EXECUTIVE SUMMARY

1. INTRODUCTION

The art of making vegetable dyes is one of the oldest known to man and dates back to the dawn of Civilization. In India, it was sidely used for colouring of fabrics and other materials. Though the very earliest dyes were discovered by accident using berries and fruits. With the experimentation and gradual development the vegetable dyes have resulted into a highly refined art.

India's expertise in vegetable dyes dates back to ancient times. Using mordants to hold fast the dye or resists to selectivity prevent them from touching the cloth were printed bales of whisper soft textiles. From 15th to 19th centuries, block printed resist dyed textiles from Gujarat and Deecan adorned Europeans and their homes. The discovery of synthetic dyes in the west in 19th century dealt a massive blow to Indian Textile Industry. Some of the chemical dyes earlier found associated with hazards effecting human life creating skin diseases and lungs problems. The environmentalist, therefore, started searching the substitute of synthetic items which has led the use of more & more natural dyes. In recent days the inherent advantages of vegetable dyes has resulted in the revival and use of vegetable dyes. The study aims to identify the various manufacturers, present status and to identify the measures for upgradation of this industry.

2. Sources of Vegetable dyes

The natural dyes are classified as monogenetic and polygenetic dyes. Monogenetic dye materials produce only one colour on textiles irrespective of mordants. Polygenetic dye matters develop different colours according to the mordant applied before dyeing.

The common sources of vegetable dyes are as under:

(i) Parts of Plants such as leaves, flowers, fruits, seeds, barks, roots of dye yielding plants.

(ii) Minerals such as prussion blue, red ochre and ultramarine blue.

(iii) Animal origins such as Lac, cochimeal and kermes.

The cultivation of trees in unused lands will yield dye matters and the fuel wood for the villages. Thus, the encouragement of cultivation of dye yielding plants and trees will boost agro-based activity in rural areas leading to rural development and employment.

3. Advantage

India is being one of the country, which possesses the natural wealth in the form of plantation in plenty. This has provided relatively better opportunity for the development of this industry in the country. The following are the major advantage for the use of vegetable dyes.

- The raw material for production of vegetable dyes are plentifully available.
- Vegetable dyes do not cause any harm to human skin and no hazards are anticipated in their manufacturing, rather some of the dyes act as health cure.
- The chemical reaction is almost absent in the manufacture of vegetable dyes and no pollution problem.
- All these dyes are harmonized with nature.

4. Limitations

Inspite of inherent advantages, the vegetable dye industry has also some limitation which leads some bottelnekness in the development.

- The yield of colour from vegetable dye plants is very low. The research shows that yield of colouring matter varies from 0.3% to 4% in the plant.

- The process of dyeing is complicated mainly due to non-availability of technical know-how and trained personnel.

- The non-reproduction of some shades is one of the drawback of these dyes due to variation in colouring matter present in the plants.

- The problem of blending of dyes to get secondary colours is main drawback to restrict versatile use. Only few dyes can be blended.

- Due to use of heavy metals in the form of mordents, the discharge from the unit is enriched with heavy metals and huge amount of organic contents causing pollution and disposal problems.

5. Major Concentration

Although, the vegetable dyes are used all over the country, but in some of the states extensive use of these dyes has been found due to their traditional occupation. The major concentration in the use of vegetable dyes in the country is given as under:-

- ***Vegetable Dyes in Rajasthan***

  The natural dyes are primarily used by the block printing units in Jaipur since very long time and mainly concentrated in Sanganer & Bagru block. There are about 60 units in Jaipur City distributed in Kaladera, Bara Gaon Jalota and Jai Rampur.

Jodhpur

There are 750 units, which are involved in dyeing and printing of fabrics by using natural dyes. The main concentration of the units is in Barmer. Their annual production is around 58 lakhs metres. The charges for dyeing and printing vary from Rs 3/- per metre to Rs. 10/- per metre. The cost of the natural dyes varies from Rs. 30/- to Rs. 100/- per kg for raw dyes and Rs. 400/- to Rs. 2000/- per kg for refined dyes. Most of the suppliers of natural dyes are operating on cottage scale.

The list of the progressive Tie & Dye craftsmen using natural dyes in Rajasthan is enclosed at Annexure-III.

Units Using Vegetable Dyes in Rajasthan

Place	Total Nos. Of unit	% of units using (N) Dyes	Nos. of units using (N) dyes	Estimated production (in Mtr./day @ 80 mtr/unit	Annual production (In lacs Mtr.)
A. **JAIPUR**					
1. Jaipur	300	20%	60	4800	1.44
2. Sanganer	500	40%	200	16000	48.00
3. Bagru	200	80%	160	12800	38.00
TOTAL:	**1000**		**420**	**29280**	**87.84**
B. JODHPUR	100	90%	90	7200	21.60
C. Barmer	500	40%	200	16000	48.00
D. Bikaner	70	60%	40	3200	9.60
TOTAL: (A+B+C+D)	**1670**		**750**	**55680**	**167.04**

Source: UPICO's Survey

- ***Vegetable Dyes in Orissa***

Like other parts of India, in Orissa there are few handloom concentrated areas, e.g., Kotapad, Nuapatana, Berhampur, etc., where natural dyeing is still in practice by the handloom weavers. The vegetable dyes commonly used in Orissa are Bixa seeds, rust iron solution, catachue, Ala, Lac and Jackfruit wood. The Ala & Jackfruit possesses an important place because of their tonal value.

