ÚZPI

ÚSTAV ZEMĚDĚLSKÝCH A POTRAVINÁŘSKÝCH INFORMACÍ

ZEMĚDĚLSKÁ TECHNIKA

Agricultural Engineering

ČESKÁ AKADEMIE ZEMĚDĚLSKÝCH VĚD

3

VOLUME 41 (LXVIII)
PRAHA 1995
CS ISSN 0044-3883

ZEMĚDĚLSKÁ TECHNIKA

Mezinárodní vědecký časopis vydávaný z pověření České akademie zemědělských věd a s podporou Ministerstva zemědělství České republiky

AGRICULTURAL ENGINEERING

An international journal published by the Czech Academy of Agricultural Sciences and with the promotion of the Ministry of Agriculture of the Czech Republic

Redakční rada – Editorial Board

Předseda – Chairman

Ing. Jiří Fiala, DrSc. (Výzkumný ústav zemědělské techniky, Praha, ČR)

Členové – Members

Doc. RNDr. ing. Jiří Blahovec, DrSc. (Česká zemědělská univerzita, Praha, ČR)
Doc. ing. Karel Brzkovský, CSc. (České vysoké učení technické, Praha, ČR)
Univ.-Prof. Dr. habil. Manfred Estler (Technische Universität München, Institut für Landtechnik, Freising, BRD)
Prof. ing. Ján Jech, CSc. (Vysoká škola poľnohospodárska, Nitra, SR)
Ing. Petr Jevič, CSc. (Výzkumný ústav zemědělské techniky, Praha, ČR)
Doc. ing. Jan Mareček, CSc. (Mendelova zemědělská a lesnická univerzita, Brno, ČR)
Ing. Richard Markovič, CSc. (Štátna skúšobňa poľnohospodárskych a lesných strojov, Rovinka, SR)
Ing. Zdeněk Pastorek, CSc. (Výzkumný ústav zemědělské techniky, Praha, ČR)
Doc. ing. František Ptáček, CSc. (Státní kontrolní a zkušební ústav zemědělský, Brno, ČR)
Prof. M. N. Rifai, Ph.D. (Nova Scotia Agricultural College, Truro, Nova Scotia, Canada)

Vedoucí redaktorka – Editor-in-Chief

Ing. Jovanka Václavíčková

Cíl a odborná náplň: Časopis publikuje původní vědecké práce a studie typu review z oboru zemědělská technika, zemědělské technologie a zpracování zemědělských produktů. Abstrakty z časopisu jsou zahrnuty v těchto databázích: Agris, CAB Abstracts, Czech Agricultural Bibliography, WLAS.

Periodicita: Časopis vychází čtvrtletně (4x ročně), ročník 41 vychází v roce 1995.

Přijímání rukopisů: Rukopisy ve dvou vyhotoveních je třeba zaslat na adresu redakce: Ing. Jovanka Václavíčková, vedoucí redaktorka, Ústav zemědělských a potravinářských informací, Slezská 7, 120 56 Praha 2, tel.: 02/25 75 41–9, fax: 02/25 70 90, e-mail: braun@uzpi.agrec.cz. Den doručení rukopisu do redakce je publikován jako datum přijetí k publikaci.

Informace o předplatném: Objednávky na předplatné jsou přijímány pouze na celý rok (leden–prosinec) a měly by být zaslány na adresu: Ústav zemědělských a potravinářských informací, vydavatelské oddělení, Slezská 7, 120 56 Praha 2. Cena předplatného pro rok 1995 je 140 Kč.

Aims and scope: The journal publishes scientific papers and reviews dealing with the study agricultural engineering, agricultural technologies and processing the agricultural products. Abstracts from the journal are comprised in the databases: Agris, CAB Abstracts, Czech Agricultural Bibliography, WLAS.

Periodicity: The journal is published quarterly (4 issues per year), Volume 41 appearing in 1995.

Acceptance of manuscripts: Two copies of manuscript should be addressed to: Ing. Jovanka Václavíčková, editor-in-chief, Institute of Agricultural and Food Information, Slezská 7, 120 56 Praha 2, tel.: 02/25 75 41–9, fax: 02/25 70 90, e-mail: braun@uzpi.agrec.cz. The day the manuscript reaches the editor for the first time is given upon publication as the date of reception.

Subscription information: Subscription orders can be entered only by calendar year (January–December) and should be sent to: Institute of Agricultural and Food Information, Slezská 7, 120 56 Praha 2. Subscription price for 1995 is 35 USD (Europe), 37 USD (overseas).

© Institute of Agricultural and Food Information, Prague 1995

MK ČR 6698

HEMP FIBRE AS A RAW MATERIAL FOR PAPER PRODUCTION IN THE ASPECT OF NATURAL ENVIRONMENT PROTECTION

KONOPÍ JAKO SUROVINA PRO VÝROBU PAPÍRU PŘI OCHRANĚ PŘÍRODNÍHO PROSTŘEDÍ

P. Baraniecki, J. Mańkowski

Institute of Natural Fibres, Poznań, Poland

ABSTRACT: Oil and fibre flax and hemp plants were cultivated in strongly devasted landscape in the region of mining and processing of copper ore. It was confirmed that cultivation of these crops reduced soil content of copper, zinc, cadmium and lead in some cases (Tab. I). These metals are absorbed by crops and are deposited particularly in their roots and seed and to a smaller extent in stems (Tab. II). The yields of stems and seeds are not considerably affected by cultivation of above crops in disturbed natural conditions (Tab. III). These results show that mentioned technical crops should be used for reclamation of soil contaminated by heavy metals with further utilization of biomass produced in the paper industry. Laboratory experiments were conducted with preparation of pulp from hemp plants. Experiments with its defibring (Tab. IV) and bleaching of pulp (Tab. V) show many advantages compared with wood: higher yielding capacity of pulp from fibre (roughly 70%) and three to four times lower consumption of alkali than in defibring compared with wood. Disadvantages of pulp from hemp fibre are in more difficult dehydration ability, more difficult desintegration of fibre and bleaching.

oil and fibre flax; hemp; heavy metals; pulp from hemp plants

ABSTRAKT: Lej olejný a přadný a konopí byly pěstovány v silně devastované krajině v oblasti těžby a zpracování měděné rudy. Bylo prokázáno, že pěstování těchto plodin snižuje v půdě obsah mědi, zinku, kadmia a v některých případech i olova (tab. I). Tyto kovy jsou plodinami absorbovány a jsou uloženy zejména v jejich kořenech a semenech a v menší míře i ve stoncích (tab. II). Výnosy stonku a semen nejsou pěstováním zmíněných plodin v narušených přírodních podmínkách výrazněji ovlivněny. Ani klíčivost semen vyprodukovaných na experimentálních pozemcích není zdevastovaným prostředím výrazněji ovlivněna (tab. III). Tyto výsledky ukazují, že zmíněné technické plodiny by mohly být použity k rekultivaci půdy kontaminované těžkými kovy s dalším využitím vyprodukované biomasy v papírenském průmyslu. Byly provedeny laboratorní zkoušky s přípravou buničiny z konopí. Experimenty s jeho rozvlákňováním (tab. IV) a s bělením získané buničiny (tab. V) ukazují ve srovnání se dřevem mnoho předností: vyšší výtěžnost buničiny z vlákna (kolem 70 %) a třikrát až čtyřikrát nižší spotřebu alkálií při rozvlákňování než u dřeva. Nevýhody buničiny vyrobené z konopného vlákna spočívají v obtížnější dehydrovatelnosti, obtížnější dezintegraci vlákna a obtížnějším bělení.

len olejný a přadný; konopí; těžké kovy; buničina z konopí

INTRODUCTION

The dynamic development of economic activity in the world caused a considerable increase in demand for different kind of raw materials and a huge amount of energy for their processing. This activity also creates high amount of wastes and sludge threatening the natural environment. Unfavorable impact on the environment is connected mainly with the processes of coal and liquid and gaseous fuels burning as well as mechanical thermal and chemical processing of mineral raw materials. Predominant role in pollution is plyed by gas and dust emissions containing toxic compounds of fluorine, phenol, sulphur, nitrogen and many heavy metals like Pb, Cd, Fe, Zn, Cu, Cr, etc.

The stock on natural lubricants is limited, energy production costs grow constantly and the environment is more and more degraded. The use of plant raw materials, specially those showing intensive biomass production, should help in thrifty utilization of traditional raw materials like petroleum, natural gas, oar coal. It should also effect the natural environment protection and stimulate the solving of agricultural problems. The cultivation of fibrous industrial plants is an alternative for food plants cultivation in ecologically degraded areas where food crops are potential danger to human's health. The region of Górny Śląsk and Legnica-Glogów Copper Mining and Production Region are the examples of ecologically degraded areas in Poland.

The above-mentioned facts resulted in the research on fibrous, industrial and non-food crops cultivated in degraded areas in order to find out how they yield in the conditions of polluted soil, to establish their effect on the soil and studying the possibilities of application of plant biomass.

MATERIALS AND METHODS

The research was conducted in the safety buffer zone of the Copper Plantin in Głogóv. The following plant materials were used: hemp – Białobrzeskie variety, fibre flax – Minerwa variety, oil flax – Bionda variety. The content of metals in the soil was estimated using the ASA method before sowing and after the harvest. During the vegetation period the development stages and necessary post-emergence treatment were carried out. After the harvest the total yield of straw and seed was estimated and morphological measurements were carried out. The samples for estimation of heavy metal content were taken.

Investigated was also the usefulness of fibrous raw materials for pulp production. The hemp fibre was cut into pieces and pulped in autoclaves in the solution of sodium hydroxide in controlled conditions of time and temperature. Obtained pulp was beaten twice and subsequently bleached in sodium hypochlorite.

RESULTS

1. Fibrous plants in ecologically degradated environment. The content of heavy metals in the soil eg. Cu, Pb, Zn, Cd before sowing and after harvest is in Tab. I.

The results in Tab. I show that generally the concentration of heavy metals in the soil was decreased as the effect of accumulation of metals in vegetative and generative parts of plants. One can presume that if the emission of metals is stopped, through utilization of filters or its elimination, the fibrous plants will gradually recultivate polluted areas and eliminate the introduction of heavy metals into the food chain of humans. The accumulation of heavy metals is shown in Tab. II.

Analyzing the content of metals in individual parts of the plant it can be said that the strongest accumulation took part in roots and next in seeds. During the study the observations regarding the effect of metals contained in the soil on the quantity and quality of yield were also carried out. The results of yields obtained are shown in Tab. III.

Based on the results obtained one can conclude that the presence of heavy metals in the soil from buffer safety zone had no negative effect on the yield of fibrous plants biomass, both the quantity and quality, neither on the sowing value of seed material. The observations of development stages showed that plants were developing properly and did not suffer any diseases when reached the proper height.

2. The usefulness of fibrous plants for pulp production. The study on possibilities of hemp fibre for long

I. The contents of heavy metals before sowing and after harvest in the soil from the safety buffer zone of Copper Plant in Głogów

Plant	Soil reaction pH	Time of sampling	Metal content (mg/kg) of dry metal of the soil			
			Cu	Pb	Zn	Cd
Fibre flax Minerwa	6.6	before sowing	194	85	38	0.5
		after harvest	145	52	16	0.3
Hemp Białobrzeskie	5.5	before sowing	135	66	21	0.3
		after harvest	138	63	15	0.2
Oil flax Bionda	5.2	before sowing	125	59	24	0.3
		after harvest	113	68	12	0.2

II. The contents of Cu, Pb, Zn and Cd in plant material of dry matter (mg/kg)

Plant	Part of the plant	During flowering stage				During the harvest			
		Cu	Pb	Zn	Cd	Cu	Pb	Zn	Cd
Fibre flax Minerwa	seeds	–	–	–	–	15.9	1.0	74.7	0.37
	stems	9.8	2.6	18.5	0.40	4.1	2.0	27.3	0.59
	roots	21.8	6.0	23.1	0.82	30.4	8.0	42.5	1.10
Hemp Białobrzeskie	seeds	–	–	–	–	21.3	0.8	64.6	0.17
	stems	22.2	4.5	13.0	0.19	9.7	2.0	11.6	0.11
	roots	86.3	14.0	34.0	0.50	41.7	6.0	21.5	0.32
Oil flax Bionda	seeds	–	–	–	–	10.0	0.1	77.0	0.35
	stems	17.5	2.3	31.7	0.27	5.7	1.0	23.7	0.49
	roots	17.8	1.8	28.2	0.30	16.8	4.0	29.6	0.72

fibre pulp production was conducted jointly with the Pulp and Paper Institute in Łódź. The results of trials of pulping of decorticated hemp fibre are shown in Tab. IV.

The above-mentioned results indicate that predicted degree of pulping (Kappa No. = 10) was reached already with addition of 10 and 11.2% of NaOH during 180 and 210 min., at 165 °C. It means that hemp fibre is an easy-to-pulp material. The average efficiency of pulps with aimed degree of pulping was around 70%, e. g. more by 25% from pulping efficiencies of wood at the similar degree of pulping. This is a great advantage of hemp together with low consumption of alkalies which is three times lower for hardwood and four times for softwood. The disadvantage of pulp obtained is its heterogeneity consisting in the presence of long and short fibres as well as mucilage substances responsible for bad dewatering. Obtained pulps were bleached with sodium hypochlorite. The bleaching results are shown in Tab. V.

The results obtained are average. The whiteness on the level of 69%, bleaching efficiency 95%, the efficiency of bleached pulp around 67%. In means that hemp fibre displays an upper suppleness to bleaching resulting in pulps of lower whiteness. The basic criterion of estimation of raw material usefulness for paper production is the possibility of forming paper sheets displaying good properties. In order to estimate these properties bleached pulps were beaten to 50 and 60 ° SR and paper sheets were formed to perform tests of mechanical properties. Results are shown in Tab. VI.

The test results show that pulp contains very long fibres not shortened during the beating process probably due to the mucilage coating them. The mucilage causes very high freeness of the pulp. The overall results proves the usefulness of hemp fibre for pulp production. It requires, however, a special processing due to bad dewatering. When compared with pulps obtained from softwood the consumption of which is 2.1–2.2 tons per 1 ton of pulp, the consumption of hemp is 1.4–1.5 tons.

RECAPITULATION

The raw materials obtained as a result of cultivation on polluted areas will be used primarily in textile, and pulp and paper industries. Very important is the possibility of long fibre pulp production based on hemp fibre. The annual pulp production in Polish climatic conditions is almost three times higher compared to the trees. Unquestionable profits for the economy can be biofuels and biolubricants based on the oil obtained form industrial crops. Due to high content of pentosans (approximately 25%), flax and hemp shives can be used for furfural production. Hemp and flax application in textile industry is commonly known. The INF, however, is introducing a new production technology of linen yarn blended with other natural and chemical fibres. The technology is based on retted, linen yarn. Moreover, the non-food plants involved in crop rotation implemented in the polluted areas will eliminate heavy metals from human's food chain, allow for gradually recultivate of such areas through the extraction of toxic compounds and will create a new direction of production of annually renewable raw materials for the industry.

CONCLUSIONS

1. It is purposeful change the structure of sown crops on the ecologically degraded area through elimination of food crops and replacing them with industrial crops.
2. The content of heavy metals in the soil did not cause any decrease in quantity and quality of fibrous crops yield.

III. The quantitative and qualitative comparison of crops

Plant	Straw yield (g/m^2)	Seed yield (g/m^2)	1 000 seed weight (g)	Germination strength (%)	Total length (mm)
Fibre flax Minerwa	534.0	70.0	5.3	92.6	773
Hemp Białobrzeskie	1 160.0	23.2	12.34	78.4	2 500
Oil flax Bionda	667.5	55.1	6.0	85.7	759

IV. The results of hemp fibre pulping

No	Estimated feature		Trial No				
			I	II	III	IV	V
1	Amount of alkalies added	(%)	11.2	15.4	25.0	11.9	10.0
2	Concentration of alkalies in pulping liquor	(g/m^2)	18.7	26.7	41.4	19.8	16.7
3	Temperature of pulping	(°C)	165	165	165	165	165
4	Time of pulping	(min)	210	210	180	180	180
5	Pulp efficiency	(%)	71.3	68.4	60.4	69.4	69.8
6	Kappa No		11.6	5.0	9.8	7.8	9.8

V. Results of hemp fibre pulps bleaching

No	Estimated feature	Trial No	
		I	II
1	Total amount of active Cl (%)	3.37	2.65
2	I. Bleaching with hypochlorate		
	amount of active Cl (%)	2.41	1.76
	remaining Cl (%)	0.5	0.01
	pH	11.8	8.9
3	II. Bleaching with hypochlorate		
	amount of active Cl (%)	1.34	0.89
	remaining Cl (%)	0.85	0.17
	pH	11.6	8.7
4	Bleaching efficiency (%)	94.8	95.1
5	Pulp efficiency in relation to raw material (%)	67.6	66.3
6	Whiteness (%)	68.7	69.9
7	Viscosity (kg/dm^3)	600	736

VI. Resistance parameters of bleached pulps from hemp fibre

No	Estimated feature	Trial No	
		I	II
1	At 50 ° SR		
	– density (g/cm)	0.562	0.387
	– self-breaking (m)	3270	3610
	– stretching ability (%)	2.6	2.0
	– burst (KPa)	164	184
	– tearing strength (Nm)	1 370	2 029
2	At 80 ° SR		
	– density (g/cm)	0.739	0.560
	– self-breaking (m)	3 460	3 380
	– streaching ability (%)	2.0	2.0
	– burst (KPa)	140	211
	– tearing strength (Nm)	520	1 262

3. Flax and hemp extract relatively high amount of heavy metals from the soil causing is gradually recultivation.
4. Laboratory research confirmed the usefulness of decorticated hemp fibre for long fibre pulp production.
5. The average efficiency of the pulp from hemp fibre was around 70% and it is higher by 25% in relation to wood pulps.
6. The consumption of alkalies in wood pulp production is 3–4 times higher than in hemp pulp production.
7. The hemp fibre shows some disadvantages, making the production difficult:
   - the limited ability to dewatering in technological processes caused by presence of mucilage substances,
   - high resistance of fibres to shortening during the beating process,
   - the upper suppleness to bleaching causing the pulps having lower whiteness.
8. The utilization of biomass from annual or perennial plants can be a basis for saving existing sources of raw materials and energy and will allow agricultural utilization of ecologically degraded areas influencing positively the humans health.

REFERENCES

BACZYŃSKA, K.: Ocena możliwości wykorzystania dekortykowanego włókna do produkcji masy celulozowej. ICP, Łódź 1990.

KOZŁOWSKI, R. – GRABOWSKA, L. – BARANIECKI, P.: Zagospodarowanie terenów skażonych ekologicznie przez przemysł jednorocznymi roślinami włóknistymi. Sympozjum Drewno-Las-Ekologia '93, Wielkopolska Fundacja im. T. Perkitnego, Poznań 1993.

KOZŁOWSKI, R. – MAŃKOWSKI, J. – GRABOWSKA, L. – BARANIECKI, P.: Dobór rodzajów i sposobów uprawy roślin przemysłowych na terenach ochronnych Huty Miedzi w Głogowie. IWN, Poznań 1993.

KOZŁOWSKI, R. – MAŃKOWSKI, J. – RYNDUCH, W. – BARANIECKI, P. – STUPIŃSKA, H.: Możliwości, kierunki i perspektywy zagospodarowania biomasy z jednorocznych roślin włóknistych i innych. Sympozjum Las-Drewno-Ekologia '93, Wielkopolska Fundacja im. T. Perkitnego, Poznań 1993.

KOZŁOWSKI, R. – MŚCISZ, J. – GRABOWSKA, L. – MAŃKOWSKI, J. – BARANIECKI, P.: Possibilities of applying of bast fibrous plants cultivated in polluted areas for pulp and particleboard production. Pacific Rim Bio-Based Composites Symposium, Rotorua, New Zealand, 1992.

MAŃKOWSKI, J. – GRABOWSKA, L. – BARANIECKI, P.: Hemp and flax cultivated on the soil polluted with heavy metals – a biological purification of the soil and a raw material for the pulp industry. Symposium Aternative Oilseed and Fibre Crops for Cool and Wet Regions of Europe, Wageningen, The Netherlands, 1994.

STUPIŃSKA, H.: Wykonanie kompletów próbek papieru z udziałem celulozy długowłóknistej z konopi. ICP, Łodź 1992.

