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Influence of pectinase enzyme Beisol PRO on hemp fibres retting

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Abstract. The analysis of hemp cultivation and usage trends in the world and Europe shows that hemp cultivation and processing in Latvia has good perspectives. This paper presents the results of a first study about the usage of pectinase enzyme Beisol PRO (4% water solution) for Latvian hemp sort "Purini" retting at different time and temperatures conditions and treatment influence on obtained fibres quality. Gravimetrical examination of the quantity of fibres and sheaves after retting, physical-mechanical tests and TG analysis, colour properties, and selected samples microscopy evaluation show that enzyme treatment is not significant for fibre separation from stem as well as TG characteristics at investigated time and temperature conditions. Use of pectinase enzyme for hemp retting in some cases increases tensile strength of fibres and causes changes of colour characteristics.

Key words: hemp, pectinase enzyme, retting, fibres quality.

1. INTRODUCTION

Industrial hemp has been grown in Europe for many hundreds of years. Today hemp is a niche crop, cultivated on 10 000 to 15 000 ha in the European Union (EU) [1]. The rapid increase of hemp fibre use in EU is connected with demands on carbon and glass fibres substitution by eco-friendly, biodegradable materials for car production [2]. In 2012, 350 000 t of wood and natural fibre composites were produced in EU [3]. The most important application sectors are constructions (decking, siding, and fencing) and automotive interior parts. Between 10–15% of the total European composites market is covered by wood-plastic composites (WPC) and natural fibre composites (NFC). The total volume of composites for the automotive industry in Europe in 2012 was 260 000 t of WPC and 90 000 t of NFC products [3].

Hemp fibres are interesting as reinforcements for composites production. They are light, with high physico-mechanical properties, eco-friendly, with good utilization possibilities [1]. Because of its unique properties, particularly its environmental benefits and the high yield of fibres, hemp is a valuable crop for the bio-based economy [4]. Bio-based polymers produce at least 247 companies in 363 locations around the world. Current producers of bio-based polymers estimate that production capacity will reach nearly 12×10^6 t in 2020 [5].

Bast fibres are separated from the natural gum and woody matter of the plant stalk in the retting process. The retting processes are based on combined action of bacterias and moisture. Old methods are dew (stems are exposed on grass field), pool, and stream (the bundles of plants are submerged in stagnant or flowing water) retting [6]. Recently, a new enzymatic scouring process known as 'bio-scouring' is used in textile wet-processing with which all non-cellulosic components from native cotton are removed [7]. Retting with enzymes allows a more controlled degradation of the fibres and a reduction of effluents [6]. The use of enzymes in the textile chemical processing is rapidly gaining globally recognition because of their non-toxic and eco-friendly characteristics with the increasingly important requirements for textile manufacturers to reduce pollution in textile production [7].

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Pectinases are a big group of enzymes that break down hectic polysaccharides of plant tissues into simpler molecules [8]. Pectinase enzyme can be used for various industrial applications including extraction and clarification of fruit juices, processing of cotton fabric in textile industry, bleaching of paper, removal of pectic waste waters and maceration of tea leaves [8,9]. Steam pretreatment is one of the most efficient pretreatment technologies [10] for partial removal of substances from the centre lamella. After the treatment the fibres can be easily separated from the stem using a subsequent mechanical routine [11]. Enzyme retting via the pectinases is capable for producing consistent high-strength renewable fibres with variable fineness values for use in novel resins, developed for natural fibre agricultural feedstock composites [12].

The analysis of hemp cultivation and usage trends in the world and Europe shows that hemp cultivation and processing in Latvia has good perspectives [13]. However, hemp fibre production resumed after nearly a century long break, therefore the farmers do not have enough information and experience. At the same time, we should think about hemp fibre producing possibilities in Latvia to obtain product with higher added value [2].

In a previous study the pectinases enzyme Beisol PRO was used in bioprocessing of the raw linen cloth before dyeing [13]. The first results about pectinase enzyme usage for hemp retting are presented in this work.

2. MATERIALS AND METHODS

The rough green hemp stalks sort "Purini" were obtained from Agriculture Science Centre of Latgale, Latvia (harvest – autumn 2012) [14].

Hemp stalks retting was realized in pectinase enzyme Beisol PRO (CHT BEITLICH Gmb, Germany) 4% water solution (bath ratio M = 50) at two temperatures: 25 °C (I) and 55 °C (II), during 2, 5, 24, or 48 h. (Notation (II_24) means that the temperature was 55 °C and duration was 24 h). A separation of fibres from the stalk after roll influence was done manually.

