CHAPTER - 2

REVIEW OF LITERATURE
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A literature review is usually a highly synthesized critique of the status of knowledge on a carefully defined topic. A review of related research serves important purposes and helps the researcher at every step of her venture, as a researcher can build appropriate methodology and design keeping in view the strengths and failure of previous researches. A review of literature yields useful hints for further research, which may prove beneficial to the future researchers.

Although Research, Development and Design activity in the field of Natural dyes is leading to substantial progress and development; since last few years, due to the occurrence of the global trend to go back to nature and patronize natural products. The dire need is felt to revive the rich heritage of Ancient art and keep it alive.

Prior to, and during the research, the researcher visited to Libraries of Amravati University, GVISH, Amravati, Vidya Bharti Mahavidyalaya., Amravati, ATIRA., Ahmedabad, Nirmala Niketan, Mumbai, Dr. P.D.K.V., Akola, and the information yielded from the 'World Wide Web' was also reviewed.

This chapter reviews in detail the progress and efforts made by the stakeholders i.e. scientists, technologists, students, weavers, dyers, entrepreneurs, designers, manufacturers and distributors of natural dyes and expectedly some meaningful hints had emerged out.

Studies are categorized and reviewed under different section and the common link among them has been identified and summarized.

2.1 Environment and Health awareness

2.2 Dye Yielding Plants and Dye Sources.

2.3 Extraction and Application Methods.

2.4 Mordants, Mordanting methods and Fastness properties.

2.5 Printing

DYEING AND PRINTING OF COTTON AND SILK WITH SELECTED NATURAL DYES
2.1 Environment and Health Awareness

Literature available on environmental issues and health hazards caused due to the use of synthetic dyes, chemicals and auxiliaries in the processing of textiles, dyeing and printing have been discussed in the present section.

Shakuntala Ramani (1989) highlights the relevance of Natural dyes in the present day context. According to her, the true understanding of the nature of natural dyes craft is necessary for the formulation of any programme for its revival. She further stated that the helter-skelter growth of technology in all walks of life has brought in its wake attendant ills of hazardous wastes and atmospheric pollution. There is a movement the world over to return to nature and protect the environment from indiscriminate exploitation and pollution by industries. Higher energy costs and strict environmental controls are already beginning to affect the manufacture of organic chemicals particularly dyes and pigments, which are closely linked to human exposure. The harmful and sometimes poisonous substances used in the colouring of toys, textiles, food and other articles meant for human consumption are now coming under strict scrutiny and rightly thinking people are advocating a return to the use of vegetable dyes. Many of the natural dyes are derived from medicinal herbs with proven value for human health.

Sewekow (1988) overview that recent ecological concerns and pollution standards have focused on the textile dyeing industry, which have brought some attention upon the use of natural dyes as an alternative to modern chemical dyes.

Smith and Wagners (1991) have compared the environmental attributes of synthetic and natural dyes.

A short history of synthetic dye production has presented. Production processes and application characteristics of synthetic and natural dyes have discussed. It is unlikely that the present demand for dyes could be met by natural dyes alone; but the need for improvement in application technology is emphasized to achieve the necessary substantivity levels.
Most of the dyes based on benzidine rings are toxic and pose health hazards to humans. India is eliminating the use of some toxic dyestuffs. It is being asked to supply cotton dyed with natural dyes such as indigo. Natural dyes can achieve satisfactory shades of yellow, dark blue, and navy blue among the colours. Some dyes such as indigo and madder red currently are in big demand. German manufacturers are demanding indigo dyed fabrics (Venugopal 1993).

Agrawal et al., (1993) has reported that, recently many companies have been exploring the commercial potential of natural dye sources. Such dyes are considered desirable because of their natural glow and variability, and because they do not create the pollution problems that arise during the manufacture of synthetic dyes. Kaul (1994) believes that the ability to produce environmentally safe dyes will influence the future success of the Indian dye production industry. He has also reported that the Indian government, recognizing this fact, recently organized a workshop on natural dyes. Leading Indian dye manufacturers, foreign exporters, and research and development organization attended the meeting. In an effort to revive the natural dye production industry the workshop encouraged the development of appropriate production technology.

Anonymous (1993) emphasized that continued pressure on synthetic dye manufacturers will lead to the development of less polluting chemicals and application processes, an environmentally responsible and realistic goal and it is believed that even though it is impossible to eliminate completely the use of synthetic dyes, enough natural dyes should be produced to satisfy current or future demand.

On the contrary to above, colourant manufacturers dispute the claim that natural dyes are more environmentally friendly than synthetic dyes. Similarly natural and synthetic colourants have been compared where toxic and/or carcinogenic effects of several natural substances used as natural colourants were found to be as environmentally detrimental as common synthetic chemicals used as colourants. It has also been said that a high percentage of agricultural land would be needed to produce sufficient vegetable dyes for cotton and would exacerbate the waste effluent burden.
The widespread adoption of natural products would necessarily result in a major shift in land usage throughout the world (Glover and Pierce 1993).

Although natural dyes are derived from nature but the metallic mordants used for improving, fastness and better fixation of textiles, are not always eco-friendly (Dalby, Gill 1993).

Another review discusses the use of dyes to colour textile materials and the subsequent process waste generated, problems encountered in the industry, including the use of natural dyes. It has been said that, the majority of natural dyes are mordant dyes, requiring application with metal salt to assist in fixation. Use of heavy metals will increase toxic waste generation and further complicate waste effluent treatment. Recent German regulations have banned the certain consumer goods containing azo dyes, due to their carcinogenicity. Although this, regulation has an international impact (Burdett 1995).

Glover (1995), compared the feasibility of natural dyes with that of synthetic dyes. Plants are the common source of natural dyes. These colourants have several disadvantages including higher costs, the required use of metal containing mordants, poor colourfastness, and poor reproducibility. Furthermore, little research has been conducted to ascertain the toxicity of natural dyes. These problems prevent natural dyes from being a viable alternative to synthetic products. The dyeing industry can reduce the environmental impact of synthetic dyeing processes by continuing its present efforts to minimize waste and improve the environmental compatibility of the dyes.

To overcome the problems regarding toxicity, the chairman of BTRA has discussed the strategies to meet increasingly stringent environmental regulations. BTRA offers the infrastructure necessary to implement test methods that standardize the estimation of red listed chemicals at the mill level. BTRA is working to standardize dyeing methods with natural dyes and has developed effective substitutes for citric and acetic acids and is applying biotechnology to wet processing methods (Anonymous 1995). With relevance to the strategy, the study has conducted by Niyati.
Bhattacharyya et al., (1995) from BTRA. In their study the eco friendliness of natural dyes and textiles, detection of heavy metals and analysis of pesticides in Natural dyes, and banned amines on Natural dyes was carried out and concluded that Natural dyes are safe and eco-friendly whenever the dyeing is carried out as per eco-standard specifications.

The application of non-toxic natural dyes and food colours on textile fibres avoids many of the problems associated with the use of more hazardous dye materials. Application of food dyes to various natural and synthetic fibres improved the fastness properties. Compounds used in food colouring offer a safe route for dyeing materials (Naik et al., 1996).

According to (Hill 1997), Natural dyes are becoming more important to the textile industry due to consumer interest, but production is currently on a relatively small scale. Dyes that were used 100 years ago are more difficult to find now because the natural resource from which they are derived have been reduced. Many dye sources could be developed for commercial production using modern agriculture. Modern dye houses using manmade dye could be converted to natural dye processes. Techniques using natural dyes are available in countries such as India. Human and environmental toxicity of natural dyes is lower than that of manmade dyes, with the exception of some mordant dyeing techniques using heavy metals. Recent research into natural dyes suggests a number of innovations of conventional dyeing techniques, such as microbial indigo production. Many natural dyes are comparable in quality with manmade dyes. International quality standards can be written to guide the growing natural dye industry. Natural dyes can be economically viable. Where as Chan, et al., (1997) said that, Natural dyes have the potential to replace some carcinogenic dyes.