Received on November 2, 1994

Contact Address:

Dipl. Ing. Przemysław Baraniecki, Institute of Natural Fibres, ul. Wojska Polskiego 71b, 60-630 Poznań, Poland, Fax: 004861/41 78 30

NEW OUTLOOK ON FLAX FIBRE PROPERTIES IN TEXTILES

NOVÝ POHLED NA VLASTNOSTI LNĚNÉHO VLÁKNA V TEXTILIÍCH

R. Kozłowski, S. Manyś

Institute of Natural Fibres, Poznań, Poland

ABSTRACT: Not only positive but also negative flax fibre a features were presented: great and irregular length and thickness, low elongation, rigidness and high impurities content. The features of linen yarns produced by traditional linen technology were shown. New flax fibre types, adapted to universal, modern, spinning techniques were presented as well as new yarns made thereof. Application possibilities of new linen yarns, mainly in clothing sector, were reported.

flax fibre; length of fibre; thickness of fibre; elongation; rigidness, impurities content; spinning technology

ABSTRAKT: V práci jsou popsány některé nepříznivé vlastnosti lněného vlákna při jeho využívání v textilním průmyslu: velká a nepravidelná délka a tloušťka, nízká průtažnost, neohebnost a vysoký obsah nečistot. Jsou také uvedeny charakteristiky lněných přízí získaných klasickými technologiemi (tab. I až III). Nové typy lněných vláken jsou vhodné ke zpracování moderními univerzálními dopřádacími technologiemi (obr. 4 až 13, tab. IV). Tato vlákna jsou charakteristická nižší tloušťkou a délkou, nižším obsahem nečistot a zlepšenými vlastnostmi povrchu. Jde o vlákna Kotex A (typu vlna), Kotex B a C (typu bavlna) z ČML Humpolec, vlákna Sanelin 03F (typu bavlna i vlna) a Senetow firmy SENECO z Francie a Pakulen (typu bavlna i vlna) z Polska. Příze získaná moderními dopřádacími technologiemi (Tab. V–XIII) je vysoce kvalitní a přitom si uchovává přednosti klasické příze: komfort a hygienu.

lněné vlákno; délka vlákna; tloušťka vlákna; průtažnost; neohebnost; obsah nečistot; dopřádací technologie

INTRODUCTION

The competition between agromaterials for industrial use and synthetic products is very hard and flax is a perfect example of it.

We have heard about difficult situation of flax fibre in West European countries, which took place only two decades ago, and efforts done or still needed to overcome some barriers in that process called *the linen renaissance*.

The main problems, still calling for progress in flax fibre production production and industrial processing are:

– The old principle of technology used which brings about growing amounts of short flax fibre/waste fibre through following stages of the processing process as it is shown in slide 1.

– The second difficult problem are dusty processing conditions, caused not only by chemical composition of flax fibre (lignin, pectins, hemicelulose, waxes which had to be partly removed during the processes), but also by soil particles brought from the field were flax was grown and due-retted.

In terms of traditional flax fibre technology short flax fibre id of low technological value.

Traditional flax fibre technology

the process	the products
scutching	1. long scutched flax fibre 2. tow (50%–75%)
hackling	1. long hackled flax fibre 2. combings (50–55%)
sliver combing	1. combed sliver 2. very short waste flax fibre

The great barrier in flax renaissance are also some of most important technological properties of flax fibre itself:

length of fibres – enormous great and irregular,
linear mass of fibre – also inconvenient great and irregular,
resistivity against splitting,
rigidness and low elongation,
high impurities content.

All these technological flax fibre features made for linen the competition against cotton and then synthetic fibres very difficult – if not impossible – without the help of positives of flax – reported in the paper concerning the *flax renaissance*.

These – rather inconvenient technological properties of flax fibre and new outlook on them are the subject of this paper.

TECHNOLOGIES DICTATED BY FLAX FIBRE PROPERTIES

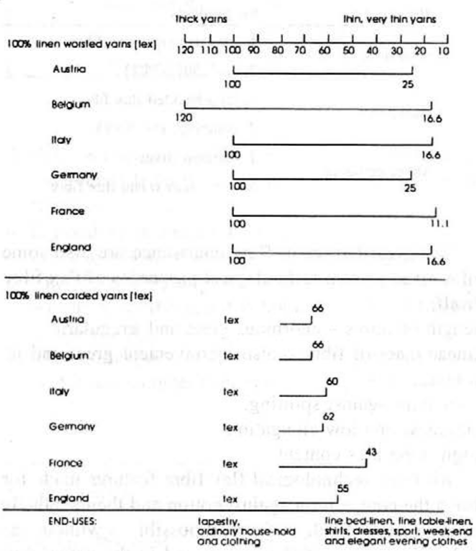
Since the year 1810, when Napoleon threw the flax fibre spinning technology open to competition, linen yarns have been produced by the technology dictated by mentioned above, quite difficult flax fibre features.

Even the first machines used in linen yarn production were not successful. They did not respect the need of flax fibre splitting during spinning process. Thus, the first flax spinning machines could produce only coarse yarns and still could not compete with hand-made *workshop linen yarns*. The first steps in splitting flax fibre boundless not only in hackling process but also in further stages of spinning were made also in France, in particular at Engeneering College in Paris, by the famous chemist Gay Lussac, who had adopted chemical treatment to flax spinning process.

Further development in changing flax fibre features – their length and thickness, resulted in mechanical and chemical treatment in the preparation stages of spinning process – including boiling or bleaching rowings – and in wet yarn formation process on the spinning frame.

In this way – despite difficult for spinner – flax fibre properties, thin yarns – up to tex 8 (Nm 125) could be produced on industrial scale.

This typical for flax wet spinning process is also nowadays in common use in all linen-producing countries. Similar, flax dry spinning system is going slowly out of use.



1. Linear mass of 100% linen wet spun yarns made in EC countries

The linear mass of these traditional linen yarns produced e. g. in West European countries is shown in Fig. 1, the main quality standards are presented in Tab. I–III. Tab I–II concern 100% linen yarns spun by unique to linen (dictated by flax fibre features), technology. Tab. III concerns traditionally spun blended linen yarns. For each of these yarns detailed requirements are given, regarding permissible irregularity of yarn density (mostly ± 5%), exact values for the strength of yarns in quality standards. The elongation of 100% linen yarns is low (ca 1.7%–2.4%).

Strict quality standards of traditional linen yarns may change from country to country to country but the main types and features of them are more or less similar.

The end-uses of traditional linen yarns are apparel, table and bed-linen, upholstery, towels, some special assortments of threads and strings. The traditional, dictated by flax fibre features, technology is still irreplacable as far as fine 100% linen yarns and 100% linen goods are concerned.

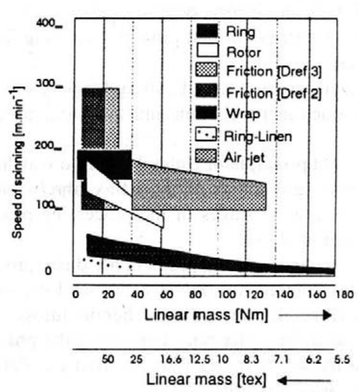
But, unfortunately, the costs of spinning in this case are very high mainly because of:

- low speed of spinning,
- low automation of the process.

The speed of spinning in traditional linen yarns production and in other spinning techniques, compared in Fig. 2, shows remarkable difference and stresses the urgent need of progress in the field of flax fibre processing. Similar conclusion can be drawn on the basis of spinning cost comparison.

It is obvious, that in the situation where features of fibre cause low speed of spinning and high costs of yarn production only the high value of end-products may keep the fibre and goods on the market. 100% linen fine fabrics and apparel made of hackled flax fibre may compete even despite:

- low speed of spinning
- high costs of the yarns



2. Speed of spinning and linear mass of yarns spun by various spinning techniques

I. Traditional linen yarns (spun by unique to flax spinning machines) 100% linen worsted wet spun yarns (made of long hackled flax fibres)

		Strength cN/tex	Errors N/loom
Extra standard ordinary – raw	V%	17.0–13.0 16.0–24.0	1–4
After chemical treatment – boiled, bleached to 1/2 or dyed dark	V%	17.1–12.7 17.5–24.5	1–4
– boiled, bleached to 3/4 or dyed bright	V%	22.0–12.7 17.5–24.5	1–4
100% linen worsted dry spun yarns (made of long hackled flax fibres)			
Extra standard ordinary – raw	V%	16.5–12.0 16.0–24.0	1–4
After chemical treatment – boiled bleached or dyed	V%	16.3–11.5 16.5–24.5	1–4

II. Traditional linen yarns (spun by unique to flax spinning machines) – 100% linen carded wet spun yarns (made of short flax fibres tow, combings)

		Strength cN/tex	Errors N/loom
Extra standard ordinary – raw	V%	12.3–10.4 18.0–25.0	3–8
After chemical treatment – boiled, bleached dyed dark	V%	12.3–10.4 18.5–25.5	3–8
100% linen carded dry spun yarns (made of short flax fibres tow, combings)			
Extra standard ordinary – raw	V%	10.8–5.9 19.0–25.0	3–16
After chemical treatment – boiled bleached or dyed	V%	10.8–5.9 19.5–26.5	3–8

just thanks to well known positives of flax which provide comfort and hygiene as well as elegance.

Unfortunately, splendid flax fibre positives were not enough to solve the competition problems of short flax fibre. By the use of traditional spinning technology only coarse yarns or yarns of medium density could be spun of tows. What is worse: carded linen yarns are rigid, irregular in every aspect and of low elongation. So short flax fibre lost its markets in household and other uses one by one and was mounted in stocks in many countries only some years ago. That is why the new outlook on the features of short flax fibre became *the must* for further flax development.

NEW OUTLOOK ON FLAX FIBRE FEATURES IN TEXTILES

New outlook on flax fibre features resulted in:

- new flax fibre types,
- new flax fibre processing technologies mainly in short flax fibre sector.

It should be mentioned, that short flax fibre represents ca 50%–60% of flax fibre production. The scutched fibre/tow ratio in West European countries and in one of Central Europe producer is shown in Fig. 3. It may look much in favour for short fibre in the case of East European flax producers.

The main technological features of flax combings and tow are presented in Fig. 4 where the lowest and best qualities of both (according to Polish standards) are used as examples.

The progress that has been carried out in many research centres adapted short flax fibre to others than unique to flax spinning systems like:

- conventional ring short/long staple spinning technique

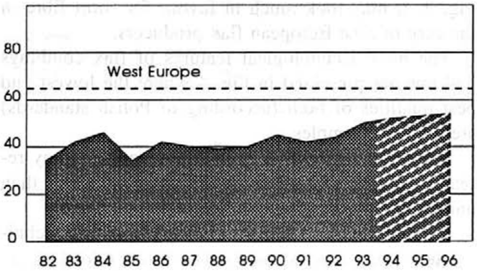
III. Traditional linen yarns (spun by unique to flax spinning machines) – Blended linen worsted wet spun yarns (made of long hackled flax fibres and man made fibres blends)

		Strength cN/tex	Errors N/loom
Standard ordinary			
With PES fibres share		17%–33%–41%–50%	
– raw		14.5–9.5	1–4
	V%	18.0–24.0	
After chemical treatment			
		16.5–9.0	1–4
	V%	18.0–24.0	
With Viscose fibres share		17%–33%	
– raw		14.0–10.0	
	V%	19.0–25.0	
After chemical treatment			
		13.5–9.0	1–4
	V%	19.5–25.5	
Blended linen worsted dry spun yarns			
Standard ordinary			
With PES fibres share		17%–33%	
– raw		13.7–10.0	1–4
	V%	18.0–24.0	
With Viscose fibres share		17%–33%	
– raw		13.0–9.5	1–4
	V%	19.5–25.0	

IV. The features of new flax fibre types marketed in Europe

Producer	Name	Type	Mean length (mm)	Mean fineness (tex)	Impurities (%)	Strength
Linen Mill Humpolec, Czech Republic	Kotex A	wool-type	50–60	2.0–3.5	max. 4.0	–
	Kotex B	cotton-type	30–35	1.3–1.8	max 2.8	–
	Kotex C	cotton-type	20–25	1.1–1.5	max 2.5	–
Seneco France	Sanelin 03F*	cotton-type	36	–	very clean	–
	Sanelin 03F*	cotton-type	48	–	very clean	–
	Sanelin 03F*	wool-type	72	–	very clean	–
	Senetow	–	–	–	–	–
Poland marketed since 1975	Pakulen**	cotton-type	43	1.1	1.4	30.0
	Pakulen**	wool-type	60–70	1.4	0.15	35.7
Institute of Natural Fibres Poznań, Poland		cotton-type	45	1.1	0.2	–
		wool-type	122	1.7	0.1	–

* made of long flax fibre, ** short flax fibre of lowest quality standards

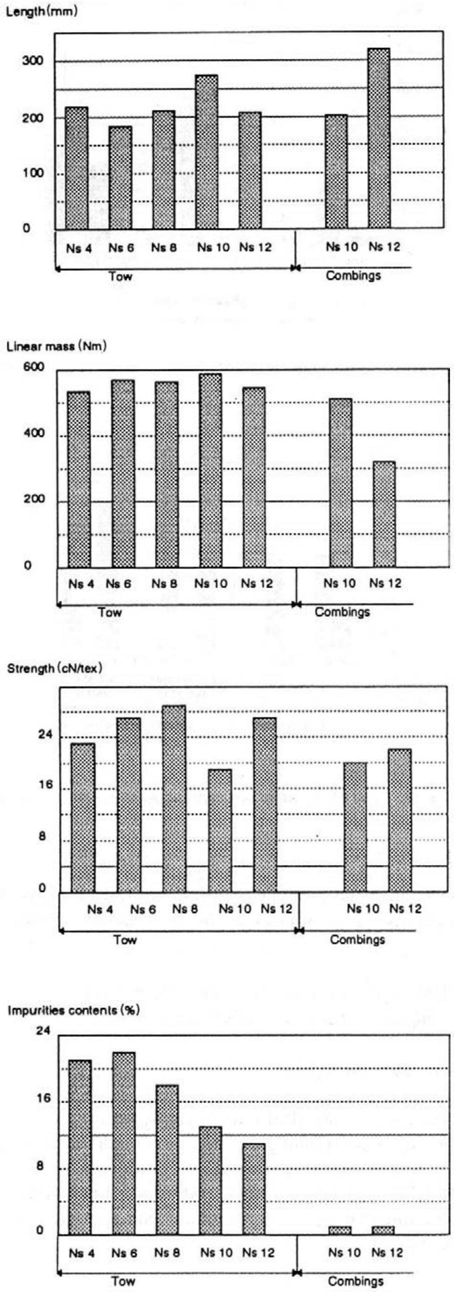


3. Fibre/tow ratio-outlook

Source: Krmela (1992)

– unconventional spinning techniques as follows:
  – rotor
  – air-jet
  – friction or
  – wrap spinning technology.

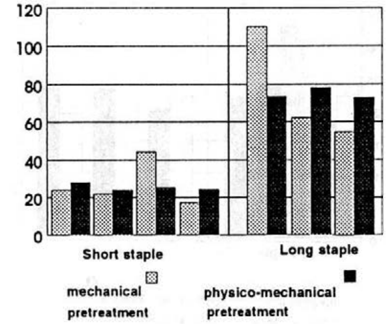
The main features of flax fibre adapted (by mechanical and/or physico-chemical processes in pre-treatment stage) to be spun by others than traditional,



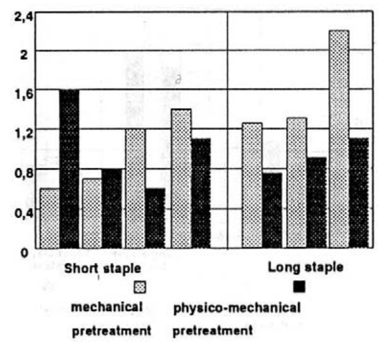
4. The features of short flax fibre (tow, combings)

unique to flax, spinning systems are presented in Fig. 5–13.

The obligatory quality standards of new flax fibre types are slowly created – step by step – according to technological progress both in fibre preparation and in spinning processes being at the moment of temporary or local value only.



5. Length of flax fibre prepared for conventional spinning techniques (mm)



6. Linear mass of flax fibre prepared for conventional spinning techniques (tex)

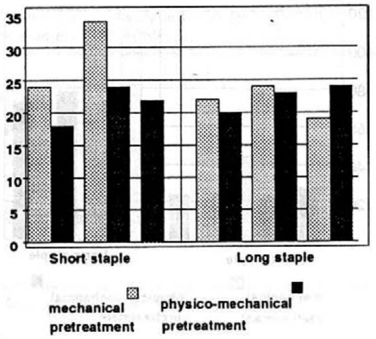
Despite of that *statu nascendi situation* in the new flax fibre assortments and their obligatory quality standards it is obvious that they represent the new outlook on technological flax fibre properties in textiles and link the linen industry with that od cotton, wool and man-made fibres processing textile sectors.

The demand for yarns with flax in the West European countries has led to the significant consumption of short flax fibre stocks. In the heat of the moment East European countries are searched not only for long flax fibre but also for combings and tow as well as for other substancial wastages of flax.

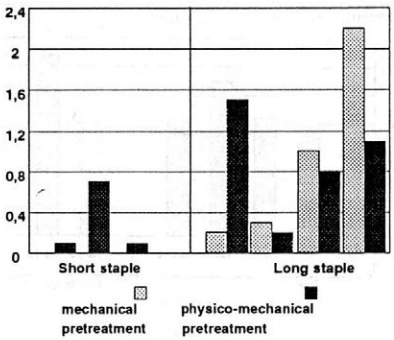
Short flax fibre prepared to be spun by machines *borowed* from other fibres are on the market produced e. g. by:

- Moravolen Humpolec – Czech Republic
- SENECO – France (both from long and short traditional flax types)
- Institute of Natural Fibres – Poland.

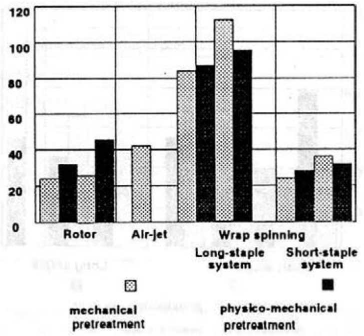
The main features of marketed short flax fibre assortments are given in Tab. IV.



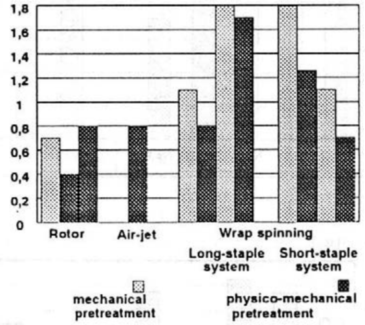
7. Breaking strength of flax fibre prepared for conventional spinning techniques (cN/tex)



8. Impurities of flax fibre prepared for conventional spinning techniques (%)



9. Length of flax fibre prepared for unconventional spinning techniques (mm)



10. Linear mass of flax fibre prepared for unconventional spinning techniques (tex)

Many a time the new type of flax fibre is produced by spinning mills themselves for home yarn production like in Poland: for Parafil and other blended linen yarns.

NEW LINEN YARNS

NEW LINEN YARNS SPUN BY UNIQUE TO LINEN TRADITIONAL TECHNOLOGY

Between traditional linen yarns the new one is 100% linen yarn for knitting, specially softened during/after traditional flax wet spinning process.

The features of 100% linen yarn for knitting are similar to those of traditional weaving yarns with favourable changes in the rigidness and softness of the yarn, which made them suitable for knitting process.

High production costs are the main barrier in marketing of these yarns. Still they suit perfectly the requirements for comfortable, hygienic apparel for hot, humid climate conditions and this decide about the prospects of that sort of yarns and goods made of them. Ladies' blouses and dresses, man's sports wear and socks are good examples of 100% knitting linen yarns application in final products for high market segments.

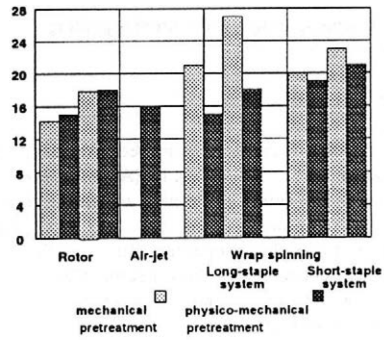
NEW LINEN YARNS SPUN BY OTHER THAN TYPICAL FOR FLAX SPINNING SYSTEMS

New 100% linen yarns

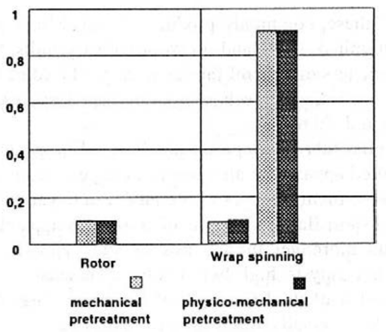
Brand-new are: 100% linen yarns, tex 50 – tex 100, spun by rotor spinning technology – reported by some of the best spinning machines producers (Tab. V) (N ü s s l i, 1994) as well as 100% rotor linen yarns of high linear mass for agricultural end-uses (tex 667) (A r t z t, 1992).

New blended linen yarns

Similar to new flax fibre forms the new blended linen yarns are in most linen producing countries *in statu nascendi*. The obligatory quality standards of their features are created and there is certainly a piece of international cooperation needed to make them satisfactory both for producers and users of them.



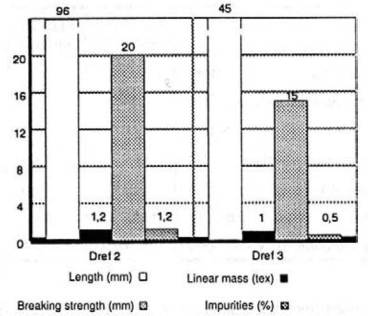
11. Breaking strength of flax fibre prepared for unconventional spinning techniques (cN/tex)



12. Impurities of flax fibre prepared for unconventional spinning techniques (%)

In such situation I cannot do otherwise than give some examples of blended linen yarns – including some brand-new assortments of them and give the information about their present features.

But we shall remember, these yarns are still in development process – as well as the new forms of flax fibre and processing technologies develop step by step over the globe.