A quantity of fibres and sheaves after conditioning of untreated and enzyme treated fibres were fixed gravimetrically. For physical-mechanical tests the pulling device Instron (Instron, UK) according to LVS EN ISO 5079:2001 was used.

Selected samples microdots were fixed with scanning electron microscopes (SEM) (FEI Quanta 200, magnification × 500).

Thermogravimetric analysis (TG) was performed using DSC (Mettler Toledo Inc., Switzerland) according to ASTM E2040-08 (2014).

The colour characteristics of untreated and enzyme treated hemp fibres were compared with the use of colour differences similarly to [15]. Colour coordinates were evaluated in the RGB system with Easy Colour QA device, which allows determining L*, a*, and b* values in CIELab-76 colour space (a* and b* are coordinates of the colour vector in a colour space, L* is lightness). The lightness difference (ΔL), colour difference (ΔE), chroma (C), and hue (H) was calculated following ISO 105-JO3:2010.

3. RESULTS AND DISCUSSION

In the analysis of the results of experiments (Fig. 1) about retting influence of the enzyme on mass ratio fibres, sheaves and dust is not observed. Maximum amount of fibres (32.0 wt%) is obtained without enzyme treating. Small decrease of fibres quantity (31.3 wt%) is observed after 5 h enzyme retting at both temperatures. It can be explained by small enzyme influence on hemp fibres additional substances.

The content of hemp fibres after retting varies between 20 and 35 wt%, according to information from literature [16,17].

The SEM microdots (Fig. 2) confirm differences of untreated and enzyme retted fibres. The enzyme affects the smaller bundles formation of hemp fibres. Observable increase of tensile strength (about 1.5 times) for samples I_48, II_5, and II_48 as well as decrease of the tensile elongation (about 1.8 times) for samples I_2 and II_48 are determined (Table 1).

TG analysis pointed at insignificant enzyme treatment behaviour on temperature influence on hemp fibres.

Hemp samples treated with enzyme (Fig. 3) give mainly greenish and yellowish colour shade. The variables of enzyme retting time and temperature contribute to differences in the lightness, redness–greenness, and yellowness–blueness of the resulting fibres. Values of lightness (L*) of treated samples are lower than for

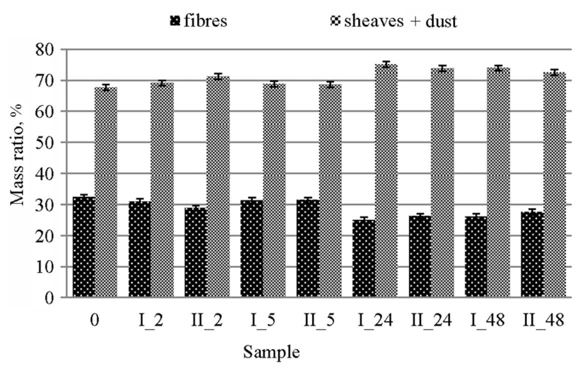

Fig. 1. Comparison of mass ratio fibres/sheaves + dust fractions separated for untreated (0) and pectinase treated (I_2–II_48) hemp stem.

A B C

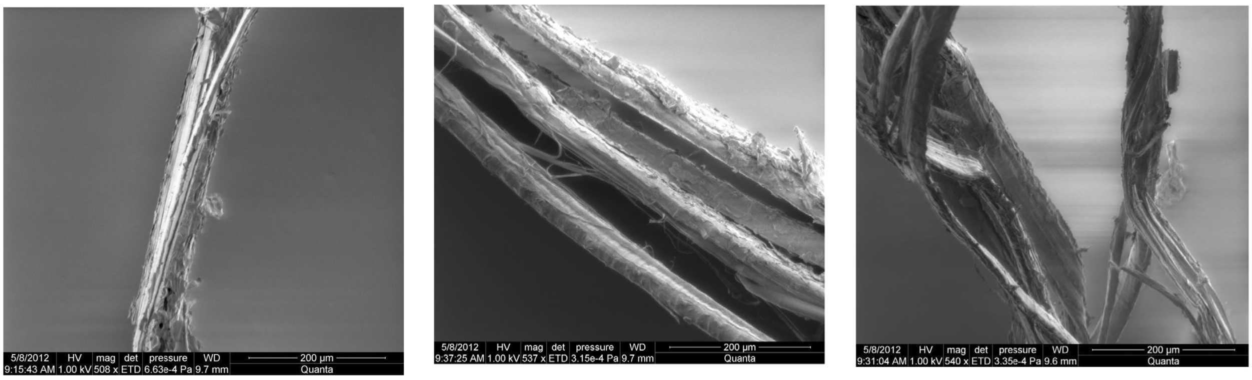

Fig. 2. SEM microdots: A – untreated fibre (0); B – after (I_48), and C – after (II_48) enzyme retting.

