

Conference Paper

Modern Aspects of Bast Fiber Production in the Genesis of Bast Fiber Culture Selection

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Abstract

The main goal of the rational use of bast fiber raw materials is to develop and apply optimal methods of its processing. Work on the creation of such technologies is carried out by leading scientists of the industry in accordance with three main areas of research: the search for ways to increase the yield of long flax fiber and improve its consumer properties by using various methods of ennobling; improving the methods to unfold bundles of technical fibers and obtain elementary bast fibers (cotonized fiber); and integrating the use of waste from primary processing of bast-fiber raw materials based on existing hydrolysis and thermal decomposition technologies. However, with some exceptions, the vast majority of research is limited to laboratory experiments, largely because the bast stem is a very complex composite. This raises a number of questions for researchers. In varieties and breeding samples with high fiber quality, the total fatty acid content is higher, and the ratio of total saturated acids to unsaturated acids is lower. A method for evaluating The selection material of the same flax based on fiber quality and lodging resistance is based on determining the total content of fatty acids and total lipids and the ratio of saturated to unsaturated fatty acids in flax stalks and seeds. Subsequent comparison of the obtained indicators of the studied selection material was according to the indicators of the standard variety.

Keywords: bast fibers, genesis, selection, chemical composition, physical and mechanical properties, non-cellulose components

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1. Introduction

The fiber of bast plants is very diverse and heterogeneous in its physical and mechanical complex (strength, flexibility, Tonin, etc.) and chemical composition [1]. Depending on these characteristics of the fiber, it is used to produce a wide variety of consumer

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properties of textiles – Batiste and burlap, fabric for bed linen and tarpaulins, towels and napkins, canvas and ropes, costume, curtain fabrics and twine. The stems of bast crops are a fairly complex of polymer organic substances. The content of the main components in them varies quite widely depending on the growing conditions and harvesting time. During studies of the chemical composition of the stems of bast crops, the results of which are shown in Figure 1, it was found that they contain components such as cellulose, lignin, water-soluble substances, ash, pectin substances [2].

2. Research

2.1. Chemical analysis

The molecular structure of some of its components, in particular, lignin, has not been fully elucidated, and there is no complete clarity on the issues of bast crystallinity and, in general, its supramolecular structure. In addition, the cellulose itself is a difficult object to study, which is mainly composed of bast fiber, since this natural polymer is insoluble in most known solvents.

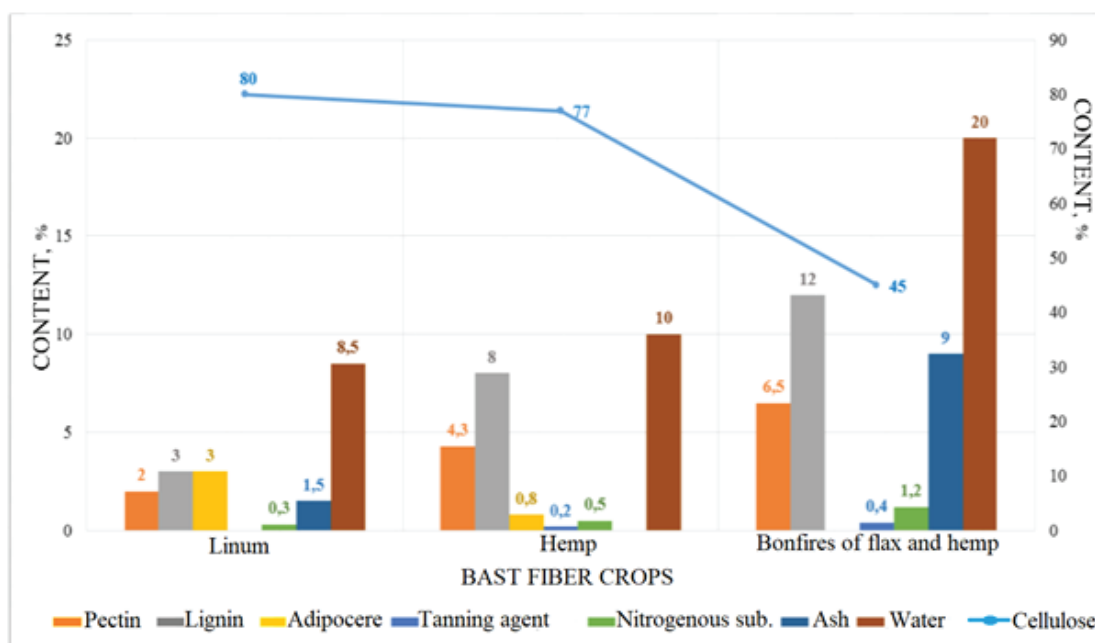


Figure 1: Chemical composition of the stems of bast-fiber crops (maximum values)

It should be noted that of particular importance for the domestic textile industry is the use of long and short bast fiber for the manufacture of textiles and cotton – like fiber-cotonine suitable for use in the production of mixed yarn and fabrics.