13. The features of flax fibre prepared for DREF-spinning system

Blended linen yarns spun by short staple ring spinning system – (cotton spinning system)

The features of blended linen yarns spun by cotton ring spinning system are presented in tab. VI, VII (Artzt, 1992; Krmela, 1992). These yarns unlimited application possibilities in healthy clothing sector (both woven and knitted apparel), in household goods, upholstery and socks production.

In the case when the blended yarns is produced by cotton ring spinning system using as raw material, the lowest quality of tow (as it is when yarn 50 tex – 40 tex produced in Poland is considered) we have to our disposal a technology for very lucrative utilization of the still substantially waste material, at scutched tow of that kind may be well loocked at (Krmela, 1993).

Our socks production at the Institute of Natural Fibres is based exactly on these kind of yarns, and we have never got others but best opinion about comfort, hygienic properties and durability of these socks with linen.

Blended linen yarns spun by long staple ring spinning system – (wool spinning system)

The features of blended linen yarns spun by long staple ring spinning system are presented in Tab. VIII. The blends possibilities as well as application possibili-

V. Brand-new – 100% linen yarns spun by rotor spinning technology (cotton system) – (Flax combings)

Linear mass	tex	50	84	100	100
Linear mass irregularity CV	%	22.2	21.0	24.1	19.7
Breaking strength	cN/tex	6.5	6.2	7.8	7.5
Elongation	%	3.7	3.9	4.4	4.1
Faults	n/1 000 m				
Thin places		510	400	510	1 150
Thick places		1 100	800	750	1 200
Neps		1 300	1 100	800	1 600

Source: Nüssli (1994)

ties of these, commonly produced blended linen yarns are unlimited. In Poland, in wool industry mills, thousands meters of apparel fabrics were produced of these yarns according to technology developed by Institute of Natural Fibres.

Similar fabrics are produced all over Europe as well as knitted apparel for all season of the year. Both types of above-mentioned new blended linen yarns have shifted short flax fibre application towards apparel sector and moreover these yarns directed apparel with linen not only to high but also to price sensitive segments of markets. Both types of these new yarns resist creasing especially when used in knittewear.

Blended yarns spun by uncoventional spinning techniques

Rotor spinning

The features of the yarns produced by rotor spinning technique are presented in Tab. IX (Artzt, 1992). The presence of flax fibres in the yarn and in the resulting fabric has his importance and gives the final product specific positive flax properties. But – as far as the appearence is concerned – the yarns manufactured both by the ring and rotor spinning cotton technology have the character of cotton yarns.

VI. Blended linen yarns spun by conventional cotton ring spinning system (flax = tow)

	Flax 10% Cotton 90%	Flax 20% Cotton 80%	Flax 15% PAC 85%	Flax 35% PAC 65%	Flax 15% Viscose 85%	Flax 30% PES 70%	Flax 30% PES 70%	Flax 30% PES 70%
Linear mass (tex)	50	50	49.7	48.2	50	45.4	47.3	51.4
Linear mass irregularity (%)	–	–	1.2	1.1	–	2.7	4.1	4.4
Strength (cN/tex)	11.5	10.3	18.2	14.4	10.3	17.3	19.5	15.7
Strength irregularity V (%)	13.7	15.6	11.5	12.7	10.4	9.5	12.4	16.4
Elongation (%)	6.1	6.0	19.4	18.5	15.2	20.3	20.0	
Twists (n/1 m)	453	443	428	407	409	486	525	516
Twist irregularity V (%)	4.2	4.4	5.4	2.2	5.9	4.9	9.1	

VII. Blended linen yarns spun by convetional cotton ring spinning technology (30% Flax –50% Viscose – 20% Cotton) (Rieter)

Linear mass	tex	64	64	31	31
Linear mass irregularity CV	%	18.0	19.2	22.0	25.0
Breaking strength	cN/tex	11.5	11.1	10.0	9.6
Elongation	%	6.0	6.5	4.8	5.2
Faults	n/1 000 m				
Thin places		20	30	280	500
Thick places		600	980	2 000	500
Neps		480	650	1 900	2 450

Source: Nüssli (1994)

VIII. Blended linen yarns spun by conventional wool spinning system (flax = combings)

	Flax 11%, Wool 22% PES 41%, PAC 26%	Flax 11%, Wool 22% PES 41%, PAC 26%	Flax 15% PAC 85%	Flax 35%, PAC 47% Wool 18%	Flax 15%, Viscose 17% PAC 68%	Flax 25%, Viscose 17% PAC 58%	Flax 26%, Viscose 14% PAC 60%	Flax 30% PAC 70%	Flax 30% Viscose 70%
Linear mass (tex)	48.6 x 1	48.9 x 2	32.1 x 2	32 x 2	54	50	55	51	68
Linear mass irregularity (%)	1.8	1.3	2.1	2.7	2.48	2.6	4.4	2.3	5.4
Strength (cN/tex)	13.1	15.5	13.8	6.5	12.9	13.0	9.9	9.9	7.3
Strength irregularity V (%)	12.5	9.3	12.1	10.1	3.9	4.2	5.0	5.4	7.5
Elongation (%)					12.8	10.7	14.9	12.6	11.0
Twists (n/1 m)	434	180	–	–	360	340	326	330	334
Twists irregularity V (%)	6.5	7.2		6.7	3.3	3.5	1.9	3.6	4.3

IX. Rotor spunblended linen yarns

Blend	Linear mass		Breaking strength	
	tex	CV%	cN/tex	CV%
10% Flax/90% Cotton	30	3.5	8.5	13.5
20% Flax/80% Cotton	42	3.5	8.0	13.5
30% Flax/70% Cotton	50	3.5	7.5	14.0
40% Flax/60% Cotton	64	3.5	7.0	14.0
10% Flax/90% Cotton	30	3.5	6.5	13.5
20% Flax/80% Cotton	42	3.5	6.5	13.5
30% Flax/70% Cotton	50	3.5	6.5	13.5
10% Flax/90% PES	30	3.5	12.0	13.5
20% Flax/80% PES	42	3.5	12.0	13.5
30% Flax/70% PES	50	3.5	11.5	13.5
40% Flax/60% PES	64	3.5	11.5	13.5

Source: Krmela (1993)

It is, however, the customer wish that the fabric, though made of blended yarns, keeps the original appearance of a linen product, characteristic for the technology of wet traditional spinning. Even to that wish technological answer is reported and even high proportion linen rotor yarns with linen character are expected in the nearest future (Krmela, 1993).

Wrap spinning

There were two main reasons that Institute of Natural Fibres decided to use the wrap spinning technology for flax. This were the two important flax negatives:
- the rigidness of flax fibre
- the low flax fibre elongation

The wrap spinning technology is specially suitable to overcome both of them. The process developed by Institute of Natural Fibres in early 1980's operates in Poland in full scale production mainly of knitting linen yarns. The features of blended short and long staple Parafil linen yarns are given in Tab. X, XI.

Friction spinning

The features of linen blended yarns spun by Dref-3 and Dref-2 spinning machines are presented in Tab. XII, XIII.

At the moment this technology was proposed in Poland for upholstery yarns mainly. But some other applications are also expected, e. g. in knitted apparel, where a yarn spun with the spinning speed 140 m/min was used in experiments conducted at the Institute of Natural Fibres in Poznań.

X. Wrapped yarns spun bz spinning frame Parafil 2 000

Kind of yarns	Linear mass tex	Breaking cN/tex	Strength V%	Elongation %	Wrapping material %
Flax – PL combed yarns					
Flax-PL combed yarn (fibre broken to 220 mm)	86.2	9.4	22.0	4.5	5.5
Flax-PL combed yarn (fibre broken to 200 mm)	75.8	7.5	18.0	1.9	5.5
Flax – combed blended yarns					
Flax-PL combed blended yarn 30% flax/70% PES	56	20.2	18.0	17.9	6.2
PL combed blended yarn 30% flax/70% viscose	100	11.5	13.9	9.7	2.3
PL combed blended yarn 30% flax/70% viscose	50	11.5	19.0	17.9	4.6
PL combed blended yarn 20% flax/30% PES/50% PAC	86	11.6	14.8	14.1	5.5

XI. Wrapped yarns spun by spinning frame Parafil 1 000

Specification	Linear mass		Breaking strength		Elongation %	Wrapping material %	Number of wraps per 1 m	Spinning speed nm/min
	tex	V%	cN/tex	V%				
Composition:								
40% Flax/30% PES/30% PAC	78.7	–	9.7	–	14.5	6.3	330	53
30% Flax/20% PES/ 50%	98.0	3.5	10.2	14.7	14.1	4.9	130	80
30% Flax/70% PES	54.5	0.2	19.1	13.5	20.0	5.0	130	80
20% Flax/40% PES/40% Viscose	57.7	2.1	14.4	13.0	14.7	5.0	130	80
20% Flax/80% PAC navy blue	51.4	2.9	9.6	20.2	12.7	5.0	130	80
20% Flax/80% PAC beige	55.4	2.5	10.5	12.8	14.6	5.0	130	80
and an experiment on manufacturing crowel to be used in knitted top fabrics								
30% Flax/20% PES/50% PAC	450.6	–	14.6	8.5	14.7	3.7	150	120

CONCLUSION

The new outlook on flax fibre features in textiles might be resumed as follows:

1. The excellent positive flax fibre features, which provide comfort and hygiene of linen goods have shifted flax fibre application towards apparel sector. The above-mentioned market changes directed the demand to fine linen yarns, which until now can be produced best by traditional (expensive) technology from best qualities of flax fibre (from long hackled flax).

2. The negative flax fibre features:
- great and irregular length,
- great and irregular thickness,
- low elongation,
- rigidness,
- high impurities content,
- resistivity against splitting

(all of them more vissible and difficult the lower the quality of the fibre present, specially in short fibre) had to change – to accommodate to more effective modern spinning techniques.

3. New forms of flax fibre adapted to short and long universal spinning systems are marketed at the moment in most linen-producing countries. Natural fibres trends in fashion and growing ecological awareness help to promote these new flax types successfully.

4. The main features of new flax fibre types may be characterized as:
- lower length and thickness (but still with wide stapel and finesses diagram),
- low impurities content (but still to be improved),
- improved surface properties.

Narrowing the stapel and fineness diagram, improving the purity and softness of new flax fibre tapes are the tasks for future development.

5. With new flax fibre features the development of the production of new linen yarns and goods become possible and is taking place all over the world.

6. Flax fibre features witch provide comfort and hygiene as well as ecological character of flax fibre will

XII. Friction linen blended yarns (spun by spinning machine DREF-3)

	Blend	Linear mass			Strength			Elongation %	Twist n/m
		tex	Nm	V%	da N	cN/tex	V%		
DREF 3	corn: PAN 38 mm coat: PES 50%, flax 50% 150 m/min	51.09	19.57	0.7	0.63	12.39	13.5	18.3	
DREF 3	corn: PES 38 mm coat: cotton 60%, flax 40% 150 m/min	53.44	18.71	1.1	1.10	20.51	9.4	11.4	
DREF 3	corn: flax 20%, PES 25%, PAN 55% coat: PES 50%, flax 50% 150 m/min	82.57	12.11	1.8	0.71	8.65	13.7	9.9	

XIII. Friction linen blended yarns (spun by spinning machine DREF-2)

No	Blend	Linear mass			Strength			Elongation %	Twist n/m
		tex	Nm	V%	da N	cN/tex	V%		
4675	corn: fil. PES 167 dtex coat: flax 20%, 25% PES, 55% PAN 150 m/min	99.70	10.03	1.6	0.94	9.43	4.0	21.1	–
4675	corn: fil. PES 167 dtex croat: flax 20%, PES 25%, PAN 55% 150 m/min	161.45	6.19	1.1	0.78	4.83	20.9	13.3	–
4675	corn: fil. PES 167 dtex coat: flax 20%, PES 25%, PAN 55% 170 m/min	152.00	6.58	1.0	1.28	8.42	6.3	20.2	–
4689	corn: fil. PES 167 dtex coat: flax 20%, PES 25%, PAN 55% 170 m/min	105.26	9.50	1.0	0.95	9.03	5.6	19.7	–
4689	corn: fil. PES 176 dtex coat: flax 20%, PES 25%, PAN 55% 130 m/min	159.06	6.29	1.1	0.71	4.44	16.8	12.5	–
	corn: fil. 167 dtex coat: flax 100% 130 m/min	108.34	9.23	0.4	1.04	9.60	6.9	8.0	–
	corn: fil. PES 167 dtex coat: flax 100% 130 m/min	149.48	6.69	1.0	0.85	5.68	21.3	6.5	–

continue to promote flax fibre production and processing even if the fashion will change its favourable approach to linen. The design of apparel may change – but the flax fibre will remain untouched by the mode dictatorship, just thanks to the improved attitiude of the buyers all the world – (who do understand all the flax positives) – and also thanks to researchers – who helped to overcome the negative flax fibre features.

REFERENCES

ARTZT, P.: Chancen und Möglichkeiten der Garnerzeugnung aus Kurzfaseflachs nach dem Rotor-Spinnverfahren. Proc. 4 Reutlingen Flachsseminar, 24–25 Februar 1992, Reutlingen, Germany.

BRUNNSCHWEILER, D.: The textile world industry – the global village. Text. Techn. Intern. Special Supplement 1992.

CALVI, F.: Situation in flax from the view of the spinning industry. V Reutlingen Flachssymposium, 7–8 März 1994, Reutlingen, Germany.

DEVIES, S.: The expansion of the linen industry. Text. Techn. Inter. 1991.

HARDING, P. W.: Textiles in the 90's. Textile World, 1992.

KOZŁOWSKI, R.: The coexistence of natural and man-made fibres after the year 2000. Natural Fibres (in press).

KOZŁOWSKI, R.: Flax – as alternative crop in polluted areas. (in press)

KOZŁOWSKI, R. – MANYŚ, S.: Flax – 2000. The renaissance of the oldest fibrous plant? Natural Fibres (in press).

KRMELA, S.: The present state and outlook of the Czechoslovak flax growing and processing. Reutlinger Flachsseminar, 24–25 Februar 1992, Reutlingen, Germany.

KRMELA, S.: Manufacture of blended yarns using cottonized flax and the properties of woven fabrics made thereof. III European Workshop on Flax, 15–17 June 1993, Bonn, Germany.

MACKIE, G.: An overview of global production/consumption of flax in clothing, household textiles and industrial uses. Natural Fibres (in press).

MACKIE, G.: Whither linen – East or West? Text. Techn. Intern. 1990.

MANYŚ, S.: Application of flax-blended Parafil yarns in woven and knitted products. Reur Technical Series, 1993 (9), Poznań.

MANYŚ, S.: Linen yarns. Pas and present. Pallavaseminaari, 22 März 1944. Savolinnassa. University of Ostiensis, Finland.

MARSANO, P.: Textiles in tomorrow's world. Proc. Textile Institute Conference, 14–15 October 1992, York, England.

NÜSSLI, E.: Rieter spinning systems. Reutlingeer Flachssymposium, 7–8 März 1994, Reutlingen, Germany.

SCHENEK, A.: Einsatzmöglichkeiten von dampf-angeschlossenen Flachsfasern. Proc. 4 Reutlingen Flachsseminar, 24–25 Februar 1992, Reutlingen, Germany.

SCHÖLLER. L.: Einsatz von Flachs in der Textilindustrie. V Reutlingen Flachssymposium, 7–8 März 1994, Reutlingen, Germany.

SCHREIBER, O. H.: Entwicklung von Maschinen zur Flachsverarbeitung – eine Investition für die Zukunft? V Reutlingen Flachssymposium, 7–8 März 1994, Reutlingen, Germany.

SCHUH, T.: Einsatzmöglichkeiten von Flachsfasern in automobiltechnischen Anwendungen. V Reutlingen Flachssymposium, 7–8 März 1994, Reutlingen, Germany.

SLATER, K.: Chemical testing and analysis. Text. Progress, *25*, 1993 (1/2).

TOPF, W.: Flachs – eine alte, ewig junge Faser. Chemiefasern. Textilindustrie, 1988 (9).

–: Proceedings of the Post-OTEMAS Pre-ITMA. Conference, 23–24 February 1994, Brandford, United Kongdom.

Received on November 2, 1994

Contact Address:

Prof. Dr. Ryszard Kozłowski, Institute of Natural Fibres, ul. Wojska Polskiego 71b, 60-630 Poznań, Poland, Fax: 004861/41 78 30

Upozornění pro autory vědeckých časopisů

Z důvodu rychlejšího a kvalitnějšího zpracování grafických příloh (grafů, schémat apod.) příspěvků zasílaných do redakce Vás žádáme o jejich dodání kromě tištěné formy i na disketách.

Týká se to samozřejmě těch grafických příloh, které byly vytvořeny v nějakém programu PC (např. CorelCHART, Quatro Pro, Lotus 1-2-3, MS Excel). Vzhledem k tomu, že nejsme schopni upravit a použít pro tisk všechny typy (formáty) grafických souborů, žádáme Vás, abyste nám také kromě originálních souborů (např. z MS Excel typ *.XLS) zasílali grafické předlohy vyexportované jako bodovou grafiku v jednom z těchto formátů:

Bitmap	*.BMP
Encapsulated Postscript	*.EPS
Graphic Interchange Format	*.GIF
Mac paint	*.MAC
MS Paint	*.MSP
Adobe Photoshop	*.PSD
Scitex	*.SCT
Targa	*.TGA
Tag Image File Format	*.TIF

Redakce časopisu

PLANT RESIDUES AS RAW MATERIAL FOR PARTICLEBOARDS

ODPADY ROSTLINNÉHO PŮVODU JAKO SUROVINA PRO VÝROBU LIGNOCELULÓZOVÝCH DESEK

R. Kozłowski, B. Mieleniak, A. Przepiera

Institut of Natural Fibres, Poznań, Poland

ABSTRACT: The usefulness of different annual plant residues (flax and hemp shives, jute, bagasse, reed stalks. cotton stalks, vetiver roots, miscantus straw, rape, oil flax, small grain straw, vetiver and saw dust) for manufacturing lignocellulose boards was presented. The plant residue was used as the only component of boards and with waste wood. The raw materials were characterized and their effect on properties of lignocellulose boards was presented. Some of economic aspects od application of this kind of raw materials under Polish conditions were also discussed.

plant residue; lignocellulose boards manufacturing; binding materials; methods of improving

ABSTRAKT: Zkoumala se použitelnost částí různých jednoletých rostlin (pazdeří ze lnu a konopí, juta, řepné řízky, vylisovaná cukrová třtina, rákos, stonky bavlny, kořeny vousatky, sláma miscantu, řepky olejné, lnu a dalších plodin, piliny apod.) pro výrobu lignocelulózových desek. Zbytky rostlin spolu s dřevným odpadem byly v tomto případě použity jako jediná složka pro výrobu desek. Údaje o místech výroby ve světě (tab. I) a v Polsku speciálně (tab. II) jsou doplněny popisem používané suroviny (tab. III a příslušný text). Vlastnosti desek jsou s ohledem na použitou surovinu popsány v tab. V až VIII. Pozornost je věnována také použitým pojidlům (tab. IX). Jsou podrobněji popsány technologie výroby lignocelulózových desek spolu s jejich ekonomickými bilancemi v polských podmínkách. Pozornost je věnována zejména deskám ze lněného pazdeří (obr. 1), třívrstevným deskám z konopného pazdeří (obr. 2), deskám z kořenů vousatky (obr. 3), třívrstevným deskám z pilin a pazdeří (obr. 4) a lignocelulózovým deskám ze slámy a stonků rostlin, připraveným metodou Stramit (obr. 5). Dalšího zlepšení kvality lignocelulózových desek se dosáhne jejich lepší povrchovou úpravou, popřípadě použitím speciálních fólií pro konečnou úpravu jejich povrchu. Významné je využívání nových typů pojiv, která mimo jiné snižují i hořlavost desek.

odpady rostlinného původu; výroba lignicelulózových desek; pojidla; povrchová úprava

INTRODUCTION

The shortage of wood together with a need of utilization the waste wood and the abundance of plant residue such as flax and hemp shives, jute, bagasse, etc inspired in 1947 the production of boards from the annual plant waste. These raw materials can be classified into following groups:

- residues of the fibre-based plants: flax and hemp shives, jute, sisal stalks;
- bagasse, reed stalks, cotton stalks, grass-like miscantus;
- residues of the oil plants: rape, sunflower, oil flax, sunflower straw, vetiver roots;
- residues of food plants: grape-vine stalks, palm leaves and stalks, small grains, arachid and rice husks, small grain straw.

These residues are specially appreciated in these parts of the world where wood resources are sober and wood supply for the building industry limited.

Most important of the raw materials mentioned above are hemp and flax shives, jute and bagasse.

First materials used for the production of particleboards were flax shives. The flax boards were well accepted on markets for furniture, building industries and transport. The technological development in particleboard production and unestablished situation in annual plant production resulted in a periodical lack of raw materials, flax shives for example. The situation forced researchers to look for other raw materials including residues to fill the gap in the accessibility of raw materials. Excellent examples of this kind were saw dust and waste wood chips. The use of the latter two components improved some of the properties of boards, specially in the scope of application in the furniture industry.

Contemporary the use of the equipment for the board production from the annual plant residue one can manufacture lignocellulose boards which contain up to 60% of wood chips. Only small changes in the equipment and technology are required.

