

**Self and Compound Shades of Turmeric, Beetroot and Blue Oxide on
Cotton and Silk fabrics**

By

SARANYA.M

(17PTF017)

A Thesis submitted to the
**Avinashilingam Institute for Home science and Higher Education for
Women, Coimbatore – 641043**

In Partial Fulfillment of the Requirements for the Degree of

Master of Science

In

Textiles and Fashion Apparel

April - 2019

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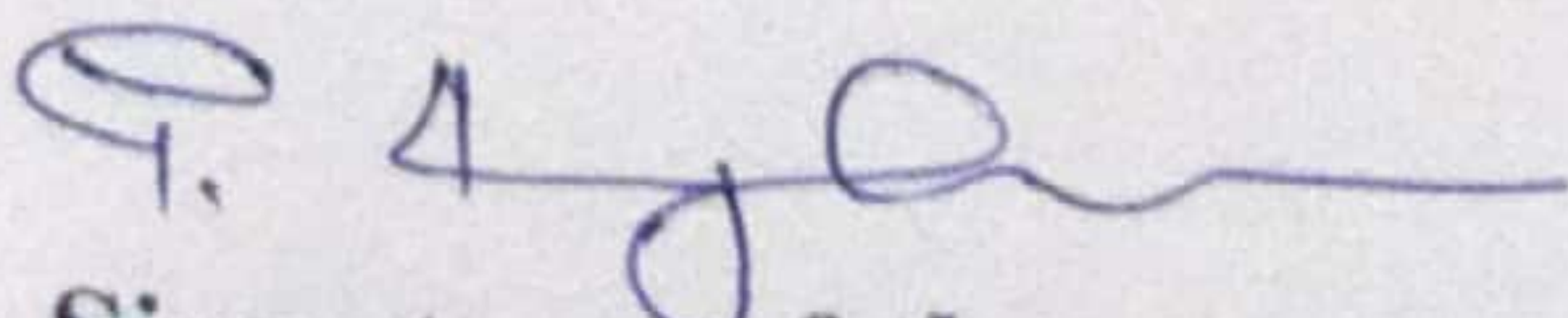
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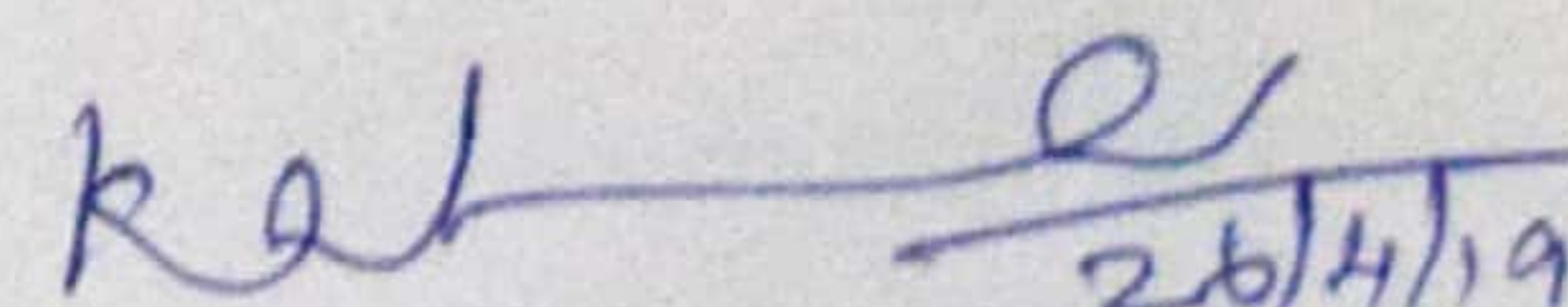
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Certified as Bonafide Research Work


**Signature of the
Head of the Department**


Signature of the Guide
26/4/19

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1. INTRODUCTION

Humans are blessed to have pleasing nature and many natural resources, which can be utilized to get beautiful colors. The dyeing came into existence from ancient times. There is no written evidence in form of paper and it is very difficult to know the exact date or year of its inception. To make fabric colorful, different varieties of natural material were dyed for dyeing. The natural dyes such as indigo and madder were used to dye textile materials which were found in Roman graves during middle of 2nd and 3rd century. In Egyptian tombs, fabrics were dyed with safflower natural dye or by minerals. The color extracted from the insect body was applied on fabric and treated with metallic hydroxide to obtain red color. India was the first to develop red and blue color with madder and indigo respectively. Vegetable dyes with tannic acid were commonly used (Sekar,2014).

The advantages of using natural colorants are manifolds such as they are eco-friendly, safe for body contact, unsophisticated and harmonized with nature. They are obtained from renewable sources and also their preparation involves a minimum possibility of chemical reactions. The shades produced by natural dyes / colorants are usually soft, lustrous and soothing to human eye (Upadhyay, 2012). Till the 19th century dyers relied on the natural sources for dyeing. During late 19th century William Henry Perkin discovered lavender dye accidentally from coal tar and this was the first step towards the decline of natural dyes. The invention of synthetic dyes and its simple way to use, cheaper in cost compared to natural dyes, easy storage and good color yield had resulted in downfall of natural dyes.

However, during the last few decades, the use of synthetic dyes is gradually receding due to an increased environmental awareness and harmful effects because of either toxic degraded products or their non-biodegradable nature. In addition to above, some serious health hazards like allergenicity and carcinogenicity are associated with some of the synthetic dyes. As a result, a ban has been imposed all over the world including European Economic Community (EEC).

Due to increasing awareness of environmental issues and pollution control, natural dyes are gaining importance as they are obtained from renewable resources and they promise to health and some of them sometimes act as a health care products. Natural dyes with few exceptions are non-substantive and hence must be used in conjunction with mordants such as tannins, metallic salts and oils. (Sheikh *et al.*,a-2012).

Textiles dyed with natural dyes were found to yield poor color, have inadequate fastness properties. Metal ions as mordant act as electron acceptors of electron donors to form co-ordination bonds with the dye molecule, making them insoluble in water. Common mordants used are alum, chrome, stannous chloride, copper sulphate, ferrous sulphate etc. (Dabera *et al.*,2016). Tannis are used as natural mordants which are high molecular weight compounds (between 500 to 3000) containing phenolic hydroxyl groups. They enable effective cross-links between proteins and other macromolecules. The stability of the tannin treated fibre depends upon the pH, ionic strength and metal chelators. Tannis may be further classified into two groups on the basis of their chemical structure as hydrolysable tannis and condensed tannis. (Teli *et al.*,2012)

Dyeing with turmeric is known for long time. Turmeric is a spice that has received much interest from both the medical / scientific world as well as from the culinary world. Turmeric is a rhizomatous herbaceous perennial plant (*Curcuma longa*) of the ginger family. The root of the turmeric plant creates strong colors, from bright yellow with no mordant to dark green with an iron modifier. Cold water works well for turmeric; for darker and more orange shades, heat can be applied. Turmeric is a great dye for beginners as it works especially well on animal or plant-based fibers with or without mordant (Sekar.,2015).

The beetroot is the taproot portion of the beet plant, usually known in North America as the beet and also known as the table beet, garden beet, red beet, or golden beet. It is one of several of the cultivated varieties of *Beta vulgaris* grown for their edible taproots and their leaves (called beet greens). Beet root is known by its red color. This red color is because of the betanin pigment found in beetroot.

Blue Oxides are man-made pigments from natural elements. They are strong in tinting strength and more opaque than other colors so can often be used at a lower ratio than natural pigments. These colors are an excellent choice for cement and stucco, but are not limited to that use. Mineral powder pigments such as oxides, ultramarines and micas are cosmetic-grade. These pigments are mined from the earth, processed and filtered to remove harmful impurities such as lead or mercury. Unlike some liquid colors they will not bleed or fade. (www.naturalpigments.com)

The compounds for adding color to textile materials are either dyes or pigments. Two or more types of dye compounds with very different properties are mixed together and dyed are called compound shade dyeing. For example: 2 compound shade dyeing, 3 compound shade dyeing or 3 color combination dyeing etc. Mixing of two or more dyes for achieving various shades with synthetic dyes is a common practice; but the studies of natural dyes for obtaining compound or mixed shades are still scarce. (Teli *et al.*, 2018).

As the sustainable solutions for the textiles processing are urgently needed, the studies that provide a concrete data on compound shades of natural dyes using natural mordants along with their fastness properties would help to satisfy consumers' demand for environmentally improved textile products. (Blandy *et al.*, 2007).

Therefore the present study entitled “**SELF AND COMPOUND SHADES OF TURMERIC, BEETROOT AND BLUE OXIDE ON COTTON AND SILK FABRICS**” is framed with the following objectives.

- To extract dye from turmeric, beetroot and blue oxide
- To dye cotton and silk fabrics with self and combination method using harda as mordant
- To select suitable proportion of dye mixtures
- To evaluate and compare the color strength of mordanted and unmordanted fabrics.

2. REVIEW OF LITERATURE

2.1 NATURAL DYES

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2.1 NATURAL DYES

Natural dyes and dyeing are as old as textiles themselves. Man has always been interested in colors. The art of dyeing has a long past and many of the dyes go back into prehistory. It was practiced during the bronze age in Europe (Siva, 2007). Natural dyes have almost vanished except for those still available for use by the individual hand-craftman. Important natural dyes based on plant or vegetable sources include indigo, obtained from the plant *indigofera tinctoria* and giving a deep blue color. It is one of the most ancient dye known. These dyes gives varying shades, tones or colors according to the type of mordant used (Stuart,1982).

2.1.1 History of Natural Dyes

The art of dyeing was as old as human civilization. From the historical records, it is learnt that natural colorants were available to people during Greco-Roman periods. Our Vedas, the Atharveda carries description of natural dyes (Nakamura, 2000). The use of natural dyeing materials is evident with the wall paintings of Ajanta, Ellora and Sithannaval and they still demonstrate the efficacy of dyeing craft that had been inherited from ancient times in India. Ancient Egyptian hieroglyphs contain a thorough description of the extraction over many thousands of years led to rather complicate dyeing process and high quality dyeing.(Muskar Rita, 2006)

Natural dyes have been used since ancient times for coloring and printing fabrics. Until the middle of last century, most of the dyes were derived from plants or animal sources by long and elaborate processes. Among these Indigo, Tyrian purple, Alizarin, Cochineal and logwood dyes deserve special mention.

Natural dyes comprise those colorants (dyes and pigments) that are obtained from animal and vegetable matter without chemical processing. Natural dyes fall into three categories on the basis of their origin.

Plant / vegetable origin

Colorants are derived from roots, leaf, bark, trunk, fruit and flowers of plants. In our country 500 plant species, have been identified as useful sources of dyes. Unfortunately most available publications refer to less than 200 species. Some of the examples of plant dye sources are turmeric, mango leaves, mesta calyx, Gulmohar, Poplar bark and Rattan jot (Vankar, 2017).

Insect / animal origin

Natural substances such as carminic acid, kermesic acid and laccaic (popularly known as lac dye) obtained from either exudation or dried bodies of insects namely, cochineal, kermes and kerria lacca (kerr) respectively are well known and these acid compounds are used for dyeing purpose from ancient times. These acid compounds particularly carminic and laccaic acids find limited use for coloring. Animal dye sources include the urine of cow, the camel dung, Shell-fish and Molluscs (James,2010).

Mineral dyes

The most commonly referred to and used mineral is 'Geru' (Redchre) known for its characteristic shade. Oxides of iron, tin and antimony have been used along with vegetable or insect dye to obtain the desired shades on fabrics, salt like copper and iron sulphate are used as auxiliaries in the dyeing/ printing of fabrics as mordants which not only helps in dye molecules adherence but also gives a gamut of colors with a dye (Vankar,2017).

Until the middle of nineteenth century all the textiles were, if necessary, dyed/printed with the use of natural products. Naturally, various recipes/ procedures were in practice in different parts of the country depending upon the availability of local special vegetable products and stage of local standardization/ skill achieved by local craftsmen (Raul, 2005).

2.1.2 Natural dye color chart

Indigo	ALUM	TIN	CHROME	IRON	COPPER
	Blue-no mordant needed				
Cochineal	Crimson	Scarlet	Lavender to Violet	Gray-violet To black	-
Brailwood	Xmas red to Gament	Pink	Deep maroon	Off-black	-
Logwood	Blue-violet	purple	Blue-black	Silver, grey, black	Gray
Fustic	Yellow	Aurora(yellow -orange)	gold	Soft green	Soft green
Madder	Brick red	Bright orange	burgandy	Off-black	-
Weld	Yellow	Cool lemon yellow	Rich yellow	sage	Soft green
Catechu	Yellow- brown	-	Red-brown	Brown- black	Medium brown

(Storely, 1992).

2.1.3 Classification of natural dyes

Dyes are classified based on their structure, source, method of application, color, etc. There are three types of classification.

i) Based on chemical structures

- a) **Anthocyanidins:** This class of dye consists of carajurin, extracted from leaves or bignonia chica and awabanin. It is applied on silk fabrics and results in blue shades.
- b) **Anthraquinones:** This dye is red in color and has anthraquinone structure. Also has good light fastness property.
- c) **Dihydropyrans:** This dye is matter of logwood and when dyed on cotton, wool, and silk it gives dark shades.

- d) **Alpha naphthaquinones:** This class of dye consists of lawsone or henna, juglone and many others. Henna is extracted from leaves of *Lawsonia inermis*. And juglone is extracted from unripe walnut.
- e) **Flavones:** yellow color is extracted from the jackfruit bark which is derivatives of hydroxyl and methoxy substituted to flavones or isoflavones.
- f) **Carotenoids:** This class of dye includes carotene orange colored pigment obtained from carrots. The dyes are extracted from saffron and annatto.
- g) **Indigolds:** This dye is extracted from *indigofera tinctoria* plant leaves, and belongs to pea family (Kurt, 2006).

ii) Based on color

Various natural dyes could present all the colors of the visible spectrum. The natural color and hue of a dye can be altered by treating with metal salts. If the dye is plant origin, the color may vary depending on the soil properties, part of the plant, season of harvesting, cultivation practices, etc (Sasha, 2010).

- a) **Blue dyes:** Extracted from indigo plant and flowers of Japanese tsuykusa.
- b) **Red dyes:** Most red dyes are found in roots or barks of plants or camouflaged in the bodies of dull grey insects. Unlike the wide abundance of yellow, the sources of red color are limited. Cochineal is an important red dye and its is the brightest of all the available natural red dyes. Manjith and Kusumbar among the vegetable sourced and lac and Kermiz among the animal sources give red colors.
- c) **Yellow color:** The important yellow dyes are extracted from black oak (*Quercus veluntina*), turmeric (*Curcuma longa*), and weld (iconfile.com).

iii) Based on color development

Natural dyes can also be classified on the basic of color development into two types *i.e.*, Monogenetic and Polygenetic dyes.

- a) **Monogenetic dyes:** The monogenetic dyes produce only one color irrespective of the mordant applied.
- b) **Polygenetic dyes:** The polygenetic dyes produce different color according to the mordant applied on the fibre (Jefferson, 2005).

2.1.4 Advantages of natural dyes

- High diversity of rich and complex natural dye colors
- Different colors go well together and rarely clash
- Excitement of unexpected results
- Satisfaction of growing own dye plants
- Self-sufficiency if growing own plants for plant dyes
- Not dependent on non-renewable materials
- Allow for endless experimentation
- Allow for the replication of ancient techniques
- Mature with age exposed to sunlight and normal use, developing a patina as colors mellow
- Aromatic smell when simmering the plants (Kendall, 2001)

2.1.5 Disadvantages of natural dyes

- Require large quantities in comparison to chemical dyes. However, many natural dyes are now sold as natural dye extracts, which do not require large quantities, and small amounts of cochineal, brazil wood and logwood dye a large amount of fiber.
- Longer time required for natural dyeing. However, the sun is used as an energy source, the dye vat can be left unattended for a long time and natural dye extracts are quick to use.
- Natural dyeing are costly.(Seema Kapoor-2012)

2.2 COTTON

Cotton, is a seed-hair fiber of several species of plants of the genus *Gossypium*, belonging to the hibiscus, or mallow, family (Malvaceae). Cotton, one of the world's leading agricultural crops, is plentiful and economically produced, making cotton products relatively inexpensive. The fibers can be made into a wide variety of fabrics ranging from lightweight voiles and laces to heavy sailcoths and thick-pilled velveteens, suitable for a great variety of wearing apparel, home furnishings, and industrial uses (Charu Swami *et al.*, 2001).

2.2.1 History

Wild or cultivated cotton has been used as a textile fiber for several thousands of years and India is generally considered to be the birthplace of cotton cloth, a fragment about 3,000 years old having survived. The plant is thus exposed to full sunlight and air, which ensures that the bolls ripen more uniformly. This is essential if the crop is to be gathered mechanically: one of the causes of irregularity of color in cotton yarn and cloth, making it difficult to bleach, dye and print, is the presence of unripe fibers (D.Jothi, 2008).

Cotton fibers have varying degrees of natural lustre because the outer layer of cellulose contains a wax which gives surface smoothness and allows even untreated cotton cloth to regain a great deal of 'newness' and smartness when ironed smooth. And because of its resistance to heat, cotton can be laundered and ironed at quite high temp; it does not start to yellow until around 120 (250) (Mamtha Hegde, 2018).

As far as the use of dyes is concerned, cotton can be printed with very fast dyes such as vats and reactives, which can be boiled without loss of color, while most of the chemicals normally used in dyeing and printing, and the dyes themselves, cause no damage to the fibers. In twentieth century cotton has enjoyed varying degrees of popularity being overshadowed by 'art' silk in 1930s, but it came back into favour in the early postwar years when the cotton Board's color, design and style centre in Manchester, the first design centre anywhere in the world, 'sold' British cotton fashion and finishing fabric throughout the world by exhibitions and promotion generally.

Now, after bad harvests and an upsurge of synthetics, cotton is again back into for greater popularity, as its excellent qualities are becoming more widely recognized (Storey, 1978).

2.2.2 Advantages of cotton

Cotton fiber differs markedly from other cellulose fibers in morphological traits. Due to many features, cotton even though it was discovered later than other fibers gained a superior position and stimulated immense development of textile industry (britannica.com).

