemp belongs to the Mulberry family (Moracea) and cultivated hemp varieties belong to the *Cannabis sativa* species. These hemp varieties can be very different in height and leafage, for example. They are usually named after their country of origin so that we have Italian, Turkish, Chinese, Indian, etc., hemp. Two hemp types have developed under the influence of climatic conditions, northern and southern types. As far as fibre yield is concerned the southern type is more important and is the most common type in Hungary. Hemp is an annual plant, its growing season is from the middle of April to the middle of September. The plant can be monoecious or dioecious. The dioecious variety is more common in Hungary.

The cross-section of a hemp stalk is nearly orbicular at the foot and angular higher up. The stalks are normally 4–10 mm thick with a height of 1.5–2.5 m. If the stalk reaches a height of 3–4 m its cross-section at the base can be as much as 20–25 mm. Similarly to flax the bast layer (phloem) of the stalk contains the valuable textile fibres. The fibre bundles form several layers in the bast and the bundles contain few unit cells. At the foot of the stalk the number of bundles increases so as to improve the stability of the plant.

4.2.1 Hemp varieties

Attempts to improve Hungarian hemp varieties were carried out in the 1930s and these trials were continued after the Second World War. The research centres in Kompolti and Szeged achieved major results. Later research work was completed in Szeged in 1970. 'F' Hemp, improved in the 1930s, was used as the basis for the research work. The aim of these researches was both to increase the yield of fibre per hectare and to maintain the fineness and strength of the fibres. ('F' hemp was named after Rudolf Fleisman, who developed this variety.)

The varieties resulting from this development work are listed below.

1. *Kompolti* (1954).
   Improved from 'F' hemp by selection.
   Southern type, dioecious.
   Growth period (fibre hemp) 110–115 days.
   Stalk yield: 11–12 tons/ha.
   Fibre yield: 31–35%.
   Developed by Iván Bocsá and partners.
2. *Unikó* – B (1965).
   Improved by crossing *Kompolti* (dioecious) and *Fibrimon* (monoecious).
   Southern type, if sown for fibre ratio of pistillate plants is higher (5% male 95% pistillate).
   Growth period: 105 days.
   Stalk yield: 10–11 tons/ha.
   Fibre yield: 29–31%.
   Developed by Iván Bocsá.
3. *Kompolti* (yellow stalk) (1974–1980).
   Improved by repeated back-crossing *Kompolti* and mutant types.
   Growth period: 100–105 days.
   Southern type, dioecious.
   Stalk yield: 7–8 tons/ha.
   Fibre yield less than that of green hemp.

4. *Kompolti* hybrid TC (1983).
   Improved by crossing Chinese dioecious, Chinese Unisex SC and *Kompolti* varieties.
   Light green hybrid, ratio of pistillates is high.
   Growth period: 115–118 days.
   Southern type, dioecious.
   Stalk yield 13 ton/ha.
   Fibre yield: 28–30%.
   Developed by Iván Bocsa and partners.
5. *Fibrikó* TC (1989).
   Improved by crossing Chinese dioecious, Chinese Unisex SC and *Kompolti* yellow hemp varieties.
   Colour of stalk is green.
   Growth period: 100–105 days.
   Southern type, dioecious.
   Stalk yield: 11–12 tons/ha.
   Fibre yield: 32–35%.
   Developed by Iván Bocsá and partners.
6. *Tiborcszallas* (2000).
   Southern type, dioecious, dark green, early type.
   Growth period: 95–100 days.
   Stalk production: 10–11 tons/ha.
   Southern type, dioecious.
   Fibre yield: 25–30%.
   Developed by Dr Antal Gyorgy.

All varieties except *Kompolti* (yellow stalk) have green stalks. The above hemp varieties all have some common characteristics. Those varieties that show an increase in stalk yield per hectare also show a decrease in fibre fineness and fibre strength. It is important to weigh these advantages and disadvantages in order to achieve the optimal balance between quantity and quality. There are also other factors to take into account when considering the production of dioecious as opposed to monoecious plants. The advantage of the higher yield of dioecious hemp is considerably weakened by the greater damage that the male plants suffer during reprocessing, and especially during chemical defoliation. Although the yield of monoecious hemp is lower, its stalk production is more even and healthier and its fibre quality is better.

Variety developers endeavour to take these factors into consideration. The first step is to produce seed for the production of fibre hemp. Good hemp seed yield is obtained on soil rich in nitrogen. Currently considerable quantities are produced in the Szabolcs–Szatmar-Bereg area of Hungary. In Hungary hemp seeds are usually planted in April with a seed density of 60 to 80 kg/ha. Fertilising is applied at the following rate.

N 80–110 kg/Ha
P.202 0–50 kg/Ha
K.20 50–200 kg/Ha

More than 110 kg/Ha of nitrogen increases the yield but decreases fibre quality. If available, farmyard manure and stable litter are preferable to chemical fertilisers.

Depending on material conditions during growth, harvesting usually takes place about 100 days after planting, at the flowering of the male plants. Usually male plants produce finer fibres than pistillate plants. Fibre yields per hectare of between 0.5 tonnes to 1.2 tonnes are considered to be satisfactory. This fairly wide variation depends on several factors, including the variety planted, weather conditions, the efficiency of the farmer and of the primary processing of the stalks. (Scutching: see 4.4 below.)

4.3 Physical and chemical characteristics of hemp

The fibre bundles are in several layers within the hemp stalks. A bundle consists of several fibres and bundles are connected by unit cells. The bundles in the inner layers are usually shorter and finer than those of the outer layers. The shape of unit cells ranges from triangular to heptagonal with rounded corners and a large pith. Unit cells are connected by lignified pectins and the basis of hemp processing lies in loosening and dissolving this bond.

The diameter of the unit cells is from 15 to 50 microns. The average length of the cells is 35–40 mm but it can vary from 5 to 100 mm. The length of fibre bundles is about 1500–2500 mm. The breaking strength of hemp fibre is a little higher than that of flax fibre; its elongation is low (2–3%). Its flexibility depends on the fineness of the bundle. The longer bundles require less twist during spinning. Although the elongation of the bundles is low their flexibility is high

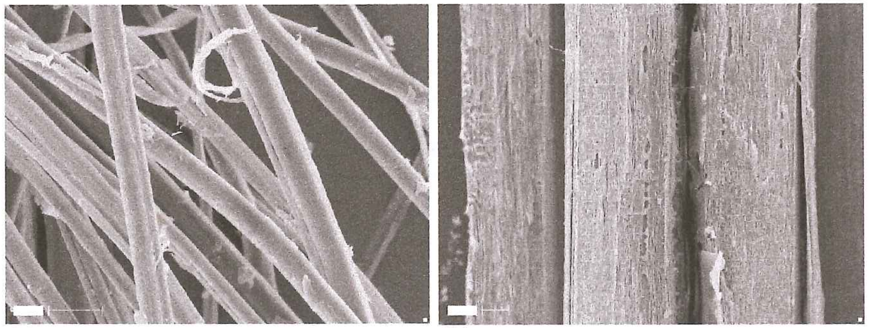
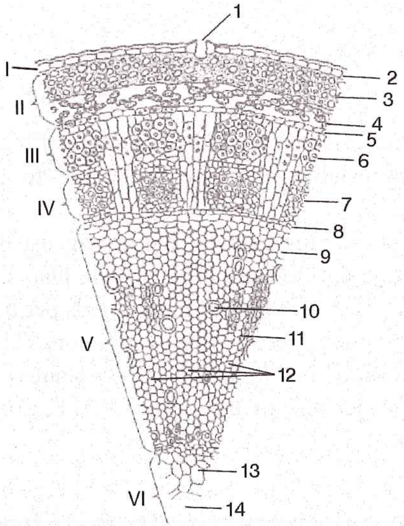

(a) (b)

Figure 4.1 Photomicrographs of (a) hemp stalks and (b) longitudinal section of hemp stalks. Source: DeMontfort University, 2004.