Such board prevent a calm surface even despite some differences in particle geometry (e. g. shives and saw dust even more) and their properties are considerably better.

Presently Polish producers of shive boards manufacture boards containing 35–100% of shives and 65–0% of saw dust.

In Western Europe: Belgium and France shive board factories were transformed into wood-derived board factories. In Poland they were transformed into mixed board factories using waste wood and flax shives, while in the Czech Republic and Slovakia into factories using saw dust and shives.

Lignocellulose boards from flax and hemp shives are produced also in Romania, Bulgaria, China and the former Soviet Union. Tab. I shows approximate sizes of lignocellulose boards made from annual plant residue in different regions of the world.

Primarily the technology and the equipment for the most plants were supplied by Verkor (Belgium), Siempelkamp (Germany) and Polimex-Cekop (Poland).

The recession in flax industry in 1975–1985, reduction of the demand for hemp and jute fibre and choke of chemical fibres – polyethylene and polypropylene ones caused considerable decrease production and freezing of research and development works on the annual plant residue boards (Mackie, 1993; Stasiak, 1993). On the other hand, the remarkable development of boards based on wood for the furniture, building industries and transport caused the rejection of boards made of annual plant residue. The quality of these boards for the contemporary applications was generally insufficient.

At the end of 1980s and in the beginning of 1990s a considerable stimulation was noticed in the best fibre-based industries in many countries of the world. This situation can be explained by the general trend toward natural products including health food and health clothing based, among others, on oil and fiber flax.

The other reason was the marvelous discovery that fibrous plants cultivated in the polluted areas can naturally decontaminate the soil from the heavy metals giving the opportunity of eliminating the food crops being cultivated on the polluted soils. Such plants can be used for lignocellulose board, fibre and pulp production with no negative effect on the environment. These are reasons for the renewed stimulation connected with the utilization of annual plant residue (Kozłowski et al., 1992). These plants are a good example of 100% utilization and a full recycling of annual plant residue which after an improvement can be used in furniture, building industries and transport where they are appreciated mainly for the wide variety of produced boards.

THE DEVELOPMENT OF LIGNOCELLULOSE BOARDS IN POLAND

The output of linen industry in Poland during the period of 1960–1973 was approximately 200,000 tons of shives. These shives became a very valuable raw material when the first particleboard producing plant was started in 1959. Their utilization increased the profits from the cultivation of flax and hemp.

The following factors are thought to be essential for the development of particleboards: the possibility of use of inexpensive raw materials being a very arduous by-products at a time:

- modest investment needed to build the plant,
- possibility of automatization of production process,
- production of the materials of different properties depending on the customer's demand.

Overall the 7 plants producing particleboards were built in Poland including 5 based on the equipment and technology of Verkor (Belgium) and Siempelkamp (Germany) and 2 based on Polish equipment. The total capacity in the best years was on the level of 210,000 m^3 of annual output.

Tab. II shows the capacity of the individual plants started in 1959. In the next years a lot of research was made to introduce improved boards and start the production of boards of special properties (water-, fire- and fungi proof) and to improve the quality according to the demand of the modern furniture and building industries.

I. Approximate production data on lignocellulose boards made of annual plant residues in different countries

Country	Number of plants	Production, capacity thousand m^3/year	Kind of raw material	Kind of board produced
Bulgaria	1	10	flax and hemp shives	flax and hemp shives boards
China	1	7.5	flax shives	flax shives boards
Czech Republic and Slovakia	4	100	flax shives, saw dust	shive-saw dust boards
Poland	4	140	flax shives, wood chips, saw dust	wood chip shive boards, hard flammable boards
Hungary	1	20	hemp shives	hemp shives boards
Romania	2	30	hemp shives	hemp shives boards
Former USSR	5	75	flax shives	boards from waste cotton
	1	20	cotton waste	

II. Particleboard plants in Poland

Plant	Date of starting the production				
	1959	1961	1963	1965	1973
	Production capacity, m³/year				
Witaszyce	36,000				
Pakość		18,000			
Koszalin			36,000		
Szczytno			36,000		
Żyrardów			18,000		
Wołczyn				48,000	
Malbork					16,000

These activities resulted at the end of 80s in approximately 70% share of improved boards in the total production. The production of waterproof and fire retardant particleboards was initiated for building industry and shipbuilding.

THE RAW MATERIALS USED IN PARTICLEBOARD PRODUCTION

The following by-products from annual plants are commonly used for the particleboard production: flax hemp shives, jute stalks, and bagasse. Reed stalks, cotton stalks, and oil crop (rape, oil flax) residues: vetiver roosts, oil flax straw, rape straw, small grain straw can also be used. For several years the saw dust has been used as a complementary raw material.

RESIDUES OF BAST FIBRE PLANTS

Flax and hemp shives and jute stalks are often classified as best raw materials. They are obtained during the production of flax, hemp and jute fibres. Flax shives, for instance, contain approximately 35.7–51.7% of cellulose and 22.1–30.1% of lignins. Depending on the method of fibre extraction different types of shives can be obtained: „biological" (water retting)), dew retted, and „green" (after decortication) (Kozłowski, 1969).

Particleboards of relatively good properties are obtanied from „biological" shives. Unfortunately, such shives are characterized by an unpleasant odour of volatile fatty acids which were formed during the retting process and were adsorbed by shives.

Hemp and flax shives have the following advantages comparing to wood:

- lower energy required for the chopping and drying which has a considerable effect on the reduction in costs of manufacture,
- low bulk density and usefulness for the production of boards in a wide range of density and thickness,
- high hardness, resilience, slenderness, and smoothness of particles.

These advantages allow for a good gluing of the surface with a low use of adhesives as well as the production of boards of good mechanical properties with lower bulk densities.

The economic, technological and exploitation problems cause the following aspects:

- content of the considerable percentage of impurities (waste fibre, sand, dust, roots, stones) and that is why a special technology is required for the raw material purification,
- unpleasant odour of "biological" shives caused by the volatile fatty acids adsorbed by the shives,
- the pH of raw materials varies to a wide extent depending on the method of fibre extraction, therefore the process has to be conducted under carefully controlled conditions.

Hemp shives, unlike the flax shives and jute residues require:

- the crumbling of the raw material,
- the greater amount of adhesives, stronger binding of particles due to a considerable content of a soft core in the inner part of stalks.

The shive properties can be altered in fairly small range depending on geographical location, local conditions of cultivation, fertilization, variety, etc.

For instance, Chilean shives comparing to the similar Polish shives show the following advantages:

- almost undetectable odour,
- lower hardness of particles,
- lower content of fibres, dusts and other impurities.

Among the disadvantages one can find following features:

- the bigger share of coarse fraction particles,
- the lower content of usable shives,
- the necessity of additional crumbling of coarse fractions in order to increase the effectiveness of raw material utilization.

Tab. III shows the quality demand for flax and hemp shives effective in Poland comparing to the quality of Chilean shives assessed on the basis of tests conducted by the Institute of Natural Fibres.

III. Quality requirements of hemp and flax shives used in Poland comparing with Chilean shives on the basis of assessment conducted in Poland (%)

Properties	Shives		
	flax	hemp	chilean
Content of usable shives	75–80	75–80	73
Moisture content	to 15	to 15	9.5
Fibre content	to 5	to 12	0.5
Roots content	9–15	–	–
Dust content	11–14	12	1.2
Other impurities	–	6–10	3.5
Organic acid content calculated for acetic acid	to 0.15	to 0.15	0.08

Source: Frąckowiak and Kozłowski, 1962; Frąckowiak et al., 1967; Kozłowski, 1973

BAGASSE AND REED STALKS

The sugar cane is cultivated in many parts of the world and bagasse is the residue material obtained each year during sugar production. In a first place it is used as a fuel in sugar plants, the remainder is used for lignocellulose board production.

The reed in Poland is available from natural reed habitats, which are not a result of cultivation of any kind. Hence both the yield and the efficiency are the result of the natural local conditions. The most valuable part of the plant – the stalks – is 1.5–5 m long with walls of thickness ranging from 0.6 to 2 mm. The stalks are used for the particleboard production. The properties of the reed straw are similar to those of sugar cane. The moisture content is the lowest during winter (14–21%). The reed straw is used for the production of reed boards which can be used in building industry and for plait of different products for home use. The reed resources in Poland are estimated to 70–75 thousand ton/year. The reed residue is estimated to 4–5 thousand tons and is to be considered also a raw material for particleboard production.

The reed displays the following advantages:

- low density (60–70 kg/m^3) an unpressed state at the moisture of 15%,
- the lowest known water adsorption among all organic building materials (most probably due to a high content of silica),
- low expansibility,
- good performance under the flame conditions probably due to a considerable content of silica.

There are also disadvantages:

- high content of ash (approximately 2.5–2.8%) which contains calcium, silicon, magnesium and potassium oxides. The high content for ash is the reason of quick blunting of the cutting equipment,
- the need of suitable crumbling of raw material due to the waxes covering the stalks which influences board quality.

The ecomomic problems regarding the reed and reed residues consist in:

- raw material stock localized in the remote parts of the country and costs of transport,
- the size and the quality of raw material and the need of storage of the material associated with this fact.

From the technological point of view the reed residue is a very good raw material for the production of light boards to be used in building industry, manufactured as special ones-water-, fire-, and fungiproof boards (Kozłowski et al., 1972).

GRASS (MISCANTUS)

A valuable raw material for the particleboard production is the China reed – *Miscantus sinensis* Giganteus. It belongs to the perennial grasses. There is a grass of a very high efficiency of biomass per the surface unit. Miscantus contains high amounts of cellulose. This grass due to the ability to accumulate heavy metals can be cultivated in polluted areas. The research on the possibility of cultivation of this plant and its possible applications is carried out in many countries of the world (Hasse, 1990).

COTTON STALKS

The cotton grows in the countries of a moderate temperature, e. g. 290–300 K throughout the year. The bushes are 0.5–1.5 m tall depending on the type of cotton and conditions of cultivation. After harvesting of fibre balls, stalks are the residue material left in the fields, which is used as a raw material for lignocellulose boards production, especially in the countries of low forestry. The efficiency of the material is low in the proportion to the content of the cortex, fibre, husks and leaves. The boards are light brown.

OIL PLANTS RESIDUES AND SMALL GRAIN STRAW

Vetiver is native to tropical and subtropical countries. This is the perennial grass about 2 m tall. Each bush consists of approximately 25 stalks. The length of roots is about 45 cm. The fresh root weighs 65 g. This species is used for the extraction of oil which can be applied in pharmaceutical and cosmetic industries (Kozłowski, 1981).

The vetiver roots have the following features:

- long, heavily twisted, rhizomes of different length, red and black in color,
- high content of mineral impurities and dust which forces to provide an intensive purification,
- alkaline reaction of the material which has to be taken into account in the binding technology.

The technological problems consist in:

- proper crumbling of the material to ensure maximum degree of crosscutting,
- necessity of installation of special equipment for dust removal due to hazardous and irratating gases and dust emitted crumbling of the material.

Features of the vetiver describes above show that is value as a raw material for particleboard production is reduced by:

- relatively low content of usable fraction (60%),
- high content of mineral impurities and dust,
- difficulties during crumbling.

Rape straw is still the residue material which due to its properties cannot be fully applied in the agriculture. In most cases the straw is chopped and distributed in the field. Taking into account the climatic and soil conditions, rape can be cultivated on the acreage of 800,000–1,000,000 hm^2 in Poland (Kozłowski, Przepiera, 1987).

Oil flax in Poland is cultivated on a very small scale presently only about 1,000 hm^2. However, a further development of cultivation of this crop is anticipated in Poland mainly due to growing interest oil Flax varieties.

Great resources of oil flax can be found in Canada, U.S.A., Argentina and the China. The waste straw of rape, oil flax and small grains can be excellent raw materials for insulating particleboard production of 'Stramit' type.

The advantages of such residue for 'Stramit' type boards are:

- low density,
- low coefficient of thermal conductivity,
- low costs of production, since the material does not have to be crumbled, nor specially purified.

FOOD PLANT RESIDUES

The valuable raw materials for lignocellulose board production are also many other residues such as: grape-vine stalks, rice husks, arachid husks, bamboo, hop, wicker residues, etc.

The attempts at using these materials for lignocellulose board production were made many times in e. g. Siempelkamp Company, INF and others with good results.

WOOD INDUSTRY BY-PRODUCTS

A considerable place in the lignocellulose board industry is taken by saw dust that complements shives. The saw dust is characterized by the following features:

- variable moisture content ranging from 70 to 120% right away after cutting a tree, to 40–60% after longer storage,
- crumbling of particles having different shape and slenderness than shive particles.

A distinguished differences in shape and slenderness were shown in Tab. IV. The data are based on slenderness coefficient estimation of individual fractions of saw dust and shives (K o z ł o w s k i, 1975).

Here are some advantages of saw dust:

- rich and accessible raw material stock,
- low price and low costs of transport due to the short distances,
- recommended sizes of particles – no additional costs of crumbling is required.

However, like other raw materials, saw dust create some technological problems such as:

- necessity of drying which imposes the introduction of additional dryers into technological line for materials containing high amount of water,
- content of high amount of impurities (different pieces of wood, bark, etc.) – there is a demand for suitable devices to remove the impurities.

THE PROPERTIES OF PARTICLEBOARDS BASED ON ANNUAL PLANT RESIDUES AND SAW DUST

As mentioned above the following annual plant residue materials are used for the production of particleboards: flax and hemp shives, jute stalks, bagasse and saw dust.

One of the most important advantages of these boards is a possibility of board production in a wide spectrum od densities from 300-750 m^3. Density ranges for individual residue materials are given in Tab. V.

The physical and mechanical properties of particleboards from annual plant residues manufactured according to the INF technology are shown in Tab. VI. The table contains the results for 19 mm boards.

Tab. VII displays physical and mechanical properties of boards tested by Siempelkamp, made of jute stalks, cotton stalks, bagasse, bamboo and arachid husks manufactured according to Siempelkamp technology. The results showed refer to the three layer boards, 19 mm thick, manufactured under laboratory conditions in Siempelkamp Company.

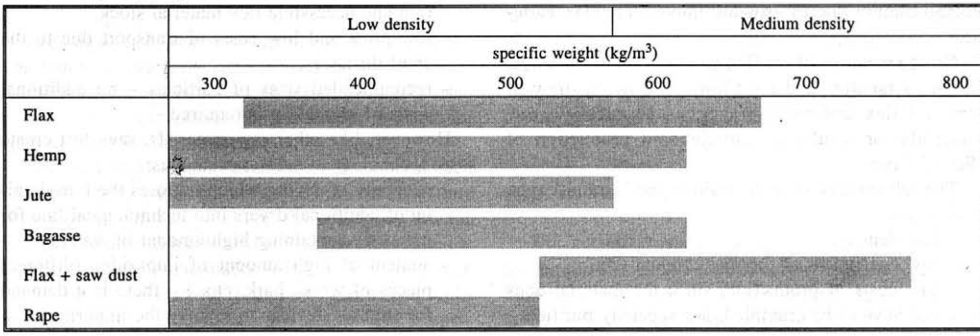
The residue materials like oil flax straw, small grain straw, reed and reed residues are very good raw materials for insulating boards according to 'Stramit'

IV. Assessment of the shape and slenderness of particles (saw dust, shives)

Fraction type	Raw material	Unit (mm)	Most frequent size of particles (mm)	Medium size of particles (mm)	Slenderness coefficient $\frac{l}{d}$
2.5 sieve	saw dust	length l	2.0–5.0	5.7	2.85
		thickness d	0.6–2.0	2.0	
	shives	length l	7.0–11.0	10.9	10.58
		thickness d	0.6–1.5	1.03	
> 2.5 sieve	saw dust	length l	1.1–2.5	2.07	2.30
		thickness d	0.6–1.5	0.9	
	shives	length l	2.6–6.0	5.8	6.44
		thickness d	0.5–1.0	0.9	

Source: K o z ł o w s k i, P i o t r o w s k i, 1987

V. The density range of particleboards from different annual plant refuse



Source: Frąckowiak, Kozłowski, 1962; Frąckowiak et al., 1967; Kozłowski, 1973; Kozłowski, Piotrowski, 1987; Niedermaier

VI. Physical and mechanical properties of particleboards made of annual plant waste, produced according to the technology of the INF

Properies	Unit	Flax	Hemp		Flax + saw dust		Vetiver roots
			particleboard	three layer particleboard	particleboard	three layer particleboard	
Density	kg/m^3	600	600	600	650	650	650
Modulus of rupture	MPa	16–18	15–16	17–18	17–18	17–18	16–17
Internal bond strength	MPa	0.3–0.4	0.4–0.5	0.5–0.6	0.5–0.6	0.5–0.6	0.5–0.6
Swelling thickness after 24 hrs	%	15–20	16–18	20–25	8–10	12–13	10–12

Source: Frąckowiak, Kozłowski, 1962; Frąckowiak et al., 1967; Kozłowski, 1981; Kozłowski, Piotrowski, 1987

VII. Physical and mechanical properties of particleboards made of annual plant waste, produced according to the technology of the Siempelkamp

Properties	Unit	Bagasse	Cotton stalks	Jute	Reed	Bamboo	Peanut husks
Density	kg/m^3	600	600	580	730	625	750
Modulus of rupture	MPa	20–21	16–17	15–16	22–23	18–19	17–18
Internal bond	MPa	0.4–0.5	0.4–0.5	0.5–0.7	0.4–0.5	0.6–0.7	0.5–0.6
Swelling thickness	%	6–7	5–6	12–15	6–7	6–8	–

Source: Niedermaier

VIII. Physical and mechanical properties of insulating boards depending on raw material used

Type of raw material	Thickness (mm)	Density (kg/m^3)	Maximum moisture content (%)	Maximum water adsorption (%)	Compressing resistance (MPa)	Bending resistance (MPa)	Thermal conductivity coefficient W/m^2.K)	Thermal penetration coefficient (W/m^2.K)	Acoustic insulation at the frequency (Hz)	
									50–3 200	200–12 800
Rape straw	50 ± 1.5	270	18	220	0.80	1.20	0.071	0.95	–	–
Oil flax straw	50 ± 1.5	490	18	190	1.15	1.60	0.069	0.92	20	22
Small grains straw	50 ± 1.5	420	18	210	1.00	1.35	0.073	0.99	19	21
Unclassified straw	50 ± 1.5	490	18	195	1.15	1.60	0.069	0.92	20	22
Reed and reed waste	50 ± 1.5	270	18	200	0.075	1.20	0.071	0.95	–	–

Source: Kozłowski, Przepiera, 1987

IX. The parameters of urea-formaldehyde resins used in the particleboard plants in Poland

Properties	Unit	Type of resin		
		112 E	Silekol	Silekol W – 1
Density at 293 K	g/cm^3	1.26–1.29	1.27	1.25–1.35
Viscosity at 293 K	MPa	300–500	700-1200	500-900
pH		7.6–8.6	7.5–9.0	7.5–8.5
Content of dry matter at least	%	64	66	65
Free formaldehyde content – at the outmost		0.15	0.30	0.30
Molar ratio of urea to formaldehyde		1.0 : 1.2	1.0 : 1.3	1.0 : 1.3

Source: Kozłowski et al., 1993

method, for instance. The physical and mechanical properties for this type of boards manufactured according to the technology of INF are given in Tab. VIII.

BINDING MATERIALS

For the production of particleboards made of annual plant residue it is necessary to apply synthetic heat-hardened glues based mainly on urea-formaldehyde or urea-melamine-formaldehyde resins. In recent years the technologies were developed where the binding materials are gypsum and cement and other original technologies such as production of boards resistant to fire according to the technology of the INF, where a new binding material was used – the polycondensation product of urea borates and urea phosphates with silicates. Among amino glues the most common are urea, melamine-formaldehyde and phenol-formaldehyde resins.

The advantages of urea resins are:

- low price,
- wide range of use when hardening can take place (368–523 K),
- short time of hardening,
- high mechanical resistance of adhesives.

Disadvantages are as follows:

- low resistance to cold water, steam and atmospherical factors,
- emission of free formaldehyde.

For the hardening of resins the most often chemicals used are ammonium chloride or ammonium sulphate and moderating additives (ammonia, urotropine, urea). The paraffin-stearic emulsion is added in order to improve water resistance.

For instance, Polish particleboard plants use three main types of urea-formaldehyde resins. The properties of these resins are shown in Tab. IX.

For the production of lignocellulose boards a degree of particle gluing is, on the average, 7–10% depending on the material used. For the shive boards this level is 7%. For the shive-saw dust boards this level ranges from 8 to 10% depending on shive share.

Alike the wood chip board industry, the very important problem concerning particleboards is the emission of free formaldehyde.

In the particleboard industry in Poland, efficient results were obtained regarding the decrease of formaldehyde emission from the boards through the following efforts:

- application of the technologies using the amino-magnesium scavenger of formaldehyde,
- pressing time elongation,
- application of modified urea-phenol glue.

The content of formaldehyde in the boards ranges from 5.88 to 8.38 mg/100 g and the emission of the formaldehyde ranges from 0.006 to 0.029 mg/1 m^3.

THE TECHNIQUES OF RAW MATERIAL PREPARATION AND TECHNOLOGIES OF LIGNOCELLULOSE BOARD PRODUCTION

The raw materials for the lignocellulose board production are obtained as a waste products of different industries. Their usability is described by the special techniques of raw material preparation and technologies of particleboard production. These factors are as follows:

- technologies of harvest, transport and storage,
- technologies of raw material preparation,
- particleboard production.