The annual meeting of the International Textile and Apparel Association, Anonymous (1998), discussed upon safety, health and environmental issues in the textile industry, which highlighted the biodegradability of bagasse geotextiles, safety of amateur dyeing and decided to make the product durable. Safety, health, and the environment must be addressed individually for each product. However, increased
environmental awareness has sparked a renewed interest in natural dyes (Tusek and Golob 1998).

An account on Natural dyestuff as an ecological alternative, (Anonymous 1998) has reported that, unlike natural dyes, manmade dyes rely on energy rich raw materials that are imported and non-renewable. Their synthesis burdens manufacturers and dyeing plants with high water consumption and contaminated effluent. Moreover, consumer complaints concerning allergic effects are increasing. The use of ecological alternative to dyeing processes initially based on manmade dyes will require larger crops of dye producing plants, elimination of metalliferrous mordant used to improve fastness values, lower production costs, and further research into allergic and toxicological properties. After more than hundred years of manmade dye research and development, a growing number of ecologically conscious customers are rediscovering the advantage of natural dyes. Their advantages include lower water and raw material consumption the later of which also reduces import dependency. In addition they are biodegradable and less prone to cause allergic reaction (Muller 1998).

Researchers have also investigated whether-how to manuals adequately warned amateur dyers of the potential risk of contact with chemicals commonly used in natural dyeing. In a survey of more than 350 books and articles available through the local public library, only two issued any warning to pregnant women or women of child bearing age reported (Chmuhailek 1998).

Natural dyes that overcome known disadvantages have application in industry. The most likely use for most natural dyes will be in novelty and niche market (Glover 1998).

To write an account on Environmental pollution and health Ramakrishna (1999), emphasized that Germany, the Netherlands, and Sweden have banned imports of textile products made using any of 20 different carcinogenic amines found in azo dyes. Demand has increased in Germany for fashion apparel, which are environmentally friendly. The Indian government has encouraged smaller dyeing and
finishing plants (those generating up to 50,000 litres of effluent per day) that do not operate their own effluent treatment plants to maintain and operate effluent treatment plants jointly by providing subsidies up to Rs.50 lakhs and low interest louds for plant construction.

Environmental concerns have also increased interest in natural dyes derived from roots, stem, bark, leaves, berries, and flowers. Ramkrishna (1999) has further reported that the United States and the European Union also banned carcinogens frequently found in manmade dye formulations. This sparked a demand for natural dyes to replace the banned dyes. It has been also pointed out that some companies achieved commercial production of cotton yarns dyed with natural indigo and other natural dyes that meet international standards of colourfastness.

Allegro is one of the major natural dyes manufacturing company. Sally Gurley started the company four years back to make natural dyes commercially viable alternative to synthetic dyes. Some of the issues that have been considered in making this reality are; the growing of the raw materials, development of dyeing technology to meet industrial standards, the transfer of technology to major textile mills. The waste material generated in the extraction process is used by the city of Longmont’s waste recycling project as carbon augment to produce compost. Alps Industries is another major natural dye producing company. The company has a production capacity of around 300 tons per year. Apart from these companies there are a large number of other producers of natural dyes. Many of them produce only single dyes such as indigo, lac, cochineal, catch etc. The present day requirements of natural dyes are about 10,000 tons, which is equivalent to 1% of the worlds synthetic dye consumption, reported (Gulrajani 1999).

Over to natural dyes as an eco solution; little information exists on the toxicological properties of natural dyes. This will likely to change with the advent of more stringent testing and eco-labelling regulations described Doriaswamy and Janakiraman (1999).

It has also been reported by Khodparast (2000) that, In Asia little systematic research exist on the toxicity of natural dyes. A central Asian textile research institute,
actively supported by the industry, could coordinate investigations in a variety of textile fields. It could define research needs, devise solution and facilitate cooperation among different Asian textile institutes. The advantages of a central Asian research institute include the protection of health and the environment, access to specialized knowledge, development of specialized equipment, and decrease in research and development costs.

To focus on environment–friendly natural dyes, Anonymos (2000) reported that some natural dyes offer health benefits, not all natural dyes can be considered harmless. Many mordants, such as those containing salts of tin and chrome, are toxic. Whereas Vandana Tiwari and Padma Vankar (2001) opined that natural dyes are considered eco friendly provided metallic salts used are the safer ones and not copper or chromium. Where Bhawana Ghorpade et al., (2000), considered Alum, Ferrous sulphate, stannous chloride and stannic chloride as an eco friendly mordants. Padma Vankar et al., (2001) performed a series of experiments to test the eco friendliness of dyes and dyed fabrics. They tested the extracts for the presence of heavy metal by inductively coupled Plasma spectrometer, pesticides with extraction, clean up and detection by GC/ECD.

In one of their study on microwave and sonicator dyeing of cotton fabric with a mixture of natural dyes using metallic mordant and bio-mordants, it was found that concentrations of heavy metal content in the extracted dyes were much below the stipulated units. The extract had presence of Zn and Hg less than 0.005%. This is because use of red listed heavy metal based mordants has been avoided. Thus the dyeing process is eco friendly.

The contamination of chlorine-based pesticides is also likely to occur during growing of the plants from soil or from preservatives during storage. The results of the analysis of extracted dyes on GC/ECD showed either absence of these contaminants or present in negligible amounts. Hence commercialisation of natural dyes can be done successfully.
Nair (2002) in his introductory speech on ‘Handlooms-exports beyond 2004’ stated that one of the strategies of handloom sector is of prime endeavour to produce as dictated by the market, cost effectiveness, high quality, adherence to delivery schedule, eco labelling, environment friendly products and production methods. Social label and ethical code are the factors that are going to guide future market.

Thus over said finding and views of the various people working in the field of textiles, research and development propose that careful judicious selection and optimum handling of inputs like chemicals, auxiliary and metal mordants which involved in dyeing with natural dyes must be a prime objective of the researcher for present times. One must follow a slogan. ‘Do not use if it is not required and if required, use only optimum quantities’. All these aim at protection of environment and consumer guarantee of safety.

2.2 Dye Yielding Plants and Dye Sources

Various sources of natural dyes used in the past researches were reviewed and presented in this section.

Saxena (1989) stated that there is a long time tradition of using natural plant based dyes in India. He reviewed the published botanical data and presented a natural order (family) wise list indicating the updated Latin names, the parts of the plant used and colour achieved. The catalogue of 136 dye bearing plants of India belonging to 61 families has been presented. The author highlights that the Rubiaccae, Anacardiaccae, Euphorbiaccae and Papilionacae are rich in dyes and more intensive work is required in these families to find new dye bearing species. The author also emphasizes the need for detailed survey of regional flora and updating the nomenclature to eliminate confusion and duplication. Finally the creation of herbaria of all the known dye bearing plants is recommended.

Another important suggestion has been made for future work in this area is that the present day distribution of these plants in India is mapped and studied ecologically with a view to put a better use of the naturally occurring plant wealth.
without damage to environment. The possibility of growing selected dye-yielding plants as commercial crops in favourable habitats are investigated.

There are so many varieties of Indigo yielding plants in India. The plant such as *Indigofera sumatrana* is called Bengal Indigo. *Indigofera tinctoria* is Madras Indigo or True Indigo. *Indigofera arreeta* is Jawa or Metal Indigo. Two other main plants species of this country for blue colour dye are *Wrightia tinctoria* is locally called pala Indigo.

Chandramouli (1989) has reported that, it is available in Madhya Pradesh, Rajasthan, Karnataka, Andhra Pradesh and Tamil Nadu. But it is used as a dye particularly in Salem district of Tamil Nadu and Seekakulam of Andhra Pradesh. It gives a very deep blue and black colour on cotton. The dried leaves are used for the preparation of dye. The green leaves give very negligible colour. *Strobilanthes flaccidifolius* is the other dye yielding plant of NEFA areas and is locally called Rampat, Mosak and Kom. It grows wild and is also cultivated.

Vednere (1990) reported a dyeing process developed for two natural dyes extracted from the leaves of teak and the bark of chir.

Kamat et al., (1990) stated that Indigo and related compounds are the most important group of natural dyes.

Verheeken (1990) believes that Dyeing with Kermes is still alive!

Frigerio(1992) stated that the textile industry renewed interest in natural dyes stems from increased consumer demand for natural and eco-friendly products.

