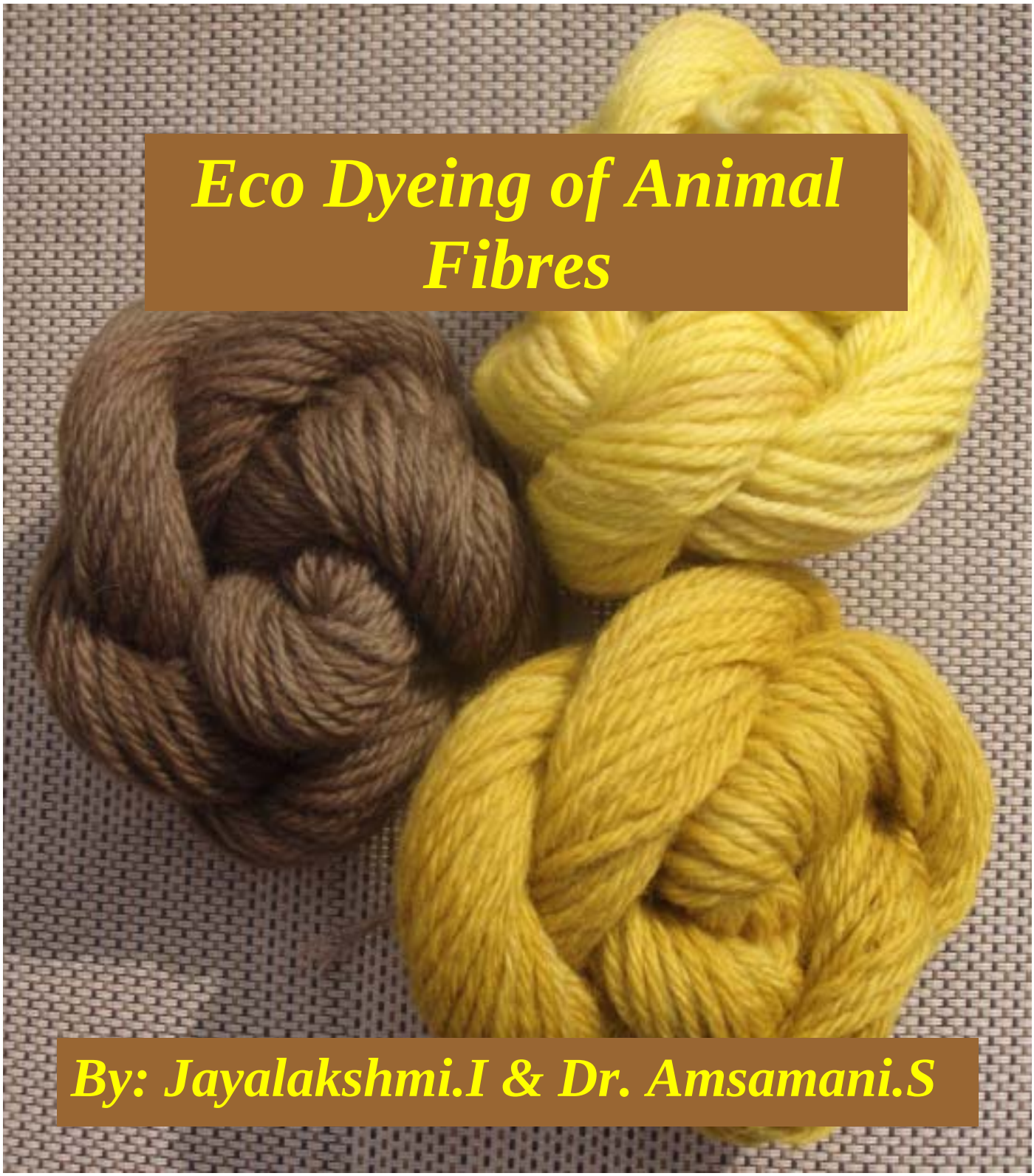

Eco Dyeing of Animal Fibres

By: Jayalakshmi.I & Dr. Amsamani.S

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ABSTRACT

Wool plays a pivotal role in the textile industry. The special feature of the fibre makes it supremely valuable as a textile fibre of outstanding importance. Wool can enhance other fibre properties when blended, extending its application into a new product. This study focused on the selection of the new developed geno type sheeps wool from CSWRI, blending it with a natural vegetable fibre which will result in obtaining of new spun wool yarns with selected proportions, eco dye the same and make wool as best suited for apparel production.

Wool grows in locks, which are called the 'Staple' consisting of thousand of individual fibres. Wool may be classified into fine, medium and coarse or carpet type wool. The quality of wool fibre depends on the breeding, climate, food, general care and health of the animal. Wool has a natural crimp which helps to increase elasticity and strength. It has springiness or resilience which no other natural fibre possesses. Wool fibres are hygroscopic and the most hydrophilic of textile fibres.