The harvest, transport and storage and techniques of initial processing depend on the type of material used. The technologies of initial processing are being adjusted in order to meet the specific conditions of contamination contained in the raw material (Frąckowiak, Kozłowski, 1965; Kozłowski et al., 1972). These conditions encompass the separation of the basic source of contaminations, e. g. fibres, roots, dusts, stones etc. In some cases the methods of crumbling of raw materials have to be chosen for a specific raw material (hemp shives, jute stacks, cotton stacks, bagasse etc.).

The technologies of board production should take into account the specificity of the raw material used, for instance: flax shives show a low permeability of mat-forming and resistance to deformation. Therefore longer pressing time must be applied. In this case, from the economic point of view, most suitable are multi-platen presses. The single-platen presses are used only when very low efficiencies are required. In the case of flax shives, the circulating frame system and stationary initial press were chosen as most suitable. The band system is not recommended due to a low permeability of the mat which makes difficult a safe insert of panel into then main press (hot one).

Loading stations have to be adjusted to a particular technology from the point of view of their kind a number. The raw materials discussed here are useful for homogeneous board production and three-layer boards.

FLAX BOARD PRODUCTION

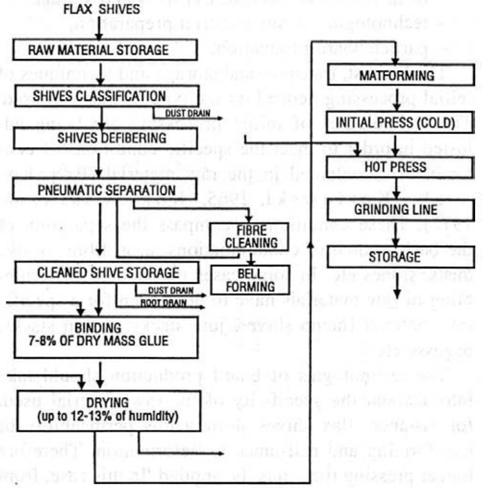
The production process of flax boards is a continuous process. There are two main stages in the process that are independent and differ in the kind and purpose of the equipment. The overall technological process for homogeneous board production is showed in Fig. 1.

During the first cycle of the production, the initital purification and sorting of shives, during the second one board production takes place (Frackowiak et al., 1967).

Purification of shives is carried out at three stages. Removal of dust and waste fibres is performed using specially constructed devices. The separation of roots is performed in the pneumatic sorter. Separated roots are ground and returned to the production. Root contaminants are present when the harvest is based on pulling (flax), whereas when the material is harvested by cutting such contaminants are not present (hemp, jute, etc.).

Purified shives transported to silos for storage, where the material is seasoned.

In the second production cycle, purified and seasoned shives are fed into the feeder of purified shives.



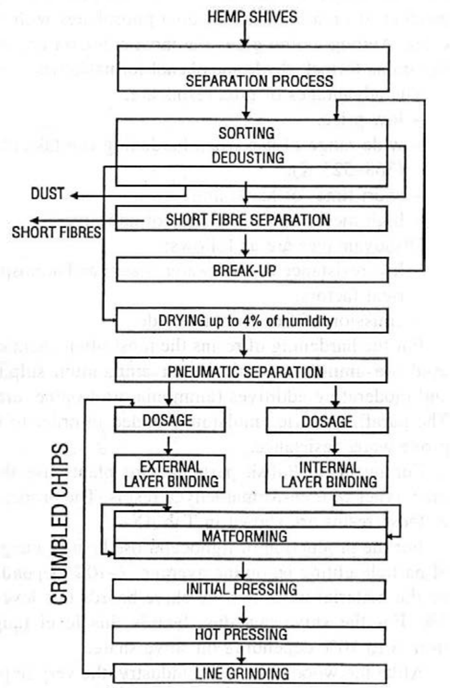
1. Homogeneous flax particleboard

The control of the raw material passing to the further production stage is ensured by band transporter control. The accuracy of feeder work depends also on the sufficient homogeneity of the upper layer of shives. These factors are crucial for the proper relation of glue to the shives.

Blending of shives can be performed using different types of blenders (the percentage of blended particles varies from 7 to 10% depending on the raw material). In Polish plants, which manufacture particleboards working on the base of annual plant wastes, the turboblenders are used. They ensure quick and uniform blending of raw material. In the further process blended shives are initially dried to the 12–13% of moisture content. This is an important technological feature because the initial polycondensation of glue takes place which increases its viscosity and binding ability.

The bulk density and thickness of the boards are controlled by the feeding device and exchangeable distance bars.

The number and the kind of forming stations depend on the kind of particleboards produced (homogeneous boards, 3-layer boards). Forming stations dose the particular amount of the material to the Cahl plates. Due to the specific conditions created by the plant material the production cycle provides the initial cold pressing with the pressure of 2.5 MPa. The pressing is to form the firm panels allowing to load them into the multishelf-hot press.



2. Three-layer, hemp particleboard

	Pressing parameters
Pressing temperature K	220–450
Pressing pressure MPa	2.0–3.0

When high temperatures are used for pressing, it is necessary, however, to take into consideration the initial drying of the material before blending (like in the case of wood chips) to the moisture content of 3–4%.

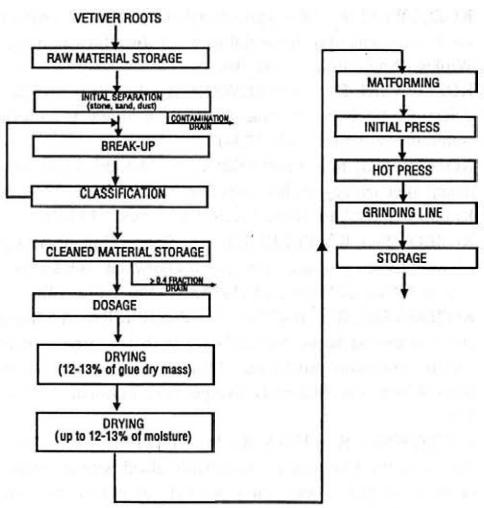
The Figs. 2, 3 and 4 show the diagrams of the subsequent stages of the production of the 3-layer hemp shive boards, 3-layer wood dust-shive boards and homogeneous boards from vetiver roots. The technologies for the production of these boards were developed in the INF. The technologies include minor technological changes resulting from the specific raw material, pressing parameters, and kind of boards.

PARTICLEBOARD PRODUCTION ACCORDING TO THE 'STRAMIT' METHOD

Annual plants residues such as rape straw, oil flax straw, small grain straw, reed and reed wastes are useful for the insulating board production, for instance according to the 'Stramit' method. The technology of such board production is showed in Fig. 5.

The production is a continuous process taking place in the device including six machines. The production is a programmed, multi-functional cycle with an automatic self-controlled temperatures (K o z ł o w s k i et al., 1987).

The press is uniformly fed with raw materials, firmly compacted and pressed. At the same time the compacting mechanism moves gradually pressed material which is subsequently blended continuously. The cardboard is fed from rolled bales which are placed over and under a board formed. Then the board is placed in a tunnel where it is dried and the glue bond is hardened.



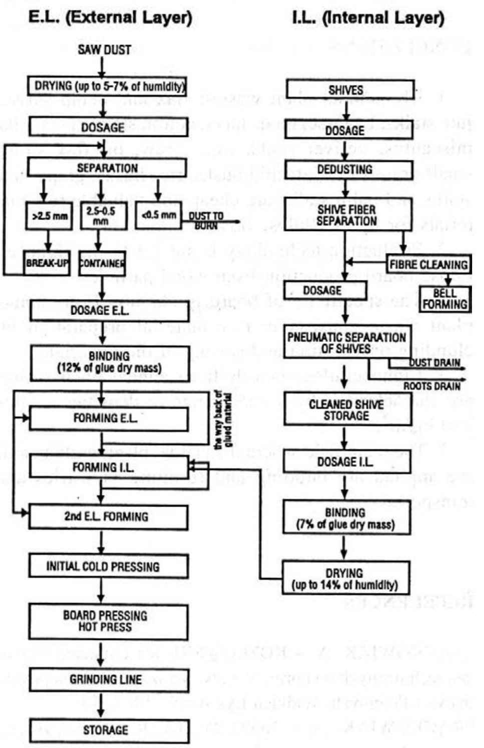
3. Homogeneous vetiver roots particleboard

THE METHODS OF IMPROVING OF LIGNOCELLULOSE BOARDS MADE OF ANNUAL PLANT WASTES IN POLAND

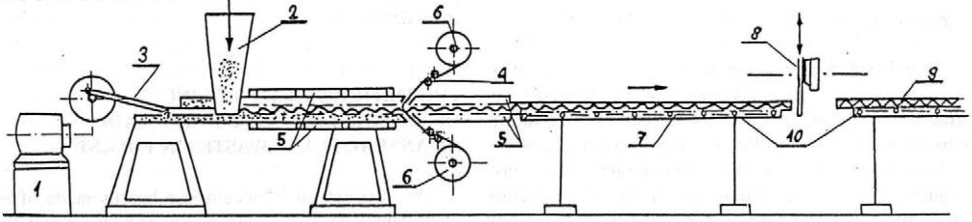
The structure of lignocellulose boards made of annual plant wastes and a possibility of board production of different densities and thicknesses created the demand for an improvement in production technologies of boards mainly for the building and furniture industries (K o z ł o w s k i et al., 1979, 1981). The research and introductory works in the plants manufacturing lignocellulose boards from the particles of annual plants resulted in the introduction of the following technologies of board improving:

- with dull laminates having specially finished surface feature which is formed during the manufacture of the laminate,
- with the foils on the paper carrier having final finished surface for the further finishing with varnish methods.

The technologies for fire resistant boards were also developed on the basis of:



4. Three-layer saw dust-shives particleboard



5. The scheme of device for insulating board production

1. main engine
2. straw feeder
3. fed material rammer for ribbon pressing
4. binding agent feeding cylinders for ribbon covering
5. heading panels of the initial and final board pressing tunnel
6. paper for board bonding
7. board ribbon bonded with paper
8. vertical saw for long cutting of board
9. ready board
10. role transportet

– new kind of binding material – a polycondensation product of urea borates and urea phosphates with silicates, lignocellulose and mineral particles e. g. vermiculite,
– amino-formaldehyde resins, lignocellulose particles, fire retards, boric acid, ammonium phosphates, urea, biuret and urea polyphosphates) (Kozłowski et al., 1984, 1989, 1992).

CONCLUSIONS

1. The annual plant wastes: flax and hemp shives, jute stalks, bagasse, reed stalks, cotton stalks, grass-like miscantus, vetiver roots, rape straw, oil flax straw, small grain straw, arachid husks, rice husks, grape-vine stalks and palm stalks are cheap and valuable raw materials for lignocellulose board production.

2. Production technology is similar to the lignocellulose board production from wood particles.

3. The specificity of board production from annual plant waste consists in raw material preparation inclunding purification and sorting of the material.

4. Lignocellulose boards from annual plant wastes are characterized by a wide range of densities – 300–750 kg/m^3.

5. The main field where the annual plant waste boards are applied are building and furniture industries and transport.

REFERENCES

FRĄCKOWIAK, A. – KOZŁOWSKI, R.: Ustalenie wymagań technicznych do normy dla płyt o paździerzy konopnych. Instytut Przemysłu Włókien Łykowych, 1962: 39.

FRĄCKOWIAK, A. – KOZŁOWSKI, R.: Wykorzystanie pyłów szlifowania płyt paździerzowych do produkcji elementów gotowych zastępujących wyroby z drewna lub wypełniaczy w przemyśle chemicznym. Instytut Przemysłu Włókien Łykowych, 1965: 59.

FRĄCKOWIAK, A. – GIEŁDZIK, F. – FIGURA, E.: Technologia produkcji płyt paździerzowych. Instytut Przemysłu Włókien Łykowych, 1967: 89.

HASSE, E.: Reisengras – ein neuer Rohstoff für die Spanplatten. Wood Raw Materials Symposium, Würzburg, Germany 1990.

KOZŁOWSKI, R.: Wpływ mocznika na skład i zawartość lotnych kwasów tłuszczowych w płynie roszeniowym i paździerzach. Instytut Przemysłu Włóken Łykowych, 1969: 136.

KOZŁOWSKI, R.: Określenie własności paździerzy konopnych chilijskich pod kątem ich przydatności do produkcji płyt lignocelulozowych. Instytut Krajowych Włókien Naturalnych, 1973: 20.

KOZŁOWSKI, R.: Technologia wytwarzania płyt paździerzowo-trocinowych na bazie surowca z Czechosłowacji. Instytut Krajowych Włókien Naturalnych, 1975: 31.

KOZŁOWSKI, R.: Określenie przydatności korzeni vetiveru do wytwarzania płyt lignocelulozowych. Instytut Krajowych Włókien Naturalnych, 1981: 19.

KOZŁOWSKI, R. – PIOTROWSKI, R.: Produkcja płyt paździerzowo-trocinowych. Prace Instytutu Krajowych Włókien Naturalnych, *XXXI*, 1987: 123–132.

KOZŁOWSKI, R. – PRZEPIERA, A.: Metoda ciągłej produkcji płyt izolacyjnych u odpadów roślin. Prace Instytutu Krajowych Włókien Naturalnych, *XXXI*, 1987: 133–142.

KOZŁOWSKI, R. – PRZEPIERA, A.: Kierunki modernizacji i intensyfikacji produkcji płyt paździerzowych. Włokna Naturalne – Natural Fibres, *XXXV/XXXVI*, 1992: 133–142.

KOZŁOWSKI, R. – BATOG, J. – PRZEPIERA, A.: Shive and wastewood based particleboard with low free formaldehyde emission properties. 27th International Particleboard/Composite Materials Symposium. Pullman, U.S.A., 1993.

KOZŁOWSKI, R. – HELWIG, M. – PRZEPIERA, A.: Properties of fire retardant particleboards glued with adhesives on basis of polycondensation products of polyborates and polyphosphates of urea with silicates. Proceedings of Technical Forum Presentation of 23rd International Particleboards/Composite Materials Symposium. Washington State University, 1989.

KOZŁOWSKI, R. – KACZMARSKA, B. – PRZEPIERA, A.: Ekspertyza dotycząca możliwości zastąpenia paździerzy lnianych i konopnych innymi dostępnymi surowcami do produkcji płyt. Instytut Krajowych Włókien Naturalnych, 1972: 42.

KOZŁOWSKI, R. – KACZMARSKA-MIELENIAK, B. – WILKOŃSKA, H.: Badania nad rozwojem produkcji, doskonalenia jakości oraz modyfikacja płyt paździerzowych oklejonych laminatami dekoracyjnymi typu vertical dla potrzeb przemysłu mablarskiego. Prace Instytutu Krajowych Włókien Naturalnych, *XXV*, 1981: 262–278.

KOZŁOWSKI, R. – MILENIAK, B. – PIOTROWSKI, R.: Uszlachtnianie płyt lignocelulozowych laminatami wtórnie formowanymi. Prace Instytutu Krajowych Włókien Naturalnych, *XXVI*, 1979: 186–196.

KOZŁOWSKI, R. – FLANC, M. – ROSOCHOWITCZ, J. – FRĄCKOWIAK, A.: Opracowanie technologii produkcji płyt paździerzowych z wykorzystaniem odpadów z obcinania i pyłow ze szlifowania. Instytut Krajowych Włókien Naturalnych, 1972: 9.

KOZŁOWSKI, R. – GRABOWSKA, L. – MAŃKOWSKI, J. – RYNDUCH, W.: Possibilities of applying of bast fibrous plants cultivated on polluted areas for pulp and particleboard peoduction. Pacific Rim Bio-Based Composites Symposium. Rotorua, New Zealand, 1992.

KOZŁOWSKI, R. – HELWIG, M. – PRZEPIERA, A. – MICIUKIEWICZ, A.: Flame retardant particleboards produced on the basis of by-products from processing of fibrous plants and other materials. Pacific Rim Bio-Based Composites Symposium. Rotorua, New Zealand, 1992.

KOZŁOWSKI, R. – PRZEPIERA, A. – PIOTROWSKI, R. – REBELKA, A.: Płyty lignocellulozowe odporne na ogień, biokorozję i wodę. Prace Instytutu Krajowych Włókien Naturalnych, *XXIX*, 1984: 173–186.

MACKIE, G.: Jute – Can it survive the battle with polypropylene? Natural Fibres – Włokna Naturalne, Poznań, *XXXVII*, 1993: 99.

MALONEY, T. M.: Modern particleboard. Dry-Press Fiberboard Manufacturing. Miller Freeman Publications 1977.

MOSLEMI, A. A.: Particleboards V. 1–3. Southern Illinois University Press 1974.

NIDERMAIER, F. P.: Technology, engineering and machinery for manufacturing of panelboard from non wood materials. Information Materials of Siempelkamp Company. Krefeld, Germany.

SHARNA, H. S.: The biology and processing of flax. M. Publications, Belfast, Northern Ireland.

STASIAK, A.: An overview of the jute crisis in Bangladesh. Natural Fibres – Włókna Naturalne, Poznań, *XXXVII*, 1993: 89.

PROZEMAK: Technical offer No. 817/93 for flaxboard manufacturing plant output of 10.000 cu.m/year. Warsaw, Poland, 1993.

PATENT – Great Britain – No. 1022.093 of Stramit Company.

PATENT – Great Britain – No. 1278.242 of Stramit Company, September 16, 1968.

PATENT – FRG –No. 1659293 of Stramit GmbH Co. KG 2849 Goldenstedt 15.

POLISH PATENT No. 205537 submitted by the INF, Poznań, March 22, 1978.

POLISH PATENT No. 99936 submitted by the INF, April 12, 1977.

Received on November 2, 1994

Contact Address:

Prof. Dr. Ryszard Kozłowski, Institute of Natural Fibres, ul. Wojska Polskiego 71b, 60-630 Poznań, Poland, Fax: 004861/41 78 30

DISCUSSION

PROCESSING OF AGROMATERIALS

The way how the agromaterials are processed depends on the purpose they are used for. If the crop is used for the energy generation simple „burning" is not feasible in the large scale. Transportation to large energy plant is costly and small plants are not effective. In the case of wet material (plants grown on sludge) drying is energy-consuming. Therefore biomass will be first transformed to biogas which could easily be done in small local units and biogas can be simply stored and transported (it not used locally).

Economy environment is another factor affecting the processing. This was demonstrated in the case of biooil. Lubricants or diesel fuel are alternative possibilities and the choice depends on economy considerations as taxes, price of mineral oil, etc.

Economy also determines the processing of potatoes. Fermentation would be the method of choice provided the price of sugar is high. Another possibility might be to use potato starch, however, to prevent water pollution during its manufacturing would ask for costly investments. Manufacturing of biodegradable packing materials would be possible if the tax regulation prefers biodegradable materials, etc.

Last but not least factor is public fashion. This affect substantially the balance between extent of using cotton, flax and synthetics as textile materials.

In the future with the decline of fossil carbon resources (coal, oil, gas) agromaterials will gain importance as starting materials for chemical industry.

Prof. RNDr. Jaroslav D r o b n í k, CSc., Institute of Biotechnology, Charles University, Praha

Contact Address:

Prof. RNDr. Jaroslav D r o b n í k, CSc., Přírodovědecká fakulta UK, Biotechnologický ústav, Viničná 5, 128 44 Praha 2, Česká republika, fax: 0042/02/29 36 43

LINSEED IN HEALTH FOOD AND NUTRITION

SEMENA LNU V DIETĚ A VÝŽIVĚ

P. Kołodziejczyk[1], P. Fedec[1], J. Kozłowska[2], R. Kozłowski[2]

[1]*P. O. S. Pilot Plant Corp., Saskatoon, Canada*
[2]*Institute of Natural Fibres, Poznań, Poland*

ABSTRACT: This paper describes possible applications of linseed based products for the health food market. The linseed oil contains particularly high levels of omega-3 fatty acids. Dietary effects of these acids may be linked to the functions of blood platelets, cholesterol levels and prevention of coronary diseases. Moreover, linseed has a high content of lignans which apparently exhibit some antitumor activity. However, there are antinutritional factors in linseed such as cyanogenic glucosinolates and it has a tendency to concentrate heavy metals within storage protein of seed. For pharmaceutical or food markets, new varieties and/or agronomic techniques need to be developed. Presented data show application of BIOFLAX, a product developed and marketed by the Institute of Natural Fibers in Poznan. The BIOFLAX, when applied as a bakery additive showed improvement in major bread functionalities.

linseed; coronary diseases; antitumour effect; BIOFLAX

ABSTRAKT: Jsou popsány možnosti uplatnění výrobků z lněných semen při zdravé výživě. Ve lněném oleji je zvlášť vysoký obsah omega-3 mastných kyselin. Dietetický význam těchto kyselin spočívá v jejich vlivu na krevní destičky a na obsah cholesterolu a jako prevence koronárních onemocnění. Kromě toho mají semena lnu vysoký obsah lignanů, které působí protinádorově. Mají však i některé nepříznivé vlastnosti, jako je obsah kyanogenních glukogenů nebo tendence ukládat v sobě těžké kovy. Pro farmaceutické a potravinářské potřeby je nutné vypěstovat nové odrůdy a vyvinout nové agrotechnické postupy. Je poukázáno na vliv přípravku BIOFLAX, který vyvinuli a na trhu nabízejí pracovníci Ústavu přírodních vláken v Poznani. BIOFLAX použitý jako přídavek do těsta zlepšuje vlastnosti chleba.

semeno lnu; koronární onemocnění; protinádorové působení; BIOFLAX

INTRODUCTION

Interest is growing for flaxseed (linseed) applications in food and health food industries. Bioactive substances of flax: α-linolenic acid and lignans have been the subject of extensive research in recent years. A new flax variety: Linola™, with an altered fatty acid profile, has been introduced in several countries. The market for functional food products, containing flaxseed components is growing due to public awareness and interest in *nutraceuticals*. Analytical methods for monitoring anti-nutritional and toxic substances in flaxseed have been developed.