Knaggs (1992) mentioned that the natural dyes come from insects, mollusks, the leaves and roots of plants, pollens, berries, and minerals. Tyre on the Phoenician coast became a centre of dye making and trading. Although many dyes were obtained from nature, only about 24 became important commercially. The most important dyes were cochineal, tyrian purple, madder, indigo, saffron, safflower, woad, and logwood.

Goel et al., (1993) mentioned the dyeing of merino wool with dyes extracted from Shyama roots.
Dapoola (1994) extracted the dye from Ginger rhizome (Zingiber oficinale).

Verma et al., (1995) pointed out that Wattle bark, which is commonly used for tanning leather, can also be used for dyeing woollen fabrics.

Goodwin (1995) mentioned some common plants containing dyes include woad, weld, madder, and golden rod and some substantive natural dyes derived from walnuts, bilberries, lichens, shellfish and fungi, which are fast by themselves.

Batha (1996) reported that Thomas Clarkson and Thomas Wardle, Morris attempted to produce acceptable versions of the four colours he thought essential to dye textiles: blue from indigo and woad; red from kermes, cochineal, and madder; yellow from weld; and brown from the husks of nuts.

Singh, et al., (1996) attempted to standardize the process for dyeing silk fabrics with a natural dye derived from the leaves of Setcreasea pollida plant the study showed that fresh leaves could be used to produce a wide range of colours.

Katti et al., (1996) examined the effects of natural dyes, including leaves, Manjista roots, and French marigold flowers, on crepe de chine white silk fabric.

Hofenk de Graff (1996) reported that before 1585, the textile industry in Leiden used madder and Brazil wood to dye fabrics red. Woad was used to dye fabrics blue. Weld was used to dye fabrics yellow. Kermes was either unknown or not used as a dye. Kermes was commonly used as a dye throughout the rest of Europe, but was replaced by cochineal from Mexico in 1550. Refugees from southern Netherlands probably introduced cochineal to Leiden after 1585. Indigo was used increasingly to dye fabrics blue in 17th century, black was obtained by using madder on fabric that had been dyed dark blue by woad, yielding a purplish black. Later, dyers used galls with iron sulphate on a blue ground to achieve a dark black. Numerous combinations of dyes on processes for dyeing yarns, stockings, and Linen are described. Cassia fistula flowers yield a dull yellow colour on cotton and silk (Prabhu and Senthilkumar 1997).
Mounter (1997) stated that different types of fungi can be used to create natural dyes and can successfully be applied with the use of mordants.

Kalyani and Jacob (1998) tapped the dye from Gulmohr (*Delonix regia*), commonly known flamboyant, peacock flower, or shimasankesula. Researcher investigated the dye from red gulmohr flowers.

Venkidusamy and Ramasamy (1998) derived a natural dye solution from fresh and dried shoe flowers from the Karaikudi region. Researchers dyed bleached, plain weave with mulberry silk.

Pant (1999) performed a series of experiments evaluated the dyeing of woollen yarns with natural dyes from oak bark, African marigold flowers and Kethula flowers. The dyes produced a wide range of soft, lustrous, pastel, and bright colours.

Radhika and Mary Jacob (1999) conducted the study of dyeing silk fabrics with dye extracted from Jatropha seeds (*Jatropha curcas*) belong to the family Euphorbiaceae.

Geeta Mahale et al., (1999) carried out an experiment of dyed silk yarns with arecanut extract which are flavonols consisting of polyphenols, fats, polysaccharides, fibres, and proteins.

Katyayini and Mary (1999) derived dyes from *Hibiscus sabdariffa*. (Commonly called mesta), dyed plain weave cotton fabrics.


El-zawahry (1999) extracted *Terminalia bellerica* fruits under different conditions to dye woollen fabrics.

Bhattacharya and Shah (1999) used natural dyes derived from teakleaves (*Thea sinensis*) and poi fruit (*Basella rubra*) to dye woollen fabrics.

Bisht and Goel (1999) reported a study dyed Bhimal fibres using kilmora root dye.
Victoria Vijaykumar and Ratna Krishnakumar (1999) reported two common weeds *Eupatorium odoratum* and *Ageratum conyzoides* found in High ranges of Munar, Kerala used by them as a dye yielding.


Preeti Pardeshi, et al., (2001) have undertaken a study to standardize production of water soluble marigold dye and comes to the conclusion that the marigold petals bear yellow colouring compounds, which can be extracted in aqueous medium, dried into a powder form and applied on textile substrates.

Namrita Kola (2001) made an attempt to dye and print cotton, silk and polyester with onion peels to produced yellow, orange and brown colours.

Shardadevi, et al., (2001) believed that peptaphorum bark is a rich source of fast natural dye suitable for silk and cotton to impart brown colour.

Shivkumar, et al., (2001) experimented with the new source of Natural dye from the flowers of *Helichrysum bracteatum* and reported that it may contain good quantity of flavonoids and will serve as a good natural dye. The plant species can be self-propagated.

Inderpal Rai and Deepti Sharma (2001) reported that the Bordi (*Zizyphus numularia*) could be used as a dye source. Natural and vegetable dye material cultivation; collection processing and dye extraction can be developed as agro based rural industry.

Sharda Devi et al., (2001) recommended *Bombax malabaricum* as a dye on silk fabrics.
Canna plants feature brightly coloured flowers with a large surface area and self-propagate, rendering them a potential source of natural dyes reported (Bhavana Ghorpade, et al., 2000).

Vandana Tiwari, et al., (2000) extracted dye from red *Impatiens balsamina* flowers to dye cotton fabrics. Another study by Vandana Tiwari; et al., (2000) concluded that Bougainvillea shows a full gamut of colours from dark magenta in acidic medium to yellow in basic medium, basic extract gives mehendi green with alum. Since the flowers grow in abundance, it can be potentially a good source of natural colourant for cotton fabrics. Tulsi leaves were also used by Vandana Tiwari et al., (2000) to extract dye and dyed cotton fabrics. Al root bark has also used by Vandana Tiwari, et al., (2001) to dye hosiery material and cotton fabric by sonicator. *Alkana tinctoria* (alkanet) belongs to family Borginaceae. The plant also called *Anchusa tinctoria*. The colouring matter in alkanet root is anchusin, a napthaquinone derivative containing three hydroxy groups, two of which are phenolic. As alkanet is a napthaquinone based dye theoretically it is expected to behave as a disperse dye. The dye pigment is insoluble in water but has been used to dye wool, silk and cotton by Vandana Tiwari and Padma Vankar (2001). Padma Vankar et al., (2001) reported that *Cassia fistula* bark which is scrapped off, is a plant waste and can be exploited as a good source of natural dye for cotton dyeing.

Another Bark i.e. Eucalyptus bark, which is shredded off and is a plant waste, can be exploited as a good source of natural dye for cotton. Padma Vankar et al., (2001) have also extracted a dye from *Cosmos sulphureus* for the dyeing of cotton fabric.

Aster and Chrysanthemum flowers for dyeing of cotton were utilized by Sujata Saxena, et al., (2002). Another study in dyeing of Pineapple fibres with natural vegetable dyes such as Manjistha and Katha was carried out (Burde and Tavawalla 2002).
Geeta Mahale et al., (2003) has extracted a dye from the leaves of *Acalypha Wilkesiana* to dye silk skins. Wool yarn has been dyed with natural colourant extracted from the bark of neem (*Azadirachta indica*) (Mathur et al., 2003).

A look at the literature available highlights that in India, natural dyes have been used by the primitive people in large number. Comparatively smaller numbers of dyes are known now. But the revival of use of natural dyes inspite of few drawbacks is growing at a faster rate.

A number of studies have been reported since 1989, regarding the natural dyes along with botanical data with family, the parts of the plants used and colour achieved. Most of the studies point out that cochineal, tyrian purple, madder, indigo woad, weld, mangistha, kermes, walnut, logwood, fungi, lichens, katha are the most prominent natural dyes to produce red, yellow, blue, black, brown and purple colours. These dyes along with their peculiar colours have been extensively studied for their extraction, purification application and performance. These dyes are still in practice. To overcome the major drawback of reproducing shades and in the direction of innovations and value addition research is going on.