UNITS USING VEGETABLE DYES IN ORISSA

Place		Total No. Of Units production mtr)	% of units using veg. Dyes	No. Of Units using veg. dyes	Estmated Production (in mtr/day @ 60 mtr/day	Annual (in lac
1.	Kotapad	160	20%	32	1920	5.76
2.	Nuaputana	180	20%	36	2160	6.48
3.	Berhampur	55	30%	16	960	2.88
4.	Cuttack	135	10%	13	780	2.34
		530		187		

Source: UPICO's Survey

- ***Vegetable Dyes in North Eastern Region***

Some of the places in this region, where natural dyes continued to be extracted or used in some form or other are Imphal, Kadampapi (Manipur), Kensa and Akoya (Nagaland), Bhoi Area (Meghalaya) and few places of Arunachal Pradesh. KUM (Khum, Khuma), dyeing is in practice in Manipur. Indigo (Indigofora tinctoria) blue is well known and the indigo

dyeing process is fairly known and so also the process of madder dyeing. Cassia Tora (Chakunda) a very cheap substitute for Indigo blue is also

used but its dyed material is not of good quality. Kum (Strobilanthes flaccidifolius) is another plant which yields blue and blue black colour. This dye is used in Manipur, Nagaland, and few other parts of the North east Hill region.

UNITS USING VEGETABLE DYES IN NORTH EASTERN REGION

S.No.	Place	Total no. of units	% of units using vegetable dyes	No. of units using vegetable dyes	Estiamted production 50Mt/day	Annaul production (In lac MT)
1.	Assam	350	15%	52	2600	7.80
2.	Meghalaya	250	20%	50	2500	7.50
3.	Manipur	300	25%	75	3750	11.25
4.	Arunachal Pradesh	150	15%	22	1100	3.30
		1050		199		

Source: UPICO's Survey

6. International Demand

The total size of the world market for dyes, pigments and intermediates is estimated at around US $ 23 billion in 1999. Dyes and pigments constitute the largest segment with a market size of 1.3 million tonnes and a market value of US $ 16 billion. The vegetable dyes constitute US $ 0.03 billion and is expected to grow in coming years.

In year 1998, Europe had imported US $ 53 million worth of "colouring matter of animal or natural origin". The major importing countries were the Germany (32%), France (17%), Italy (14%) and the U.K. (10%). The largest suppliers were Mexico and Peru each with about US $ 15 million exports to Europe. Imports from India were less than US $ 3 million (approx 5%). The US imports of natural colorants are worth over US $ 4 million (Rs. 180 crores).

7. Indian Scenario

The application of natural dyes in textile industry is in the form of (a) Dyeing of yarns, which are then woven into cloth, carpet or any other usable form (b) Dyeing of clothes woven earlier (c) Block Printing, where the Textile materials are printed with the help of printing blocks and (d) Kalamkari where the "Kalam" or pen is used to draw beautiful designs on the cloth.

Some of the Important Natural Dyes Manufacturers in India

1. M/s. ALPS Industries Ltd.
(100% EOU)
57/2, Site-4, Shahibabad
Industrial Area,
Ghaziabad-201010
Phone :- 772565, 66,67,68
Fax:- 7704426, 772810

2. M/s. Prerena
Reg. Office 5th Floor
Sanam Chamber-I
5, Park Road
Lucknow
Phone:- 238577, 239047
Unit
B-81, Vibhutikhand
Gomti Nagar,
Lucknow
Phone:- 392480, 300411

3. Mr. M.C. Jain
Sam Veg. Colours Pvt. Ltd.
B-90 Ghandhinagar,
Moradabad-244001.
Phone:- 4910872, 491027

4. Sh. Yawar Alisha
Director
AMA Herbal Laboratories
Pvt. Ltd.
Corp. Office: 352/116-G,
Talkatora Road,
P.O. Rajajipuram
Lucknow-226 017
Phone:- 417610 (o)
397543 (R)
Fax:- 412713, 218227

5. M/s. Gupta Brothers (Shellac)
P.O. Bindu
District. – Ranchi
Bihar-325 304
Phone:- 2240
Fax:- 06530-2240, 30894

7. Rohini Herbal Pvt. Ltd.
220A, Bansi Trade Centre
581/51, M.G. Road, Indore
Phone:- 0731-282664
Fax:- 0731-702018

6. Padmavati Group
IInd Floor, 13,
Dr. Thirumoorthy Nagar
1, Street, Nungambabbam
Chennai-600 034
Tel:- 044-8264481
Fax:- 044-8270438
Email:- padmavati@epages.webindia.com

8. M/s. Delux India Pvt. Ltd.
No. 2/C Kula Sekara
Perumal Street
Sripirumbudur- 602105
Kanchipuram (T.N.)
Phone:- 044-236343

Source : Compiled by Study Team

In India, Alps Industries is a leading natural dye producing company. The company is located at Ghaziabad and started R&D project under the guidance of Shri K.K. Agarwal, Chairman of the Company. The company put up a pilot plant for the extraction, concentration and spray drying of natural dyes. It is offering natural dyes (water extract) without using any solvent. It is producing natural dyes by extracting coloring matter from leaves, fruits, rind, bark etc.

