A STUDY ON COLOR FASTNESS OF SILK COLORED FABRIC DYED WITH NATURAL DYESTUFF

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A STUDY ON COLOR FASTNESS OF SILK COLORED FABRIC DYED WITH NATURAL DYESTUFF

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ABSTRAC

The objective of the research is to study color fastness after rubbing, washing and exposure to light of silk fabric dyed with the natural dyestuff Terminalia catappa Linn. The experiment is based on varying dyeing conditions and the fixing agent.

This study is divided into 3 x 12 treatments and each treatment is composed of 3 replications. The experiment design is a randomized completely block design which is comprised of 3 concentrations of dye solution and 12 dyeing conditions.

The results of the experiment show that dyeing without a fixing agent sets a good to very good class of color fastness because *pheophytin* has an annular structure, thus offering the benefit of solidity by forming a strong and extremely stable chemical bond and has resistance to heat, light and migration fastness, and good to excellent weathering.

The results of the study can be used to determine a trend to encourage rural people to dye silk with natural dyestuff, and as basic information for the customer to help classify clothing for appropriate use.

KEY WORDS : SILK / COLOR FASTNESS / DYEING / NATURAL DYE / TERMINALIA CATAPPA LINN

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การศึกษาความคงทนของสีของผ้าไหมที่ย้อมด้วยสีธรรมชาติ (A STUDY ON COLOR FASTNESS OF SILK COLORED FABRIC DYED WITH NATURAL DYESTUFF)

บัวบุษย์ เรืองศรี 4637486 ENRD/M

วท.ม.(การวางแผนสิ่งแวดล้อมเพื่อพัฒนาชุมชนและชนบท)

คณะกรรมการควบคุมวิทยานิพนธ์ : สมพงษ์ ธงไชย, D.Tech.Ed., วาสนา วราภักต์, M.Tech., พิจักษณ์ หิญชีระนันทน์, M.Sc.

บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อศึกษาความคงทนของสีต่อการซัก ความคงทนของสีต่อการขัดถู และความคงทนของสีต่อแสง ของผ้าไหมที่ย้อมด้วยสีจากใบหูกวางสด เมื่อใช้สภาวะในการย้อมและสารช่วยติดสีที่แตกต่างกัน โดยใช้การทดลองแบบ แฟคทอเรียลแบบสุ่มในบล็อกสมบูรณ์ (Factorial arrangement in Randomized Completely Block Design) โดยมีความเข้มข้นของน้ำสี 3 ระดับความเข้มข้น และสภาวะที่ใช้ในการย้อม 12 สภาวะ ดังนั้นในการศึกษาครั้งนี้จึงมี 3 x 12 การทดลอง และในแต่ละการทดลองทำ 3 ซ้ำ

ผลการทดลองแสดงให้เห็นว่า สภาวะการย้อมที่ไม่ใช้สารช่วยติดสีนั้นให้ระดับความคงทนของสีอยู่ในเกณฑ์ดี ถึง ดีมาก เนื่องจากสารให้สีในใบหูกวางคือ *ฟีโอไฟติน (pheophytin)* ซึ่งมีคุณสมบัติที่สามารถเกิดพันธะเคมีกับ พอลิเปปไตด์ของไหมได้โดยที่มีความเสถียรของพันธะสูง และยังมีคุณสมบัติที่ทนต่อความร้อน, แสง และสภาพอากาศได้ดี และมีความคงทนต่อการเคลื่อนที่ของโมเลกุลเป็นอย่างดี

จากการศึกษาครั้งนี้ จะสามารถนำไปใช้เป็นแนวทางในการส่งเสริมให้ชาวบ้านย้อมผ้าไหมด้วยสีธรรมชาติ และสามารถใช้เป็นข้อมูลพื้นฐานในการจำแนกการใช้งานของผ้าไหมให้เหมาะสมสำหรับผู้บริโภคได้ด้วย

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CHAPTER 1
INTRODUCTION

1.1 Background and State of problems

Clothes are one of the four basic needs for human and that are widely used in common lives. Silk is the queen of Thai fabrics; it can be showing the Thai culture. Silk is one of the important of Thai export goods. The first quarter in 2002, exported values of silk fabric is 134.7 millions baht (1). In 2004 Ministry of Industry set up the exhibition "OTOP AND THAI TASTE" at Germany, Thai silk and Thai spa were the most interesting goods which Thai and German government decided to sign agreement for join the business together (2).

Thai government has commanded to Vocational Education Department to study, develop the knowledge and technicians and encourage to research and development the process to produce Thai silk fabric (3).

The effect from globalization is the important power to push the development of this knowledge is continued. Globalization makes a lot of pollutions. Many people around the world realize that. These peoples make consumer power to use free chemical goods and environment friendly goods only. Then these powers make the continued development and research about natural dyestuffs and the process of dyeing with natural dyestuffs.

In former times, dyestuffs were all obtained from natural products. The majorities were of vegetable origin; plants trees and lichens, some were obtained from insects and mollusks. Although there is no evidence showing that how and when Thai people know the process of dyeing, they could use some natural products such as leaves, barks, heart of woods and fruits for dyeing long ago.

After that, synthetic dyestuff is improving to widespread used. Its effect to natural dyes are not used incentively because inconvenient process such as collecting dyestuffs, dye extraction, preparation and use of dye auxiliaries.

The dyeing process from natural dyes consumes a lot of time, labors, fuel and costs, so the natives who weave their clothes with hand looms prefer synthetic dyes to natural dyes. The knowledge of using natural dyes is then almost disappeared. Also, there are a few natural dye literatures remaining nowadays.

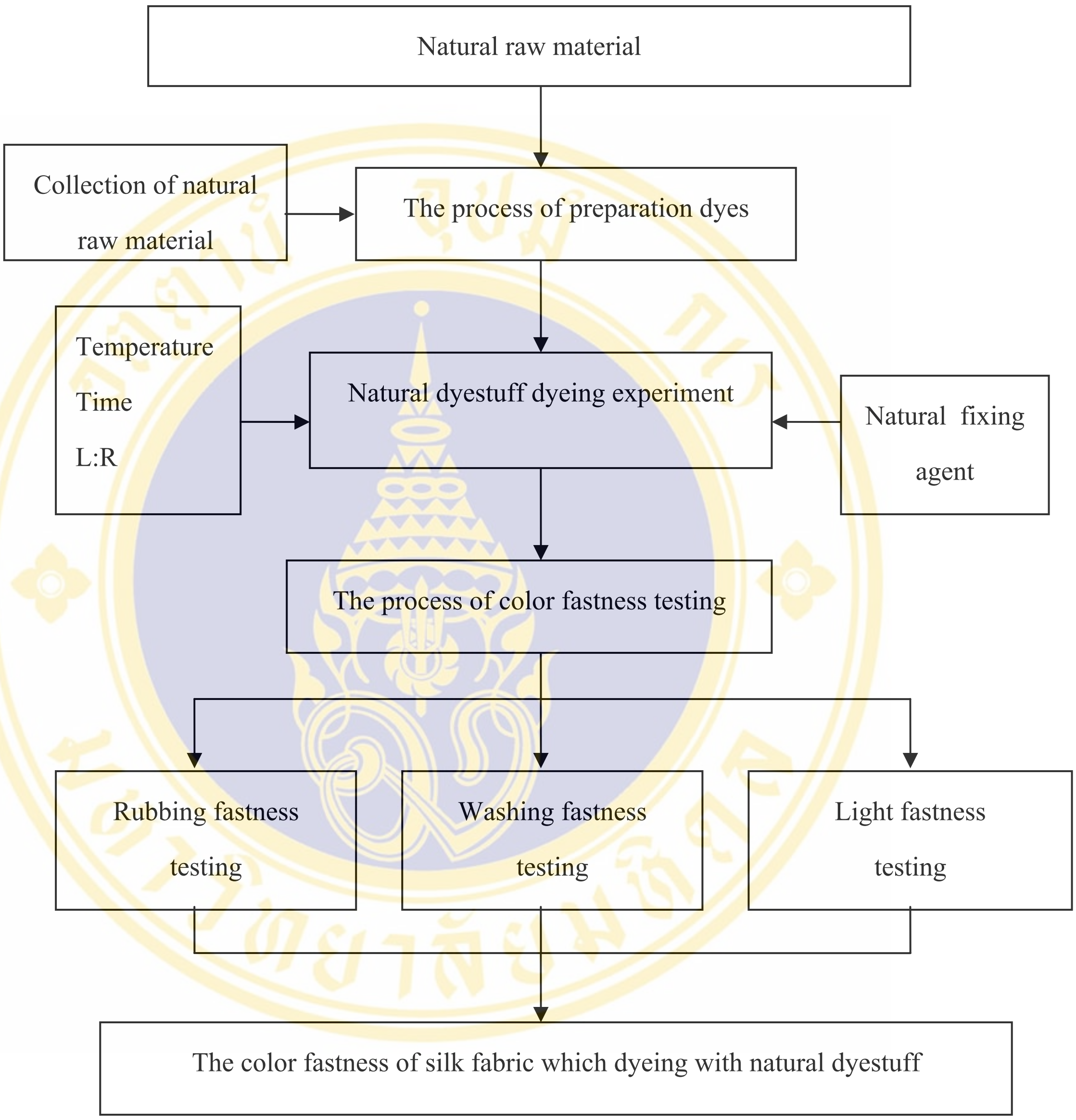
Although the use of synthetic dyes is quicker and easier than that of natural dyes but synthetic dyes are mostly toxic from their molecular structure such as some organic substances or heavy metals such as chromium, tin and lead (4). Beside, the synthetic dyes are also easily deteriorated when keeping for along time.

Paisan Kongkhachuichai and survey group met many villages who weave and dyeing silk fabric with synthetic dyes, peoples poured untreated dye solution into public canal or pound not only that, dyers are remiss the safety for her health and not protection from directly touch and smell. Beside, the synthetic dyes and chemical auxiliaries are be left behind in the fabric, its can be harm to the consumer (5).

At present time, dyeing silk fabrics with natural dyes in Thailand is much widespread. It is better for environment such as water, not to support water pollutions from dyes solution and chemical auxiliaries.

Natural dyes is inferior than synthetic dyes, color fastness such as rubbing fastness, washing fastness and light fastness are lower. At present time not much to study on color fastness of silk color fabrics which dyeing with natural dyestuffs, then not have basic data to use for improving the quality of silk fabrics which dyeing with naturaldyestuff

1.2 Conceptual Framework



1.3 The Objective of Study

To study about color fastness for rubbing, washing and light of silk fabric which dyeing with natural dyestuff in case of Terminalia catappa Linn. leaves that has different dyeing conditions and fixing agent.

1.4 Limitation of Study

1.4.1 Major color in this study is green from leaves of *Terminalia catappa Linn.* Preparing by boiling with distilled water after that filtering.

1.4.2 Process of rubbing, washing and light fastness testing with Industrial Thai Standard No. 121 book 1, 3 and 5, 1975 (see in Chapter III).

1.4.3 The period of time for studying between June 2004 – April 2005.

1.5 Definition in Research

1.5.1 Color Fastness means properties of silk fabric which dyeing with fresh leaves of *Terminalia catappa Linn.* solution that was processed of color fastness to rubbing, washing and light fastness testing with Industrial Thai Standard No. 121 book 1, 3 and 5, 1975 (see in Chapter III).

1.5.2 Silk Fabric means degummed silk weave fabric 100 %

1.5.3 Natural Dyestuff means dyeing solution prepared by boiling leaves of *Terminalia catappa Linn.* with distilled water at 60 degree celsius, 60 minutes. After that filtering, it is completely to use to dyeing solution for dyeing experiment.

1.6 Expectation

1.6.1 The result of this research can be used in database of color fastness to rubbing, washing and light of silk color fabric which dyeing with *Terminalia catappa Linn.*, its could be classified for appropriate use.

1.6.2 To promote industry of silk to produce many products that the consumer can be choose from natural dye together with synthetic dye.

1.6.3 To make Thai people should be aware to preserve the process of dyeing silk with natural dyestuff because it as cultural heritage for Thai nation forever.

CHAPTER 2
LITERATURE REVIEW

2.1 Historical of Dyeing (4)

Dyestuffs and dyeing are as old as textiles themselves, predating written history. Fabrics dating from 3500 B.C. have been found in Thebes that still possess the remains of blue indigo dye. Fabrics discovered in ancient tombs in Egypt were colored yellow with dye obtained from the safflower plant. Beautifully colored fabrics dating back several thousand years have been unearthed in China, Asia Minor, and same sections of Europe. Until 1856 all dyestuffs were made from natural materials, mainly animal and vegetable matter with a few minerals for special colors.

One of the animal sources was a tiny insect native to Mexico, from which a bright red dye was extracted. This insect was used by the Aztecs to color thieve fabrics, and when the Spaniards invaded Mexico in 1518, they called the insect and dyestuff “cochineal”. Cochineal is an anthraquinoid type of dye. A tiny mollusk, Murex brandaris and Murex trunculus, found on the Phoenician coast near the city of Tyve, produces a beautiful purple.

The year 1856 marked a turning point in the history of dyes. William H. Perkin, a 17-year-old English boy and chemist’s assistant, while trying to make artificial quinine from coal tar, accidentally produced the first synthetic dyestuff, a purple color called mauve, a basic dye. This discovery launched the modern dyestuff industry. Today, nearly all dyes are synthetically compounded, and in most cases they are superior in every way to natural dyes.

2.2 Theory of Dyeing (4)

The way in which dyeing of a textile fiber, proceeds has received great attention, but no fully satisfactory explanation has been given so far. Unless the dyeing is formed by precipitation of particles within the fiber, an essential feature of the dyeing process is that the dye molecule must be capable of entering the fiber structure. The path for the dye molecules is provided by the *intermicellar* spaces in the fiber and once the dye has entered the fiber structure it becomes firmly attached to the surface of the *micells* either by purely physical forces or by chemical combination. The former mode of attachment is believed to be prevalent in the dyeing of *cellulosic fibers*, the latter mode in dyeing of *proteinic fibers*.