Among the fore stated dyes the use of tyrian purple has been eliminated, may be due to the non-availability of the shellfish. It is imperative to suggest here that new dye sources should be tapped to produce a purple colour, because purples and blues are rare by themselves in natural dyes.

Attempts also have been made to use different dye sources in the recent years. Padma Vankar and co-workers have performed the series of experiments on newer dye sources at IIT, Kanpur.

### 2.3 Extraction and Application Methods

The review of the past researches in accordance with the extraction and application methods has been presented in this section.

Verma and Gupta (1995) extracted the dye from wattle bark, which comprises 15 to 20 percent of the barks dry weight. Tests of wattle bark dyes on 36 woollen
fabric samples investigated the influence of copper, alum, iron and chrome mordants for dyeing at 100 degrees centigrade for 1 hour at pH 6.5.

Singth et al., (1996) attempted to standardize the process for dyeing silk fabrics with a natural dye derived from the *Sectreasea pallida* plant. Tests indicated that 100gms of fresh Nargis leaves in 100 millilitres of water with 60 minutes of extraction time and 30 minutes of dyeing time achieved the best result.

Researchers have also investigated the use of natural Kamala dye for the dyeing of silk. The experimental dye derived from a fine powder obtained from dried kamala fruits and verified that ideal dyeing conditions included the use of 1gm of dye to 100 millilitres of water, the use of 300 milligrams of sodium bicarbonate for extraction, a 60 minute extraction period, and 30 minutes of dyeing time Sing et al., (1996).

Prabhu and Senthikumar (1997) crushed *Cassia fistula* flowers, dissolved them in distilled water, and allowed the solution to stand for a day. The dye extracts were compared for wash fastness and light fastness. The natural dye yielded a dull yellow colour for both cotton and silk and achieved good light fastness and fair wash fastness.

Venkiduswamy and Arunkumar (1997) boiled the shoe flowers in water for 20-30 minutes, filtered the mixture using a nylon fabric, dried and ground the filtrate into fine powder, mixed the powder with hot water, boiled the mixture for 30 minutes, and cooled the mixture before dyeing.

Kalyani and Mary (1998) investigated the use of gulmohr dyes extracted from red flowers. Aqueous and alkaline methods of extraction were the best. Optimal concentration for dyeing was 3gms of gulmohr flower in 100 millilitres of water.

Another study by Katyayini and Mary (1999) extracted a dye directly from mesta calyx and it was found to be optimum as compared to the powdered form of dye extraction such as aqueous, alkaline, acid and alcohol. Aqueous method was found to be the best method. The optimum concentration for dyeing with mesta calyx were 3 grams of mesta calyx in 100ml of water per one gram of sample which gave...
best results. The optimum time for dye extraction and dyeing was found to be 60 minutes, and 30 minutes of time was considered optimum for mordanting the samples.

Kumar and Bharti (1998) experimented to dye cotton fabrics with Eucalyptus hybrid bark, at a liquor ratio of 1:40, gradually raising the temperature of the dye bath to 100 degrees centigrade. Aqueous extract of the bark yielded bright brown dye and provided the widest range of shades.

Radhika D. and Mary Jacobs (1999) investigated the dyeing of silk fabrics with dye extracted from *Jatropha curcas* (seeds) with acidic methods as optimum. Where as alkaline method of extraction produced the maximum amount of dye from *Jatropha* seeds to dye plain weave cotton fabrics.

Extraction of *Terminalia bellerica* fruits under different conditions occurred optimal dyeing when using extracts obtained via boiling 5 grams of fruit in 100 millilitres of water for 90 minutes, adjusting the dye bath to pH7, and dyeing the wool for 60 minutes at the boiling point (El-Zawahry and Kamel 1999).

Extraction conditions for tesu flower, pomegranate rind and dolu bark were optimised by Ansari, et al., (1999) by studying the effect of pH of extraction media, temperature and time of soaking, extraction and mass to liquor ratio on dye yield. The optimum pH values for tesu, Pomegranate and dolu bark were found to be 10 M: L ratio for tesu was 1:20 while for Pomegranate and dolu bark it was found to be 1:10. Optimum temperature for tesu and Pomegranate was 80° and for dolu bark it was optimum at 70° C. Optimum soaking time in hours was 16 hours for all the three dyes and optimum extraction time was found to be 2 hours for each dye. The extracted dyes were then dried in hot air over at 70±1° C, cooled in dessicator and crushed to obtain the dyes in the powdered form.

Vatsala and Murugappa (1999) have suggested a microbial fermentation technology for dye extraction with its major advantages as specific extraction of dye stuff, Bio-transfermentation of dyestuff to a colouring agent, degradation of non specific toxic organic compounds, increased rate of extraction and maximum extraction of colouring agent from a unit volume of dye stuff material etc.
An attempt has made by Gulrajani et al., (1999) to dye nylon with Annato. For this the conditions of the dye bath were varied. The pH of the dye bath was varied between 3-7 and it was observed that best dyeing results were obtained at pH4 and pH6. The samples dyed at pH4 were yellower in comparison to those dyed at pH6. Dyeing were also carried out at temp of 70° C. and 90° C. at dye concentrations of 1-20% keeping the pH at 4 and 6. It was observed that the dye bath exhaustion, levelling and fastness properties of the dye is better at 90° C in comparison to 70° C. and better at pH in comparison to pH4.

Bhawana Ghorpade et al., (2000) have stated that ultrasound energy assisted extraction of the red dye from sappan wood in aqueous medium and cotton dyeing in sonicator using eco friendly mordants such as Alum, Ferrous sulphate, stannous chloride and stannic chloride showed impressive results. Aqueous extraction of Sappan wood dye by sonicator yielded dark red dye. Similarly methanolic extract of Sappan wood dye gave good results in cotton dyeing by sonicator using same mordants.

A process development for the extraction of natural dye from the leaves of teak plant (*Tectona grandis)* has been carried out with 20% aqueous methanol using soxhlet. A brick red shade dyeing for silk/wool using the isolated dye in presence of different mordant has achieved successfully by Nanda et al., (2001). The researcher further stated that in the above method it is possible to obtain various intensities of colour shades for silk and wool fabrics by using known quantity of dye powder. The isolated dye powder can be stored and marketed for commercial purposes.

Vandana Tiwari, et al., (2000) concluded in their study that for Balsam the dye uptake was better in methanolic extract while the aqueous extract showed better fastness properties although the shades were lighter in the later case. The optimum concentrations for dyeing with balsam were 25-ml of methanolic extract with 10 gms of fabrics sample (cotton). The optimum time was a hour in sonicator.

Vandana Tiwari, et al., (2000) in their next study stated that the acidic dye extract was darker shade of magenta as compared to neutral medium. Basic extract of
the dye showed yellow coloration. They further concluded that Bougainvillea shows a full gamut of colours from dark magenta in acidic medium to yellow in basic medium.

Padma vankar et al., (2001) in her study of dyeing cotton fabric with *cassia fistula* bark was optimised the dyeing conditions in terms of dye material concentration, dye extraction time, dyeing time and mordanting time. The trial proportions used were 2,3,5,6 gm dye material concentration where 5 gm was found to be optimum. Trial proportion used for dye extraction time, dyeing time and mordanting time were 30,45,60 and 90 minutes where 60 minutes time was found optimum for extraction, dyeing and mordanting.

Another study by Padma vankar (2001) stated the optimisation of dyeing parameters, as optimum concentration of cosmos dye is 10gm flowers in 100ml water gave the best result. It was observed that the optical density of the sample left for one hour was maximum. It was further observed that among the aqueous and methanolic extraction, the dye content is more in the methanolic extract. The dye uptake in microwave is better for methanolic extract dyeing. Padma Vankar (2001) has also utilized supercritical fluids to extract and purify natural colorants from plant sources. This extraction process consists of contacting the supercritical fluid and natural product in an extraction vessel at high pressure, where the solubility of the desired product is appreciable in the supercritical fluid (CO₂). For the dyeing of cotton with the use of eco friendly mordant bright yellow coloured fabric is obtained which shows very good fastness properties both in the case of microwave as well as sonicator dyeing methods.