Deluxe International, Chennai is a Company, which produces natural indigo. The capacity of the plant is 5 tones per month. They claim purity content of 36% and ash content 36% and the rest is filler. The price offered by the Company is around Rs. 600/- per kg.

The team has visited Rajasthan, Madhya Pradesh, Orissa, northern states, Chhattisgarh and Jharkhand. There are number of dyers and printers who are using vegetable dyes for dyeing of cotton fabrics.The total production of the vegetable dye-stuff is estimated at about 2 to 2.54 tonnes per day in there regions.

It is further found that vegetable dyeing is carried out in a big way in Himachal Pradesh. It is also observed that 11000 tonnes of Rheum Emodi is also being used in the manufacture of vegetable dyes in nearby regions of Kangra and Kullu Manali. Such dyes are used for dyeing of wool for used.

8. Prices

The price of vegetable dyes varies from manufacturer to manufacturer. Actually, there is no fixed formula to calculate the price of the vegetable dyes. It depends upon the availability of raw material and the processing facilities required to produce individual dyes and also their demand.

9. Demand

The major consumers of vegetable dye-stuff are (a) Carpet industry located at Bhadoi and nearby areas, (b) Silk producing areas scattered in and around Varanasi, (c) Kanjivaram, (d) Madhya Pradesh and (e) west Bengal. The sector wise consumption of vegetable dyes is given as under:-

VEGETABLE DYE CONSUMPTION STATEWISE

S.No.	State	No. of artisans engaged in vegetable dyeing	Expected lakh metres of cloth dyed/annum	Qty. Of dye used (tonnes)	Require-ment of raw material (tonnes)
1.	Andhra Pradesh	350	10.50	52.50	2620
2.	Orissa	550	16.50	82.50	4120
3.	Assam	600	18.00	105.00	5250
4.	Arunachal Pradesh	400	12.00	75.00	3750
5.	Manipur	300	9.00	45.00	2250
6.	Meghalaya	300	9.00	45.00	2250
7.	Rajasthan	1000	30.00	150.00	7500
8.	Karnataka	400	12.00	60.00	3000
9.	Himachal Pradesh	250	7.50	37.50	1870
10.	Uttaranchal	150	4.50	22.50	1120
		4300	127.00	675.00	33730

Source: UPICO's Survey

10. Brief description of Vegetable dyes

The vegetable dyes are broadly used in colouration of textile fabric, edible items, pharmaceuticals and cosmetics goods. The dyes used for dyeing purposes are given below: Based on end usage, a brief note on vegetable dyes have been given as under:-

I TEXTILE

Following dye stuffs are used in the coloration of wool, silk, cotton and synthetic fabric:

i. Lac Dye:

It is extracted from lacifer lacca insect. It is used for dyeing of wool, silk and cotton fibers. It gives reddish with tin mordant and purplish with copper mordant.

Lac dye is also a derivative of lac and is similar to cochineal dye and has been in use for coloring food and fabrics since ancient times. Being protein in nature the dye is most suitable for dyeing different types of natural fiber like silk, wool, cotton, etc. Different shades like Olive Green Ruby Red, Amethyst, Yellow, Black, Purple, Steel, Gray, etc., can be obtained by using various mardants.

The forest area nearby Ranchi has a big potential of insect Kerria Lacca. Lac is a natural red dye with good light, wash and rubbing fastness. The dyes are obtained as a by-product of Shellac industry.

ii **Annatto:**

It is prepared from the seed of annatto. It is used in the dyeing of silk and wool. It gives orange and peach colour. Its botanical name is bixin.

iii **Harda:**

It is prepared from fruits of Harda and it yields yellow and gray colours with aluminum and ferrous mordants respectively. It can be used in coloration of wool and silk.

iv **Himalayan Rhubard:**

It is manufactured from Himalayan sherb. The roots of this plant is used for the manufacture of dye stuff. It gives yellow and orange colours. It can be used directly and with Alum Mordant on wool/silk.

v **Indigo Blue:**

It is a fermented dye of leaves of indigo ferra tinctoria. It gives blue colour. It can dye cotton, wool and silk.

vi **Kamala Dye:**

It is prepared from the deposits on flowers of Kamala tree. It gives yellow colour on wool and silk. It can be used directly or with mordant also.

vii **Manju Phal:**

It is manufactured from the nut galls of Manju Phal tree. It is used for dyeing of silk and wool, both directly or with mordant. It is gives cream and grey colours with alum and iron mordants.

viii **Gum Arabic:**

It is manufactured from the bark of Indian Gum Arabic tree. It is used for dyeing of cotton with mordants. It yields brown shade having very good fastness.

ix **Trigonella foenum graecum:**

It is prepared from the fenugreek seeds. It is used in the dyeing of cotton fabrics. It gives yellow shade with metallic mordents like copper sulphate and ferrous sulphate.

x **Golden Dock:**

It is prepared from rumexmaritinus seeds. It yields brown colour on cotton with alum, copper sulphate and ferrous sulphate mordants.

II **COSMETICS**

The vegetable dyes from dolu and rind of pomegranate are used in coloration of lipsticks and other cosmetics. They are manufactured by water extraction method. The coloring matter can be extracted with Super Critical Fluid Extraction Method .