The dyeing process can be conceived as taking place in three phases, attachment of the dye molecule to the surface of the fiber, penetration into the intermicellar space as well as diffusion through the fiber, and orientation (fixation) along the long chain molecules.

All fibers has one property is resemblance, that has long chain of polymer such as silk is *polypeptide*, cotton is *polycellobios*. The pattern of molecular arrangement within the fiber, *crystallinity* indicates that fiber molecules are parallel to one another; *amorphous* indicates that fiber molecules are arranged in random. Dye molecule is big, can not to penetration into fiber molecule that has *orientation* and *crystalline.* Water is the media in textile dyeing, when retting the fiber it could be swelling and making the big pore in the fiber molecule, dye molecule easily to penetrate into fiber molecule.

2.3 Dye Chemistry (5)

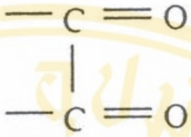
The ability of an organic compound to create this desired color derives from the presence of chemical group called *chromophores.* Substances that include chromophores in various arrangements produce the sensation of different color hues. Chromophores are made up of such organic molecular arrangements as the following

Nitro group NO_2

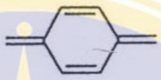
Nitroso group $-N=O$

Azo group $-N=N$

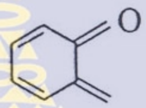
Alphadiketone group



Paraquinonoid group

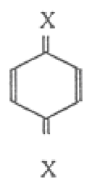


Othoquinonoid group

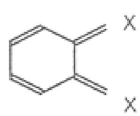


All chromophore groups called *chromogen*. Although chromophores confer color on a substance, the intensity or brightness of the color depends on the presence of one or more substances called *auxochromes*. Furthermore, the auxochromes may give water solubility to a dye and provide the groups that form associative bonds with a fiber. These include *hydroxyl group (-OH), amino group* ($-NH_2$), *alkyl aminogroup* ($-NHR$, $-NR_2$), *sulfonic group* ($-SO_3H$) and *carboxyl group (-COOH)*. Dyestuffs themselves or combinations of other chemicals with dyes in the dye bath contribute bath chromophores and auxochromes for the actual dyeing process.

Scientist believe main structure of all chromophores is aromatic compound in unsaturated condition like structure of *quinine* such as following



p-quinonoid



o-quinonoid

x are group of atom

Many dyes can be produce in structure of *quinonoid* and it can be reverse that has different condition, called isomeric chain as following

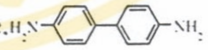
(quinonoid) (benzenoid)

This structure can be making affected for staining or color changing when textile fabrics will be exposed by sunlight, detergent, rubbing or other factors.

2.4 Classification of Dyestuff

Classifications of dyestuff from source of dye are as following

2.4.1 Synthetic Dyestuff

Synthetic dyestuffs are made from synthetically reaction. Its has atom group that made more resistance to fastness, easy to dyeing and cheep but many dyestuff has cancer compound, its shown in Figure 2.1 which is *azo dyestuff* (6), when its decomposed give *benzidine compound* (benzidine. ) example are shown in Figure 2.2

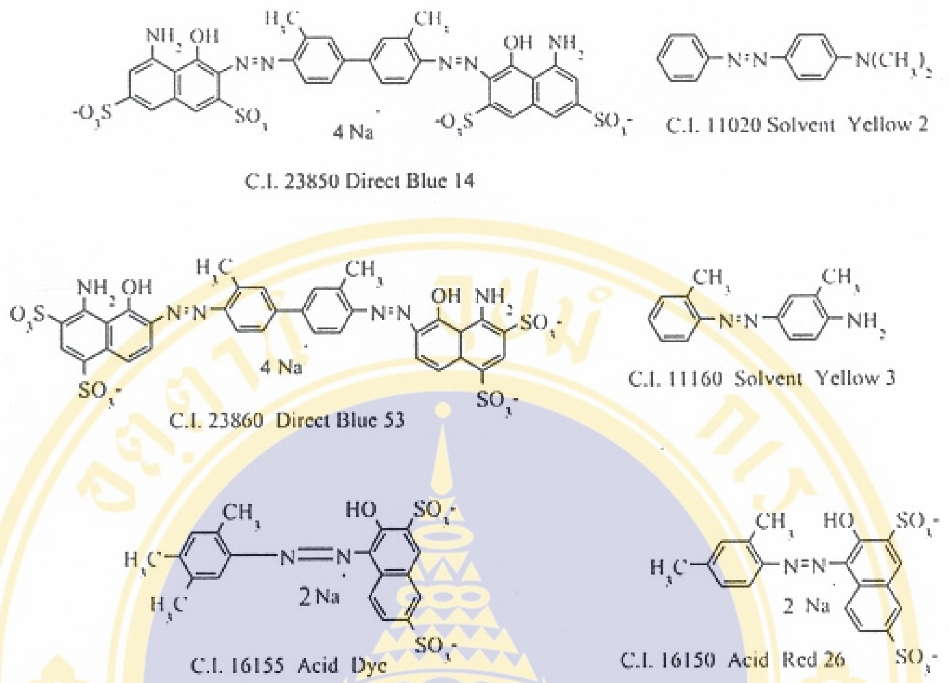


Figure 2.1 Azo dyestuff

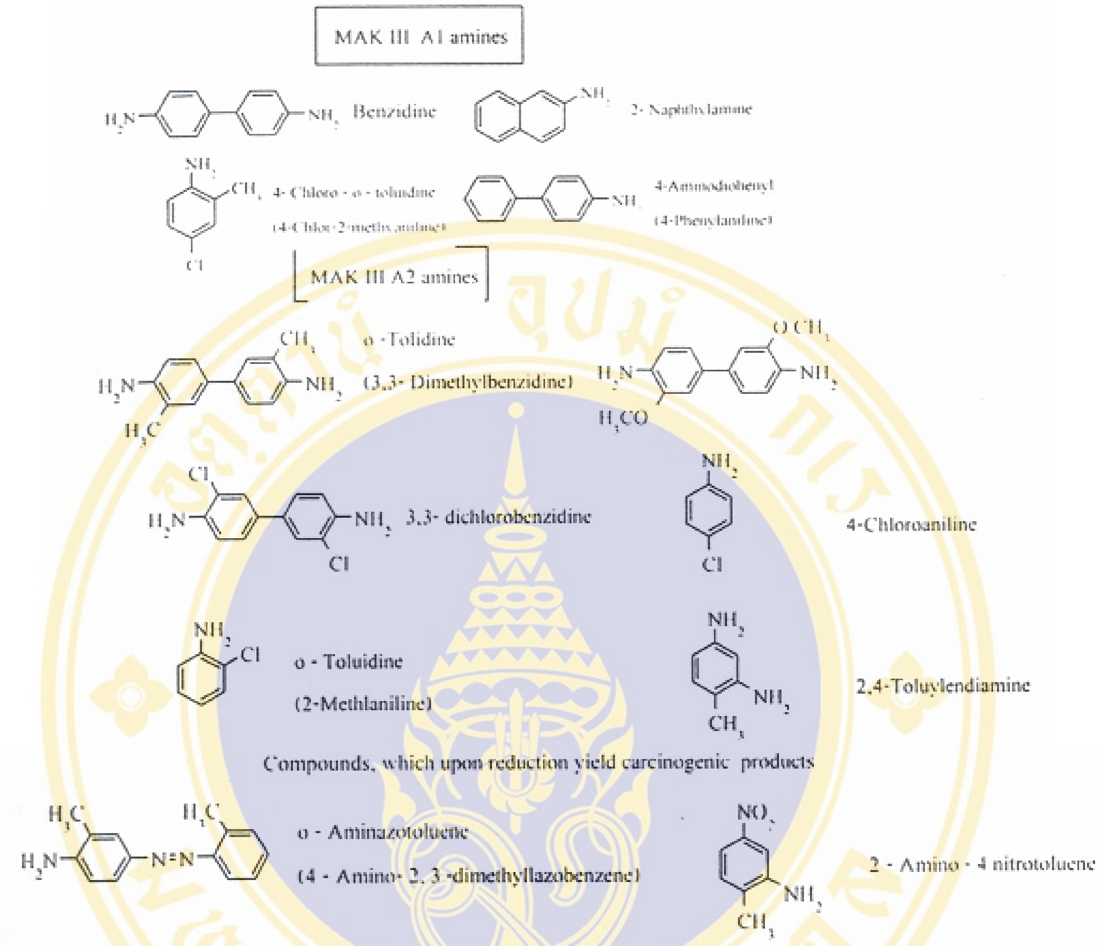


Figure 2.2 Decomposed Azo dyestuffs

2.4.2 Natural Dyestuff

Natural dyestuffs are from plant, animal, microorganism and mineral. Dyestuffs from plant are organic compound, it obtainable from root, bark, trunk, heartwood, leaf, flower, gain and seed. Majority dyestuff from animal is dry insect such as *Lac*. Majority dyestuffs from microorganism are fungus, yeast and bacteria. Its can be classified as the following (6, 7, 8)

2.4.2.1 *Flavonoids* to give yellow or yellow-orange, chemical structure is C_6-C_3-C_6 such as Morin from heartwood of Jackfruit, Carthamin from Safflower. C_6 is benzene ring and C_3 must to joint with oxygen atom to occur the heterocyclic ring, if it have carbonyl group at heterocyclic ring, we called *flavone*. If have hydroxyl group at heterocyclic ring, we called *flavonol*.

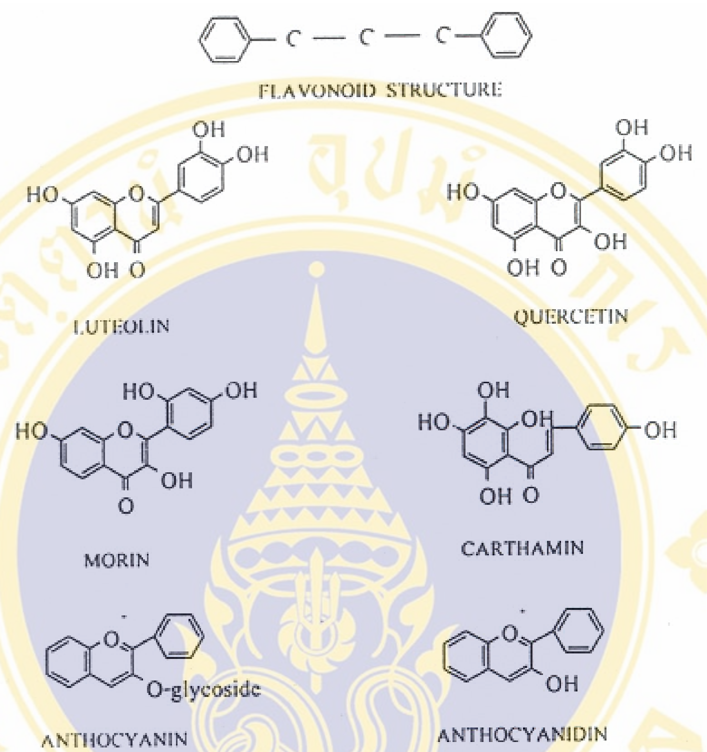


Figure 2.3 Structure of Flavonoids matter

2.4.2.2 *Carotenoids* is one of lipid compound we called *terpene*, when in molecule have oxygen we called *terpenoids* or *isopenoids* that has synthesized from *isopenthane unit* such as *crocetin* from Saffron that give yellow color. This group has single bonding alternated with double bonding.

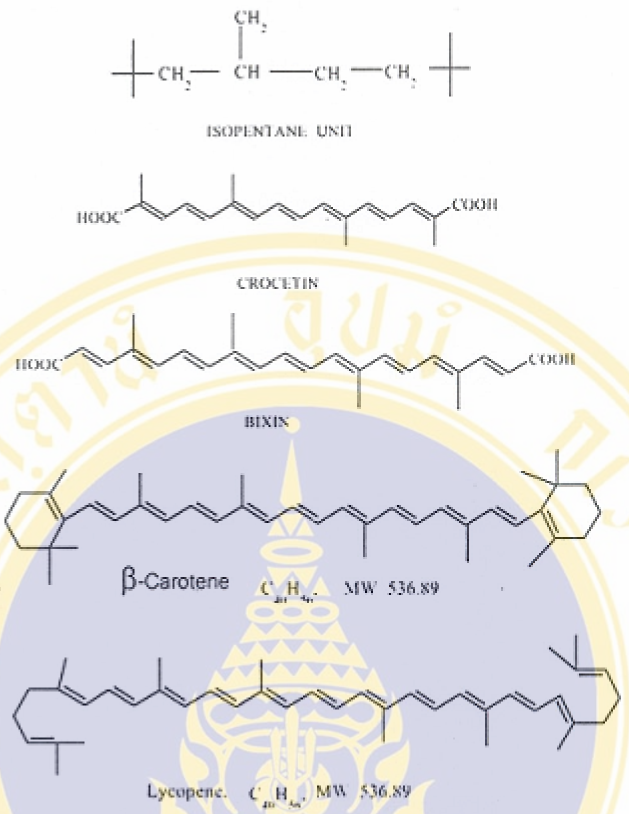


Figure 2.4 Structure of Carotenoids matter

2.4.2.3 Anthraquinones and Napthraquinones is three ring system chemical structures and must to give red-orange color to yellow-brown color such as *alizarin* from madder, *laccaic acid* from Lac, and *alkanin* from alkanet plant.