A number of studies have been reported in the literature available on extraction and application methods. It has been observed that, aqueous, acidic, alkaline and methanolic extraction methods are in practise. The methods such as fermentation methods and supercritical fluid extraction are also in practise at the various academic institutes and research laboratories.

The studies regarding extraction brought to notice that, results varies with the condition employed, such as pH, temperature, time and concentration. However
studies conducted so far are not found adequate to be conclusive, because results may vary with the stalk of natural dyes available.

The natural dye manufacturers may collect or buy the natural dyes from different places with varying climatic conditions, soil types and pH to fulfil the trade between demand and supply.

It is really difficult to standardize the natural product as the state of maturity and the age of natural products, fresh and bright, tender or matured, fresh or cenasing (with respect to leaves) definitely affects the results.

On the other hand, individual chemical constituents of the dye yielding plants of the same family with different genus and species may vary. Therefore, series of experiments should be undertaken right from the taxonomical and agronomical researches regarding the dye sources, their cultivation, exploration up to the extraction and application techniques to overcome the major constraints of reproducing shade, inadequate fastness properties and availability to maintain the trade between demand and supply.

2.4 Mordants, Mordanting Procedures and Fastness Properties

Studies on the mordants, mordanting procedure and fastness properties were screened and some of the relevant studies were collected and presented as follows.

Goodman (1985) stated that choice of mordant was found to affect light fastness more than the dyestuff or length of exposure.

Anonymous (1988) reported that the dye features a light fastness of 3-4 on wool, depending on the mordant and is also suitable for silk fabrics. Processing requires a mordant. Improvement of dye fastness to perspiration on woollen fabrics involves increasing the amount of alum up to 10 percent.

Hashimoto (1989) studied the fluorescent behaviour of natural dyes using cotton and silk. It was concluded that the fluorescent intensity depended largely on the dyes and mordants and conformed to concentration quenching. The effect of the mordant on the fluorescent intensity was corrected with the type of metal in the
mordant. Copper and iron were found to decrease the fluorescent intensity. Fluorescent intensity increased when the dyes were exposed to light even though the dyes faded.

Dalby (1993) reported a fixing recipe that uses a 2 percent formic acid additive with only one-third the customary amount of potassium dichromate. Copper recipes can be improved with acetic acid, which improve light and wash fastness.

Gulrajani et al., (1993) employed three methods—pre mordanting, simultaneous mordanting and dyeing and post mordanting to evaluate the effect of mordants on the shade, light fastness, and launderability of silk and woollen fabrics dyed with a series of natural red dyes. Although none of the mordants significantly altered the colour depth of the dyed silk fabrics.

Gupta (1990) stated that Pomegranate rind can be used as a mordant and as a substitute for Harda, and comparable and even deeper shades with equal fastness properties can be achieved. In some cases the rind can be used to produce new shades.

Prior to the application of Madder and Savalkodi, Padhye and Rathi (1990), treated cotton fabrics with mordants and other chemicals and stated that depending on the nature of the mordants and the concentrations of mordants and dyes used, shades obtained varied greatly.

Nishida and Kobayashi (1992) evaluated the dyeing properties of a natural vegetable dyes such as chestnut peels, persimmon leaves, oak leaves, coffee and green tea. The dyes were used on plain-weave silk, cotton, silook, silk and silook blend and cashimilon and stated that Ferric sulphate after treatments improved the light fastness on silk and silook more than after treatment with an aluminium salt.

A study of dyeing silk fabrics with walnut bark revealed that colourfastness improved when the silk samples were mordanted with stannous chloride and alum, and light fastness improved when the samples were mordanted with potassium dichromate and copper sulphate (Singh et al., 1993).

Teli et al., (1994) evaluated the performance properties of cotton fabric dyed with Catechu, before, and after mordanting with alum, citric acid, potassium...
dichromate, iron sulphate, and copper sulphate. They observed that some performance characteristic and shades depend upon the type of salt selected for pre-treatment. Higher concentration of tannic acid and metal salts yield deeper shades. The method of application significantly affected the shade values of the dyed woollen fabric samples. The mordants had a negligible effect on the light fastness of the dyed silk fabric samples. The use of a mordant did not improve the light fastness of dyed woollen fabric samples- indeed the addition of such metals as copper or tin actually diminished it.

Achwal (1995) investigated the mordanting of wool by using alum or aluminium sulphate as mordants and the comparison of k/s values showed that for the five natural dyes studied, increasing the alum quantity up to 10 percent in pre mordanting increased the depth of dyeing, but further increases has no significant effect.

Anonymous (1995) proposed that alum and aluminium sulphate should be used as mordants in dyeing with natural dyes, as their environmental toxicity is low.

Venkidusamy and Ramasamy (1995) reported that in dyeing of silk with shoe flower extract when stannous chloride used as a mordant yielded bright shades, potassium dichromate yielded a dull and dark shade, and ferrous sulphate yielded a shade of graphite black. Optimum concentrations for the various mordants were 4 percent for stannous chloride, 6 percent for potassium dichromate. Post mordanting yielded the best results for ferrous sulphate. Pre mordanting yielded the best results for potassium dichromate. Pre mordanting and post mordanting yielded similar results for stannous chloride.

Singh et al., (1996) stated that the best shades of colour resulted when using 25 gms of alum, 10gms of copper sulphate, 4 grams of chrome, and 8 grams of ferrous sulphate per 100 grams of silk. Pre mordanting yielded the best results for copper sulphate, stannous chloride and ferrous sulphate. Simultaneous mordanting yielded the best results for chrome and ferrous sulphate.
The majority of natural dyes require the addition of metal salt or mordants, to create an affinity between the fibre being dyed and the pigment said Paul et al., (1996). They further stated that Natural dyes do not possess good light stability and may also undergo marked changes in hue with repeated washing. Brown, grey, and black shades provide the best light fastness, whereas yellow and blue tend to fade most readily. Natural red dyes are generally stable when exposed to light and washing.

On study of Dyeing silk with Natural Dye Singh et al., 1996 concluded that a mercury bulb tungsten fluorescent lamp light fastness tester evaluated light fastness of the dyed samples. An Atlas launder-O-meter assessed wash fastness; where potassium dichromate and ferrous sulphate produced the best pre mordanting results. Potassium sulphate and stannous chloride produced the best post mordanting results. All samples provided good to very good fastness properties.

Chattopadhyay et al., (1997) studied different mordanting techniques and assessed the colour strength in k/s values. Pre mordanting with higher alum or ferrous sulphate mordant concentrations increased the k/s values for both jute and cotton fabrics. Simultaneous mordanting with increased mordant concentrations decreased the k/s value for both fabrics. Post mordanting with increased alum and ferrous sulphate concentrations increased k/s values. Ferrous sulphate showed better results with all techniques for both fabric types. Jute fabric showed higher depth of shade for all mordanting techniques that did the cotton fabric. The greatest improvement in k/s values resulted from simultaneous mordanting jute fabrics at low mordant concentration.

Nalankilli (1997) reported that Tannin is the most widely used mordant. Myrabolan (Fruit skin) and Sumac (leaves and twigs) are the most important sources of tannin. Cotton has a low affinity for most natural dyes. When basic dyes are applied to tannic acid mordanted cotton; electrovalent bond is formed between the dye and acidic groups in the tannic acid.
Kalyani and Jacob 1998 investigated in their study that pre-mordanting produced the best results on cotton fabrics. The samples exhibited poor to good wash fastness.

Kumar and Bharti (1998) evaluated the dyeing and fastness properties of Magnifera indica bark dye on cotton fabrics. Ferrous sulphate treatment in pre mordanting and tannic acid treatment resulted in darker and duller shades. Stannous chloride mordanting yielded lighter shades with slightly higher b* values. Simultaneous dyeing and mordanting resulted in lighter shades than did pre mordanting or post mordanting methods. Magnifera indica dye alone resulted in medium wash fastness and light fastness properties. Using metal salts or tannic acid increased wash fastness and light fastness of dyed cotton fabrics.