Rys. 1. The anatomical structure of hemp stem:
I - cuticle
II - prinary cortex
III - secondary cortex
IV - real bast
V - woody tissue
Vi - core
1 - stoma
2 - cuticle
3 - collenchyme
4 - primary cortex parenchyma
5 - mesderm
6 - primary fibre
7 - secondary fibre
8 - vegetable pulp
9 - wood parenchyma
10 - vessel
11 - woody fibre
12 - core gleam parenchyma
13 - core parenchyma
14 - core channel

Figure 4.2 The structure of hemp stalk. Source: Akademia Rolnicza im. Augusta Cieszkowskiego w Poznaniu.

and this can cause problems during spinning. Blending flax with hemp improves both the elongation and the flexibility of the yarns, which is low in 100% hemp yarns. However, these blends also decrease the strength of the yarn.

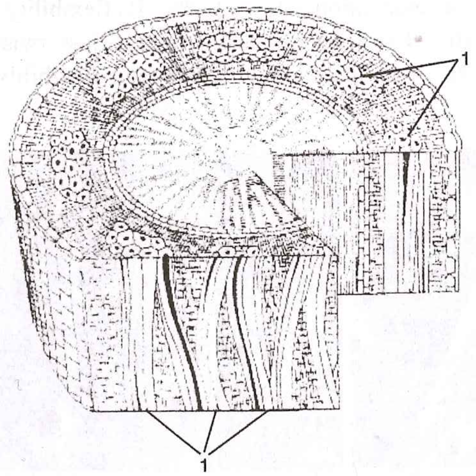


Figure 4.3 (a) Line drawing of cross- and longitudinal section of hemp stalk (1 = distribution of fibre bundles and joints between fibres by anastomosises). Source: PWRiL, Warsaw, Poland.

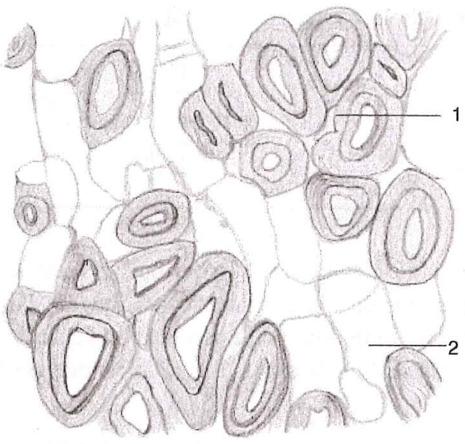


Figure 4.3 (b) cross-section through hemp fibres (1 = fibre bundle; 2 = cortical parenchyma). Source: Gesamtverband der Deutschen Versicherungswirtschaft. Courtesy: www.tis-gdv.de.

Due to the hygroscopicity of hemp its moisture regain is good and this has a favourable effect on all fibre processing. Moisture increases the turgidity of the fibre. Normally accepted fibre regain is 12%. In order to compare and describe the physical characteristics of hemp fibre bundles the following measurements are usual:

- length of fibre bundles
- weight of these bundles
- breaking strength of bundles (10 mm test length)
- drape of bundles: this is a measure of the flexibility of the fibres. A 'hand' of flax fibres 27 cm long is suspended at its middle and the distance between the ends is measured. This can vary between 2 and 10 cm. The shorter the distance the finer the fibres.
- torsional stiffness of bundles.

The fineness and degree of separation and spinnability, for example, are also used to describe hemp fibres.

The principal constituent of hemp fibre is cellulose, at about 77% of the total weight. The remainder consists of pectins, lignin, vegetable waxes and fats, various water-soluble substances and about 10% of hygroscopic water. As hemp is

Table 4.1 The chemical constituents of hemp fibre

Pectin/lignin	9.5%
Water soluble substances	2.1%
Vegetable wax and fat	0.6%
Mineral matter	0.8%
Hygroscopic water	10.0%
Cellulose	75.0%
Other	2.0%
	100%

Table 4.2 The physical characteristics of hemp fibre

Diameter	15–50 microns
Length	1500–2500 mm
Tenacity	40–70 N/Tex
Elongation at break	23%
Regain	12%

more lignified than flax its cellulose content is smaller but it is less sensitive to chemicals. It is resistant to bases and only strong acids can damage it. Hemp is less subject to rot than flax. Further information on the physical and chemical characteristics of hemp fibres can be found in the tables of the appendix to Chapter 1.

4.4 Primary processing of hemp stalks, fibre separation

The fibre yield of unretted hemp straw is about 25%. The yield of long fibre of unretted straw varies from 10% to 13% and of short fibre from 12% to 15% (see also Fig. 4.2). The retting, breaking and scutching of hemp is similar in principle to that of flax (Chapter 3) and the machinery and processes used are also similar. However, the greater length and thickness of the hemp stalk compared to that of flax needs to be taken into account and hemp processing machinery is generally larger and more robust.

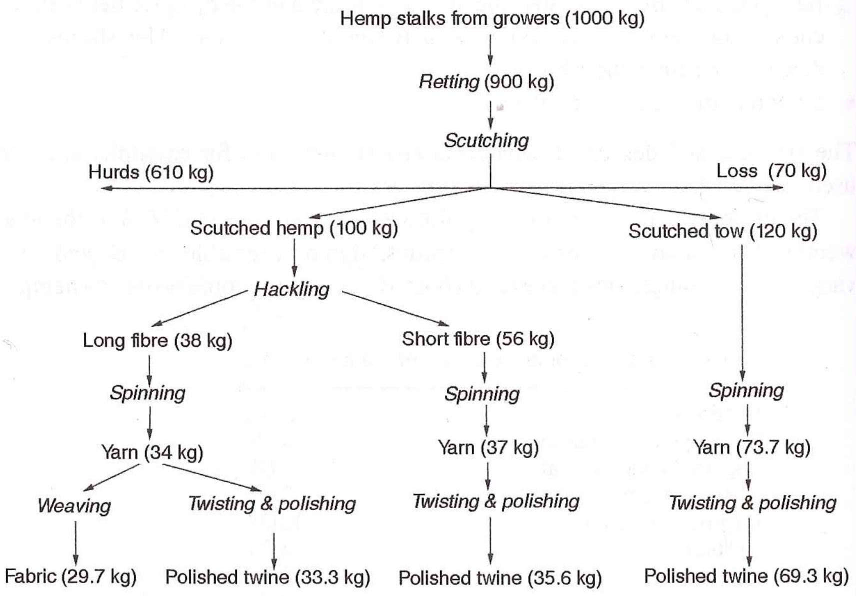


Figure 4.4 Hemp textile fibre production flowchart and yields.