III **EDIBLE DYES**

Most common dye, which can be used for coloration of the edible items, are annatto seeds. The water soluble extract can be used for coloration of butter and oil soluble extract can be used for colouration of ghee & ice cream, etc. They are simple extracts of annatto seeds, which give 55 to 60% yields when their extract is prepared. Lac dye is also a derivative of lac and is similar to cochineal dye and has been in use for coloring food besides fabrics since ancient times.

11 Preparation of Vegetable Dye

The basic raw materials required for manufacturing of vegetable dyes are natural produce and requires following steps for manufacturing of vegetable dyes.

i Collecting the parts of the plants (leaves, barks, stems, flowers, fruits, seeds).

ii Testing of raw material for assessment of colour contents.

iii Dyeing.

iv Size reduction by pulverizing

v Separation of different size by vibrating screen.

vi Extraction of colouring component

vii Phase separation

viii Fine filtering

ix Drying of coloring matter (Dyes) in spray dryer.

x Packing:

- Liquid form
- Paste form
- Power form

12. Extraction

The vegetable dyes extraction is broadly divided into extraction method & extraction technology.

I ***Methods of Dye Extraction***

The extraction methods of vegetable dyes basically depends on medium in which the dye is extracted. There are mainly four methods used in extraction of natural dyes.

i. ***Aqueous Method:***

- Boil known amount dyestuff in 100 ml. of soft water at 100 C.
- Filter the dye solution
- Record the optical density

ii ***Alkaline Method:***

- Prepare 1% alkaline solution with addition of 1 g. Socium carbonate/Sodium hydroxide in 100 ml. of water.
- Enter the dye material and boil at 100 C.
- Filter the dye solution
- Record the optical density

iii **Acidic Method**

- Prepare 1% of acidic solution by adding 1 ml. of HCL in 100 ml. of Soft water.
- Enter the dye material and boil at 100 C.
- Filter the dye solution
- Record the optical density

iii. **Alcoholic Method**

- Add 50 ml. of alcohol to 50 ml. of water
- Enter the dye material and boil
- Filter the dye solution

II **Extraction Technology**

The extraction can be carried out in aqueous, acid or alkaline medium. At present, in India mostly small scale producers/manufacturers are using

this method. Even the local dyers using more crude method for extraction using metallic flax and crude process in refined way using blender condenser, distillation plant and drier and crystallization unit with the capacity of 300 tonne per year.

The modern techniques of extraction are carried out with the use of extraction plant, reverse osmosis process and the latest is supercritical fluid extraction method. This method is very common in developed countries.

III **Solvent Extraction**

This technique was developed just before the dawn of twentieth century. Now it has been commercialized in recent years. This technology has been improved to reduce waste generation and eco-effectiveness of extraction methodology. Ultrasonic extraction followed by micro-wave extraction of solid finds extensive use mainly based on organic solvents extraction.

Super Critical Fluid Extraction is a further advancement making significant step over the use of conventional solvent extraction technology. It uses CO_2 as extraction media. It is non-hazardous and subject to minimum waste generation. This technique is used for the extraction of natural products in food, pharmaceuticals and chemical industries too.

Advantages of Supercritical CO_2 extraction technique:

- It makes it possible to work at moderate temperature without effecting the organoleptic qualities and the active ingredients of the extracts obtained.

- Moreover, it makes it possible to obtain 100% natural extracts, completely free from extraction solvent residues. At the end of extraction, an expansion phase (achieved by reducing pressure) causes the carbon dioxide to change from the supercritical state to the gaseous state, which enables it to be removed completely from the CO_2 extract obtained.

IV Microwave Assisted Extraction Technology

The Microwave Assisted Extraction Technology is a high-speed method used to selectively target compounds from various raw materials. The technology uses a microwave applicator as the energy source during solvent extraction leading to the following advantages:

- Faster processing
- Betten yield
- Improved quality
- Lower energy consumption
- Reduced solvent level
- Low capital investments

V Continuous Steam Distillation Process:

The Continuous Steam Distillation Process, as the name suggested is a separation process using steam as a media but instead of batch type, this process is continuous. The process consists of a totally insulated pneumatic conveying system using super heated steam as a carrier gas.

13 Mordanting

Mordents such as alum, chrome, copper sulphate, ferrous sulphate, cream of tartar, stannous chloride, tartaric acid are used as mordants. Three basic methods of mordanting are in vogue on yarns/fabrics. The use of

different mordants change the colour of same dyestuff. Thus different colour tones are possible due to mordanting with single mordant or combination of mordants.

i ***Premordanting*:**

In this method the yarn/fabric is mordanted in the first stage and then dyed in the second stage.

- Prepare an aqueous solution by dissolving required amount of suitable Mordant in water.
- Enter the yarn/fabric and boil for 30 to 45 minutes
- Dye the yarn/fabric in the prepared dyebath
- Wash, rinse and dry

ii ***Simultaneous Mordanting***

In this method the mordant and the dye are applied simultaneously in the same bath.

- Record the optical density of the extracted dye liquor. Dip the yarn/fabric in the extracted dye liquor and boil for 15 minutes.
- Add required amount of mordant to the extracted dye solution and stir well and boil for 30 to 45 minutes.
- Record the optical density of the dye liquor
- Wash, rinse and dry
- Boil the dyed material in the mordanting liquid for 30 to 40 days.

iii ***Post Maordanting*:**

In this method the fabric is first dyed and then mordanted.