Table 1. Mechanical properties and color parameters of untreated and enzyme treated hemp fibres

Sample	Tensile strength, N/tex	Tensile elongation, %	L*	a*	b*	ΔE	C	H
0	0.49	5.53	68.94	1.35	16.06	70.79	16.12	3.79
I_2	0.47	2.99	63.63	4.17	15.34	6.05	2.91	4.69
I_5	0.47	3.44	61.02	3.81	15.93	8.29	2.46	4.71
I_24	0.43	4.27	58.50	5.21	15.68	11.13	3.87	4.32
I_48	0.74	3.26	59.26	4.68	14.90	10.30	3.52	7.40
II_2	0.44	3.48	59.29	6.64	16.33	11.01	5.30	4.76
II_5	0.71	4.17	61.32	6.65	15.03	9.33	5.39	7.15
II_24	0.55	5.08	64.29	5.57	15.52	6.29	4.25	5.47
II_48	0.71	3.07	62.54	5.51	15.02	7.70	4.28	7.11

A B C

Fig. 3. Pictures of fibres and sheaves after separating from stem of untreated (A) and enzyme treated I_48 (B) and II_48 (C) samples.

untreated sample (Table 1). The colour vectors co-ordinates demonstrate the decrease of green and blue shade of samples after enzyme treating. The various yellowish shades are observed for different samples. Lightness difference (ΔL) characterizes the difference between lightness of the sample and lightness of the standard (untreated fibre). The colour difference (ΔE) denotes common colour difference of the sample and the standard. Most significant decrease of lightness difference (Fig. 4) is observed after 24 h of treating at

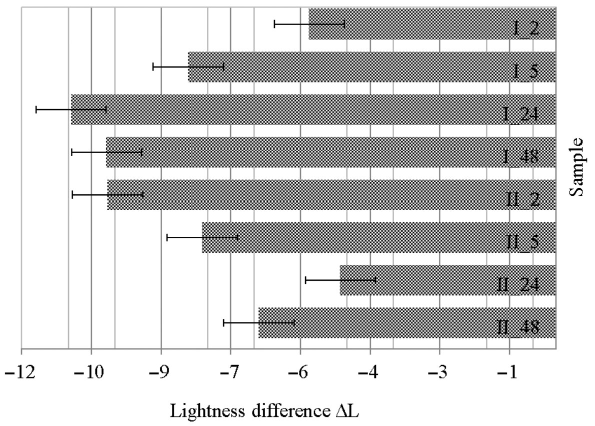

Fig. 4. Lightness difference of enzyme treated (I_2–II_48) hemp fibres.

25 °C. Chroma (C) is a parameter of intensity or saturation. Value of hue (H) points various shades of samples. To sum up, enzyme retting causes diverse colour characteristics changes of separated hemp fibres.

4. CONCLUSIONS

The first investigations about pectinase enzyme use for Latvian hemp stems "Purini" retting show that enzyme retting:

- influence is not significant in case of fibre separation from stem and TG characteristics at investigated time and temperature conditions;
- promotes formation of smaller fibre bundles;
- improves the mechanical propeties of hemp fibres.

Varied changes of colour characteristics of hemp stems are caused by temperature as well as treating time.

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Pektinaasi ensüümi Beisol PRO mõju kanepikiu leotamisele

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Maailma ja Euroopa kanepi kasvatamise ning kasutamise trendide analüüs näitab, et kanepi kasvatamisel ja töötlemisel on Lätis head väljavaated. Artiklis on tutvustatud esmase uuringu, kus katsetati pektinaasi ensüümi Beisol PRO (4% vesilahus) mõju Läti kanepisordi "Purini" leotamisele erineva aja jooksul erinevatel temperatuuridel, tulemusi. Samuti on uuritud töötluse mõju saadud kiu kvaliteedile. Kiudude koguse gravimeetriline analüüs pärast leotamist, füüsikalis-mehaanilised katsetused, termogravimeetriline analüüs, värvusomaduste ja valitud näidiste mikroskoopiline uurimine näitasid, et ensüümiga töötlemisel polnud kiu eraldamisele varrest märkimisväärset mõju. Pektinaasi ensüümi kasutamine kanepi leotamiseks tõstis mõnel juhul kiu tõmbetugevust ja muutis kiu värvusomadusi.