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Value Added Products from Natural Fibres of Indian Himalayan Region

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***Abstract*:- There are various types of fibres available as textile fibres. These are either natural or manmade (synthetic). Recent trends show that use of natural fibres is increasing all across the world as compared to synthetic fibres because natural fibres are eco-friendly, skin friendly and most importantly they are biodegradable. The Indian Himalayan region has enormous nature's fibre wealth, including pine needles. These fibres are being used by the local people in a very casual way to fulfil their bare minimum needs. Due to insufficient possibilities of employment in hills, poverty prevails in the hills. Further, the most negative and damaging impact is that pine needles (called 'perul' in local language), fall down every year in abundance which catch fire and become highly combustible after getting dried. This leads to a forest fire causing huge losses to the people living in the region. Thus it can be concluded that there is strong need to open the path for generation of employment at hills. Textile is the second largest employment giving industry in India so it is better to exploit the use of natural fibres of the region to bring happiness to the hill people by upbringing their livelihood & earnings and reducing chances of forest fires. Considering this need, NITRA got involved in development of value added products using the fibres extracted from Pine needles and other fibrous plants, which are available or can be grown in Himalayan region such as Ramie (Boehmeria Nivea), Flax (Linum usitatissimum) and Hemp (Cannabis sativa), pine needle etc. It has been observed that the products developed from these fibres have very high domestic and export demand. Indigenous flax fibres have very good probability of replacing flax fibres which are imported from European countries. Huge demand of high value garments produced from flax fibres can be a boost for the local people of Himalayan region.**

INTRODUCTION

Himalayan region is full of biodiversity with enormous fibre wealth. There are more than one hundred species known for fibre potentiality such as Himalayan giant nettle, cannabis, agave, bhimal, bamboo, sun hemp, ramie, pine etc [1]. Amongst the crops, flax (one of the nature's strongest vegetable fibres) and ramie (with white silky lustre) are two bast fibre crops which show immense commercial potentiality due to their suitability to the climatic conditions of the foothills of Himalayas. While many of these cellulosic plants contain fibrous morphology but the economic viability of the plant largely depends upon ease of extraction of fibres, percentage yield, consistency in quality and physical & chemical attributes as well. Undoubtedly, livelihood and living conditions of the tribal and traditional people living in the region can be improved by making better economic exploitation of these plants which are there in abundance [1].

It is well known fact that the traditional uses of the fibres, presently available, are the production of handicrafts, ropes, twines, handloom articles and ethnic wears which add limited values to these fibres. Such low end products with limited value addition may not provide enough economic return to farmers and labours involved. To augment the economic return, obviously commercial production based on advanced agricultural practices and subsequent extraction of good quality fibres with consistent properties will be required. The eco-friendly natural fibres have become more popular in use of apparel and home textiles due to awareness of the negative impact of non bio-degradable synthetic fibres. The use of natural plant fibres such as flax, hemp, kenaf, Jute etc. as reinforcement in both thermoplastic and thermoset have increased dramatically during the last 20 years. These natural bio-composites compare well with glass fibre reinforced polymer composites in terms of recyclability when using a thermoplastic and energy recovery through incineration when using a thermoset matrix.[2,6].

Flax is an erect annual plant growing to 1.2m tall, with slender stems. Flax fibre is extracted from the bast or skin of the stem of the flax plant. Presently, the flax fibre (bionomial name: Linum usitatissimum) is being imported from Belgium, China and France for production of yarns and fabrics in India. Besides raw fibres, Indian companies also import white linen fibres, tops and fabrics from the same sources. Why not to grow improved variety of these fibres here in India by playing with land preparation techniques, sowing methods, selection of quality seeds and other parameters and ultimately transfer benefits to the poor people living in these regions. Present pure linen fabric market in India is about 200 crores. Linen with cotton and other fibres have equal market share like pure linen [4]. With increasing Country's GDP and availability of disposable income, the market demand is expected to grow faster in comparison to present growth rate of 8 – 10%. The existing major manufacturer has recently doubled its yarn manufacturing capacity. Not only this, 3-4 major manufacturers have come into the Indian market after setting up their flax spinning plants. All the raw material for linen fabrics i.e. flax fibres are being imported from European countries.