1. Cotton fabric show good durability and utility (but still cotton fabric are inferior to synthetic fabrics in durability). Cotton is a chemically stable material; it stays undamaged even under the continuous exposure of weak acids and alkalis.
2. High water-absorbing capacity. In humid atmosphere cotton fabric can absorb 27% of water without getting damp.
3. Cotton fabric has very good breathable characteristics, it is hypoallergenic, agreeable to touch, and it suits perfectly for people with skin hyper sensibility.
4. It has low thermal-conductivity, therefore it is an ideal material for both summer and winter clothes: in summer it prevents your skin from heat, and in winter it preserves the warmth of your body.
5. Cotton fabrics are easy to dye.
6. Cotton fabrics have very low elasticity characteristics, so they almost don't stretch.
7. They are easily washable and can be ironed even at high temperature.

Cotton fabric is often used with WR (water resistance), OP (oil proof), and flame retardant (FR) finishes. Cotton fabric often finds its application in producing work wear with high hygienic requirements and clothing for protection against low temperatures. (xmtextiles.com)

2.2.3 Physical properties of cotton

1. **Cotton:** The color of the fiber could be white, creamy white, bluish white, yellowish white or grey.
2. **Tensile strength:** Cotton is moderately strong fiber. It has a tenacity of 3-5 gm/den. The strength is greatly affected by moisture; the wet strength of cotton is 20%, which is higher than dry strength.
3. **Elongation at break:** Cotton does not stress easily. It has an elongation at break of 5-10%
4. **Elastic recovery(ER):** Cotton is inelastic and rigid fiber. At 2% extension it has an ER of 74% and at 5% extension it has an ER of 45%
5. **Specific gravity:** Specific gravity is 1.54.
6. **Moisture Regain (MR %):** Standard moisture regain in 8.5.

7. **Effect of heat:** Cotton has an excellent resistance to degradation by heat. It begins to turn yellow after several hours at 120 °C and decomposes markedly at 150 °C. As a result of oxidation, cotton is severely damaged after few minutes at 240 °C. Cotton burns in air.
8. **Effect of sun light:** There is a gradual loss of strength when cotton is exposed to sun light and the fiber turns yellow. The degradation of cotton by oxidation is done when heat is promoted and encouraged. By sun light much of the damage is caused by UV-light and by the shorten waves of visible light.
9. **Effect of age:** Cotton shows a small loss of strength when stored carefully. After 50 years of storage cotton may differ only slightly from the new fibers (Gupta *et al.*, 2010).

2.2.4 Chemical properties of cotton

Cotton is a natural cellulosic fiber and it has some chemical properties. Chemical properties of the cotton fiber are given below:

1. **Effect of acids:** Cotton is attacked by hot dilute acids or cold concentrated acids which it disintegrates. It is not affected by acids.
2. **Effects of alkalis:** Cotton has an excellent resistance to alkalis. It swells in caustic alkalis (NaOH) but it does not damaged. It can be washed repeatedly in soap solution without any problem.
3. **Effect of organic solvent:** Cotton has high resistance to normal cleaning solvents. Cotton is dissolved by the copper complexes, such as cupraammonium hydroxide, cupricethylenediamine and concentrated 70% H₂SO₄.
4. **Effect of Microorganism:** Cotton is attacked by fungi and bacteria. Mildews and bacteria will flourish on cotton under hot and humid condition. They can be protected by impregnation with certain types of chemicals. Copper naphthenate is one of the chemical. (textilefashionstudy.com)

2.2.5 Uses of cotton

Cotton is known for its versatility, performance and natural comfort. It is used to make all kinds of clothes and home wares as well as for industrial purposes like tarpaulins, tent, hotel sheets and army uniforms (John Harkin, 1969).

Cotton fiber can be woven or knitted into fabrics such as velvet, corduroy, chambray, velour, jersey and flannel. In addition to textile products like underwear, socks and t-shirts, cotton is also used in fishnets, coffee filters, book binding and archival paper. Cotton is a food and a fiber crop. Cotton seed is fed to cattle and crushed to make oil. This cottonseed oil is used for cooking and in products like soap, margarine, emulsifiers, cosmetics, pharmaceuticals, rubber and plastics.

Linters are the very short fibers that remain on the cottonseed after ginning. They are used to produce goods such as bandages, swabs, bank notes, cotton buds and x-rays (cottonaustralia.com.au).

2.3 SILK

Silk is one of the popular fabrics for apparel because of its unique properties. Silk is most luxurious, comfortable and absorbent (equal to wool). The best fabric for drape, luster and finest “hand” etc. these are some of the fabrics which make the fabric more popular. The fabric is cool in summer and warm in winter (Saxena, 2014).

2.3.1 Orgin of silk

Silk fiber originates from the silkworm as a continuous protein filament. The silk worm as a means of self-protection spins a cocoon around its body by extruding the contents of two silk filaments through a spinner at its mouth. The two filaments solidify on coming in contact with air and form a composite thread. The filament is continuous and measures from 350 meters in Indian breeds of silkworm to 1800 meters or more in the Japanese varieties (Shabbir *et al.*, 2016)

2.3.2 History of Silk fabrics

Silk is a natural protein fiber produced by mulberry silkworm which is used for textile manufacturing. Silk fiber has a triangular prism-like structure which allows silk

cloth to refract incoming light at different angles and with that to produce different colors.

History of silk began in the 27th century BC in China where it remained as sole use until the commercial ways appeared from China to the Mediterranean Sea. There is also evidence of silk and silkworm cultivation of their own. In time Chinese lost their secret to the Koreans and later the Indians (Prayag, 2001).

2.3.2 Varieties of Silk

There are four different types of silk each of which is produced by a distinct variety of silkworm feeding on the leaves of certain plants. These are : (i) Mulberry silk (ii) Tasar silk (iii) Eri silk and (iv) Muga silk. India produces all the four varieties of silk and is the only country which produces the golden colored Muga silk of Assam. All the four species of silk have 4 stages in their life cycle namely, the egg, larva, pupa and moth (Mohd Yusuf *et al.*, 2013)

2.3.3 Physical properties of Silk

The physical properties of silk are,

Color: The color of silk fiber could be yellow, brown, green or grey.

Tensile Strength: Silk is a strong fiber. It has a tenacity of 3.5 – 5 gm/den. The strength is greatly affected by moisture; the wet strength of silk is 75 – 85%, which is higher than dry strength

Elongation at break: 20 - 25% at break.

Elastic Recovery: Not so good.

Specific Gravity: Specific gravity is 1.25 to 1.34.

Moisture Regain (MR%): Standard moisture regain is 11% but can absorb up to 35%.

Effect of Heat: Silk can withstand at higher temperatures than wool. It will remain unaffected for prolonged periods at 140 . Heat tends to encourage the decomposition of silk with atmospheric oxygen.

Luster: have excellent luster (ijarp.org).

2.3.4 Chemical Properties of Silk

Chemical properties of the silk fiber are given below:

Effect of Acids: The fibroin of silk can be decomposed by strong acids into its constituent amino acids. In moderate concentration, acids cause a contraction in silk. Dilute acids do not attack silk under mild conditions.

Effects of Alkalis: Silk is less readily damaged by alkalis than wool. Weak alkalis such as soap, borax and ammonia cause little appreciable damage. Silk dissolves in solutions like concentrated caustic alkalis.

Effect of Organic Solvent: Silk is insoluble in the dry-cleaning solvents in common use.

Effect of Insects: Insect does not affect silk.

Effect of Mildew: Silk is affected by mildew slightly (Mohammed *et al.*, 2015).

2.3.5 Uses of silk

Bulk of silk fibers produced is utilized in preparing silk clothes. Uses of pure silk are decreasing gradually due to its high cost and costly maintenance. Production of synthetic fibers has posed a serious threat to the silk fibers. So they are combined with other fibers natural and synthetic fibers are in great demand not only in India but also in foreign countries. Seeing this demand many textile industries are manufacturing clothes like Teri-silk, cot silk etc (Jian, 2010).

2.4 TURMERIC

Turmeric is a plant that has a very long history of medicinal use, dating back nearly 4000 years. In Southeast Asia, turmeric is used not only as a principal spice but also as a component in religious ceremonies. Because of its brilliant yellow color, turmeric is also known as “Indian saffron.” It is the most popular natural dye in textile dyeing (Kendall, 2001).

2.4.1 Properties and uses

Turmeric colorants are insoluble in water but water-soluble complex can be made by metal complexation. The curcuminoids are soluble in polar organic solvents but are

insoluble in non-polar solvents. Light absorption characteristics depend upon the solvent employed. They are soluble in aqueous alkaline solvents; however in alkali the colour shifts from yellow to red and brown red. Turmeric oleoresins and colorants are unstable to light and alkaline condition. Color and stability of curcuminoids are further affected by temperature, chemical oxidation, metal ions, enzymes and solvents. The alteration of color is most commonly due to degradation, although hue may also be affected by pH and metals. Poor stability of curcuminoids greatly limits their utilization as a food colorant. With emulsification turmeric colorants are used to color aqueous food stuff.

Complex formation with some cations or phosphorylation also increases the water solubility. They are gaining recognition for this antioxidant, anti-inflammatory, anti-carcinogen and antimicrobial properties.

The proportion of three different curcuminoids in turmeric colorants vary from source to source. Each of the curcuminoids has slightly different chemical properties. Among the three curcuminoids-curcumin predominates, and therefore properties of turmeric colorant preparation are usually similar to those of curcumin itself.

Turmeric is widely used in the food industry in canned product pickles, soups, mixes and confectionary. It is usual yellow colorant in mustard and pickled cauliflower.

A synthetic colorant having characteristics similar to curcuminoids is tartrazine. However tartrazine is water soluble and more stable as against curcuminoids.

Turmeric colorants dye wool, silk and unmordanted cotton with a yellow shade which has poor light fastness and alkali fastness. The substantive properties are to be explained by the close analogy with benzidine derivatives (Sekar., 2014).

2.5 BEETROOT

Beetroot (*Beta Vulgaris L.*) is a crop belonging to the Chenopodiaceae family having, bright crimson colour. It is famous for its juice value and medicinal properties; and known by several common names like beet, chard, spinach beet, sea beet, garden beet, white beet and Chukander (in Hindi). They will keep for 4-5 days when refrigerated in the vegetable crisper. Beets are used for bunched greens, bunched roots, and beetroots

and by processors for many products. Beetroots for processing and fresh markets are harvested mainly in September and October. A yield of 20,000 kg per hectare is possible (Beetroot, 1983).

2.5.1 Specifications of beetroot powder

1. Chemical/Physical Properties

- Color: Red to purple
- Specific Gravity: 0.7□0.8
- Color Intensity (O.D. @ 537 nm): 0.3□0.4
- Consistency: Free Flowing Powder;
- Solubility: All parts are soluble in water.

Microbiological Properties Standard Plate count/g, Max: 200 Yeast/g, Max: 5 Mold/g, Max: 5 E. coli/g; Nil Salmonella/25 g.

2. Packaging: 20 kg in HDPE drums or 15 kg in corrugated boxes.

3. Storage conditions: Protect from any exposure to air, light and heat. Do not freeze.

4. Shelf-life: Min 6 months (Khalida et al., 2016).

2.5.2 Uses of beetroot

Beetroot pigment is commonly used as a food dye. It changes color when heated so can only be used in ice-cream, sweets and other confectionary, but it is both cheap and has no known allergic side-effects.

There are nine other species in the *Beta genus* and also have the common name beet, although *Beta vulgaris* is the most well-known and commercially important beet (NRCS, 2006).

2.6 BLUE OXIDE

Ochre is the name given to a family of natural earth pigments containing iron oxide. The name is also loosely associated with any pigment that may be derived from basic processing by the crushing or grinding of minerals or mineral aggregate (rock and clay).

Natural earth pigments have formed an important part of the varied cultures of Australia's First People for as long as humans have walked the continent. The earliest confirmed example of ochre usage in Australia as both a form of ceremony and artistic expression is the ritual burial of a Koori Warrior known as 'Mungo man', at Lake Mungo in Mutti, Barkindji, and Ngiyampa country in south western New South Wales (indiamart.com).

2.6.1 History of blue oxide

It exhibits an intense dark blue masstone with a slight reddish blue undertone. Blue oxide has rarely been found on European easel paintings, but it has been identified in medieval paintings in Germany and in English medieval polychromy. The School of Cologne used it to depict skies in the 13th and 14th century,

2.6.2 Permanence and Compatibility

Blue oxide is recognized to generally be stable, but there have been instances where it was observed to alter from its blue hue to a yellow color. The mineral's color change from colorless to blue on initial exposure is due to increased ferric ion concentrations, and so it has been established that mechanical and chemical processing can produce a change in color (www.iconofile.com).

3. METHODOLOGY

The methodology pertaining to the study “**Self and Compound Shades of Turmeric, Beetroot and Blue Oxide on Cotton and Silk Fabrics**” is discussed under the following headings:

3.1 MATERIALS

3.1.1 Selection of natural dye sources

3.1.2 Selection of fabric

3.1.3 Selection of mordant

3.1.4 Selection of mordanting technique

3.2 NATURAL DYE EXTRACTION

3.2.1 Extraction of dye from selected sources

3.2.2 Extraction of mordant from harda

3.3 PREPARATORY PROCESS

3.3.1 Desizing of cotton

3.3.2 Bleaching of cotton

3.3.3 Degumming of Silk

3.3.4 Mordanting of cotton and silk

3.4 DYEING OF COTTON AND SILK

3.4.1 Self shade dyeing

3.4.2 Compound shade dyeing

3.5 FABRIC EVALUATION

3.5.1 Fabric thickness

3.5.2 Color strength

3.5.3 Color fastness tests

3.5.3.1 Washing fastness

3.5.3.2 Rubbing fastness

3.5.3.3 Pressing fastness

3.5.3.4 Sunlight fastness

3.5.4 Absorbency tests

3.5.4.1 Drop test

3.5.4.2 Sinking test

3.5.4.3 Wicking test

3.1 MATERIALS

3.1.1 Selection of natural dye sources

The natural dye sources selected for the present study are turmeric, beetroot and blue oxide.

TURMERIC (*Curcuma longa*)

Turmeric is a common spice and a major ingredient in curry powder (Plate – I). Its primary active substance is used to color foods and cosmetics. *Curcuma longa* Linn (Haldi) roots and tuber, was used for dye preparation which was collected from the local market. Fresh rhizomes of turmeric were washed and cleaned with distilled water. They were sliced and dried at 80 °C for one hour in a hot air oven. Dried rhizomes were grinded into powder using blender (Syafinar *et al.*, 2015).

BEETROOT (*Beta vulgaris*)

The Beetroot is the taproot portion of the beet plant (Plate – III). Beetroot is known by its red colour. This red color is because of the betanin pigment found in beetroot. The color responsible for the red hue of red beet juice is a group of molecules called Betalains (Nikhilesh *et al.*, 2015). *Beta vulgaris* was used for dye preparation which was collected from the vegetable market. Fresh beetroots were washed and cleaned with distilled water. Then peeled fresh beet roots were made into thin slices. The slices were dried in the sun covered with a net. Dried beetroot slices were grinded into powder with the help of blender (vegetablefacts.com).

BLUE OXIDE (Vivianite)

Blue Oxide is a rare mineral of hydrated iron phosphate that exhibits an intense dark blue color (Plate – V). It is found principally in two environments: In the oxidized upper layers of ore deposits, where it may appear as dark indigo, blue-black, or green crystals. It is also found in organic rich environments often lining the inside of ancient mollusk shells, but sometimes associated with bones, decaying wood and other organic material. It is generally stable and dark blue in color. This blue oxide pigment was purchased from the retail paint store (naturalpigments.com).

3.1.2 Selection of fabrics

Cotton fiber is obtained from the cotton plant. Cotton fabrics are extremely durable and resistant to abrasion. Cotton accepts many dyes and are usually washable, and can be ironed at relatively high temperature. Cotton is known for its versatility, performance and natural comfort. Plain weave is relatively inexpensive for construction and extensively used for cotton fabrics. They ravel out less than other weaves (Daberao *et al.*, 2016).

Silk is one of the popular fabrics for apparel because of its unique properties. Silk is most luxurious, comfortable and the most absorbent of fabrics (equal to wool). It is also a best fabric for drape, color, luster and finest “hand”. These are some of the factors which make the fabric more popular. The fabric is cool in summer and warm in winter (textilelearner.com).

Hence, pure 100% Cotton and Silk fabrics were selected for the present study and purchased from Coimbatore North Sarvodaya Sangh Khadi Gramodyog Bhavan, Coimbatore. The purchased cotton fabric has GSM of 100-150 and silk 50-100.

3.1.3 Selection of mordant

A mordant is a substance used to set dyes on fabric or tissue sections by forming a coordinating complex with the dye which then attaches to the fabric or tissue.

Harda (*Terminalia chebula*), which contains tannic acid, has traditionally been used in India as a vegetable mordant in the dyeing of cotton with natural dyes (Plate – VII). It is prepared from fruit of Harda. It yields yellow and grey shades with aluminium and ferrous mordants respectively. It has always been used as a primary component for cotton dyeing in India. Using higher percentage of harda yield a brownish yellow, while the lower percentage yield a light buff color. It is used for dyeing of wool and silk and cotton fiber base fabrics (researchgate.com).

Hence, harda powder was selected as a mordant for this study. The selected mordant powder was purchased from the herbal distributor.

3.1.4 Selection of mordanting technique

Three different mordanting methods were adopted, which are discussed below.

- ✓ **Pre-mordanting method:** Pre-mordanting, where the mordant is applied first, followed by dyeing.
- ✓ **Simultaneous-mordanting method:** Simultaneous mordanting, where mordant and dye are mixed together and applied.
- ✓ **Post-mordanting method:** Post-mordanting, where the dyeing is done first and then mordanting is carried out.

In this study, pre - mordanting method was found to be suitable for dyeing with selected sources. Hence pre-mordanting technique was carried out.

3.2 METHODS

3.2.1 Extraction of dye from selected dye sources

Five gram of each selected dye powder such as turmeric, beetroot and blue oxide was pasted with the little amount of water and then mixed with 100ml of water individually. The extractions were carried out at 100 °C for 20-30 minutes. The resulting liquid was filtered, centrifuged and made to original volume and used for dyeing (Plate – II, IV & VI).

