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Evaluation of Water-retted Flax Fibre for Quality Parameters

Zofija JANKAUSKIENĖ[1*], Kęstutis BAČELIS[1], Arvydas VITKAUSKAS[2]

[1]*Upytė Research Station of Lithuanian Institute of Agriculture, Linininkų 3, Upytė, Panevėžys district, 38 294, Lithuania*
[2]*Department of Textile Technology, Kaunas University of Technology, Studentų 56, LT-51424 Kaunas, Lithuania*

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In some late years a number of fibre flax varieties and new breeding lines have been created and investigated at the Upytė Research Station of Lithuanian Institute of Agriculture (LIA). The fibre quality parameters of the new varieties of fibre flax are studied and compared with those of standard flax varieties. Flax was pulled at the stage of early yellow ripeness, warm water-retted, threshed, scutched and hackled. Long fibre content was calculated from the dry mass of unretted straw. Fibre quality's parameters of some flax varieties ("Belinka" (standard), "Baltučiai", "Ariane") and new breeding lines (No. 01057-12, No. 1698-13a, No. 1864-24, No. 1963-3) grown in 2001 – 2003 are investigated. The main properties of flax fibre as fineness, flexibility, and tensile strength are measured, and the data obtained by common methods and some new modern methods are compared. The flax varieties producing the fibre of higher qualities are revealed.

Keywords: breeding, flax, fibre, properties, quality, varieties.

1. INTRODUCTION

Flax fibre is a traditional and highly valuable raw material for Lithuanian textile industry, its quantity and quality is permanently at focus of both agricultural and textile specialists. Flax fibre has found its application on various products as apparel, household textiles and industrial end-uses. High higroscopicity in conjunction with a relatively low fibre rigidity, the possibility of spinning suitably fine yarns from it are the basic advantageous characteristics of the long flax fibre stimulating demand for increased quantities of suitable fibre, especially for linen fabrics. These have a cool and pleasant hand, provide comfort in wear, are easy washable and non-allergenic, therefore are very popular among fashion designers and consumers [1, 2].

High fibre quality can primarily be achieved by creating new flax varieties, and using up-to-date breeding methods [1 – 7]. Flax cultivation techniques, weather and soil conditions as well as the flax straw processing (scutching, hackling) have a great effect on fibre quality [6, 7 – 9]. On the other side, flax variety should be high fibre-yielding and resistant to lodging and diseases [5, 10 –13].

The most important criteria describing fibre quality are fibre divisibility and fineness, strength and flexibility. A number of modern methods and equipment for flax fibre testing have been developed [14 – 19].

In some late years a number of fibre flax varieties and new breeding lines have been created at the Upytė Research Station of Lithuanian Institute of Agriculture (LIA). The aim of the present study was to evaluate the fibre quality of the Lithuanian fibre flax varieties and new breeding lines, to compare fibre quality parameters with those of the standard fibre flax variety, and to compare the data of fibre quality parameters determined by different methods and equipment.

[*]Corresponding author. Tel.: +370-45-555413; fax.: +370-45-555573.
E-mail address: *soja@upyte.lzi.lt.* (Z. Jankauskienė)

2. EXPERIMENTAL

The trial was carried out during the years 2001 – 2003. The meteorological conditions during this period of time were diverse. In 2001 the weather conditions were adverse, especially in the second half of the growing season. Heavy precipitation lodged flax stand. The year 2002 was characterised by a shortage of moisture during the growing season. In 2003 because of the lack of precipitation in the first half of the growing season flax did not perform well, the end of the growing season was rainy and the flax stand was partially lodged.

Flax was pulled at the stage of early yellow ripeness, threshed by a MS thresher. Stems were retted in warm water (33 ºC ÷ 37 ºC), then scutched by a flax breaker SMT-200. Long fibre content was calculated from the dry mass of unretted straw. Fibre was hackled by combs No. 9 and No. 13.

Part of the fibre samples was analysed using the newest testing methods. Breaking tenacity of the fibre was measured by Automatic Tensile Tester STATIMAT ME on 6 mg ÷ 10 mg specimens, at 3 mm gauge length and by weighing of each individual specimen (the results were averaged of 5 individual measurements). Index of fibre fineness was obtained by the Air Flow Electronic Fibre Fineness Meter WIRA (on 1.200 g samples, each sample – in 3 replications; each replication was averaged of 3 measurements). Fibre image analysis was used to assess the divisibility and fineness of fibres. The diameter of fibre bundle and single fibre was measured under Nikon light microscope at 500× magnification with computer using the MicroScan v. 1.3 (MicroScan Video Viewer 768-576) software. The fibre sections of 0.5 μm in thickness were prepared from the snippets of fibre (about 1 cm in length and 3 cm in diameter) packed into thin cigarette paper, and using Historesin (containing hydroxyethyl methacrylate) as a mounting medium. 20 measurements both of single fibre and fibre bundle were provided for each flax variety. The micrograph of fibre cross-section of variety "Baltučiai" with some measured elementary fibres and fibre bundles is shown in Fig. 1.