Kohra et al., (1998) studied the effect of dyes and mordants on the degradation of cellulosic fabrics and found that the fabrics dyed with curcumin and potassium aluminium sulphate faded more than the fabrics dyed with iron sulphate. Researchers further examined the effect of sericin coating, mordants and dyes on the degradation and colour fading of silk fabrics processed with natural dyes. Light induced colour changes occurred in the iron mordanted and curcumin dyed/aluminium mordanted fabrics.

Gupta et al., (1998) investigated the effect of alum mordants on the fastness of fabrics dyed with three vegetable dyes: henna, pomegranate, and catechu. An experiment subjected; dyed cotton, silk and viscose fabrics to mordanting with 10 percent alum solution for 1 hour at 85-90 degree centigrade. Fabrics dyed with all three vegetable dyes exhibited moderate to good fastness. The highest degree of fastness in cotton fabrics occurred in alkali and neutral media. Silk fabrics exhibited the highest fastness rating in neutral and acidic media and also high exhaustion in acid medium. Viscose fabrics exhibited moderate to good fastness properties in alkali and neutral media.
Ela Dedhia (1998) stated those natural dyes with organic and inorganic mordant in various combinations; identifying natural dyes on fabrics; and sequestering agents that improve the fastness properties of natural dyes.

Gurumallesh and Senthilkumar (1998) evaluated the effect of natural dye Rosa indica on cotton and silk fabrics. They dyed the pre mordanted samples using 6 percent tannic acid or 6 percent myrobalan extract in conjunction with 3 percent copper sulphate, aluminium sulphate, potassium dichromate, ferrous sulphate, stannous chloride and tarter emetic. Fastness properties for all silk and cotton fabrics varied slightly and indicate sufficient dye ability.

Kumar and Bharti (1998) stated that Metal salts or tannic acid improved the fastness properties. Using metal salts as mordants provided the widest range of shades.

Increasing mordant concentrations did not increase dye uptake in the cotton or silk fabric samples, except for the ferrous sulphate, which increased dye uptake in cotton. Both silk and cotton fabrics showed good light fastness Samy et al., (1998).

Teli and Singh (1998) reported that hues changed according to the type of mordant and metal salt used. However, all shades had performance properties well within acceptable limits for commercial applications. Mordants included a commercially available natural mordant and tannic acid.

Copper and iron mordanting resulted in higher light fastness properties, including light fastness rates of 3-4 for onion and lac and 3 for turmeric. Mildly acidic conditions yielded consistently good colour values on polyester concluded Lokhande et al., (1998).

Gogoi (1998) examined the dyeing behaviour of eri silk in the presence of different mordants and with the application of selected metallic salts during dyeing with turmeric dyes. Mordanting of de-gummed and bleached plain-woven eri silk fabric samples occurred in 5 percent solutions of various mordants, followed by dyeing with turmeric dyes. Bright yellow coloration resulted with the use of aluminium sulphate, a mordanting with stannous chloride yielded bright orange. A
brownish colour resulted from treatment with potassium dichromate. Olive green resulted from treatment with ferrous sulphate. Results indicated that mordanting increased the colourfastness properties and that mordanting significantly affected the dyeing of eri silk fabrics with vegetable dyes. Another study by Gogoi (1998) determined the effects of various metal salt mordants on turmeric dyed silk. Untreated eri silk dyed yellow. Treatment with aluminium sulphate resulted in a bright yellow shade. Stannous chloride mordant yielded a bright orange colour. Potassium dichromate resulted in a brownish shade and ferrous sulphate resulted in an olive green colour. Experiments on colourfastness to washing light, and crocking showed the influence of mordanting on the level of colour change. The study concluded that mordant treatments before dyeing improved the colourfastness properties of turmeric dyed eri silk.

When mordanted with \(\text{FeSO}_4\), \(\text{CuSO}_4\), \(\text{K}_2\text{Cr}_2\text{O}_7\) or alum, dyed silk fabrics showed an initial increase in concentration, or a negative fade, followed by a linear curve conforming to a zero order fade. Samples mordanted with ferrous salt had the strongest resistance to colour change. No initial increase in concentration occurred with wool samples. Changes in relative humidity did not affect fading for either type of fabric, and mordanting had a minimal effect on the fading mechanism (Deepti Gupta 1999).

Geeta Mahale et al., (1999) concluded that increasing dyeing time and mordant concentration did not increase dye up take.

Khanna and Ela Dedhia (1999) investigated that mordant and pre-treatment increased the strength of the ratanjot dye, for which a combined ferrous sulphate/calcium hydroxide mordant created the most favourable conditions. Mordants decreased the dye strength for eucalyptus dyes. Ferrous sulphate was the most favourable mordant. Light fastness ranged from poor to fairly good for the ratanjot dyed fibres and from fairly good to excellent for the eucalyptus dyed fibres.

Geeta Mahale et al. (1999) conducted a study, on Marigold as a Natural colouring Agent and Assessment of its colourfastness. The mordanted silk skeins
samples had excellent wash fastness. Non-mordanted samples had good wash fastness in light shades and fair wash fastness in darker shades. Mordanted and non-mordanted samples had excellent dry and wet rub fastness. Non-mordanted samples and samples mordanted with potash alum and potassium dichromate had poor light fastness in darker shades. Copper sulphate mordanting conferred good to excellent light fastness.

Vastrad et al., 1999 have investigated that Golden rod imparted lemon yellow, cream, and light green yellow shades, depending on the mordant. Marigold produced golden yellow, light brown, and light rust. Onion skin produced light tan, rust or beige. Golden rod samples mordanted with alum or chrome exhibited poor wash fastness, whereas samples mordanted with tin exhibited fair wash fastness. Marigold dyed samples exhibited fair wash fastness. Alum showed good fastness to dry crocking and perspiration.

The role of the mordants for colour fastness has been analysed and it seen that treatment with tannic acid and alum as pre mordant before dyeing gives better colour fastness to washing rubbing and perspiration. Ferrous sulphate coordinates with two Brazilian molecules, here again pre mordanting along with tannic acid seems to be the choice of method. Pre mordanting along with tannic acid showed reasonably good results. Where as stannous chloride as a post mordant in the absence of tannic acid showed better results towards washing, perspiration and rubbing. The colours are slightly darker with tannic acid and pre mordanting method because of the increased interaction of the dye molecules with tannic acid and metal salts (Bhawana Ghorpade et al., 2000).

Deo and Paul (2000) dyed the ecru denim swatches with onion extract using natural mordants such as harda, tartaric acid and tannic acid separately and in combination. Harda-tartaric acid combination was found to be the best followed by tannic acid- harda and tartaric acid- tannic acid combinations. Synergistic effect of mordant was observed while using the binary combinations of mordants. Meta mordanting gave the best results for harda-tartaric acid and tartaric acid-tannic acid combinations, while pre-mordanting gave best result for tartaric acid-harda combination. They found an overall improvement in performance properties of the
samples dyed with various combinations over that of single mordanted and control samples. In their study of dyeing, ecru denim swatches with onion extract using potassium alum in combination with natural mordants harda and tartaric acid. Synergistic effect of mordants was observed while using the binary combinations of mordants, over performance properties.

Sujata Saxena et al., (2001) in their investigations have concluded that cotton can be successfully dyed with marigold and chrysanthemum flowers. Pre mordanting with alum was found to be the best for marigold in terms of good colour yield and fastness properties. Cotton samples dyed with chrysanthemum flower extract have excellent fastness to light irrespective of the mordant used which is significant in view of the poor light fastness of many natural yellow dyes.

Shardadevi et al., (2001) have utilized Peltaphorum bark to dye silk and cotton in their study. All three methods namely premordanting, simultaneous and post mordanting were employed and found that premordanting method gives deep shades compared to other methods. On the contrary post-mordanting method seemed to have removed the reddish tinge. They further observed that mordants have contributed for getting good colours more than the mordanting methods in case of silk dyeing. Observing the results of dyeing cotton, the mordants and mordanting methods also contributed for getting bright colours. With alum and copper sulphate mordants, pre and post mordanting methods seemed to have produced bright colours. All the shades of Peltaphorum dyed silk were found to be very fast to the fabric servicing conditions. Like silk, cotton also showed very good to excellent fastness to all servicing conditions. Alkaline perspiration conditions found to be significant in deepening the colours.

