

УДК:543.34:543.422.3

**THE EFFECT OF EXTRUSION PARAMETERS ON THE DISPERSITY OF
WILD BARLEY CELLULOSE POWDERS**

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Abstract. This study is dedicated to investigating the influence of extrusion parameters on the dispersity of technical cellulose powders derived from wild barley (*Hordeum murinum*). In the course of the research, the effects of screw rotation speed, temperature regime, and raw material moisture content on the particle size of the final product were analyzed. The experiments established that mechanochemical processing using a planetary roller extruder makes it possible to modify the structure of cellulose fibers and obtain highly dispersed powders with particle sizes ranging from 40 to 60 microns. It was confirmed that the resulting powders increase the hardness of rubber composites while preserving their elastic properties, which indicates their potential for use as effective fillers in industrial applications.

Keywords. Wild barley (*Hordeum murinum*), Cellulose powder, Dispersity, Extrusion, Screw speed, Planetary roller extruder, Mechanochemical processing, Particle size, Rubber composites.

Currently, controlling the physicochemical properties of microcrystalline and powdered celluloses derived from plant-based raw materials is one of the most pressing issues. Wild barley (*Hordeum murinum*), as a cellulose-rich plant, offers an opportunity to expand the local raw material base. The dispersity (particle size) of cellulose powders is a key indicator that determines their effectiveness in the paper industry, pharmaceuticals, and the production of composite materials.

Typically, the main difference between powdered cellulose and microcrystalline cellulose or nanocellulose is its lower degree of crystallinity and higher degree of polymerization [2]. Furthermore, certain types of powdered celluloses may contain significant amounts of lignin, resins, fats, and mineral components [3]. The distinctiveness of powdered cellulose is attributed to the combination of the aforementioned properties, which are impossible to achieve through chemical processing alone. For this reason, finding methods that allow for the production of powdered cellulose while preserving its degree of polymerization and crystallinity is currently considered highly promising.

Powdered celluloses are obtained by grinding a cellulose mass that is either pure or contains impurities (lignin, resins, fats, etc.). If necessary, additional stages of chemical and thermal treatment can also be applied. The applications of the final powdered product are determined by its physicochemical and structural properties.

Oxidative delignification of plant raw materials using hydrogen peroxide is recognized as one of the promising methods for obtaining cellulose semi-finished products. Cellulose intended for chemical processing, such as nitration, must possess specific properties and contain at least 97% α -cellulose.

Cellulose isolated from the wild barley plant is distinguished from other plant species by its chemical composition and fiber structure. Extrusion technology is one of the most effective methods for obtaining high-quality powders with a specific dispersity from this raw material. The extrusion process applies both thermal and mechanical force to the cellulose chains, completely altering the fiber structure and converting them into micron-sized powders.

During the process, the most important factor affecting the degree of dispersity—that is, the fineness of the particles—is the screw rotation speed. As the screw speed increases, the shear stress generated inside the extruder cylinder intensifies. This mechanical force breaks the bonds between the crystalline regions of the cellulose fibers and significantly reduces the average particle diameter. Experiments show that when the rotation speed reaches a certain upper limit, the quantity of fractions ranging from 40 to 60 microns in the powder is maximized.

The moisture content of the raw material indirectly affects dispersity. In a low-moisture environment, the frictional force inside the extruder increases, leading to greater abrasion of the fiber surfaces and, consequently, the formation of a finer powder. Conversely, high moisture content plasticizes the cellulose, reducing the efficiency of

its mechanical grinding. The pressure of the product exiting through the die is also important, as the cellulose mass extruded under high pressure undergoes sudden expansion upon release into the atmosphere. This process helps the particles become even finer and acquire a porous structure.

In this study, technical cellulose samples isolated from the wild barley plant (*Hordeum murinum*) were used as the initial raw material. The processes of grinding the cellulose fibers into a powder and their mechano-chemical treatment were performed in a planetary roller extruder. The extrusion process was monitored at a temperature range of 90-95°C across all zones of the device. A stable thermal regime (temperature) for the process was maintained using liquid thermostats integrated into the technological line. Depending on the extruder design and the number of zones, the residence time of the material in the working cylinder (extrusion duration) was set between 3 and 15 minutes. This allows for controlling the degree of dispersion of the cellulose composition over a wide range.

In the study, the process of isolating cellulose from wild barley straw was conducted in an alkaline solution with a concentration of 2.0-3.5% by mass, at a hydromodule of 1:10, in a medium containing 0.2% by mass of hydrogen peroxide and 0.3% by mass of a surfactant (Sintanol ALM-10). The digestion process was carried out at a temperature of 93°C for 80-110 minutes, and to enhance the system's reactivity, a thermo-physico-chemical activation step was introduced 25 minutes after the start of the treatment. The thermo-physico-chemical activation process was performed in several ways, including ultrasonic treatment of the digestion solution along with the cellulose-containing mixture in a I/100-6/4 apparatus for 8 minutes, and mechanical destruction of the material, with a moisture content of 85-92%, in a roller leveler consisting of a metal base and a pressure roller.

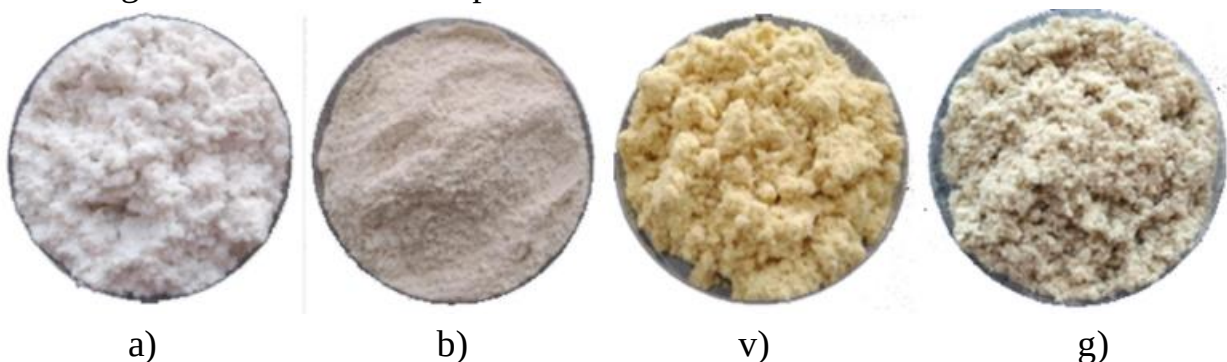


Figure 1. Cellulose-containing materials after being processed according to the proposed technology, in which a planetary roller extruder was used as the thermo-physicochemical activation device: a) cotton; b) flax; c) alfalfa; d) wild barley.

After the soda cooking process was completed under thermo-physicochemical activation conditions, the resulting cellulose pulp was washed using press filtration until the medium's hydrogen ion index (pH) became neutral.

Research has determined that the intensive processing of wild barley straw in a planetary roller extruder leads to an increase in α -cellulose content and a decrease in extraneous components. The resulting cellulose powders have been confirmed to significantly increase the hardness of rubber composites while maintaining their elastic properties, which enables the creation of an effective filler for next-generation materials.

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