The different technical and mechanical processes applied during primary processing produce scutched hemp (long fibres) and tow (short fibres) that are suitable for spinning. The residual product, hurds, is used for various non-textile purposes and particularly for animal litter. The purpose of primary processing is to separate the flexible bast fibres from the ligneous hurds as gently as possible or when necessary, using more powerful biological and mechanical processes. Naturally the application of these processes is determined by the economics involved:

- the quality of the hemp stalks; colour, length, diameter, etc.
- the required fibre yield and acceptable ratio of long and short fibres
- the quality of the fibres, colour, strength, fineness, cleanliness, etc.

Different technical and mechanical factors are taken into account as to which process should be chosen and which particular technology is chosen depends on the quality of the stalks. These are classed as follows.

1st class; water retted, used for finer yarns
2nd class; water retted, for medium count and thicker yarns
3rd class; unretted, fibres mechanically separated and used for blending or spinning coarse yarns.

Fibre separation may be done by using biological, mechanical or chemical methods or more usually a combination of retting, breaking and scutching.

Table 4.3 Yields during primary processing

Before retting	Raw hemp stalks	100%
After retting	Retted hemp stalks	90%
Mechanical processing	Hurds	61%
	Scutched hemp	10%
	Hemp tow	12%
	Waste	7%

4.4.1 Retting

Retting is a biological process that removes the pectic substances that bind the fibres to the other constituents of the hemp stalk. Retting precedes the mechanical separation (scutching) of the fibre from the stalk and is essential if fibre breakage during scutching is to be minimised. During retting the moisture content of the stalks is increased. This encourages the growth of certain bacteria and/or fungi which selectively attack and remove the pectic contents. There are two methods of retting, ground retting and water retting

Ground retting

In ground retting the stalks are laid in swathes on the ground as they are harvested. The combined action of dew and showers of rain provide the necessary conditions for the development of the micro-organisms on the stalks. Ground retting is effective if rainfall reaches 600 mm per month at harvest time.

Water retting

In water retting the necessary increase in moisture content is obtained by steeping bundles of stalks in concrete tanks containing water. Typical sizes of tank would be within the ranges of 50 m to 100 m in length, 5 to 10 m in width and 1 to 1.2 m in depth. The bundles of stalks are lifted into the tanks by mobile cranes and held beneath the surface of the water by wooden or iron frames which cover the tanks. The tanks are then filled with water. Both surface water from rivers, at temperatures of around 15 °C to 20 °C or from bore-holes from between 25 °C to 30 °C are used. The higher the temperature the shorter the retting period, at the lower temperatures retting typically takes seven to ten days but only five to six days at the higher temperatures. Naturally, meteorological conditions also affect the length of retting time and it is for this reason that in Hungary, for example, water retting is carried out only between April to October.

When retting is sufficiently advanced the stalks are gathered and stooked in the open fields so that they can dry. This stops the retting process and the stalks are then stacked in large ricks until they are required for further processing. These are thatched with bundles of hemp stalks to protect them from the weather. The advantage of ground retting over water retting is that it is more economical. The disadvantage is that the process is difficult to control and depends entirely on favourable meteorological conditions

4.4.2 Mechanical processing

The purpose of mechanical fibre separation, or decortication, is to separate the flexible fibres from the stiff and more brittle ligneous woody parts (called hurds) of the stalks. The entire operation is carried out in a 'scutching line' consisting of two pairs of scutching turbines and associated mechanisms which separate and remove shorter fibres (also used as a textile raw material), hurds, dust and earth and other waste matter from the long fibres.

Breaking

The stalks are delivered to the primary processing plant in bundles or 'sheaves'. The first step is to open these sheaves; the stalks are then either fed into vertical breaking rolls or placed on a conveyor which feeds them through several pairs of horizontal parallel breaking rolls. The first breaking operation consists of splitting the stalks down their lengths. This requires considerable mechanical force. The actual breaking process is done by the action of pairs of smooth and ribbed breaking rolls on the stalks. The weight and pressure of the smooth surface rolls splits the stalks lengthways and the ribbed rollers of gradually reduced pitches then transversally and progressively break the hurds into smaller and smaller pieces. Most of these separate from the fibre and fall through or out at the end of the machine before the start of the next operation. The hurds are collected and used for various purposes.

The effectiveness of the breaking process depends on the quality of the stalks.

- It is possible to use raw (unretted) healthy stalks. In this case the broken stalks contain more than 60% fibre but the end product is more suitable as a raw material for paper manufacture.
- Stalks of green fibre hemp that are thin and easily breakable, contain 50–55% fibre and the fibres produced are suitable for spinning.
- In the case of dew-retted hemp stalks further mechanical separation can produce fibre suitable for the long and short fibre spinning systems.
- Breaking is most effective when the stalks have previously been retted. (The proportion of hurds is diminished and fibre content is over 50%.)

Scutching

The principal purpose of scutching is to remove the hurds which still adhere to the fibres bundles. Also scutching further softens and affines the fibre bundles and removes lignin from the fibres. Scutching produces long ('line') fibre, short ('scutched tow') fibre, hurds and waste matter (dust, earth, etc.). In past times scutching was done by hand and this produced good-quality fibre. However, productivity was low and the process was therefore uneconomical; in due course it was replaced by mechanical (turbine) scutching.

In turbine scutching the broken stalks are fed into grippers that present the stalks, held vertically, between two scutching turbines, which are placed horizontally, parallel and close to each other. These turbines have three or four blades which, as the turbines rotate in opposite directions, beat the stalks and thus remove the hurds. A scutching line consists of two pairs of turbines, the grippers reversing the presentation of the stalks when passing from the first pair to the second thus ensuring that the whole stalk is scutched. (See also Chapter 3 Flax.)

The effectiveness of scutching is controlled by varying the speed of rotation of the turbines (peripheral speed) and the rate at which the stalks proceed through the two pairs of turbines. Turbine scutching produces fibres whose quality is the average of the batch being processed. It does not enable any selection of fibres of different quality.

Hemp tow processing

The preliminary mechanical processing of the dried stalks involves some fairly vigorous handling of the raw material, including breaking, scutching and the separation of the line fibres from the tow and other by-products. The stronger, more solid fibre bundles keep their original lengths and parallelism. During breaking and scutching the weaker and shorter fibres (tow), especially those at the foot of the stalks, break away and are removed together with the hurds, dust, soil, etc., by a pneumatic suction system placed below the scutching turbines.

After scutching the tow fibres are separated from the hurds and other impurities by passing them over a high output reciprocating screen. The hurds are removed pneumatically and may be sold for use as a natural fertiliser, for the heat insulation of buildings, as fuel or as animal litter (especially for horses and poultry). The hemp tow is then passed through a conveyer drier that can use either hot or cold air. To achieve the required quality the tow moisture content needs to be within the range of 7% to 10%. After drying the tow is passed through various breaking and cleaning rollers and over further reciprocating screens, all aimed at cleaning the fibres and removing impurities but in addition, the high pressure breaker rollers further split and affine the tow fibres. These are all high output processes.

In the past tow fibres of various qualities were produced. These differed, for example, in cleanliness and length and were used by industries such as paper manufacture or textiles. Today, however, tow processing is simpler and only one or two different qualities are required. Fibre cleanliness, colour and yield are the determining factors.