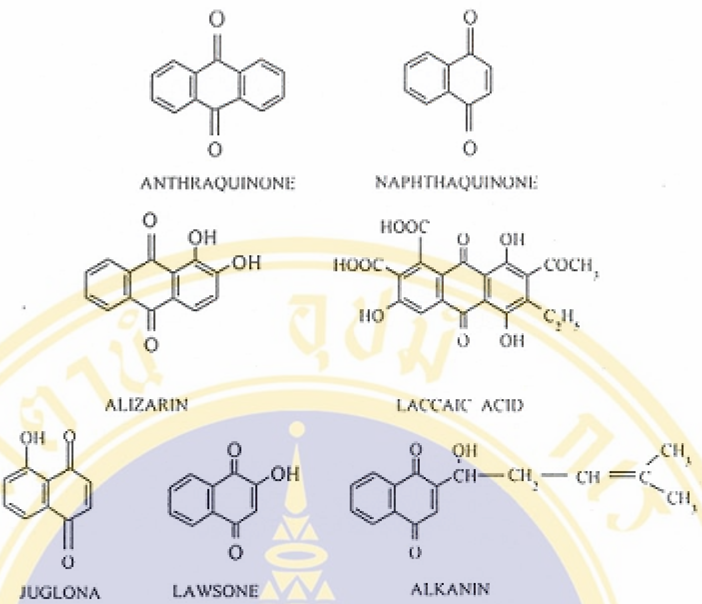


Figure 2.5 Structure of Anthraquinones and Napthraquinones matter

2.4.2.4 Alkaloids normally in alkaloids molecule must to have one atom of nitrogen that has one property is alkali, these are weak alkali or strong alkali up to number of nitrogen atom in alkaloids molecule such as Indigo and Tyrian.

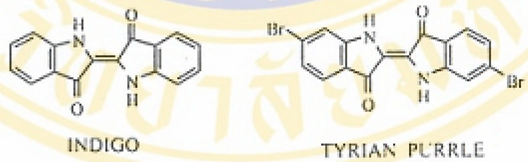


Figure 2.6 Structure of Alkaloids matter

2.4.2.5 Mixed matter that has different chemical structure from four types on the upper. The matters in this group are Curcumin and Chlorophyll.

2.5 Dyeing with Natural Dyestuff

2.5.1 Natural Dyestuff

Natural dyestuff could use some plant products such as leaves, barks, heart of woods, seed and fruits for dyeing. Interested plants in recorded are following

Table 2.1 Natural dyestuff for dyeing silk (9)

Color	Raw material
1. Khaki	curcuma, leaves and bark of teak
2. Dark khaki	heartwood of jackfruit
3. Green khaki, dark green	leaves of myrobalan, heartwood of jackfruit and bark of oroxylum
4. Light green	leaves of sesbania
5. Dark green	bark and leaves of myrobalan
6. Green-yellow	leaves of pineapple mixed with lime juice
7. Yellow	curcuma, heartwood of maclura and root of morinda coreia
8. Light yellow	heartwood of maclura, root of morinda coreia mixed with citrus hystrix juice
9. Dark yellow	heartwood of jackfruit
10. Yellow-orange	flower of bixa orellana
11. Cream	root of morinda coreia
12. Orange	leaves and gain of bixa orellana
13. Red	root of morinda coreia and euphorbiaceae mixed with fish oil
14. Red	seed of bixa orellana and root of morinda coreia
15. Indigo blue	root and leaves of indigofera
16. Black	bark and leaves of myrobalan and gain of diospyros

Table 2.2 Natural dyestuff from plant and animal (10)

Item	Thai Name	Botany Name	Section	Color
1	Kannika	*Nyctanthes arbor-tristis Linn.*	flower tube	gold
2	Khoo	*Quercus spp.*	bark	dark yellow
3	Gealea	*Maclura cochinchinenis Corner.*	heartwood	yellow
4	Kongkangbailek	*Rhizophora mucronata Poir.*	bark	brown
5	Kongkangbaiyai	*Rhizophora apiculata Bl.*	bark	brown
6	Khanoon	*Artocarpus heterophyllus Lamk.*	heartwood, root	brown-yellow
7	Khanoonpa	*Artocapus lanceifolius Roxb.*	heartwood	yellow
8	Kontha	*Harrisonia perforate Merr.*	fruit	black
9	Kram	*Indigofera tinctoria Linn.*	trunk	navy blue
10	Khang	*Albizia odoratissima Benth.*	bark	brown
11	Kheam	*Cotylelobium melanoxylon Pierre.*	bark	dark brown
12	Khumpa	*Mallotus philippinensis Muell Arg.*	root, flower	red
13	Khumphoy	*Carthamus tinctorius Linn.*	flower	red
14	Khumsad	*Bixa Orellana Linn.*	meat to covered seed	orange
15	Chalabdang	*Acacia leucophloea Willd.*	wood	red-brown
16	Takobthai	*Flacaurtia cataphracta Roxb.*	leaves	green-brown
17	Tubtoaton	*Diospyros ehretioides wall.ex.G.Don*	fruit	black
18	Teawhhon	*Cratoxylum formosum(Jack) Byer*	bark	dark brown
19	Thongwaw	*Butea monosperma O.Ktze.*	flower	yellow
20	Teanking	*Lawsonia inermis Linn.*	leaves	magenta
21	Nonsi	*Peltophorum Pterocarpum Back.ex.Heyne*	bark	yellow-brown
22	Pradoo	*Pterocarpus macrocarpus Kurz*	heartwood	dark red
23	Prasak	*Bruguiera gymnorrhiza Lamk.*	bark	red-brown

Table 2.2 (Continue) Natural Dyestuff from plant and animal (10)

Item	Thai Name	Botany Name	Section	Color
24	Prongkhao	*Ceriops decandra Ding Hou*	bark	brown
25	Phang	*Caesalpinia sappan Linn.*	heartwood	red
26	Phaddang	*Lumnitzera littorea(Jack) Voigt.*	bark	brick colored
27	Payom	*Shorea roxburghii G. Don*	bark	brown-orange
28	Pud	*Gardenia collinsae Craib*	wood	cream
29	Pudsonn	*Ervatamia coronaria Stapf*	meat to covered seed	red
30	Peka	*Oroxylum indicum Vent*	bark	khaki
31	Maklumton	*Adenanthera pavonina Linn.*	wood	red
32	Makaem	*Canarium Craib.*	fruit	black
33	Maklua	*Diosyros mollis Griff.*	fruit	black
34	Makhamthai	*Tamarindus indica Linn.*	leaves	yellow
35	Makhampom	*Phyllanthus emblica Linn.*	bark, leaves	brown-yellow
36	Madakeenon	*Garcinia thorelii Pierre*	rubber	yellow
37	Matoom	*Aegle marmelos Corr.*	fruit skin	yellow
38	Mapood	*Garcinia vilersiana Pierre*	bark	yellow
39	Mayompa	*Ailanthus triphysa Alston*	leaves	black
40	Mahad	*Artocarpus lakoocha Roxb.*	bark	brown-yellow
41	Mungkud	*Garcinia mangostana Linn.*	fruit skin	yellow
42	Yomhom	*Toona ciliate Roxb.*	flower	magenta
43	Yawbann	*Morinda citrifolia Linn.*	root, bark, leaves	yellow
44	Yawpa	*Morinda coreia Ram.*	root skin	red
45	Yukaliptus	*Eucalyptus camaldulensis Behnh*	leaves	brown-yellow

Table 2.2 (Continue) Natural Dyestuff from plant and animal (10)

Item	Thai Name	Botany Name	Section	Color
46	Rong	*Garcinia Hanburyi F.*	rubber	yellow
47	Rokfa	*Terminatia alata Heyne ex Roth.*	bark	black
48	Lebrog	*Toddalia asiatica Lamk.*	root	yellow
49	Lean	*Melia azedarach Linn.*	leaves	green
50	Sontalay	*Casuarina equisetifolia J.R.Forst.*	bark	brown-red
51	Samawthai	*Terminalia chebula Retz.*	bark, fruit	black
52	Samawpipek	*Terminalia bellerica Roxb.*	bark, fruit	green-brown
53	Sadao	*Azadirachta indica Juss.var.siamensis Veleaton*	bark	red
54	Suk	*Tecton grandis Linn.f.*	heartwood	khaki
55	Seesead	*Acacia catechu willd.*	wood	brown
56	Samaedum	*Avicennia officinalis Linn.*	bark	brown-red
57	Homm	*Strobillanthes flaccidifolia Ness*	leaves	navy blue
58	Hukwang	*Terminalia catappa Linn.*	leaves	green-brown
59	Aoychang	*Lannea coromandelica Merr.*	bark	brown
60	Krung	*Laccifer Lacca Kerr.*	insect	red

Table 2.3 Natural dyestuff from plant (11)

Item	Thai Name	Botany Name	Section	Color
1	Khaminchun	*Curcuma domestica Valeton*	root	yellow
2	Kheelek	*Cassia Siamea Britt*	heartwood	yellow
3	Kanluang	*Nauclea Orientais Linn.*	heartwood	yellow
4	Mhon	*Morus indica Linn.*	heartwood	yellow
5	Sanead	*Adhatoda Vasica(L) Ness*	leaves	yellow
6	Supanniga	*Cochlospermum religiosum(L) Alston*	heartwood	yellow
7	Keakhao	*Dolichandrone rheedii Seem*	leaves	green
8	Supparod	*Ananas bracteatus Schult.F.*	leaves	green
9	Tubtim	*Punica granatum Linn.*	fruit skin	green
10	Whaw	*Eugenia Cumini(L) Druce*	fruit	light purple
11	Nommaew	*Uvaria Kurzii King*	bark	brown
12	Takona	*Diospyros retrofracta Bakh*	fruit	brown
13	Mak	*Areca Catechu Linn.*	fruit	brown
14	Kongkang	*Rhizophora apiculata BL.*	bark	brown
15	Maplub	*Diospyros Embryopteris*	fruit	brown
16	Samawhin	*Vitex pubescens Vahl*	fruit	black
17	Seepub	*Carallia lucida Roseb*	fruit	black
18	Krajai	*Caesalpinia sepiaria Roxb.*	fruit	black
19	Mek	*Macaranga tanarius Mrell.Arg.*	leaves	navy blue
20	Homm	*Baphicacanthus cusia Brem*	leaves	navy blue
21	Kheega	*Adeia Penangiana Wilde*	bark mixed with heartwood of jackfruit	green

2.5.2 Dyeing Process (12)

Dyeing process are 3 types of classification as the following

2.5.2.1 Direct Dyeing

Natural dyestuffs are soluble dye and produce direct bonding with fiber. Cellulose fiber such as cotton have many hydroxyl group, it can be produce hydrogen bonding with dyes molecule. Silk and wool are polypeptide that has acidic group and basic group, its can be produce ionic force. Direct dyeing is low color fastness property and unbright colored.

2.5.2.2 Vat Dyeing

Color matters are not soluble dye thus first step must to bring out the dye are soluble such as Indigo dye from *Indigofera tinctoria Linn.* and *Strobillanthes flaccidifolia Ness.* This process must to repeat dyeing many times up to require color.

2.5.2.3 Mordant Dyeing

This process necessary to used mordant for better fixed between dyes molecule and fiber. Favorite mordant are metal-salt solution and tannin. Majority of metal-salt is *alum* or *potassium aluminum sulfate.* This process can be dyeing in 3 methods such as the following

1) Retting the fiber in mordant solution before dyeing process

2) Dyeing with dyes solution mixed with mordant solution

3) Dyeing fiber with dyes solution after that retting the colored fiber in mordant solution

2.5.3 Terminalia catappa Linn.

2.5.3.1 Botany characteristic

Scientific name is *Terminalia catappa Linn.* It is Combretaceae family (13, 14) and Terminalia genus. It has many common name are as, Tropical Almond, Singapore Almond, Bengal Almond, Umbrella Tree (13, 14). It has many local names in each country, in Thailand: Cone (Naratiwas), Dudmue (Trung), Tapung (Pisanuloke and Satul) (13, 15).

Terminalia catappa Linn. is middle tree, 8-28 meters high. It can be found in various parts of the world especially in Asia, tropical climate area (16, 17). In Thailand, this is growing by the road side and even along sea coasts (13, 15). Shape of leaf is oval shape that has 8-12 centimeters wide and 15-25 centimeters long and shedding leaves in winter (13, 15, 17).

2.5.3.2 Color matter in *Terminalia catappa Linn.* leaves.

1) Tetrapirol such as porphirin contained with chlorophyll that is magnesium complex and has green colored. When treated with thermal, the color can be change in brown-green of pheophytin compound (18, 19).

2) O-heterocyclic such as Flavonoid that has contained with Flavones, Flavonols and Anthocyanins (20).

Except the upper color matter, *Terminalia catappa Linn.* has one important component that is Tannin (21), its can be used in dyed production process and can help to better fixation of dyes. Component of tannin are Lacic acid, Allagic acid, Corilagin and Brevipholin carboxylic (22).

2.6 Silk

2.6.1 Introduction of silk (23)

Silk fiber is produced by the larvae of a wide variety of mouths, but the *Bombyx mori* is the major one raised under controlled conditions. Life cycle of the silk has 4 steps as following

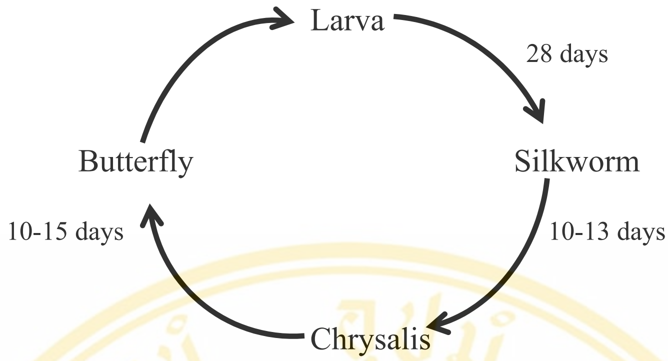


Figure 2.7 Life cycle of silk

The larva attaches itself to a specially constructed straw frame, rears its head, and begins to spew the silk liquid, which hardens upon contact with air. The larva spins by moving its head in a figure-eight motion and constructs the cocoon from the outside. As it spins, the larva decreases in size and upon completion of the cocoon the carterpillar changes into the dormant chrysalis stage.

