COMMODITY BULLETIN
Journal homepage: https://c-bulletin.com.ua/en
DOI: 10.62763/ef/1.2024.09

Article's History: Received: 27.12.2023 Revised: 26.03.2024 Accepted: 26.04.2024

Vol. 17, No. 1, 2024, 9-16

UDC 677.11.021

Analysis of the properties of bast raw materials as a component of fabric for military uniforms

Halina Boyko*

PhD in Technical Sciences, Associate Professor
Kherson National Technical University
29016, 11 Instytutska Str., Khmelnytskyi, Ukraine
https://orcid.org/0000-0001-8773-5525

Vladyslav Prokopchuk

Postgraduate Student
Kherson National Technical University
29016, 11 Instytutska Str., Khmelnytskyi, Ukraine
https://orcid.org/0009-0006-3694-3029

Abstract. The relevance of the present research is determined by the need to replace imported raw materials for manufacturing military clothing with Ukrainian raw materials of industrial hemp and oilseed flax. The aim was to analyse the quality properties of bast raw materials and determine their potential for use in military uniforms. In the course of solving the set goals, the methods of complex analysis, synthesis, observation, measurement, comparison and generalisation of the obtained results and information were applied, as well as standard methods generally accepted in the light industry were implemented. It is noted that hemp cottonin and oilseed flax fiber, in contrast to other natural fibers, are more durable, resistant to abrasion, decay, and are characterised by sanitary, antistatic, hypoallergenic and antibacterial properties. It has been revealed that fabrics made of these fibers are durable, have high resistance to ultraviolet radiation, hold colour well, do not fade, etc. The academic paper analyses scientific studies on the use of this raw material for various types of military clothing, protective body armour, and gunpowder production. By determining the main properties of the bast raw materials under study, the possibility of using this raw material in some types of military uniforms was established. The main feature of the structure and components of the research was the systematic and comprehensive study of the quality properties of bast raw materials at all stages of its processing. It was proposed to use oilseed flax fibers and hemp cottonin instead of cotton fibers in fabrics for military purposes. This will reduce the state's material expenditures on the purchase of fabric for the defense sector and, at the same time, it will help bring the Ukrainian light industry to a new quality level and increase the competitiveness of Ukrainian manufactured goods in the global market. Knowledge of the properties of bast raw materials can help manufacturers improve the quality of fabrics for military purposes

Keywords: fibers; hemp; oilseed flax; properties; fabrics for military purposes

Introduction

The global market of the latest developments in modern military uniforms is evolving at a high pace, which creates unique challenges and opportunities for armies and manufacturers. This growing pace of development is explained by various factors, such as: the improvement of technologies, resulting in the rapid development of technical processes, in particular, information processes; the need to adapt to modern threats,

Suggested Citation:
Boyko, H., & Prokopchuk, V. (2024). Analysis of the properties of bast raw materials as a component of fabric for military uniforms. *Commodity Bulletin*, 17(1), 9-16. doi: 10.62763/ef/1.2024.09.

*Corresponding author

increase the efficiency and security of military personnel due to automated systems and protection against various types of threats. The relevance of this research paper is explained by the fact that the study of the properties of Ukrainian bast crops for the purpose of their use in the military sphere will enable light industry companies to produce their own raw materials and supply the armed forces with superior quality uniforms.

The scientific work of L.M. Degenstein *et al*. (2021) is focused on the development and use of smart textile materials for camouflage in the visible and infrared (IR) spectrums. They considered "smart textiles", which include fabrics and materials containing embedded electronic components, sensors, or other advanced technologies. These textile materials can adapt and respond to changes in the environment, making them very valuable for camouflage applications.

E. Delihasanlar & A.H. Yuzer (2020) described the use of three-dimensional metamaterials, which makes it possible to fine-tune the electromagnetic properties of the material, create absorber characteristics according to specific requirements. This technology can be applied in the defense sector and military purposes to achieve stealth, in telecommunications for signal absorption and interference reduction, as well as in the development of advanced wearable devices to enhance communication capabilities and sensors. The integration of textiles with three-dimensional metamaterials opens up promising opportunities for creating unique materials with special electromagnetic properties that influence various fields of technology and industry.