2.2. Physical and mechanical properties

The production of cottonized flax yarn mixed with cotton makes it possible to reduce the need for the latter by 30-50 %. At the end of the last century, there was a significant increase in demand for cottonine in various countries of the world. Manufacturers' interest is primarily due to the possibility of expanding the raw material base of natural fibers and partially replacing chemical fibers with cheaper and environmentally friendly raw materials, as well as increasing the variety of popular household products. The use of cottonine for their manufacture allows increasing the volume of bast fiber usage by 25-40%, bringing it to 65-70 % [3]. A comparative characteristic of the physical and mechanical properties of various types of fibers is shown in Figure 2.

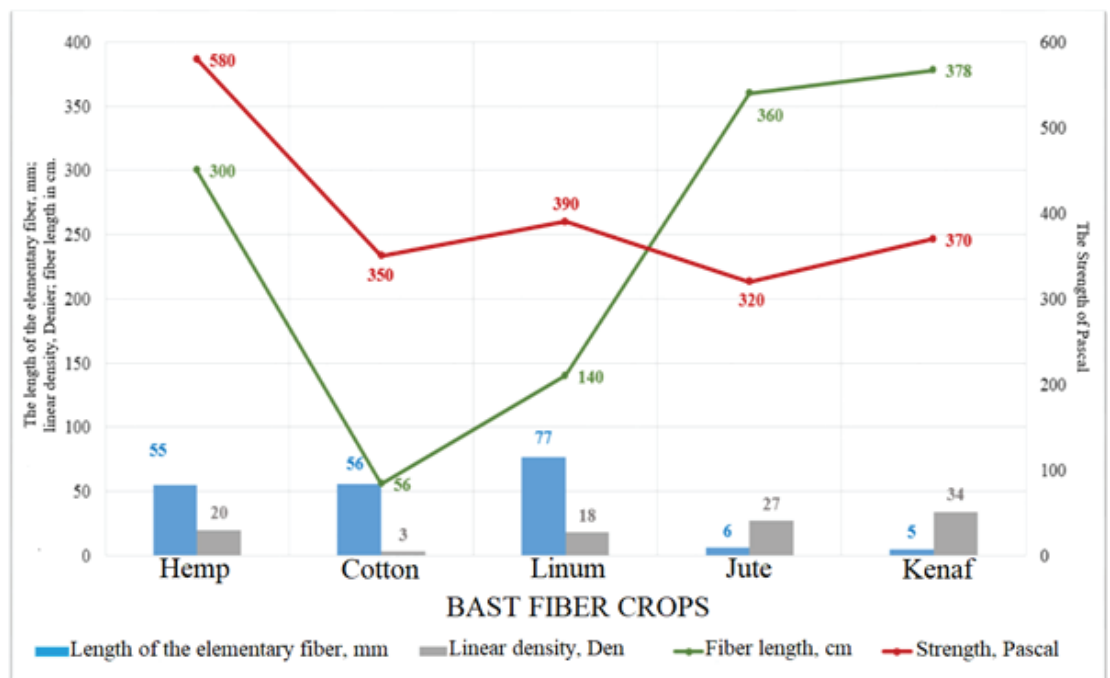


Figure 2: Comparative characteristics of physical and mechanical properties of various types of fibers (maximum values).

Mechanical processing methods are used to isolate the fiber. The main methods of processing bast crops are considered to be processing of dry and wet trusts, processing of dry and green stems.

Processing dry trusts is the most common method of processing flax and hemp. According to this method, the stems after collecting plants are threshed, removing the seed pods, and then subjected to biological treatment in the fields by spreading or in factories using heat exposure to moisture. In both cases, the task of biological treatment is to destroy the covering and parenchymal tissues surrounding the bast bundles, and thus prepare the stems for easy separation of the fibers from the wood.

Wet trestli treatment is only used for kenaf and jute. In this case, the trust obtained after soaking, do not dry, and immediately processed by a special machine. This method is based on the mechanical separation of fiber from wood in high humidity conditions. However, it is not used for flax and hemp, since the fibers of these crops in wet form have little strength and are easily destroyed during processing.