Agricultural industries in developed countries provide abundant amounts of food staples to their population. To alleviate overproduction of basic agricultural commodities, politicians desperately seek new crops to offer farmers (voters), entrepreneurs and applied research organizations in the quest of *value-added* food products. Resulting *niche markets* may appear for the *special products* (including health food markets, functional foods, nutraceuticals, etc.). The general public has become more focused on *healthy* aspects of food as a result of better education regarding eating habits, and often to aggressive and not always sincere advertising campaigns of *health food* producers promoting their products. In addition, rising medicare costs for the aging population of these countries is taxing. The rationale for this observed trend is simple, prevention is less expensive than treatment. In fact, despite considerable expenditure on cancer or coronary disease research, the prevention: i. e. balanced diet, healthy life-style, is still the number one *treatment*.

Regardless of the reasons for this phenomenon, the health food market is growing rapidly and entrepreneurs are seeking new sources of bioactive substances for incorporation into foods. These developments are creating interest in theoretical and applied research related to biological activity of new or traditional foods and their components. Flax or linseed (*Linum usitatissimum)* is a perfect example of how food trends may stimulate research and development of new products.

Flax is an ancient crop cultivated for over 8 000 years, likely of Asian origin and known to ancient societies of India, China and Egypt. Flaxseed contains 35–45% oil and approximately 25% protein at 10%

moisture. The unique seed coat contains a water dispersable carbohydrate or gum mucilage (2–7% by weight). Traditional flax oil is a highly unsaturated, readily oxidized oil – referred to as a *drying oil* due to high α-linolenic acid levels. New, low linolenic flax varieties produce a stable oil with great potential for edible uses.

Linola^{TM} is a chemically mutated flax variety with altered fatty acid composition. This low linolenic flax variety, registered in Canada as Linola^{TM}, was developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia and United Grain Growers Limited (UGG, Canada) (Green, Dribnenki, 1994).

FLAX LIPIDS

Lipids play an important role in human diet, serving as a reserve energy source for metabolic processes. More importantly, lipid fatty acids are basic building blocks of cell membranes.

Certain dietary polyunsaturated fatty acids (PUFA) are capable of regulating cellular eicosanoid biosynthesis. This aspect is noteworthy because excessive production of eicosanoids may exacerbate chronic pathophysiological conditions (i.e. coronary disease, inflammation). Consumption of ω-3 PUFA is associated with reduced incidence of coronary arterial diseases. Flaxseed oil is rich in ω-3 PUFA's and especially α-linolenic acid (up to 65% of total fatty acids).

Most terrestrial plants synthesize only the ω-6 series of fatty acids, i.e. linolenic acid (18 : 2*n*-6). Flax oil with its high linolenic acid (18 : 3) content is unique amongst other crops, and belongs to the *fish oil* class.

THE OMEGA-3 VS. OMEGA-6 BALANCE

Evident shifts in Western diets have occurred within the last two centuries influenced by industrialization and modern agriculture. As a result (n-3) fatty acids are currently under-represented in Western diets, where total fat consumption is high. Recently the role of (n-3) polyunsaturated fatty acids in human development, disease prevention and treatment has been examined. The triacylglycerol lowering effect of (n-3) PUFAs is one of the most consistent findings (Kinsella et al., 1990).

LIGNANS AND THEIR ROLE IN HUMAN DIET

Reports suggest that the incidence of cancer is lower in countries favoring vegetarian diets, but which dietary factors are responsible is unknown. Lately, attention has focused on lignans, natural products widely distributed in plants. Substances belonging to this group have exhibited antitumor activities (Axelson et al., 1992).

A novel group of lignans has been confirmed as a mammalian metabolite. These lignans: enterolactone [trans-2,3-bis(3-hydroxybenzyl)-γ-butyrolactone] and enterodiol [2,3-bis(3-hydroxybenzyl) butan-1,4-diol] may be primarily derived from plant lignans or other precursors in the diet. These substances indicate tumor growth suppression, particularly breast cancer. Although an association appears for low urinary excretion of mammalian lignans in non-vegetarians and postmenopausal women with breast cancer as opposed to healthy subjects, the mode of action is unclear (Stetchell, 1981, Axelson, 1992). Lignan production from precursors, present in food, could occur in the colon by intestinal flora. Finally, not all food groups produce the same amount of lignans, but in a wide range of food staples screened for lignan production in animals and humans, flaxseed flour and its defatted meal produced exceptionally high lignan levels: i. e. 100-800 times more than plant foods commonly found in vegetarian diets (Thompson et al., 1991).

ANTINUTRITIONAL AND TOXIC FACTORS IN FLAXSEED

Generally, substances impairing feed value by restricting availability of meal constituents to animals are known as antinutritional factors. Toxic factors are poisonous substances and their maximum tolerance (daily uptake) levels are usually regulated. As an example, flaxseed contains a certain amount of cyanogenic glucosides; linamarin, linustatin and neolinustatin. Levels of cyanogenics are influenced by cultivar, location and climatic conditions (Oomah et al., 1992). Levels of cyanogenic substances in flaxseed usually range from 300 to 800 mg/100 g (0:3–0.8%).

CADMIUM UPTAKE BY FLAX PLANTS

Concerns about heavy metals as contaminants in the environment are increasing. Since food is the main route for metals entering the body, monitoring of metal levels in agricultural crops and food stuffs is needed. Flaxseed, as a human food source or supplement, is receiving more attention as evidenced by growing markets for flax-based healthy food products, bakery additives and new flax varieties (Linola^{TM}) designed for human consumption.

In response to public concern about cadmium contamination in food products, nineteen countries in 1986 established maximum permissible limits in foodstuffs (Walker, 1988). For example, the Australian National Health and Medical Research Council (NHMRC) set maximum permissible concentrations of cadmium in bran, wheat germ and other unspecified foodstuffs at

0.2 and 0.05 mg/kg of fresh food, respectively. In Germany, a 300 ppb (0.3 mg/kg) limit for cadmium has been introduced. The German study indicated genotypic differences may be associated with uptake and accumulation of cadmium. Moreover, location (soil type, pollution) affected cadmium levels. In one site study where 15 varieties were tested, none met the 300 ppb minimum; some samples exceeded 1 700 ppb (Marquard et al., 1990).

Comprehensive North American data regarding cadmium levels for different varieties, soil types and locations is lacking. Fragmentary information suggests higher cadmium levels occur in specific varieties (i. e. Omega) popular in the United States. This appears to be consistent with analytical data gathered in our laboratory where seed samples of the Omega variety from N. Dakota indicated up to 1 300 ppb cadmium.

A more extensive study is required before generalizations can be made about varietal and regional variations in cadmium levels of flax. The German studies suggest that in certain locations, flaxseed having acceptable cadmium levels within allowable specification may be unattainable. On the other hand, development of flax varieties accumulating lower cadmium levels is also a possibility.

EFFECT ON THE HEALTHY FOOD MARKET

The findings presented above certainly will support further development of new varieties of food products and food additives based on flax meal/flour. An example of such a product is Bioflax (INF Poznań, Poland)

Our data has shown that Bioflax – a preparation based on defatted flax flour is an excellent natural additive to bakery products. Its nutrient composition is presented in Tab. I.

It was observed that it improves the texture of bakery products, the moisture is better retained by products containing Bioflax, and additionally, these products keep their freshness for prolonged periods of time. Another advantage is the higher nutritional value of baking goods enriched with the linseed additive.

I. Nutrient composition of Bioflax (per 100 g of preparation)

Energy	(kcal)	230
Protein	(g)	41
Fat	(g)	9.6
Ash	(g)	4.6
Dietary fiber	(g)	11.6
Carbohydrates	(g)	21
Mucilage	(g)	11

Results showing the influence of Bioflax® additive on the quality features of wheat bread are presented in Tab. II. Tests show that addition of Bioflax to wheat bread has an influence on:

- extension of bread freshness,
- improvement in leaf volume as a result of growth of the hygroscopicity of dough,
- improvement of quality features of bread: porosity and bread value number.

CONCLUSION

In recent years flax components have attracted a great interest due to the latest medical research results.

Flax seed contains the following:

- ω-3 fatty acids which influence blood platelet aggregation, lowering the level of the cholesterol and preventing coronary heart disease,
- an exceptionally high level of lignan precusors, known as anti-tumor agents at 100-800 times higher than in popular consumer products.

These properties allow for a wide use of flax products on the healthy food market:

- a wider use of flax seed oil in the human diet,
- possibility of changing animal lipid composition as a result of applying PUFA-components of flax in animal feed,
- a wider application products from defatted flax meal in food.

II. The influence of Bioflax addition on quantity features of wheat bread

Level of Bioflax addition (%)	Hygroscopity of dough (%)	Number of bread value (points)	Coefficient of porosity (points)	Compresibility after 72 h (%)
0	60.0	147	95	63.8
1	61.0	135	93	66.8
2	62.8	129	95	70.0
3	64.0	139	93	69.6
4	65.0	159	100	66.4
5	66.6	176	100	67.0
7	69.4	167	98	65.6
9	72.0	168	98	70.4

Bioflax® an example of a new healthy food product offered as a natural additive to bread, has been prepared by the INF, Poznań. Bioflax® addition improved the quality features of bread, its porosity and its general value and retarded staling.

REFERENCES

AXELSON et al.: Nature, 1992 (298): 1207.

GREEN, A. G. – DRIBNENKI, J. C. P.: Lipid Technology, *29*, 1994.

KINSELA, J. E. et al.: Amer. J. Clin. Nutr., *52*, 1990: 1.

KOŁODZIEJCZYK, P. – KOZŁOWSKA, J.: Flax in Europe. Production and Processing. Proceedings of the FAO European Regional Workshop on Flax. Bonn, 1993.

MARQUARD, R. von – BÖHM, H. – FRIEDT, W.: Fat Sci. Technol., *92*, 1990: 468–472.

OOMAH, D. – MAZZA, G. – KENASCHUK, E. O.: J. Agric. Food Chem., *40*, 1992: 1346–1348.

STETCHELL et al.: Lancet, July 4, 1981: 4.

THOMPSON, L. U. et al.: Nutrition et Cancer, *16*, 1991: 43.

WALKER, J. M.: In Bur. Rural Resources, Proc. 2, Cadmium Accumulations in Australian Agriculture, Canberra, 1988: 176–185.

Received on November 2, 1994

Contact Address:

Paul Kołodziejczyk, Ph. D., P. O. S. Pilot Plant Corporation, 118 Veterinary Road, Saskatoon, SK., Canada, S7N 2R4, Fax: (306) 975-3766

FLAX PRODUCTION IN THE CZECH REPUBLIC

PRODUKCE LNU V ČESKÉ REPUBLICE

L. Rosenberg[1]**, P. Šmirous**[2]**, S. Krmela**[3]

[1]*State Institute for Testing in Agriculture, Brno, Czech Republic*
[2]*Linen Association of the Czech Republic, Šumperk, Czech Republic*
[3]*Moravolen, a. s., Šumperk, Czech Republic*

ABSTRACT: The development of flax production since 1985 is presented. Between 1985 and 1993 there has been a 70% decrease in the area of flax grown and matching decrease in the harvest of dew-retted flax. There has been a small revival in flax production since 1994 and it is anticipated that 13–15 thousand hectares will be devoted to growing flax in 1995–96. This would seem to indicate a stabilisation of the situation. The surveys of flax processors are published.

flax stem; flax fibre; scutching mills; spinning mills

ABSTRAKT: V příspěvku je uveden vývoj produkce lnu v České republice v období od roku 1985. Mezi léty 1985 až 1993 poklesla výměra lnu o 70 % (obr. 1). Tento pokles se projevil zhruba 50% poklesem produkce dlouhého vlákna (obr. 2). Zde se pozitivně projevila lepší odrůdová skladba pěstovaného lnu. K určitému zvýšení výměry lnu došlo v roce 1994 (11 tisíc hektarů) a růst se očekává i v dalších letech. V budoucnosti lze předpokládat jistou stabilizaci pěstování stonkového lnu na výměře v rozmezí od 13 tisíc hektarů při celkové roční produkci vlákna 7 až 8 tisíc tun. Jsou uvedeny základní údaje o zpracovatelích stonkového lnu: obr. 4 obsahuje údaje o 19 tírnách a obr. 5 údaje o přádelnách, které v současné době zpracovávají stonek lnu, popřípadě lněné vlákno.

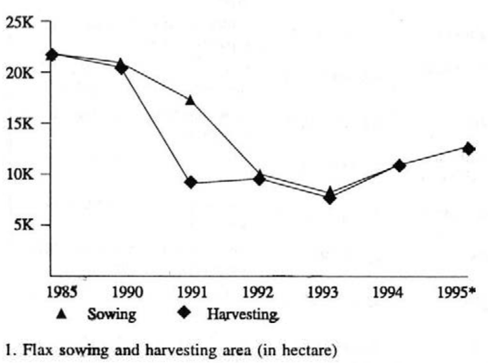
stonek lnu; lněné vlákno; tírny; přádelny

INTRODUCTION

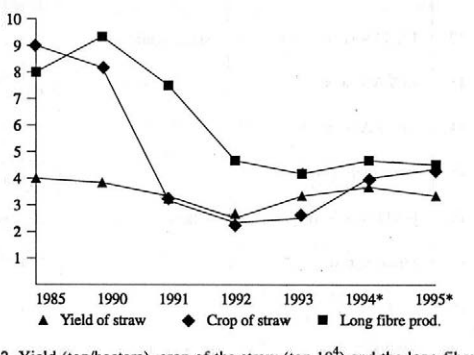
Flax is the only textile crop grown in the Czech Republic on a large scale. The crop has proved to be suited to the poorer soils and climatic conditions of the highlands and better mountain areas (Rosenberg et al., 1992). Flax growing and processing has traditionally been an important part of the Czech textile production. Because it can be produced domestically it has an advantage over other plant raw materials which have to be imported (Krmela et al., 1993). The changes in the economic system after 1989 brought a lifting of price controls, a removal of subsidies for flax growing and a loss of guaranteed eastern market. This led to a period of stagnation in the flax industry and in the flax production as well.

THE DEVELOPMENT OF FLAX PRODUCTION SINCE 1985

The sowing area in 1985 was 23 thousand hectares and yield of dew-retted flax was 4 ton per hectare. This situation represents the maximum growing area and



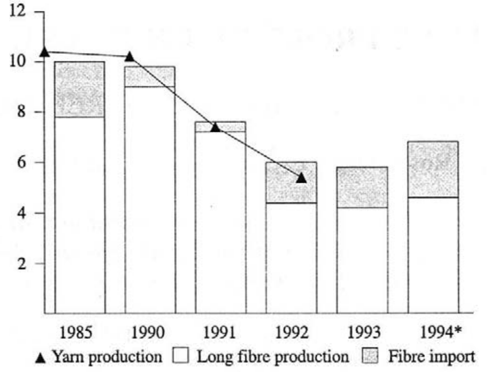
1. Flax sowing and harvesting area (in hectare)



2. Yield (ton/hectare), crop of the straw (ton.10^4) and the long fibre production (ton.10^3)

yield during the eighties. Subsequent development has been charted through statistical surveys. Fig. 1 shows a stable level of flax production at an area over 20 thousand hectares up until 1990.

The change from the previous economic system and its consequent reorientation towards a market economy removed all state interventions in agriculture and the



3. Long fibre production (ton.10^3), fibre import and yarn production (ton.10^3)

4. Scutching mills in the Czech Republic in 1994

Legend:

No	Name of company	Address	Place	Phone	Specification of production
1	Českomoravský len, a. s.	Lnářská 499	396 12 Humpolec	42 367 2811	flax boards, nonweaved text.
2	Českomoravský len, a. s.	5. května 951	396 12 Humpolec	42 367 2151	scutching flax, short fibre/shive separation
3	Českomoravský len, a. s.	Domanínek 1217	593 01 Bystřice nad Perštejnem	42 505 2146	scutching flax, short fibre/shive separation
4	Českomoravský len, a. s.	Božejov 77	394 61 Božejov	42 366 77277	scutching flax, short fibre/shive separation
5	Českomoravský len, a. s.	Bobrová 13	592 55 Bobrová	42 616 93224	scutching flax, short fibre/shive separation
6	Českomoravský len, a.s.	Rváčovská 1210	539 01 Hlinsko v Čechách	42 454210721	scutching flax, short fibre/shive separation
7	LUŽAN, a. s.		387 93 Bavorov	42 342 97261	scutching flax, short fibre/shive separation
8	Českomoravský len, a. s.	Písečné 39	593 01 Bystřice nad Perštejnem	42 505 93131	scutching flax, short fibre/shive separation
9	Českomoravský len, a. s.	Pomezí 352	569 71 Pomezí	42 463 8271	scutching flax, short fibre/shive separation
10	Českomoravský len, a. s.	Stará Říše 182	588 67 Stará Říše	42 66 98237	scutching flax, short fibre/shive separation
11	Českomoravský len, a. s.	Větrný Jeníkov 167	588 42 Větrný Jeníkov	42 66 95116	scutching flax, short fibre/shive separation
12	LENAS, a. s.	Malá Šťáhle	795 01 Rýmařov	42 647 84527	scutching flax, short fibre/shive separation, flax rope
13	LUŽAN, a. s.		391 81 Veselí nad Lužnicí	42 363 85321	flax boards, scutching flax, short fibre/shive separation
14	LENKA, s. p.		285 09 Kácov	42 328 94326	scutching flax, short fibre/shive separation
15	Sázavolen, s. r. o.		582 86 Leština u Světlé nad Sázavou	42 451 901	scutching flax, short fibre/shive separation
16	KATEX, s. r. o.	Vítkov	793 04 Stará Libavá	42 646911531	scutching flax, short fibre/shive separation
17	Tírna, s. r. o.		789 91 Štíty	42 649901186	scutching flax, short fibre/shive separation, shive briquettes
18	L. B. V.		340 22 Nýrsko	42 186 71181	scutching flax, short fibre/shive separation
19	LINEN 3, s. r. o.	Lhota u Trutnova	541 03 Turnov	42 439 4061	scutching flax, short fibre/shive separation

flax processing industry. This has put the Czech Republic at disadvantage when competing with E.C. countries where such intervention still exists. In addition the industry has suffered from the collapse of the east European market. The area of flax sown in the Czech Republic dropped to 17 thousand hectares in 1991. Furthermore, bad climatic conditions, particularly the draught which prolonged the dew-retting season by two months, has meant that only 10 thousand hectares of this, could be harvested. The quality of fibre was also poor. This decline continued, reaching its lowest point in 1993. There has been an increase of some 11 thousand hectares of flax grown in 1994 and further increase is expected. Not only was there a reduced area of flax sown during these years but yields per hectare were also lower. Straw crops have continued to be low because of this situation (Fig. 2). Straw production has dropped to 30 % of 1985 levels although fibre production has only fallen by 50 % due to the introduction of better flax varieties.

Our textile industry demanded about 10 thousand tons of long fibre per year in the period 1985–1990 (Fig. 3).

The short fall in better quality fibre was made up to some extent by imports, but there is still not sufficient raw flax to meet the demands of the textile industry. Fibre stores, including short fibre have been exhausted. Previously, as short fibres were of limited use, a large store had been amassed, but with the introduction of new technology this too has been utilised. Now we are in a situation where a shortage of raw flax exists including shives for board production. Board production is quite profitable and amounts to 60 thousand cubic meters of board per year. Fig. 3 documents the halving of yarn production up until 1992 and the predicted decrease for 1993.

5. Spinning mills in the Czech Republic in 1994

RESTRUCTURALISATION OF FLAX INDUSTRY

The processing industry has passed through the privatisation. Scutching mills, the first step of flax processing were previously monopolised by Českomoravský len Humpolec, which had 29 factories with 31 scutching mills. Four factories were closed during 1991–1992 and one new factory was set up. Flax is now processed in 18 factories using 8 scutching mills from Deportere and 17 of existing UTR mills with capacity 25–45 thousand tons of retted flax in one shift. The present capacity of the scutching mills is more than sufficient. Shive board production also takes place in two these factories. A by-product of short fibre processing is the production of fuel briquettes and a felt „fleece". Fig. 4 shows the location of flax processing plants. Flax yarns were previously produced in 11 spinning mills run by Texlen and Moravolen. Texlen and Moravolen were transformed to joint-stock companies and some factories became independent. Flax yarns are now produced in 9 spinning mills (Fig. 5).