The silkworm extrudes the liquid from two tiny orifices or spinnerets in its head. The filaments, coated with a gummy substance called *sericin*, come from two glands within the worm.

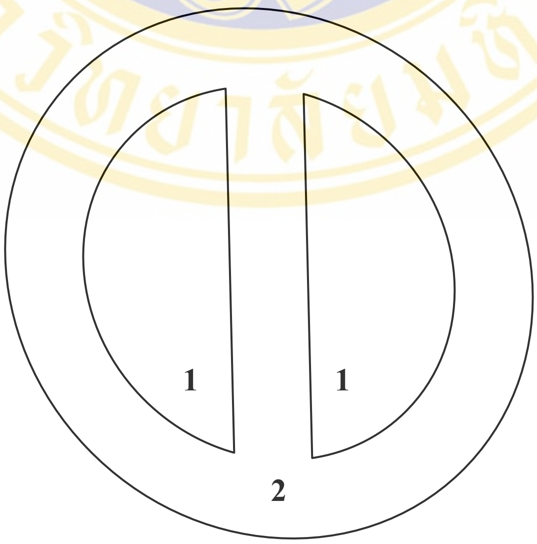


Figure 2.8 Fibroin and Sericin

1. Fibroin 2. Sericin

2.6.2 Component of raw silk

Table 2.4 Component of raw silk (23)

Component	Percentage
Fibroin	56-67
Sericin	22-25
Moisture	10-11
Salt and other mineral	1-1.5

Silk is a protein fiber. The protein is called *fibroin*; as it is secreted, it is surrounded by the gummy protein substance called *sericin*. The sericin holds the fibroin filaments together. Fibroin is composed of about 15 amino acid that form a polypeptide chain.

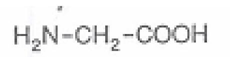
2.6.2.1 Fibroin is a part of fiber called fibrous protein, component of amino acid in fibroin are shown in Table 2.5

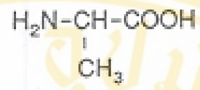
Table 2.5 Component of amino acid in Fibroin

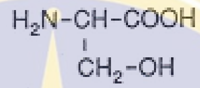
Type of amino acid	Percentage
Glycine	40
Alanine	25
Serine	15
Tyrosine	10
Valine	3
Glutamine acid	2
Aspatic acid	2

Structure of fibroin has 2 sections, one is called *crystalline* and one is called *amorphous*. Crystalline is the molecular arrangement is highly oriented, which gives the fiber high strength. Amorphous is the molecular arrangement is low oriented, which gives the fiber are flexibility and more dyes absorption.

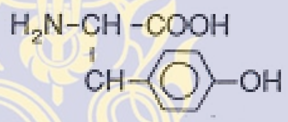
Crystalline in fibroin has amino acid as the following

Glycine 

Alanine 

Serine 

Amorphous in fibroin has amino acid as the following

Tyrosine 

2.6.2.2 Sericin is a part of fiber called non-fibrous material, it is opaque yellow material, component of amino acid in fibroin are as the following

Table 2.6 Component of amino acid in Sericin

Type of amino acid	Percentage
Serine	33
Aspatic acid	17
Trionine	8
Glutamic acid	6
Tyrosine	3
Lysine	3
Histydine	1
Other	26

2.6.3 Structure of silk

Structure of silk are shown in as the following

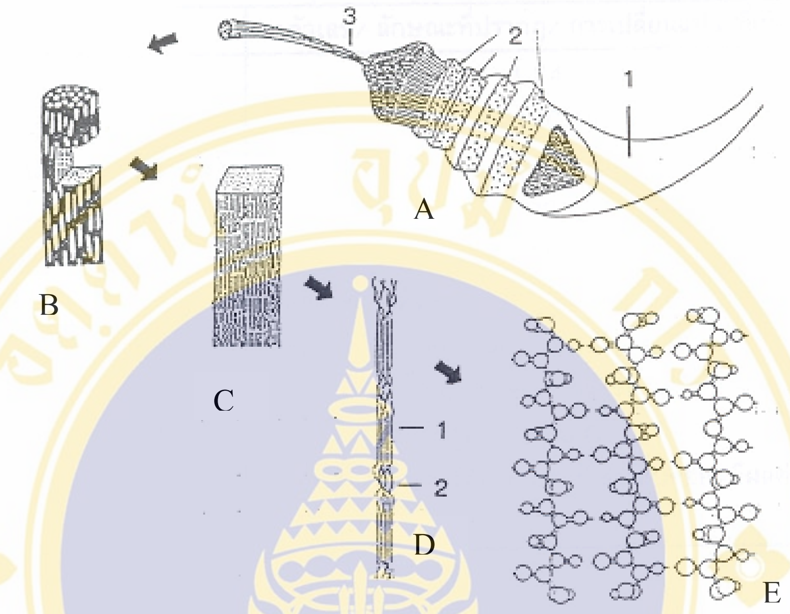


Figure 2.9 Structure of silk (23)

A. Silk fiber: 1. Fibroin, 2. Sericin, 3. Fibrill
B. Fibrill
C. Micro fibril
D. 1. Crystalline, 2. Amorphous
E. Arrangement of amino acid in micro fibril

2.6.4 Properties of silk

Properties of silk are shown in the table as following

Table 2.7 Properties of silk (23)

Property	Evaluation
Density	1.34 g/ccm
Tenacity dry wet	 2.4-5.1 g/d 2.0-4.3 g/d
Elongation dry wet	 10-25 % 33-35 %
Elastic recovery	92 % recovery at 2 % extension
Moisture absorption at 20°C,65 % R.H.	11 %
Resistance to acid alkali Sunlight	 Low; dissolves or damaged by most mineral acid; organic acid do not damage. Strong alkali damage fiber; weak alkali have little or no effect. Prolonged exposure causes fiber breakdown.

2.7 Color Fastness

Dyers and dye makers have, over a period of at least half a century, given much attention to the fastness of colored materials when exposed to various influences such as light, washing, perspiration, rubbing, bleaching and acid-alkali. In the early days of dye discovery and manufacture more attention was paid to increasing the number of dyes available. When a fair number of dyes were known and made, then came careful selection from the viewpoint of fastness.

Today a newly discovered dye is not put into production until it is shown either that it has a peculiarity of shade which is much desired, or that it has fastness properties superior to those of the dye which it is likely to supplant. The result of this rigid selection is that at least one hundred times as many new days are being discovered as are ultimately manufactured on large scale.

Most works where dyes are made or applied have laboratories for the purpose of testing their products. A great deal of care is taken throughout this country as well as in other to ensure that the fastness of colors is sufficient to meet general and particular requirements.

2.7.1 Fastness to light

This method is intended for determining the resistance of the color of textiles of all kinds and all forms to the action of daylight. This method is one of the difficulties of testing for fastness is to secure results within a reasonable period of time. Actually there is not better or more reliable test of a colored material than to wear it, or otherwise expose it to the actual adverse influences which it will meet in use. But this may take many months, and a large number of samples may have to be tested in order to secure a reliable average result. Consequently a number of accelerated tests have been devised stemming from the first systematic method of testing developed by the French scientist Du Fay in about 1730. In many cases they can be relied upon, but in other there is considerable doubt as to their accuracy. Yet, so great is the need for rapidity in testing, that these doubtful methods have to be used until more reliable ones are devised.

It has been found that the violet end of the spectrum including the ultra-violet light is most harmful in the fading of colored materials. Special fading lamps are now sold for testing fastness in which the proportion of ultra-violet light is somewhat greater than of ordinary sunlight. Other sources of illumination for testing and comparison purposes have been made to resemble sunlight very closely. The great advantage of these fading lamps is that the exposure of a sample of colored material can be carried out continuously for 24 hours per day, and testing is thus made independent of the weather or reason.

Dyes fade by the action of the sunlight decomposing them into simpler, less colored or differently colored substances. Sometimes it is found that the decomposition of the dye also promotes decomposition and consequent weakening of textile material on which it is dyed.

Textile auxiliaries are available which can, by application to colored textiles, increase their fastness to light. Such auxiliaries can act by being more reactive to light so that they reduce the harmful action of the incident light on the dye by themselves being decomposed first. By contrast, some auxiliaries, applied to colored fabrics to ensure special effects such as resistance to creasing, can reduce the fastness to light.

Much research has been given to elucidating the manner in which various internal and external conditions attendant on the light fading of dyes in textile materials is influenced, and the reactions involved have been found to be very complex. Small amounts of oxides of nitrogen and sulphur which may be present in the surrounding air in industrial cities, and of ozone in more sunny localities, can have not only a marked but also an uncertain influence. Temperature and moisture conditions can materially govern the rate of fading and substances present in the textile material together with the dye can often produce abnormal fading in light.

As might be expected light fading varies with the chemical nature of the dye and also with that of type of fiber present in textile material.

2.7.2 Fastness to washing

In the case of tests for washing fastness it is usual not only to carry out standard washing of the colored material and note the loss of color, but also to wash this material with white fabric or yarn and ascertain if there is any staining of the white. Of course, washing tests of graded severity are used and they must be correlated with the type of material. For example, it might be useful to see if colored cotton fabric kept its color in a boiling soap and soda liquor, but this test would never be applied to wool goods, for in actual use wool materials would never be exposed to such drastic conditions. A so-called wash-wheel machine is frequently used for washing tests.

The wash-wheel machine has a metal frame which carries a number of small pots each containing detergent liquor, a number of steel balls and the fabric under test. The frame is rotated, partly immersed in water heated to any desired temperature. The loss of color and any staining of white fabric washed with the fabric sample can thus be determined.

Recently and with the increased use of domestic washing machines has become more clearly recognized that the rubbing together of the fabrics and garments in the detergent liquor can have harmful effects.

One such harmful effect is that a colored material can acquire a so-called frosted appearance. This arises when the dye is not uniformly distributed within each fiber but is concentrated in its surface thus leaving the interior white or nearly so. The rubbing in the detergent liquor can irregularly remove such surface located dye to expose the white interior of the fiber so that the all-over appearance gives the fabric the appearance of having a thin frost covering over its colored textile. This same defect can result when the fabric consist of two or more types of fiber dyed to the same shade so as to present a solid coloring but with one type of fiber surface dyed or liable to a greater loss of dye than the other fiber.

The same rubbing can also cause a marking-off of the color of one fabric on to another differently colored fabric. Obviously this trouble can be avoided by not washing mixed colored materials. But, it can also occur when the washed materials are taken out from the washing machine and (before rinsing thoroughly) allowed to lie especially when they are warm for then the dyes can bleed (if not sufficiently fast) in those parts where the fabrics are firmly pressed together. Residual detergent and especially ordinary soap in the fabrics can promote dye bleeding and hence the advisability to rinse early and thoroughly in cold water.

2.7.3 Fastness to rubbing

This type of fastness of color which needs to be considered is that associated with rubbing. It is an interesting fact that some colored materials can be very fast to light and even to washing and yet stain white material when rubbed on it. Dyeing which rub badly are usually those in which the dye particles are present more on the surface of the fibers than inside them. In applying some types of dyes it is a difficult problem to avoid this defect. The naphthol range of dyes is especially liable to this fault and dyers have to take special precautions in the dyeing. The process to test of this type can made by crock meter with white fabric, put white fabric in end of finger and rubbed on colored fabric for ten times with dry and wet white fabric.

The standards for testing of color fastness to light, washing, and rubbing are has many methods and many associations such as AATCC (American Association of Textile Chemist and Colourist), BS (British Standard), JIS (Japanese International Standard), ISO (International Organization for Standardization), and TIS (Thai Industrial Standard). All methods are difference condition in testing process.

