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Method for Refining Terry Products Using Biotechnology

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Abstract. A rational choice was made for the recommendation for implementation at "Rechitsa Textile" LLC technology of processing terry linen cloths using silicone softeners and enzyme-containing compositions based on them. As a result of a study of the process of biochemical processing of linen terry cloths using individual silicone emollients and enzyme-containing compositions produced by Ferment LLC, a scheme for biochemical processing of textile materials in a periodic manner was established and recommended for practical use. The technology gives both bulk and soft neck to terry products, while increasing the physical, mechanical and hygroscopic properties, allows to preserve the ecological purity of production and the environment since enzymes are 100% biodegradable.

INTRODUCTION

In the Republic of Belarus, a number of enterprises produce cotton terry household products, which are distinguished by a wide assortment spectrum, bright colors, and resistant to repeated washing. When choosing this product, the consumer primarily prefers the organoleptic and tactile characteristics of the product. According to this criterion, domestic products are inferior to imported goods due to insufficient softness and bulk.

This drawback is most clearly manifested when flax fiber is added to the yarn – the rigidity of the products is significantly increased. This is due to the natural properties of flax: according to its chemical composition, it contains 5% lignin [1].

The leader of the Belarusian market of manufacturers of terry products is Rechitsa Textile LLC. One of the reasons for the rigidity of the products of this manufacturer is the lack of final finishing of terry cloths and finished products from them.

Known classical methods of fabric softening, which create an effect through the use of various types of silicone emollients [2]. Their significant drawback is the fragility of the achieved result and its instability to household treatments: during the washing process, the silicone emollient is washed out of the fiber and the effect achieved during finishing is noticeably reduced during the subsequent use of the products [3].

Currently, methods of softening textile materials from cellulose fibers using bioprocessing are relevant. The use of biotechnological methods of finishing textile materials involves the use of effective biocatalysts – enzymes for the implementation of certain physical and chemical processes in "mild" conditions [4,5]. Thus, the development of rational schemes for finishing textile materials from cellulose fibers in the presence of enzymes that improve the consumer characteristics of finished textiles in milder, more benign conditions, and improve environmental performance is an urgent scientific and technical task in the development of textile finishing production.

In most cases, domestic textile enterprises use imported drugs in the final softening technologies, which leads to an increase in the cost of the production process, and, accordingly, the finished product. In the Republic of Belarus, relatively recently, Ferment LLC entered the textile auxiliaries market, offering a wide range of textile chemicals, including silicone emollients and enzyme compositions for processing cellulose-containing textile materials [6].

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The purpose of the work is to select a rational technology for finishing terry linen cloths and products made from them using silicone softeners and enzyme-containing compositions based on them for recommendations for implementation at "Rechitsa Textile" LLC.

MATERIALS AND METHODS

The object of the study is samples of flax-containing terry cloths produced by "Rechitsa Textile" LLC (Republic of Belarus) art. 6c03.513 with an areal density of 450 g/m^2.

To process the products, we used preparations RG-NR520, RG-G9609/600, RG-G9609/600 + C 300 from Ferment LLC (Republic of Belarus) and Allfalin from Clariant (Switzerland), the characteristics of which are presented in the Tab. 1.

The subject of research is the technological process of the final softening finishing of linen-containing terry cloths with silicone emollients and enzyme-containing compositions in a periodic manner. A periodic method of material processing was studied according to traditional technology [7-9] and according to new schemes (Scheme 1, Scheme 2). The sequence of processing steps is shown in Tab. 2.

TABLE 1. Characteristics of the drugs used

Drug name	Characteristics
RG-NR520	Wetting agent
RG-G9609/600	Hydrophilic Microsilicone Emulsion
Enzitex C	Neutral cellulase (CMC), activity 10,000 u/g, optimal conditions for pH action from 5.5 to 6.5, operating temperature 40-60°C.
RG-G9609/600+C 300 u/g	Hydrophilic microsilicone emulsion with an enzyme preparation "Cellulase" with an activity of 300 u/g
Allfalin	Silicone softener