3.2.2 Extraction of mordant from Harda

Five gram of mordant (harda) powder was pasted with the little amount of water and then mixed with 100ml of water. The extraction was carried out at 100 °C for 20-30 minutes. The resulting liquid was filtered, centrifuged and made to original volume and used for mordanting (Plate – VIII).



PLATE – I
Curcuma longa L (Turmeric)



PLATE - II
TURMERIC EXTRACT



PLATE – III
Beta vulgaris (Beetroot)



PLATE - IV
BEEETROOT EXTRACT



PLATE – V
BLUE OXIDE



PLATE – VI
BLUE OXIDE EXTRACT



PLATE – VII
HARDA



PLATE – VIII
HARDA EXTRACT

3.3 PREPARATORY PROCESS

The pre-treatment of the selected fabric includes the following

3.3.1 Desizing of cotton

Desizing is the process of removing starch materials present in the grey fabric. For cotton fabric, desizing was carried out with solution containing 2g/l of non-ionic detergent for 1hour. The desized material was thoroughly washed with tap water and dried at room temperature. It was soaked in distilled water prior to dyeing or mordanting.

3.3.2 Bleaching of cotton

After desizing, the material was used for bleaching. It is the process of removing natural coloring matters present in the cotton. Hydrogen peroxide is the best and most common used bleaching agent. In this study, bleaching process was carried with the help of hydrogen per oxide (1%). The material was boiled along with hydrogen per oxide solution at 90°C for 1hr. Then it is rinsed with cold water for about 3 to 5 times. Then the fabric was allowed to dry.

3.3.3 Degumming of silk

Degumming of silk involves the cleavage of peptide bonds of sericin (Ibrohin et al., 2007). Degumming is the essential step during which sericin is totally removed and silk fibers gain the typical shiny aspect soft handle and elegant drape highly appreciated by consumers (Freddi *et al.*, 2003). The method of degumming are classified according to the degumming alkaline degumming and degumming using synthetic detergents. But soap degumming is always highly practiced. The purchased fabric was degummed as per the method stated (Anandan *et al.*, 2006).

A clean stainless steel vessel was taken and to it 5 gram soap, 5 gram soda and 20 ml of H₂O₂ was added and mixed well. The liquor ratio was maintained as 1:20. Later the required amount of soft water was added and the fabric is immersed into this solution. The above solution was boiled for a period of 90 minutes based on the studies (Reddy and Krishnan, 2003) and the temperature was adjusted to 80-85 °C in a water bath. After

that the fabric was removed and washed with hot and cold water thrice, the fabric was dried in shade.

3.3.4 Mordanting of silk and cotton

The mordanting of cotton and silk fabric was carried out in dye bath keeping the liquor to material ratio as 30:1. The fabrics were introduced into the mordant solution (harda) at 95 °C for 60 minutes. After mordanting the fabric was squeezed and dyed using extracted natural dye.

3.4 DYEING OF COTTON AND SILK

Dyeing recipe for cotton and silk fabrics using the extracted natural dye are as follows.

Dye solution - 100ml

M:L:R - 1:30

Temperature - 100 °C

Time - 60min

3.4.1 Self shades on cotton and silk

For self-shades the pretreated and mordanted fabrics were dyed with each dye extract namely turmeric, beetroot and blue oxide separately following the above recipe.

The mordant fabrics were introduced into the dyebath and dyeing was carried out. Afterwards dyed samples were rinsed in cold water and air-dried at room temperature.

3.4.2 Compound shades on cotton and silk

For compound shade dyeing, the cotton and silk fabrics were dyed with mixture of 2 dyes i.e., Turmeric with Beetroot, Beetroot with Blue oxide, and Blue oxide with Turmeric.

The mordanted fabrics were dyed using combination of two dyes i.e., turmeric and beetroot, beetroot and blue oxide, blue oxide and turmeric taken in proportion 30:70,

50:50 and 70:30. The mordanted fabrics were introduced into the dyebath and dyeing was carried out. After dyeing, the dyed material was washed with cold water and dried at room temperature.

To determine the efficiency of mordant, dyeing was done without mordant.

3.5 FABRIC EVALUTION

3.5.1 Fabric thickness

Thickness is a parameter of a fabric which controls handle, creasing, thermal resistance, heaviness or stiffness in use and many other properties of fabric. The principle of the measurement of fabric thickness is expressed in B.S. Hand book as follows. “Essentially, the determination of the thickness of a compressible material such as a textile fabric consists of the precise measurement of the distance between two planes parallel plates when they are separated by the cloth, a known arbitrary pressure between the plates are applied and maintained. It is convenient to regard one of the plates as the pressure foot and the other as the anvil” (textilestudycenter.com).

Fabric thickness is defined as the distance between the upper and lower surface of the material when measured under a standard pressure using the Shirley’s Thickness Tester (Plate – IX) with an accuracy of 0.01mm as explained by Stoker et al., 2005. The fabric was placed between the pressure foot and anvil the reading was noted from the dial. Minimum three readings were taken from different places of original and dyed fabrics. The mean value was calculated and recorded (Chavan *et al.*, 2015).

3.5.2 Color strength

The color yield of both dyed and mordanted samples were evaluated by light reflectance measurements using Premier Colorscan machine (Plate – X). The color strength (K/S value) was assessed using the Kubelka-Munk equation

$$K/S = (1-R)^2/2R$$

Where K is the sorption coefficient, R is the reflectance of the dyed fabric and S is the scattering coefficient.

Dyed fabrics were simultaneously evaluated in terms of CIELAB color space (L^* , a^* and b^*) values. In general, the higher the K/S value, the higher the depth of the colour on the fabric. L^* corresponding to the brightness (100=white, 0=black), a^* to the red-green coordinate (+ve=red, -=yellow, -ve=blue). As a whole, a combination of all these parameters enables one to understand the tonal variations (Bhardwai *et al.*, 2017).

3.5.3 COLOUR FASTNESS TESTS

3.5.3.1 Washing Fastness

To test for fastness for washing the sample is twisted together with an equal quantity of white cloth and soaked in a natural solution of soap and water at temperature of 50 °C for about twenty minutes in Rota dyer (Plate – XI). The sample is then squeezed out and dried. If the color is fast to washing it should be unchanged after this test. Moreover, the color should not have bled into the white cloth, which should be unmarked. The undyed samples were evaluated on the respective standard scales (rating 1:5; where 1: poor; 2: fair; 3: good; 4: very good and 5: excellent). (Teli et al., 2012)

3.5.3.2 Rubbing fastness

The rub fastness of the dyed fabric was carried out by rubbing the fabrics manually and checking for fading of color by using Crock meter (textilemate.com).

Dry and wet crock test was carried out with dry and wet rubbing clothes respectively using SASMIRA Crock Meter (Plate - .XII). Each dyed sample was cut to a size of 10 cm long and mounted on a flat base of the crock meter. A square white material was wrapped around the rubbing finger and hand in position with the ring. Each sample was given twenty rubs. The white square cloth was removed from the rubbing finger of the crock meter and the color transfer was assessed using the grey scale. Similarly a damp white material was wrapped for wet crocking. The staining on the white fabric, both in wet and dry condition was noted using grey scale.

3.5.3.3 Pressing fastness

The dyed sample should be covered with two pieces of thin bleached and unfinished cotton cloth damped with boiling water. It should then be ironed out with iron

hot enough to singe wool. The iron should be used until the covering cloth is dry. The ironed portion should be compared with original cloth and in addition, the white covering cloth should be inspected for any indication of bleeding (Gyanendra *et al.*, 2015).

3.5.3.4 Sunlight fastness

The purpose of color fastness to light test is to determine how much the color will fade when exposed to a known light source (textilelearner.com). This test measures the resistance to fading of dyed textile when exposed to sunlight for a certain time which about 24 hours to 72 hours and compare the change with original unexpected sample the changes are assessed by grey scales (Plate – XIII).

3.5.4 Absorbency test

3.5.4.1 Drop test

Test method: AATCC Test Method TS-018

This test method is designed to measure the water absorbency of textiles by measuring the time it takes a drop of water placed on the fabric surface to be completely absorbed into the fabric. Sample is placed over the top of a beaker so that the center is unsupported. A measured drop of water is placed on the fabric 1 cm from the surface (Plate – XIV). Time is recorded until the water drop absorbs completely (nptel.com).

3.5.4.2 Sinking test

The pressure required to force-water through a fabric may be determined and by the information used is the assessment of the fabric ability to do a particular job. This involves a simple test of wettability of fabric. In this test, a small square specimen about 1×1 inch is cut and drape it to the surface of water in a beaker (Plate – XV). The time taken for the specimen to sink below the surface is observed. The shorter the time, the greater the wettability.

3.5.4.3 Wicking test

The wicking or capillary travel method measures the rapidity of absorption. 5 pieces of sample were cut measuring 15 cm length and 2.5 cm width. One end of the

sample strip was pasted with a glass rod which was placed on heavy wooden blocks and at the other end two grams weight was attached to keep the sample straight (Plate – XVI). At the weighed end 2 cm of the sample was allowed to immerse in a tray of distilled water. The rise of the water level in the strip was noted by keeping time as constant (1 minute). The same procedure was repeated for other samples and the mean value was calculated and recorded. (Gulrajini, 2001).



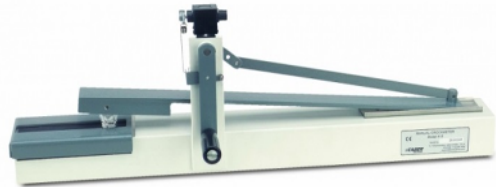
**PLATE- IX
THICKNESS GAUGE**



**PLATE - X
PREMIER COLORSCAN
SPECTROMETER**



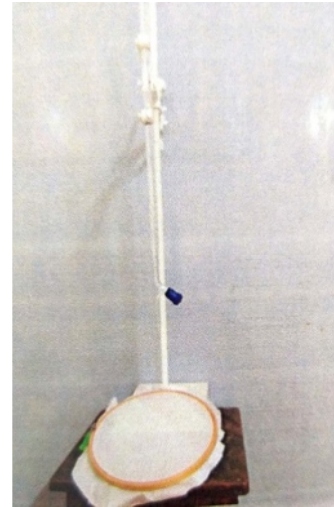
**PLATE - XI
ROTA DYER**



**PLATE - XII
CROCKMETER**



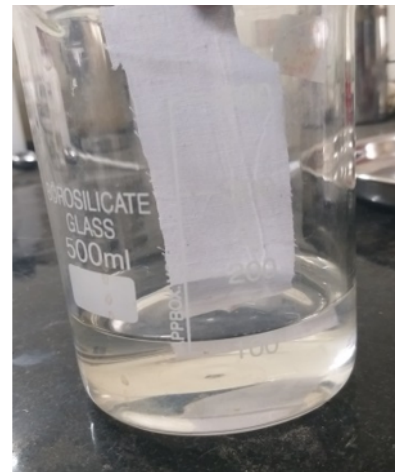
**PLATE – XIII
GREY SCALE**



**PLATE – XIV
DROP TEST**



**PLATE - XV
SINKING TEST**



**PLATE - XVI
WICKING TEST**

TABLE – I

NOMENCLATURE OF THE SAMPLE

S.No	Nomenclature of the Sample	Details of the Sample
1	OC	Original Cotton
2.	OS	Original Silk
3.	TM	Turmeric
4.	BR	Beetroot
5.	BO	Blue Oxide
6.	MT	Mordant Technique
7.	UM	Unmordant
8.	M	Mordant
9.	FS	Fabric Shades

4. RESULTS AND DISCUSSION

The results and discussion of the research work entitled “**Self and Compound Shades of Turmeric, Beetroot and Blue Oxide on Cotton and Silk Fabrics**” is presented under the following headings:

4.1 Evaluation of dyed fabrics

4.1.2 Fabric thickness

4.1.3 Colour strength

4.1.1 COLOR FASTNESS TESTS

4.1.1.1 Washing fastness

4.1.1.2 Rubbing fastness

4.1.1.3 Pressing fastness

4.1.1.4 Sunlight fastness

4.1.2 ABSORBENCY TEST

4.1.2.1 Drop test

4.1.2.2 Sinking test

4.1.2.3 Wicking test

4.1 EVALUATION OF DYED FABRICS

The dyed fabrics were analyzed for thickness, color strength, colorfastness and absorbency properties.

4.1.1 FABRIC THICKNESS

The fabrics thickness of the self and compound shades of dyed cotton and silk fabric were determined and results are presented in Table II, III, IV and V.

TABLE – II

FABRIC THICKNESS OF SELF SHADE COTTON FABRICS

S.No	Samples		Mean (mm)	Loss or gain	Percentage
1.	OC		0.30	-	-
2.	TM	UM	0.34	0.04	13
		M	0.40	0.10	33
3.	BT	UM	0.33	0.03	10
		M	0.38	0.08	27
4.	BO	UM	0.35	0.05	17
		M	0.39	0.09	30

TABLE - III

FABRIC THICKNESS SELF SHADE SILK FABRICS

S.No	Samples		Mean (mm)	Loss or gain	Percentage
1.	OS		0.09	-	-
2.	TM	UM	0.11	0.02	22
		M	0.13	0.04	44
3.	BT	UM	0.12	0.03	33
		M	0.14	0.05	56
4.	BO	UM	0.15	0.06	66
		M	0.17	0.07	77

From the Table II and III, it is clear that the fabric thickness increased in all the dyed fabric samples. In cotton, fabric thickness was found to be maximum (33%) in Harda pre-mordanted fabric dyed with turmeric. In silk, the maximum (56%) increased was found beetroot mordanted dyed sample when compared to unmordanted.

The increase in fabric thickness in mordanted sample might be done to increased uptake of dye entered by mordant. Hence it could be concluded that mordanting increased the thickness of the fabric.

TABLE - IV
FABRIC THICKNESS OF COMPOUND SHADE COTTON FABRICS

S.No	Samples			Mean (mm)	Loss or gain	Percentage
	OC					
1.	TM	BR	MT			
	30%	70%	UM	0.37	0.07	23
			M	0.42	0.12	40
	50%	50%	UM	0.41	0.11	36
			M	0.39	0.09	30
	70%	30%	UM	0.45	0.15	50
		M	0.39	0.09	30	
2.	BR	BO	MT			
	30%	70%	UM	0.45	0.15	50
			M	0.41	0.11	36
	50%	50%	UM	0.44	0.14	46
			M	0.42	0.12	40
	70%	30%	UM	0.44	0.14	46
		M	0.35	0.05	16	
3.	BO	TM	MT			
	30%	70%	UM	0.40	0.10	33
			M	0.35	0.05	16
	50%	50%	UM	0.40	0.10	33
			M	0.45	0.15	50
	70%	30%	UM	0.40	0.10	33
		M	0.41	0.11	36	

From Table IV, it is clear that the compound shade of cotton has increased the thickness of all the fabric, when compared to their original fabric. In turmeric and

beetroot combination, the fabric dyed with 30:70 ratio of mordanted dyed sample was found to be show maximum (40%) increase in thickness when compared to other ratios. In Beetroot and Blue oxide combination, 30:70 ratio of unmordanted dyed sample was found to be maximum (50%) increase in thickness when compared to other ratios. In Blue Oxide and Turmeric combination, 50:50 ratio of mordanted dyed sample increased (50%) in thickness when compared to other ratios.

TABLE - V

FABRIC THICKNESS OF COMPOUND SHADE SILK FABRICS

S.No	Samples			Mean (mm)	Loss or gain	Percentage
	OS			0.09	-	-
1.	TM	BR	MT			
	30%	70%	UM	0.11	0.02	22
			M	0.12	0.03	33
	50%	50%	UM	0.10	0.01	11
			M	0.13	0.04	44
	70%	30%	UM	0.10	0.01	11
M			0.11	0.02	22	
2.	BR	BO	MT			
	30%	70%	UM	0.11	0.02	22
			M	0.12	0.03	33
	50%	50%	UM	0.11	0.02	22
			M	0.14	0.05	56
	70%	30%	UM	0.12	0.03	33
M			0.15	0.06	67	
3.	BO	TM	MT			
	30%	70%	UM	0.11	0.02	22
			M	0.11	0.02	22
	50%	50%	UM	0.12	0.03	33
			M	0.12	0.03	33
	70%	30%	UM	0.11	0.02	22
M			0.14	0.05	56	

From Table V, it is clear that the compound shades of silk have increased the thickness of all the fabric, when compared to their original fabric. In Turmeric and Beetroot combination, the fabric dyed with 30:70 ratio of mordanted dyed sample was found to show maximum (44%) increase in thickness when compared to other ratios. In Beetroot and Blue Oxide combination, 50:50 ratio of mordanted dyed sample was found to show maximum (56%) increase in thickness when compared to other ratios. In Blue Oxide and Turmeric combination, 70:30 ratio of mordanted dyed sample was found to maximum (56%) increase in thickness when compared to other ratios.

The increase in fabric thickness in mordanted sample might be done to increased uptake of dye entered by mordant. Hence it could be concluded that mordanting increased the thickness of the fabric.

4.1.2 COLOR STRENGTH

The color strength of self and compound shades of dyed cotton and silk fabric samples were shown in the Table – VI, VII, VIII and IX.

TABLE – VI
COLOR STRENGTH OF COTTON FABRICS (Self Shade)













S.No	Samples(C)	K/S	L*	a*	b*	FS	
1.	TM	UM	33.167	71.189	1.791	54.830	
		M	63.913	71.010	3.048	71.771	
2.	BR	UM	21.641	57.483	-14.128	-24.249	
		M	28.838	54.913	-13.670	5.275	
3.	BO	UM	15.589	61.716	10.271	7.566	
		M	25.395	58.184	11.159	17.578	

TABLE – VII
COLOR STRENGTH OF SILK FABRICS (Self Shade)

S.No	Samples (Silk)		K/S	L*	a*	b*	FS
1.	TM	UM	121.054	66.729	3.344	76.232	
		M	163.039	65.249	1.669	70.379	
2.	BR	UM	12.740	64.495	5.233	7.177	
		M	29.845	58.910	9.098	25.453	
3.	BO	UM	14.572	61.773	-11.146	-12.082	
		M	22.497	59.588	-12.324	8.917	

In general, the higher the K/S value, the higher the depth of the color on the fabric. From Table VI and VII, the result clearly indicates that the color strength of the mordanted dyed sample was found to be higher when compared to unmordanted sample. In both cotton and silk self-shade, turmeric was found to show higher color strength when compared to Beetroot and Blue Oxide. In color co-ordinates, decreasing L* values means shades becoming deeper. Also b* values increased indicates lowering of blueness and increasing of yellowness.