Processing of dry stems is used in small volumes mainly for flax straw. Unlike other methods, the stems are not subjected to biological destruction before machining. As a result of this process, a bast is extracted from the stems, which is further processed with chemical reagents at one of the subsequent stages of processing for cleaning from the integumentary and parenchymal tissues. The method is characterized by the complexity of separating the bast from the wood, the need to apply more intensive and prolonged mechanical influences, which leads to additional energy costs.

The purpose of all the above processing methods is to extract the largest amount of pure undamaged long fiber from the stems, the proportion of which in the composition of the stems is only 25-30 %. The woody part of the bast stalk-fire is a rather complex of polymer organic substances. The content of the main components in it varies quite widely depending on the growing conditions and harvesting time. As a result of chemical analyses, it was found that the fire contains components such as cellulose, lignin, water-soluble substances, ash and pectin substances. Table 1 shows the percentage of non-cellulose components of the woody part of the bast stalk [4].

2.3. Analysis for the presence of non-cellulose components

Conducted physical and chemical analyses indicate that the fire contains a complex of valuable chemicals, similar in composition to the wood of coniferous and deciduous trees.

In developed foreign countries where flax and hemp processing technologies are applied, the share of waste used as fuel (pellets and briquettes) is significantly reduced, while it is considered more cost-effective to use bonfire for manufacturing industrial and household products.

For example, in Argentina, high-quality paper is produced on the basis of hemp raw materials, in particular stamp and craft cardboard. In Hungary, crushed bast fiber is used as a filler in the manufacture of plastic products, furniture parts, accessories, decorative tiles, and the like.

TABLE 1: The content of non-cellulose components in the woody part of the bast stalk.

NON-CELLULOSE COMPONENTS	CONTENT, %	
	LINUM	HEMP
Ash	2,07	2,01
EXTRACTABLE SUBSTANCES		
Ether	1,2	2,1
Alcohol benzene	2,7	3,3
Hot water	7,3	8,8
Cold water	5,8	4,5
LIGNIN, INCLUDING		
Acid insoluble	20,5	17,9
Acid-soluble	3,3	4,4
PECTIN SUBSTANCES, INCLUDING		
Polyuronic acids	54,1	46,7
Geksogena	31,4	30,3
Pentosans	14,4	12,4

In Belgium, France and Finland, parts are pressed from bonfires to replace business wood in the production of consumer goods, interior design of public and residential buildings.

In Germany, the possibility of obtaining a liquid fuel substitute for petroleum products from crushed bonfires is being studied.

Analyzing the composition of chemicals that are formed in the bast stalk at different stages of processing, it is possible to make sure that it is advisable to use the waste of processing bast raw materials for the development of resource-saving technologies for hydrolysis and pyrolysis of bonfires and the production of paper, cardboard, charcoal and coal sorbents on their basis, cellulose for the manufacture of acetates, powdered cellulose, monosaccharides for the production of feed yeast and alcohol, lignin for plastics, vanillin, substances with fungicidal properties, etc. [5].

In recent years, the possibility of obtaining polycrystalline silicon based on hemp raw materials, which is used in the electronics industry to produce rectangular multicrystalline blocks, cylindrical crystals, and plates for solar energy by directional crystallization methods, has also been considered. It is mainly used in the manufacture of silicon-based crystal and thin-film photo converters, LCD screens, substrates and process layers of integrated circuits. Most of the ultra-pure polysilicon is obtained from monosilane (a fairly poisonous substance), based only on the fact that this method has proven to be the most economically feasible.

The destruction of the stem structures, the violation of the fiber-wood connection, the scrapping and removal of wood in the process of crumpling and flapping are based on certain differences in the properties of the fiber and wood. These natural differences can be greatly enhanced or weakened artificially. Therefore, knowledge of the mechanical properties of the stem as a whole and its individual components is the basis for building a technological process and choosing a particular variant of mechanical actions [6].

3. Results

A careful analysis of the latest theoretical research in this direction has revealed one significant drawback, which is due to the modern requirements of the country's economic development, namely, it concerns the general unification of technical solutions during the processing of bast crops. The technology and equipment for processing raw materials with different initial physical and mechanical characteristics for each of the individual cases are described very carefully in the research works, which causes the use of additional mechanical or chemical effects on the fiber after its primary processing. This leads to a decrease in the technological and economic indicators of the finished product and does not contribute to obtaining the desired result.