Wool can enhance other fibres, properties when blended, extending its application into new product. Blending takes place in the opening and cleaning process prior to carding i.e. blow room blending. However, perfect blending never obtained practically because it needs an infinite number of fibre properly measurements, doubling, bales etc. To achieve proper blending each component should be opened as completely as possible so that fibres can be mixed as intimately as possible to form a homogeneous blend. Homogeneous blending can be achieved by bringing fibres together in finest possible sub-divisions. A homogeneous textile material may contribute economy, durability, physical protection, colour and appearance to a blend views Park and Shore (2000).

Wool can be processed on the woolen or semi-worsted system is often dyed as in loose stock. Wool fibres are always carded but not all wool fibres are combed. If they are to be used for woolen yarns, they are only carded. For worsted yarns, they are both carded and combed. Woolen yarns are shorter and fuzzier than worsted yarns, which have been straightened out in the combing process expresses Alexander (1990). Worsted spinning is considered superior to synthetic spinning. Worsteds are an exception, as their yarns are tightly twisted and firm and worsted fabrics are smooth and have a crisp feel. Wool, mixed with cotton produces in the fabric a distinct hardness and heaviness about the material, which further tends to soil readily, fade and wrinkle.

Wool like cotton is considered a relatively easy fibre to dye. It is more readily dyed due to the polarity of its polymers and its amorphous nature. Wool dyeing, to improve its quality and appearance both in the pure and blended form is a challenging art. Wool is being dyed in India since long. Wool dyeing can be done in top, yarn or fabric stages. Colouring of wool enhances its beauty and luster. Colouring started with natural resources and because of its limited shades and fastness synthetic dyes over took the natural dyes. People started accepting these synthetic dyes due to their dark and vivid shades and good fastness

properties. Now people are aware that these synthetic cause number of hazards to life like health, environmental etc. They are looking back for their renewal of natural dyes that can produce vivid shades with good fastness properties.

Both the dyeing and spinning technicians have an upper hand in the job market. Shankar and Vankar (2005) predict awareness and concern for the environmental issues has led to extensive research for use of natural dyes for wool dyeing. In some parts of India, wool were dyed with natural dyes depending upon the availability of colour yielding raw materials and their end use.

METHODOLOGY

Selection of Wool Fibre: Bharat Merino wool fibre obtained from CSWRI, Mannavanur, Kodaikanal, was selected for the study

Scouring of Wool Fibre: Scouring is the first step in wool processing is very unique to the wool fibre. The wool fibre was immersed in water for over night to remove all impurities in it. Then the wool fibre was treated with a solution of 6 ml of non-ionic detergent and three grams of sodium carbonate keeping M:L ratio as 1:60 of soft warm water divided between the three bowls as quoted by Dagur (1996) at 52 ± 2°C temperature and soaked for three to five minutes in each bowl. The wool fibres were immersed in the three bowls for three to five minutes and agitated at intervals. Move the wool gently there must be no violent agitating. After the desired time, the wool fibres were rinsed and dried at room temperature or in open air.

Spinning: Wool fibre was spun through short staple system popularly known as cotton spinning system for production of finer quality and more varieties of value added woven and knitted fabrics. Thus indigeneously developed short but fine wool in blends with pre determined per centages of cotton was spun.

Selection of Wool Yarns and its Blend: A pure wool yarn and two types of wool blended yarns, were spun and taken for the study as shown below in Table I

TABLE-I
SPUN WOOL YARNS

S.N	SPUN YARNS PRODUCED	
1	100% Bharat Merino	100% BM
2	50:50 Bharat Merino : Cotton	50:50 BM
3	60:40 Bharat Merino : Cotton	60:40 BM

Preparation of yarn for dyeing: Wool contains natural oils and other impurities, which are to be removed before dyeing. To remove the impurities in wool yarn, skeins were soaked in a warm 0.5% solution of soft liquid detergent for 30 min, keeping M:L ratio 1:20. After kneading and squeezing, the skeins were rinsed in water and dried in shade.

Wetting/Soaking: The skeins were soaked in water to remove air and soften the yarn to facilitate dye penetration.

Selection of Dye: Annatto and Turmeric were selected for the study. The dye materials were dried in shade and powdered. The dye per centage used for the study was 2%, 4% and 6%.

Annatto seed is also known as achiote. This seed grows on the annatto tree. It is used primarily in Mexican and Caribbean cooking to impart a rich yellow / orange colour. This plant (a tropical shrub), stands alone in its family; a profusely fruiting shrub, reaching 6-20 feet tall and age up to about 50 years.