Thus, as noted by T. Lim *et al.* (2020), scientific achievements and developments in the field of improving and enhancing military uniforms are constantly advancing. P.I. Dolez *et al.* (2018), S.G. Kalan *et al.* (2019) studied the features of using various fiber components for military purposes as well as developed special emulsions and sprays providing fabrics with new protective properties: waterproof, chemical, heat and frost resistance, masking and making the military invisible, providing the ability to withstand high-speed impact and retain shape during and after impact, etc.

V.M. Durach & L.G. Nikolaychuk (2021) have found that the production of military clothing for the armed forces is a promising sector in the Ukrainian market; however, the quality standards for such products are very high. It is necessary to use high-quality, natural materials, mainly of Ukrainian origin for the successful implementation of the technological process of sewing military uniforms and providing the army with high-quality products.

Moreover, it is necessary to have Ukrainian raw materials of high quality in order to obtain selected, natural, environmentally friendly military fabrics. T.N. Holovenko *et al*. (2019) argue that hemp and oilseed flax are examples of rapidly renewable resources that are becoming increasingly relevant in the world since the interest in sustainable and renewable materials has grown. Growing hemp and oilseed flax does not require large amounts of pesticides or water, and their roots help improve soil quality. A particularly important advantage is that these plants are widespread on Ukrainian land and can become an alternative to imported raw materials. The entire potential of plants can be used for military purposes. R.B. Malabadi *et al*. (2023) have established that the fibers of these plants can be used for the production of natural, environmentally friendly and high-quality clothing, body armour, gunpowder; the seeds of these bast crops can be used as a nutritious, healthy ingredient in the military diet; straw and bast as a material for composites that can be used as a construction and insulation material for military dugouts; bast as a material for the production of fuel briquettes that can be used for stoves and homemade stoves that are widely used by the armed forces.

The purpose of the research was to study the qualitative properties of bast raw materials and evaluate the possibility of using them in the field of military equipment.

Materials and methods

Studies on this scientific work began in 2021 and continue to the present day. The first studies of bast fiber raw materials were conducted at the research laboratory of Kherson National Technical University, and in 2024 the main studies are being conducted at the laboratories of Khmelnytskyi National University. In accordance with the objectives of the research, a breeding variety of monoecious hemp "Glyana" was selected for the experiments, with the following properties: straw yield is 64.2 c/ha, seed yield is 16 c/ha, total fiber content is 32.7%, long fiber content is 24.7%, average fiber diameter is 1, THC content is 0.001%. The variety is relatively resistant to lodging, shedding, drought, and disease and pest damage at the level of 8-9 points. The oilseed flax variety "Orpheus" was selected for these experiments for its quality indicators: average fiber length of 45 mm and fiber content in the stem of 21%.

The first stage of the research was aimed at determining the physical and mechanical properties of the obtained fibers. The fiber was obtained from industrial hemp straw at "Hemp Bio Group" LLC (the city of Irpin, Kyiv region) on the "CannaSystems" decorticator (Canada, New Zealand, Australia), which simultaneously collects and processes industrial hemp stems (Boyko *et al*., 2020). It can be used both in the field and in stationary conditions. Oil flax fibers were obtained on a modernised flax tow scutching unit (KPAL) (modernisation of the KPAL was carried out according to the scientific work of H.A. Tikhosova (2011)) in the conditions of the Private Joint Stock Company (PJSC) "Flax Mill "Starosambirsky" (Ukraine). The fiber production process at the modernised KPAL consists of the following technological stages: raw material processing in the milling machine of the flax tow scutching unit, fiber separation in the carding machine after pressing and their subsequent cleaning on the coarse carding machine.