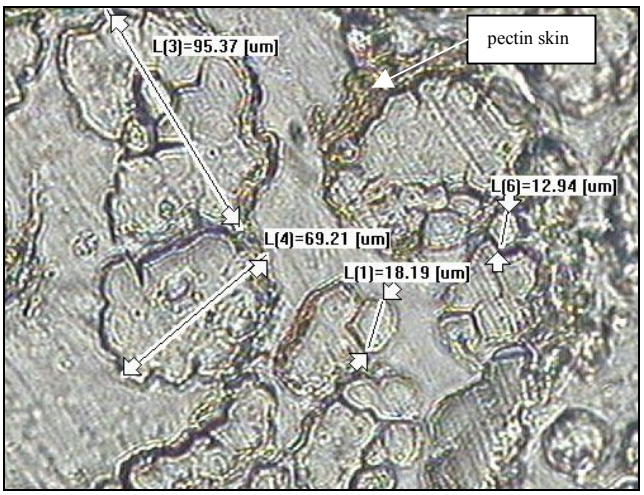

Fig. 1. The micrograph of flax fibre cross-section with elementary fibre and fibre bundle measurements of variety "Baltučiai"

The other part of the samples was studied using fibre testing methods developed in former USSR [20]. Fibre flexibility and breaking strength were measured by measured by gravimetric method considering the fibre Flexometer G-2 and Fibre Dynamometer DK-60 correspondingly (30 measurements of fibre specimens, divisibility (estimating 5 flax fibre specimens, i. e. fibre tufts, each of 1 cm length and 10 mg mass). As an integrated index of flax fibre quality the fibre durability was calculated using the formula [20]:

$$DY = 2.1 + 0.1y + 0.2F_b + 0.013f\,, \quad (1)$$

where y is a fibre flexibility (in mm), F_b is a breaking strength (in kgf), and f is a fineness (in conventional units).

3. RESULTS AND DISCUSSIONS

Averaged data from 2001 – 2003 show that the variety "Ariane" and breeding line No. 1864-24 had the highest fibre content (19.2 % ÷ 19.5 %), and the lowest fibre content was identified for "Belinka" (15.8 %) and "Baltučiai" (16.0 %) flax straw.

Fibre quality of the variety "Belinka" is known as the standard of good quality, thus for the evaluation of fibre quality in our trials the variety "Belinka" was chosen as a reference variety.

After 3 years of study we have found that most flexible fibre was obtained from the variety "Baltučiai" (52.3 mm), which was by 24.5 % more flexible than the standard fibre "Belinka" (Table 1). Less flexible than the standard fibre was the fibre from the variety "Ariane" and from the breeding line No. 1864-24.

Table 1. Long fibre flexibility and durability

Variety or breeding line	Fibre flexibility, mm				Fibre durability		
	2001	2002	2003	Average	2001	2002	Average
"Belinka" (standard)	35.1	40.6	50.3	42.0	11.3	12.9	12.1
"Baltučiai"	48,3	55.9	52.6	52.3	13.1	14.8	14.0
"Ariane"	37.8	39.0	44.7	40.5	10.6	11.9	11.3
01057-12	39.9	37.1	45.3	40.8	11.0	13.0	12.0
1698-13a	38.1	54.6	42.3	45.0	10.8	13.6	12.2
1864-24	35.6	34.7	41.6	37.3	10.9	12.7	11.8
1963-3	43.0	54.2	37.0	44.7	12.0	13.7	12.9

Table 2. Long fibre fineness

Variety or breeding line	Fibre linear density, tex			Index of fibre fineness (IFS)		
	2001	2002	Average	2001	2002	Average
"Belinka" (standard)	4.00	3.60	3.80	75.7	64.6	70.2
"Baltučiai"	3.95	3.75	3.84	80.0	67.0	73.6
"Ariane"	4.17	4.65	4.41	113.4	99.3	106.4
01057-12	5.18	5.53	5.35	89.3	86.6	88.0
1698-13a	4.55	4.85	4.70	84.6	92.8	88.7
1864-24	5.13	5.08	5.22	112.6	93.0	102.8
1963-3	4.05	4.13	4.09	88.2	77.0	82.6

Table 3. Long fibre strength

Variety or breeding line	Fibre breaking strength, N			Coefficient of variation (v), %		Fibre breaking tenacity, cN/tex		
	2001	2002	Average	2001	2002	2001	2002	Average.
"Belinka" (standard)	72.4	73.6	73.0	4.8	10.2	48.7	59.3	54.0
"Baltučiai"	89.2	67.7	78.4	16.1	23.4	47.3	53.4	50.4
"Ariane"	72.9	67.2	70.1	17.4	13.4	43.7	53.0	53.4
01057-12	85.1	64.1	74.6	1.4	13.4	47.8	60.9	54.4
1698-13a	84.0	81.6	82.8	15.2	3.8	42.0	60.0	51.0
1864-24	73.0	67.0	70.0	17.3	6.8	47.6	69.8	58.7
1963-3	67.8	52.8	60.3	15.6	8.6	46.2	54.3	50.3

Fibre breaking tenacity of breeding line No. 01057-12 was approximately equal to that of the standard variety "Belinka". Fibre breaking tenacity of variety "Baltučiai" and of breeding lines No. 1698-13a and No. 1963-3 was a little lower (by 5.6 % ÷ 6.9 %) than that of the standard variety.