TABLE - VIII

COLOR STRENGTH OF COTTON FABRICS (Compound Shade)

S.NO	Samples		MT	COLOR VALUE	CIE color co-ordinates			FS
	TM	BR		K/S	L*	a*	b*	
1.	30%	70%	UM	46.880	66.685	5.995	55.407	
			M	63.916	62.739	7.847	56.321	
	50%	50%	UM	62.736	69.790	10.140	50.081	
			M	78.016	63.960	11.660	61.542	
	70%	30%	UM	61.325	61.961	12.965	51.990	
			M	97.053	60.613	12.442	63.854	
2.	BR	BO	MT	K/S	L*	a*	b*	
	30%	70%	UM	22.130	57.579	-15.125	0.834	
			M	23.234	56.822	-8.258	3.589	
	50%	50%	UM	14.928	64.050	-9.757	9.327	
			M	18.352	57.689	-0.119	-3.095	
	70%	30%	UM	16.335	63.396	-0.370	-2.798	
M			19.234	61.827	-9.239	14.861		
3.	BO	TM	MT	K/S	L*	a*	b*	
	30%	70%	UM	55.904	62.399	-16.486	33.393	
			M	73.626	61.033	3.369	56.128	
	50%	50%	UM	60.111	57.833	-5.531	2.315	
			M	69.121	56.018	-9.465	45.608	
	70%	30%	UM	67.964	53.721	-13.487	38.233	
M			84.666	52.467	-1.022	43.290		

From Table VIII, it is clear that the color strength of all the compound shades cotton has increased. when compared to their original fabric. In Turmeric and Beetroot

combination, 70:30 ratio was found to produce maximum increase in color strength when compared to other ratios. In Beetroot and Blue Oxide combination, 30:70 ratio showed increased color strength when compared to other ratios. In Blue Oxide and Turmeric combination 70:30 ratio showed maximum increase in color strength when compared to other ratios.

TABLE - IX
COLOR STRENGTH OF SILK FABRICS (Compound Shade)

S.NO	DYE		MT	COLOR VALUE	CIE colour co-ordinates			FS
	TM	BR		K/S	L*	a*	b*	
1.	30%	70%	UM	98.999	63.225	2.469	65.516	
			M	111.593	60.542	4.364	64.180	
	50%	50%	UM	104.457	64.833	2.859	70.063	
			M	117.485	62.859	4.185	69.015	
	70%	30%	UM	107.040	62.751	4.408	66.920	
			M	112.079	64.886	4.892	72.040	
2.	30%	70%	UM	12.473	65.729	-10.387	4.698	
			M	23.896	59.047	-5.492	13.857	
	50%	50%	UM	12.999	64.170	-9.821	-0.391	
			M	29.198	56.477	-1.820	16.571	
	70%	30%	UM	11.843	65.313	-7.406	1.145	
			M	22119	59.911	-3.437	13.729	
3.	30%	70%	UM	76.107	58.649	-14.397	48.451	
			M	113.424	56.838	4.008	58.589	
	50%	50%	UM	85.289	62.383	-12.309	58.266	
			M	103.579	56.679	0.036	55.698	
	70%	30%	UM	87.895	58.863	-7.322	54.365	
			M	100.983	54.361	-4.018	50.644	

From Table IX, it is clear that the color strength of all the compound shades silk has increased, when compared to their original fabric. In Turmeric and Beetroot combination, 50:50 ratio was found to produce maximum increase in color strength when compared to other ratios. In Beetroot and Blue Oxide combination, 30:70 ratio showed increased color strength when compared to other ratios. In Blue Oxide and Turmeric combination, 30:70 ratio showed increased in color strength when compared to other ratios.

Hence it could be concluded that the color strength of mordanted dyed samples was high when compared to unmordanted samples.

4.1.3 COLOR FASTNESS TESTS

The dyed fabrics were subjected to colorfastness test such as washing, rubbing, pressing and light fastness.

4.1.3.1 WASHING FASTNESS

The dyed fabrics were analysed for colorfastness to washing and the results are presented in Table – X and XI

TABLE - X
COLOR FASTNESS TO WASHING (Self shade fabrics)

S.No	Samples		Color change	
			Cotton	Silk
1.	TM	UM	4	4-5
		M	5	5
2.	BR	UM	4	4
		M	4-5	4-5
3.	BO	UM	4	3-4
		M	4	4

5 – Excellent; 4 – Very Good

TABLE - XI**COLOR FASTNESS TO WASHING (Compound shade fabrics)**

S.NO	DYE		MT	Color change	
				Cotton	Silk
1.	TURMERIC	BEETROOT			
	30%	70%	UM	4	4
			M	4-5	5
	50%	50%	UM	4	4
			M	5	5
	70%	30%	UM	4	4
		M	4	5	
2.	BEETROOT	BLUE OXIDE	MT		
	30%	70%	UM	3-4	4
			M	4-5	5
	50%	50%	UM	3-4	3-4
			M	4	4-5
	70%	30%	UM	3-4	4
		M	4	4	
3.	BLUE OXIDE	TURMERIC	MT		
	30%	70%	UM	4	4-5
			M	4-5	5
	50%	50%	UM	4	5
			M	5	5
	70%	30%	UM	4	4-5
		M	4-5	5	

From Table X and XI, it is evident that all self and compound shade mordanting dyed samples showed very good and excellent fastness to washing. In Turmeric and Beetroot combination, the fabric dyed with 50:50 ratio was found to showed good fastness to washing when compared to other ratios. In Beetroot and Blue Oxide combination, the fabric dyed with 30:70 ratio was found to showed good fastness to washing when compared to other ratios. In Blue Oxide and Turmeric combination, the fabric dyed with 50:50 ratio was found to showed good fastness to washing to other ratios.

Hence it could be concluded that, pre-mordanted cotton and silk samples showed excellent color fastness to washing.

4.1.3.2 RUBBING FASTNESS

The dyed fabrics were analysed for colorfastness to rubbing and the results are presented in Table – XII and XIII

TABLE - XII
COLORFASTNESS TO RUBBING (Self shade fabrics)

S.NO	Samples		COLOR STAIN			
			Cotton		Silk	
			Dry	Wet	Dry	Wet
1.	TM	UM	5	4-5	4-5	5
		M	5	5	5	5
2.	BR	UM	4-5	4	4-5	4
		M	5	4-5	5	4-5
3.	BO	UM	4-5	4	4-5	4-5
		M	5	4-5	5	5

TABLE - XIII
COLOR FASTNESS TO RUBBING (Compound shade fabrics)

S.NO	DYE		MT	COLOR STAIN			
				Cotton		Silk	
	TM	BR		Dry	Wet	Dry	Wet
1.	30%	70%	UM	4	4	4-5	4-5
			M	4-5	4-5	5	5
	50%	50%	UM	4-5	4	5	5
			M	4-5	4-5	5	5
	70%	30%	UM	4	4	4	4-5
			M	4	4-5	4	4-5
2.	30%	70%	MT				
			UM	4-5	4	4-5	4
	M	4-5	4	5	4-5		
	50%	50%	UM	4	4	5	5
			M	5	4	5	5
	70%	30%	UM	4-5	4	5	4
M			4-5	4	5	4	
3.	30%	70%	MT				
			UM	5	4-5	5	4-5
	M	5	5	5	5		
	50%	50%	UM	4-5	5	5	5
			M	5	5	5	5
	70%	30%	UM	5	5	5	4-5
M			5	5	5	5	

From Table XII and XIII, it is evident that all self and compound shades of cotton and silk dyed samples showed good fastness to rubbing. In Turmeric and Beetroot combination, both 30:70 and 50:50 ratios of dyed sample showed good fastness to rubbing when compared to 70:30 ratio. In Beetroot and Blue Oxide combination 50:50 ratio of dyed sample showed good fastness to rubbing when compared to other ratios. In Blue Oxide and Turmeric combination, all ratios of dyed sample showed good fastness to rubbing.

Hence it could be concluded that, pre-mordanting cotton and silk dyed samples showed excellent color fastness to rubbing.

4.1.3.3 PRESSING FASTNESS

The dyed fabrics were analysed for colorfastness to pressing and the results are presented in Table – XIV and XV

TABLE - XIV

COLOR FASTNESS TO PRESSING (Self shade fabrics)

S.NO	Samples		COLOR CHANGE	
			Cotton	Silk
1.	TR	UM	3-4	4
		M	4-5	5
2.	BR	UM	4	4
		M	4-5	4-5
3.	BO	UM	4	4
		M	4-5	4-5

TABLE - XV
COLORFASTNESS TO PRESSING (Compound shade fabrics)

S.NO	SAMPLES		MT	Color change	
	TM	BR		Cotton	Silk
1.	30%	70%	UM	4	4-5
			M	4-5	5
	50%	50%	UM	4-5	5
			M	5	5
	70%	30%	UM	4	4-5
			M	4-5	5
2.	BR	BO	MT		
			UM	4	4
	30%	70%	M	4	4-5
			UM	4	4-5
	50%	50%	M	4-5	5
			UM	4	4-5
70%	30%	M	4	5	
		UM	4	4-5	
3.	BO	TM	MT		
			UM	4	4-5
	30%	70%	M	4	5
			UM	4-5	5
	50%	50%	M	5	5
			UM	4	4-5
70%	30%	M	4-5	5	
		UM	4	4-5	

From Table XIV and XV, it is evident that all self and compound shades of cotton and silk dyed samples showed good fastness to pressing. In all the combinations, 50:50 ratio of dyed sample showed good fastness to pressing when compared to other ratios. Hence it could be concluded that, cotton and silk dyed sample showed excellent color fastness when compared between unmordanted and mordanted samples.

4.1.3.4 SUNLIGHT FASTNESS

The dyed fabrics were analysed for colorfastness to sunlight and the results are presented in Table – XVI and XVII

TABLE - XVI

COLORFASTNESS TO SUNLIGHT (Self shade fabrics)

	Samples		Color change	
			Cotton	Silk
1.	TR	UM	5	5
		M	5	5
2.	BR	UM	4	4-5
		M	4	4-5
3.	BO	UM	4-5	5
		M	4-5	5

TABLE – XVII
COLORFASTNESS TO SUNLIGHT (Compound shade fabrics)

S.No	Samples		MT	Color change	
	TM	BR		Cotton	Silk
1.	30%	70%	UM	4-5	4-5
			M	4-5	5
	50%	50%	UM	5	4-5
			M	5	5
	70%	30%	UM	4-5	4-5
			M	5	5
2.	BR	BO	MT		
			UM	4-5	4-5
	30%	70%	M	5	5
			UM	4	4-5
	50%	50%	M	5	5
			UM	4-5	4-5
70%	30%	M	5	5	
		UM	4-5	4-5	
3.	BO	TM	MT		
			UM	4	4-5
	30%	70%	M	4-5	5
			UM	4-5	5
	50%	50%	M	5	5
			UM	4-5	4-5
70%	30%	M	4-5	5	
		UM	4-5	4-5	

From Table XVI and XVII, it is evident that all self and compound shades of cotton and silk dyed samples showed good fastness to sunlight. In Turmeric and Beetroot combination, both 50:50 and 70:30 of dyed samples showed good fastness to sunlight when compared to 30:70 ratio. In Beetroot and Blue Oxide combination, all the ratio of dyed sample showed good fastness to sunlight. In Blue Oxide and Turmeric combination, 50:50 ratio of dyed sample showed good fastness to sunlight to other ratio.

Hence it could be concluded that, pre-mordanting cotton and silk dyed samples showed excellent color fastness to sunlight.

4.1.3 ABSORBENCY TEST

To assess the fabric absorbency drop test, sinking test and wicking test were carried out and results are presented in tables.

4.1.3.1 DROP TEST

The dyed fabrics were analysed for drop test and results are presented in Table – XVIII and XIX

TABLE - XVIII
DROP TEST (Self shade fabrics)

S.No	Samples		Mean (seconds)		Loss or gain		Percentage	
			C	S	C	S	C	S
1.	OC - 54 OS - 45		-	-	-	-	-	-
2.	TM	UM	2	2	52	43	96	95
		M	1	1	53	44	98	97
3.	BT	UM	2	2	52	43	96	95
		M	1	1	51	44	98	97
4.	BO	UM	2	2	52	43	96	95
		M	1	1	51	44	98	97

TABLE - XIX**DROP TEST (Compound shade fabrics)**

S.No	Samples			Mean (seconds)		Loss or gain		Percentage	
	OC – 54		OC – 45	-		-		-	
	TR	BR	MT	C	S	C	S	C	S
1.	30%	70%	UM	2	2	52	43	96	95
			M	1	1	53	44	98	97
	50%	50%	UM	2	2	52	43	96	95
			M	1	1	51	44	98	97
	70%	30%	UM	2	2	52	43	96	95
			M	1	1	51	44	98	97
2.	BR	BO	MT						
	30%	70%	UM	2	2	52	43	96	95
			M	1	1	53	44	98	97
	50%	50%	UM	2	2	52	43	96	95
			M	1	1	51	44	98	97
	70%	30%	UM	2	2	52	43	96	95
M			1	1	51	44	98	97	
3.	BO	TR	MT						
	30%	70%	UM	2	2	52	43	96	95
			M	1	1	53	44	98	97
	50%	50%	UM	2	2	52	43	96	95
			M	1	1	51	44	98	97
	70%	30%	UM	2	2	52	43	96	95
M			1	1	51	44	98	97	

From Table XVIII and XIX, it is clear that the time taken by the dyed UM and M cotton and silk samples to absorb one drop of water is less when compared to original. Hence it could be concluded that absorbency of the fabric, increased in all the samples irrespective of mordanting.

4.1.3.2 SINKING TEST

The dyed fabrics were analysed for sinking test and results are presented in Table – XX and XXI

TABLE – XX

SINKING TEST (Self shade fabrics)

S.No	Samples		Cotton		Silk	
			Mean (sec)	%(Loss or Gain)	Mean (sec)	%(Loss or Gain)
1.	Original fabric		35	-	28	-
2.	TR	UM	5	85	3	89
		M	4	88	2	92
3.	BR	UM	5	85	3	89
		M	4	88	2	92
4.	BO	UM	5	85	3	89
		M	4	88	2	92

TABLE - XXI

SINKING TEST (Compound shade fabrics)

S.NO	Samples			% (Loss or Gain)			
	OC – 35	OS – 28		Cotton		Silk	
2.	TR	BR	MT				
	30%	70%	UM	5	85	3	89
			M	4	88	2	92
	50%	50%	UM	5	85	3	89
			M	4	88	2	92
	70%	30%	UM	5	85	3	89
		M	4	88	2	92	
3.	BR	BO	MT				
	30%	70%	UM	5	85	3	89
			M	4	88	2	92
	50%	50%	UM	5	85	3	89
			M	4	88	2	92
	70%	30%	UM	5	85	3	89
		M	4	88	2	92	
4.	BO	TR	MT				
	30%	70%	UM	5	85	3	89
			M	4	88	2	92
	50%	50%	UM	5	85	3	89
			M	4	88	2	92
	70%	30%	UM	5	85	3	89
		M	4	88	2	92	

From Table XX and XXI, it is clear that the time taken for sinking of the dyed cotton and silk samples decreased when compared to the original fabrics. The minimum time taken is 5 seconds by the unmordanted samples and 4 seconds by the pre-mordanted samples. Hence it could be concluded that dyeing resulted in increased absorbency of the fabric.

4.1.3.3 WICKING TEST

The dyed fabrics were analysed for wicking test and results are presented in Table – XXII and XXIII

TABLE - XXII
WICKING TEST (Self shade fabrics)

S.No	Samples		Cotton		Silk	
			Mean (cm/min)	Loss or Gain	Mean (cm/min)	Loss or Gain
1.	OC-1.90 OS-1.50		-	-	-	-
2.	TR	UM	1.74	0.16	1.45	0.05
		M	1.70	0.20	1.40	0.10
3.	BR	UM	1.74	0.16	1.45	0.05
		M	1.70	0.20	1.40	0.10
4.	BO	UM	1.74	0.16	1.45	0.05
		M	1.70	0.20	1.40	0.10

TABLE – XXIII**WICKING TEST (Compound shade fabrics)**

S.NO	Samples			Cotton		Silk	
	TR	BR	MT	Mean (cm/min)	Loss or gain	Mean (cm/min)	Loss or gain
1.	OC – 55 OS –46						
2.							
	30%	70%	UM	1.74	0.16	1.45	0.05
			M	1.70	0.20	1.40	0.10
	50%	50%	UM	1.74	0.16	1.45	0.05
			M	1.70	0.20	1.40	0.10
	70%	30%	UM	1.74	0.16	1.45	0.05
			M	1.70	0.20	1.40	0.10
3.	BR	BO	MT				
	30%	70%	UM	1.74	0.16	1.45	0.05
			M	1.70	0.20	1.40	0.10
	50%	50%	UM	1.74	0.16	1.45	0.05
			M	1.70	0.20	1.40	0.10
	70%	30%	UM	1.74	0.16	1.45	0.05
			M	1.70	0.20	1.40	0.10
4.	BO	TR	MT				
	30%	70%	UM	1.74	0.16	1.45	0.05
			M	1.70	0.20	1.40	0.10
	50%	50%	UM	1.74	0.16	1.45	0.05
			M	1.70	0.20	1.40	0.10
	70%	30%	UM	1.74	0.16	1.45	0.05
			M	1.70	0.20	1.40	0.10

From Table XXII and XXIII, it is clear that the time taken for wicking of the dyed cotton and silk samples decreased when compared to the original fabrics. The minimum time taken is 1.74 minutes by the unmordanted samples and 1.70 minutes by the pre- mordanted samples. Hence it could be concluded that dyed samples increased the absorbency of the fabric.

5. SUMMARY AND CONCLUSION

The globalization of markets and increasing demand for products has created a deep interest in the use of raw materials from natural resources. Consumer awareness in the matters of environmental and health problems has a direct bearing on textiles and clothing. Organic awareness and environmental consciousness of consumers have revived the interest on natural dyed textiles. The major advantages of natural dyes are that they are biodegradable, non-carcinogenic, non-mutagenic and color soothing to human eyes. Dyeing with natural dyes can be a way of value addition to the textile products.