- Prepare the dye soluttion and record the optical density
- Dye the yarn/fabric in the dye solution

- Record the optical density of the dye liquor after dyeing
- Prepare the aqueous solution by adding required amount of suitable mordant.
- Boil the dyed material in the mordanting liquor for 30 to 45 minutes.
- Wash, rinse and dry

14 Application Method of Vegetable Dyes in Textile Sector

i. ***Dyeing of Wool:***

The required amount of dye is added to the dyebath. Add sodium hydroxide to adjust the pH to 9, to dissolve the dye. Stir well to dissolve the dye. Add material to the dyebath and maintain at 80° C for 15 minutes, Add acetic acid to the dyebath to lower the pH to 4. Maintain the temperature at 80° C for 20 minutes.

Post Treatment:

Conduct soaping of the dyed material with non-ionic detergent (0.5gpl) at 60° C for 20 minutes. Hot wash and then cold wash the material.

ii ***Dyeing of Silk:***

Add the required amount of dye to the dyebath. Add sodium hydroxide to adjust the pH to 9, to dissolve the dye. Stir well to dissolve the dye. Add material to the dyebath and maintain at 80° C for 15 minutes. Add acetic acid to the dyebath to lower the pH to 5. Maintain the temperature at 80° C for 20 minutes.

Post Treatment:

Conduct soaping of the dyed material with non-ionic detergent (0.5gpl) at 60° C for 20 minutes. Hot wash, and then cold was the material.

iii *Dyeing of Cotton:*

Add the required amount of dye to the dyebath. Stir well to dissolve the dye. Add material to the dyebath and maintain at 80° C for 45 minutes.

Post Treatment:

Post treat the material with ferrous sulphate (1.0%) at room temperature with constant stirring. Conduct soaping of the dyed material with non-ionic detergent (0.5gpl) at 60° C for 20 minutes.

iv **Dyeing Synthetic Fibers with Natural Dyes**

It is possible to dye nylon polyester and acrylic fibre with selected natural dyes. Few dyes have high affinity for synthetic fibers and bright and deep shades can be obtained. The quinon based dyes exhibit exceptional fastness properties, though dyes based on other chromoforic group may not be so fast. Non-polar dyes such as lawsone and juglone exhibit a behaviour similar to that of dispersed dyes on polyster. Annatto being an acid dye, shows two different behaviours on different fibres. It behaves as a dispersed dye on polyster and as an acid on nylon. Berberine behaves as a typical cationic dye and shows high affinity for acrylic fiber. The process of dyes is endothermic in all cases.

15 Marketing Aspects

With the diversity in the use of vegetable dyes in various sectors, the future of such dyes is envisaged to be bright due to the following reasons:

- Most of the dyes are from natural source (vegetable, animal and minerals) that can be replenished, if planned properly.

- These dyes are eco-friendly
- These dyes are hygienic and human skin friendly
- The manufacturing and application of these dyes are subject to least environmental problems

In comparison to natural dyes, synthetic dyes are reported to cause skin and other disease. The manufacturing and its application on fiber are creating environmental pollution like water pollution, air pollution and the use of synthetic dye and its manufacturing is prone to health problems to users and workers involved in the industry.

The vegetable dyes can be used for coloration of the product in following industries:

- Textile industry (coloration of fabrics & yarn)
- Food industry (sweets, confectionery and bakery products)
- Leather industry (coloration of footwears/garments)
- Cosmetics industry (soap, creams, powders, locations, lipstics, etc.).

i ***Food Items:***

This is the sector where vegetable dyes can be consumed in appreciable amount. This sector can consume 10 to 20 tonnes of vegetable dyes in a year. Moreover, the consumption of vegetable dye in beverage sector can be upto 30 to 40 tonnes a year, provided sincere efforts are made.

ii ***Leather:***

Leather industry is already using vegetable tannin for tanning of leather sole. However, this use is confined to cottage and small-scale leather units. The large manufactures are using Chrome Tanning. At present, none of the leather units are using vegetable dyes for colouration of their

products. If sufficient and offensive efforts are done, the vegetable dye can capture in leather sector in a big way.

iii ***Textile:***

There is a big potential for use of vegetable dyes in textile industry. These dyes can be used for colouration of textile material at different stages such as on the yarn, on the fabric and even can be applied on the apparels.

16 Conclusion

Natural dyes are derived from plants, animals, insects and the minerals. A wide range of climatic zones and latitude in India has resulted in a rich bio-diversity and thus the many sources of natural dyes. As it is clear from the previous pages there are about 200 dye yielding plants found in India out of them 100 dye plants are found in Himalayan region. The most famous vegetable dyes are Madar, Indigo and Majitha. In the previous chapters, we have identified 28 dye-stuffs, which can be commercially exploited for the manufacture of vegetable dyes, which can be used for colouration in food, pharmaceuticals and cosmetics and in dyeing of cotton, silk and wool fabrics.

As we know the synthetic dyes are commonly in use for the dyeing of fabrics, but they are not eco-friendly and harmonious to human skin. Specially the dyes from Azo group, as many physicians say are injurious to skin and even lungs, resulting in slow allergic and skin diseases. Moreover, many countries specially European and American stopped using fabrics dyed with synthetic dyes. At present, we cannot export apparel, woolen and silk carpet dyed in synthetic dyes belonging to Azo group. From export point of view the woollen yarn and cotton fabric are required to be dyed in natural dyes or safe synthetic dyes, otherwise the country willl loose a substantial export market.