Flax is a crop of the temperate zone and long day plant. It requires a cool humid climate temperature ranging from 10º to 24ºC, rainfall ranging from 155 – 200 mm with high humidity during growing season. The environment has considerable influence upon the amount of fibres in the

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stem. Easson [5] found that small variations in time of sowing had no great effect on the straw yield but the fibre content was influenced significantly. It has been found that the highest potential fibre yield is obtained three weeks after flowering. Climate and soil types are other two important factors affecting potential yield. Considering the availability of similar weather in Himalayan region, it was planned to cultivate good variety flax fibre which can increase the income of local residents and save foreign currencies. Table-1 and 2 are shown here to have a fair idea of physical and chemical properties of the various natural textile fibres, commonly used by the textile industry.

Table 1: Mechanical Properties of Natural Fibre[6]

Fiber	Tensile strength (MPa)	Elongation at Failure (%)	Young's Modulus (GPa)	Density (gm/ cm3)
Hemp	690	1.6	70	1.47
Flax	345 – 1500	2.7 – 3.2	27.6	1.5
Sisal	468 – 700	3 – 7	9.4 – 22	1.45
Ramie	400 – 938	1.2 – 3.8	61.4 – 128	1.55
Kenaf	295 – 1191	1.6	53	1.2
Jute	393 – 800	1.16 – 1.5	13 – 26.5	1.3 – 1.49
Cotton	287 – 800	7 – 8	5.5 – 12.6	1.5 – 1.6
Wool	50 – 315	13.5 – 35	2.3 – 5	1.3
Coir	131 – 220	15 – 40	4 – 6	1.15 – 1.46
Bamboo	140 - 230	2.5 – 3.7	11 – 17	0.6 – 1.1

Table 2: Chemical Properties of Natural Fibre[6]

Name of plant fiber	Hemicellulose (%)	Moisture (%)	Cellulose (%)	Lignin (%)	Ash (%)	Pectin (%)	Wax (%)
Flax	16.7	10	64.1	2	13.1	1.8	1.5
Jute	12	10	64.4	0.2	0.5 – 2.1	11.8	0.5
Ramie	13.1	10	68.6	0.6	NA	1.9	0.3
Sisal	12.0	10	65.8	9.9	4.2	0.8	0.3
Kenaf	18 – 24	NA	37 – 49	15 – 21	2.4 – 5.1	8.9	0.5
Hemp	12 – 22.4	6.5	55 – 80.2	2.6 – 13	0.5 – 0.8	0.9 – 3.0	0.2
Cotton	5.7	10	82.7	28.2	NA	5.7	0.6
Coir	11.9 – 15.4	0.2 – 0.5	19.9 – 36.7	32.7–53.3	NA	4.7 – 7.0	NA
Bamboo	12.5 – 73.3	11.7	48.2 – 73.8	10.2–21.4	2.3	0.37	NA

A lot of pine needles fall on the ground every year and they are a major source of forest fires in Himalayan region. Presently local people use some of them to produce charcoal and few attempts have been made to produce hand-made papers using pine needle pulps which has a limited use such as files, cards etc.

EXPERIMENTAL

The pine needles were collected from the ground of Almora, Uttarakhand and neighbouring areas where Pine forests are abundantly available. Those needles were brought to NITRA, Ghaziabad and extraction of fibres was attempted. Various chemical combinations were tried to get the best textile grade fibres. Sodium hydroxide (NaOH) solution was used for preliminary treatment and then Aluminium chloride (AlCl3) solution was used for final treatment. After a number of trials, optimum time, temperature and concentration(gpl) were finalised. Then the fibres were extracted by mechanically rubbing the treated leaves and dried.

For producing Indian Flax proper seeds are required. It was observed that Central Research Institute for Jute &

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Allied Fibres (CRIJAF) under ICAR had undertaken some trials and they have developed a variety of JRF2 which gives good result in Indian atmosphere. But large scale trials were not been taken for commercialization. NITRA procured seeds from them and planted in around 7 acres of land during 2017-18. Five acres of land was at G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand and around 2 acres of land was at NITRA, Ghaziabad. The sowing time was November end to beginning December 2017 and the plants were harvested during April, 2018. Fibres were extracted after retting and scutching was done.