In the present study, colorants extracted from turmeric, beetroot and blue oxide have been chosen for its dyeability. The colored constituents of these natural dyes possess properties which find good application in textile industry. The cotton and silk fabric dyed with turmeric, beetroot and blue oxide imparts beautiful shades and fastness properties. Lot of research has been carried out on natural dyeing of textiles fibers using variety of natural dyes and mordants, the area mixing of natural dyes to get different shades is still remained unexplored.

Hence the present study **“SELF AND COMPOUND SHADES OF TURMERRIC, BEETROOT AND BLUE OXIDE ON COTTON AND SILK FABRICS”** was carried out with the following objectives:

- To extract dye from turmeric, beetroot and blue oxide
- To dye cotton and silk fabrics with self and combination method using harda as mordant
- To select suitable proportion of dye mixtures
- To evaluate and compare the color strength of mordanted and unmordanted fabrics.

METHODOLOGY ADOPTED

Natural dye was extracted from turmeric, beetroot and blue oxide by conventional method. Cotton and silk fabrics were selected with self and compound shades with different ratios. For self-shade the selected cotton and silk fabrics were dyed separately with the selected natural dye extracts at 100 °C for 60 minutes, with material liquor ratio of 1:30. For compound shade, the selected cotton and silk fabrics were dyed using combination of two dyes taken in proportion 30:70, 50:50 and 70:30 at 100 °C for 60 minutes, with material liquor ratio of 1:30. The dyed mordant and unmordant fabrics were evaluated and compared. Pre-mordanted dyed fabrics were evaluated for physical, comfort, color fastness and absorbency properties.

FINDINGS

- Pre-mordanting technique was found to be suitable mordanting technique for both self and compound shade dyeing
- Turmeric, beetroot and blue oxide at a concentration of 5 per cent was found to be the optimum concentration for dye extraction
- A contact time of 60 minutes resulted in maximum dye extraction
- Dye extraction was found to be maximum at 100°C
- The mass liquor ratio selected was 1:30
- Fabric thickness was found to be increased in all the dyed samples mordanted with harda when compared to unmordanted samples
- All the dyed samples exhibited good to excellent color fastness to washing, rubbing, pressing and sunlight
- Absorbency of all the cotton and silk dyed fabrics were found to be increased when compared to original samples
- Color strength of cotton and silk dyed fabrics were found to be increased in mordanted samples when compared to unmordanted sample

CONCLUSION

The result of this study proved that the fabrics dyed with two color combination natural dyes can be successfully used for dyeing cotton and silk fabric to obtain wide range of bright colors. The fastness properties seemed to have remained unchanged with the use of combination of dyes. Major advantage in this dyeing is being eco-friendly and can help to minimize the problems of effluents from synthetic dyes. As textile industry is looking for more and more sustainable solutions for dyeing techniques, use of natural dyes in combination with natural in combination mordants is going to be promising in near future.

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APPANDIX - I

SELF SHADE FABRICS

TURMERIC

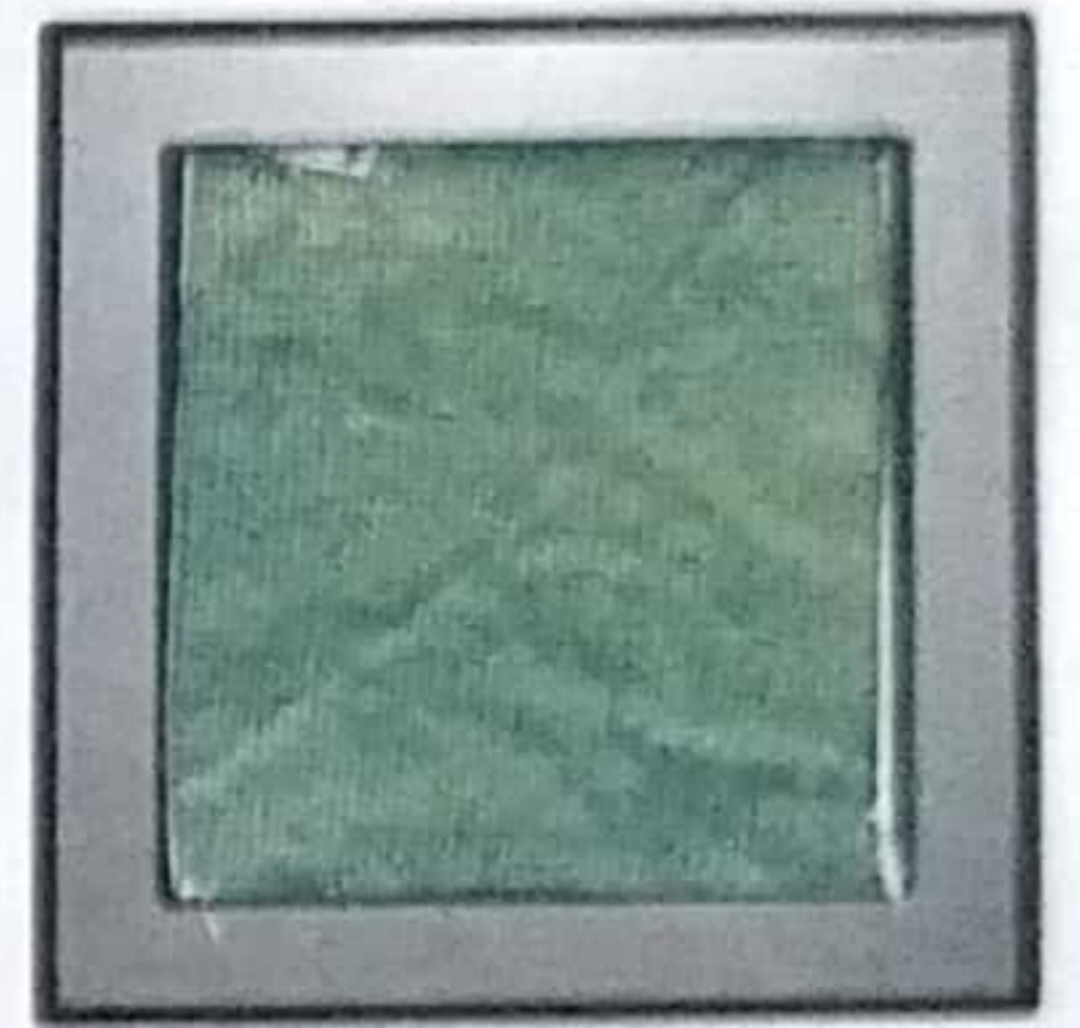
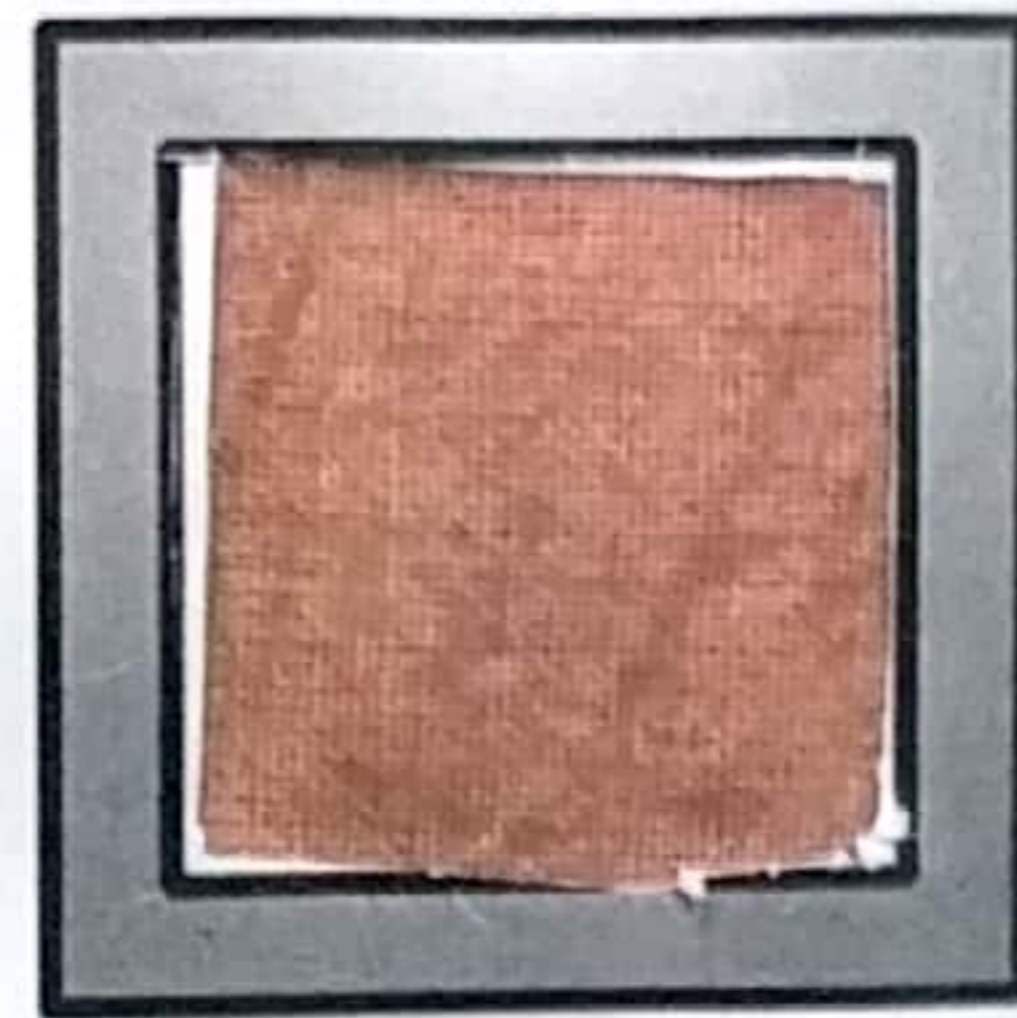
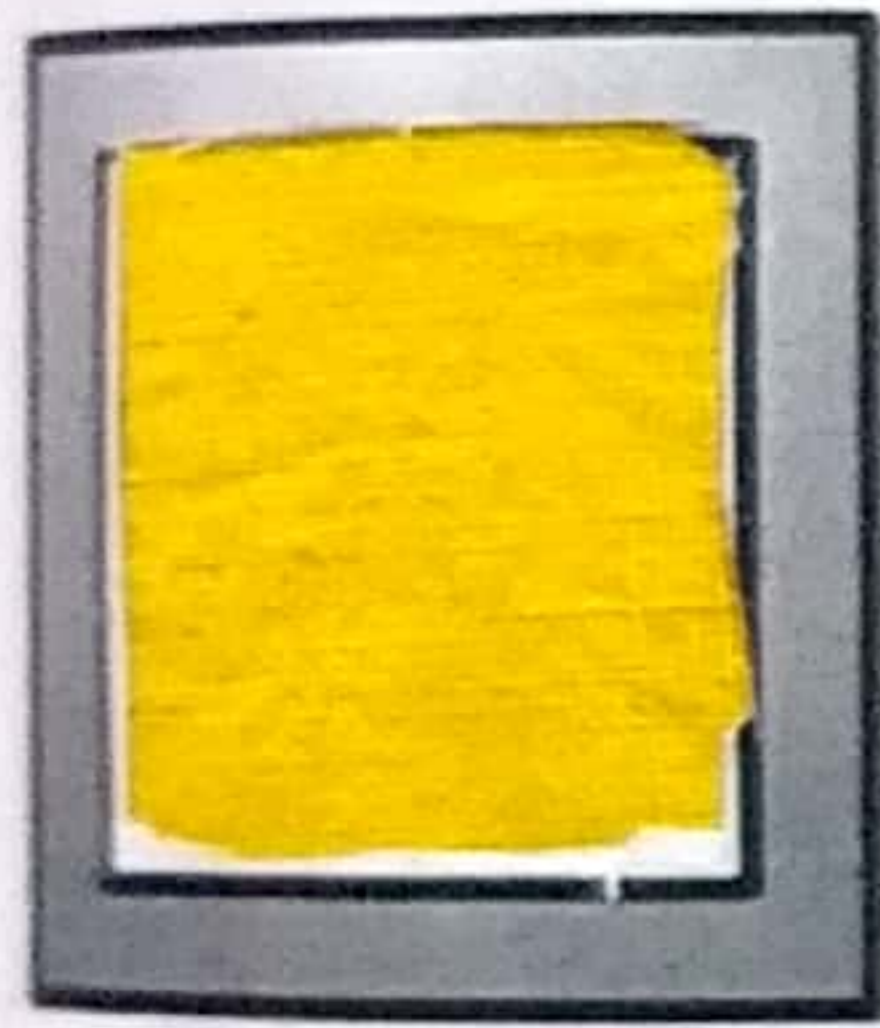
BEETROOT

BLUE OXIDE

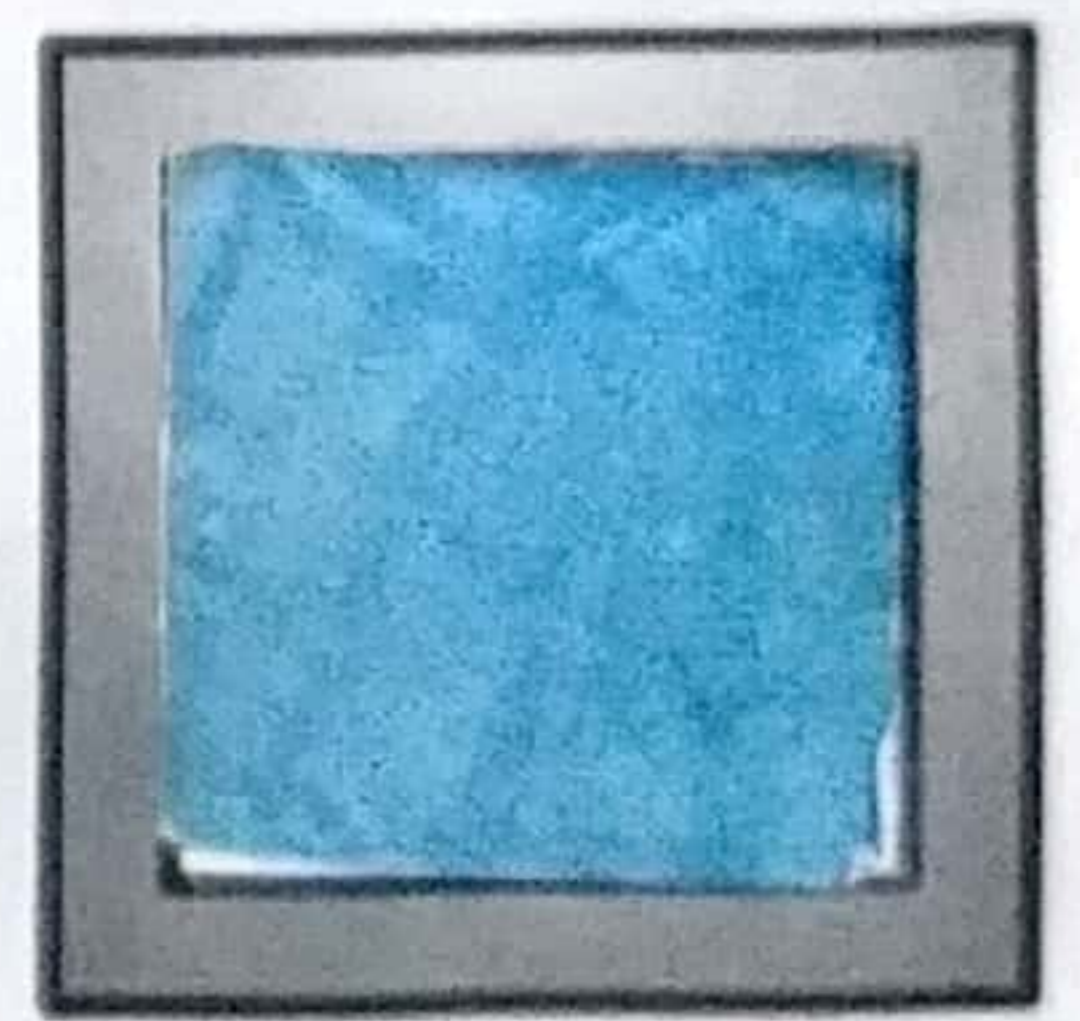
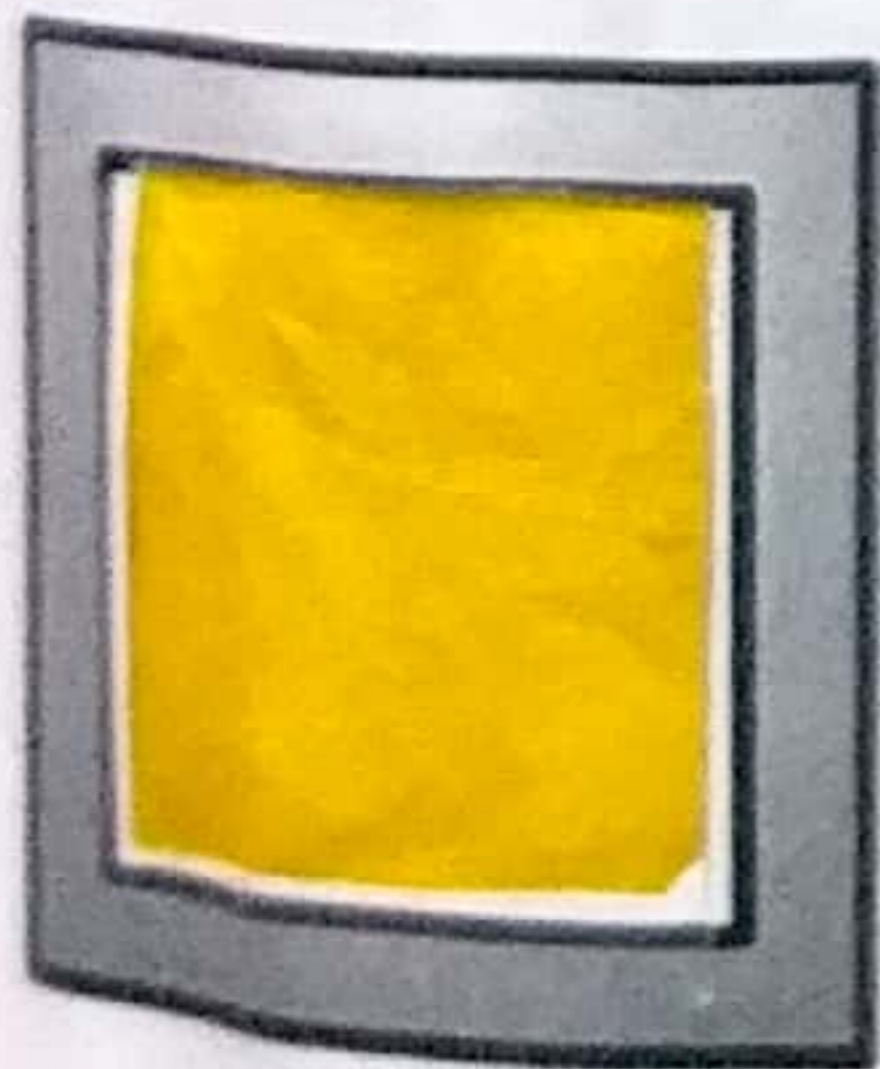
Unmordanted cotton dyed samples