FUTURE EXPECTATIONS

Considering the current world boom of this crop, its versatility (long fibre, short fibre, shive, seed, oil meal) and its ecological advantages, it is anticipated

Legend:

No	Name of company	Address	Place	Phone	Specification of production
20	MORAVOLEN	Štefánikova 1	787 01 Šumperk	42 649 4611	hackling, spinning, weaving
21	MORAVOLEN		789 56 Sudkov	42 649 2731	hackling of long fibre and short fibre, yarn TEX 58-125
22	MORAVOLEN	Tř. Hrdinů 67	792 01 Bruntál	42 646 3951	wet spinning, dry spinning, flax yarn of wool type
23	NOBLESLEN, s. r. o.	Šumavská 17	787 01 Šumperk	42 649 4619	flx yarn TEX 30-74
24	KALUS, s. r. o.	Jaselská 29	746 01 Opava	42 653 211621	short fibre yarn
25	VRSAN, s. r. o.	Jesenická 196	793 26 Vrbno pod Pradědem	42 646 52314	flax yarn TEX 42-105
26	TEXLEN, a. s.	Horská 52	541 29 Trutnov	42 439 6551	hackling, spinning, weaving
27	TEXLEN, a. s.	Trutnov 4	541 02 Trutnov	42 439 6551	hackling of long and short fibre, wet and dry spinning yarn
28	TEXLEN, a. s.	Mladé Buky	542 23 Mladé Buky	42 439 947191	short fibre yarn
29	TEXLEN, a. s.	Libeč	541 06 Trutnov 4	42 439 3731	short fibre yarn
30	PÁJA, s. r. o.	Náchodská 140	541 03 Trutnov	42 439 3821	short fibre yarn, BD yarn-by cotton technology

that interest in flax and flax products will continue to increase. Current demand for long fibre for the textile industry stands at 8–10 thousand tons per year. It is clear now that 80% of this must be supplied by domestic production. It is assumed that the area of flax grown will stabilise at 13–15 thousand hectares producing 7–8 thousand tons of fibre. As a foundation for these changes we foresee a need for stability for flax growers, as flax is indisputably a risky crop. Growers face problems particularly with outdated harvest machinery. Purchase of new, more specialised machines involves many issues and demands a close co-operation between growers, flax processors and the Ministry of Agriculture.

LITERATURE

KRMELA, S. – ŠTAUD, J. – ŠMIROUS, P : The present state and outlook of the Czechoslovak flax growing and processing. Flachs-Perspektiven für die Zukunft, 4. Reutlinger Flachsseminar 24–25 Februar 1992. IAF Reutlingen, 1993: 100-110.

ROSENBERG, L. – HOCHMAN, M. – ŠTAUD, J. – ŠMIROUS, P. : Pěstování lnu a luskovin. In : Proc. Restrukturalizace zemědělství v horských a podhorských oblastech. Nové Město na Moravě, 3. – 5. 11. 1992. ČIAE, MZe, Praha 1992: 102–115.

Received on November 2, 1994

Contact Address:

Ing. Ladislav Rosenberg, State Institute for Testing in Agriculture, Hroznová 2, 656 06 Brno, Czech Republic, Fax: 0042/05/43 21 24 40

ACTUALITIES

EVALUATION OF TEST STANDARDS FOR MEASURING THE FIBRE CONTENT AND STRENGTH VALUES OF FLAX

The industrial use of natural fibres requires precise data of the fibre quality. The breeding of fibre plants has to meet the industrial requirements. Therefore standardized test procedures for physical properties are necessary to gain reproducible and appropriate data.

EVALUATION OF TEST STANDARDS FOR MEASURING THE FIBRE CONTENT

Flax breeding is based on quality and quantity. The gravimetrical property "fibre content" is a criterion for the variety selection which is based on quantity. Particularly for breeders, the method of determining the fibre content must be simple and rapid since a great number of varieties must be tested for fibre content.

Task

After having analysed the current methods, like NaOH- separation, picture analysis and NIR, one based on mechanical decortication was tested (Tab. I). Therefore a method to determine the fibre content by means of mechanical decortication with 4 pairs of rollers (BAHMER-Lab-Flax-Breaker) was developed.

Definition

$$\text{fibre content } w = \frac{m_{\text{fibres}}}{m_{\text{whole stalk}}} \cdot 100 \quad (\%)$$

Due to the good correlation between $w_{m_1 \times 4}$ and $w_{m_1 \times 4 + B}$ it is possible to abandon the additional wet chemical dissolution according to B r e d e m a n n. Instead of this wet chemical dissolution a calculation can be done by means of the regression straight line. In this way the determining of the fibre content can be simplified to a considerable degree. The named correlation has to be checked and adjusted yearly (Tab. II).

However, this is still unsatisfactory. Therefore the mechanical method was further developed.

Method of decortication with four pairs of rollers (Fig. 1)

Steps for the removal of the sample:

– manual pulling of a sample meter taken from the trial plot,

– removing a roughly 20 g – sample from this material.

Steps for the preparation of the sample:

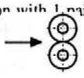
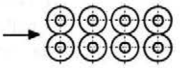
– stripping off the seed pods,

– leaving roots intact since these break off automatically during the rolling process,

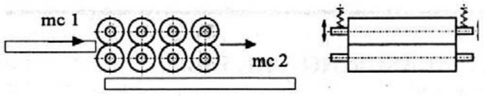
– conditioning of the air-dried material: 12 h at 40 °C,

– weighing the mass of the whole stalk: $\Rightarrow m_{\text{whole stalk}}$.

I. Processes for determining the fibre content

chemical process	mechanical process	optical process
wet chemical dissolution according to B r e d e m a n n W_B	decortication with 1 pair of rollers  $W_{m_1 \times 4}$	NIR-spectroscopy W_{NIRS}
	decortication with 4 pairs of rollers  $W_{m_4 \times 6}$	IBAS (partial areas of the cross-section area determined by means of picture analysis) W_{IBAS}
water retting with a following swingle process W_{R+S}		
predecortication with 1 pair of rollers with an additional wet chemical decortication according to B r e d e m a n n $W_{m_1 \times 4 + B}$		
predecortication with 4 pairs of rollers with an additional wet chemical decortication according to B r e d e m a n n $W_{m_4 \times 6 + B}$		

Decortication



1. Schematic view of the four pairs of decortication rollers

mc – metal container

Parameters of the decorticator

Manufacturer	Gebr. Bahmer			
Type	Bahmer-Labor-Flachsbrecher "Flaksy"			
Number of pairs of rollers	4			
Pair of rollers	1	2	3	4
Setting of the spring force (N)	each 40	each 40	each 40	each 40
Frequence of rotation (N_{max}) (rpm)	80	80	96	110
Outside diameter of the rolls (mm)	57.5	55.5	53.5	51.5

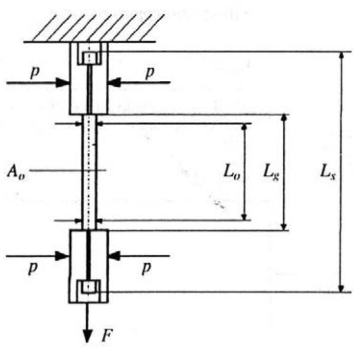
The laboratory flax breaker was equipped with two metal containers:

– metal container 1 (mc 1) helps to feed the sample through the decorticator,

– metal container 2 (mc 2) collects the decorticated sample which is separated into fibre bundles and rests (woody parts, roots etc.).

Steps of decortication:

- putting the sample with the roots first on mc 1,
- inserting the sample to the decorticator,
- collecting the decorticated sample on mc 2,
- putting mc 1 aside mc 2,
- lifting the material from mc 2 to mc 1,
- cleaning mc 2,



2. Sample clamping

p = pressure

F = force

A_o = original cross-section area

II. Correlation coefficients r among various processes of determining the fibre content

Method	$W_{m_1 \times 4 + B}$	W_{IBAS}	W_{NIRS}
W_{IBAS}	0.72^{**}		
W_{NIRS}	0.77^{***}	0.44	
$W_{m_1 \times 4}$	0.75^{***}	0.82^{**}	0.53^{**}

(Significance level: *= 5%, **= 1%, ***= 0.1%; n = 32, for IBAS n = 12); (Final report of the research programme, 1993)

- inserting the sample of mc 1 again to the decorticator,
- repeating this procedure 8 times,
- weighting the mass of the fibre bundles: $\Rightarrow m_{\text{fibres}}$.

EVALUATION OF TEST STANDARDS FOR MEASURING THE TENSILE STRENGTH, PERCENTAGE ELONGATION AND THE YOUNG'S MODULUS OF ELASTICITY

Problem

In addition to the economically most important gravimetrical material property "fibre content" secondly mechanical properties for nontextile use have to be discussed, which permit establishing of mechanical quality of the fibre bundles and flax stalks.

Task

An appropriate quality criteria for short fibres in technical applications has to be defined and measured.

Based on the metallic tensile test standard DIN 50145 the mechanical properties "tensile strength", "percentage elongation" and "Young's modulus of elasticity" of flax have been measured. A universal testing machine was used, equipped with a special clamping device.

Tensile test

The sample with its cross section A_0 is fixed with two clamping jaws of which the upper one is fixed. If a force F is exerted to the lower clamping jaw the sample will be lengthened slightly (Fig. 2). The diagram (Fig. 3) shows the correlation between this force and the length.

To exclude the slip within the jaws the test was started with a preload F_{pre} of 5 N (stalk test) and 0.1 N (fibre bundle test).

The force F divided by the cross section area A_0 is the stress (Fig. 4):

$$\text{stress} \quad \sigma = \frac{F}{A_o} \quad (\text{MPa}) = \left(\frac{\text{N}}{\text{mm}^2}\right)$$

$$\text{percentage elongation} \quad \varepsilon = \frac{L - L_0}{L_o} \cdot 100 \quad (\%)$$

where: L – length

L_o – original length

tensile strength:

$$\sigma_r = \frac{F_{max}}{A_o} \quad (MPa) = \left(\frac{N}{mm^2}\right)$$

percentage elongation:

$$\varepsilon_r = \frac{L_r - L_o}{L_o} . 100 \quad (\%)$$

Young's modulus of elasticity:

To assure a nearly straight curve the quasi modulus was calculated from the range of 40 to 60% of σ_r

$$E_{40/60} = \frac{\sigma}{\varepsilon} \quad (MPa) = \left(\frac{N}{mm^2}\right)$$

Removal of the sample:

Stalk	Fibre bundle
manual pulling of a sample meter taken from the trial plot	decortication of stalks in order to get the fibre bundles
10 stalks are taken out at random, samples with visible defects are rejected	fibre bundles are taken out at random, samples with visible defects are rejected

Preparation of the samples:

Stalk	Fibre bundle
measuring the technical stalk length	
cutting of the samples in the middle of the technical stalk to a length of 150 mm each	cutting of the samples to a length of 75 mm each
conditions: 36 h at 40 °C (afterwards the dry-mass--content is about 95%)	conditions: ambient test conditions
until the tensile test intermediary storage in an exsicator	
prior to the tensile test determining of the stalk cross-section area A_o (see next)	prior to the tensile test determining the fibre bundle cross-section area A_o (see next)

Determining the cross-section area A_o by means of a laser micro-meter:

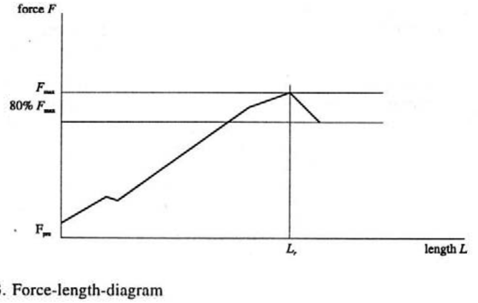
Stalk	Fibre bundle
Manufacturer	Takikawa
Type:	LDM 302 H; error < 0.025
measuring the diameter	
location of measuring: middle of the sample	
2 readings, turned 90 ° around the longitudinal axis	6 readings, turned 30 ° around the longitudinal axis
diameter from the average	min. / max. value = sub- / main axis of an ellipse
cross-section area A_0 from the circle area	cross-section area A_0 from the circle area

Parameters of the tensile test:

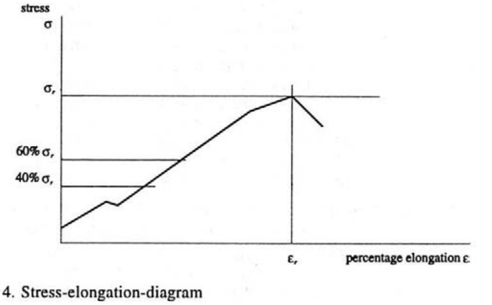
	Stalk test	Fibre bundle test
Manufacturer	Zwick	
Type:	Typ 1445	
measuring of the elongation	with an elongation sensor	with jaw
original gauge length L_o	23 mm	same as gauge length
measuring error	< 0.1%	< 1%
gauge length L_g	25 mm	25 mm
sample length L_s	150 mm	75 mm
test speed	3 mm/min	2 mm/min
perforce F_{pre}	5 N	0.1 N
measure range "force"	0.2–10 kN	1–50 N
measuring error	< 0.2%	< 0.2%
calculation of Young's modulus	40–60% of F_{max}	40–60% of F_{max}
cut off point	80% of F_{max}	80% of F_{max}
clamping jaw:		
means of force exertion	pneumatic	pneumatic
clamp jaw pressure	6 bar	6 bar
clamp length x -width	50 x 60 mm	–
clamp diameter	–	17,5 mm
clamp material	polyurethane	polyurethane

Data input and interpretation

The control of the entire experimental process takes place by means of PC and software package "Zwick 7005a".



3. Force-length-diagram



4. Stress-elongation-diagram

Results of the tensile test

tensile strength:

$$\sigma_r = \frac{F_{max}}{A_0} \ (\text{MPa}) = \left(\frac{\text{N}}{\text{mm}^2}\right)$$

percentage elongation:

$$\varepsilon_r = \frac{L_r - L_0}{L_0} . 100 \ (\%)$$

Young's modulus of elasticity:

$$E_{40/60} = \frac{\sigma}{\varepsilon} \ (\text{MPa}) = \left(\frac{\text{N}}{\text{mm}^2}\right)$$

CONCLUSIONS

– Material properties are quality parameters.

– The determining of the gravimetrical property fibre content is undertaken at present with highly diverse methods and in part unsatisfactory correlations between these processes.

Material properties	Stalk	Fibre bundle	Elementary cell***
d_0 (mm)	0.5–3.5	0.05–0.18	0.01–0.075
L_0 (cm)	25–110*	< 80	1–4**
σ_r (MPa)	50–170	250–1 000	600–2 000
ε_r (%)	0.6–1.8	1.3–3.2	2–3
$E_{40/60}$ (GPa)	7–17	11–26	29–85

*technical stalk length, **average cell length, ***taken from literature IfLB/Pütz, 6/92

– For this reason a suitable mechanical method for determining the fibre content both for dried and fresh flax stalks has not yet been developed.

– The property of the fibre bundle can be adaquately determined by means of the tensile test with stalks.

– Fibre content, tensile strength, percentage elongation and Young's modulus of elasticity are selection criteria for varietal breeding.

Dipl. – Ing. Andreas Beckmann,
Prof. Dr. – Ing. Karl-Hans Kromer
Institute of Agricultural Technology, University of Bonn

Contact Address:

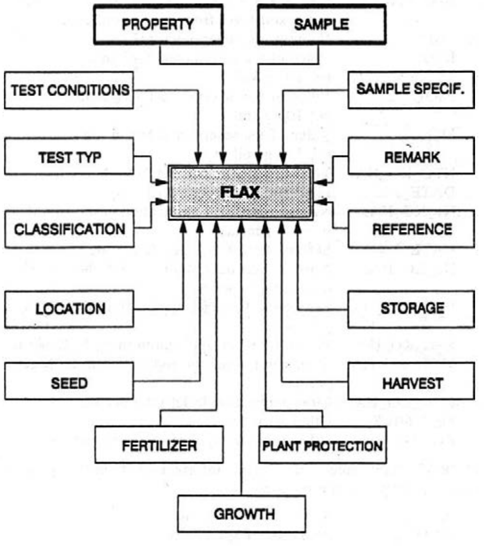
Dipl. – Ing. Andreas Beckmann, Institut für Landtechnik der Universität Bonn, Nussallee 5, 531 15 Bonn, Germany, Fax: 0049228/73 23 70

ACTUALITIES

DATABASE FOR PHYSICAL PROPERTIES OF FLAX (DBPP FLAX)

Physical properties of agricultural products vary much more than do those properties of engineering materials. An engineer or scientist often needs to know specific properties when designing a machine or system. He must also be aware of the variability due to variety as well as the possible deviations in the property values. Therefore it is not only necessary to provide a table of specific properties, but other facts that affect the properties such as climate conditions under which the product was produced, soil type, harvesting date, stage of maturity, loading rates and test procedures in general. For this reason a hard copy of data sheets are made available and published in the Journal of International Agrophysics.

However it is difficult to use these data sheets internationally and to update these copies as new data become available. In an effort to provide the needed physical properties of food and agricultural products to design engineers, a relational database system has been designed in a cooperative research effort with the Department of Agricultural Engineering of the Virginia Polytechnic Institute at Blacksburg, Virginia and the Institut für Landtechnik of the University Bonn in Bonn. For physical implementation and data manipulation, dBase IV – a database management system – was used.



1. Structure of the DBPP FLAX

The database offers the opportunity to retrieve data for the following purposes:

– to provide the design engineer on-line physical properties to meet his needs,

– to observe how other factors affect the listed values and make value judgements as to the validity of the specific property,

– to identify clearly those areas where physical properties data are missing and influence research funding decisions to provide the needed data,

– to identify the source of the data so that the original source can readily be studied for any reason.

This paper describes the database for physical properties of flax.

STRUCTURE OF THE DBPP FLAX

The database consists of 16 relations (files). The names of the relations and the names of the respective attributes (columns) are as follows: FLAX, PROPERTY, SAMPLE, SAMPLESP, TSTTYP, TSTCOND, CLASS, REMARK, REFERENC, LOCATION, SEED, GROW, FERTIL, PLPROT, HARVEST, STORAGE (Fig. 1)

The relation FLAX is the heart of the database. The other relations contain additional information to the data in the relation FLAX. In the following the meaning of the relation and the attribute names are explained:

FLAX: Flax; contains the properties data

NO:	Number of the record
MEAN:	Mean value of a property
SD:	Standard deviation
MIN:	Minimum value of the given range
MAX:	Maximum value of the given range
N_O_M:	Number of measurements
PR_NO:	Key to relation PROPERTY
CL_NO:	Key to relation CLASS
SA_NO:	Key to relation SAMPLE
SP_NO:	Key to relation SAMPLESP
TT_NO:	Key to relation TSTTYP
TC_NO:	Key to relation TSTCOND
LO_NO:	Key to relation LOCATION
SE_NO:	Key to relation SEED
GR_NO:	Key to relation GROW
FE_NO:	Key to relation FERTIL
PP_NO:	Key to relation PLPROT
HA_NO:	Key to relation HARVEST
ST_NO:	Key to relation STORAGE
RE_NO:	Key to relation REFERENC
RM_NO:	Key to relation REMARK

PROPERTY: Property; containts a list of properties of interest and the information about the tested objects

PR_NO:	Key to relation PROPERTY
PROPERTY:	Property name
UNIT:	Unit in which the property is given

STALK:	Stalk been measured? (Yes or No)
FIBRE_BU:	Fibre bundle been measured? (Yes or No)
FIBRE_SI:	Single fibres been measured? (Yes or No)
SEED:	Seeds been measured? (Yes or No)

SAMPLE: Sample; contains information about the tested sample

SP_NO:	Key to relation SAMPLE
VARIETY:	Variety of the sample
PART:	Tested part of the plant
PASECTION:	Part section; further details about the part

SAMPLESP: Sample specification; contains the description of the sample with regard to is shape and size (geometrical properties)

SP_NO:	Key to relation SAMPLESP
SHAPE:	Shape of the sample
SIZE1:	A size of the sample (e. g. length)
S1_VALUE:	Value of SIZE1
S1_UNIT:	Unit of SIZE1
SIZE2:	A second size of the sample
S2_VALUE:	Value of SIZE2
S2_UNIT:	Unit of SIZE2
SIZE3:	A third size of the sample
S3_VALUE:	Value of SIZE3
S3_UNIT:	Unit of SIZE3

TSTTYP: Test typ; contains the description of the test method

TT_NO:	Key to relation TSTTYP
TESTTYP:	Name of the used test method
INPUT1:	Name of a first test parameter (e. g. test speed)
I1_VALUE:	Value of INPUT1
I1_UNIT:	Unit of INPUT1
INPUT2:	Name of a second test parameter
I2_VALUE:	Value of INPUT2
I2_UNIT:	Unit of INPUT2
INPUT3:	Name of a third test parameter
I3_VALUE:	Value of INPUT3
I3_UNIT:	Unit of INPUT3

TSTCOND: Test conditions; contains information about some variables which may influence the property being measured

TC_NO:	Key of the relation TSTCOND
CONDITION1:	Name of a first variable (e. g. temperature)
C1_VALUE:	Value of CONDITION1
C1_UNIT:	Unit of CONDITION1
CONDITION2:	Name of a second variable
C2_VALUE:	Value of CONDITION2
C2_UNIT:	Unit of CONDITION2
CONDITION3:	Name of a third variable
C3_VALUE:	Value of CONDITION3
C3_UNIT:	Unit of CONDITION3
CONDITION4:	Name of a fourth variable
C4_VALUE:	Value of CONDITION4
C4_UNIT:	Unit of CONDITION4