Annatto has pointed leaves and pink, white or pinkish white flowers. The small reddish-orange seeds, inside a prickly heart-shaped pod, are crushed and used as food colouring. Approximately 50 seeds grow inside of the pod.

Depending on the colour of the flowers, the seedpod is either green or red; the seeds have the same coating in both. The red colour is due to apo-carotenoids that are in the seed epidermis. These seeds are processed to obtain the orange-yellow pigments, bixin and norbixin (carotenoids), as dye for the food, cosmetic and soap industries. This dye is used to colour the cheddar cheese and is also used for the coloring of rice.

Turmeric is one of the well known commonly occurring natural dyes. This plant is extensively cultivated in India. The main use of turmeric is an essential ingredient in cooking as it imparts a yellow colour to the food stuffs. It is used to give colour and softness to the skin. It is taken internally as it has therapeutic effect against gastric disorders and applied externally as it has healing effect on the skin. The dye is extracted from the fresh or dried rhizomes of turmeric - Curcuma longa, the pigments is known as Curcumin. It is a substantive dye capable of dyeing silk, wool and cotton. The colour obtained by direct dyeing with turmeric is not washed off by water.

Selection of Mordants: Bio-Mordants namely Pomegranate rind was undertaken for the study. The mordants were used in 1% concentration.

The rind of pomegranate fruit is the source of natural tannins and yellow dye. It is a free of 2.5 meter height bearing large reddish brown fruits thick skin of fruit is used as dye. Anar (Punica granatum) is known to have been cultivated in the Middle East more than five thousand years ago. It is indigenous to orient Greece and India. It is also cultivated in Europe and Africa. The tannin present in the rind is of myrobalon type. The rind of Pomegranate is also the source of a dye that gives yellowish brown to khaki shades and has been used for dyeing wool and silk.

Selection of After Treatment: Natural fixing agent Carissa carandus Linn was used for the study.

The Karonda also Karaunda, Karanda, is a shrub which produces berry-sized fruits. Karonda (Carissa carandus L.) is a fruit of dry areas and flourishes well on lands with high temperatures. At present it is grown on a limited scale in Rajasthan, Gujarat and Uttar Pradesh. It is a fruit of Indian origin and under the changing world trade scenario it can be

exploited on a commercial scale as a fruit for the processing industries. Less showy than the Carissa, the karanda has attracted more interest as a source of fruit and as a medicinal plant than as an ornamental. Its botanical name was in recent years changed to *Carissa congesta* Wight (syn. *C. carandas* Auct, formerly widely shown as *C. carandas* L.). It is called *kerenda* in Malaya, *karaunda* in Malaya and India; Bengal currant or Christ's thorn in South India; *nam phrom*, or *namdaeng in* Thailand; *caramba, caranda, caraunda and perunkila* in the Philippines. The leaves are evergreen, opposite, oval or elliptic, 1 to 3 inches (2.5-7.5 cm) long; dark-green, leathery, glossy on the upper surface, lighter green and dull on the underside.

Optimization of Dyeing Variables: A series of experiments were conducted to determine the medium for dye extraction, optimum concentration of dye material, time of extraction of dye, dyeing time and concentration of mordants.

Medium of Dye Extraction: Dye from Annatto and Turmeric were extracted in aqueous medium.

Method of Mordanting: The wool samples were mordanted by four mordanting techniques. Pre-mordanting (mordanting before dyeing), Simultaneous mordanting (mordanting and dyeing together), Post mordanting (mordanting after dyeing) and Pad mordanting (mordanting is carried out before and after dyeing).

Optimization of Dye Extraction Time: Known amount of dye material was taken in three beakers, each containing 100ml of water and selected medium. The dye was extracted after soaking for 48 hrs, 30 min, 60 min and 90 min respectively. To each extracted solution known weight of woolen yarns were added and dyeing was carried out, per cent absorption was calculated for each sample and on the basis of results, time for dye extraction was optimized.