Due to the absence of standard methods for evaluating the quality of hemp cottonin and oilseed flax fibers, the methods for assessing the quality of fibers specified in the regulatory documents for cottonised flax and cotton were used to determine the main physical and mechanical parameters: TU 17 U 00306710.079 2000. Cottonin made of short flax fiber. Technical conditions, TU.U.05495816.005-2000. Cottonised linen fiber. Technical conditions (Holovenko, 2019), DSTU GOST 3274.5:2009 (ISO 4913-81). Cotton fiber. Methods of length determination (2009). The study of the physical and mechanical characteristics of oilseed flax fibers was carried out according to DSTU 5015:2008. Short flax fiber. Specifications (2008).

The set objectives were achieved by using the methods of theoretical and experimental studies, which make it possible to obtain a complete picture of the physical and mechanical structure of hemp cottonin and flax fiber and formulate practical conclusions and recommendations for changing their properties, for further implementation of this raw material in the production of military garments.

As a result of a critical analysis of the current regulatory documents, it was recommended to evaluate hemp cottonin and oilseed flax fibers according to the following physical and mechanical parameters: tensile load, tensile elongation, linear density, fiber length and actual moisture content. These indicators make it possible to classify fibers by functional purpose. The length of hemp and flax fibers was determined in accordance with TU 17 U 00306710.079-2000. Cottonin made of short flax fiber. Technical conditions (Holovenko, 2019). In order to determine the linear density of hemp cottonin and flax fiber, the method of determining this indicator by cleavage is applied. This method characterises not only the thickness of the fibers but also their ability to further split. Strands of fibers of a certain length are prepared and cut into 20 mm long sections for the study with a total weight in mg. The total number of fibers cut in this way is then counted. A whole fiber and a fiber split by less than half its length are each considered one fiber, and a fiber split by more than half its length is considered as many fibers as the number of ends it has been split into, and then the linear density is calculated using the formula:

$$T_p = 1000\frac{M_s}{L_s n}, \tag{1}$$

where T_p – linear fiber density, tex (g/km); M_s – weight of fibers, g; L – length of fibers, km; n – number of fibers in a strand, pcs.

Due to the lack of modern methods, existing textile laboratories propose to study the tensile properties of hemp and oilseed flax fibers according to the methodology given in GOST 3274.1-72 (ISO 3060-74, ISO 1973-76). Textiles. Cotton fibres. Determination of breaking tenacity of flat bundles (1976). The steaming of hemp cottonin fibers was carried out using a laboratory autoclave (the device was developed in the laboratory of Kherson National Technical University) under special conditions. In the laboratory conditions of Kherson National Technical University, samples of mixtures of natural (cotton, wool) and chemical fibers (lavsan, nylon, nitron) from 5% to 30% with oilseed flax fiber and hemp cottonin were made using a laboratory fiber mixer "Labormixer" (Hungary). The following modes were used to steam the bast fiber material, which are shown in Table 1.

Table 1. *Modes of steaming hemp cottonin*

Pressure		
heating, cooking – 1.2-7.1 kgf/cm^2	steaming – 1.8-2.3 kgf/cm^2	rinsing – 0 kgf/cm^2
Temperature		
heating, cooking – 90-160^{0}C	steaming – 140-121^{0}C	rinsing – 40°C
Duration of the operation		
heating, cooking – 30 min	steaming – 20 min	rinsing – 10 min

Source: *developed by the authors*

After steaming the hemp cottonin, according to the method described above, a second study was conducted to determine changes in the physical and mechanical properties of the test fiber. The main attention was paid to the relative tensile elongation of hemp cottonin.

Results and discussion

The main purpose of protective clothing is to provide optimal and comfortable conditions for people in difficult or extreme situations. Such clothing should be comfortable and practical, withstand contamination and heavy physical exertion, and effectively disguise the person using it.