[*Editor's note*: recently, with the rapid development of the use of bast fibres in composite products (see Chapter 10), the differing technical specifications of hemp tow required for this growing demand is again increasing the variety of qualities required.]

Chemical fibre separation

Chemical fibre separation was an experimental process and consisted of scutching unretted stalks The long fibres were retted by steeping in an alkaline solution, which was then neutralised and rinsed off. (The neutralising of the fibres is essential because, if they were left in an alkaline state they would suffer damage.) Tow and long fibre were then further processed in the normal way.

4.5 Hemp spinning and spinning machinery

Scutched hemp and tow fibres used to be spun using different technologies and these were clearly separated. Different types of machines and equipment were developed and used to produce different yarns. Today these differences are hardly noticeable, the two technologies overlap and the same machines are suitable for both types of fibre. In Hungary and in most other hemp producing countries, some traditional technologies and machines have totally disappeared, for example wet spinning and the chemical separation of hemp fibres.

[*Editor's note*: wet spinning is still carried out to a limited extent in Romania where counts of up to 30s metric are available. Similar counts are also produced in China but in this case their processing is more akin to their methods of processing ramie.]

Fibre blending, the fundamental element of 'old-time' spinning, has completely changed. Previously hemp fibres of different character, handle and degree of separation were used depending on the spinning mill processing the fibres and the intended end-use of the yarn to be spun. Today scutched hemp fibres of different qualities and origin are used as blending components. Sometimes hemp-jute blends are also used in normal hemp processing and not only for the production of hessian type fabrics. The increasing variety of synthetic fibres (polyamide, polyacrylonitrile, polypropylene, texturised polypropylene, polyethylene, viscose, etc.) are also now blended with hemp.

The purpose of blending different fibres, or different qualities of hemp, is to satisfy the following requirements:

- the production of cheaper yarns
- to compensate for shortages of hemp fibre
- to improve spinnability
- to improve quality
- to decrease production costs.

4.5.1 Long fibre spinning

Yarn preparation

The purpose of yarn preparation is to make fibre 'hands' (bundles of parallel fibres that can be fed onto the aprons of the first draw-frames) of the same length and thickness from scutched hemp and also to further divide them in order to increase the fineness of the fibres and produce an even sliver.

Fibre softening

The process of fibre softening helps to increase the fineness of the fibre bundles. The fibre-pressing machine that is used for this purpose has ribbed rolls loaded with springs that greatly soften the fibres as they move backward and forward through the machine. Softening can be made more effective if the hemp is treated with a water-oil emulsion before it is fed into the machine. This also significantly decreases the release of dust during processing.

Fibre cutting

Before hackling, softened scutched hemp has to be reduced to a certain length (usually 60–70 cm) so that the fibres can be processed on the hackling frames. The rough roots and tangled tips of the scutched hemp are also removed during the cutting process. This shortening is done on a cutting machine, which does not really cut the fibres but tears them. The scutched hemp is fed into the machine by hand and firmly held until the 'cutting' has taken place. After cutting the hemp – cut to size – is baled or tied into packages of 20 kg (the capacity of the cutting machines) and after resting for three to ten days in conditions of high relative humidity the packages are then hackled.

Hackling

The purpose of hackling is to

- parallelise the fibres
- separate and 'affine' (split) the fibres
- remove short fibres (tow) and knots of tow
- remove the remaining hurds and other impurities that have not been removed during previous processing.

Hackling is the term used in hemp (and flax) processing to denote the process which, for other fibres such as wool, cotton and synthetics, is called combing. During this process the hemp fibres are drawn through 'pins' held by wooden boards. The short fibres produced as a by-product of hackling (hackled tow) is used to spin the better qualities of short fibre yarns. The hackled hemp is then baled and, if possible, rested. No further selection is carried out.

Hemp fibres leave the hackling frame in the form of a sliver which receives a preliminary drawing operation before the yarn preparation (spinning and drawing). This is done on machines which are in fact modified drawing frames but in addition can insert small amounts of twist to give the sliver greater cohesion. Each frame has four horizontal belts separated from each other. The hackled hemp is placed on these belts, suitably overlapped so as to form as even a sliver as possible, drawn and doubled, fed into the drafting zone and wound onto the bobbin.

Drawing and doubling

As in the spinning of other textile fibres the purpose of these operations is to further separate the fibres and regularise the slivers. Five consecutive drawing and doubling operations are usual. The last of these introduces a small amount of twist and produces a rove. During these drawing and doubling stages, selecting cans of the same length but of different weight ensures the production of slivers of uniform fineness. Gill boxes are usual in these drafting and doubling operations. Intersecting gill drawing frames are not common in the hemp industry due to limited demand, high production costs and small development budgets. Today only a few old machines of this type are in operation. Refurbished machines manufactured by Mackie (UK) Bolelli (Italian) and LCS (Russia) from the 1960s are used at present.

Table 4.4 Yield of scutched hemp during hackling and cutting

Long fibre	3.8%
Short fibre	5.6%
Waste	6%

The percentages indicated are percentages of the original weights of hemp stalks (Tables 4.6–4.7).

It is preferable to combine as many slivers as possible during the first drawing operation. This ensures satisfactory blending and evenness of slivers. The length of sliver produced can be measured during processing. After the production of the required length the operative is informed by a visual signal. The filled can is then replaced by an empty one. It is also possible to obtain the linear density of the sliver by weighing the coiler can. The rove weights produced for long fibre spinning are between 2.5 to 5 g per metre. This is the final operation of yarn preparation. A hemp roving frame is similar to a flax tow roving frame but somewhat larger and heavier.

Spinning

Wet spinning used to be the more important of the two types of spinning system used for hemp, but this has now disappeared in Hungary (see 4.5). This general demise of hemp wet spinning is due to unfavourable working conditions, changes in demand, high production costs and regulations concerning the protection of the environment. Today, in Hungary, hemp is only dry-spun; Mackie (UK) and Bolelli (Italy) are the most commonly used spinning frames. The quality, evenness and tensile strength of the yarn depend on the raw material and the technology used. Usually the envisaged end-use determines the counts of the yarns produced.

The most commonly produced hemp yarns today are for weaving, usually 100% hemp, and are produced from selected fibres in the count range of Nm 3.5–5 (285–200 tex). Hemp yarns of similar counts are produced to make special twines and binders, sometimes blended with flax. In recent years there has been a demand for yarn of Nm 2–0.60 (500–1666 tex) for the manufacture of special ropes of high tensile strength. The raw material used is hackled long fibre hemp blended with good quality scutched flax fibre. Spinning takes place on Bolelli spinning frames of the semi-worsted type.

Winding

Hemp yarn is wound on cone winders. During winding thin sections and knots are removed. Yarn breaks during spinning are hand knotted. Hemp winding is labour intensive, modern automatic machines are not in common use and the usual yarn package is a cone containing 2–2.5 kg. The winding of heavy count yarns is done on cross winders similar to those used for short fibre.