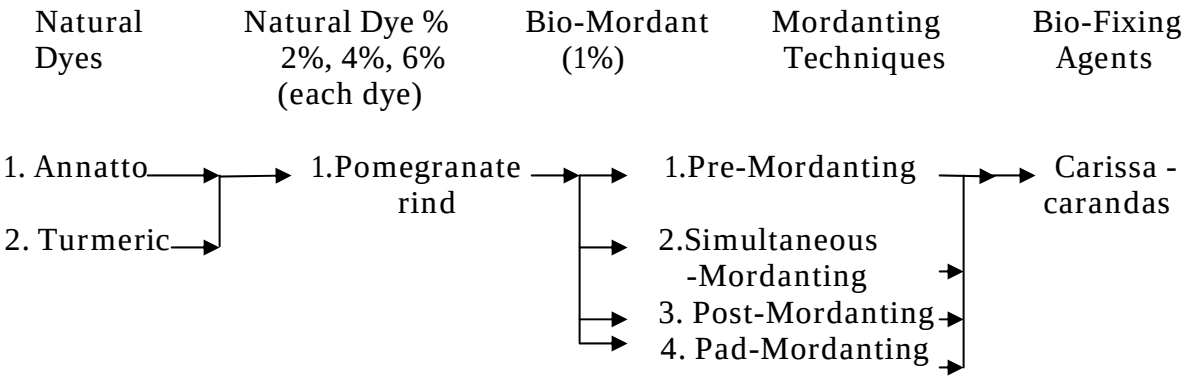
Optimization of Dye Concentration: To optimize the dye concentration dye solution of each concentration (i.e) 2%, 4% and 6% / 100 ml of water were prepared separately and optical density of each solution recorded before dyeing. After that wool samples were dyed in each of the respective dye solution. Optical density after dyeing was measured and per cent absorption was calculated for each sample. Based on per cent absorption, best concentration for Annatto and Turmeric was optimized.

Optimization of Dyeing Time: Two dye solutions of Annatto and Turmeric were prepared with optimized concentration of dye material and extraction time. To each solution known weight of woolen yarns were added and dyeing was carried out at 30 min, 45 min and 60 min respectively. Per cent absorption was recorded for each sample and based on results, best dyeing time was optimized for each dyes.

Dyeing of Woolen Yarns: After optimization of dyeing variables, known amount of woolen yarns were dyed with optimum concentration of dye at optimum dyeing time.

The 100% Bharat Merino, 50:50 Bharat Merino, 60:40 Bharat Merino were dyed using the following combination as shown in Table II obtaining 24 shades for each yarn.

TABLE-II
FLOW CHART OF DYEING PROCESS IN PILOT STUDY



Each woolen yarns were then treated with the fixing agent. After dyeing, the woolen yarns were steeped in the fixing solution for 10 min. Fixing solution was prepared with 0.375 gram of fixing agent in 7.5 litres of water. The dyed woolen yarns were hydro extracted and dried.

YARN TESTING

Yarn Tests: The yarn tests were carried out either after spinning or after dyeing to find out yarn count, yarn strength and elongation, colour measurement and absorption and colour fastness tests for yarn dyed samples.

Yarn Count: Instead of the different yarn count systems formerly used for various yarns, the tex system has now been introduced as the standard of yarn count by Ishida (1978). The yarn is defined in a yarn number (i.e) Cotton count, Tex, Denier, Worsted Count, Metric Count etc. The Metric count and Tex are generally used in the woolen based industry. The metric count is defined as “The yarn length (meters) in one gram is called metric count”, whereas the Tex is defined as “Weight of 1000 meters in grams is called Tex”, Shakyawar (1996). The yarn is cut into small strands and count of yarn is determined. Alternately a pre-determined length of yarn is cut and accurately weighed to determine the yarn count. Tex system was used to determine the yarn count (i.e) the weight in grams of 1000 meters of yarn. The count was calculated as per the formula given by Sharma and Goel (2003). The test was repeated for 10 samples of each yarn and average was calculated as:

$$N\ (Tex) = (W \times 1000) / L$$

Where, L = length in meters, N = count or number, W = weight of yarn in grams.

The yarn count was analyzed for all the wool and wool blended samples and the yarn count is shown in Table III.

Single Yarn Strength and Elongation: Yarn strength was measured with “single thread strength tester”. This is a motor driven pendulum type STATIMAT 4 strength tester with a 500 mm gauge length, 4k clamp type and 100N load cell, 0.5cN/tex pre tension at an average test speed of 410 mm/min. The pendulum was arrested with a catch and also the movement of the upper clamp was arrested. 20 inches of each wool yarn was taken and clamped between the upper clamp and the lower clamp. The extra material was cut off exactly at the

clamp position and then the catches are taken out. When the machine was started, the lower jaw traverses downward imposing the tension on the specimen and thereby pulling the upper clamp and in its turn will make the pendulum to move over the quadrant scale. When the specimen ruptures, the pendulum arm was retained in the position by a set of pawl working over the serrated portion of the quadrant. The position of pendulum arm gives the breaking load of the specimen. Every time the pendulum arm was brought to zero position and the movement of the upper jaw arrested. The strength was recorded in ounces or grams and the elongation in per cent. For the recorded results the tenacity was calculated using the formula

Tenacity in g / Tex = (Mean breaking load in kg x 1000) / Tex

Apart from the breaking load, the elongation is also measured by noting down the relative position of the upper clamp. The elongation scale directly reads the difference in the movement of both the lower and upper jaws. This can also be calculated in terms of per centage of the original length of specimen as follows

Elongation % = (Elongation scale reading / Gauge length) x 100

Single yarn strength and elongation was carried out for both original spun wool yarn and spun dyed wool yarns and the results are shown in Table IV and Table V.