In some situations, uniforms can save a soldier's life or help them complete a combat mission. The range of protective military clothing is growing every year. Time-tested fabrics are used for production, and new high-tech textile materials are being developed (Malbon & Carr, 2019). A range of military clothing and special-purpose equipment (weapon covers, backpacks, sleeping bags, tents, etc.) is made from various types of fabrics:

• Natural materials: wool, moleskin, "afghan" and profit, which are characterised by the highest level of comfort during wear. They provide breathability; they are resistant to dust; they absorb moisture and are easy to wash and maintain, but some of them wear out quickly, wrinkle and shrink after washing. Jackets, pants and overalls are often made of these materials, and cotton is used for thermal underwear.

• Synthetic fabrics: polyester and nylon, which are highly durable, elastic, lightweight, hydrophobic, windproof, and wear-resistant. Although these garments are compliant with and can be resistant to chemicals, they can melt and cause burns when burned. It is also prone to electrification and fading. It is recommended to dry such clothes at a low temperature and wash them in cold water. This type of fabric is used to make demi-season and summer clothing, as well as for backpacks, gloves, belts, bags, and cargo vests.

• Combined fabrics consisting of cotton and polyester and represented by such types as greta, raincoat, shirt fabric and ripstop. They combine the positive hygienic properties of natural materials with the high wear resistance of synthetic fibers.

Thus, modern textiles for military uniforms are mostly made of synthetic, artificial fibers and cotton fibers. For Ukraine, all these fibers are imported raw materials. In order to search for a Ukrainian raw material base for use in the defense sector, further studies in the present academic paper were conducted directly with natural raw materials – hemp cottonin and oilseed rayon fibers.

Fabrics made of bast fiber materials are characterised by high air permeability, which helps preserve oxygen in the structure of textile products. This prevents the development of anaerobic bacteria and their spread inside various types of clothing, knitwear and footwear. The use of such materials will not only provide high-quality products for the defense sector but also promote the use of Ukrainian raw materials.

Ensuring the high quality of materials for the defense industry is possible only if the quality of raw materials is constantly monitored at each stage of the technological process. The main feature of the structure and components of the studies to be conducted in this research work is the systematic and comprehensive study of the quality properties of bast raw materials at all stages of its processing. For this purpose, modern and updated methods of decortication of raw materials and methods for determining the physical, mechanical, sanitary and chemical properties of hemp and oilseed flax fibers were used.

Criteria are used that include length, thickness and breaking load to evaluate the suitability of fibers for further processing on spinning equipment. These parameters together determine the spinning ability of the fiber. For this purpose, the length, linear density, breaking load, elongation, and normalised moisture content were studied. Table 2 shows the physical and mechanical properties of the bast fibers under study.

Table 2. *Quality indicators of bast fiber components that can be used in protective clothing*

No.	Indicator	Oilseed flax	Hemp cottonin
1	Fiber length, mm	33-55	50-90
2	Relative breaking load, sN/tex	6-8	16.2-17.0
3	Relative tensile elongation, %	2.0-2.3	9.5-17.2
4	Linear density, tex	0.60-1.20	0.71-1.44
5	Standardised moisture content, %	8.5-15.0	12.0

Source: *developed by the authors*

The equipment of cotton processing enterprises using the carded spinning system utilises fibers with a linear density of 0.16-0.33 tex and a cross-sectional size of 15-19 microns (Slizkov *et al.*, 2007). As can be observed from Table 2, hemp cotton and oilseed flax fibers have a higher linear density, which exceeds the standard cotton fineness. The analysis of the data on the strength of hemp cottonin and oilseed flax fibers, which is one of the key indicators of their quality, presented in Table 2, makes it possible to conclude that the tensile load of these fibers is much higher than the maximum value of the tensile load of medium-fiber cotton fiber, which is 0.003 daN (Slizkov *et al.*, 2007). In addition, the relative tensile elongation of hemp cottonin, which is 9.5-17.2%, indicates that the manufacture of mold-resistant products from one hundred percent yarn is not recommended.