Some of merits of Natural Dyes are – they are obtained from renewable resources, free from health hazards, eco-friendly and pollution free, however, its availability is less because of very few organized manufacturers, non-standardization of raw material and manufacturing process and complexity of process involved in application of natural dyes. Though the synthetic fabric like nylon , acrylic, polyester can be dyed with vegetable dyes, the colour yield and the fastness properties are stile not upto the mark and requires more experimentation and research..

The use of natural dyes has increased gradually during the last couple of years. The main users are (i) hobby groups (ii) designers, (iii) traditional dyers & printers (iv) NGO's (v) museums (vi) academic institutes and research associations etc.

The consumption of synthetic dyes has been estimated at 1 million ton per year. As per report of German Ministry of Food Agriculture & Forestry, about 90000 tons of natural dyes can be produced every year. At present USA is one of the major importers of the natural dyes. The total imports of these dyes, which is about 3500 tons per year, works out to be 0.4% of synthetic dyes. The import of natural dyes of EU countries were 5300 tons per year, which is about 0.53% of synthetic dyes. From the above figures it is clear that the requirement of the natural dyes is about 10000 to 12000 tones, which is equivalent to 1% of the worlds' total dyes consumption. As it is said, most of the dyes possess poor light fastness, but is can be improved by choosing the post-treatment carefully. The post treatment with copper or chromium or combination of these salts is given to some dyes. The washing fastness of the natural dyes can be improved by post-treatment with Alum or by fixing agent.

If we analyse the facts related to the use of natural dyes, we can conclude as under:-

i One of the major imperatives to use the natural dyes is the knowledge gap. Most of the researches in this area are carried away by empirical information reported in literature without any scientific reasoning or basis.

ii Non-availability of natural dyes in standard form, which may be in powder and paste or solution form. This is due to the fact that the composition of natural large number of material (dye yielding plants) is unknown.

iii There is severe shortage of trained dyers. Most of the so-called textile chemists in the country are trained to use synthetic dyes. Even the teachers have very poor appreciation for this century old technology of dyeing. If we want to exploit vegetable dyes for generating revenue and employment, comprehensive training programmes have to be launched. More knowledge of vegetable dyes may be included in the syllabus of courses leading to degree/diploma.

iv There is a dearth of books on technology of dyeing with natural dyes.

v. Unnecessary advertisement and publicity being given to the natural dyes spearheaded by synthetic dye manufacturing companies.

vi We should keep in mind that natural dyes are not substitutes of synthetic dyes. They have their own market and not going to stay at the cost of synthetic dyes.

vii The dyes are manufactured from different part of the dye yielding plants using their parts such as leaves, flowers, bark, stem root, seed. The extraction of the dyes is done in the following manner:

- Reverse Osmosis Process
- Super-critical Extraction Method
- Microwave extraction method
- Solicitor extraction method
- By boiling in aqueous solution

The extraction of the dye-stuff from its source by boiling can be done in following ways:

- Aqueous method
- Alkaline method
- Acidic method
- Alcholoic method

The range of wave length in the spectrum for different colours observed in Laboratories are as under:-

COLOUR	**WAVE LENGTH**
Violet	400 to 430 NM
Blue	430 to 460 NM
Blue-green	460 to 500 NM
Green	500 to 570 NM
Yellow	570 to 590 NM
Orange	590 to 610 NM
Red	610 to 700 NM

viii. As already narrated in conclusion part there is potential of vegetable dyes in pharmaceutical as well as cosmetic industries where the value addition is much higher, some projects may be funded to carry out the research work in this field. Such projects should be jointly handled by academic institutions like IIT, State Agricultural University and the pharmaceutical and cosmetic industries. Some of the research institution, who have already done some work in these fields can undertake further advanced this work and Department of Chemical Technology, Bombay University and IIT Kanpur, Bombay and Delhi.

ix. First and foremost thing to promote the use of vegetable dyes in textile is to promote its superiority over synthetic dyes through arranging serious of campaigns and workshops to make the people aware about the advantages of natural dyes specially the advantages of vegetable dyes from health point of view. Unless and until the people are aware about this fact , they will not like to purchase vegetable dyed cloth for the higher price, as the synthetic dyed cloth is cheaper.

x. One research project may also be funded to find the possibility of making totally herbal based hair dye in different shades with the use of beri, babool, mehdi, catechu (Katha) etc.

xi The tribal belt ranging from Chhatisgarh to Orissa via Jharkhand is very forestry. Most of the tribal people are utilizing the plants for dyeing purposes. Though the methods are traditional taking long time in dyeing and extraction. The wastage of raw material is on higher side. These methods are crude and complicated innovative methods should be developed for extraction and dyeing and training and demonstration be

organized for the tribal and other local people engaged in vegetable dye extraction and its use.

xii. It has been reported that communities who were earlier engaged in vegetable dyeing, have now shifted to other professions. Their knowledge has not been documented anywhere effecting further research & development to generate commercial interest.

xiii. No efforts have been done on issues like intellectual property rights in particular to ensure that traditional and indigenous knowledge that dyers/weavers have is respected and protected. Its commercial use by others be allowed to be done with the consent of these people and with appropriate sharing of profits.