Colour Measurement and Absorption: The depth of the colour was determined by using spectrophotometric data in the form of K/S values. The dyed wool yarns 100% BM, 50:50 BM and 60:40 BM were measured using Macbeth 7000 A spectrophotometer to find K/S, L, a, b, c, H values of all the dyed yarn wool samples dyed from natural processing.

K /S is the ratio of absorption co-efficient (K) versus the scattering co-efficient (S) for a reflectance measurement. K/S is given at wavelength of maximum absorption views Gangakhedkar (1991).The ratio is derived mathematically from the reflectance measurement as follows, Sarkar at al (2006)

$$K / S = (I - R)^2 / 2R$$

When R is the reflectance of an infinitely thick layer of material illuminated with light of a known wavelength expresses Uttam and Gangwar (2006). The greater the K/S value the greater is the intensity of the dyed sample.

L is a measure of the lightness of an object and ranges from 0 (black) to 100 (white),
a is measure of redness (positive a) or greenness (negative a)
b is a measure of yellowness (positive b) or blueness (negative b)
c is a measure of chroma (saturation) and represents distance from the neutral axis.
H is measure of hue and is represented as an angle ranging from 0° to 360°,

The optical density of the dye solution before and after dyeing was also estimated using the spectrophotometer on the basis of the Nano metric value of the colour used. The dye absorption was calculated using the following equation

Dye absorption % = (Optical density before dyeing – O.D after dyeing) / Optical density before dyeing

The K/S, L, a, b values along with maximum wavelength and per centage of absorption are given for the above mentioned dyed wool yarns in Table IV.

Colour Fastness Testing:

Each dyed samples were tested for colour fastness against light, washing, rubbing and perspiration. The washing fastness test was carried out as per the recommendation of ISI test no.3. Fastness against rubbing was determined by using AATCC test method 8-1974. Fastness to sunlight was carried out according to ISI – 971 – 1156 test method. Each sample was then evaluated for colour change and graded by using grey scale. Fastness against rubbing was determined by using AATCC test method 8-1974. Fastness to sunlight was carried out according to ISI – 971 – 1156 test method. Each sample was then evaluated for colour change and graded by using grey scale.

RESULTS AND DISCUSSION

YARN TESTS
Yarn Count

The Yarn Count of the nine spun wool varieties are given below in Table III

TABLE-III
YARN COUNT

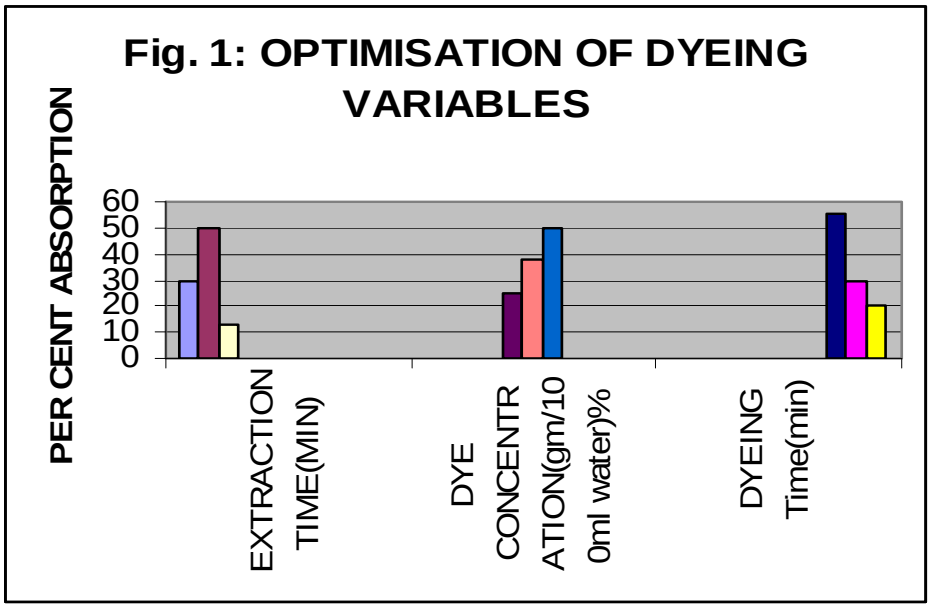
S.N	SPUN WOOL YARN	MEAN COUNT VALUE (Ne)	S.D	CV%	WORSTED COUNT
1	100% BM	1.29_s	0.10	7.5	636.67
2	50:50 BM	1.83_s	0.18	9.9	484.04
3	60:40 BM	2.13_s	0.44	20.7	415.87

The yarn count of 100% BM spun wool yarn was 1.29s Ne, 50:50 BM spun wool yarn was 1.83s Ne and 60:40 BM spun wool yarn was 2.13s Ne.