2.8 Related Research

From Namaoi Wongtien (1997: 21-23), the study of chemical constituent of color matter of jackfruit and cape marigold says, when the dye solution are as in acid condition might be give yellow color, but in alkali condition might be give green color or brown color. (24)

From Paisarn Kongkhachuichai (2000: 87-90), the study of technical for dyeing silk fiber with lac dye says, condition in used in dyeing process are as temperature, time, type of fixing agent and quantity of fixing agent, all are the factors that has effected to color fastness. The favorite of natural fixing agent are lemon, tamarind, zinc oxide, and water from an artesias well. (5)

From Nontalee Chinwongamorn (2000: 33-34), the study of thermodynamic and factors to involve in dyeing silk says, the solution for solve the problem of color fastness for natural dyestuff are 1) used fixing agent as alum, salt, lemon, tamarind, garcina, zinc oxide and water from an artesian well that are the media for made chemical bonding between dyes molecule and fiber 2) control some factor that has effect to color fastness are as temperature, pH, and time 3) suitable technique and efficiency for dye extract from raw material. (25)

From Motoi Minakawa and groups (1987: 91-96), the study of dyeing silk with curcuma says, fabric color in finished process up to the pH of fixing agent in used and increasing of capable of dyeing when used dyeing temperature at 80-90^{o}C and dyeing time at 60 minutes. (26)

From Narumol Saratapun (1987: Abstract), the study of dyeing silk with curcuma which 4 fixing agent are as iron, copper sulfate, acetic acid, and alum in 2, 4, 6, and 8 % o.w.f. at 80-85^{o}C 30 minutes, the result of this study are the iron and copper sulfate gives tallow-brown and yellow-green in accordance, but acetic acid, alum and pure dye solution gives yellow-gold. The results of color fastness to washing are iron 6%, copper sulfate 2%, and alum 8% o.w.f. that give the best fastness and the result of color fastness to light is copper sulfate at all percentage are gives the best fastness.(27)

From Nantanut Pichetwit (1987: Abstract), the study of dyeing silk with calubur leaves with 4 fixing aagent are as alum, copper sulfate, iron, and chrome in 1, 2, 3, and 4 % o.w.f. at 80-85^{o}C 30 minutes, the result are alum in 3, 4 % o.w.f. gives cream color, copper sulfate 1 % o.w.f. give yellow-green color and chrome in 1, 2 % o.w.f. gives yellow-gold color. Copper sulfate, alum, chrome and iron are gives color fastness result from high to low in accordance.(28)

From Charoensri Benjamala (1998: 49-53), the study of quotient of fixing agent for dyeing silk with coconut skin as 2 fixing agent are alum and acetic acid in 2, 4, 6, 8, and 10 % o.w.f., the result of fabric colored are little difference and result of color fastness to washing are all fixing agent make too much change and color fastness to light (xenon arc) are equal.(29)

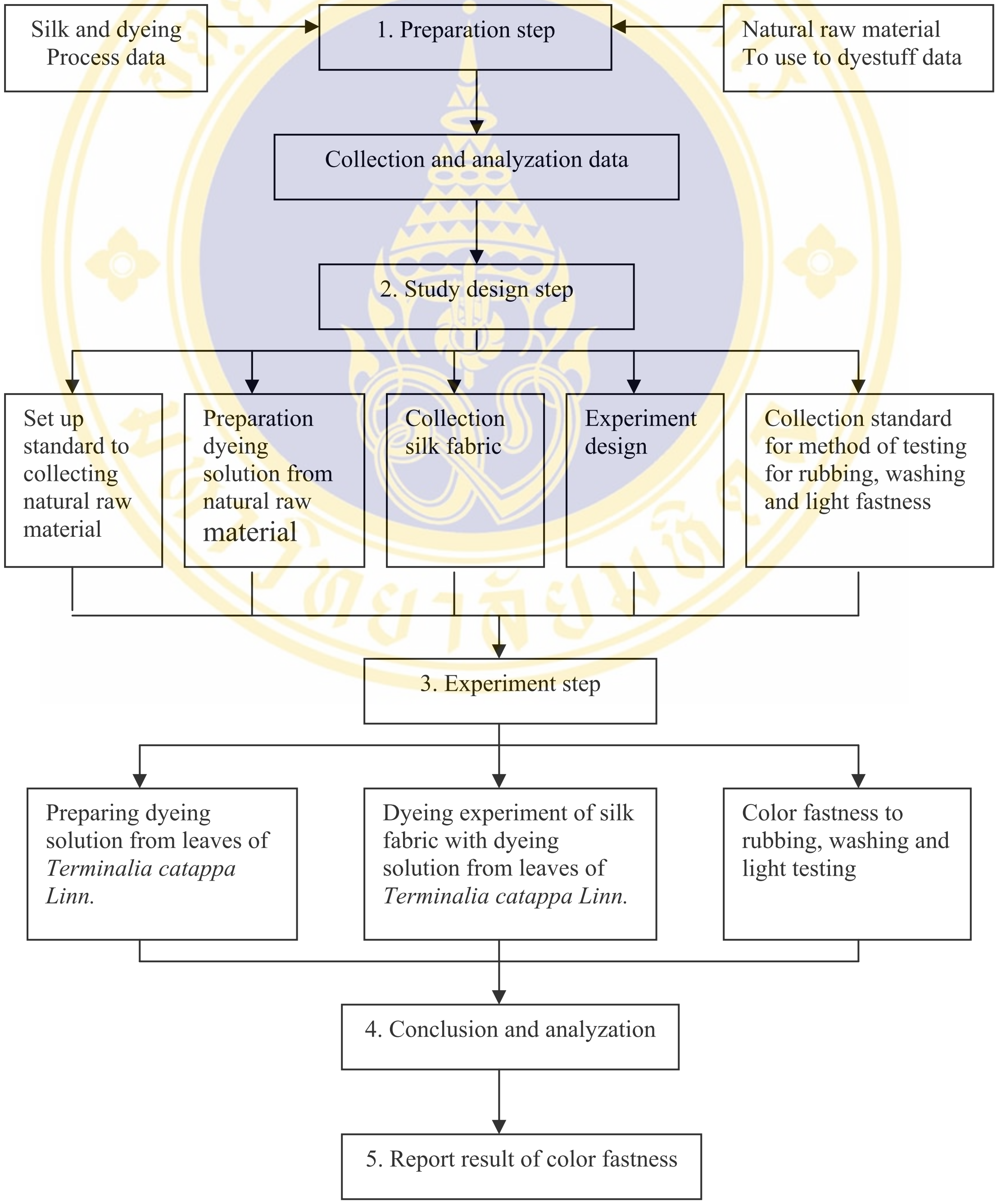
From Nujira Rassamipaiboon (2000: 37-42), the study of condition in dyeing process and color fastness to washing and light of silk with petal of calubur at 30, 60, and 80^{o}C, pH 3, 5, 7, and 9, and dyeing time at 30, 60, 90, and 120 minutes which fixing agent is 5% o.w.f. of alum, the result are at 30^{o}C must to use dyeing time at 30 minutes and pH 5, at 60^{o}C must to use dyeing time at 90 minutes and pH 5, and at 90^{o}C must to use dyeing time at 30 minutes and pH 9. (30)

From Supab Rohkarn (2001: 77-79), the study of dyeing silk with banana leaves which 4 fixing agent are as alum, acetic acid, iron, and ashes at 2, 4, 6, and 8 % o.w.f., the result of color fastness to washing, ashes is the best result and color fastness to light, iron is the best result.(31)

From Chontira Mochadaporn (2003: Abstract), the study of dyeing silk with Terminalia catappa Linn. leaves, the result of appropriated dyeing condition is at 80^{o}C, 45 minutes and chrome is the best fixing agent that gives minimum color change when testing of color fastness to washing and light.(32)

CHAPTER 3
METHODOLOGY

This study is experiment study that be emphasize to study on color fastness of silk color fabric which dyeing with *Terminalia catappa Linn.* leaves. It has steps of study as below diagram



3.1 Preparation Step

3.1.1 Collection data

Collected all data to concern this study from book, research and website

3.1.1.1 Silk: characteristic and properties

3.1.1.2 Dyeing: dyeing history and dyeing theory

3.1.1.3 Natural Dyestuff: raw material from plant and dyeing process

3.1.1.4 Color Fastness: standard and method

3.1.2 Collection and analyzation

3.2 Study Design Step

3.2.1 Set up standard to collecting natural raw material

3.2.1.1 To give green colorant

3.2.1.2 To be able to find at all district

3.2.1.3 Has dye affinity for silk fabric

3.2.1.4 Dyeing machinist has experience in that raw material

From all above, researcher collected raw material to use in this experiment is fresh *Terminalia catappa Linn.* leaves in position 5-15 from top(32) and before bring its to make dyes solution, bring its to keep in standard room at 27^{o}C 24 hours (33)

3.2.2 Preparation dyeing solution

Pounded fresh *Terminalia catappa Linn.* leaves then add distilled water and boiling at 60^{o}C 60 minutes after that filter dye solution, its complete to use.

3.2.3 Collection of silk fabric

In this study used 100% weaving silk fabric that has degummed and all of fabric is the same lot. Before use in the experiment, bring it is to keep in standard room at 27°C 24 hours (33)

3.2.4 Experimental design

This experiment be emphasize to study color fastness to rubbing, washing and light of silk color fabric which dyeing with *Terminalia catappa Linn.* leaves that has different condition and different dye fixing agent.

The experimental design is set up in factorial arrangement in randomized completely block design, comprised of 2 factors; factor A are 3 concentration of dyes liquor and factor B are 12 levels of dyeing conditions, so there are 3x12 treatments and there are 3 replications for each treatments as below table

Table 3.1 Experimental treatments

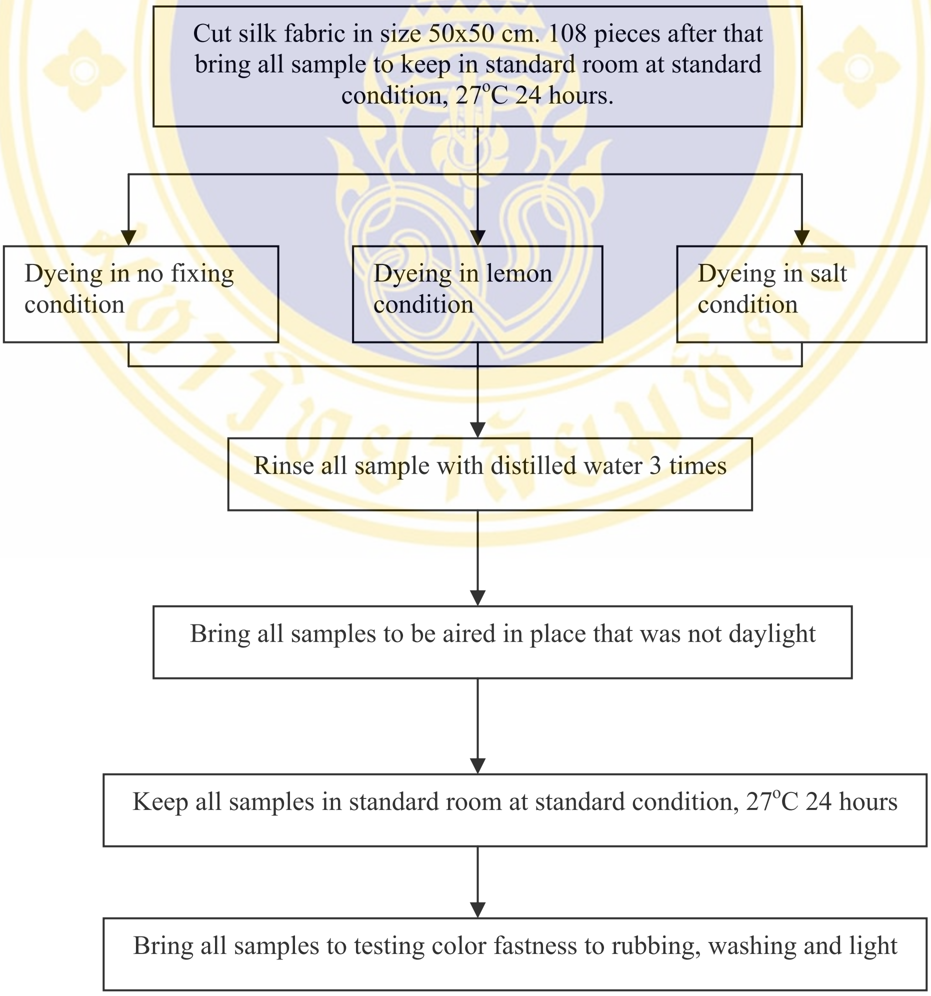
Dyeing Condition (Factor B)	Concentration of dye solution (Factor A)					
	Maximum		Middle		Minimum	
	1:1 (a_1)	No. of sample	1:3 (a_2)	No. of sample	1:5 (a_3)	No. of sample
No fixing agent , 60°C ,45 min (b_1)	a_1b_1	3	a_2b_1	3	a_3b_1	3
No fixing agent, 60°C ,60 min (b_2)	a_1b_2	3	a_2b_2	3	a_3b_2	3
No fixing agent, 80°C ,45 min (b_3)	a_1b_3	3	a_2b_3	3	a_3b_3	3
No fixing agent, 80°C ,60 min (b_4)	a_1b_4	3	a_2b_4	3	a_3b_4	3
Lemon, 60°C ,45 min (b_5)	a_1b_5	3	a_2b_5	3	a_3b_5	3
Lemon, 60°C ,60 min (b_6)	a_1b_6	3	a_2b_6	3	a_3b_6	3
Lemon, 80°C ,45 min (b_7)	a_1b_7	3	a_2b_7	3	a_3b_7	3
Lemon, 80°C ,60 min (b_8)	a_1b_8	3	a_2b_8	3	a_3b_8	3
Salt, 60°C ,45 min (b_9)	a_1b_9	3	a_2b_9	3	a_3b_9	3
Salt, 60°C ,60 min (b_{10})	a_1b_{10}	3	a_2b_{10}	3	a_3b_{10}	3
Salt, 80°C ,45 min (b_{11})	a_1b_{11}	3	a_2b_{11}	3	a_3b_{11}	3
Salt, 80°C ,60 min (b_{12})	a_1b_{12}	3	a_2b_{12}	3	a_3b_{12}	3

3.2.5 Standard for method of color fastness testing

Standard for method of color fastness testing is Thai Industrial Standard No.121 book 1, 3, 5 and 14, 1975. That has referred from International Organization for Standardization (ISO), ISO/R 105-1959, ISO/R 105/IV-1968 and ISO/R 105-1959 part 2, 3.

3.3 Experiment Step

Framework for experiment step are shown in the below diagram



3.4 Color Fastness Testing Step

Test the color fastness properties of all samples by the Thai Industrial Standard Method No.121 book 1, 3 and 5, year 1975.

3.4.1 Color fastness to light (35)

This method is intended for determining the resistance of the color of textiles of all kinds and all forms to the action of daylight.

A specimen from the textile material to be tested and the selected standard are exposed simultaneously under specified conditions to the amount of exposure required to produce a specified degree of color change or alternatively to a specific amount of radiant energy. The color fastness to light of the specimen is rated by comparison of the change between the exposed and unexposed portions of the sample with gray scale for color change.

3.4.1.1 Apparatus and Materials

1) Applicable Blue Wool Light Fastness Standards, they range from No.1 (very low light fastness) to No.8 (very high light fastness), each standard being approximately twice as fast as the one below it.

Table 3.2 Blue wool light fastness standards.