Another conclusion by Bhawana Ghorpade (2000) emphasizes that synthetic fabric like (Terycot) and cotton fabric can be dyed successfully with lac dye. Use of eco friendly mordants not only produced eco friendly fabric but they also produced different colours. Other results of the use or different mordants with 4 percent owf revealed that in all the samples, pre mordanting was better than post mordanting. Since, among the used mordants stannic chloride gave very good results. Researchers

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tried to experiment with different percentage of stannic chloride (4%, 6%, 8% and 10%) in combination with tannic acid and myroblan to compare the results of dye-uptake and fastness properties. However best result was observed for 4 percent mordant owf in terms of shade, but fastness property was better for 10 percent owf.

According to Padma Vankar et al., (2000), development of shades and fixation of natural dyes on natural fibres like cotton depends on the use of mordants. Mordants provide specific colours as well as improved wash and light fastness. Similarly another study with different mordant concentration showed difference in shade on the fabric.

One more study by Padma et al., (2001) indicate that Cassia fistula bark imparts fast colour on cotton fabric. Researchers used copper and chromium mordants, which are not considered to be eco friendly, only to examine how much of the mordant remained on the fabric after dyeing. Interestingly, it has been found that, premordanting the fabric with these non-ecofriendly mordants is quite safe, as the metal content in the fabric is less than 0.02 ppm, however their fastness properties are fairly good. Maturing the fabric for one week after quenching with these mordants and then dyeing render the fabric safe.

It has been prominently stated that pre mordanting with metallic salts was most suitable for fastness property study. Good ranges of colour shades were obtained by the use of metallic salts. Alkanet dye provides very attractive and soothing colours on cotton (Vandana Tiwari and Padma Vankar, 2001).

In a very recent past natural mordant was obtained by concentrating aqueous extract of banana flower petaloids under reduced pressure and evaporating it to dryness. Bharat Merino sheep wool yarn dyed with turmeric (Curcuma longa) was subjected to mordanting separately with natural mordant and chromium under the identical conditions. Out of the different concentrations 0.5, 1.0, 1.5, 2.5, and 3.5 % (on the wt of yarn) of the mordants used, 3.5% natural mordant and 1.5% chromium showed similar colour fastness, reflectance, colour shade and k/s values (Mathur and Gupta 2003).
Detail studies on mordants, mordanting methods and fastness properties reveal that mordants are considered to be an integral part. However according to some authors the dyes belonging to particular class of dye do not require mordant for fixation, when applied to the relevant class of fibres. Still scientists are using mordants in the natural dyeing process for the development of shades for the addition in colour palette.

Reviews in this section clearly indicate that most of the work has been carried out on the dyeing of cotton fibre, which needs mordant for the fixation of dye. Many of the studies have also came to the conclusion that, mordants provide specific colours as well as improved fastness properties, irrespective of the type of mordant, mordant concentrations, mordanting time, and the method of mordanting. It is also evident from the studies that alum is the most commonly used metal mordant. 10% alum concentration was found optimum in many studies. Use of alum and aluminium sulphate has proposed for the dyeing with natural dyes as their environmental toxicity is low.

Very few studies revealed the use of natural mordant and that too natural vegetable mordants.

Recently, the interest is further arisen in natural mordants which are eco-friendly and non carcinogenic in nature.

Most of the researchers have found pre-mordanating method as best for improving fastness properties and for imparting colours. Uncertainty in producing colours in post mordanting method was observed frequently. Studies also reveal that in most cases the properties of natural dyes are comparable to those of synthetic dyes. Therefore, proper selection of mordants with due consideration towards ecology and the need to confirm to the stringent standards of performance that are applied to the synthetic dyes, much more research and development effort needs to go in this area.
2.5 Printing and Value Addition of Natural Dyed Products

The hand printing industry received a major set back in the second half of 19th century with the influx of synthetic dyes which were cheap and easy to apply. The toxic effects arising from the production and consumption of synthetic dyes are being realised and the natural dyes have entered an era of revival. Today the green-minded consumers are looking upon natural dyes as an economically safer alternative. The use of natural dyes has increased substantially. The hobby groups, Designers, Traditional dyers and printers Non- government organisations (NGO’S), Museums Academic Institute and Research Associations/Laboratories and Industries are coming forward to look upon. Here some of the references regarding value addition and printing have been cited to focus upon the R & D during the last 10 to 12 years.

The handicraft industry in many countries has evolved around local talent in the art and craft of dyeing yarn with natural dyes and weaves them to produce speciality fabrics. Printing of natural dyes by direct, resist or dyed style is the speciality of printers of Rajasthan while Kalamakari with natural dyes is practised in Shi Kalashasti, Andra Pradesh (www.icr.com.au).

New colours were introduced by (Udayini and Jacob 1988) to Kalamakari painting on Indian textiles. Orange, blue, garnet, and lavender were used on desized, bleached, and cleaned grey cotton material. Washing, sunlight, perspiration, and pressing were employed in order to test for colourfastness. Blue was rated the most efficient colour.

Rudie (1992) stated that Dixie yarns have introduced its Earth wide collection of cotton yarns dyed with chemical-free, naturally – occurring plant and mineral dyes. An increasing sympathy for environmental concerns has spurred customer interest. Jansen Natural Harmony and Exprit feature Dixie’s Earth wise yarns in sweaters. Other knitwear developments include novelty and heavier knits composed of 100 percent cotton, pointelles and thermals for women’s wear, and reversible knits. Executives at Burlington knitted Fabrics predict a growing popularity for heavier interlock ranging from 16-20 ounces, small jacquards with micro ‘no-pattern’ textured
patterns, new suede knits, and knits dyed in a wide range of so called natural colours. Rudie (1992) further emphasized that the improved technology has expanded the range of natural fibre home textile offerings. Dixie yarns are now available to dye any natural yarn without chemicals, resin, or formaldehyde. The company is offering 20 colours of natural dyes made from vegetables, insects, minerals, roots, berries flowers, and bark for its Earth wide yarns, threads, and fabrics. The natural dyes are being used by J.P. Stevens for its Utica’ Simply Cotton’ program, as well as in New Marks’s Nature’s Loom Collection. Cotton’s share of the home fabrics market increased from 58 percent in 1990 to 59 percent in 1991. Both Wamsutta and Fieldcrest are offering products made from Supima cotton. Linen fabrics, including natural lines, have become popular. A milkweed floss and goose down comforter is now available.

Lonsinger (1992) has reported that Dixie yarns’ Earth wise products are 100 percent cotton yarns coloured with all natural dyes. The earth wise line is available in 20 colours derived from vegetables, insects, berries, bark, flowers, roots, and minerals. The new dyes create subtle, one – of – kind shades that fade naturally. The line should appeal to manufacturers hoping to take advantage of the growing call for environment products.

Sankaranarayanan (1993) has stated that the Tasara is an organization of weavers based in calico, India. In Sanskrit, ‘Tasara’ means ‘Weaver’s Shuttle’. The Tasara exhibition, held at the Vimonisha Gallary in Madras, familiarizes the public with the various aspects of weaving of naturally dyed fabrics and related processes and acquaints weavers, dyers, crafts people, artists, and textile designers with the aesthetic and technical aspects of textile design and manufacturing. Another concern of Tasara is improving the socio-economic status of craftsman.

The Indian village of Bagru in the state of Rajasthan is renowned for the production of fabrics with hand block printed designs in only vegetable dyes. The tradition of hand block printing in Bagru is only about 150 years old. The major colours used are red and black against cream. The black derives from rusty horseshoe nails and jaggery (an unrefined brown sugar from palm sap) and the red derives from pigmented sand. The two types of resist paste are mud and botanical resist pastes.

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Bagru fabrics are notable for their animal, floral and geometric motifs and, in particular, their gool borders, which consist of several borders with motifs that are progressively smaller as they approach the central or medallion, motif (Phadke and Sharma 1993).

Lal (1994) has also thrown a light on traditional Sanganeri and Bagru prints and reported about popular colours, which include blue, which is produced using indigo, yellow, which is produced using myrobalan flowers, and mustard green, which is produced using pomegranate rinds with traditional motifs. He has stated that popularity of Sanganeri and Bagru prints is growing because of their beauty and because they pose no threat to human health or the environment.