Selection of Optimized Dyeing Variables

Medium of Extraction: Dye for Annatto and Turmeric were extracted using aqueous medium.

Dye Extraction Time: The dye was extracted at 30 min, 60 min and 90 min and the results are shown in Fig.1. Figure shows that maximum per cent absorption was found to be 60 min after soaking for 48 hrs, therefore it was selected as optimum.



Dye Concentration and Dyeing Time: Woollen yarns were dyed with different concentration of Annatto and Turmeric at different time. Maximum per cent absorption was obtained with 6% of dye per 100 ml of water and at 30 min dyeing time, as optimum and is shown in Fig.1.

Selected Shades for Woolen Yarns: Out of the twenty four shades obtained for each 100% Bharat Merino (100%BM), 50:50 Bharat Merino(50:50 BM) and 60:40 Bharat Merino(60:40 BM), one shade was selected based on the visual evaluation by a panel of judges for each wool yarn as shown in Table IV

TABLE-IV
SELECTED DYE SHADES FOR FINAL STUDY

S. NO	WOOL YARN	NATURAL DYE	NATURAL DYE %	BIO-MORDANT 1%	MORDANTING TECHNIQUE	BIO FIXING AGENTS
1	100 BM%	ANNATTO	4%	POMEGRANATE RIND	PRE	CARISSA CARANDAS
2	50:50 BM	TURMERIC	6%		PAD	
3	60:40 BM	ANNATTO	6%		SIMULTANEOUS	

Fastness Grades: The Colour Fastness Properties of 100% BM are shown in Table V. The Colour Fastness Properties of 50:50 BM are shown in Table VI. The Colour Fastness Properties of 60:40 BM are shown in Table VII.

TABLE-V
FASTNESS GRADES OF 100%BM WOOLEN YARN

Dye Per centage: 4% Dyeing Time: 30 min Dye Extraction Time: 60 min
Extraction Medium: Aqueous Mordanting Time: 30 min Fixing Agent Time: 10 min

Mordanting Method	Fastness Properties of 100% BM Wool Yarn										
	Sunlight	Washing		Dry Rubbing		Wet Rubbing		Acidic Perspiration		Alkaline Perspiration	
		CC	CS	CC	CS	CC	CS	CC	CS	CC	CS
Control	2	2	3	3	3	2	3	3	3	2	3
Pre-Mordanting	3	3	5	5	4/5	3	4/5	3/4	3/4	4/5	4/5
Simultaneous Mordanting	3	3	4	5	4/5	4	4/5	3/4	3/4	4/5	4/5
Post-Mordanting	3	3	3	5	4/5	3	4/5	3/4	3/4	4/5	4/5
Pad-Mordanting	4/5	4/5	5	5	5	4/5	5	4	5	4/5	5

TABLE-VI
FASTNESS GRADES OF 50:50 BM WOOL YARN

Dye Per centage: 6% Dyeing Time: 30 min Dye Extraction Time: 60 min
Extraction Medium: Aqueous Mordanting Time: 30 min Fixing SolutionTime: 10 min

Mordanting Method	Fastness Properties of 50:50 BM Wool Yarn										
	Sunlight	Washing		Dry Rubbing		Wet Rubbing		Acidic Perspiration		Alkaline Perspiration	
		CC	CS	CC	CS	CC	CS	CC	CS	CC	CS
Control	3	3	4	4	4	2	3	3	3	3	3
Pre-Mordanting	5	4/5	5	5	5	4/5	5	4	5	4/5	5
Simultaneous Mordanting	3	3	4	5	4/5	4	4/5	3/4	3/4	4/5	4/5
Post-Mordanting	3	3	3	5	4/5	3	4/5	3/4	3/4	4/5	4/5
Pad-Mordanting	4/5	4	5	5	4/5	4	4/5	3/4	4/5	4/5	4/5

TABLE-VII
FASTNESS GRADES OF 60:40 BM WOOL YARN

Dye Per centage: 6% Dyeing Time: 30 min Dye Extraction Time: 60 min
Extraction Medium: Aqueous Mordanting Time: 30 min Fixing SolutionTime: 10 min