4.5.2 Short fibre spinning

Yarn preparation

Two kinds of fibre are used in short fibre spinning, the short fibres produced during scutching (scutched tow) and the short fibres produced during hackling (hackled tow). Tangled (where the ends of the scutched fibres may be uneven and tangled together) and scutched tow with high hurd content can be used as part of the blend to produce good quality yarn of this kind and the raw material usually used is tangled tow of different lengths, fineness and cleanliness. As in all spinning the objective is to produce a yarn containing parallel fibres in the count required and the blending constituents chosen for producing yarn spun from short fibre depend on the envisaged end use. Blending is usually more varied than it is in yarns made of long fibre. The counts of yarn produced vary from Nm 0.20–1 (5000–1000 tex) to Nm 1–5 (1000–200 tex).

Table 4.5 Process weight loss during long fibre processing: (a) weaving; (b) twine manufacture

(a) Weaving		
Spinning	Loss during preparation, spinning and winding	10%
Twisting		2%
Weaving		1%
Finishing		13%
(b) Twine manufacture		
Spinning	Loss during preparation and spinning	10%
Twisting		2%
Polishing		
Finishing		4.3%

Pre-carding

The purpose of pre-carding is, as the name suggests, to prepare the fibres for carding; this involves the removal of the remaining hurds, untangling the tow, forming the sliver and coiling it into cans. The diameter of the cylinders and other rolls of the pre-card are larger than in final carding and the card wires stronger. This process carries out the rough cleaning and cards the fibres. Hungarian practice is not to blend fibres during pre-carding. The card slivers produced at the pre-carded stage are kept separate and blending takes place during final carding.

Final carding

The purpose of final carding is the further removal and the elimination of knots, blending and paralysing the fibres, affining them and forming a carded continuous sliver. The final cards (Mackie (UK), CST-1 15, Russian) usually consist of the following units:

- feeder
- card
- drawhead.

In the feeder the pre-carded coils of sliver are unwound and fed into the card. The card web is led between the condensing and main cylinder and after carding the slivers are led off the main cylinder into the drawhead that draws and doubles the sliver.

The length of the sliver can be measured continuously. A scale in front of the drawhead measures the irregularity of the weight of the sliver and varies the rate of drawing the lap through the drawhead. This continuous control of the lap weight enables the production of a final carded sliver of uniform weight per metre. As a can contains 400 metres the linear density of the sliver may also be established by weighing the can. Blending is usually carried out on the final card. The different coils are fed into the card as required by the blending ratio; carding, then doubling, ensures good blending of the different components.

Drawing and doubling

The draw frames are similar to those used to produce long fibre yarn. An important difference is the shorter drafting zone due to the shorter fibres being processed. The slivers pass consecutively through three draw frames. In the first and second stages of drawing gill boxes with chains are used, a special chain moving the pinned gill-bar. These gill boxes cannot produce evenly drawn slivers. In the third stage a gill box with a pulley is used. These are not suitable for correcting the defects of the slivers produced in the first two stages. These three-stage gill boxes are more suitable for spinning the rougher and thicker yarns. It is preferable to use gill boxes with pulleys (not chains) when producing finer and level yarns of good quality.

Spinning

Spinning is done on frames similar to those used for the spinning of long fibres except that, as in draw frames, the drafting zone is shorter. The fineness of the yarn to be spun determines the type of the spinning frame used. The tensile strength of the blend of fibres used can affect the fineness of the yarn. Improving the composition of the blend by, for example, blending long fibre with short improves spinnability. In practice there are two main machine types. One frame is used to produce thicker yarns and handles sliver weighing from 10 to 14 g per metre. The other frame is a modified fly-frame and handles sliver of 3 to 8 g per metre. Both these frames produce counts in the range of Nm 0.20 to Nm 1.

Winding

Fine and thick yarns require different winding machines. Fine yarns spun from long fibres to counts of between Nm 1 to Nm 6 and from short fibres to counts of between Nm 1 to Nm 15 are wound on cone winders. Usually 2 to 2.5 kg packages are made when subsequent processing justifies this length of yarn. Thicker yarns in the range of Nm 0.20 to 1 (spun from long or short fibres) are wound on cross winders, with a stroke of 8–10 inches. The weight of the cheeses produced can be varied between the limits of 4.5 kg to 10 kg. A considerable advantage of these cheeses is that due to their hardness they can be shipped on pallets, which also saves space.

4.6 Weaving

The quantity and variety of hemp fabrics produced in the last 15 years has decreased significantly. Former weaving companies have either left these particular markets or changed to weaving fabrics for the same end-uses but made from other fibres. For example, the demand for hemp canvas, covers and sacks had decreased as their users, both general consumers and the armed forces, have changed over to fabrics made from synthetic fibres which are easier to handle and resist mildew and other kinds of natural degradation. Also, in many cases, these fabrics made from synthetic fibres are cheaper than those made from hemp.

Other factors that encouraged the decline in hemp fabric production were the disappearance of wet spinning (in Hungary), and of the chemical separation of hemp fibres, and the deterioration in quality of both locally produced and imported scutched hemp. All these trends led to a decrease in the production of hemp yarns of suitable quality and price. On the other hand a more positive factor was, in some fabrics, the replacement of hemp warps by cotton warps. This helped maintain the level of fabric production and eased the shortage of quality hemp yarns. In turn this helped to maintain an efficient level of fabric production.

Table 4.6 Process weight loss during fibre processing: (a) short fibre; (b) hemp tow

(a) Short fibre	
Pre-carding	9%
Fine carding	14%
Spinning	15%
Twisting	4%
Polishing	
Finishing	4.5%
(b) Hemp tow	
Pre-carding	15%
Fine-carding	15%
Spinning	15%
Twisting	5%
Polishing	
Finishing	8%

This situation lasted until the collapse of the former Comecon market but the development of an interest in natural products, especially flax and hemp fabrics suitable for clothing, increased market demand in the beginning of the 1990s. The flax industry increased its yarn and fabric production by significantly increasing spinning and weaving production facilities. The hemp industry, as it could spin only fairly coarse counts, was not so well placed to produce yarns for apparel fabrics but nonetheless did take the necessary action to enable the industry to be able to supply a part of this market. Firstly, hackled fibre was produced from quality selected scutched fibre, then Nm 5 yarn was spun from this fibre and used to produce 500–700 g/m^2 hemp fabrics, or, secondly, after yarn preparation, the rove was chemically treated (bleached rove). This could be spun to finer counts to produce fabrics of 250 g to 300 g/m^2.

Hemp yarns have lower elasticity than cotton yarns, for example, this limits their use to simple weaves such as plains and twills. Today (2002) hemp has achieved only a token penetration of the apparel market. The volumes are small and the costs are high and the possibilities of market and technological development are therefore limited but, despite the substantial decrease in hemp woven production, weaving, both for fabrics and carpets, remains the most important outlet for hemp yarns.

4.7 Fabric finishing

Finishing hemp fabric requires considerable experience. The objectives are to remove dirt, regularise fabric structure, bleach it slightly and ensure maximum dimensional stability. Hemp fabrics are usually sold in their natural colour, but to produce a level shade a mild bleaching treatment is used. This process is similar to that used for flax fabrics of similar weight.