Mordanted cotton dyed samples



Unmordanted silk dyed samples



Mordanted silk dyed samples



APPANDIX - II
COMPOUND SHADE FABRIC SAMPLES

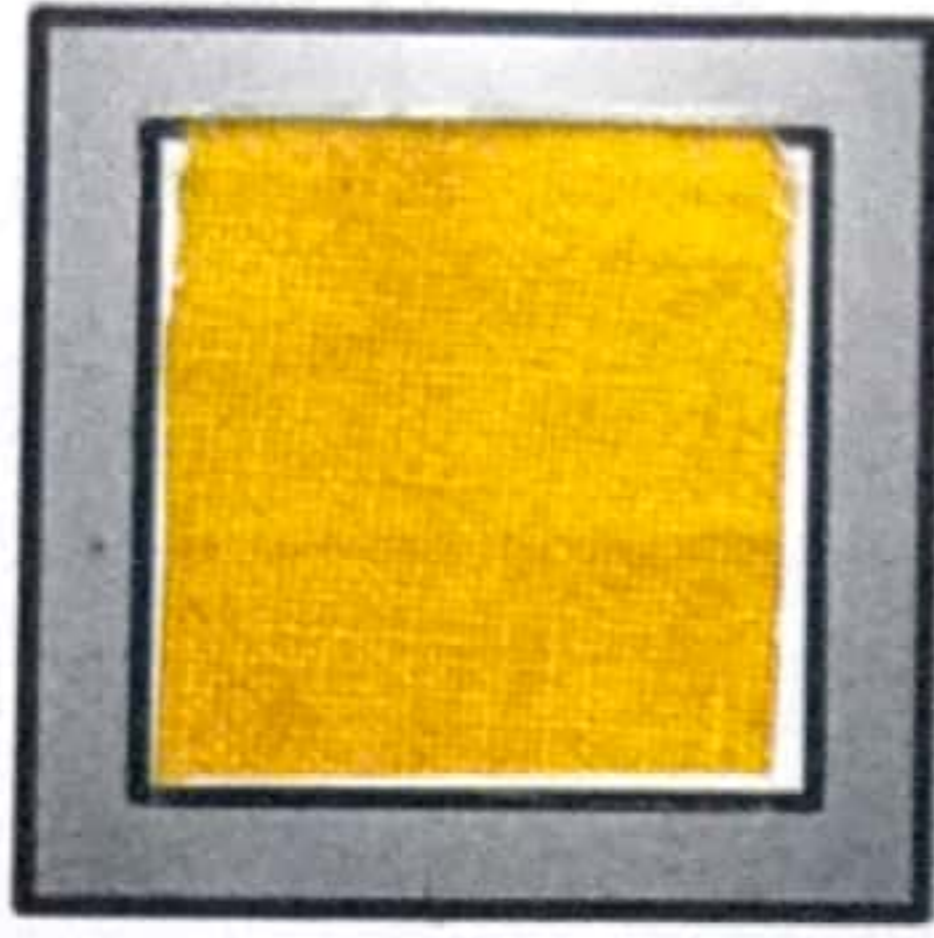
TURMERIC AND BEETROOT

Unmordanted cotton dyed samples

30:70



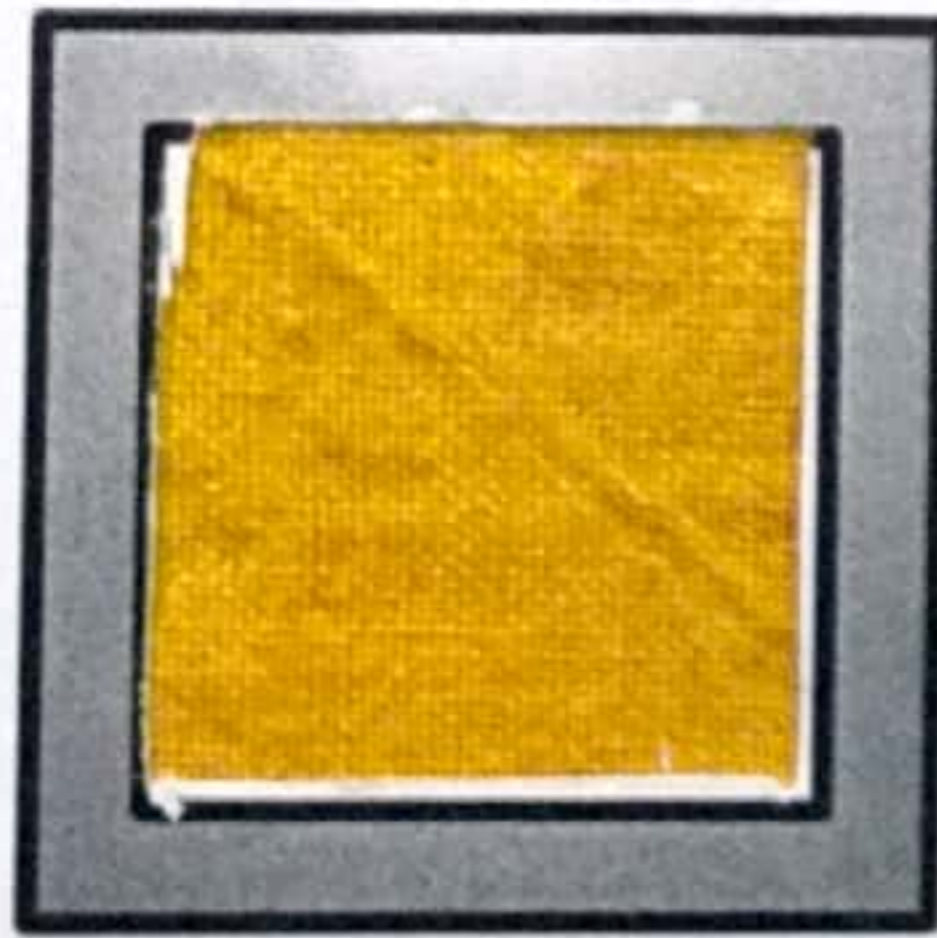
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70:30