CLASS: Classification; contains the different classes of physical properties

CL_NO:	Key to relation CLASS
CLASS:	Classification of the property

REMARK: Remark; contains additional remarks to data

RM_NO:	Key to relation REMARK
REMARK:	Remark text

REFERENC: Reference; contains literature list or address to identify the origin of the data

RE_NO:	Key to relation REFERENC
AUTHOR1:	First author of the publication or test sheet
ET_AL:	Co-author(s) of the publication or test sheet
TITLE:	Title of the publication or test sheet
PUBLISHER:	Information on book, magazine or similar, in which the publication is printed or address of the research institute
YEAR:	Year of publication or date of test sheet

LOCATION: Location; contains information about the cultivation sites

LO_NO:	Key to relation LOCATION
LAND:	Land where the crop is grown
STATE:	State or country where the crop is grown
CITY:	City or village where the crop is grown
ALTITUDE:	Altitude of cultivations sites
AVER_TEMP:	Average temperature at the cultivation sites
AVER_RAIN:	Average rainfall at the cultivation sites
SOIL_TYPE:	Name of the soil
SOIL_POINT:	Number od points of the soil

SEED: Seed; contains information about the seed of the plant

SE_NO:	Key to relation SEED
PRIM_TILL:	Primary tillage before the seeding
SEC_TILL:	Secondary tillage before the seeding
SE_DATE:	Seed date
SE_TECHN:	Seed technique, type of machine
SE_DEPTH:	Seed depth
SE_SPACE:	Seed space, distance of seeds in the row
ROW_SPACE:	Row space, distance between rows
SEEDS_M2:	Seeding rate in seeds per square meter
TKG:	Thousand-seed weight
KG_HA:	Seeding rate in kilogram per hectare
SE_OTHER:	Other information about the seed
IRRIGAT1:	Date of the first irrigation
IR1_MM:	Quantity of first irrigation in mm
IRRIGAT2:	Date of the second irrigation
IR2_MM:	Quantity of second irrigation in mm

GROW: Growth; contains information about the growth of the crop

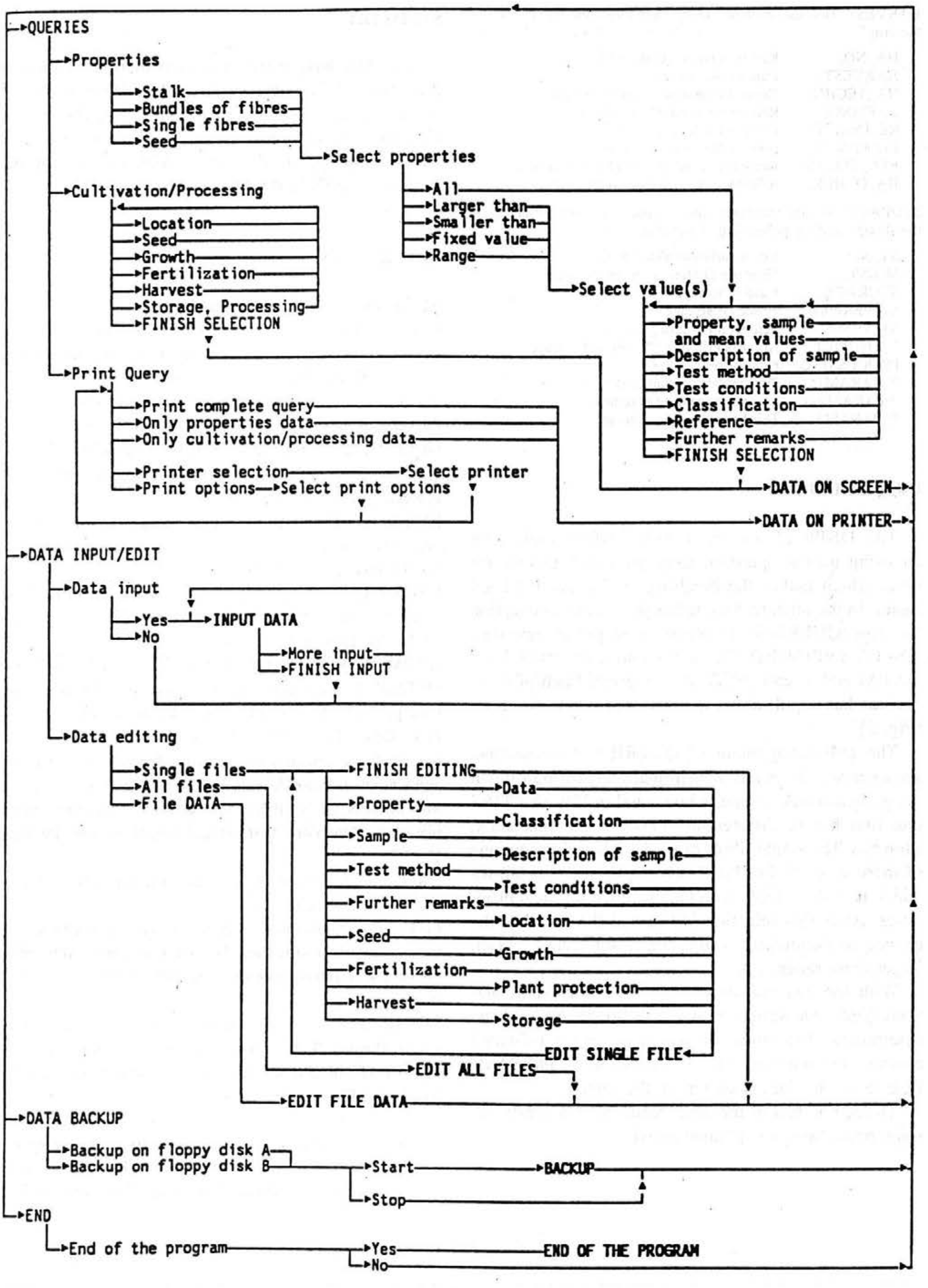
GR_NO:	Key to relation GROW
PLANTS_M2:	Number of plants per square meter
GR_HEIGHT:	Average height of the plants at the end of growing
STALK_LEN:	Average length of the stalk at the end of growing

FERTIL: Fertilization; contains information about the fertilizer application to the crop

FE_NO:	Key to relation FERTIL
CROP_BEFOR:	Name of the crop which grew on the field before
NMIM_ANAL:	Date of the NMin-analysis
KGHA_0_30:	Determined NMin in the soil layer from 0 to 30 cm depth, in kg per ha
KGHA_30_60:	Determined NMin in the soil layer from 30 to 60 cm depth, in kg per ha
KGHA_60_90:	Determined NMin in the soil layer from 60 to 90 cm depth, in kg per ha
STD_ANALY:	Date of the standard analysis for basic nutrients in the soil layer from 0 to 30 cm depth
PH:	Value of the determined pH
K_2O:	Value of the determined K_2O in mg per 100 g soil
P_2O_5:	Value of the determined P_2O_5 in mg per 100 g soil
MG:	Value of the determined Mg in mg per 100 g soil
NTO_KG_HA:	Total nitrogen fertilizing in kg N per ha
DATE_1:	First date of nitrogen fertilizing
N1_KG_HA:	Nitrogen fertilizer application at the first date in kg N per ha
DATE_2:	Second date of nitrogen fertilizing
N2_KG_HA:	Nitrogen fertilizer application et the second date in kg N per ha
P_2O_5_KG_HA:	Phosphatic fertilizer application in kg P_2O_5 per ha
K_2O_KG_HA:	Potash fertilizer application in kg K_2O per ha
MGO_KG_HA:	Magnesium fertilizer application in kg MgO per ha
CAO_KG_HA:	Lime application in kg CaO per ha
FE_OTHER:	Other fertilizer
KG_HA:	Other fertilizer application in kg per ha

PLPROT: Plant protection; contains information about the application of plant protection products

PP_NO:	Key to relation PLPROT
DATE_1_:	First date of application
PROTECT_1:	Name of the plant protection product
KG_L_HA1:	Application in kilogram or liter per ha



2. Using the DBPP FLAX

DATE_2_:	Second date of application	DATE_3_:	Third date of application
PROTECT_2:	Name of the plant protection product	PROTECT_3:	Name of the plant protection product
KG_L_HA2:	Application in kg or l per ha	KG_L_HA3:	Application in kg or l per ha

HARVEST: Harvest; contains information about the harvest of the crop

HA_NO:	Key to relation HARVEST
HARVEST:	Date of the harvest
HA_TECHN:	Harvest technique, kind of machine
RETTING:	Retting on ground? (Yes or No)
RE_PERIOD:	Period of retting in days
RECOVERY:	Date of the straw recovery
REC_TECHN:	Recovery technique, kind of machine
HA_OTHER:	Additional information to harvest

STORAGE: Storage and processing; contains information about the storage and the processing of the crop

ST_NO:	Key to relation STORAGE
MOIST:	Moisture content w. b. of the straw
STORAGE:	Kind of storage
ST_PERIOD:	Period of storage
ST_TEMP:	Temperature during storage
ST_HUMID:	Atmospheric humidity during storage
PROCESSING:	Kind of processing
P_PARAM1:	First processing parameter
P-PARAM2:	Second processing parameter
P_PARAM3:	Third processing parameter

Using the DBPP FLAX

The DBPP FLAX has a user surface built with choosing menus, question catalogues and appeals for input which makes the handling of the DBPP FLAX easier. In the main menu one has the chance to question for data (QUERIES), to renew or to put in new data (DATA INPUT/EDIT), to backup data (BACKUP DATA) and to end (END) the program. Each of these choices has a pull-down menu to open new windows (Fig. 2).

The pull-down menu of QUERIES, for example, shows new sub menus which again have a pull-down menu themselves. If one is interested in PROPERTIES one first has to differentiate between the flax stalk, fibre bundles, single fibres or seeds. After choosing one of these parts of the flax a new popup menu is shown which includes a table with the available physical properties. After this selection is finished the user has the chance to delimit the values he is interested in (all, larger than, range, ...).

With the last pull-down menu the interested relations (files, see structure of the DBPP FLAX) can be determined. The minimum which is always indicated contains the relations FLAX, PROPERTY and SAMPLE. Now the data is shown on the screen.

To see the data of the other relations it is nearly the same procedure as explained above.

SUMMARY

The data base offers a documentation of physical properties of flax fibre, particularly related to non-textile use. It also may be the basis of DSS for growing fibre of a predetermined quality. In the future the data base will be managed by the ZADI, making the data available via INTERNET.

REFERENCES

ALISKAN, Y.: A relational data base design for agricultural products. Wageningen 1989 (unpublished report).

DATE, D. J.: An introduction to database systems. Reading, Addison-Wesley Publishing Company 1981.

DATE, D. J.: An introduction to database systems – Vol. II. Reading, Addison-Wesley Publishing Company 1985.

DULL, G. G.: Nondestructive quality evaluation of agricultural products: A definition and practical approach. J. Food Protec., Vol. 41, 1978 (1): 50–53.

ESSEX, E. – FINNEY, JR.: Engineering techniques for nondestructive quality evaluation of agricultural products. J. Food Protect., Vol. 41, 1978 (1): 57–62.

KROMER, K. -H.: Zerkleinerung von Mais in Trommelschneidwerken. [Habilition.] München 1983. 185 S. und VDI. – Technische Universität.

KROMER, K. -H, – HAUGH, C. G. – ALISKAN, Y. – PÜTZ, P.: Physical properties data base for food and agricultural products. Proc. 4th ICPPAM, Rostock 1989.

MARION, J. E. – AYRES, J. L. – STEELE, B.: Nondestructive quality evaluation of agricultural products – industrial application. J. Food Protec., Vol. 41, 1978 (1): 54–56.

MOHSENIN, N. N.: Physical properties of plant and animal materials. New York, Gordon and Breach Science Publisher 1980.

OKOS, M. R.: Physical and chemical properties of food. ASAE Publication 09–86.

PÜTZ, P.: Datenbank für physikalische Eigenschaften von festen landwirtschaftlichen Stoffen und deren Anwendung für Faserlein. [Dissertation.] Bonn 1993. 140 S. – Universität Bonn.

ŘEZNÍČEK, R. et al.: Physical properties of agricultural materials. Prague 1984. – Universtity of Agriculture.

SITKEI, G.: Mechanics of agricultural materials. Budapest, Akademiai Kiado 1986.

Dr. Peter Pütz, Dipl. – Ing. Andreas Beckmann,
Prof. Dr. – Ing. Karl-Hans Krommer
Institute of Agricultural Technology, University of Bonn

Contact Address:

Dr. Peter Pütz, Institut für Landtechnik der Universität Bonn, Nussallee 5, 531 15 Bonn, Germany, Fax: 0049228/73 25 96

POKYNY PRO AUTORY

Časopis uveřejňuje původní vědecké práce, krátká sdělení a výběrově i přehledné referáty, tzn. práce, jejichž podkladem je studium literatury a které shrnují nejnovější poznatky v dané oblasti. Práce jsou uveřejňovány v češtině, slovenštině nebo angličtině. Rukopisy musí být doplněny krátkým a rozšířeným souhrnem (včetně klíčových slov).

Autor je plně odpovědný za původnost práce a za její věcnou i formální správnost. K práci musí být přiloženo prohlášení autora o tom, že práce nebyla publikována jinde.

O uveřejnění práce rozhoduje redakční rada časopisu, a to se zřetelem k lektorským posudkům, vědeckému významu a přínosu a kvalitě práce.

Rozsah vědeckých prací nemá přesáhnout 15 stran psaných na stroji včetně tabulek, obrázků a grafů. V práci je nutné používat jednotky odpovídající soustavě měrových jednotek SI (ČSN 01 1300).

Vlastní úprava rukopisu má odpovídat státní normě ČSN 88 0220 (formát A4, 30 řádek na stránku, 60 úhozů na řádku, mezi řádky dvojité mezery), k rukopisu je vhodné přiložit disketu s prací pořízenou na PC v některém textovém editoru, nejlépe v T602. Tabulky, grafy a fotografie se dodávají zvlášť, nepodlepují se. Na všechny přílohy musí být odkazy v textu.

Pokud autor používá v práci zkratek jakéhokoliv druhu, je nutné, aby byly alespoň jednou vysvětleny (vypsány), aby se předešlo omylům. V názvu práce a v souhrnu je vhodné zkratek nepoužívat.

Název práce (titul) nemá přesáhnout 85 úhozů. Jsou vyloučeny podtitulky článků.

Krátký souhrn (Abstrakt) je informačním výběrem obsahu a závěru článku, nikoliv však jeho pouhým popisem. Musí vyjádřit všechno podstatné, co je obsaženo ve vědecké práci, a má obsahovat základní číselné údaje včetně statistických hodnot. Musí obsahovat klíčová slova. Nemá překročit rozsah 170 slov. Je třeba, aby byl napsán celými větami, nikoliv heslovitě. Je uveřejňován a měl by být dodán ve stejném jazyce jako vědecká práce.

Rozšířený souhrn (Abstract) je uveřejňován v angličtině, měly by v něm být v rozsahu cca 1–2 strojopisných stran komentovány výsledky práce a uvedeny odkazy na tabulky a obrázky, popř. na nejdůležitější literární citace. Je vhodné jej (včetně názvu práce a klíčových slov) dodat v angličtině, popř. v češtině či slovenštině jako podklad pro překlad do angličtiny.

Úvod má obsahovat hlavní důvody, proč byla práce realizována a velmi stručnou formou má být popsán stav studované otázky.

Literární přehled má být krátký, je třeba uvádět pouze citace mající úzký vztah k problému.

Metoda se popisuje pouze tehdy, je-li původní, jinak postačuje citovat autora metody a uvádět jen případné odchylky. Ve stejné kapitole se popisuje také pokusný materiál.

Výsledky – při jejich popisu se k vyjádření kvantitativních hodnot dává přednost grafům před tabulkami. V tabulkách je třeba shrnout statistické hodnocení naměřených hodnot. Tato část by neměla obsahovat teoretické závěry ani dedukce, ale pouze faktické nálezy.

Diskuse obsahuje zhodnocení práce, diskutuje se o možných nedostatcích a práce se konfrontuje s výsledky dříve publikovanými (požaduje se citovat jen ty autory, jejichž práce mají k publikované práci bližší vztah). Je přípustné spojení v jednu kapitolu spolu s výsledky.

Literatura musí odpovídat státní normě ČSN 01 0197. Citace se řadí abecedně podle jména prvních autorů. Odkazy na literaturu v textu uvádějí jméno autora a rok vydání. Do seznamu se zařadí jen práce citované v textu. Na práce v seznamu literatury musí být odkaz v textu.

Na zvláštním listě uvádí autor plné jméno (i spoluautorů), akademické, vědecké a pedagogické tituly a podrobnou adresu pracoviště s PSČ, číslo telefonu a faxu, popř. e-mail.

INSTRUCTIONS FOR AUTHORS

Original scientific papers, short communications, and selectively reviews, that means papers based on the study of technical literature and reviewing recent knowledge in the given field, are published in this journal. Published papers are in Czech, Slovak or English. Each manuscript must contain a short and a longer summary (including the key words).

The author is fully responsible for the originality of his paper, for its subject and formal correctness. The author shall make a written declaration that his paper has not been published in any other information source.

The board of editors of this journal will decide on paper publication, with respect to expert opinions, scientific importance, contribution and quality of the paper.

The paper extent shall not exceed 15 typescript pages, including tables, figures and graphs.

Manuscript layout shall correspond to the State Standard ČSN 88 0220 (quarto, 30 lines per page, 60 strokes per line, double-spaced typescript). A PC diskette should be provided with the paper, written in an editor program, preferably T602. Tables, figures and photos shall be enclosed separately. The text must contain references to all these annexes.

The **title** of the paper shall not exceed 85 strokes. Subtitles of the papers are not allowed either.

Abstract is an information selection of the contents and conclusions of the paper, it is not a mere description of the paper. It must present all substantial information contained in the paper. It shall not exceed 170 words. It shall be written in full sentences, not in form of keynotes, and comprise base numerical data including statistical data. It must contain key words. It should be submitted in English and if possible also in Czech or Slovak.

Introduction has to present the main reasons why the study was conducted, and the circumstances of the studied problems should be described in a very brief form.

Review of literature should be a short section, containing only literary citations with close relation to the treated problem.

Only original method shall be described, in other cases it is sufficient enough to cite the author of the used method and to mention modifications of this method. This section shall also contain a description of experimental material.

In the section **Results** figures and graphs should be used rather than tables for presentation of quantitative values. A statistical analysis of recorded values should be summarized in tables. This section should not contain either theoretical conclusions or deductions, but only factual data should be presented here.

Discussion contains an evaluation of the study, potential shortcomings are discussed, and the results of the study are confronted with previously published results (only those authors whose studies are in closer relation with the published paper should be cited). The sections Results and Discussion may be presented as one section only.

The citations are arranged alphabetically according to the surname of the first author. References in the text to these citations comprise the author's name and year of publication. Only the papers cited in the text of the study shall be included in the list of references. All citations shall be referred to in the text of the paper.

If any abbreviation is used in the paper, it is necessary to mention its full form at least once to avoid misunderstanding. The abbreviations should not be used in the title of the paper nor in the summary.

The author shall give his full name (and the names of other collaborators), academic, scientific and pedagogic titles, full address of his workplace and postal code, telefon and fax number or e-mail.

ZEMĚDĚLSKÁ TECHNIKA AGRICULTURAL ENGINEERING

Volume 41, No. 3 1995

OBSAH - CONTENT

Baraniecki P., Mańkowski J.: Hemp fibre as a raw material for paper production in the aspect of natural environment protection – Konopí jako surovina pro výrobu papíru při ochraně přírodního prostředí 85

Kozłowski R., Manyś S.: New outlook on flax fibre properties in textiles – Nový pohled na vlastnosti lněného vlákna v textiliích 89

Kozłovski R., Mieleniak B., Przepiera A.: Plant residues as raw material for particleboards – Odpady rostlinného původu jako surovina pro výrobu lignocelulózových desek 101

Kołodziejczyk P., Fedec P., Kozłowska J., Kozłowski R.: Linseed in health food and nutrition – Semena lnu v dietě a výživě 113

Rosenberg L., Šmirous P., Krmela S.: Flax production in the Czech Republic – Produkce lnu v České republice 117

DISCUSSION

Drobník J.: Processing of agromaterials 112

ACTUALITIES

Beckmann A., Kromer K.-H.: Evaluation of test standards for measuring the fibre content and strength values of flax 121

Pütz P., Beckmann A.: Database for physical properties of flax (DBPP FLAX) 125

Vědecký časopis ZEMĚDĚLSKÁ TECHNIKA ● Vydává Česká akademie zemědělských věd – Ústav zemědělských a potravinářských informací ● Redakce: Slezská 7, 120 56 Praha 2, tel.: 02/25 75 41, fax: 02/25 70 90 ● Sazba: Studio DOMINO – ing. Jakub Černý, Pražská 108, 266 01 Beroun, tel.: 0311/240 15 ● Tisk: ÚZPI Praha ● © Ústav zemědělských a potravinářských informací, Praha 1995

Rozšiřuje Ústav zemědělských a potravinářských informací, referát odbytu, Slezská 7, 120 56 Praha 2