CHAPTER EIGHT: CONCLUSIONS AND RECOMMENDATIONS

In this research mainly the physical and chemical properties, dye ability and the fastness properties of lotus fibres were tested to ascertain their suitability for use as a textile raw material. Based on the laboratory experiments some of the textile properties of lotus fibres were tested and identified as notable qualities of Lotus fibre;

- Compared with cotton fibres lotus fibres have a lower strength
- Lotus fibres are very fine and longer.
- Lotus fibres have the property of good hygroscopicity.
- Have a high moisture regain and absorbancy.
- Fibres have a soft handle
- Hand extracted fibres have a bright luster
- Fibres can be obtained in parallel form by the hand extraction method
- Fibres are longer and fine

8.1. Tensile Strength of Lotus Fibres

Lotus spun yarns of different counts were manually produced from hand extracted lotus fibres and subjected to tensile strength tests. The test results revealed that the average breaking tenacity of the lotus yarn was 6.254cN/tex and the average elongation at break was 2.23 %.

Above tenacity is very low when compared with cotton yarn's breaking tenacity. So, these manually produced yarns cannot be used in modern high speed looms or knitting machines. But the coarser yarns manufactured from lotus fibres will have the necessary strength for weaving on hand looms.

Further, the proper mechanical equipments and machineries have to be introduced to insert uniform twist throughout the length of the yarn in order to produce yarn of uniform strength and thickness. The fibres are packed inside the petioles in parallel form. These fibres can be extracted in parallel form as long fibres from the lotus petioles. As such, in the lotus yarn spinning system fibre parallelization processes

such as combing, drawing, drafting, etc. can be eliminated. The mechanical devices commonly used in basic yarn spinning systems will be sufficient for the extraction, spinning and winding of lotus yarns for weaving and knitting purposes, but these systems have to be modified to suit the fibre length. As the lotus fibres are long, sufficient strength of spun yarns for weaving and knitting can be produced with lower twist insertion. This type of yarns will eliminate the snarling problems in knitting process.

Fibre extraction and the direct production of non-woven textile material is the another way to use these fibres in an economical manner. Non-woven technology is another way of making fabrics directly from fibres. A non-woven fabric consists of a web formed by fibres or fibrils. A binder may be incorporated to hold fibres firmly and provide mechanical integrity and strength as required. A web structure can be obtained from highly oriented fibre configuration produced by the carding process followed by an air laying process. The bonding of fibres is accomplished either mechanically through entanglements or bonding using a binder suitable for natural fibre. The manufacturing processes involved in this method are faster and more economical.

So, another economical advantage of the long fibre length of lotus fibre is the suitability of these fibres for use as a raw material for non woven textile material manufacture.

8.2. Moisture Regain and Moisture Content

Moisture regain and moisture content of raw Lotus fibres are 12.323% and 10.971% respectively at standard atmosphere condition. Both values are very much higher when compare with cotton and other common natural cellulosic fibres. Above moisture regain and moisture content properties were tested on raw lotus fibres. If the fibres are pretreated, both values will go up. When the moisture content value of a material is greater, garment manufactured from the material will give good comfort properties to the wearer. Because of the higher moisture content property of Lotus fibres some researchers say "Lotus fibres has the property of keeping the wearer warm during cold weather and cool during warm weather."

8.3. Water Absorbent Property and Fibre Fineness

Lotus fibres are hydrophilic in nature and the water absorbent capability is very high. Further it was proven that the lotus fibres are very fine and the diameter is 4.3939 ± 0.2017μm. That means lotus fibre is a natural cellulosic microfiber. Generally microfibers have superior power for absorbing water. Therefore, the non woven materials produced from the lotus fibres can be used wherever materials of higher moisture absorbent properties are needed such as wound care materials, high absorbent materials used as medical care products, hydrogel material, etc.

Dressings do not heal wounds but properly selected dressings do, however, promote healing and prevent further harm to the wound. An ideal dressing should maintain a moist environment at the wound interface and act as a barrier to micro-organisms. *[53]*. Some of the requirements considered as ideal for of wound dressing materials are;

1. Absorbing exudates and toxic components from the wound's surface
2. Maintaining a high humidity at the wound-dressing interface.
3. Allowing gaseous exchange
4. Providing thermal insulation
5. Protecting the wound form bacterial penetration
6. Being non-toxic
7. Easily removable without causing trauma to the wound

Generally, non-woven dressings are highly homogeneous and soft; and they are combined with highly absorptive layers of fibres such as cotton, rayon, etc. *[53]*

Lotus plants and plant products are used as a part of health care systems since ancient times. The seeds of lotus plant are commonly used in folk medicine in the treatment of tissue inflammation, cancer and emesis and given to children as diuretic and refrigerant in treating skin diseases. The seeds possess antioxidant, antipyretic and anti-fertility properties.*[54]*. By using lotus fibres in wound care products, it could be possible to utilize the healing properties of this medical plant to promote healing. Further research has to be carried to confirm this property.