Range of light fastness	Dye
1	C.I. Acid Blue 104
2	C.I. Acid Blue 109
3	C.I. Acid Blue 83
4	C.I. Acid Blue 121
5	C.I. Acid Blue 47
6	C.I. Acid Blue 23
7	C.I. Solubilized Vat Blue 5
8	C.I. Solubilized Vat Blue 8

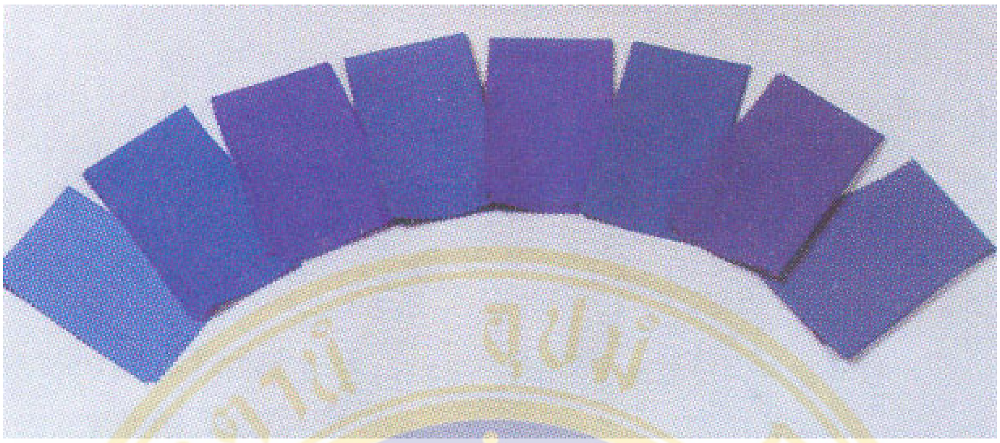


Figure 3.1 Blue wool light fastness standards.

2) Exposure rack, facing due south in the Northern Hemisphere, north in the Southern Hemisphere, and sloping at an angle from the horizontal approximately equal to the latitude of the place where the exposure is made. The rack should be placed so that shadows of surrounding objects will not fall on the exposed textiles, and covered with window glass to protect the specimens from the weather, the glass being not less than 50 mm. from the surface of the specimens; adequate ventilation shall be provided.

Figure 3.2 Lightandother Visual machine

3) Opaque cardboard

4) Gray scale for color change

Figure 3.3 Gray scales for color change

3.4.1.2 Tested specimens

An area of the textile not less than 10x60 mm. is used when the several periods of exposure are made side by side on the same specimen. The small specimen wound close together on the white cardboard to give even coverage.

3.4.1.3 Procedures of light fastness testing

1) Arrange the specimen to be tested and the standards as shown in Figure 3.4 with card AB covering one-quarter of the total length of each specimen and standard.

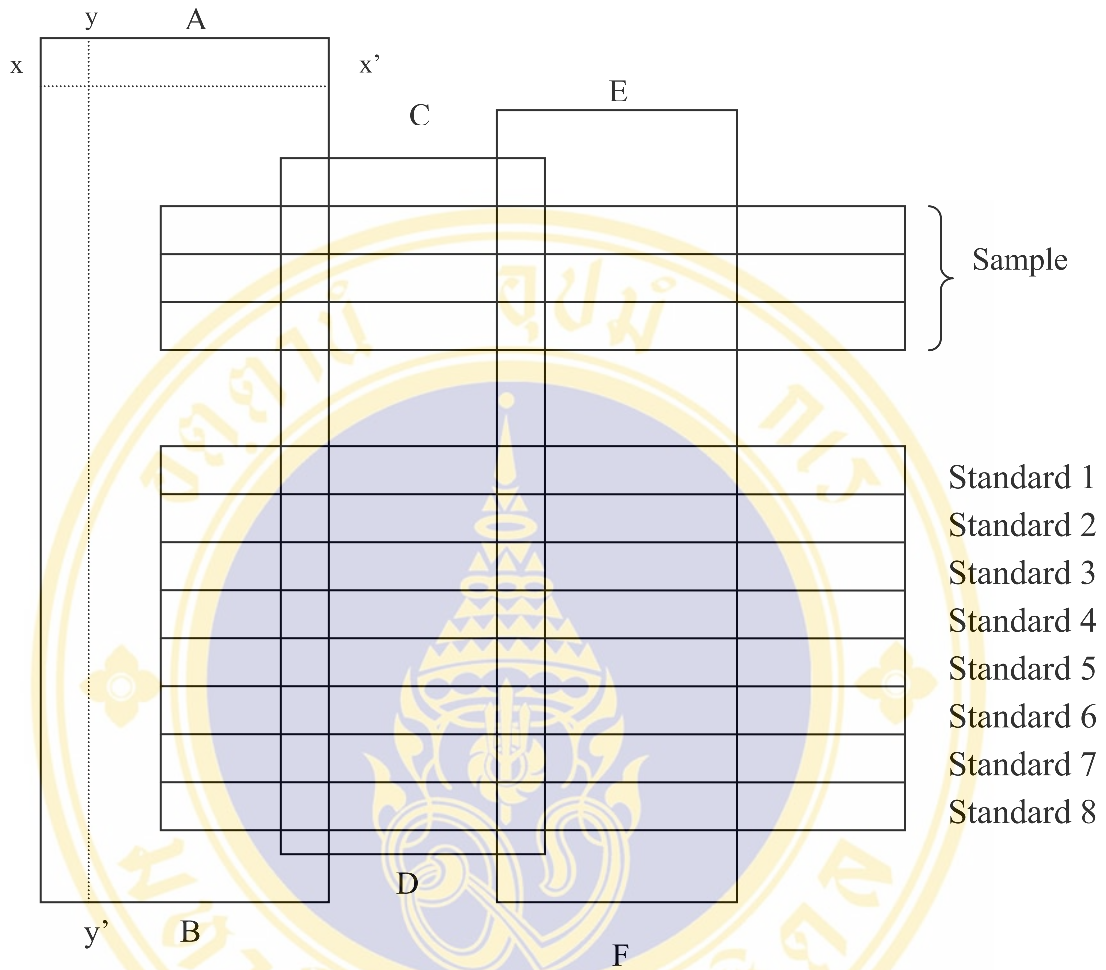


Figure 3.4 Mounting for light fastness test

Note: AB Opaque covers. May be hinged at xx' or yy' so that it can be Lifted and returned to the same place over the specimens and standards.

CD Second covers.

EF Third covers.

2) Expose them simultaneously for 24 hours per day under the conditions enumerated in section 2) at 3.4.1.1 follow the effect of light by lifting the cover periodically and inspecting the standards.

3) When a change in standard 3 can just be perceived, inspect the specimens and rate their light fastness by comparing any change that has occurred with changes that has occurred in standard 1, 2 and 3.

4) Replace the card AB in exactly the same position, and continue to expose until a change in standard 4 can just be perceived, at this point fix an additional cover CD in the position shown in Figure 3.4, overlapping the first cover.

5) Continue to expose until a change in standard 6 can just be perceived, then fix the final cover EF in the position shown, the other two covers remaining in position. Expose until either (a) a contrast is produced on standard 7 equal to the contrast illustrated by grade 4 of the gray scale, or (b) a contrast equal to grade 3 has been produced on the most resistant specimen, whichever occurs first. Remove the three covers.

6) Compare the changes in the specimens with those in the standards.

3.4.1.4 Assessment of light fastness

1) Preliminary assessment of light fastness

When a change in color of the specimen under test can just be perceived; note the number of the standard showing a similar change; alternatively, when a change in color of standard 3 can just be perceived, assess any change that has occurred in the specimen in comparison with the changes in standard 1, 2 and 3. Continue to expose after the preliminary assessment as required to evaluate fully the light fastness.

2) Detailed assessment of light fastness

Compare the changes in color of the test specimen with the changes which have occurred in the standards. The light fastness of the specimen is the number of the standard which shows similar changes in color (visual contrast between exposed and unexposed parts of the specimen).

3.4.2 Color fastness to washing (35)

This method is intended for determining by mechanical means the resistance of the color of textiles of all kinds and in all forms to the action of detergent as used in washing.

A specimen of the textile in contact with specified undyed cloths is agitated in detergent solution, rinsed, and dried. The change in color of the specimen and the staining of the undyed cloths are assessed with standard gray scales.

3.4.2.1 Apparatus and Materials

1) Launder-O meter

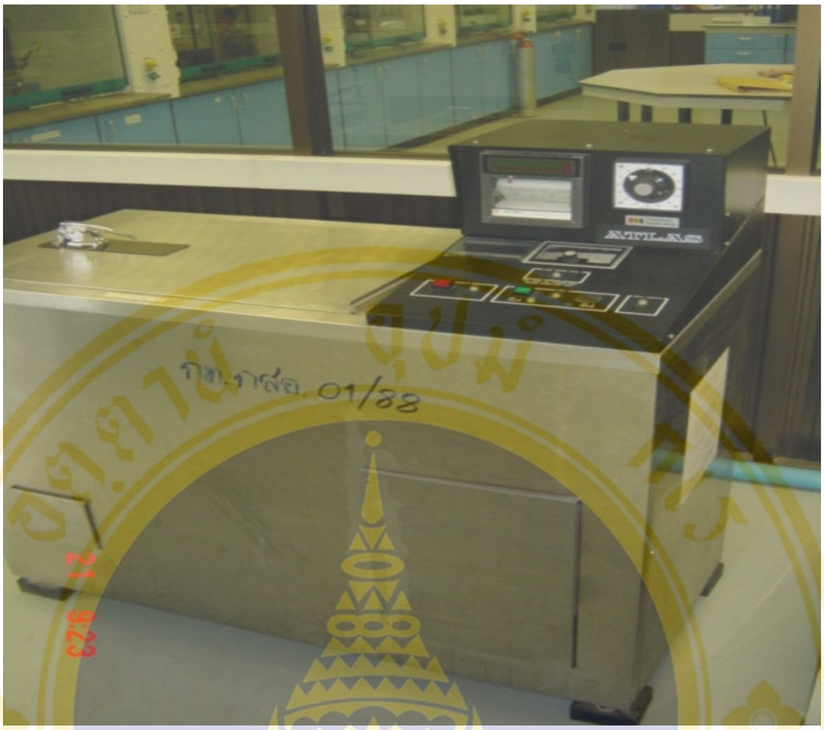


Figure 3.5 Launder-O meter

2) Two undyed cloths (silk and cotton), each 40 mm. x 100 mm.

3) Detergent that containing not more than 5% of moisture and complying without the fluorescent and brightening. Detergent solution containing 5 g/l

4) Distilled water

5) Gray scale for color change

6) Gray scale for staining

Figure 3.6 Gray scales for color change and staining

3.4.2.2 Tested specimens

An area of specimen not less than 40mm. x 100 mm.. Cover between specimens with two pieces of undyed cloths after that sewing around all four sides.

3.4.2.3 Procedures

1) Place the composite specimen in the container and add the necessary amount of detergent solution, to give a liquor ratio to 50:1

2) Adjust the Launder-O meter to maintain the designated bath temperature at 42 +/- 2^{o}C

3) Treat the composite specimen by starting the machine and running at 42 rpm. For 30 minutes

4) Rinse the composite specimen twice in cold distilled water and then in cold running tap-water for 10 minutes, and squeeze it

5) Remove the stitching along the two long sides and one short side, open out the composite specimen, and dry in air at room temperature

6) Assess the change in color of the specimen and the staining of the undyed cloths with the gray scales

3.4.2.4 Evaluation

1) Change in color: The effect on color of the test specimen can be expressed and defined by reference to the gray scale for color change which classified into various classes as follows

Class 5 – negligible or no change as shown in gray scale step 5 (very good class)
Class 4 – a change in color equivalent to gray scale step 4 (good class)
Class 3 – a change in color equivalent to gray scale step 3 (middle class)
Class 2 – a change in color equivalent to gray scale step 2 (poor class)
Class 1 – a change in color equivalent to gray scale step 1 (very poor class)

2) Staining: Staining can be evaluated by gray scale for staining, the results can be indicated by classes as

Class 5 – negligible or no staining (very good class)
Class 4 – a staining equivalent to gray scale step 4 (good class)
Class 3 – a staining equivalent to gray scale step 3 (middle class)
Class 2 – a staining equivalent to gray scale step 2 (poor class)
Class 1 – a staining equivalent to gray scale step 1 (very poor class)

3.4.3 Color fastness to rubbing (35)

This method is intended for determining the resistance of the color of textiles of all kinds to rubbing off and staining other materials. Two tests are made, one with a dry rubbing cloth and one with a wet rubbing cloth.

A colored test specimen fastened to the base of a Crock meter is rubbed with white crock test cloth under controlled conditions. Color transferred to the white test cloth is assessed by a comparison with gray scale for staining.

3.4.3.1 Apparatus and Materials

1) Crock meter

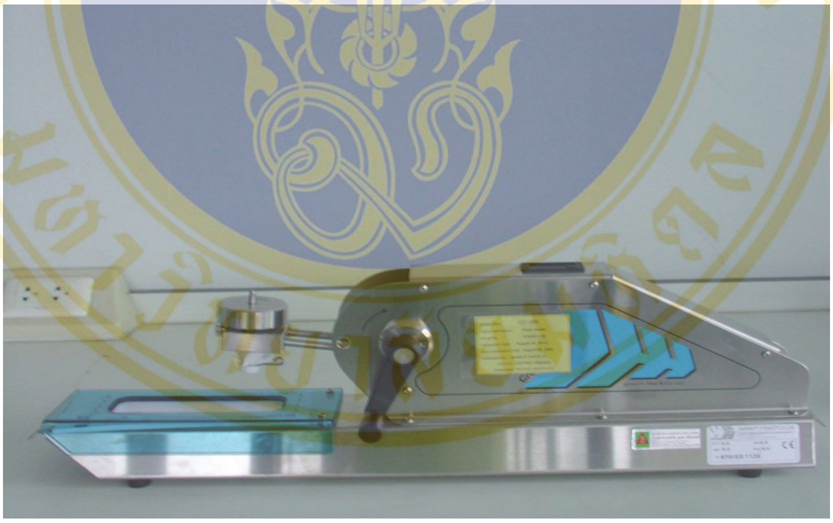


Figure 3.7 Crock meter

2) Crock meter test cloth

3) Gray scale for staining

Figure 3.8 Gray scales for staining

3.4.3.2 Tested specimens

Two specimens are used, one each for the dry and the wet tests. An area of specimen not less than 140 mm. x 50 mm.