The first stage of fabric finishing is scouring, using a gentle alkaline liquor. This removes dirt and also the natural waxes, proteins and pectins that are present in the fibres. After scouring and bleaching the fabric is dried and dimensionally stabilised, usually in a stenter. Normal maximum shrinkage standards are 2.5% in the warp and 1.5% in the weft. Drying hemp fabrics is similar to drying flax fabrics. The fabric may shrink significantly and the rates of shrinkage in warp and weft are usually different. It is therefore important to remove warp and weft tensions and stabilise the fabric as much as possible. For certain end users the fabric is used in its unfinished state. This is the case for example in articles made from leather where the hemp fabric is used as trim or accessories. A soil resistant finish is sometimes applied to these fabrics. Due to limited production and consumption and despite it being the major consumer of hemp yarn, the finishing of hemp fabric is limited to only a few thousand square metres per year. This gives little incentive to weavers and textile machinery manufacturers to develop new finishes.

4.8 Production of other hemp products

The largest demand for hemp yarns that are to be further processed is for the production of string, twine, cord and rope. These are yarns made from both long and short fibres. The precise type of yarn used will depend on the intended use of the final product, the required strength and desired aesthetics.

4.8.1 Twine

Two or more yarns are twisted together. The purpose is to make a product of greater regularity and strength than the original yarns. The yarn on yarn friction that results from the original yarns being twisted around each other produces a greater tenacity that the sum of the tenacities of the original yarns. Twines, cords and ropes are described by the number of yarns from which they are made. If more than six yarns are plied the yarns will be assembled in several stages. Usually identical count yarns are assembled to produce these products. Various types of twisting frame are used to ply the yarns; for instance, fly doublers and cap doublers. In addition to their use in the manufacture of twines, strong ropes and cordage, hemp yarn – but in its original unpolished state – is also used in agriculture as baler twine and in pre-cut lengths for use as binders.

4.8.2 Twine polishing and balling

Twine is made from hemp singles or twisted hemp yarns; its surface is smooth, even, shiny and clean. These surface effects are obtained by using a starch finish and polishing with wax and paraffin on a polishing frame. Depending on the demand of the market, twines are made from long or short fibres. Twines made from long fibre yarns are strong, level, attractive and suitable for special purposes. Twines made from short fibre yarns are less even, of lower quality and are for more general use. Twines are usually two or three stranded but can be produced with four to six strands. Twines with several strands are made from finer yarns. In a polishing machine the structure of the yarn is loosened and the handle softened in a warm soapy bath. The twines are then passed over cleaning rollers which remove 'proud' fibres, knots and sliver. During this cleaning process the twines receive a further intensive warm wash.

After the application of a starch finish the twines are bleached or, if required, dyed. Excess moisture is then removed by squeezing rollers. Finally the twine is dried by passing over heated cylinders. Drying temperatures depend on the thickness of the twine and are approximately 100–120 °C. Polishing is carried out by two pairs of polishing cylinders covered with polyethylene or hemp rope. These cylinders also apply paraffin to the surface of the twine, which is already saturated with starch, producing a shiny and attractive appearance. Twines are usually packaged as balls, but cross-wound spools or skeins are also possible and can be produced to defined lengths. Balling frames may be automatic or manual. The latter are suitable only for satisfying special demands and have low productivity. Automatic balling frames can satisfy most usual requirements.

4.8.3 Cord and rope production

Cords are assembled from yarn or twine. The individual components are 'pre-twisted' during production. The degree of twist imparted during this operation determines the softness or stiffness of the cord. Cords normally have 3 × 2 strands and are usually called six-stranded cords. Rope structure is similar to that of cord. Usually products with diameter above 5 mm are called ropes and the number of yarns to be twisted and assembled to form them will depend on the fineness of the yarns and the thickness of rope required; they are usually assembled from three or four strands. The diameters of currently produced ropes range from 5 mm to 40 mm. These are packaged on rolls of various sizes.

4.9 Environmental and health and safety considerations

The main natural processes involved in growing and processing hemp are mostly environmentally favourable, but some may be harmful. Growing hemp is beneficial to the environment. It is biodegradable and in addition to being a good rotational crop has the ability to selectively absorb pollutants, such as heavy metals, from soils. Its very rapid growth and high leaf cover eliminates weeds by smothering them and therefore avoids the necessity of applying weed control chemicals during its growth period. Also hemp cultivation needs only low levels of chemical fertilisers and in some cases none. The hurds and leaves can be ploughed back into the soil as natural fertiliser or used for other purposes such as animal litter, after which it finds further use as an (enhanced) natural fertiliser. The hurds are also used in the manufacture of paper and for fibreboard in building and furniture making. Little or none of the plant is wasted.

On the negative side, water retting requires large amounts of clean water. However, after retting the used water is polluted, it is poor in oxygen and rich in floating and dissolved organic matter. Cleaning and regenerating this polluted water in an industrial plant would require an enormous provision of energy and the costs are such that they would jeopardise the viability of hemp production. Present procedure is natural water regeneration, which requires adequate areas of land. Organic matter is allowed to settle and the lack of oxygen is remedied over time. Reed bed filtration has also been shown to be effective. Polluted water is also produced during the polishing of twine. Fortunately only small quantities of water are involved so this is not a major problem.

During scutching and spinning hemp dust and fragments of hurds and short fibre become airborne; air filtration systems are therefore required to improve the quality of the air and of the working conditions generally. The wearing of facemasks to protect the health of operatives is a legal requirement in many countries, but is not always strictly enforced. During the processing of hemp – breaking, scutching, softening, cutting, hackling, drawing, spinning – significant amounts of dust are released. This amount is much larger than the amounts released during the processing of other natural fibres. This is due to the size and structure of the dried hemp stalk, the composition of the fibres, the gradual separation of the epidermis, pectins and lignin and also because the machines used in hemp fibre processing were built 30–40 years ago or use the technology of that period. These have many open working surfaces with the result that the large amount of dust that they generate is not enclosed and eliminated but distributed throughout the atmosphere of the enclosed areas of the hemp factory. However, even with more modern enclosed machines a certain amount of dust is inevitably released into the air.

Dust that is not removed by air-conditioning plants can cause mild fever, coughing or in more serious cases bronchial or lung diseases. However, hemp dust, due to its relatively larger size, cannot penetrate deeply into the body and therefore its harmful effects are less than that those of diseases caused by the absorption of smaller particles produced by some other industrial processes.

Another disadvantageous effect of hemp processing is the noise levels in some of the working areas of the factory, which are usually higher than acceptable. These high noise levels are caused by the machinery used, and more particularly by their age. The possibilities of decreasing the noise levels in these old mills and with old machines are limited. The prevention of hearing loss can be solved by the use of individual protective equipment ranging from simple earplugs to modern protective earmuffs, but here again, although their use may be mandatory these health and safety regulations are not always applied.

Beside the constant use of individual protective equipment regular medical examinations are also very important. Different screening tests for ears, lungs, bronchial tubes and possibly legs should all be part of a preventative health policy. Equipment and machines used in hemp processing are potentially dangerous as there are many moving parts and these parts often cannot be protected from accidental or intentional body contact. Where possible, potential points of danger are protected by housings, barriers, wire nettings, etc. In highly dangerous machines multiple protective locking systems are built in. Their purpose is to prevent the machine being started until it is safe to do so. Accidents can be prevented by regular machine checks. The observation of well planned technological handling and maintenance programmes and instructions will ensure safe operation. Also a thorough knowledge of safe working practices by all the operatives concerned is essential.