Non-woven materials made out of lotus fibres may suit the application and find extensive utilization in wound care products as the major function of dressings is to provide a soft and resilient hand, absorb and retain exudates.

8.4. Comfort Property

Since the lotus fibre has an oval cavity, it has more surface area, easily absorbs and evaporates moisture better than other cellulosic fibres. Because of this quick moisture evaporating property of lotus fibre, garments made out of lotus fibre do not stick to the skin of the wearer and provides comfort to the wearer.

8.5 Dyeability of Lotus Fibres

Reactive class of dye was applied on pre-treated lotus fibres and it was found that the dye absorption properties and the wash fastness properties satisfied the quality level required for textile products.

8.6. Chemical Resistance Property

Chemical resistance behavior of lotus fibre is similar to other cellulosic fibres, It is proven that 70% H_2SO_4 dissolves Lotus fibres at 20°C, 60% H_2SO_4 damages the fibre at 20°C and 10 % NaOH causes swelling of fibres.

8.7. Sustainability and Eco-friendly Environmental Concepts

Aesthetic values and comfort have always been the major consideration when selecting clothing and bound to be so in the future too. But, since of late, another factor has come in to the formula; survival of mankind. The environmental changes are fast making the world unsuitable for comfortable living. The new industrial developments are polluting the environment and now emphasis is more on "eco friendliness". In this context, the textile industry is considered as one of the major industries that contribute to pollution of the environment. Research is being done to reduce the adverse effects.

In selection of garments, discerning people look for comfort both in the texture (hand feel) and thermal resistance (comfort both in hot and cold atmospheres). They are willing to pay enormous prices to acquire fabrics with such properties. The technology of Fabric Finishing has reached such heights that it is able to artificially create these properties in fabrics but it involves the use of chemicals which are not eco friendly. The search is now on to produce such fabrics with the least damage to the environment.

The Lotus Fibre figures prominently as a fibre that possesses right characteristics for comfort. Lotus fibres are soft and fine by nature and have the property of keeping the wearer warm during cold weather and cool during warm weather. The growing, harvesting, fibre extraction and weaving is done manually and waste produced is bio friendly. So here is a fibre which possesses some exquisite properties waiting to be used by the connoisseurs.

During this project the special properties of moisture absorption and thermal insulation of Lotus fibres have been confirmed. In addition the other properties which make a yarn suitable for fabric manufacture such as strength, elongation, extension, uniformity etc have been studied and found to be most suitable for fabric manufacture.

Considering these properties, Fabrics made from Lotus fibres would be highly appreciated by discerning wearers who value comfort in the clothing they wear. Lotus fabric manufacture is also very environmental friendly. This would also provide employment to many, as it is a very labour intensive process. Sri Lanka which has the ideal conditions for growing lotus plants and abundant labour would benefit immensely by developing the growth and manufacture of Lotus Fabrics to exploit the niche export market.

The data collected during this research adequately proved that fabrics can be turned out with lotus fibre and that many benefits can be obtained. It is now up to an enterprising person or organization with a pioneering spirit to embark on a Pilot Project to start manufacture of Lotus fabrics. The raw material is available in abundantly, the equipment required are basically the equipment used in handloom

weaving. The only additional equipment required is the Doubling/Twisting machine to prepare the warp yarn which can be made by altering a standard Pirn Winding machine used in the Handloom Industry. In this context, a person who is already engaged in handloom fabric manufacture could easily engage in such a project.

For the success of producing Lotus fabrics on a commercial basis, the general public should be made aware of the possibility and the benefits that can be achieved and develop a demand. As this is something hereto unknown to Sri Lankans, the success achieved in Myanmar in fibre extraction, weaving of lotus fabrics and the popularity and high income generated by these exquisite items can be popularized by publishing articles in Newspapers and by using electronic media such as Radio and Television

The time is now ripe, considering the special properties and the environment friendliness of the manufacture and the agricultural suitability of our island to grow Lotus, for Sri Lanka to exploit the possibility of using this natural fibre to produce fabrics to a niche market.

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Appendix – I

Frequency table of maximum fibre length of Lotus fibres extracted from 3 inch length of 1000 petioles.