3.4.2.3 Procedures

1) Dry rubbing test: It can be carried out by the following steps

- Place a test specimen on the base of the Crock meter so that it rests flat on the abrasive cloth with its long dimension in the direction of rubbing.

- Mount a 50mm. x 50 mm. square of white testing cloth, with the weave oblique to the direction of rubbing, over the end of the finger which projects downward from the weighted sliding arm. Use the special spiral wire clip to hold the test square in place.

- Lower the covered finger onto the test specimen and cause it to slide back and forth in a straight line along a track 100 mm. long on the dry specimen.

twenty times by making ten complete turns of the crank at the rate of one turn per second.

- Remove the white test square and evaluate.

2) Wet rubbing test: It can be carried out by the following steps.

- Repeat the test with a fresh dry specimen and undyed cloth which has been wetted with distilled water and squeezed to a take-up of 100%.

- The rest of the procedure is the same as the dry rubbing test
- Air dries the white test square before evaluating

3.4.2.4 Evaluation

1) Evaluate the amount of color transferred from the specimen to the white test square under examination by means of gray scale for staining.

2) Back the test square with three layers of white test cloth while evaluating.

3) Classification of dry and wet crocking fastness are as follows

Class 5 – negligible or no color transfer (very good class)

Class 4.5 – color transfer equivalent to step 4-5 on the gray scale for staining (good to very good class)

Class 4 – color transfer equivalent to step 4 on the gray scale for staining (good class)

Class 3.5 – color transfer equivalent to step 3-4 on the gray scale for staining (middle good class)

Class 3 – color transfer equivalent to step 3 on the gray scale for staining (middle class)

Class 2.5 – color transfer equivalent to step 2-3 on the gray scale for staining (middle poor class)

Class 2 – color transfer equivalent to step 2 on the gray scale for staining (poor class)

Class 1.5 – color transfer equivalent to step 1-2 on the gray scale for staining (poor to very poor class)

Class 1 – color transfer equivalent to step 1 on the gray scale for staining (very poor class)

3.4.4 Gray scale for color change (35)

This change describes the use of the gray scale for evaluating changes in color of textiles. The scale consists of five pairs of standard gray chip, each pair representing a difference in color or contrast (shade and strength). The corresponding numerical fastness ratings are approximately in table 3.3. The results of color fastness tests are rated by visual observation by comparing the color on standard scale.

Table 3.3 Numerical fastness rating of gray scale for color change

Color Difference in N.B.S. Unit	Fastness Rating	Meaning
0 +/- 0.2	5	Very good class
1.5 +/- 0.2	4	Good class
3.0 +/- 0.2	3	Middle class
6.0 +/- 0.2	2	Poor class
12.0 +/- 0.2	1	Very poor class

3.4.4.1 Use of the scale

1) Place a part of the original textile and the tested specimen of it side by side in the same plane and oriented in the same direction. Place the gray scale nearby in the same plane. The surrounding field should be uniform gray scale of a

brightness which is slightly less than that of the darkest member of the gray scale. Illumination of the surfaces with the north skylight or equivalent source with illumination of 538 lux(50 lumens per square foot) or more. The light should be incident upon the surfaces at approximately 45^{o} and the direction of viewing approximately perpendicular to the plane of the surfaces.

2) Compare the difference between original and tested textile by the gray scale.

3) Rating the specimen by the number of the gray scale.

4) In using the gray scale the character of the change in color whether in hue, saturation, and brightness or any combination of these is not rated; the overall difference or contrast between original and tested specimen is the basis for the evaluation.

3.4.4.2 Evaluation

The effect on the color of the test specimens can be expressed and defined by reference to the gray scale for color change which classified into various class as follows

Class 5 – negligible or no change as shown in gray scale step 5 (very good class)
Class 4 – a change in color equivalent to gray scale step 4 (good class)
Class 3 – a change in color equivalent to gray scale step 3 (middle class)
Class 2 – a change in color equivalent to gray scale step 2 (poor class)
Class 1 – a change in color equivalent to gray scale step 1 (very poor class)

3.4.5 Gray scale for staining (35)

Staining describes the use of the gray scale foe evaluating staining on undyed textiles in color fastness test. The scale consists of one pair of white and four pairs of gray and white color chips; each pair representing the contrast. The standard numerical fastness ratings are shown in table 3.4. The staining of undyed cloth in color fastness test is rated by visually comparing the difference in color of the stained and unstained cloth by the scale.

Table 3.4 Numerical fastness rating of gray scale for staining

Color Difference in N.B.S. Unit	Fastness Rating	Meaning
0 +/- 0.2	5	Very good class
4.0 +/- 0.3	4	Good class
8.0 +/- 0.5	3	Middle class
16.0 +/- 1.0	2	Poor class
32.0 +/- 2.0	1	Very poor class

3.4.5.1 Use of the scale

1) Place a part of the unstained undyed textile and the tested specimen side by side in the same plane and orient in the same direction. Place the gray scale for staining nearby in the same plane. The surrounding field should be uniform gray of brightness slightly less than that of the darkest member of the gray scale for evaluating change in color. Illumination the surfaces with the north skylight or equivalent source with illumination of 538 lux(50 foot-candles) or more. The light should be incident upon the surfaces at approximately 45^o and the direction of viewing approximately perpendicular to the plane of the surfaces.

2) Compare the visual difference between original undyed and tested pieces with the differences represented by the gray scale.

3) The fastness rating of the specimen is that number of the gray scale which corresponds to the contrast between the original and tested pieces.

3.4.5.2 Evaluation

Staining can be evaluated by gray scale for staining. The results can be indicated by classes as:

Class 5 negligible or no change as shown in gray scale step 5 (very good class)
Class 4 a change in color equivalent to gray scale step 4 (good class)
Class 3 a change in color equivalent to gray scale step 3 (middle class)
Class 2 a change in color equivalent to gray scale step 2 (poor class)
Class 1 a change in color equivalent to gray scale step 1 (very poor class)

3.5 Data Analysis

Color fastness testing data will be analyzed by Analysis of Variance (ANOVA) which test statistic significance by F-test.

CHAPTER 4
THE RESULT OF STUDY

A study on color fastness of silk color fabric dyed with natural dyestuff in case of Terminalia catappa Linn. leaves in 36 treatments and each treatment is composed of 3 replications. Results of the study are shows in the following

4.1 Rubbing Fastness

Table 4.1 Results of rubbing fastness in 1:1 concentration conditions

Condition	Level of rubbing fastness					
	Replication 1		Replication 2		Replication 3	
	dry	wet	dry	wet	dry	wet
No fixing agent, 60°C, 45 minutes	5	5	5	5	5	5
No fixing agent, 60°C, 60 minutes	5	5	5	5	5	5
No fixing agent, 80°C, 45 minutes	5	5	5	5	5	5
No fixing agent, 80°C, 60 minutes	5	4-5	5	4-5	5	4-5
Lemon, 60°C, 45 minutes	5	5	5	5	5	5
Lemon, 60°C, 60 minutes	5	5	5	5	5	5
Lemon, 80°C, 45 minutes	5	5	5	5	5	5
Lemon, 80°C, 60 minutes	5	5	5	5	5	5
Salt, 60°C, 45 minutes	5	4-5	5	4-5	5	4-5
Salt, 60°C, 60 minutes	5	4-5	5	4-5	5	4-5
Salt, 80°C, 45 minutes	5	4-5	5	4-5	5	4-5
Salt, 80°C, 60 minutes	5	4	5	4	5	4

From Table 4.1, the results of all sample of dry rubbing fastness are all equal in grade 5 that has the maximum rubbing fastness property, is set in very good class, it means dyes molecule not to fading to the white fabric, but the result of wet rubbing fastness, dyeing condition with salt at 80°C 60 minutes that has minimum fastness at grade 4, it means that the degree of this property is set in fairly good class.

Table 4.2 Results of rubbing fastness in 1:3 concentration conditions

Condition	Level of rubbing fastness					
	Replication 1		Replication 2		Replication 3	
	dry	wet	dry	wet	dry	wet
No fixing agent, 60°C, 45 minutes	5	5	5	5	5	5
No fixing agent, 60°C, 60 minutes	5	5	5	5	5	5
No fixing agent, 80°C, 45 minutes	5	5	5	5	5	5
No fixing agent, 80°C, 60 minutes	5	5	5	5	5	5
Lemon, 60°C, 45 minutes	5	5	5	5	5	5
Lemon, 60°C, 60 minutes	5	5	5	5	5	5
Lemon, 80°C, 45 minutes	5	5	5	5	5	5
Lemon, 80°C, 60 minutes	5	5	5	5	5	5
Salt, 60°C, 45 minutes	5	5	5	5	5	5
Salt, 60°C, 60 minutes	5	5	5	5	5	5
Salt, 80°C, 45 minutes	5	5	5	5	5	5
Salt, 80°C, 60 minutes	5	5	5	5	5	5

From Table 4.2, the results of color change for all dry and wet rubbing fastness are all equal in grade 5 that has the maximum rubbing fastness property, is set in very good class, it means dyes molecule not to fading to the white fabric.

Table 4.3 Results of rubbing fastness in 1:5 concentration conditions

Condition	Level of rubbing fastness					
	Replication 1		Replication 2		Replication 3	
	dry	wet	dry	wet	dry	wet
No fixing agent, 60^{o}C, 45 minutes	5	5	5	5	5	5
No fixing agent, 60^{o}C, 60 minutes	5	5	5	5	5	5
No fixing agent, 80^{o}C, 45 minutes	5	5	5	5	5	5
No fixing agent, 80^{o}C, 60 minutes	5	5	5	5	5	5
Lemon, 60^{o}C, 45 minutes	5	5	5	5	5	5
Lemon, 60^{o}C, 60 minutes	5	5	5	5	5	5
Lemon, 80^{o}C, 45 minutes	5	5	5	5	5	5
Lemon, 80^{o}C, 60 minutes	5	5	5	5	5	5
Salt, 60^{o}C, 45 minutes	5	5	5	5	5	5
Salt, 60^{o}C, 60 minutes	5	5	5	5	5	5
Salt, 80^{o}C, 45 minutes	5	5	5	5	5	5
Salt, 80^{o}C, 60 minutes	5	5	5	5	5	5

From Table 4.3, the results of color change for all dry and wet rubbing fastness are all equal in grade 5 that has the maximum rubbing fastness property, is set in very good class, it means dyes molecule not to fading to the white fabric.

Table 4.4 The analysis of variance for wet rubbing fastness

Source of Variation	df	SS	MS	F
Treatment	35	5.25000	0.15000	1.86590*
Concentration of dye solution (A)	2	3.75000	1.87500	23.32380*
Dyeing condition (B)	11	18.41667	0.03788	1.67424*
A x B	22	1.97950	0.08998	1.11930
Error	70	5.62730	0.08039	
Total	105	10.87730		

* Significance at .05

Table 4.4 shows the analysis of variance; it indicated that there was significance in factor A and factor B at .05, but interaction between factor A and factor B was non-significance.

Table 4.5 The analysis of variance for dry rubbing fastness

Source of Variation	df	SS	MS	F
Treatment	35	4.24739	0.12135	1.00597
Concentration of dye solution (A)	2	0.09106	0.04553	0.37744
Dyeing condition (B)	11	0.35156	0.03196	0.26494
A x B	22	3.80476	0.17294	1.43364
Error	70	8.44410	0.12063	
Total	105	12.69149		

* Significance at .05

Table 4.5 shows the analysis of variance, it indicated that there was non-significance all source of variation.

4.2 Washing Fastness

Table 4.6 Results of washing fastness in 1:1 concentration conditions

Condition	Level of washing fastness		
	Replication 1	Replication 2	Replication 3
No fixing agent, 60°C, 45 minutes	5	5	5
No fixing agent, 60°C, 60 minutes	5	5	5
No fixing agent, 80°C, 45 minutes	4-5	4-5	4-5
No fixing agent, 80°C, 60 minutes	4-5	4-5	4-5
Lemon, 60°C, 45 minutes	5	5	5
Lemon, 60°C, 60 minutes	5	5	5
Lemon, 80°C, 45 minutes	5	5	5
Lemon, 80°C, 60 minutes	5	5	5
Salt, 60°C, 45 minutes	2-3	2-3	2-3
Salt, 60°C, 60 minutes	2	2-3	2
Salt, 80°C, 45 minutes	2	2	2
Salt, 80°C, 60 minutes	2	1-2	1-2

From Table 4.6, the results of color change for all dyeing condition with lemon that the highest group of washing fastness are equal in grade 5, is set in very good class, it means silk colored fabric not to change in color after washed, but all dyeing condition with salt that the lowest group of washing fastness are in grade 1-2 to 2-3 that are set in poor to fairly class.