It has been reported by Alder (1995) that Park B. Smith has developed a new Eco ordinates collection of all natural, vegetable dyed home furnishings. Challenges of using vegetable dye include achieving colour consistency and building inventory. The United Nations has helped the manufacturer to develop its natural dye industry. More than 20,000 workers are employed by the Eco-ordinates collection. The product line blends ecological concerns with fashion and after dye ability. Colours include linen, hunter green, royal blue, terra cotta, rose, ivy, natural cotton, and natural jute. The product line includes duvet covers, pillow shams, dust ruffles, lap shawls, tablecloths, placemats, napkins, rugs, shower curtains, drapery pairs, decorative pillows, tab top panels, valances, chair pads, slice rugs, and table runners. Mix and match possibilities or the collection have also grown.

It has become evident from the review by Martinenghi (1995) that Giuseppe Menta an Italian fabric designer has opened a workshop in which he did all of his own weaving and printing, and became reorganized for his expertise in the fields of colour and printing, as well as his innovative blends of mohair/crepe de chine and silk/linen. Menta is currently collaborating with a Japanese chemical engineer to identify plants and other natural substances to prepare his exclusive dyes. In 1992, he launched the Mente Veste Natural line, a collection of special fabrics manufactured according to ecologically sound principles.
Among the recent years researchers studied the feasibility of using natural root dolu for dyeing and printing cotton fabric. Dolu used with such mordants as potassium dichromate, aluminium potassium sulphate, ferrous sulphate, stannous chloride, tartaric acid, and tannic acid produces a range of colours. Results showed that gum Arabic was the best thickener for printing. Printing the fabric with mordant followed by dyeing with dye extract resulted in the brightest colour. Higher concentrations of mordants, except for stannous chloride, produced better printing results. Equal concentrations of tartaric acid and another mordant produced the best results. Dyed fabrics showed excellent colourfastness (Goel and Chauhan 1997).

Another study by Gupta and Goel, (1997) has investigated that a natural dye extracted from the native Indian tesu flower may be suitable for block printing with a mordant. A series of laboratory tests evaluated the effects of printing paste recipes and type of mordant on the colour development of block prints on white silk fabrics using tesu-derived dyes. A low percentage of alum produced no print. Copper sulphate alone did not produce good colour prints, whereas stannous chloride imparted excellent orange prints. The addition of tin with alum, chrome, or ferrous sulphate created a wide range of shades. A 1-10 percent concentration of chrome produced a light to dark reddish maroon colour. Optimal concentrations of most mordants were approximately 6 percent. Results indicated that natural dyes extracted from tesu flowers are suitable for printing fabrics using premordanting methods. On the contrary printing with Manjastha Goel and Chauhan, (1996) investigated that lower concentrations of mordant resulted in a wider range of shades compared with medium concentration. Where as brighter colours were obtained with higher concentrations. Researchers obtained a variety of colours, including ochre brown and dull henna. An equal proportion of mordant and tartaric acid offered the best results and brightest colours.

On the other hand members of the Khatri caste dominate the fabric printing and dyeing business in the Kutch District in Gujarat, India. Families that traditionally practiced block printing and tie-dyeing now specialize. The local government is supporting the return of natural dyes primarily for block printing fabrics for export.
Natural dyes, such as indigo, madder, turmeric and pomegranate rind are often used with aniline dyes. Increasing national and international demand exists for block and tie-dyed fabrics. The Khatries incorporate old designs into new products for export. Family businesses recently instituted innovative quality control measures. Such as replacing wiped colour with sprayed colour, to achieve homogenous dyeing (Edwards 1998).

It has been documented in Anonymus, (1999) that Kashmiri artisan’s hand woven pashmina shawl in the 18th and 19th centuries was for the aristocratic Indian market and for export in Europe, where the designing through vegetable dyes was in practice to create variety of colours and shapes.

An alternative approach, by Chavan (1999) was made for printing. In his work an attempt has been made to shorten the print sequence by printing with print paste containing natural dye and mordant together. The prints were evaluated in terms of colour yield, staining of non-printed portions, wash fastness (colour change) and light fastness and it was concluded that in the modified approach there is a danger of dye-metal complex formation in the print paste itself leading to loss of print paste stability and colour value. To overcome these problems, pre-metallization of the natural dye is suggested. The premetallized dye can be used as pigment along with a binder. The choice of thickener is critical in this approach. Another small attempts were made by Kavita Patel (1999) and Surabhi Patel (1999) on block printing with teak leaf on cotton fabric and printing of cotton polyester with Eclipta alba.

Another study on designing by Pavni Agrawal (2001) tends to highlight the development procedure of a product line with its co-ordinates, for a bedroom range. The product line was developed using natural dyes on silk, with traditional block printing technique. Natural dyes Rhubab, Gallnuts, Harda, Madder and Cutch were selected for the study. The fastness of all the dyes was tested and it was rated good to excellent for each dye.

It has been stated by Bina Rao (2001), that in today’s context, Natural dyes, as colouring matter in textiles and use of these textiles in fashion is more relevant than
ever before. There is growing awareness, concern and interest in consumers, promoters and manufacturers. She further raised the question as, how popular natural fabrics were in history? If they were! Why did they lose the importance now?

During the 18th century, Indian chintz (Handblock printed natural dye textiles) became very popular in Dutch fashion as well.

In 1680’s hand block-printed textiles were used as fashion fabrics in France. Fashionable ladies and gents wanted Chintz for skirts, blouses, gowns, vests and dressing gowns as well. At the same time in England the boom of so-called ‘Musuli Patanam Chintz’ from the coast of Coromandal was at its heights.

This Chintz were specially made in India in bridal combinations, big floral designs, brilliantly coloured and boldly patterned than the English and French Chintz.

However the popularity and demand went on increasing and Indian printers and dyers could not keep up to the demand in large volumes.

Traditionally colours were never based on fashion but were influenced by religion, regional climatic conditions and natural surroundings, but the same colours grouped in different combinations are called colour forecast.

The forecast of winter 2000-01 opened a new era of colour; its perception and its utilization were modified, which extended freedom to the palette of hues to create one’s own chromatic harmony in originality. Trends that immerged were very favourable for natural dyes as all 27 colours shades, that came as, forecast were the shades very much possible to achieve with natural dyes and it applied to the trends of spring summer 2002, where colours are the chromatic expression and fashion theme is based on opening of new avenues and creating newer fabrics.

In September 2001, at the world eco-fibre and Textile forum, designers from many countries, presented their latest line of casual and evening wear which were made of natural fabrics in natural dyes, styled as per the world standards and preferably matching to the mood of the season while presented on the ramp.
An upcoming Indian designers who focussed totally on variety of woven textures, dyed in Indigo and woven with gold thread with dash of Indian hand embroidery as an evening wear collection and Tribal fabrics of Bastar which are well known for their brilliant ‘Aal’ red colour used in contemporary international style. Casual range was tailored out of Creative Bee’s exclusive hand block prints with natural dyes, which were based on the theme of rain forest.

A literature available and studies conducted on printing and value addition by using natural dyes depicts that printing, painting and dyeing was in vogue since historic times.

Today due to the growing environmental awareness promotion of using natural dyes for dyeing and printing has become optimistic and promising.

Number of persons from various fields are involved in this line. But it is clear from the literature cited that very little experimentation was carried out regarding the printing procedures, performance towards various conditions that need to be assessed for various end uses such as apparel fabrics, upholstered fabric and various other accessories.

Application of natural dyes in weaving and knitting technology is evident from the literature, however attempts have also been made to offer expertise knowledge.

A review also suggested the need to introduce new colours as commercially viable. The dye sources such as Indigo, madder, ‘Aal’ red, Cutch, Gallnuts, Harda, Pomegranate rind, are still in use. Replacing these conventionally used sources with some new vegetable dye sources or blending and combinations of conventionally used dye sources with that of new dye sources to extend the colour palette will find beneficial.

Among the beneficiaries fashion and interior designers may find new avenues and create newer and fashion fabrics for the green minded consumers.