Maximum Length of Lotus Fibre (inch) [x]	Frequency [f]	Cumulative Frequency	[fx]
11	0	0	0
12	3	3	36
13	4	7	52
14	6	13	84
15	15	28	225
16	27	55	432
17	24	79	408
18	35	114	630
19	39	153	741
20	56	209	1120
21	89	298	1869
22	87	385	1914
23	74	459	1702
24	84	543	2016
25	77	620	1925
26	59	679	1534
27	46	725	1242
28	42	767	1176
29	38	805	1102
30	33	838	990
31	30	868	930
32	27	895	864
33	24	919	792
34	14	933	476
35	10	943	350
36	12	955	432
37	12	967	444
38	9	976	342
39	3	979	117
40	6	985	240
41	3	988	123
42	2	990	84
43	2	992	86
44	1	993	44
45	1	994	45
46	2	996	92
47	2	998	94
48	1	999	48
49	1	1000	49
50	0	1000	0
TOTAL	1000		24850

Appendix – II

Test results of lotus yarn count, tenacity and elongation

Specimen	Weight of specimen (g)	Length (cm)	Tex	Breaking Strength (cN)	Elongation (%)	Tenacity (cN/tex)
I	0.0042	40	10.50	58.7	1.170	5.590476
II	0.0053	40	13.25	110.4	1.620	8.332075
III	0.0058	40	14.50	123.6	2.075	8.524138
IV	0.0063	40	15.75	98.70	1.763	6.266667
V	0.0074	40	18.50	121.6	1.850	6.572973
VI	0.0078	40	19.50	139.9	1.944	7.174359
VII	0.0086	40	21.50	118.5	2.034	5.511628
VIII	0.0095	40	23.75	119.0	2.116	5.010526
IX	0.0097	40	24.25	190.4	1.756	7.851546
X	0.0116	40	29.00	176.4	2.291	6.082759
XI	0.0122	40	30.50	218.2	1.913	7.154098
XII	0.0136	40	34.00	254.0	2.171	7.470588
XIII	0.0149	40	37.25	286.0	2.749	7.677852
XIV	0.0156	40	39.00	185.0	1.805	4.743590
XV	0.0156	40	39.00	203.3	1.980	5.212821
XVI	0.0163	40	40.75	264.0	2.171	6.478528
XVII	0.0166	40	41.50	218.2	1.913	5.257831
XVIII	0.0170	40	42.50	196.0	2.179	4.611765
XIX	0.0172	40	43.00	318.0	3.225	7.395349
XX	0.0177	40	44.25	337.6	2.344	7.629379
XXI	0.0178	40	44.50	233.3	2.750	5.242697
XXII	0.0178	40	44.50	305.7	2.433	6.869663
XXIII	0.0181	40	45.25	277.3	2.634	6.128177
XXIV	0.0182	40	45.50	244.5	1.965	5.373626
XXV	0.0186	40	46.50	281.8	2.254	6.060215
XXVI	0.0187	40	46.75	233.3	2.750	4.990374
XXVII	0.0189	40	47.25	261.3	2.710	5.530159
XXVIII	0.0191	40	47.75	254.3	3.091	5.325654
XXIX	0.0192	40	48.00	248.0	2.389	5.166667
XXX	0.0195	40	48.75	311.9	2.849	6.397949

Appendix – III

Test results of lotus yarn count and the wet stage tenacity and elongation

Specimen	Weight of specimen (g)	Length (cm)	Tex	Breaking Strength (cN)	Elongation (%)	Tenacity (cN/tex)
I	0.0048	40	12.00	61.3	1.683	5.108333
II	0.0053	40	13.25	68.5	2.598	5.169811
III	0.0054	40	13.5.0	73.7	1.710	5.459259
IV	0.0061	40	15.25	93.7	1.785	6.144262
V	0.0066	40	16.50	105.0	2.475	6.363636
VI	0.0072	40	18.00	121.6	2.280	6.755556
VII	0.0081	40	20.25	87.3	3.585	4.311111
VIII	0.0087	40	21.75	98.8	3.264	4.542529
IX	0.0093	40	23.25	113.7	2.961	4.890323
X	0.0105	40	26.25	125.2	2.669	4.769524
XI	0.0113	40	28.25	115.6	1.612	4.092035
XII	0.0132	40	33.00	134.4	2.025	4.072727
XIII	0.0133	40	33.25	174.6	3.101	5.251128
XIV	0.0142	40	35.50	240.0	3.796	6.760563
XV	0.0155	40	38.75	268.4	2.944	6.926452
XVI	0.0155	40	38.75	204.0	2.963	5.264516
XVII	0.0157	40	39.25	193.4	2.494	4.927389
XVIII	0.0168	40	42.00	207.3	3.103	4.935714
XIX	0.0171	40	42.75	232.0	3.284	5.426901
XX	0.0177	40	44.25	189.0	2.576	4.271186
XXI	0.0179	40	44.75	226.3	2.867	5.056983
XXII	0.0180	40	45.00	240.5	2.492	5.344444
XXIII	0.0181	40	45.25	227.8	2.983	5.034254
XXIV	0.0184	40	46.00	241.9	3.015	5.258696
XXV	0.0186	40	46.50	166.6	3.470	3.582796
XXVI	0.0187	40	46.75	270.3	3.235	5.781818
XXVII	0.0189	40	47.25	288.4	3.072	6.103704
XXVIII	0.0190	40	47.50	189.0	2.576	3.978947
XXIX	0.0192	40	48.00	243.5	1.964	5.072917
XXX	0.0232	40	58.00	316.4	2.595	5.455172