4.10 Production and market trends

After an initial increase, continuous decline marked the period between 1960–2000. After 1990 (change from the command economy) the unviable companies, unwilling or unable to move with the times, did not survive. Only five hemp and flax mills out of the former 15 operate today (2002), three hemp and two flax mills. The trend is shown in Tables 4.7–4.9. The causes of these large-scale changes are as follows:

1. Discontinuation of subsidies.
2. The period from sowing to producing finished products is 1.5–2 years. This lengthy period can be financed only by significant increases in costs.

Table 4.7 Hemp, flax and jute production 1960–1991

1960	69.8% (Value HUF 1.343 million, gross production)
1965	88.7%
1970	88.5%
1975	95.2%
1980	100.0%
1985	118.4%
1990	88.7%
1991	55.1%
1993–2000	N.A (estimate approx. 25–30%)

Table 4.8 Hemp, flax and jute industry: number of employees

1960	13,640
1970	12,974
1980	13,805
1985	12,312
1990	9,322
1991	4,783
1993–2000	N.A. (estimate approx. 2,000 employees)

Table 4.9 Hemp area under cultivation

1950	20,000 ha
1960	10,000 ha
1985	5,000 ha
1990	1,000 ha
2001	700–800 ha

3. Hemp products can be partly replaced by synthetic yarns and fabrics.
4. Synthetic products are considerably cheaper
5. These trends were evident in both the hemp and flax industries and textile machinery manufacturers saw little point in developing new and more productive equipment for a rapidly declining market.
6. Market demand for hemp products decreased dramatically, especially in Hungary, due to 3 above.
7. Export demand also decreased in Europe and although demand increased in North America this did not compensate for the decline in Europe.

4.11 Conclusions

4.11.1 Hopes for the next decade

1. As protection of the environment assumes greater importance it is likely that the consumption of hemp products will cease to decline.
2. New end-uses for hemp and flax may increase the volume of hemp cultivation.
3. Beside the traditional end-uses the manufacture of specialised products may also increase production and consumption.
4. There is and will continue to be a need for closer co-operation between research and development institutes and industrial hemp companies in the fields of production technology and product development.
5. More powerful and aggressive marketing will be needed emphasising the advantages of natural fibres.
6. Continuous cost analysis is needed to achieve decreases in costs.

The Hungarian hemp industry has been through enormous changes in the last decade and in particular the number of mills has decreased significantly. However, this fact could, for the next few years, be an advantage as the volume produced today of a more up to-date variety of products can meet market demand. It is therefore possible that a better balance will be achieved between production and sales. This is probably the most important and encouraging factor for companies at present operating this industry.

[*Editor's note*: This, in fact, is happening as a new market is developing in composite products for the automotive market.]

PART 2

4.12 Present trends

As has been described by the authors in the first part of this chapter, and as is confirmed on a global scale by Table 4.10, production of hemp fibre has decreased dramatically over the last 45 years, and again the causes of this global decline have been similar to those in Hungary. These can be summarised as the loss of the captive markets in eastern Europe, the ex-USSR and China, all of which were major producers and consumers of hemp and hemp products. In turn, this decline was due the lack of investment and of technological and product development; all whilst having to face increasing competition from synthetic fibres, both in their export markets and to some extent, in their own and adjoining countries' markets.

World production for the years 1997 to 2003 by country is set out in Table 4.11 and the areas cultivated for certain countries and years are indicated in

Table 4.10 World production of hemp fibre (tonnes) 1961–2003

Year	Tonnes	Year	Tonnes	Year	Tonnes	Year	Tonnes
1961	299,923	1972	271,467	1983	154,636	1994	51,509
1962	304,549	1973	266,777	1984	152,906	1995	56,636
1963	310,775	1974	260,460	1985	157,157	1996	65,837
1964	339,596	1975	236,234	1986	*c.* 163,000	1997	63,506
1965	340,821	1976	238,046	1987	167,516	1998	73,629
1966	368,373	1977	233,658	1988	152,049	1999	61,140
1967	348,338	1978	215,318	1989	107,814	2000	50,618
1968	300,486	1979	207,200	1990	83,997	2001	60,917
1969	297,691	1980	186,443	1991	66,442	2002	67,950
1970	280,278	1981	149,097	1992	76,331	2003	77,450
1971	282,269	1982	133,792	1993	63,568		

Source: FAOstat.

Table 4.11 World production of hemp fibre by country 1997–2003

	Hemp fibre and tow production (million tonnes)						
	1997	1998	1999	2000	2001	2002	2003
World	63,506	73,629	61,140	50,618	60,917	77,450	67,950
Chile	4,000	4,000	4,000	4,048	4,095	4,095	4,095
China	19,225	16,896	13,000	14,000	20,186	35,000	38,000
France	260	400	370	370	260	360	360
Hungary	2,086	1,989	350	129	150	120	120
Italy			507	437	221	1,281	1,281
Korea, Dem. People's Rep.	11,000	12,000	12,000	12,500	12,500	12,500	
Korea, Rep. of	448	267	326	263	235	224	224
Poland	150	50	50	50	50	50	50
Romania	9,600	11,100	7,300	1,400	800	800	800
Russian Fed.	3,000	2,200	4,100	7,100	5,400	6,000	6,000
Serbia and Montenegro	457	200	200	30	20	20	20
Spain	9,980	22,527	17,160	7,047	15,000	15,000	15,000
Turkey	2,300	1,000	777	1,244	1,000	1,000	1,000
Ukraine	1,000	1,000	1,000	2,000	1,000	1,000	1,000

Source: FAOstat.
Courtesy: Food and Agriculture Organization of the United Nations.

Table 4.12 Hemp areas harvested (ha) in certain countries outside the EU 1996–1999

	1996	1997	1998	1999
Bulgaria		48	8	8
Canada	0	0	2,000	1,200
Chile	4,200	4,200	4,200	4,200
China	58,000	15,000	15,000	15,000
Croatia	14	14	14	14
Hungary	1,200	900	1,077	1,077
Korea, Dem. Republic of	17,000	17,000	17,000	17,000
Korea, Republic of	250	250	250	250
Romania	1,000	2,000	3,080	3,000
Russian Federation	11,490	9,490	6,260	10,230 16,980 (2000)
Ukraine	4,000	3,500	2,000	2,000
Yugoslavia, Fed. Rep. of	679	1,000	1,000	1,000

Source: FAOstat. Russian Federation statistics: A. Surinov, General Director, State Commit. of the Rus. Federat, on Statist., (GOSKOMSTAT of Russia), Dep. Of Foreign States Statistics and Intern. Cooper., Moscow, Russia. Canada, China, Hungary, Romania, Ukraine, Fed. Rep. of Yugoslavia Statistics: Michael Dr Karus, nova-Institut für politische und ökologische Innovation, Nachwachsende Rohstoffe, Thielstr. 35, 50354 Hürth Germany. Courtesy: Prof. Dr R. Kozlowski.