Mordanting Method	Fastness Properties of 60:40 BM Wool Yarn										
	Sunlight	Washing		Dry Rubbing		Wet Rubbing		Acidic Perspiration		Alkaline Perspiration	
		CC	CS	CC	CS	CC	CS	CC	CS	CC	CS
Control	3	3	3	3	3	2	3	2	3	3	3
Pre-Mordanting	4	4	5	5	4/5	4	4/5	3/4	3/4	4/5	4/5
Simultaneous Mordanting	5	5	5	5	5	5	5	4/5	5	4/5	5
Post-Mordanting	4	4	4	5	4/5	4	4/5	3/4	3/4	4/5	4/5
Pad-Mordanting	4/5	4/5	5	5	5	4/5	5	4	4/5	4/5	4/5

Natural Colours extracted from Annatto and Turmeric was found to be very fast on woollen yarn. The initial fastness grades from the above tables shows 2-3. But after the application of fixing treatment to the woolen yarns the fastness grades increased to 4 – 5, which reveals that sunlight fastness was excellent in all the samples. No colour change and staining were noticed to washing. No colour staining was found in dry and wet rubbing whereas no colour change was there in dry crocking but negligible to slight colour change was found to be in turmeric dye in wet crocking. Dye was found to be resistant to perspiration. In case of colour change negligible change was found in both acidic and alkaline perspiration but whereas no samples showed colour staining.

Single Yarn Strength Test

The nine spun wool yarns were tested to find out their strength for original spun wool yarns and dyed wool yarns and the result is shown in Table VIII and Fig.2.

TABLE-VIII
SINGLE YARN STRENGTH

S.N	Spun Wool Yarns	Mean Strength (G)	S.D	S.E	CV%	T (Paired)
1	1o 1d	882.86 683.36	101.68 84.65	22.74 18.93	11.52 12.39	5.782**
2	2o 2d	702.14 1002.17	171.25 210.21	38.29 47.00	24.39 20.98	7.946**
3	3o 3d	1151.38 948.32	241.08 282.47	55.31 64.78	20.94 29.77	3.982**

** - Significant at one per cent level

From the above Table VIII, it is evident that the strength of the dyed yarn has increased for 50:50 Bharat Merino Yarn and the result shows that the strength of the original spun wool yarns and dyed wool yarns are significant at one per cent level.

4.1.2.3 Single Yarn Elongation

The spun nine original spun wool yarns and dyed wool yarns elongation is shown in Table IX and Fig. 3.

TABLE-IX
SINGLE YARN ELONGATION

S. N	Spun Wool Yarns	Mean Elongation %	S.D	S.E	CV %	T (Paired)
1	1o 1d	24.38 18.25	4.52 2.56	1.01 0.57	18.52 14.03	5.186**
2	2o 2d	22.39 25.58	2.52 3.62	0.56 0.81	11.25 14.17	3.728**
3	3o 3d	20.38 18.05	4.07 2.42	0.93 0.55	19.96 13.40	3.861**

** - Significant at one per cent level

From the above Table IX, it is evident that the elongation of the dyed yarn has increased for 50:50 Bharat Merino Yarn and the result shows that the elongation of the original spun wool yarns and dyed wool yarns are significant at one per cent level.