The fibre durability describes resumptive long fibre quality. Experimental results from 2001 – 2002 indicate that the best result was given by the variety "Baltučiai" – the durability was the highest (14.0 km) and by 15.7 % higher than that of standard "Belinka" (Table 1).

The result of breeding line No. 1963-3 was close to the standard – the fibre durability was by 6.6 % higher than that of standard "Belinka". The lowest data were of the variety "Ariane", it was by 6.7 % lower than that of the standard "Belinka".

Flax fibre is of composite structure. It is fine when it can be divided into thin separate elementary fibres and when the content of single fibres in the analysed sample is high. Hence the fibre divisibility data reflect fibre fineness.

Averaged fibre testing data from 2001 – 2003 suggest that only the fibre from the variety "Baltučiai" had approximately the same value of linear density as the fibre of "Belinka" (Table 2). The value of fibre fineness of breeding line No. 1963-3 was by 7.2 % lower, and the values of fibre fineness of the other varieties were much lower when compared with the standard "Belinka".

Fibre analyses also confirmed that the finest was fibre obtained from varieties "Belinka" and "Baltučiai" and from breeding line No. 1963-3 (fibre fineness index varied from 70.2 to 82.6) (Table 2). When comparing fibre fineness data obtained by different methods the good congruity of the results ($R^2 = 0.97$) was obtained for the same three accessions – "Belinka", "Baltučiai" and No. 1963-3. Some disagreement appeared between fibre fineness data for varieties "Ariane", and No. 01057-12.

Data of long fibre strength and scattering of the results measured at INF are presented in Table 3. The highest fibre breaking tenacity was determined for the fibre of breeding line No. 1864-24; it was by 4.68 % higher than that of the standard "Belinka" (Table 3).

Table 4. Diameter of long fibre bundle and of elementary fibre

Variety or breeding line	Diameter of fibre bundle, μm	Coefficient of variation (v), %	Diameter of elementary fibre, μm	Coefficient of variation (v), %
2001				
"Baltučiai"	134.0	21.4	19.8	30.2
01057-12	143.5	27.8	18.3	32.5
1698-13a	119.4	26.0	20.9	24.2
1864-24	117.4	6.8	20.3	25.3
1963-3	139.0	38.7	20.3	26.0
2002				
"Belinka"	59.2	–	17.7	24.4
"Baltučiai"	69.2	–	13.7	25.2
01057-12	86.5	–	18.1	27.2
1698-13a	62.4	–	16.0	25.5
1864-24	170.5	–	15.9	31.7
1963-3	104.1	–	16.6	30.9

The measurements of the diameter of fibre bundles and elementary fibres confirmed that the quality of fibre samples tested in 2001 was not very high – the diameter of fibre bundle was very large (Table 4), some bundles still had pectin skin (Fig. 1). The diameter of elementary fibres was 18 μm ÷ 21 μm. In 2002 the diameter of fibre bundles as well as the diameter of elementary fibres was smaller.

It is seen in Tables 1 – 4 that due to adverse weather conditions in 2001, quality indices of fibre are significantly lower than those from flax grown in 2002 and 2003. This resulted in higher data scattering.

We also should concede that the fibre data obtained from two or even three year of flax growing and investigation were insufficient in quantity to determine more pronounced and reliable qualitative dependence between fibre yield and quality parameters as well as relationship between the quality parameters themselves. The attempts to provide regression analysis of the obtained data have shown the values of coefficient of determination varied in the range from 0.3 to 0.7.

CONCLUSIONS

The fibre flax variety "Baltučiai" showed the high level of long fibre quality: the values of fibre flexibility and durability were the highest, while the values of fibre fineness and breaking tenacity were very close to that of the standard variety "Belinka". The Lithuanian early ripening flax fibre variety "Baltučiai", despite its little less fibre-yield, should be definitely recommended to be overspread in Lithuanian agriculture.

New breeding lines No. 1864-24, No. 1963-3 and No. 01057-12 distinguishing for high yield of long fibre (1.09 t/ha ÷ 1.15 t/ha) showed little lower quality than that of standard variety, however, the level of their main properties could be evaluated as acceptable. These breeding lines could be turned to the new varieties in future.

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