TABLE 2. Scheme of processing linen terry cloths

Conventional bioprocessing		Scheme 1	Scheme 2
Wetting in RG-NR520 (c = 3 g/l; t = 30^{o}C; τ = 10 min) ↓			
Enzyme wash with Enzitex C (c = 3%; t = 40^{o}C; τ = 40 min; pH = 5)	Enzyme wash with Enzitex CKP (c = 3%; t = 40^{o}C; τ = 40 min; pH = 5)	Wash with composition RG-G9609/C300 (c = 20 g/l; t = 40^{o}C; τ = 40 min; pH = 5)	Washing RG-G9609/600 (c = 20 g/l; t = 40-50^{o}C; τ = 20 min; pH = 5)
↓	↓	↓	↓
Rinsing	Rinsing	Spinning	Spinning
↓	↓	↓	↓
Enzyme deactivation (t = 90^{o}C; τ = 5 min)	Enzyme deactivation (t = 90^{o}C; τ = 5 min)	Drying (t = 20^{o}C)	Drying (t = 20^{o}C)
↓	↓	↓	↓
Finishing Allfalin (c = 20 g/l; t = 40-50^{o}C; τ = 20 min; pH = 5)	Finishing RG-G9609 (c = 20 g/l; t = 40-50^{o}C; τ = 20 min; pH = 5)	Mechanical friction	Mechanical friction
↓	↓		
Spinning	Spinning		
↓	↓		
Drying (t = 20^{o}C)	Drying (t = 20^{o}C)		
↓	↓		
Mechanical friction	Mechanical friction		

The most important quality indicators of terry cloths are soft, filled neck and hydrophilicity, therefore, the following qualitative characteristics were selected for the study:

- for assessing the neck of the canvases – the thickness of the, total porosity, drape by the disk method;
- for the assessment of hygienic properties – air permeability, water absorption.

The total porosity of the terry cloth R, % shows what part of the tissue volume is the total volume of all pores between the threads and is calculated by the formula:

$$R = 100 - \frac{m \cdot \gamma \cdot 10^5}{L \cdot B \cdot b} \quad (1)$$

where m – mass of the fabric, g;
γ – average density of the fiber substance, mg / mm3;
L – length of the fabric, mm;
B – width of the fabric, mm;
b – fabric thickness, mm.

RESULTS AND DISCUSSION

The results of measuring the qualitative characteristics of linen terry products after biological treatment with the studied preparations are presented in Fig. 1-3. The control sample is taken as a terry linen-containing cloth produced by "Rechitsa Textile" LLC without final softening finishing.