Mordanted cotton dyed samples



Unmordanted silk dyed samples

30:70



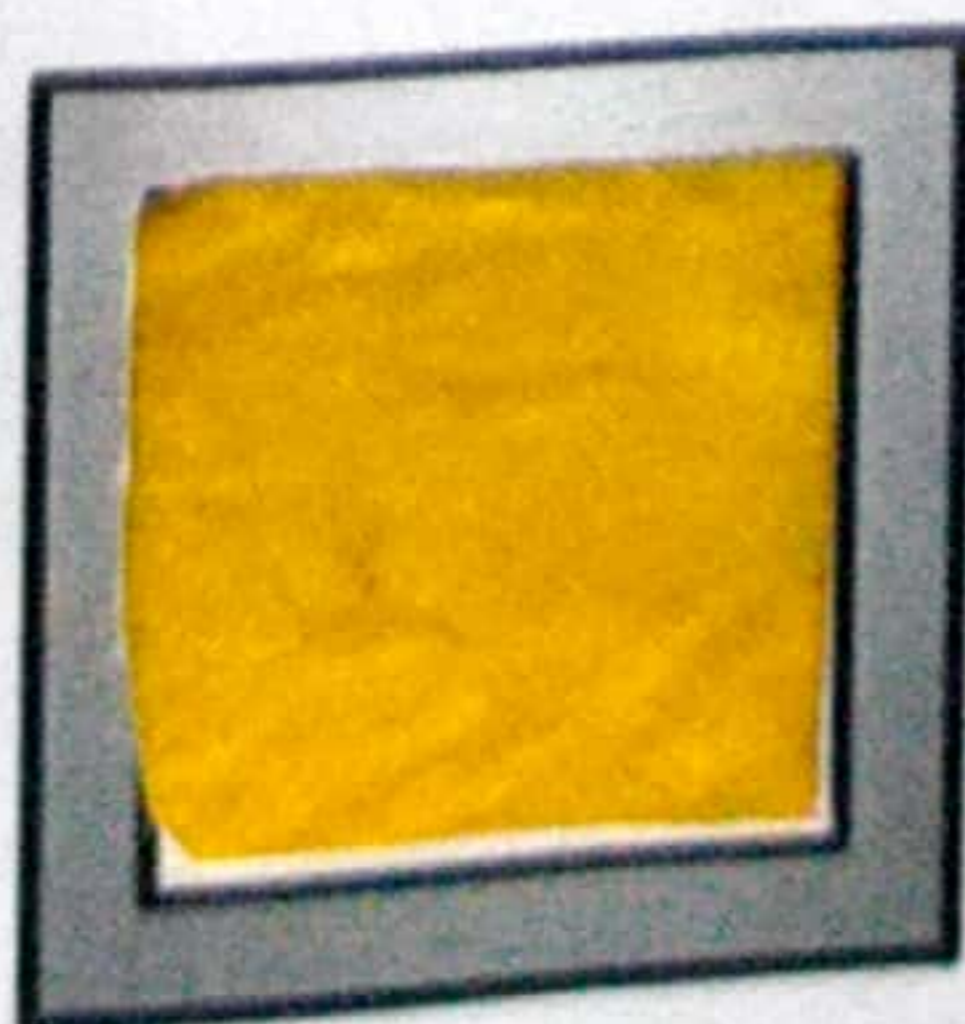
50:50



70:30



Mordanted silk dyed samples

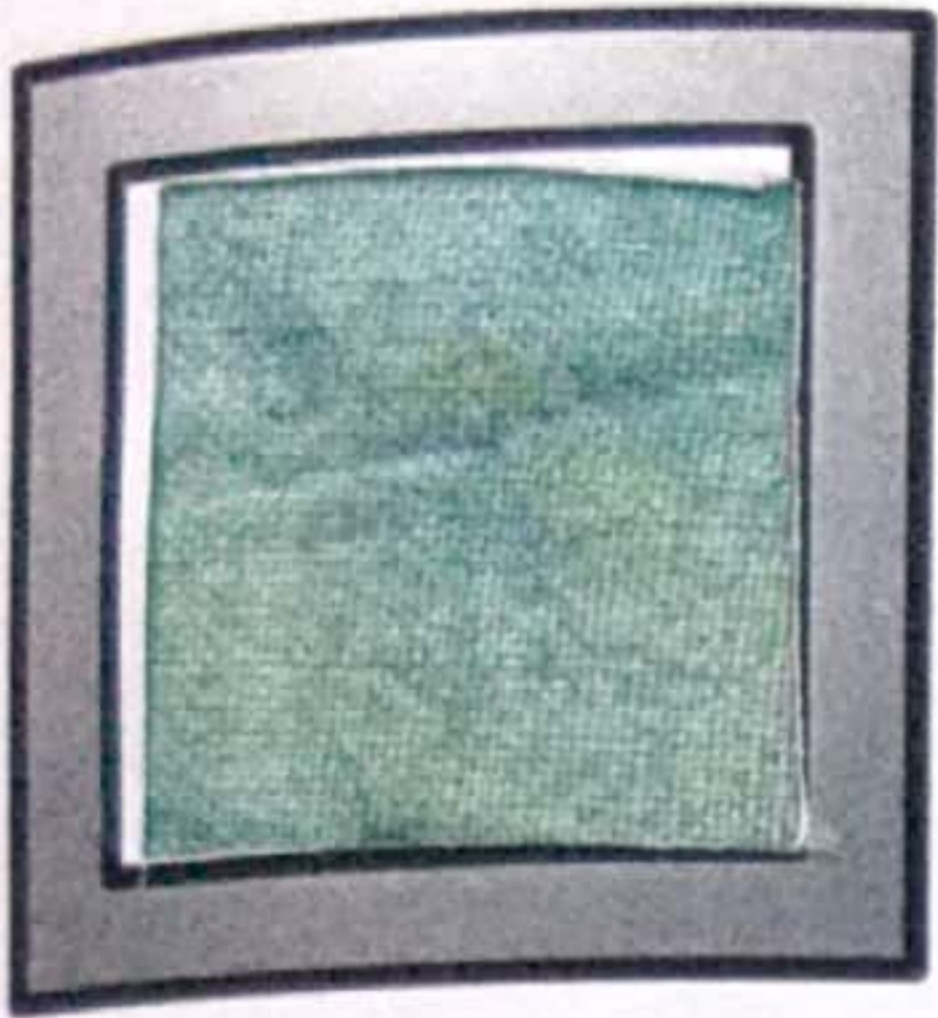


APPANDIX – III

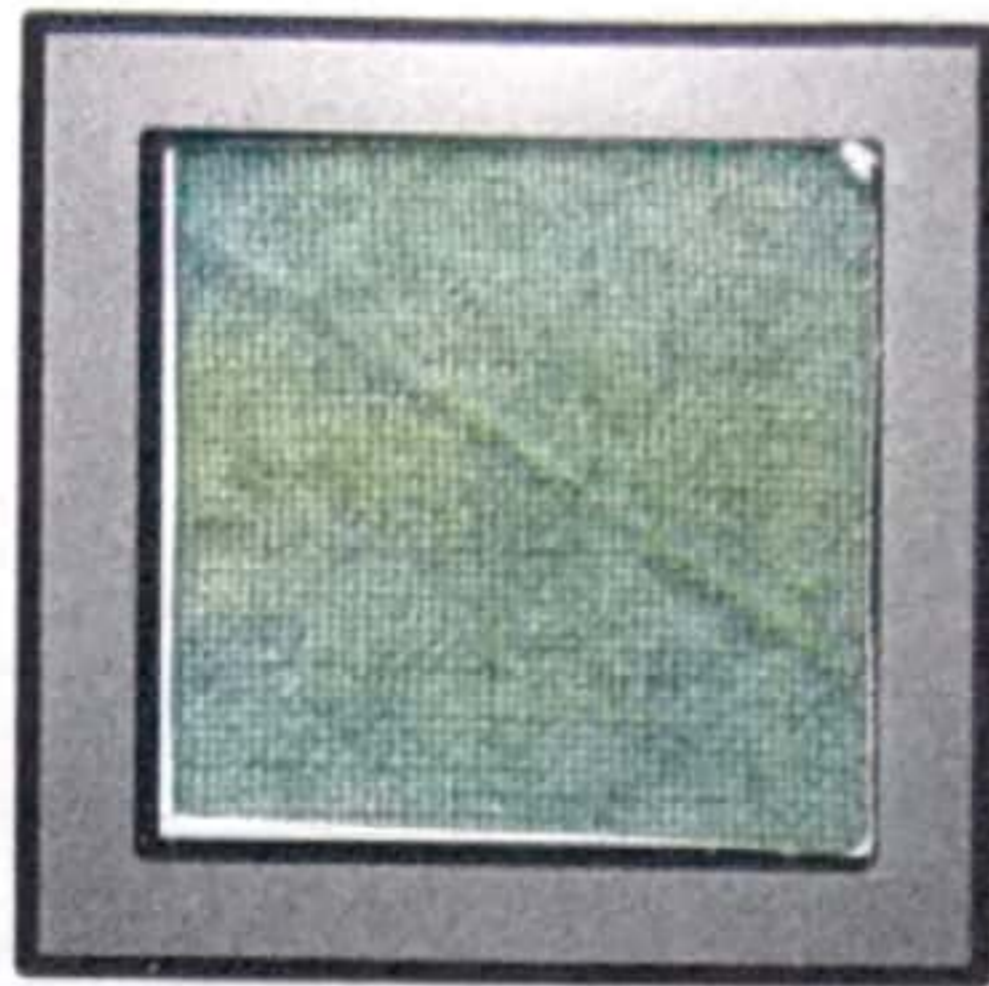
BEETROOT AND BLUE OXIDE

Unmordanted cotton dyed samples

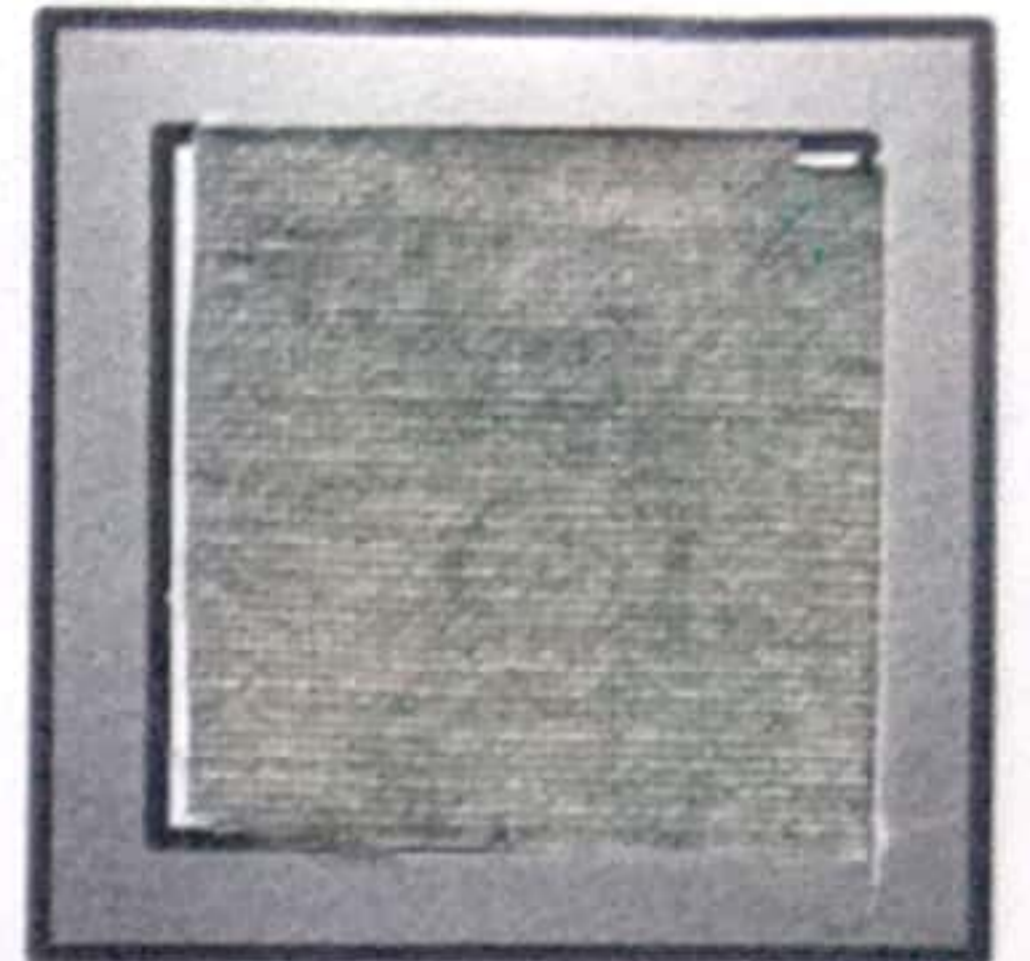
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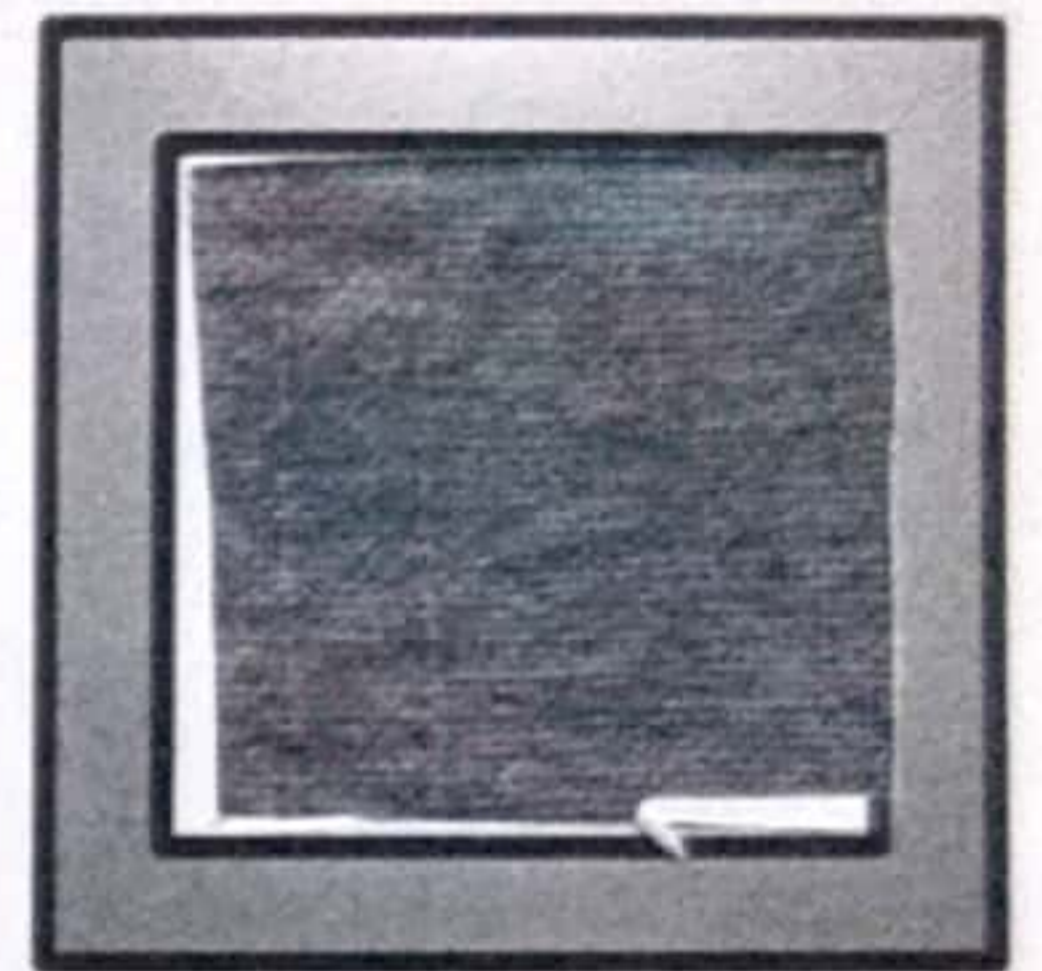
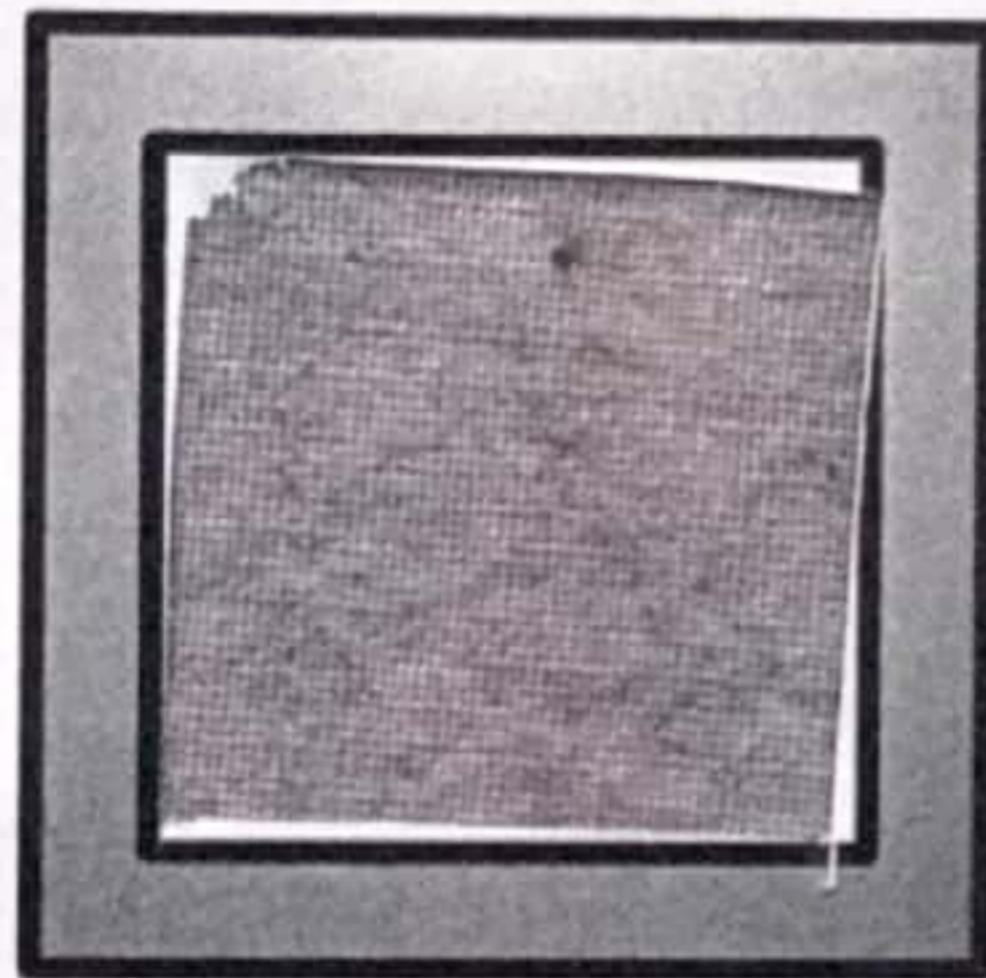
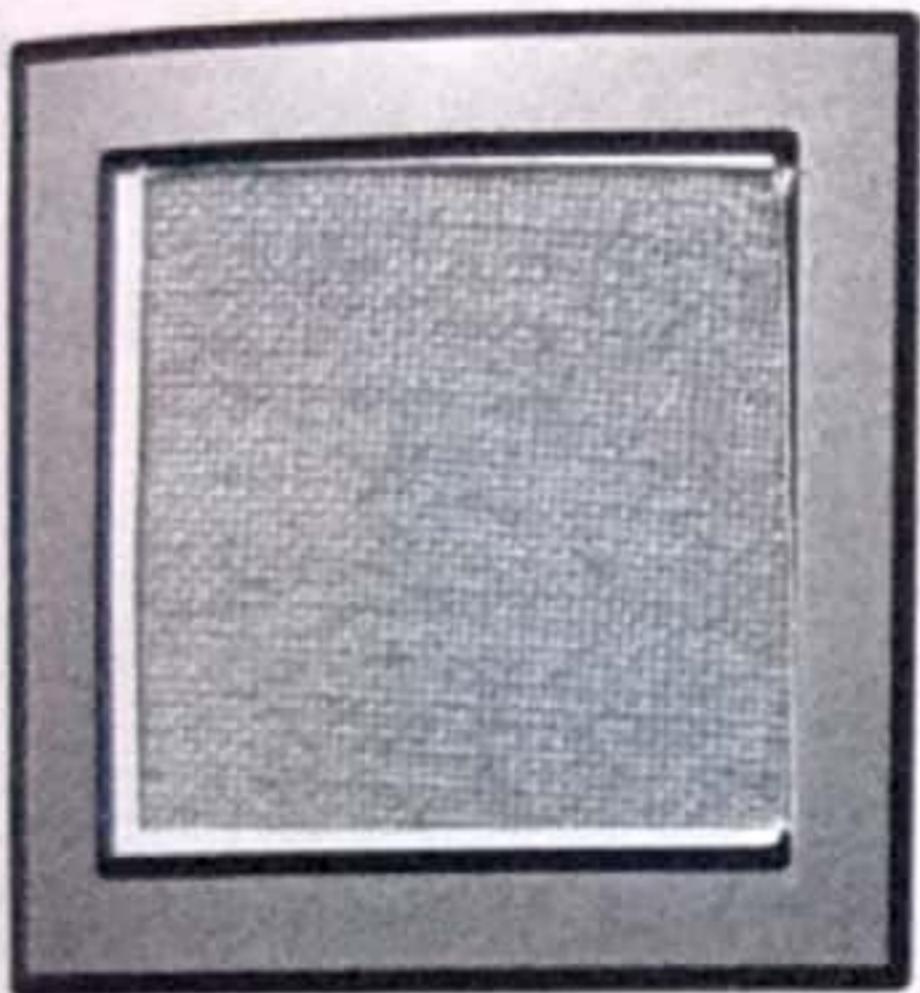
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70:30



Mordanted cotton dyed samples

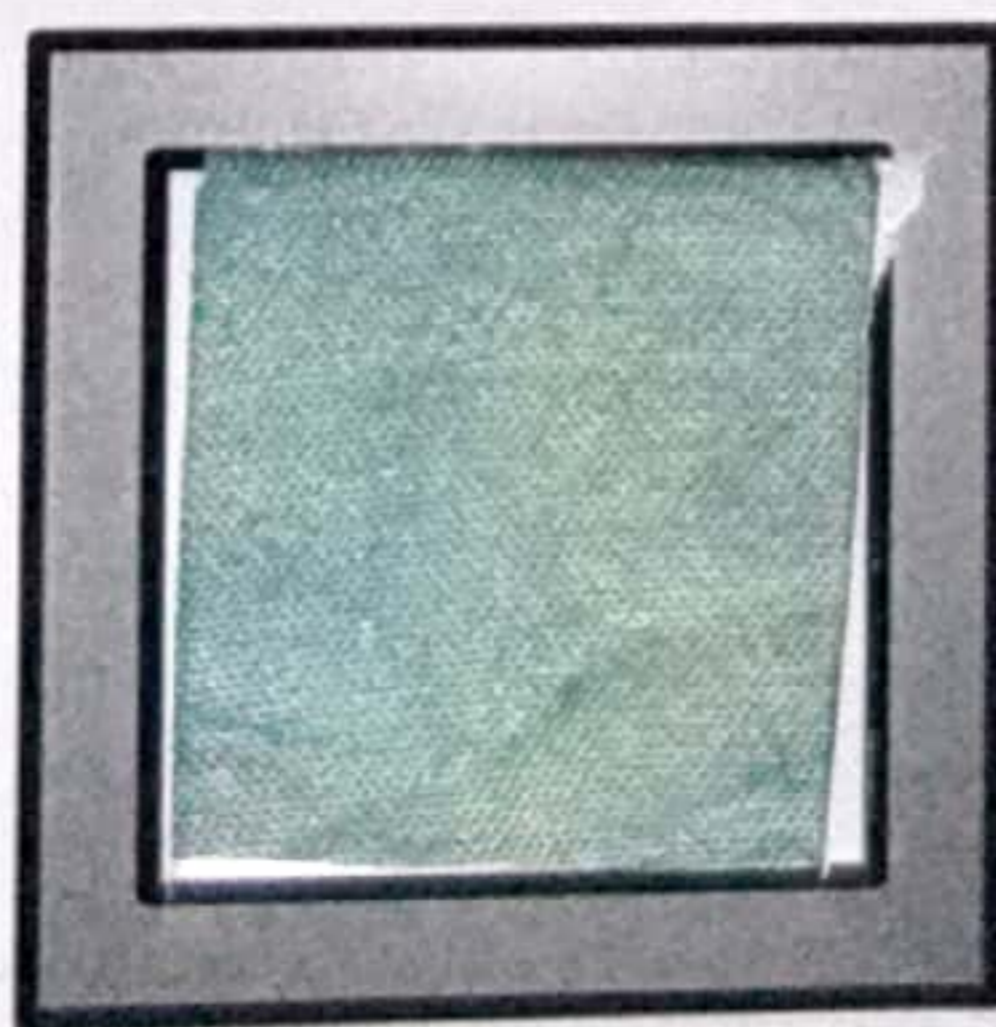


Unmordanted silk dyed samples

30:70



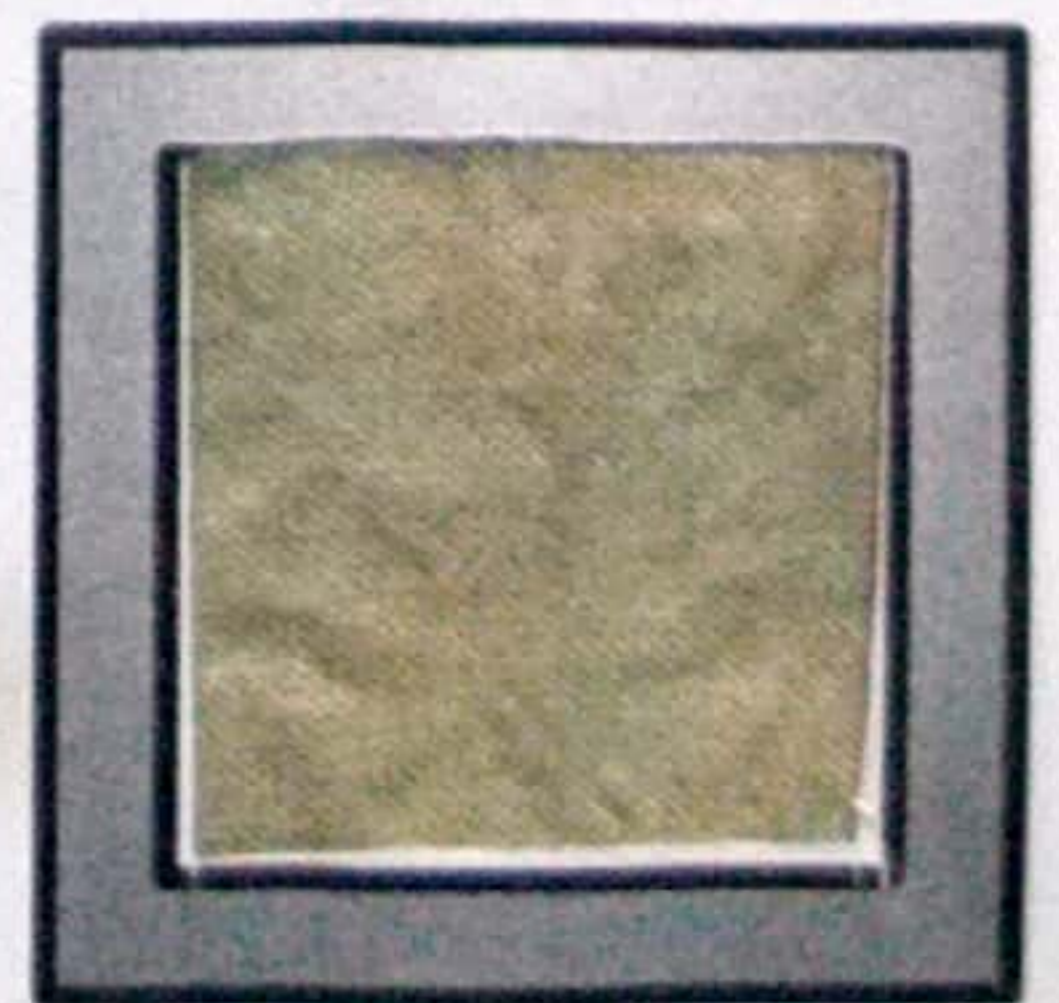
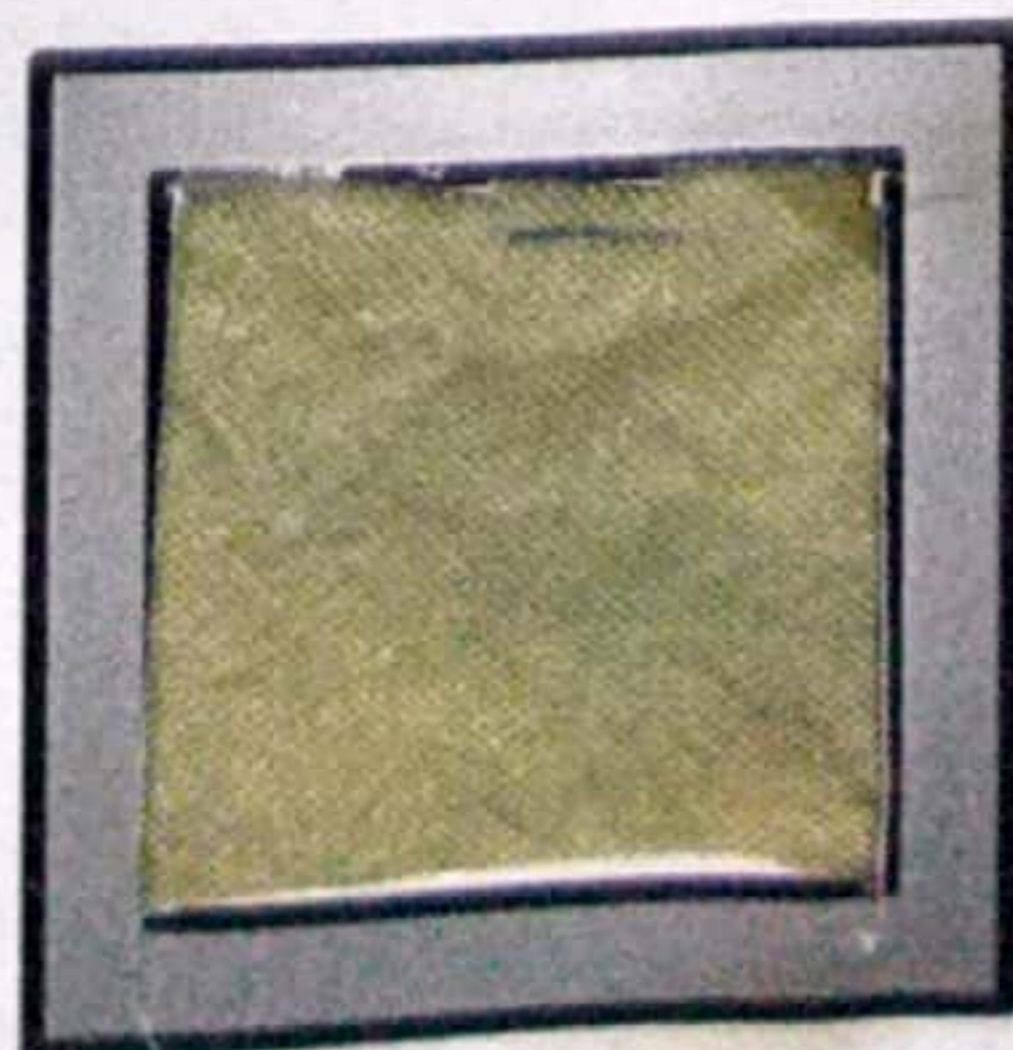
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70:30