xiv. The diversity inherent in nature, which allows for a vast number of combinations & permutations of the mineral content of the local soils and local water with dye bearing and adjunctive plants, is the critical factor in the establishment and sustainability of natural dyeing practices with strong local and regional identities. One plant may be useful in one region and not in other. For example, the dye obtained from Bixa orellana when in South India, produces only a fleeting colour, but in Rajasthan, the colour is fast to light and washing. There are examples of plants producing different colours in different places.

xv It was found that training of artisan groups is carried out to greater extent in southern parts of country such as at Pasalpudi, Hyderabad with the sponsorship assistance of Council of Science & Technology, NHDC, UNDP, DRDA, etc. Training of resource persons is also found very limited.

xvi. Publication of booklets in English & local languages highlighting local resources, local dyeing process, etc., to help promote vegetable dyeing is missing, except in few parts of Andhra Pradesh.

xvii Indepth research in marketing and market opportunities in different kinds of vegetable dyed fabrics is missing.

xviii Links have been found missing between growers/collectors, users and customers.

xix. Backward & forward linkages to resource base (dye materials, water & fuel) and markets, new sources of dye materials, water & fuel may have to be found suited to contemporary circumstances.

xx Linkage between cluster of local practices, e.g., dye material collection, dyeing, weaving & other craft production is not in existence restricting the organized growth of vegetable dyeing of textiles.

xxi Indigo dyeing was the mainstay in earlier time when vegetable dyeing was at its top. It is expected that the same will be again the mainstay of natural dyeing, if the natural dyeing industry is to be survived. The other colours will be taking the secondary places because indigo dye particularly on cotton can be produced with a lesser energy and investment than any other colour. Because there is more dye content in the plant and also it is the only dye on cotton that does not need a mordant Indigo dyeing is also a cold process needing no fuel.

xxii There has been a remarkable reduction in yield of indigo, which is now reported to be around 10 kg an acre as against a much higher as reported to be in the early nineteenth century when natural indigo use was at boom.

xxiii There is vast potential of use of vegetable dyes in food industry, confectionery, edible oil and sweets.

17 Recommendations

The Vegetable Dyeing Industry was nearly vanished towards the middle of Nineteenth Century and since then it is practiced in few pockets in selected states of the country. There are reported to be about 6500 artisans (which includes mostly tribal people and village artisans) who are

practicing this trade. This was reported to be as high as 3,00,000 artisans in middle of nineteenth century. Most of the artisans have left this traditional work because of non-availability of sufficient work and uneconomical financial returns. It is actually the NGO's who have tried to revive this trade in the last over 20 years and trying to develop this skill through organizing trainings, seminars, workshops and also providing guidance to such tribal people with the assistance of international agencies like United Nations. Positive impact has been reported in the already practicing artisans during the survey to UPICO's team. It is also reported that the international demand of vegetable dyed textiles including carpets is on the rise because of ban on use of synthetic dyes particularly belonging to Azogroup. We cannot expect the total switch over to vegetable dyes from synthetic dyes, however the beginning can be made by replacing atleast 2-3% of the synthetic dyed textile particularly from the export point of view. Based on the finding in the report, following recommendations are made:

i Organized scientific research is suggested to assess the availability and suitability of forest resources without affecting ecological balance for utilization of the same for production of dye materials.

ii Organized research is also suggested particularly on local availability of the raw materials e.g. forest and agricultural resource from the point of view of dye content and its colour fastness etc. as the local soil conditions gives different dyeing content fastness in the same dye plant in different places. Hence a particular dye plant is more suitably grown in a particular region for best results.

iii The availability of standard dyers is limited, as there are only eight manufacturers in the country. More manufacturing units should be encouraged as per important project profiles given in this report.

iv Most of the dyers and dye manufacturers are the tribal and village people who are practicing vegetable dyeing since many generations. These people are extracting dyes using old traditional methods. Efforts should be made to collect the information on the extraction and application through detailed survey investigation and to document the same authentically so that further research work could be carried out based on the information available from these people.

v The use of standard dyes both in the form of paste and powder manufactured by the leading companies in our country should be promoted through training and education to enable artisans to produce more qualitative and standard textiles in the vegetable dyed form. For this, training programmes should be designed of different duration in consultation with the practicing artisans, local NGOs and the research institutions.

vi To promote the production of vegetable dyed cloth, it is proposed that more young persons be trained as dyers. For this an Action Plan may be prepared for training and guidance for atleast 5-10 thousand artisans per year for a period of 5 years. The training duration may vary from one month to 3 months. Concerning departments may be suggested make suitable budgetary provisions under the rural employment oriented schemes to encourage employment through production of vegetable dyes.

vii Certificate & Diploma courses may also be planned in the govt. textile institutions for a duration of 1-3 years particularly on the subject of vegetable dyeing.

viii The vegetable dyes have tremendous scope and value addition particularly for use in food production, pharmaceutical and cosmetic Industry. Research for development of vegetable dyes for the aforesaid fields should be undertaken by appropriate authorities such as IIT, Department of Chemical Technology, Bombay and institutions who have already done work in the past in this field.

ix Public awareness may be generated through advertisement, holding of workshops, seminars etc with regard to benefits of using vegetable dyed cloth in comparison to synthetic dyed cloth. As we are aware that the vegetable dyed cloth is about 5% costlier than the synthetic dyed cloth if benefits are publicised the middle and upper class people may like to partially use vegetable dyed cloths alongwith synthetic dyed cloth thereby resulting in increased demand.