Therefore, an urgent task of scientists in the industry is to develop new resource-saving technologies for processing bast crops, with the production of bast fiber based on an increased degree of purification with predictable geometric parameters, which depends primarily on the growing conditions and post-harvest refinement of raw materials. But this trait is clearly controlled by the plant's genetic systems and is well inherited [7], which is of great importance in breeding work. Therefore, the selection and creation of genetic sources with high levels of elements spinning ability of fibre, as original forms for further work is relevant in the breeding of new varieties with high fiber of improved quality.

At the early stages of selection, it is necessary to analyze thousands of breeding samples, and sometimes individual plants on the basis of fiber quality, so the method of determining it should be simple, accessible for mass analysis, which makes it possible to obtain reliable information about the hemp fiber ability when creating a new source material for further selection work.

The importance and relevance of this issue is due to the expediency and need to develop and create laboratory devices for spinning small samples of fiber (5÷10 g) in order to objectively evaluate the selection material on this basis, to identify high-quality

samples, and thus accelerate the pace of breeding and introduction into production of new highly productive varieties with high spinning properties.

Fiber quality is a complex indicator and it can not be measured only by metric units of measurement-length, mass, volume, area, etc. Therefore, in search of an objective assessment of fiber quality at the first stages of selection, many scientists have proposed principles for determining a quality trait based on various determinants, sometimes even unrelated to this indicator. Thus, it was found that there is a correlation between the quality and fiber wrapping – the wrapping of high-quality fiber is 2.66, and the wrapping of low-spinning fiber is 4.72 conventional units.

Based on this, a method was developed based on the ratio of the number of elementary fibers on the cross section of the stem to its mass. The higher the ratio, the better the fiber quality.

Later [8] it was proposed to calculate the correlation coefficients between the linear density, flexibility and breaking load of the fiber in different parts of the stem: upper, middle and basal – the higher the coefficients (0.93-0.98), the better the fiber quality.

A comprehensive method of determining the quality of fibre on physico-mechanical (density of elementary fiber, lignification of the middle plates) and chemical (content of Hemi-cellulose and lignin in the fiber) indicators based on the densities of elementary fibers (not below the 1.515 g/cm^3), the woodiness of the median plates (20 %), the content of hemicellulose (within $9.0\div 9.5$) and lignin ($2.5\div 3.0$ %) for fiber with increased spinning capacity.

Some methods are based on the principle of the structure of the stem on a cross-section in microscopic studies.

Thus, when studying the number and shape of bast bundles, the diameter, shape and density of elementary fibers, the number of lignified fibers, the ratio of the fibrous and woody parts of the stem on a cross-section of the stem, it can be concluded that the anatomical structure of the stem varieties and breeding samples are very different, and it is advisable to evaluate and select the selection material on the basis of «fiber quality».

Thus, a comparative study of the technological assessment of the quality of the fiber and the anatomical structure of the stem can establish that the most optimal are three indicators-the diameter of the elementary fibers, the degree of their variation and the area of fiber bundles. These parameters are not inferior in reliability to technological indicators. It is established that the degree of confidence in breeding research increases if these indicators are applied comprehensively.

The quality of the fiber is better judged by the anatomical structure of the elementary fibers and bast bundles – the smaller the wall thickness and smaller holes in the elementary fibers and the denser the connection of the elementary fibers in the bast bundles, the better the fiber quality.

In addition to the above, a practical interest for fiber quality selection in its early stages is the correlation coefficient between the fiber's toning and flexibility. The higher the correlation coefficient between these indicators, the better the fiber quality.

A number of researchers attribute the quality of fiber at the early stages of selection to the presence of various chemical compounds in the fiber, seeds, and plant stems [9]. In particular, the content of K_2O oxide in a unit of dry matter of the fibrous part of the flax stem by chemical analysis, allowed us to conclude that the significance of the mass fraction of potassium in the fiber – the higher this indicator, the better the fiber quality.

4. Conclusion

Thus, it can be seen that the feature «fiber quality» of bast crops is complex both in its functional purpose and in its definition (measurement). Therefore, to determine the spinning ability of the fiber in the selection of bast plants, different principles were proposed, which we discussed above. All of them are side effects. A direct indicator of the quality of the fiber is its strength during spinning, which in production conditions is expressed in the number of «breaks» per 100 spindles per hour. The most reliable and objective assessment of the quality of the fiber is its spinning on special laboratory spinning equipment, taking into account the indicator of thread breakage, expressed in time. The spinning ability of the fiber is a complex feature that is fundamental in the selection of bast-fiber plants, so as a result of research, several principles for determining the quality of the fiber were proposed, which are based on various indicators, sometimes even unrelated to this feature.

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Conflict of Interest

The authors have no conflict of interest to declare.

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