Mordanted silk dyed samples

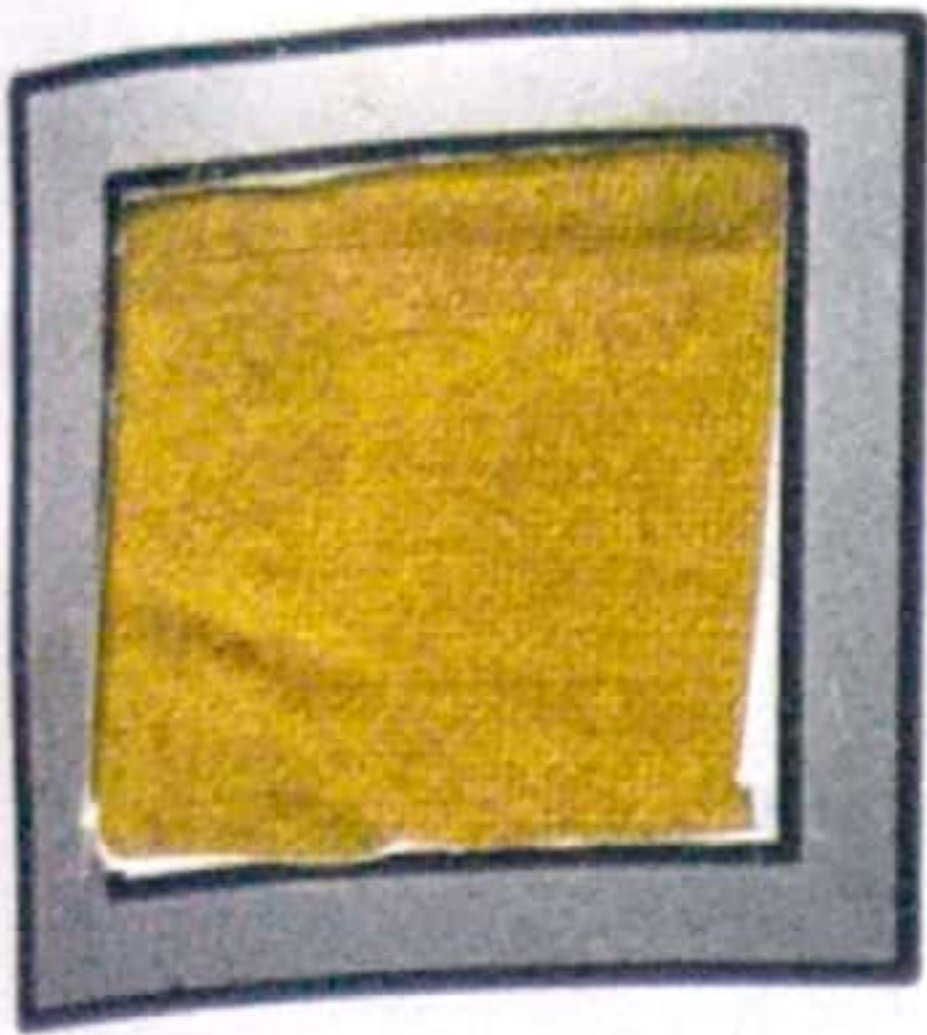


APPANDIX- IV

BLUE OXIDE AND TURMERIC

Unmordanted cotton dyed samples

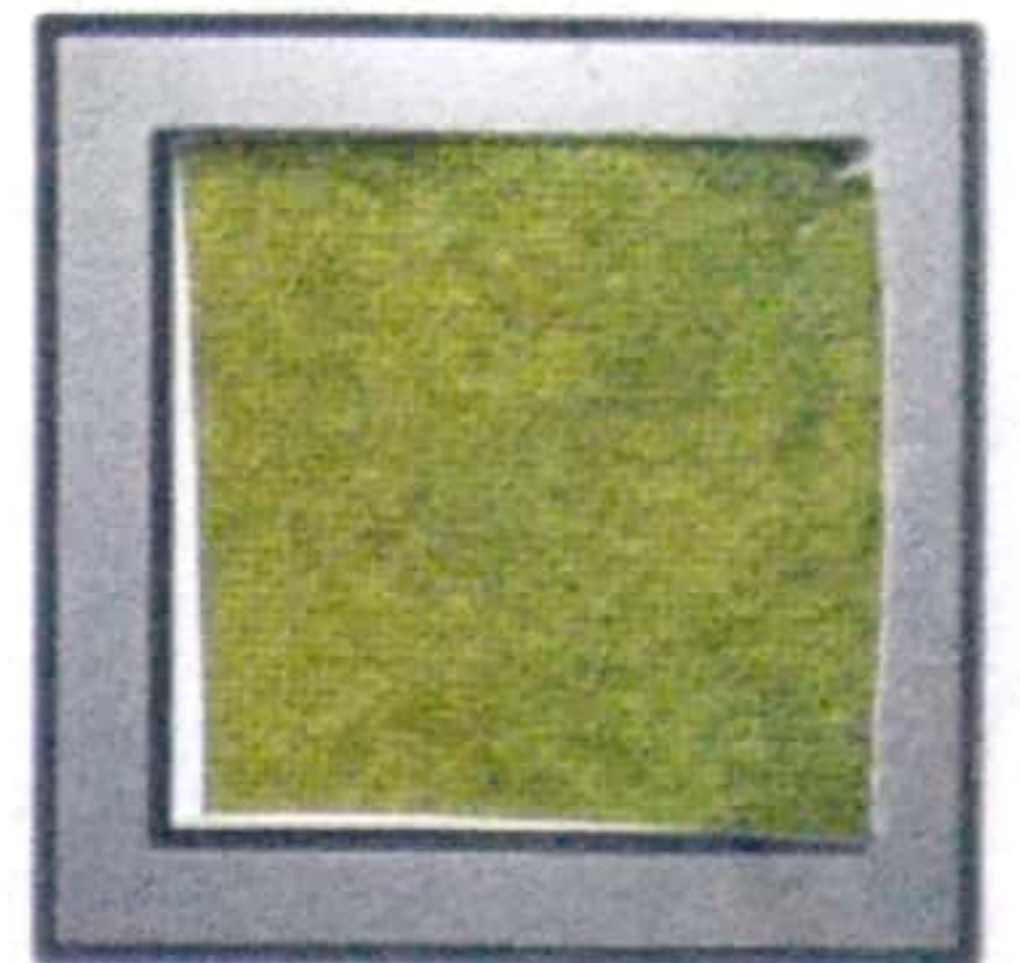
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50:50



70:30

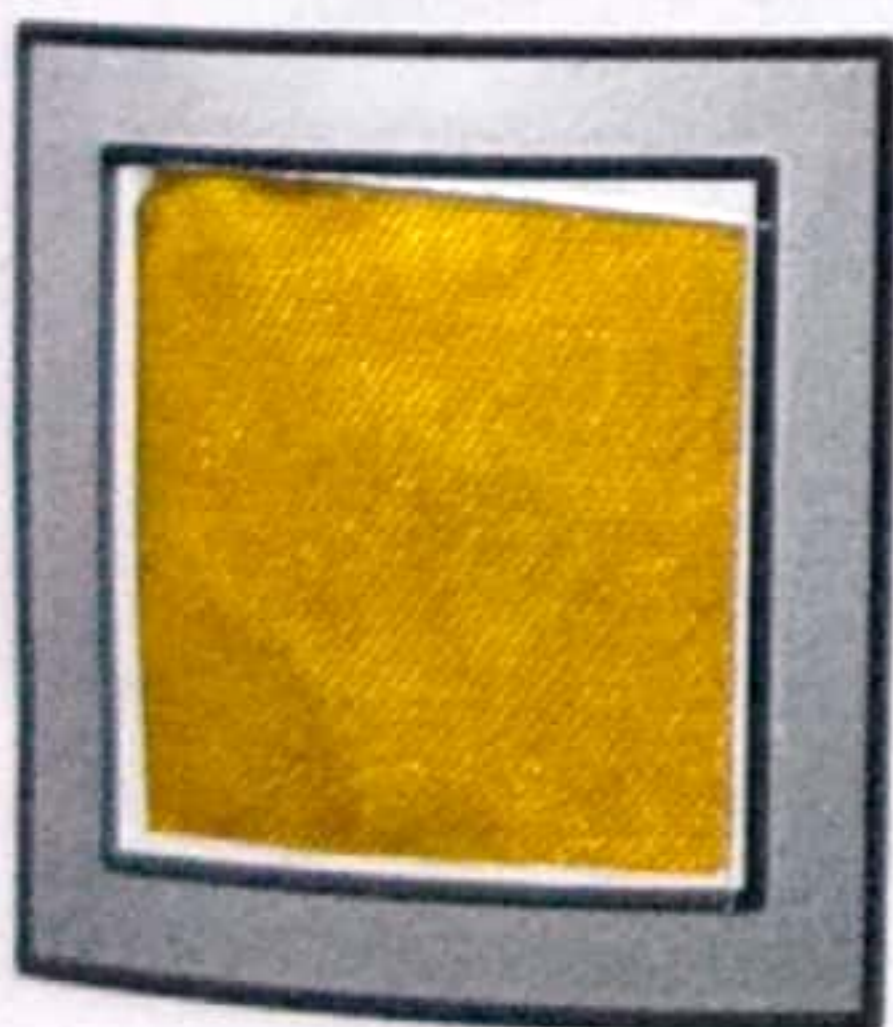


Mordanted cotton dyed samples

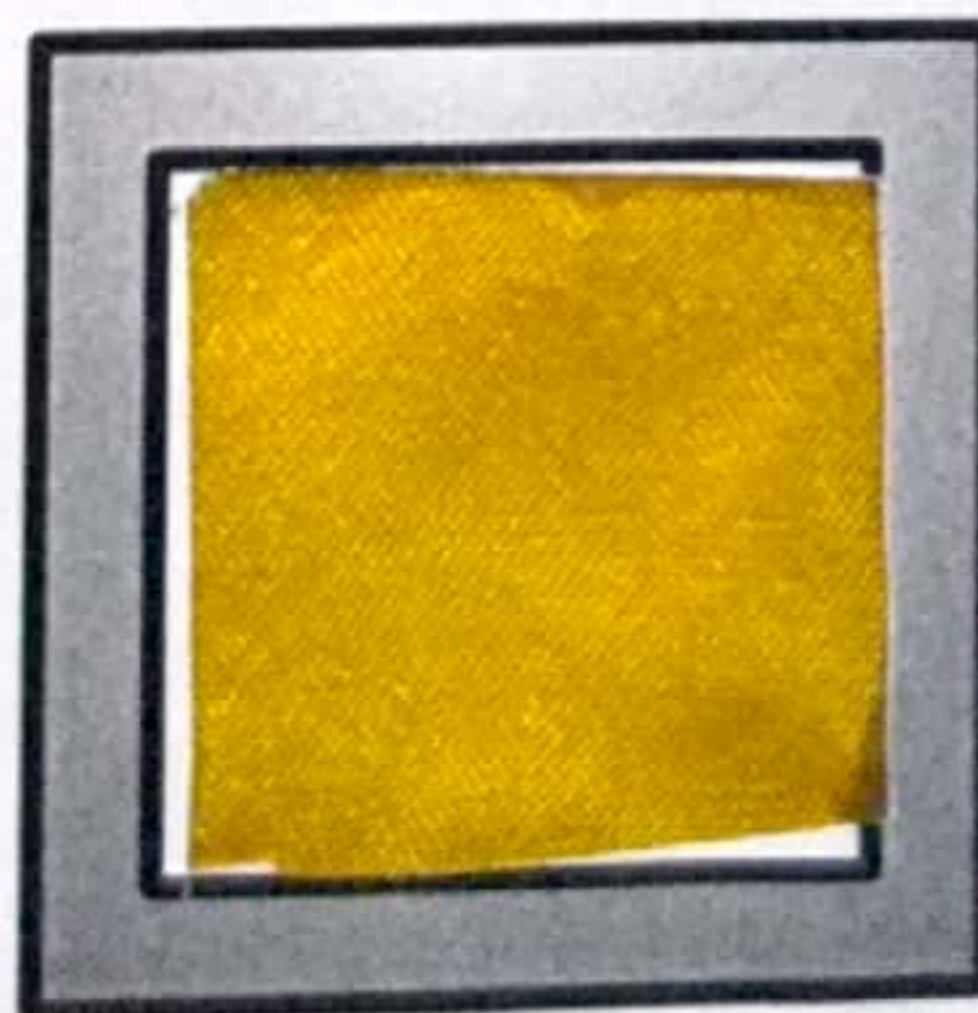


Unmordanted silk dyed samples

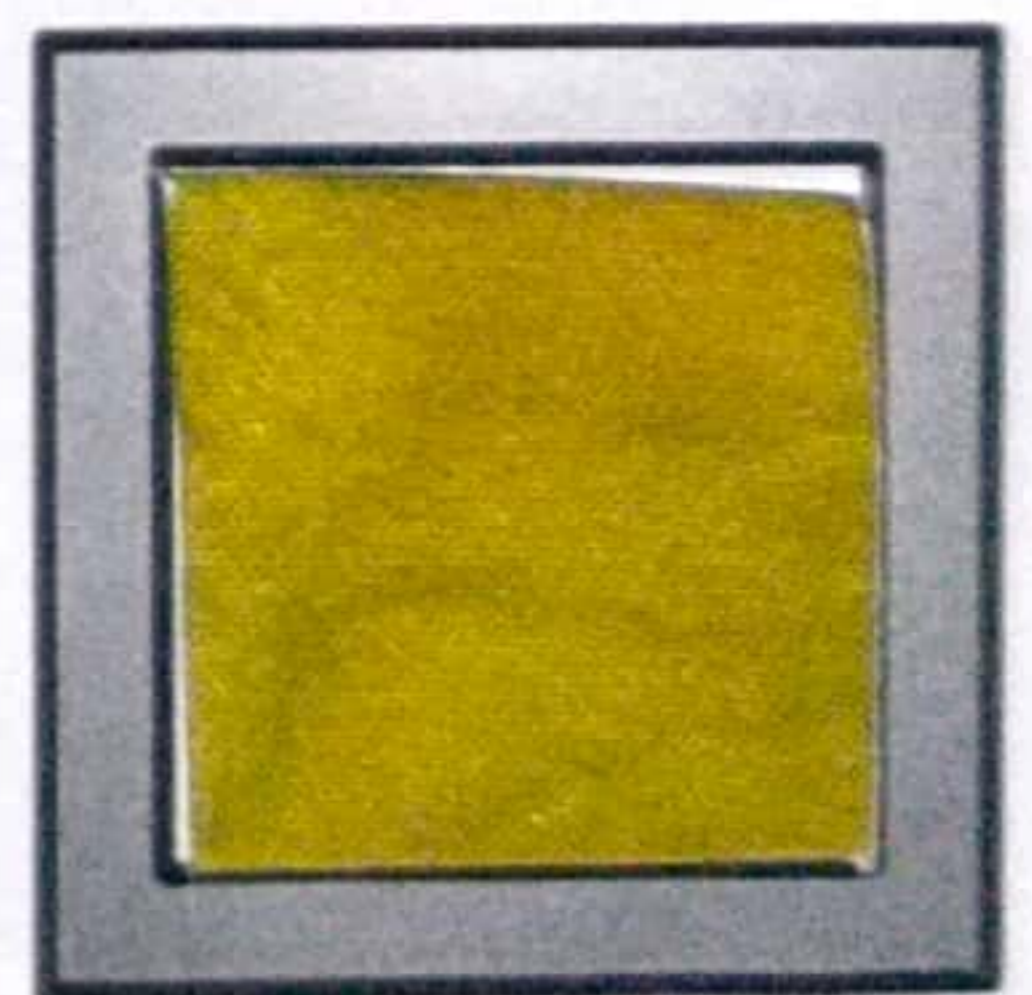
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50:50



70:30



Mordanted silk dyed samples