RESULTS & DISCUSSION

Pine Fibres

The properties of the extracted pine needle fibres were assessed. These are shown in Table-3 "Physical properties of Pine needle fibres". As the fibres have low tenacity value it was blended with cotton fibre and yarns were spun. The SEM photographs of the cross section of the pine needle fibres and longitudinal structure have been shown in Fig. 1 to Fig. 4. Both Fig. 1 and Fig. 2 show the cross-sectional view of pine needle fibres at different magnifications. The figures show a hollow structure which is different from conventional natural fibres used in common. The Fig. 3 and 4 show the longitudinal view of pine needle fibres which are not fully cylindrical and somehow looks rough. It was observed that it has high moisture regain value (around 12%). It is expected that this hollow structure will result in products with high thermal resistance value and good water absorbency.

Table 3: Physical Properties of Pine needle fibres

Parameters	Pine needles
Tenacity (g/den)	1.10
Min.	0.32
Max.	3.63
Average	1.10
CV%	66.80
Elongation%	5.94
Min.	0.80
Max.	10.10
Average	5.94
CV%	41.25
Count (Denier/Ne)	87.69/60.61
Bundle strength (g/tex)	5.64
Elongation%	6.9

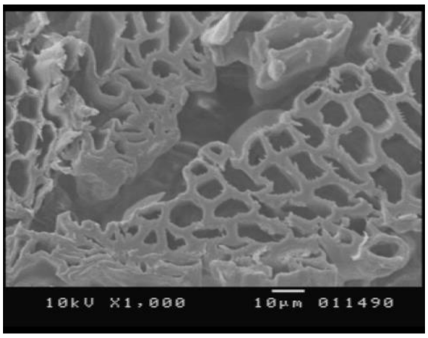

Figure -1

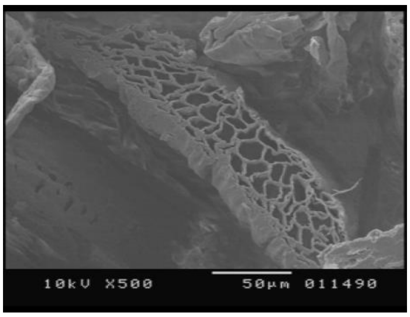

Figure – 2

Fig.1 and Fig.2 : Cross-sectional view of pine needle fibres at different magnifications

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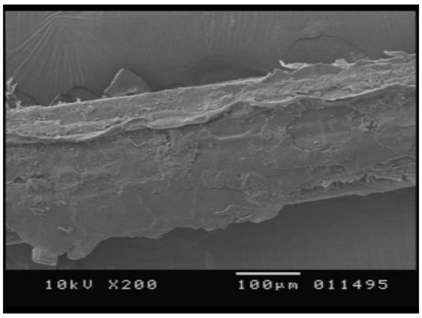

Figure - 3

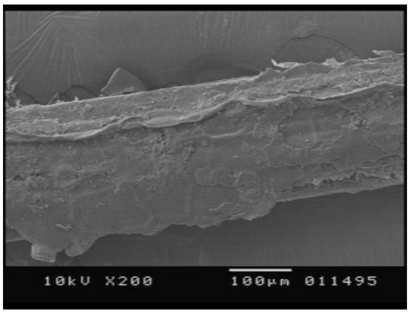

Figure – 4

Fig.3 and Fig.4 : Longitudinal view of pine needle fibres

FLAX FIBRES

The flax fibres, produced in India, were assessed for their various properties and the same were compared with the some of the European flax, sourced from a commercial fabric manufacturer. The SEM photographs of the flax fibres are shown in Fig. 5 to 8. Both Fig. 5 and Fig. 6 show the cross sectional view of the flax fibres and different magnification. It can be seen that the fibres are mature and similar to available fibres elsewhere. The Fig. 7 and Fig. 8 show the longitudinal view of Indigenous flax fibres at different magnifications. The properties are shown in Table-4. It can be seen from the Table that there is no significant difference in properties of these fibres. However, single fibre tenacity of Indian flax is lower than imported fibre, but the bundle strength of Indian fibre is higher. The appearance shows small difference and the Indian variety looks little harsher. This may be the reason for having higher bundle strength as compared to the bundle strength of imported fibres.