Table 4.7 Results of washing fastness in 1:3 concentration conditions

Condition	Level of washing fastness		
	Replication 1	Replication 2	Replication 3
No fixing agent, 60^{o}C, 45 minutes	5	5	5
No fixing agent, 60^{o}C, 60 minutes	5	5	5
No fixing agent, 80^{o}C, 45 minutes	4-5	4-5	4-5
No fixing agent, 80^{o}C, 60 minutes	4-5	4-5	4-5
Lemon, 60^{o}C, 45 minutes	5	5	5
Lemon, 60^{o}C, 60 minutes	5	5	5
Lemon, 80^{o}C, 45 minutes	5	5	5
Lemon, 80^{o}C, 60 minutes	5	5	5
Salt, 60^{o}C, 45 minutes	4-5	4	4-5
Salt, 60^{o}C, 60 minutes	4	4-5	4
Salt, 80^{o}C, 45 minutes	4	3-4	4
Salt, 80^{o}C, 60 minutes	3-4	4	4

From Table 4.7, the results of color change for all dyeing condition with salt that the lowest group of washing fastness are in grade 3-4 to 4-5, are set in fairly to fairly good class, but all dyeing condition with lemon that the highest group of washing fastness are equal in grade 5, is set in very good class, it means silk colored fabric not to change in color after washed.

Table 4.8 Results of washing fastness in 1:5 concentration conditions

Condition	Level of washing fastness		
	Replication 1	Replication 2	Replication 3
No fixing agent, 60°C, 45 minutes	5	5	5
No fixing agent, 60°C, 60 minutes	5	5	5
No fixing agent, 80°C, 45 minutes	4-5	4-5	4-5
No fixing agent, 80°C, 60 minutes	4-5	4-5	4-5
Lemon, 60°C, 45 minutes	5	5	5
Lemon, 60°C, 60 minutes	5	5	5
Lemon, 80°C, 45 minutes	5	5	5
Lemon, 80°C, 60 minutes	5	5	5
Salt, 60°C, 45 minutes	4-5	4-5	4-5
Salt, 60°C, 60 minutes	4-5	4-5	4-5
Salt, 80°C, 45 minutes	4-5	4-5	4-5
Salt, 80°C, 60 minutes	4-5	4-5	4-5

From Table 4.8, the results of color change for all dyeing condition with salt and dyeing condition without fixing agent at 80°C are lowest group of washing fastness are in equal in grade 4-5, are set in good class, it means very slightly change in color in colored fabric. Other condition are equal in grade 5, is set in very good class.

Table 4.9 The analysis of variance for washing fastness

Source of Variation	df	SS	MS	F
Treatment	35	84.87966	2.42513	1.55131
Concentration of dye solution (A)	2	72.18056	36.09028	23.08625*
Dyeing condition (B)	11	36.34417	3.30402	2.11352*
A x B	22	76.68342	3.48561	2.22968*
Error	70	109.42960	1.56328	
Total	105	194.30926		

* Significance at .05

Table 4.9 shows the analysis of variance, it indicated that there was significance in factor A, factor B and interaction between factor A and factor B at .05, but treatment was non-significance.

4.3 Light Fastness

Table 4.10 Results of light fastness in 1:1 concentration conditions

Condition	Level of light fastness		
	Replication 1	Replication 2	Replication 3
No fixing agent, 60^{o}C, 45 minutes	4-5	4-5	4-5
No fixing agent, 60^{o}C, 60 minutes	4-5	4-5	4-5
No fixing agent, 80^{o}C, 45 minutes	4-5	4-5	4-5
No fixing agent, 80^{o}C, 60 minutes	4-5	4-5	4-5
Lemon, 60^{o}C, 45 minutes	4-5	4-5	4-5
Lemon, 60^{o}C, 60 minutes	4-5	4-5	4-5
Lemon, 80^{o}C, 45 minutes	4-5	4-5	4-5
Lemon, 80^{o}C, 60 minutes	4-5	4-5	4-5
Salt, 60^{o}C, 45 minutes	4-5	4-5	4-5
Salt, 60^{o}C, 60 minutes	4-5	4-5	4-5
Salt, 80^{o}C, 45 minutes	4-5	4-5	4-5
Salt, 80^{o}C, 60 minutes	4-5	4-5	4-5

From Table 4.10, the result of light fastness for all sample are equal in grade 4-5, it means that the degree of this property is set in fairly good class.

Table 4.11 Results of light fastness in 1:3 concentration conditions

Condition	Level of light fastness		
	Replication 1	Replication 2	Replication 3
No fixing agent, 60°C, 45 minutes	4-5	4-5	4-5
No fixing agent, 60°C, 60 minutes	4-5	4-5	4-5
No fixing agent, 80°C, 45 minutes	4-5	4-5	4-5
No fixing agent, 80°C, 60 minutes	4-5	4-5	4-5
Lemon, 60°C, 45 minutes	4-5	4-5	4-5
Lemon, 60°C, 60 minutes	4-5	4-5	4-5
Lemon, 80°C, 45 minutes	4-5	4-5	4-5
Lemon, 80°C, 60 minutes	4-5	4-5	4-5
Salt, 60°C, 45 minutes	4-5	4-5	4-5
Salt, 60°C, 60 minutes	4-5	4-5	4-5
Salt, 80°C, 45 minutes	4-5	4-5	4-5
Salt, 80°C, 60 minutes	4-5	4-5	4-5

From Table 4.11, the result of light fastness for all sample are equal in grade 4-5, it means that the degree of this property is set in fairly good class.

Table 4.12 Results of light fastness in 1:5 concentration conditions

Condition	Level of light fastness		
	Replication 1	Replication 2	Replication 3
No fixing agent, 60°C, 45 minutes	4-5	4-5	4-5
No fixing agent, 60°C, 60 minutes	4-5	4-5	4-5
No fixing agent, 80°C, 45 minutes	4-5	4-5	4-5
No fixing agent, 80°C, 60 minutes	4-5	4-5	4-5
Lemon, 60°C, 45 minutes	4-5	4-5	4-5
Lemon, 60°C, 60 minutes	4-5	4-5	4-5
Lemon, 80°C, 45 minutes	4-5	4-5	4-5
Lemon, 80°C, 60 minutes	4-5	4-5	4-5
Salt, 60°C, 45 minutes	4-5	4-5	4-5
Salt, 60°C, 60 minutes	4-5	4-5	4-5
Salt, 80°C, 45 minutes	4-5	4-5	4-5
Salt, 80°C, 60 minutes	4-5	4-5	4-5

From Table 4.12, the result of light fastness for all sample are equal in grade 4-5, it means that the degree of this property is set in fairly good class.

Table 4.13 The analysis of variance for light fastness

Source of Variation	df	SS	MS	F
Treatment	35	1.14665	0.03276	0.92621
Concentration of dye solution (A)	2	0.01250	0.00625	0.17670
Dyeing condition (B)	11	0.13889	0.01263	0.35708
A x B	22	0.23958	0.01089	0.30789
Error	70	2.47590	0.03537	
Total	105	3.62255		

* Significance at .05

Table 4.13 shows the analysis of variance, it indicated that there was non-significance all source of variation at .05.

CHAPTER 5
DISCUSSION

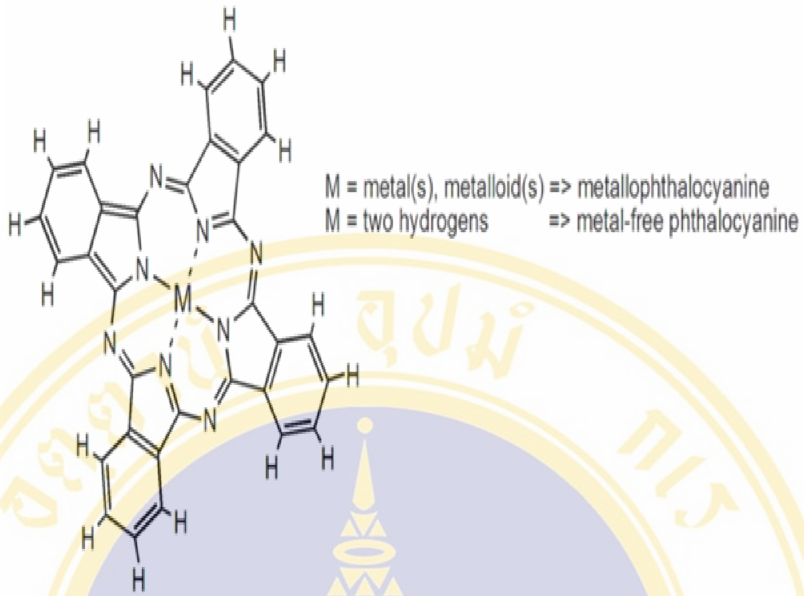
The result of a study on color fastness of silk color fabric dyed with natural dyestuff in case of Terminalia catappa Linn. leaves can be discuss in the following

5.1 Concentration of Dye Solution

The results of the experiment show that the concentration of dye solution has the maximum effect only to washing fastness because in deep shade (1:1 concentration of dye solution) makes more color change to silk fabric after washed, but in other concentration of dye solution has slightly effect. Therefore, it's resembled to Nontalee Chinwongamorn (25), the study of thermodynamic and factors to involve in dyeing silk. For rubbing fastness and light fastness, the results of the experiment show that the concentration of dye solution no effect to their fastness.

5.2 Dyeing Condition

The results of the experiment show that the dyeing condition with lemon has the highest group of color fastness, but slightly difference to the dyeing condition without fixing agent. The results of the experiment show that dyeing without a fixing agent sets a good to very good class of color fastness because the essential chemical structure of the color matter in Terminalia catappa Linn. is *pheophytin* that has chemical structure in the following



The chemical structure of *pheophytin* is an annular structure, thus offering the benefit of solidity by forming a strong and extremely stable chemical bond and has resistance to heat, light and migration fastness, and good to excellent weathering. Thus, the dyeing condition without fixing agent as sets a good to very good class of color fastness.

Therefore, it is resembled to the research in www.biosci.ohio-state.edu., but it is not resembled to Narumol Saratapun (27), Nantanut Pichetwit (28), Charoensri Benjamala (29), Nujira Rassamipaiboon (30), and Supab Rohkarn (31) because all of them not to dyeing with Terminalia catappa Linn. and their fixing agents were chemical fixing agent. For Chontira Mochadaporn (32), is the same study of dyeing silk with Terminalia catappa Linn. leaves, but different fixing agent, the result of her study is the appropriated dyeing condition is at 80^{o}C, 45 minutes and chrome is the best fixing agent that gives minimum color change when testing of color fastness to washing and light.

CHAPTER 6
CONCLUSION AND RECOMMENDATION

A study on color fastness of silk colored fabric dyed with natural dyestuff has the objective of the research is to study color fastness after rubbing, washing and exposure to light of silk fabric dyed with the natural dyestuff Terminalia catappa Linn. The experiment is based on varying dyeing conditions and the fixing agent. This study is divided into 3 x 12 treatments and each treatment is composed of 3 replications. The experiment design is a randomized completely block design which is comprised of 3 concentrations of dye solution and 12 dyeing conditions. After dyeing, brings all samples to the process of rubbing, washing and light fastness testing with Industrial Thai Standard No. 121 book 1, 3 and 5, 1975.

6.1 Conclusion

6.1.1 The condition that use lemon in every concentration and every dyeing condition has the highest class of rubbing fastness and the analysis of variance indicated non-significance different among fixing agent, dye concentration and dyeing conditions.

6.1.2 The appropriate condition for good class of rubbing fastness is pure dye in 1:5 of dye concentration at $60^{O}C$ 45 minutes.

6.1.3 The condition that uses lemon in every concentration and every dyeing condition has the highest class of washing fastness.

6.1.4 The appropriate condition for good class of washing fastness is pure dye in 1:5 of dye concentration at 60^{O}C 45 minutes.

6.1.5 All dyeing condition, dye concentration, and fixing agent are all same in grade 4-5 for light fastness; it means that the degree of this property is set in fairly good class and the analysis of variance indicated non-significance different among fixing agent, dye concentration and dyeing conditions.

6.1.6 The appropriate condition for good class of light fastness is pure dye in 1:5 of dye concentration at 60^{O}C 45 minutes but it is set in fairly good class.

6.1.7 The results of the experiment show that dyeing without a fixing agent sets a good to very good class of color fastness because *pheophytin* has an annular structure, thus offering the benefit of solidity by forming a strong and extremely stable chemical bond and has resistance to heat, light and migration fastness, and good to excellent weathering.

6.2 Recommendation

6.2.1 Comment and suggestion in this research

6.2.1 The restriction of this study is the native dyeing recipe, which is received from interviewing of the natives, is not the best recipe in the experiment dyeing because they are possessive and keep the real recipe as a secret. So, the dyeing results in this study may be in error.

6.2.2 The important caution during the dyeing process is necessary to stir the dye bath frequently in order to prevent the discoloration and need to check pH in dye bath before and after dyeing.

6.2.3 To keep silk fabrics which is dyed with natural dyestuff on prolong life, it should be avoided the inferior properties, i.e. should be cleaned by dry cleaning liquid and should not be cleaned often, and should be kept indoors.

6.2.4 The results of the study can be used to determine a trend to encourage rural people to dye silk with natural dyestuff, and as basic information for the customer to help classify clothing for appropriate use.

6.2.2 Recommendation for the further study

This study is a preliminary research of color fastness of silk color fabric which dyeing with natural dyestuff in case of Terminalia catappa Linn. leaves, the scope is too wide to study exhaustively. Further studies should be focused on the following items

6.3.1 For this study, used only Terminalia catappa Linn. leaves in Mahidol University and kept on September – October 2004, in further studies may be use the different place, and period times.

6.3.2 For this study, used only fresh Terminalia catappa Linn. leaves, in further studies may be use the different such as dry leaves.

6.3.3 For this study, dye extraction by boiling with distilled water, in further studies may be use the different method such as extract by solvent.

6.3.4 For this study, used only 100% degumming weaving silk fabric, in further studies may be use the different type.

6.3.4 For this study, used natural fixing agent 2 type these are lemon and salt, in further studies may be use the different such as tamarind, slosh, water from an artesian well, and zinc oxide.

6.3.5 For this study, dyeing with dyes solution mixed with fixing agent together in same step, in further studies may be ret the fabric in fixing agent before and after dyeing step.

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