x, The hair dye has huge demand all over the world. It is suggested that a research project may be funded to undertake research for the development of suitable vegetable dye having similar properties as the chemical dye.

xi. It is further suggested that the department connected with the intellectual property rights may prepare guidelines to protect the process and the materials being used by tribal people for vegetable dyeing so that its commercial use is promoted under the intellectual property rights thereby helping the people having knowledge with appropriate sharing of profits.

xii To promote the local resources and its use for manufacture of dyes it is suggested to take up publication of books and literature by the concerned departments both in English and regional language so as to facilitate the use of the local resources for the manufacture of different varieties of vegetable dyes.

xiii The forward and backward linkages to resource base and market are one of the important aspects of promotion of this industry. It is suggested that organized farming of the vegetable dyes plants be encouraged as is being done in the other countries particularly Austria. For this a study needs to be carried out by the concerned department to understand the steps required to promote organized cultivation of such plants to have the uniform quality of vegetable dyes. It is also suggested that the department connected with international market research should carry out regular research on the market opportunity, type of demand and the same should be circulated to the manufacturers and dyers so that the production is planned as per the variation of demands in the international markets.

xiv As known, indigo dyeing is the main stay in vegetable dyes. Its cultivation has to be specifically planned and organized. The yield of indigo is around 10 Kg/hectare. This is reported to higher in earlier years. The agricultural developments universities and research institutions may suitably consider undertaking research so that the yield is increased to around 25 Kg/acre thereby making this activity more viable.

xv Dye manufacturing unit : 10 to 15 units are recommended to be set up for the manufacturing of vegetable dyes with the capacity of 1 tonne per day each. Two-three units must be set up to manufacture the dye –stuff by using most sophisticated advance technology-Super Critical Extraction

Method, as this process is used in extraction of the annatto, a food natural dye. This unit will cost about Rs 10 to 12 crores. It is also recommended that small scale industries using simple Boiling Extraction Process may be set up with the production capacity of 10 to 20 kgs of dye-stuff per day, which will meet the requirement of the cotton dyers & printers. Such unit will also cost Rs. 10 to Rs. 15 lacs per unit.

xvi To develop this industry, the dyeing units may also be set up, which will use vegetable dyes to dye cotton fabrics at commercial level. At present in India there are only few dyeing industries, which are using vegetable dyes in organized sector. Until and unless the process houses for vegetable dyes are set up, there will not be limited growth in the vegetable dye scenario. In addition to this , existing process houses may also be encouraged to use natural dyes in place of synthetic dyes.

xvii Few units should also be promoted, which will manufacture vegetable dyes from the plant source and a part of it will be consumed by themselves in-house and rest will be sold to the other consumers. There is only one such unit in Northern India, which is doing this job. This unit will encourage other units to use vegetable dyes for dyeing and printing purpose.

xviii As it is clear from the narration appearing in preceding pages that there is an acute shortage of the skilled workers suitable for natural dye based process houses. The art of dyeing with vegetable dyes in known only to some old artisans and is not common . There is need to train the youths for carrying out dyeing of the fabric with natural dyes. It is recommended that some training centers may be set up at least 4-5 in number in each

State, specially at the places where the potential of use of vegetable dyes in already existing. The names of the places recommended for establishing training centers are:-

UTTAR PRADESH	**Bhadohi, Agra & Varanasi**
UTTARANCHAL	**Haldwani , Dehradun, Srinagar, Pauri, Almora & Ranikhet**
PUNJAB	**Ludhiana & Amritsar**
HARYANA	**Hissar & Panipat**
RAJASTHAN	**Jaipur, Bikaner, Amjer, Jodhpur& Jaisalmer**
GUJARAT	**Ahmedabad, Katak, Rajkot & Surat**
MAHARASHTRA	**Bombay, Nagpur, Pune, Sholapur & Auranagabad**
ANDHRA PRADESH	**Kanchipuram, Warangal, Trichu, Mysore, Coimbature & Madurai**
KERALA	**Trivendram , Cochin & Calicut**
BIHAR	**Patna & Bhagalpur**
WEST BANGAL	**Calcutta, Murshidabad & Bardman**
ASSAM	**Guwahati, Agartala & Shillong**
J & K	**Srinagar & Jammu**
ORISSA	**Bhuwneshwar, Cuttack & Kalahandi**
MADRAS	**Salem, Coimbatore & Madurai**

xix A research project for exploring lac for manufacturing of natural dyes should be commissioned to Bihar Agricultural University, Patna/Indian Lac Research Institute, Ranchi. The nature of project should be one agronomical and also one for technological nature.

xx. Technological institutes which undertaking the academic programme (UG & PG) should also be sanctioned financial assistance for promotion of vegetable dyes. They should be asked to study how research work already done in research labs, can be exploited commercially in textile industry. They should also be advised to incorporate technological and chemical aspects of vegetable dyes in their curriculum so that there may not be shortage of chemists and technicians for this industry in future. The course for degree student should be as under:-

"Plant, source of colouring matter its availability, extraction methods- Aqueous, Alkaline, Acidic, Alchoholic, Super critical Solvent Extraction , Continuous Steam Distillation, sonicator assisted extraction. Microwave Assisted Extraction, Chemical Composition of Natural Dyes with Chemicals Structures & Colour Index.

xxi. It is also recommended that Bureau of Indian Standard may undertake work of preparing standards for vegetable dyes.