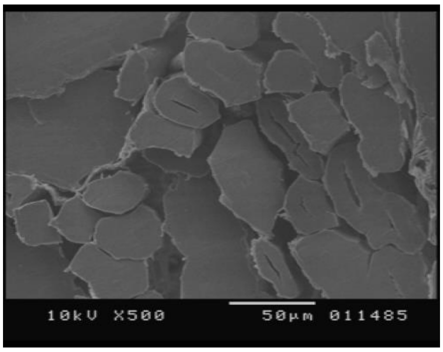

Figure - 5

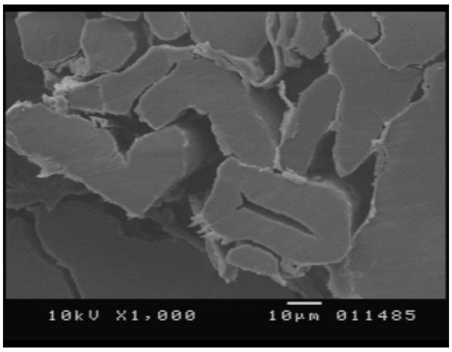

Figure – 6

Fig.5 and Fig.6 : Cross sectional view of the flax fibres and different magnification

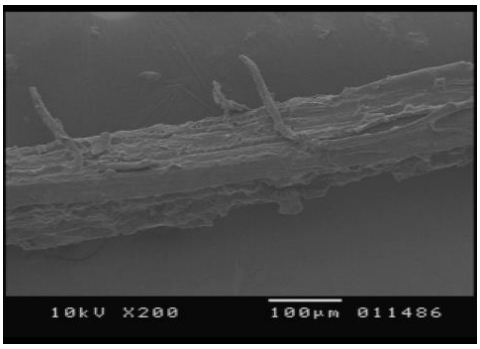

Figure – 7

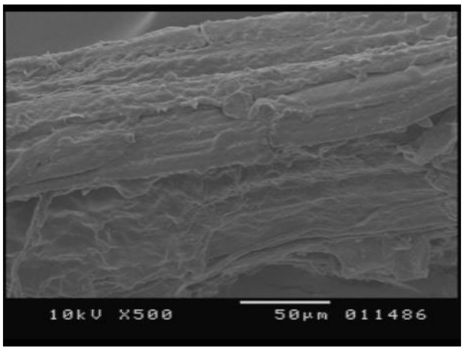

Figure – 8

Fig.7 and Fig.8 : Longitudinal view of Indigenous flax fibres at different magnifications

Table 4: Physical Properties of Flax fibres

Parameters	Indian flax	Imported flax
Tenacity (g/den)	3.43	4.18
Min.	0.56	0.86
Max.	7.34	7.19
Average	3.43	4.18
CV%	48.77	42.05
Elongation%	2.11	2.26
Min.	0.70	0.70
Max.	4.50	4.40
Average	2.11	2.26
CV%	41.38	35.12
Count (Denier/Ne)	40.81/130.24	38.52/137.98
Bundle strength (g/tex)	63.49	40.82
Elongation%	0.61	0.75

The pine needle fibres (PNF) have been blended with cotton in different ratios and it was found difficult to spin yarn as the percentage of PNF fibres increases. Also it is observed that there is preferential loss of PNF in carding, resulting in less PNF percentage in resultant yarn. The yarns with 70:30 Cotton: PNF (actual in yarn stage) was successfully spun and yarns were sized and woven into fabrics using loom. The fabrics have unique look and are useful to produce Jackets, home textiles and apparels.

The Indian flax fibres were processed in very small scale in a commercial company in Eastern India which is the leader in flax processing. The fabric produced in small scale was found as good as that of produced from imported flax fibre. This preliminary small scale trial showed that yield is much lower (to the extent of 50%) during spinning operation. This is due to improper extraction of fibre and scutching of Indian flax fibre. The scutching was done using crude manual method which needs to be improved to get better yield of yarn from fibre.

CONCLUSIONS

The results show that there is ~~a~~ very good possibility of producing high value textile products using Pine needles which are abundantly available as plant waste and can help improve the economy of Indian Himalayan region. Also it will help in reduction of forest fire which is the cause of huge loss of human and animal life.

Flax fibre produced in India can replace the use of imported flax fibre, thereby, reducing import of the same and generating income for the people living in the Himalayan region.

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