Table 4.13 Hemp areas harvested (ha) in certain countries of the EU 1996–2001/2

	1996	1997	1998	1999	2000/01	2001/02
Austria	661	938	974	289	287	860
Belgium			0	1	0	0
Denmark			26	23	7	7
Finland	2	53	1,218	93	59	2
France	7,588	10,980	9,682	9,515	7,700	6,900
Germany	1,362	2,766	3,553	3,993	2,967	1,948
Italy	0	0	255	197	151	200
Ireland	0	23	28	22	6	0
Luxembourg	5	13	13	0	0	0
Netherlands	893	1,322	1.055	872	806	946
Portugal			770	185	4	0
Spain	1,450	4,828	19,860	13,473	6,103	784
Sweden					0	0
Switzerland	150	200	250	250	250	
UK	1,697	2,293	2,556	1,517	2,245	2,566
Total EU	**13,658**	**23,216**	**39,990**	**30,179**	**20,404**	**14,213**
Poland	1,296	240	158	36	53	153

Source 1996–1999 statistics: Michael Dr Karus, nova-Institut für politische und ökologische Innovation, Nachwachsende Rohstoffe, Thielstr. 35, 50354 Hürth Germany. Source 2000/2001 and 2001/2002 statitsitcs: Mr Jordi Petchamé Ballabriga, Administrator, Olives, huile d'olive et plantes textiles, D.G. VI.C4 Loi 130 7/126, European Commission, Rue de la Loi 200, B-1049, Bruxelles, Belgium. Courtesy: Prof. Dr R. Kozlowski.

Tables 4.12–4.14. There are discrepancies between the figures provided by the FAO and the INF, particularly in that the production of Canada Austria, France, Germany, Italy, UK, the Netherlands and few other countries producing small quantities are not included in the FAO data. The total areas harvested by these countries come to about 15,000 Ha and assuming a yield of two tonnes per hectare this would add 30,000 tonnes to the FAO total in 2002 of 77,450 tonnes (Table 4.11). However, this estimate of 30,000 tonnes is perhaps high because

Table 4.14 Russian federation: area cultivated and fibre produced 1995–1999

Year	Hemp cultivated area in Russia Total (ha)	Summary output of hemp fibre (tonnes)
1995	9,170	4,300
1996	11,490	4,030
1997	9,490	2,980
1998	6,260	2,190
1999	10,230	4,140
2000	16,980	7,070

Source: A. Surinov, General Director, State Committee of the Russian Federation on Statistics (GOSKOMSTAT of Russia), Department of Foreign States Statistics and International Cooperation. Courtesy: Prof. Dr R. Kozlowski.

market research carried out by the nova-Institut[1] on behalf of the European Industrial Hemp Association (EIHA) in 2003 shows EIHA members production of hemp fibre in 2000 at around 20,500 tonnes (Table 4.13). Although not all European Hemp production is included in the IIHA figure their report estimates that they do account for 80 to 90% of EU hemp fibre production. Taking, therefore, EU production at approximately 23,000 tonnes world production in 2002 would have reached 100,000 tonnes.

FAO figures for 2003 (Table 4.11) show a decrease of about 10,000 tonnes over the previous year but EU production certainly increased, therefore world total for that year would be between 90,000 and 95,000 tonnes. However, it must be remembered that not all of this production is for textiles as considerable quantities are used for paper and composite products (see below).

4.13 Future trends

It is clear that, since the mid 1990s, hemp is experiencing a renaissance. This is based on two factors; the development both of new markets and new technologies.

4.13.1 Recent technical developments

The fact that retting is necessary for the effective extraction of the fibres from most bast and leaf fibre producing plants places them at a disadvantage when compared to other fibres. If fibre extraction processes involved could be improved or retting eliminated both the quality and the prices of these fibres could be improved. During the 1990s and especially in the cases of hemp (and flax), efforts have been made to remove the need to ret the stalks before fibre extraction. These have all relied on the fact that if the stalks are processed immediately or soon after harvesting the gums binding the fibres to the rest of the plant have not solidified. It is then possible to peel the long ribbons of fibre from the rest of the stalks without damaging them, as happens when mechanical force is used during traditional scutching. Two German companies developed large harvester-decorticators. These aimed at producing short fibres suitable for industrial (mainly non-woven) and not apparel or furnishing end-uses. These two machines have not been commercially successful and one of the companies has closed down.

A different approach was adopted by an Australian company and has, at the time of writing (2004) been successfully developed to prototype level. In this case the decorticators are mounted on the rear of a self-propelled harvester. This produces ribbons of fibres which are automatically bagged by the harvester-decorticator, and hurds, which can be either spread over the field being harvested to be ploughed in for the next crop, or bagged for sale (as animal litter or for particle board or paper manufacture, for example). The bagged ribbons of fibre are then processed, degummed, either by washing, chemically or by enzyme treatment, and after drying are suitable for spinning on cotton, worsted or other spinning systems. Sample quantities of 100% hemp, hemp/cotton and hemp/wool yarns have been produced and further trials are at present (early 2004) taking place.

4.13.2 New markets

Apparel

The major problem with traditionally produced hemp is that the fibre is relatively coarse (15–50 μ) and capable of being spun only to a finest count of 3s metric, which for all practical purposes limits its use to heavy industrial fabrics. By using selected hemp fibre and by spinning from bleached rove (see the first part of this chapter), 'bottom weight' apparel fabrics can be produced. However, they are expensive when compared to cotton and coarse when compared to linen, but they do have a niche in the 'environmentally conscious' market.

Composite materials

This is a new market for bast and leaf which started developing in the mid-1990s (see Chapter 10). When compared to reclaimed cotton or wood fibre, which have been used up to now, the use of bast and leaf fibres improves the performance of the press-moulded composite panels which are used for the interior trim of cars. This market has developed rapidly and in 2000 consumed over 28,000 tonnes of vegetable fibres, of which 3,500 tonnes was hemp (source: nova-Inst.).

So far nearly all these panels have been press-moulded and the use of these fibres for making composites using this technology is expected to continue to develop. But considerable R & D is taking place in the use of these fibres for injection-moulded composites. At present the major fibre used for this purpose is glass fibre, priced at around US$3,000 per tonne. Bast and leaf fibres are selling into this purpose at between €500 and €600 per tonne and if the development of vegetable fibre injection moulded technology succeeds the consumption of these fibres will increase substantially. However, one must also bear in mind that hemp produced in the European Union is subsidised under the Union's Common Agricultural Policy (CAP), as are flax and many other crops. Whilst it is not expected that these subsidies will be removed in the immediate future they may well be reduced and it is difficult to foretell what the effect of an increase in hemp (and flax) prices, in comparison with those of jute, sisal and coir, will have on the relative consumption of these fibres for this particular end-use. Nonetheless, it is difficult to be pessimistic about hemp in the medium term

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[1] *European Hemp Industry 2002.* M. Karus, nova-Institut, Hürth, Germany.

and the forecast of Mr G. Mackie, who is a long established consultant in this area of textiles, expects present production to double by 2020.

[*Editor's note*: The present (2004) rate of the EU subsidies for cultivation and processing hemp are as follows:

	€/hectare
Cultivation	350
Short fibre processing	90]

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4.15 Glossary of terms

Affine *see* glossary Chapter 3.

Breaking *see* glossary Chapter 3.

Can Cylindrical receptacle about 1 m high into which slivers and rovings are collected after being processed.

Cannabis sativa Hemp's botanical name.

Cheese A type of yarn packet in the form of a cylinder similar to the shape of certain cheeses.

Hackling *see* glossary chapter 3.

Hurds Non-fibrous woody matter produced as a by-product of scutching.

Retting *see* glossary chapter 3.

Scutching *see* glossary chapter 3.

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*, Chinagrass, 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.