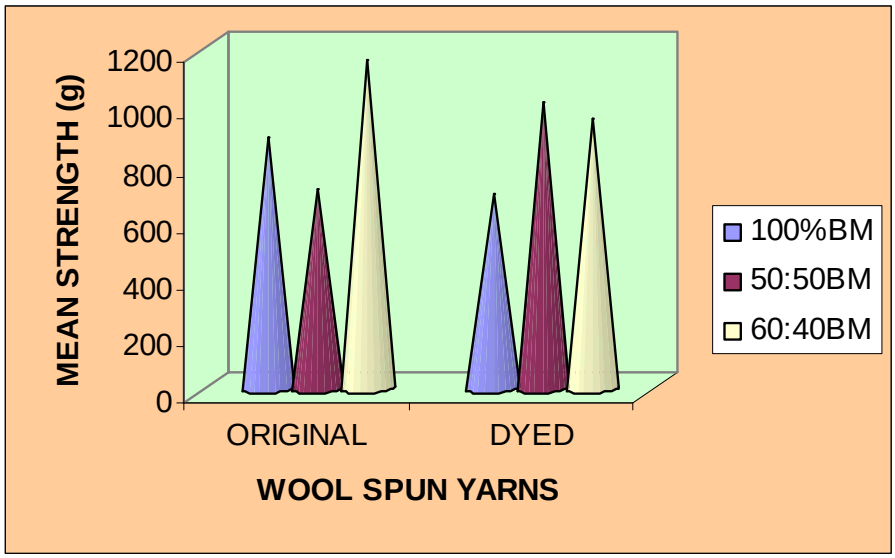


Fig.2: SINGLE YARN STRENGTH

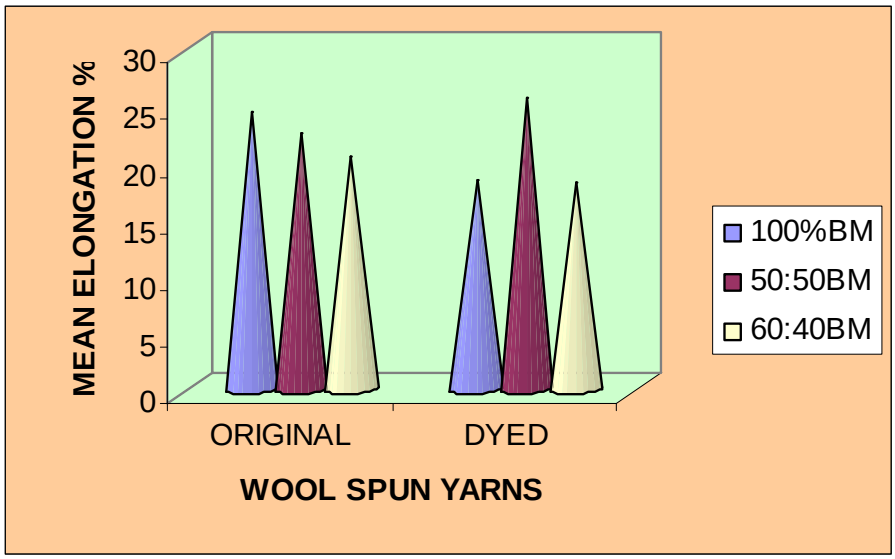


Fig. 3: SINGLE YARN ELONGATION

Colour Measurement and Absorption

The colour strength (K/S value) L, a, b values of D65 light at 10° absorber with its maximum wavelength and dye absorption % (Dye pick up) is shown in Table X.

TABLE-X
COLOUR MEASUREMENT AND ABSORPTION

S. NO.	DYED WOOL YARNS	COLOUR STRENGTH					DYE ABSORPTION
		K/S VALUE	L	a	b	AT MAX. WAVE LENGTH (nm)	ABSORPTION %
1	100% BM	4.2	53.85	13.99	27.44	400	93
2	50:50 BM	26.5	59.31	8.58	66.26	430	94
3	60:40 BM	5.5	48.46	30.28	19.64	400	90

From the above Table X, it is evident that the dyed wool yarns had a very good colour strength and the dye had absorbed to its maximum at the given wavelength

Wool is an ideal fibre for use in the construction of clothing, attractive in appearance, pleasing to touch, dye easily and permanently and resilient enough to retain their shape. Wool never wears out, not absorb odors, afford protection from heat and cold alike and easily cleaned. In wool dyeing, with natural dyes, the depth of the dyeings was very good on wool under the same dyeing conditions as for other fibres.

References:

- Alexander (1990), Textile Products Selection, Use and Care, John Wiley and Sons Inc., New York, P.30

- Dagur.R.S (1996), Laboratory Scouring Yield, Advances in Wool Blending, Special Training Course on Wool and Woolen Projects Development and Evaluation, 11th September – 10th October, Organized by Human Resources Development Section, Central Sheep and Wool Research Institute, Avikanagar, Rajasthan. Pp.8-10.

- Shakyawar.D.B and Gupta.N.P (1996), Advances in Wool Blending, Special Training Course on Wool and Woolen Projects Development and Evaluation, 11th September – 10th October, Organised by Human Resources Development Section, Central Sheep and Wool Research Institute, Avikanagar, Rajasthan. P.129.

- Park.J and Shore.J (2000), Dyeing Blended Fabrics – The Ultimate Compromise, Textile – Chemist and Colourist, January, American Dyestuff Reporter, Vol.32, No.1, Pp.47 to 49.

- Shankar.R and Vankar.P.S (2005), Dyeing with Celosia Cristata Flower on Modified Pre-Treated wool, Colourage, July, Vol. LII, No.7, Colour Publication Pvt. Ltd., Mumbai, P.53

- Sarkar.D, Mazumdar.K and Datta.S (2006), Solvent Extraction of Yellow Colouring Matter from Natural Source Flowers and its Application on Hydrophobic Substrates, Man Made Textiles In India, January, Vol.XLIX, No.1, SASMIRA Publications, Mumbai, P.20

- Sharma.A and Goel.A (2003), Blending Technology: A New Step for Performance Improvement, Man Made Textiles In India, October, Vol.XLVI, No. 10, SASMIRA Publications, Mumbai, P.379.

- Uttam.M and Gangwar.A.K (2006), Effect of Single Yarn Strength on Tensile Strength of Cotton Fabric, Man Made Textiles In India, January, Vol.XLIX, No. 4, SASMIRA Publications, Mumbai, P.143.

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