Taking into account all the advantages of this type of bast fiber components listed above, the main disadvantages of these fibers were highlighted in the present research. The main disadvantage of oilseed flax fibers is their low strength; therefore, it is not recommended to use them in 100% composition for yarns intended for military textiles. Hemp cottonin also has one significant drawback: due to its high fat content (up to 3%), it has a high tensile elongation; therefore, it is not recommended for use in form-resistant products.

In order to reduce the tensile elongation of hemp cottonin, the raw material was steamed in a laboratory autoclave. After steaming, repeated studies of the physical and mechanical properties of hemp fiber were carried out. The studies showed that the tensile elongation decreased from 17% to 7.3%, which was due to changes in the chemical composition of hemp cottonin, namely a decrease in the content of fatty acids to 1.0-1.2%.

The strength of oilseed flax fibers was increased by mixing this type of fiber with various natural and chemical fibers up to 30%. This stage was not aimed at suppressing the naturalness of this fiber but rather at improving its quality properties. Compositional combinations with other fibers up to 30% were also carried out with hemp cottonin. Table 3 shows the properties of fiber components that are proposed to be added in an amount of up to 30% to the mixture with bast fibers.

Table 3. *Quality indicators of fiber components added to the compounds*

No.	Indicator	Fiber components of compounds				
		cotton	wool	lavsan	nitron	nylon
1	Fiber length, mm	35-50	45-190	100	35-150	65-90
2	Relative breaking load, sN/tex	24-36	10-14	32-40	25-34	35-46
3	Relative tensile elongation, %	7.0-9.0	20.0-67.0	43.0-55.0	25.0-31.0	45.0-65.0
4	Linear density, tex	0.66-0.22	0.20-5.00	0.55	0.11-2.50	0.40
5	Standardised moisture content, %	8.5	18.3	1.0	5.0	1.0-2.0

Source: *developed by the authors*

All the fibers listed in Table 3 had a positive effect on the resulting yarn to one degree or another, in different percentages in a mixture with oilseed flax and hemp cottonin fibers. According to the research results, after all these components were added at 5%-30% to oilseed flax fibers and hemp cottonin, it was found that the yarn strength increased, elongation decreased (in blends with hemp cottonin), spinning properties improved, and all the disadvantages of bast fibers were balanced, thereby increasing the possibility of using these mixed yarns in fabrics for military uniforms.

Thus, having data from previous studies of both raw materials and yarns for military fabrics, it is possible to compare them with existing studies on the use of bast fibers in military garments. There aren't many works like this one. It is evident from a comparison with the research by the Ukrainian scientists N.V. Ostapenko and L.G. Nikolaychuk that the former provides a more detailed description of the raw materials' qualities, highlighting both the benefits and drawbacks of the fibers and utilising a variety of techniques to address the shortcomings of the fibers under study. On the other hand, the research conducted by scientists N.V. Ostapenko *et al.* (2021) and L.G. Nikolaychuk (2021) is more focused on the known facts about hemp fiber and goes into great detail about the legal aspects of growing this kind of raw material. The joint work of the US Army Research, Development and Engineering Center and the Department of Defense is more informative in this area (Military uniform fabric produced with hemp fibers, 2021). According to the data of their study, a fabric made of hemp fibers for marines was produced and its properties were compared with those of cotton fiber fabric, which has been used in this area since 2022. The publication also highlighted the advantages of hemp fabric and the possibility of replacing cotton with hemp fiber in this type of fabric for military uniforms. However, the scientific work included studies with 100% use of hemp fibers in yarn for marine uniforms without indicating the disadvantages of the fiber and their elimination.