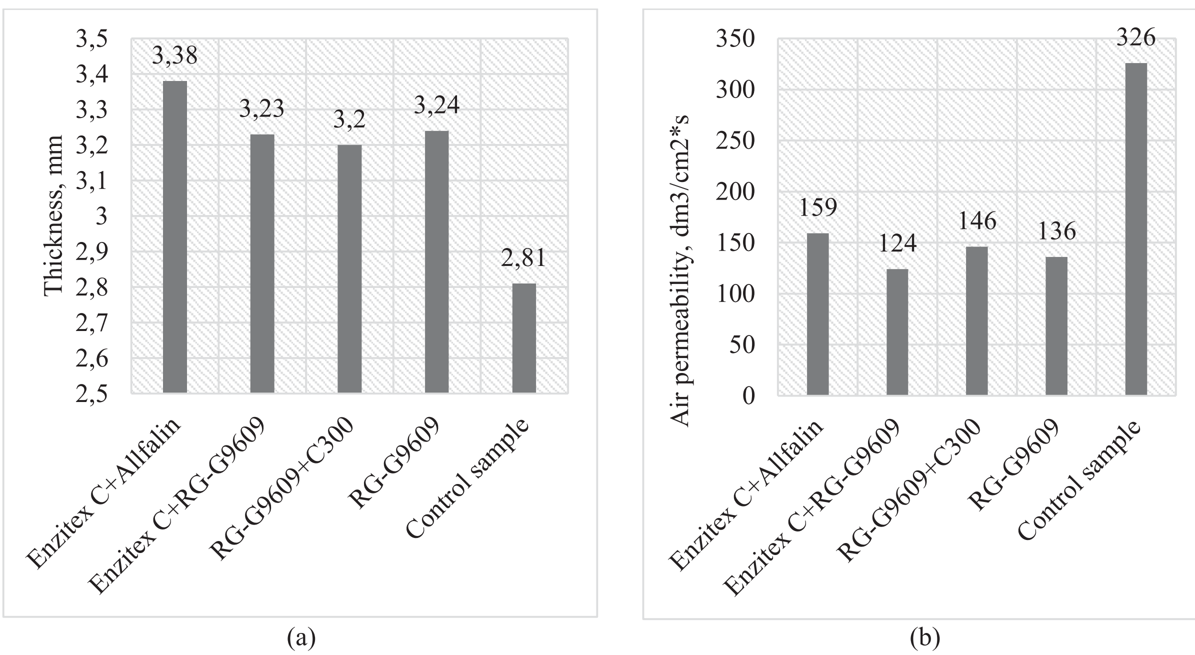

FIGURE 1. Assessment of: (a) thickness of samples; (b) air permeability of samples

According to the studies, the thickness of the processed fabrics increased in comparison with the control sample by 13.8%, which is associated with the shrinkage of the material during the biochemical processing, as a result of which the diameter of the yarn increased and the air spaces in the weave overlapped [10]. This phenomenon is confirmed by the histogram of air permeability, the values of which decrease in inverse proportion to the thickness values by an average of 55% compared to the control sample.

The total porosity of the materials after final finishing also decreases (Fig. 2), which confirms the indicator of air permeability. Changing the values of these indicators in aggregate allows you to give the products a more aesthetic appearance, "fluffy" volumetric neck.

After finishing, the water absorption indicator exceeds the control by 28% on average. The highest value is taken by the sample treated according to Scheme 1 with the hydrophilic enzyme-containing composition RG-G9609/600 + C 300 U/g. This is due to the fact that after exposure to the enzyme, the cellulase destroys the primary wall of cellulose fibers, which helps to remove various impurities from the fiber. Thus, the textile material acquires increased water absorption capacity and hydrophilicity.

Figure 3 shows a histogram of the drape coefficient of the samples under study. Drapability (the ability of textile materials to form soft, rounded folds) is a fundamental property in softening textiles. This property depends on the mass and flexibility of the material, its structure, natural and elastic properties of fibers, the type of finishing of the material or product [11]. When analyzing histograms, it should be borne in mind that the higher the drape coefficient, the more rigid the fabric, and vice versa. And also the more the number of folds, the better the tissue under study is draped. All processing methods lead to softening of the material – the coefficient of drape is 10% lower compared to the control sample, which confirms the visual and tactile assessment of experts. The sample treated with the composition RG-G9609 / C300 has the lowest drape coefficient and a greater number of folds.