Scientists from many countries are studying and improving the properties of protective textiles for the armed forces. Many developments are devoted to special coatings for military textiles that provide unique protective properties (Pimenta *et al.*, 2021). For instance, scientists at the US Army Research, Development and Engineering Center, Natick, Massachusetts, Q.T. Truong & N. Pomerantz (2018) were engaged in improving the properties of military fabrics by applying an omniphobic coating that increases the durability of clothing, helps to self-clean, protects the armed forces from getting wet and protects them during missions in chemically and biologically contaminated environments. Scientists from the Federal University of Santa Catarina, Brazil, were engaged in the improvement and development of new technological processes in the production of military textiles (Steffens *et al.*, 2019). The study of the water-repellent and waterproof properties of protective textiles made of various fibers and materials for the purpose of conceptualising the distribution of special materials for different types of troops was carried out by C. Loghin *et al.* (2018) from the Defense Clothing and Textiles Agency, UK. The well-known company OTEX Specialty Narrow Fabrics (2023) is one of the largest manufacturers in the United States that produces high-performance textiles for the military with new fibers such as Kevlar, Nomex, Spectra, etc. using new technologies developed by leading state institutes.

I.I. Shuvo & P.I. Dolez's (2023) research focuses on the application of several unprocessed natural and synthetic materials in military apparel. The use of bast fibers in this kind of industry has not been the subject of many studies, which makes this area promising for further consideration. Some studies in this area have focused on the development of a homogeneous hemp fiber fabric with significant performance advantages over conventional textile fabrics intended for the Marine Corps (Military uniform fabric produced with hemp fibers, 2021). This fabric will have significant performance benefits, lower cost, lighter weight, and will be stronger, more comfortable, and more environmentally friendly than the existing option. Additional desirable attributes of the fabric will be the ability to provide protection against vectors, such as protection against insects, improved flame retardancy, that is, the ability to self-extinguish, and camouflage protection that exceeds current requirements for visual and near-infrared rays. Chinese scientists have also been working in this area since China is the largest supplier of hemp fiber to European countries (Zhang *et al*., 2018; Liu *et al*., 2019). Ukrainian scientists have also made a major breakthrough in developing an improved variety of industrial hemp called "Sofia" (Ukrainian scientists have developed a new variety of hemp, which can be used to make body armor for the military, 2022). This type of plant will be used in the production of gunpowder, as well as raw materials for ropes and parachutes. After all, these fabrics are lighter than synthetic Kevlar, which has been used since the 60s to make bulletproof vests, which means that the armor plates that are made of them will withstand the impact of armor-piercing bullets. Ukrainian scientists such as L.V. Krasnyuk *et al. (*2019), V.M. Durach & L.G. Nikolaychuk (2021), O.V. Chepeliuk *et al*. (2021), in cooperation with specialists in production technologies, have developed new and improved traditional methods of manufacturing fabrics from natural fibers for the needs of the modern defense industry. The aforementioned techniques and technologies are all typically predicated on the application of unique solutions along with the utilisation of synthetic and artificial fibers. The drawbacks of all of these methods include high production costs, poor hygienic and sanitary standards, breathable fibers, and a deficiency of natural ingredients. As a result, there is a growing need to find high-quality natural components for the manufacturing of protective fabrics.

No scientific papers on the use of oilseed flax fibers for military fabrics were found. Therefore, based on the literature studies, it was concluded that this scientific area requires further research in order to more accurately predict the use of flax fibers in fabrics for military purposes. The use of such materials will help provide the defense industry with high-quality products as well as support Ukrainian raw materials.

Conclusions

Ensuring high quality materials for the defense sector is possible only if innovations are introduced, own resources are used and quality control is ensured at every stage of the technological process. For this purpose, modern and updated methods of decortication of raw materials and methods for determining the physical, mechanical, sanitary and chemical properties of raw hemp and oilseed flax were used in the research.

The analysis of literary sources has enabled the identification of primary scientific directions in improving military fabrics, indicating that the main materials for military gear are cotton and synthetic fabrics. Additionally, it has been pointed out that Ukrainian textile industry enterprises depend on imported raw materials. The fibers of oilseeds like hemp and flax, which are widely grown in Ukraine, may serve as the basis of the natural raw material base. A thorough examination of these raw resources' use patterns was done in order to ascertain their quality attributes.

The results of the experimental studies undertaken allowed for the identification of both benefits and drawbacks in the features of bast crops. Different natural (cotton, wool) and chemical (nylon, nitron, polyester) fibers were added in varying percentage ratios (5-30%) to the combination containing bast fibers in order to highlight the benefits and lessen the drawbacks. Moreover, steam treatment was conducted under certain regimes for hemp cottonin in order to reduce the relative elongation at break from 17.2% to 7.3%. Ukrainian raw materials, such as oilseed flax fibers and hemp cottonin, will allow for improving the quality and reducing the cost of clothing for armed forces' needs.

Therefore, conducting scientific research will reduce the state's material expenditures for purchasing quality environmentally friendly materials for the defense complex while simultaneously promoting the advancement of Ukrainian light industry productions to a new qualitative level, enhancing the competitiveness of Ukrainian products in the global market.

Further studies of the present scientific work will be directed towards examining the obtained fabrics for their use in various types of military equipment. As of 2023, the utilisation of domestic raw resources for Ukraine represents a highly promising direction in the light industry, especially when aimed at improving the properties of protective textiles intended for military equipment.

Conflict of interest

None.

Acknowledgements

We would like to express our gratitude for the invaluable technical assistance provided in obtaining oilseed flax fibers and hemp cotton to the following companies: "Hemp Bio Group" LLC (Irpin, Kyiv region); "Flax Mill "Starosambirsky".

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Аналіз властивостей луб'яної сировини як компонента тканини для військового обмундирування

Галина Бойко

Кандидат технічних наук, доцент
Херсонський національний технічний університет
29016, вул. Інститутська, 11, м. Хмельницький, Україна
https://orcid.org/0000-0001-8773-5525

Владислав Прокопчук

Аспірант
Херсонський національний технічний університет
29016, вул. Інститутська, 11, м. Хмельницький, Україна
https://orcid.org/0009-0006-3694-3029

Анотація. Актуальність даної наукової роботи визначається потребою заміни імпортованої сировини для виготовлення військового одягу на українську сировину технічних конопель та льону олійного. Метою було провести аналіз якісних властивостей луб'яної сировини та визначити її потенціал для використання у військовому обмундируванні. В процесі вирішення поставлених завдань було застосовано методи комплексного аналізу, синтезу, спостереження, вимірювання, порівняння та узагальнення отриманих результатів та інформації, а також реалізовано стандартні, загальноприйняті у галузі легкої промисловості методики. Зазначено, що конопляний котонін та волокно льону олійного, на відміну від інших натуральних волокон, більш міцні, стійкі до стирання, гниття, в них переважають санітарно-гігієнічні, антистатичні, гіпоалергенні та антибактеріальні властивості. Визначено, що тканини з цих волокон довговічні, мають високий опір ультрафіолетовому випромінюванню, добре тримають фарбування, не вигорають та не вицвітають тощо. Проаналізовано наукові роботи, де вивчалися застосування даної сировини для використання різних видів військового одягу, захисних бронежилетів, у виробництві пороху. За рахунок визначення основних властивостей досліджуваної луб'яної сировини було встановлено можливість використання даної сировини в деяких видах військового обмундирування. Головна особливість структури та складових досліджень полягали у систематичному та комплексному вивченню якісних властивостей луб'яної сировини на всіх етапах її переробки. Було запропоновано замість бавовняних волокон в тканинах військового призначення використовувати волокна льону олійного та конопляний котонін. Це дасть змогу зменшити матеріальні витрати держави на закупівлю матеріалів для оборонного комплексу та водночас сприятиме виведенню українських виробництв легкої промисловості на новий якісний рівень, підвищить конкурентоспроможність українських виробів на світовому ринку. Знання властивостей луб'яної сировини може допомогти виробникам підвищити якість виробництва тканин для військового застосування

Ключові слова: волокна; коноплі; льон олійний; властивості; тканини військового призначення