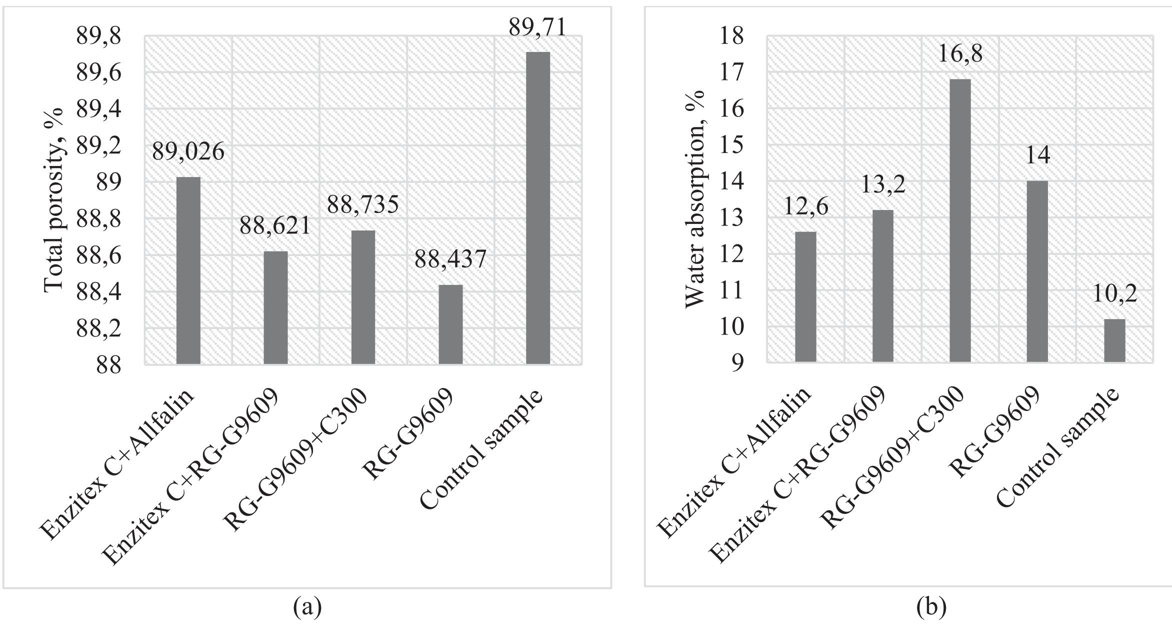

FIGURE 2. Assessment of: (a) the total porosity of samples; (b) water absorption of samples

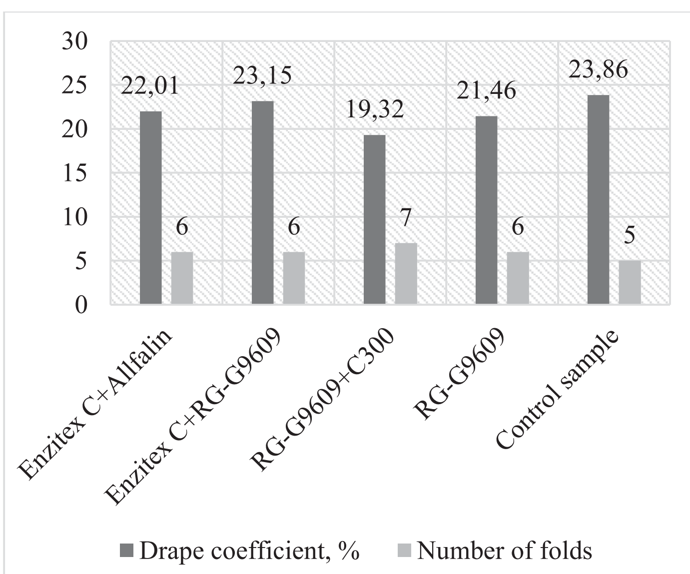

FIGURE 3. Assessment of the drape of the samples

The quality characteristics of the materials obtained were also assessed by the visual perception of finished products and by the tactile parameters of the sample. On the basis of an expert assessment by a group of respondents, consisting of specialists from the enterprise "Rechitsa Textile" LLC and employees of specialized departments of the educational establishment "Vitebsk State Technological University", a canvas processed according to Scheme 1 was chosen as the best sample. Texture, increased bulk and crimp of the pile threads of the product after processing (Fig. 4.5).

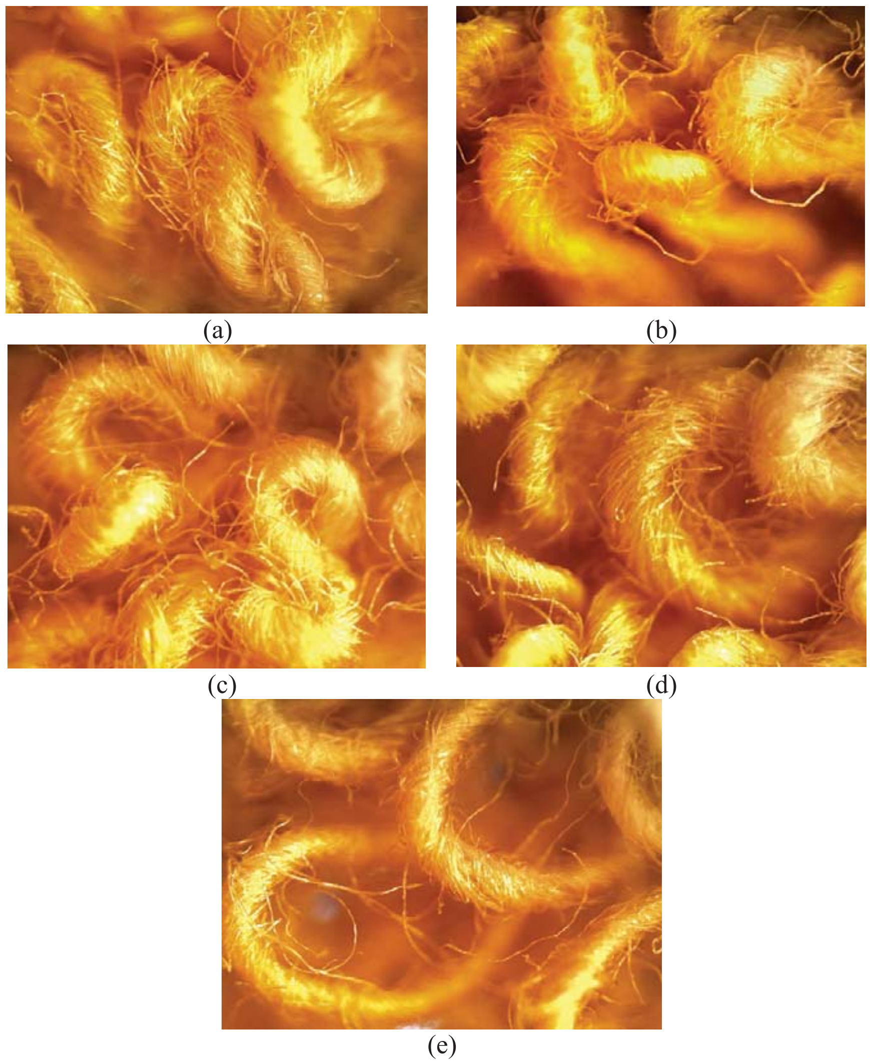

FIGURE 4. Micrographs of pile threads of terry cloths: (a) Enzitex C + Allfalin; (b) Enzitex C + RG-G9609; (c) RG-G9609 / 300 (scheme 1) (d) RG-G9609 (scheme 2) (e) before processing

FIGURE 5. Photographs of the surface of terry cloths: (a) before processing (b) Enzitex C + Allfalin

CONCLUSION

As a result of a study of the process of biochemical processing of linen terry cloths using individual silicone softeners and enzyme-containing compositions produced by Ferment LLC, a scheme for biochemical processing of textile materials in a periodic manner, shown in Figure 6, was established and recommended for practical use.

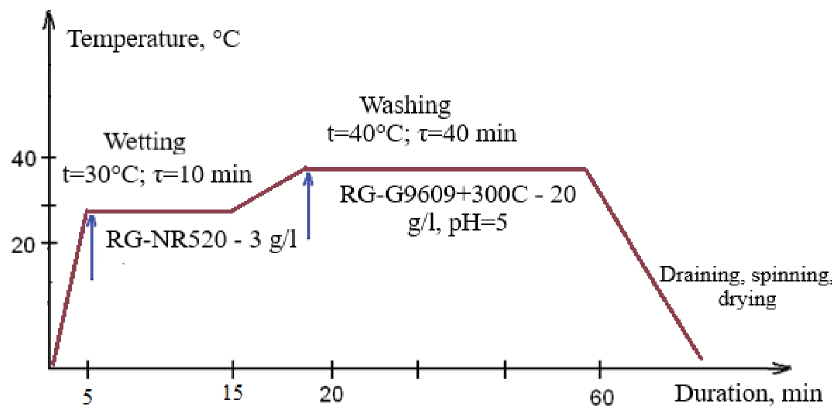

FIGURE 6. Technological diagram of the periodic method of processing linen terry products

The advantages of the developed technology:

• giving terry products an increased bulk and soft neck, while increasing the physical, mechanical and hygroscopic properties;

• no negative impact on the ecological situation of production and the environment, since enzymes are 100% biodegradable [12];

• no destructive effect on the fiber-forming polymer - cellulose;

• reducing the cost of finished products due to the possibility of using Belarusian drugs produced by LLC "Ferment", processing at low temperatures (40-50°C) in a neutral alkaline medium (pH = 5).

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